REVIEW ARTICLE

Technological devices for the assessment and rehabilitation of hand and finger function in multiple sclerosis: A systematic review

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ABSTRACT

Multiple sclerosis (MS) is a chronic neurological disease that often leads to impairments in hand function, these limitations affect their quality of life. The use of technological devices in the parameterization and rehabilitation of manual dexterity in people with multiple sclerosis (pwMS) has gained significant attention due to their potential to improve the assessment and rehabilitation for the upper limb. This systematic review aims to provide an overview of the technological devices used for assessing and rehabilitating hand function in pwMS. It focuses on sample size, participant characteristics, tools and methodologies, intervention types, frequency and duration, and the anatomical regions and variables analysed. A systematic search was conducted in PubMed, Web of Science and Scopus, identified studies using technological devices for hand function assessment and rehabilitation in PwMS. Data were extracted on sample size, participant demographics (age, sex, MS type, and disease duration), tools used, intervention protocols and primary variables analysed. The review included 15 studies with a total of 865 pwMS, 28 healthy persons and 2123 healthcare professionals. The studies employed a variety of tool, tests, activities and protocols, going from traditional appliance to sensor-equipped devices. Rehabilitation protocols varied in frequency, duration and in format, with sessions lasting between 40 and 60 minutes, conducted 2–6 times per week over 4–8 weeks and conducted in person or telematic. Technological interventions show potential to improve hand function and treatment adherence. However, further research is needed to validate their predictive performance, optimize intervention protocols, and address challenges such as accessibility and long-term effectiveness.

Keywords: Hand, Multiple sclerosis, Parameterization, Rehabilitation, Technology.

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INTRODUCTION

Multiple Sclerosis (MS) is a neurodegenerative disease characterized by the demyelination within the central nervous system, in which the own immune system mistakenly attacks the myelin sheath that covers the nerve fibre (Harris et al., 2009). This damage disrupts the normal transmission of the nerve signals, resulting in impaired nerve conduction and a wide range of neurological symptoms. People with MS (pwMS) often experience motor and sensory disturbances, cerebellar dysfunction, fatigue, visual impairments, cognitive decline, speech and swallowing difficulties, as well as bladder, bowel and sexual dysfunction (Pugliatti et al., 2006, Lundy-Ekman, 2014). Among these manifestations, decreased manual dexterity and grip strength are particularly disabling, as they significantly limit the ability to perform activities of daily living (ADL) (Harris et al., 2009).

Worldwide, approximately 2,8 million people are affected by MS (Feigin, 2019), making it the leading non-traumatic cause of disability in young adults across Europe and North America (Evans et al., 2013, MSFI, 2020). Demographic data indicates that around 90% of pwMS are between 15 and 50 years old, and the female-to-male ratio has increased to almost 3:1 in recent decades (Coyle and Seeman, 2021, Ahlgren et al., 2011, Compston and Coles, 2002, Wallin et al., 2012, Orton et al., 2010). Paediatric-onset MS (<18 years) remains rare (<5% of cases), and onset after age 60 occurs in <1% of the cases (Coyle and Seeman, 2021).

Often referred to as "*the disease with a thousand faces*" due to its unpredictable course and wide variability of symptoms, MS affects various neurological functions such as strength, coordination and sensitivity (McDonald et al., 2001). Fifteen years after diagnosis, most patients experience significant hand dysfunction, forcing them to compensate with their upper limbs during everyday tasks such as buttoning clothes or handling utensils, which significantly reduces their independence, contributes to the progression of the disability and substantially increases their overall disability and loss of quality of life (Jonsdottir et al., 2019).

As a result of the wide range of neurological symptoms, pwMS tend to be significantly less physically active than healthy individuals of the same age, with up to a 30% reduction in aerobic capacity (Romberg et al., 2004, Brown and Kraft, 2005). Physically inactivity has been shown to lead to de-conditioning, which in turn contributes to the progression of disability (Motl et al., 2013). As a result, pwMS often reports difficulties in performing ADL, such as cooking or personal hygiene, which can seriously affect their self-perception and psychological well-being (Månsson and Lexell, 2004). In some cases, these limitations are associated with jog loss and reduced social integration (Chruzander et al., 2013). For these reasons, physical activity is strongly recommended as a key component of a multidisciplinary approach to MS treatment (Johansson et al., 2007).

Nowadays, advances in robotics are showing their potential in rehab, by increasing patient adherence and giving healthcare staff accurate quantitative data, which lets them personalize training and measure motor skills during therapy (Carpinella et al., 2009, Lamers et al., 2016). At the same time, telemedicine, which has been promoted since the SARS-CoV-2 pandemic in 2020, offers advantages such as greater adherence, time and cost efficiency, access without the need for travel and a reduction in the healthcare workload (P, A. J et al., 2003).

However, current devices are often limited to specific task or treat hand as a functional unit, without parameterizing the performance of each finger. This technological gap, coupled with the clinical complexity of MS, highlights the need for more versatile and personalized solutions.

The objectives of this systematic review are: (1) identify the technological devices used for the assessment and improvement of manual function in pwMS; (2) analyse how these devices address the parameterization of manual strength and dexterity, considering the specific involvement of the fingers; (3) evaluate the effectiveness of rehabilitation interventions using these devices and the reported clinical outcomes; and (4) examine healthcare professionals perspective on the implementation, execution and content of technology-assisted rehabilitation, as well as to identify recent trends and innovations in the design of tools for this purpose.

METHOD

This section explains how the research was done. The design of the same is described and it is explained how it was put into practice, justifying the choice of the methods used. This section should contain the type of quantitative research, the scope or depth of the research (exploratory, correlational and/or explanatory), population and sample, and the techniques used should be added. This section is fundamental, because it is the one that will allow the scientific community to reproduce the result. Most of this section should be written in the past tense, in a descriptive style.

Register

The systematic review was registered on the Open Science Framework platform (OSF) (https://osf.io/anjr4/?view_only=05969c336a0847028766e96f574eb63e) the 6 de February of 2026 (DOI: 10.17605/OSF.IO/ENQRK).

Procedures

The guidelines followed for the development of this systematic review were those established in the PRISMA 2020 guide (Page et al., 2021a, Page et al., 2021b).

Data sources and search strategy

Initially, four databases were to be used: Océano, Scopus, Web of Science and PubMed. However, given that Océano database draws all of its articles from the other three databases, it was decided to omit it from the final search.

The search strategy was developed by several authors (PP, NV and AM) specifically for the PubMed database (added below) and was applied to the title, abstract and keyword fields. This strategy was subsequently modified to adapt to the syntax and specific descriptions of the other databases. The bibliographic search was conducted in the PubMed, Web of Science and Scopus electronic databases, using the Boolean operator AND/OR in combination with the keywords: (((((((((("*multiple sclerosis*"[Title/Abstract]) AND (hand[Title/Abstract])) OR ("*upper limb*"[Title/Abstract])) OR ("*upper extremities*"[Title/Abstract])) OR (finger[Title/Abstract])) OR ("*hand grip*"[Title/Abstract])) AND (rehab*[Title/Abstract])) OR ("*hand training*"[Title/Abstract])) OR ("*finger training*"[Title/Abstract])) NOT ("*cerebral rehabilitation*"[Title/Abstract])) AND ((y_5[Filter]) AND (excludepreprints[Filter]) AND (casereports[Filter] OR classicalarticle[Filter] OR clinicalstudy[Filter] OR clinicaltrial[Filter] OR clinicaltrialphasei[Filter] OR clinicaltrialphaseii[Filter] OR clinicaltrialphaseiii[Filter] OR clinicaltrialphaseiv[Filter] OR clinicaltrialprotocol[Filter] OR observationalstudy[Filter] OR patienteducationhandout[Filter] OR randomizedcontrolledtrial[Filter] OR review[Filter] OR scopingreview[Filter] OR systematicreview[Filter] AND (humans[Filter]) AND (english[Filter]) AND (alladult[Filter])).

One author (PP) conducted the initial search, during which all collected references were uploaded to the Rayyan QCRI platform to remove duplicates. Two reviewers (PP and NV) independently assessed potentially eligible titles and abstracts, jointly resolving disagreements to minimize potential interpretation biases. The full texts of potentially eligible records were analysed according to the inclusion criteria for final selection. Reasons for exclusion were documented. In cases where articles were unavailable, authors were contacted by email.

Eligibility criteria

Original, peer-reviewed, full-text studies were included/excluded using the PICOS method (participants, interventions, comparators, outcomes and study design). The selection criteria are presented below (Table 1). To be included, a study had to have been published in a scientific journal within the las five years, to find the most recent and up-to-date evidence in the field. It was also established that the minimum number of participants in the study had to be at least 20, all of whom had to be diagnosed with MS, regardless of gender and the MS type, but with the restriction that patients had to be adults (>17 years old). This decision was made in order to have a study population large enough to produce meaningful results. One aspect that was considered when including articles, especially those on rehabilitation, was that the study used technology in the rehabilitation process, whether to enable telerehabilitation, to assist the patient or through augmented reality video games.

Table 1. Inclusion and exclusion criteria using the PICOS method.

Category	Inclusion criteria	Exclusion criteria
Participants	Adults with a confirmed diagnosis of multiple sclerosis (MS); ≥17 years; any sex; any MS subtype.	Participants without MS; paediatric samples (<16 years); mixed-age samples where adult data cannot be separated.
Interventions	Rehabilitation interventions that incorporate technology (e.g., telerehabilitation, assistive technologies, augmented reality or serious games) as part of the therapeutic process.	Rehabilitation interventions without any technological component when technology is required for inclusion.
Comparator	Any reported comparator (usual care, alternative intervention, sham, baseline, etc.).	
Outcomes	Measures of hand strength and/or dexterity, and studies that report parameterization and/or rehabilitation of these outcomes in MS patients.	Studies that do not explicitly assess or report hand strength/dexterity parameterization or rehabilitation
Study design/Other	Original, peer-reviewed, full-text studies published in scientific journals within the last 5 years; minimum sample size ≥20; sufficient methodological detail for critical appraisal	Conference abstracts, proceedings, unpublished studies; systematic reviews (not included as primary data, though screened for primary study references); studies with <20 participants or insufficient methodological detail; publications >5 years old.

Although systematic reviews were not included directly, they were examined to see if they contained references to studies that did not appear in the searches but were of interest.

Data extraction and synthesis

The process of extraction data from the final selection of articles was carried out entirely by the author of the review, which facilitates methodological consistency throughout the study. Data extraction for each article had two aspects, the first one, was to compile the main objective of the study and characterize the participating population. The second aspect involved extracting the measures and tests performed, the devices used in the study and the main conclusions reached.

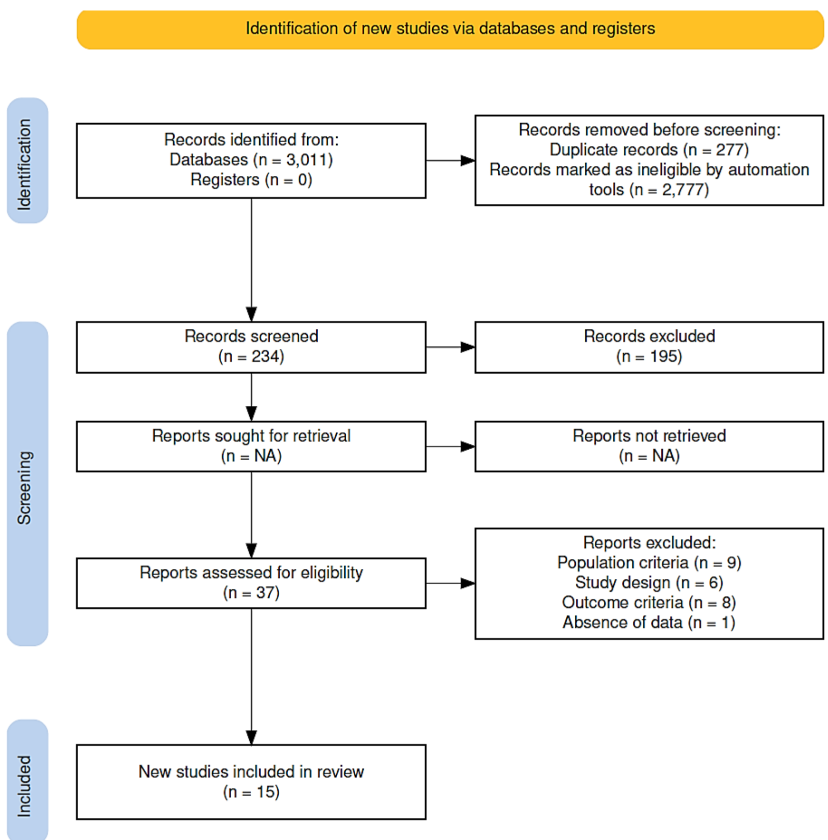
RESULTS

Study selection

Potentially eligible studies were exported directly from scientific databases to the Rayyan platform (https://www.rayyan.ai/) for duplicate removal and screening, applying the previously established inclusion and exclusion criteria. After this initial procedure, a total of 3.037 records were identified. Figure 1 shows the flow diagram for the study selection process. Duplicate records (n = 277) were removed. Subsequently, after reviewing titles and abstracts, 2.777 records were discarded and 234 full texts were screened. Of these, 234 studies were excluded after applying the eligibility criteria. Finally, 15 studies were considered eligible for the systematic review.

Study presentations

The results of the selected studies are presented according to the main objectives of each study, differentiating between those focused on the parameterization of hand strength and dexterity, those addressing rehabilitation interventions and the last one focused on the execution and content of rehabilitation, but from the healthcare personnel point of view. In all cases, the information extracted is structured in two tables. The first table shows the main objective of the study and the characteristics of the participant population, while the second table summarizes the measures and test applied, the devices used and the main conclusions of each study, information on the duration and frequency of the interventions is also included. This organization allows for a clear and systematic comparison between the studies included.



Source: Page et al. (2021b).

Figure 1. PRISMA flow diagram.

Study characteristics

A total of 1105 participants information was gathered, of which 865 where pwMS, 28 healthy persons used as normative values in in the study Pau et al,. 2021 and 212 where healthcare professionals that participated in the survey about the implementation of rehabilitation (Rasová et al,. 2020). All the studies the groups were composed of both women and men, but the number of women was higher than, involving 733 (66,33%) women.

A total of 669 people participated in the parameterization studies, of whom 65,63% were women (n = 439). For objective measurements, two studies used the JAMAR hand dynamometer to measure isometric grip strength (Pau et al,.2021, Grange et al,.2025), three performed fine motor skills (9-HPT) and gross motor skills tests (BBT) (Bertoni et al,.2022, Pau et al,.202, Grange et al,.2025) and one studied positioning and opposition movements (Signore et al,.2020). Only one article used sEMG sensors to measure muscle contractions (Beretta-Piccoli et al,.2020).

In terms of results and/or subjective tests, two studies used the MAM-36 and MFIS (Prada et al., 2020, Grange et al., 2025), while those that appeared in only one study were ABILHAND (Prada et al., 2020), FIM (Prada et al., 2020), HADS (Prada et al., 2020), LSI (Prada et al., 2020), FSMC (Beretta-Piccoli et al,.2020) and SDMT (Grange et al., 2025).

In the rehabilitation group, a total of 224 people participated in the eight studies, with 48,21% (n = 108) belonging to the experimental groups and 51,79% (n = 116) to the control groups. The percentage of women were 61,54% for the total, 55,75% for the control group and 44,25% for the experimental group. As for the objective measurements taken, in half of the studies, the JAMAR hand dynamometer was used to obtain isometric grip strength (Blázquez-Fernandez et al,. 2024, Pruszyńska et al,. 2022, Marcos-Antón et al,. 2023, Dastan et al,. 2025), while in only one trial, opposition grip strength with 2 and 3 fingers and lateral pinch strength, by using the PinchGauge (Blázquez-Fernandez et al,. 2024).

Seven of the eight studies chose de 9-HPT as the method for assessing fine manual dexterity (Blázquez-Fernandez et al,. 2024, Cuesta-Gómez et al,. 2022, Pruszyńska et al,. 2022, Marcos-Antón et al., 2023, Tramontano et al,. 2020, Ciatto et al,. 2024, Dastan et al,. 2025, Solaro et al,. 2020), while four trials used de BBT for gross manual dexterity (Blázquez-Fernandez et al,. 2024, Cuesta-Gómez et al,. 2022, Marcos-Antón et al,. 2023, Ciatto et al,.2024).

The 25% of the studies measures range of motion, one at the forearm and wrist level (Marcos-Antón et al,. 2023) and the other at the wrist and each finger separately (Ciatto et al,.2024). In the subjective testing section, three studies used the MSIS-29 (Blázquez-Fernandez et al,. 2024, Cuesta-Gómez et al,. 2022, Marcos-Antón et al,. 2023), one used the FSS (Blázquez-Fernandez et al,. 2024) and two used the MFIS (Dastan et al,. 2025, Solaro et al,. 2020) and NRS (Ciatto et al,.2024, Solaro et al,. 2020), also one quarter of the trials used the ABILHANH (Blázquez-Fernandez et al,. 2024, Marcos-Antón et al,. 2023).

While the tests that were only used by one of the trials were, TMT (Cuesta-Gómez et al,. 2022), SCWT (Cuesta-Gómez et al,. 2022), MBI (Tramontano et al,. 2020), MSQiL-54 (Tramontano et al,. 2020), RMI (Tramontano et al,. 2020), MRC (Tramontano et al,. 2020), DASH (Ciatto et al,.2024), AMSQ (Dastan et al,. 2025), PBMSI (Dastan et al,. 2025), IPA (Dastan et al,. 2025) and BPI (Dastan et al,. 2025).

Parameterization

Below are the extracted data from the six articles focused on parameterization. The first table (Table 2) show the objective to be achieved in each study and the characterization of the participant population (age, duration of illness, MS type…).

The second table (Table 3) shows the measurements and tests performed on patients, the material used in the trials and the conclusions reached in the study.

Table 2. Principal outcome and population characteristic of the parameterization studies.

Study	Principal outcome	nº	Age (X ± σ) [Range] (years)	Gender (%)	MS Type (%)	Disease duration (X ± σ) [Range] (years)	EDSS (X ± σ) [Range]
Prada et al., 2021	Compare the relationship between the MAM-36 and the ABILHAND questionnaire to detect impairments in pwMS	51	56.3 ± 10.00 [33-82]	72.55-F 27.45-M	54.94-RR 45.06-P*1	34 ± 12	5.5 ± 1.6 [1.5-7.5]
Bertoni et al., 2022	Examine alterations in bilateral fine and gross motor skills according to the degree of disability	212	54.07 ± 12.81	63.68-F 36.22-M	52.83-RR 18.87-PP 28.30-SP	18.91 ± 10.95	6.50 (5.50-7.00) *2
Signore et al., 2019	Explore the effects of aging on finger motor performance in pwMS, considering duration and phenotype	96	42.1 ± 9.5	69.80-F 30.20-M	84.40-RR 15.6-SP	[0.6-44.2] (8)*3	0-7 (2.5) *3
Pau et al., 2021	Apply methodology with two accelerometers on wrist to quantify activity, intensity and asymmetry in the upper limb	28 (28)*4	50.6 ± 9.5	71.43-F 28.57-M	67.86-RR 14.29-PP 17.86-SP	-	4.5 ± 1.9
Beretta-Piccoli et al., 2020	Quantify actual upper limb activity in terms of time, intensity and asymmetry using wrist accelerometers	21	47 ± 11	57.14-F 42.86-M	57.14-RR 14.29-PP 25.57-SP	-	4.3 ± 1.0
Grange et al., 2025	Examine alterations in bilateral fine and gross motor skills according to the degree of disability	261	51.4 ± 13.3 [19-85]	64.40-F 35.60-M	52.90-RR 18.40-PP 28.70-SP	14.61 ± 10.84 [0-53]	5.03 ± 1.9 [0.00-8.50]

*Note. X = Mean/σ = Standard deviation/RR = Relapsing-Remitting/PP = Primary Progressive/SP = Secondary Progressive/EDSS = Expanded Disability Status Scale/F = Female/M = Male. *1 = Progressive type/*2Median (IQR)(Interquartile Range)/*3(Median)/*4Healthy Controls (for nominals values).*

Table 3. Measurements, test, devices used and conclusion of the parameterization articles.

Study	Measures obtained	Tests performed	Devices and software used	Conclusions
Prada et al,.2020 [xx]		Manual Ability Measure-36 (MAM-36) y ABILHAND, Edinburgh Handedness Inventory, Functional Independence Measure (FIM), Hospital Anxiety and Depression Scale (HADS), Life Satisfaction Index (LSI), Modified Fatigue Impact Scale (MFIS)		Both tools, MAM-36 and ABILHAND are valid for assessing upper limb functionality in pwMS. It maintains that a multidimensional approach is necessary for a better evaluation
Bertoni et al,.2022		Fine manual dexterity (9-HPT) and gross manual dexterity (BBT)	R-Software	The study found that, in most pwMS, both fine and gross motor skills were altered with respect to normative values, with gross motor skills being more prevalent and appearing in earlier stages of the disease. Regarding the MS phenotype, gross motor skills showed more alterations and a higher prevalence.
Signore et al,.2020	Self-positioning with and without marked rhythm, sequences of opposing movements with each finger and motor performance	Finger positioning and opposition movements with marked rhythm (2Hz) and self-paced	Sensor-Engineered Glove (GAS, ETT S.p.a., Italy), hoc tool software and Stata V.14	Evidence of worsening motor performance in the finger in pwMS due to age and disease progression. Deterioration in bilateral coordination compared to normative data for healthy individuals of the same age. Relationship between age and level of disability (EDSS) with hand functions.
Pau et al,.2021	Vector magnitudes per axis, time and unilateral use ratios, mono and bilateral use index, isometric grip strength	Fine motor skills (9-HPT) and gross motor skills (BBT)	Triaxial accelerometer (Actigraph GR3X), Actilife V6.13.3 software, MATLAB and dynamometer (JAMAR®)	The use of portables devices for bilateral monitoring of the upper limb proved to be a valid tool for assessing the contribution of each limb in unilateral and bilateral movements, facilitating clinical and rehabilitation follow-up

Beretta-Piccoli et al,.2020	Maximal and submaximal contractions (20% and 60% MVC), endurance time and surface electromyography (sEMG)	Fatigue Scale of Motor and Cognitive Functions (FSMC)	Ergonomic chair (COR1), load cell, adhesive electrode mesh (MUC1), torque meter and EMG signal amplifiers (OT-Bioelettronica)	Surface electromyography (sEMG) parameters were useful for indirectly assessing fatigue and muscle performance in pwMS during submaximal contractions, especially in the biceps brachii.
Grange et al,.2025	Isometric grip strength (JAMAR®)	Fine motor skills (9-HPT), gross motor skills (BBT), Manual Ability Measure-36 (MAM-36), SDMT and MFIS-21	Dynamometer (JAMAR®) and IBM SPSS Statistics V26 software	Fatigue in pwMS is present in both subjective and objective assessments, affecting upper limb dexterity. Combined assessment of strength, dexterity and fatigue can optimize clinical interpretations and rehabilitation

Note. MAM-36 = Manual Ability Measure-36/FIM = Functional Independence Measure/HADS = Hospital Anxiety and Depression Scale/LSI = Life Satisfaction Index/ MFIS = Modified Fatigue Impact Scale/9-HPT = 9 Hole Peg Test/BBT = Block and Box Test/ FSMC = Fatigue Scale of Motor and Cognitive Functions/ SDMT = Symbol Digit Modalities Test/MFIS-21 = Modified Fatigue Impact Scale.

Rehabilitation

For those articles focused on rehabilitation, as in those on parameterization, the information extracted was separated into two groups of tables. The first one (Table 4) shows the objective of the trial and the characteristics of the study population, which in this case is composed of two groups, the control group and the experimental group. The second table (Table 5), as in the previous case, shows the measurements and tests carried out on the patients, the material used in the trials, the conclusions reached in each study and in addition, shows information on the duration and frequency of the session.

For the devices used, one article used the PowerBall, another article used the Nintendo Switch, the Pablo Tyromotion exoskeleton was also used in one trial, in other study the used the MYO Armband sensor and another used the SenseWear Armband, with their corresponding virtual environment software. This set of studies shows how conventional rehabilitation therapies combined with new technologies/devices were more effective than those that only used conventional rehabilitation techniques.

Table 6. Characteristics of the population in the survey of implementation of rehabilitation.

Study		**Rasová et al,. 2020**				
Principal Outcome		To describe aspects of the content and delivery in MS physical therapy across Europe, analyse key factors, and evaluate general recommendations related to the implementation of physical therapies in clinical practice				
Characteristics		Total (%)	Region			
			East (%)	North (%)	South (%)	West (%)
Total respondents		212	35(16.5)	65(30.7)	91(42.9)	21(9.9)
Gender	Female	154(72.6)-F	25(71.4)-F	56(86.2)-F	63(69.2)-F	10(47.6)-F
	Male	58(27.4)-M	10(28.6)-M	58(13.8)-M	28(30.8)-M	11(52.4)-M
Age	21-30	65(30.7)	17(48.6)	15(23.1)	25(27.5)	8(38.1)
	31-50	123(58.0)	15(42.9)	38(58.5)	61(67.0)	9(42.9)
	>50	24(11.3)	3(8.6)	12(18.5)	5(5.5)	4(19.0)
Profession	Physiotherapist	201(94.8)	32(91.4)	62(95.4)	89(97.8)	18(85.7)
	Researcher	14(6.6)	3(8.6)	2(3.1)	5(5.5)	4(19.0)
	Other profession	8(3.8)	2(5.7)	4(6.2)	0(0.0)	2(9.5)
Educational level	Doctoral	18(8.5)	6(17.1)	2(3.1)	10(11.0)	0(0.0)
	Masters	69(32.5)	21(60.0)	19(29.2)	22(24.2)	7(33.3)
	Bachelor	87(41.0)	6(17.1)	39(60.0)	31(34.1)	11(52.4)
	Diploma specialist	23(10.8)	0(0.0)	3(4.6)	19(20.9)	1(4.8)
	Other education	15(7.1)	2(5.7)	2(3.1)	9(9.9)	2(9.5)
Years in practice	0-2	28(13.2)	12(34.3)	8(12.3)	6(6.6)	2(9.5)
	03-oct	63(29.7)	8(22.9)	13(20.0)	36(39.6)	6(28.6)
	>10	121(57.1)	15(42.9)	44(67.7)	49(53.8)	13(61.9)
Worktime with MS patients	0%-24%	87(41.0)	22(62.9)	18(27.7)	40(44.0)	7(33.3)
	25%-49%	40(18.9)	4(11.4)	10(15.4)	22(24.2)	4(19.0)
	50%-74%	33(15.6)	1(2.9)	15(23.1)	14(15.4)	3(14.3)
	75%-100%	52(25.5)	8(22.9)	22(33.8)	15(16.5)	7(33.3)

Table 4. Principal outcome and population characteristic of the rehabilitation studies.

Study	Principal outcome	Population (n)		Age (X ± σ) [Range](years)		Gender (%)		Disease duration (X ±σ) (years)		MS type (%)		EDSS (X ±σ) [Range]	
		Control group	Study group	Control group	Study group	Control group	Study group	Control group	Study group	Control group	Study group	Control group	Study group
Blázquez-Fernández et al,. 2024	Investigate the effects of a training protocol using the Powerball® in combination with conventional physical therapy on muscle strength, coordination, fatigue, functionality and quality of life in pwMS	13	12	46,33 ±1,90	53,00 ±2,06	53,80-F 46,20-M	33,40-F 66,60-M	14,00 ±3,47	17,75 ±3,20	50-RR 50-SP	25-RR 25-PP 50-SP	5,55 ±1,09	4,38 ±2,05
Cuesta-Gómez et al,. 2022	Assess the effects of NS®, combined with conventional intervention, on improving grip strength, coordination, movement speed, fine and gross motor skills, functionality, quality of life and executive function in pwMS	10	11	48,11 ±3,49	53,70 ±2,10	80-F 20-M	36,36-F 63,64-M	17,78 ±2,68	20,10 ±3,39	50-RR 10-PP 40-SP	54,55-RR 36,36-PP 9,09-SP	5,00 ±0,33	6,40 ±0,33
Pruszyńska et al,. 2022	Evaluate the effectiveness of using a commercial augmented reality system in pwMS treatment	15	15	41,40 ±4,61	38,33 ±7,61	73,33-F 26,67-M	73,33-F 26,67-M	9,60 ±4,34	9,93 ±5,42	-	-	-	-
Marcos-Antón et al,. 2023	Assess the effectiveness of games specially developed for the MYO Armband® capture sensor in improving forearm and wrist mobility, upper limb muscle strength, dexterity, fatigue, functionality, quality of life, satisfaction and adverse effects	15	15	47,87 ±6,70	48,67 ±7,63	66,67-F 33,33-M	40-F 60-M	13,20 ±7,60	17,27 ±10,70	53,33 RR 20,00 PP 26,67 SP	46,67-RR 13,33-PP 40,00-SP	6,0 [2,5]*1	6,0 [1]*1
Tramontano et al,. 2020	Assessing the effects of sensor-based motor rehabilitation using the PABLO®-Tyromotion device as an addition to conventional rehabilitation therapy	16	14	52,30 ±5,40	46,70 ±10,40	62,50-F 37,50-M	57,14-F 42,86-M	22,40 ±9,50	17,30 ±7,60	81,25-SP 18,75-PR	71,43-SP 28,57-PR	7,10 ±1,00	6,70 ±1,80
Ciatto et al,. 2024	Examine the impact of assistive training robots (Hand Tutor TM) on range of motion and manual dexterity in pwMS compared to the conventional population	15	15	46,53 ±10,91	54,73 ±7,45	60-F 40-M	66,66-F 33,33-M	-	-	53,30%RR 13,30%PP 33,30%SP	6,60%RR 93,30%SP	6,73 ±1,09	5,43 ±1,29
Dastan et al,. 2025 *2	Evaluate the effects of an 8-week synchronized telerehabilitation program focused on upper limb training and hand-arm functions in pwMS and compare the results with asynchronous telerehabilitation	15	15	37 (34,0; 55,0)	46,00(41,0; 54,0)	80-F 20-M	80-F 20-M	9,75 (4,75;17)	10,20 (7,16;24,66)	80-PP 13,30-PP 6,70-SP	80-RR 6,70-PP 13,30-SP	2,5(2,0; 5,5)	3,5 (2,0; 5,5)
Solaro et al,. 2020 *3	Compare the efficacy and tolerance of training assisted by robots with haptic technology versus sensorimotor technology in improving upper limb functions in pwMS	17	11	46±10 [26-69]	53±10 [33-67]	59-F 41-M	58-F 42-M	13±8	15±10	35-RR 24-PP 41-SP	10-RR 47-PP 42-SP	5±1	6±1

*Note. X = Mean/σ = Standard deviation/RR = Relapsing-Remitting/PP = Primary Progressive/SP = Secondary Progressive/EDSS = Expanded Disability Status Scale/F = Female/M = Male. *1 = Median (IQR), Experimental group = Synchronized Telerehabilitation Treatment group, Control group = Asynchronous Telerehabilitation Treatment/*2Control group = Sensorimotor, Experimental group = Haptic.*

Table 5. Measurements, test, devices used and conclusion of the rehabilitation articles.

Study	Measures obtained	Test performed	Devices and software	Sessions	Conclusions
Blázquez-Fernandez et al,. 2024	Isometric grip strength, two-finger opposition grip, lateral pinch grip, three-finger pinch grip	BBT, 9-HPT, MSIS-29, ABILHAND and FSS	PowerBall® 250 Hz, JAMAR® and Baseline Pinch Gauge®	2 sessions/week 45 min/session 8 weeks (16 sessions)	The Powerball® system, combined with conventional physical therapy, produced significant improvements within the group, with excellent satisfaction and adherence to the treatment. However, no significant differences were observed in comparison with the control group
Cuesta-Gómez et al,. 2022	Isometric grip strength	QuickDASH, 9-HPT, BBT, MSIS-29, TMT and SCWT	Dr Kawashima's Brain Training® for the Nintendo Switch® (NS)	2 sessions/week 60 min/session 8 weeks (16 sessions)	Although the 8-week protocol showed improvements in the different measures ans test performed, no significant differences were observed between the two analysis groups. While the addition of the video game showed no adverse effects and increased the subjects' level of satisfaction and compliance
Pruszyńska et al,. 2022	Isometric grip strength	9- HPT and re-moving balls from a box and place them on a tray.	Neuroforma AR system y JAMAR®	5 sessions/week 40-45 min/session 4 weeks (20 sessions)*1	It emphasizes the important role that rehabilitation plays in slowing down deterioration. It highlights the value of remote rehabilitation, where patients with grater motor difficulties can undergo rehabilitation from home. Patients also showed widespread acceptance and a high degree of willingness to perform the exercise
Marcos-Antón et al,. 2023	Range of motion of different joints (dorsiflexion, palmar flexion, pronation and supination) and isometric grip strength	Coordination, fatigue, functionality, 9-HPT, BBT and variables of quality of life (MSIS-29 and ABILHAND)	Sensor MYO Armband® and JAMAR®	2 sessions/week 60 min/session 8 weeks (16 sessions)	The combination of the MYO Armband® with conventional physical therapy produced positive effects in the measurements taken, in addition to demonstrating high usability and user satisfaction
Tramontano et al,. 2020	-	9-HPT, MBI, MSQoL-54, RMI and MRC	PABLO®-Tyromotion and IBM SPSS Statistics Software (V 23)	3 sessions/week 40 min/session 4 weeks (12 sessions)	Visual and auditory feedback during training can be a very useful complement to pwMS. The group that used PABLO®-Tyromotion showed a higher percentage of improvement compared to the control grup. Only the experimental group showed significant improvements in quality of life (MSQoL), suggesting that the use of this technology helps to motivate and generate greater enthusiasm among pwMS
Ciatto et al,.2024	Range of motion of extension and flexion movements, and frequency of cyclic	9-HPT, BBT, DASH and NRS	Hand TutorTM, Hand TutorTM device and R (V4.3.0)	6 sessions/week 45 min/session 4 weeks (20 sessions)	The rehabilitation program proved to be feasible and well received by the patients, especially those with the most severe disabilities. The experimental group achieved better results than the control group in terms of upper limb functionality after the program
Dastan et al,. 2025 *2	Isometric grip strength, physical activity, energy and metabolic expenditure	9-HPT, AMSQ, PBMSI, MFIS, IPA and BPI	JAMAR®, SenseWear Armband, Skype V7.24, SenseWear Professional Software and IBM SPSS	2 sessions/week 40-60 min/session 8 weeks (16 sessions)	Found that synchronized telerehabilitation is effective in terms of fatigue, quality of life and participation of pwMS, and although, asynchronous telerehabilitation also showed improvements, they were not as significant as those in the other group
Solaro et al,. 2020 *3	Resistive stiffness (kr) and tool stiffness (km)	9-HPT, Arat, MFIS and NRS	Planar robotic manipulators, eye chart and H3DAPI (virtual environment)	2 sessions/week 40 min/session 4 weeks (8 sessions)	The haptic modality showed slight improvement in upper limb dexterity training. Individuals with pyramidal impairments showed better adaptarion to task difficulty (both for the tool and resistance stiffness) compared to those with cerebral or mixed impairments

*Note. BBT = Block and Box Test/9-HPT = 9 Hole Peg Test/MSIS-29 = Multiple Sclerosis Impact Scale/FSS = Fatigue Severity Scale/TMT = The Trial Making Test/SCWT = The Stroop Colour and Word Test/MBI = Modified Barthel Index/MSQoL-54 = Multiple Sclerosis Quality of Life-54 RMI = Rivermead Mobility Index/MRC = Medical Research Council/DASH = Disabilities of the Arm Shoulder and Hand/ NRS = Neurological Rating Scale/AMSQ = Arm Function in Multiple Sclerosis/PBMSI = Patient Reported Preference-Based Multiple Sclerosis Index/ MFIS = Modified Fatigue Impact Scale/IPA = Participation and Autonomy Impact Questionnaire/BPI = Brief Pain Inventory/aRAT = Action Research Arm Test. *1Telerehabilitation sessions/*2 Experimental group = Synchronized Telerehabilitation Treatment group, Control group = Asynchronous Telerehabilitation Treatment/*3Control group = Sensorimotor, Experimental group = Haptic.*

Table 7. Topics covered, devices used and conclusion of the implementation of the rehabilitation process.

Study	Rasová et al,. 2020
Topics covered in the questionnaires	-Adjustments made based on the level of disability -Details of the therapy sessions (duration, frequency, intensity and composition) -Perception of the accessibility, effectiveness and sustainability of physical therapies -Therapeutics approach (how much time was spent on manual manipulation techniques, how much on giving verbal instructions and information, and how much on demonstration)
Software used in statical analysis	-Statistical Environment R (V 3.5.0)
Conclusions	-Identify variations in therapies across Europe, where a large disparity was found between regions -Recommendations on access to treatment and adaptation based on the degree of disability -Mentions the need for standardization and/or guidelines to improve the quality and consistency of therapies for pwMS -Highlight the differences in therapeutic approaches and long-term follow-up in different European regions

Implementation of the rehabilitation

The last type of study, which was selected, was one where the purpose of it was to analyse and know better how the physical therapies were conducted across Europe. For these reasons the population of study here were the health professionals that work with pwMS. In Table 6 are show the characteristics of the people who respond to the questionnaire, while in Table 7 is shown the topics asked, software used and the conclusions that they reached.

212 people from 26 European countries participated in the survey on the content and development of physical therapies. Of those who participated, 72,6% (n = 154) were women, with 58% aged between 31 and 50 years old. Furthermore, 94,8% of the entire group surveyed were physical therapists, with 57,1% having more than 10 years of experience in the rehabilitation of pwMS.

DISCUSSION

One of the key objectives of this systematic review was to collect and analyse studies focused on the use of non-invasive technological devices for the direct assessment of manual function and hand dexterity in pwMS following rehabilitation interventions. In addition, we set out to evaluate the impact of these interventions on grips strength, digital dexterity and functional improvement of the hand in pwMS

Parameterization (objective vs subjective measures)

When assessing the qualities and disease progression presented by pwMS, the outcomes mostly came from two types of measurements, objective and subjective.

Objective measurements provide quantitative and standardized data (Marcos-Antón et al., 2023), making possible the assess of distinct aspects, like manual dexterity (Bertoni et al, 2022), grip strength (Severijns et al., 2015). Due to the nature of been based in standardized protocols and instrument, these measurements are highly reproducible and consistent, making easier to monitor changes in physical function over time (Pau et al., 2021).

In the evaluation of fine manual dexterity, the 9-HPT is recommended as a gold standard test (Feys et al,). For the 9-HPT a clinically important worsening over time has been suggested as20% (Goodkin et al., 1988). The protocol for this test consists of removing 9 pegs one by one from a container and insert them into a board with 9 holes, then removing them from the board and placing them back into the container (Negaresh et al., 2019). Among its advantages is the simplicity of its administration, since it only requires measuring the time it takes to complete the task. Another benefit is that the size of the pieces to be moved and board to deposit the pegs can be varied in order to make the task easier for the patient (Pruszyńska et al., 2022).

For the gross manual dexterity, the BBT is a frequently used standardized procedure, showing good responsiveness a low floor and ceiling effect when applied to pwMS (Bertoni et al., 2022; Solaro et al., 2020). The BBT evaluates gross manual dexterity by counting the number of 2.5-cm cubes a participant can transfer from one compartment of a divided box to the other within 60 s; the total number transferred is the score. The BBT is brief, easy to administer and sensitive to changes in gross hand function. The BBT test has been validated for pwMS and clinically important worsening over time has been suggested as 3,5 cubes (participant perception), 5,2 (clinical perception) or 15% (Goodkin et al., 1988).

For grip strength the common standard is the HGT that evaluates isometric force by using a hand dynamometer. To perform the HGT, the position of the arm became very important, neutral shoulders, the elbow flexed at 90º, forearm in a natural position, wrist between a dorsiflexion of 0º and 30º, and between 0º and 15º of cubital deviation (Solaro et al., 2020). For the test three measurements are made, being the score the average of the three (Solaro et al., 2020).

Subjective measures show greater heterogeneity: Patient Reported Outcomes Measures (PROMs) differ in domain coverage, item content and scoring, and some scales emphasise activities or participation while omitting aspects important to patients. These types of self-report questionnaires, like the WHODAS 2.0, investigates the subjects' level of functioning, thus allowing a more comprehensive assessment of disability by considering domains of activities and participation as well as the impact of the environmental factors on them (Curatoli et al., 2025). This heterogeneity, together with day-to-day fluctuations in patients' perceptions (influenced by mood, fatigue, etc.), can reduce concordance with objective performance tests. Therefore, and because correlations between PROMs and objective measures are often modest, it is advisable to include both types of assessment for a comprehensive evaluation of upper-limb function. Cite reviews or validation studies that document these discrepancies (Prada et al., 2021).

Disability assessment

An important factor for healthcare professionals when choosing rehabilitation treatment or tests to better monitor the disease is knowing the degree of disability. The EDSS is commonly used for this assessment in PwMS, This numerical scale ranges from 0 to 10, with the following divisions of disability levels: mild (EDSS≤3,0), moderate (3,5≤EDSS≤5,5) and severe (EDSS≥6,0) (Solarto et al., 2020). The EDSS focuses on ambulatory and motor skills. This scale has the disadvantage that it must be performed in person and in front of a neurologist, which in situations of mobility or economic restrictions that the patient may have (since it requires to move to a specialized centre), this can cause inconvenience and prevent the evaluation from being performed correctly. For this reason, a variation of the EDSS has been in use for several years, now being conducted by telephone and has been validated for trained personnel (Lechner-Scott et al., 2003). The PDDS is a more economical and simpler alternative to the EDSS for better monitoring of the course of the disease. For this scale, the score ranges from 0 to 8, with the following subgroups: mild (PDDS≤1), moderate (2≤PDDS≤3), severe ambulatory (4≤PDDS≤6) and severe non-ambulatory (PDDS≥7) (Bertoni et al., 2015).

Tang et al., 2022 found that upper limb tremor affects up to 50% of people with MS (Meador et al., 2016; Alusi et al., 2001) and used a scale to measure Quality of Life (QOL) in essential tremor. This scale correlates closely with EDSS-measured physical disability, similar to the MSIS-29 (Hoogervorst et al., 2004), but the QUEST scale offers a more accurate QOL assessment for MS patients with upper limb tremor. Selecting the most appropriate scale allows for precise monitoring of disability and supports tailored rehabilitation strategies.

Improvements in rehabilitation techniques

The systematic review highlights the significant role of technological advancements in the rehabilitation of hand function in pwMS, the devices and his function that appear in the selected articles is shown in Table 8.

Table 8. Devices used in the articles.

Category	Devices	Used for
Evaluation and parameterization	Dynamometers (JAMAR® and Pinch Gauge)	To measure isometric grip and pinch strength
	Tri-axial Accelerometers (Actigraph GT3X	Monitor bilateral upper limb activity
	Sensor-Engineered Gloves	Assess finger opposition movements and positioning
	Surface Electromyography (sEMG)	Evaluate muscle fatigue and performance during contractions
Rehabilitation	PowerBall® 250 Hz	Increasing grip strength and coordination and reducing non-specific wrist pain
	Dr Kawashima's Brain Training® for the Nintendo Switch® (NS)	Infrared motion sensors for training manual dexterity
	Neuroforma AR system	Augmented reality system for arm mobility exercises
	Sensor MYO Armband®	Motion capture sensors for forearm and wrist rehabilitation
	PABLO®-Tyromotion	Sensor based exoskeleton for motor rehabilitation
	Hand TutorTM	Assistive robots for manual dexterity training
	SenseWear Armband	3-axis accelerometer to measure physiological parameters
	Planar robotic manipulators	Robot-assisted rehabilitation
	H3DAPI (virtual environment)	Virtual environment
Telerehabilitation	Skype	Conduct online meetings

On one hand, there are devices designed to perform tasks that define movement patterns and grip forces in the hand (Cuesta-Gómez et al., 2020). Digital medical metrics can be obtained and processed, resulting in objective measurements that characterized movement such as quality, speed, efficiency and delicacy, while also measuring the grip force generated (Kanzler et al., 2020).

The reviewed studies provide robust evidence of the effectiveness of technological interventions in enhancing hand function and quality of life for people with MS. The use of the PowerBall® 250 Hz in combination with conventional physiotherapy resulted in significant improvements in coordination and manual dexterity of the more affected UL as measured by the BBT (Blázquez-Fernandez et al,. 2024) (Table 9).

Table 9. Outcomes of the BBT test in the article Blázquez-Fernández et al., 2024.

Group	Side	Before (X ± σ) [nº of block]	After (X ± σ) [nº of block]	Follow-up (X ± σ) [nº of block]	Two-paired comparisons: Pre Vs. Post *p*-value	Pre Vs. Follow up *p*-value	Post Vs. Follow up *p*-value
Control	More affected	39.23 (± 10.20)	40.77 (± 10.89)	45.08 (± 11.55)	>.999	.069	.005
	Less affected	41.69 (± 10.61)	42.46 (± 11.24)	45.46 (± 10.38)	>.999	.012	.282
Experimental	More affected	44.5 (± 7.65)	49.17 (± 10.15)	52.08 (± 9.53)	.048	.001	.38
	Less affected	47.75 (± 9.55)	49.92 (± 11.97)	54.83 (± 9.93)	.312	<.001	.034

Not only are material devices being improved, but augmented reality is also introduced as a complement to conventional therapy programs for hand dexterity, achieving greater treatment intensity at affordable cost (Schwarz et al., 2019). The use of video games through virtual reality has benefits in terms of spatial-temporal organization, attention, concentration and benefits decision-making speed, memory social contact when playing in groups, spontaneity and originality (Schwarz et al., 2019, Waliño-Paniagua et al., 2019). In the reviewed literature the use of augmented reality and virtual reality systems Neuroforma AR System, allowed patients to carry out multiple arm mobility exercises remotely, with the physical therapist remotely supervising and selecting the exercises to be performed (Dastan et al,. 2025). The trial showed that in the 9-HPT there was a significant reduction in the execution time (seconds) in both sides of the body (weak and strong side) (Table 10).

Table 10. Outcomes in the 9-HPT in the article Pruszyńska et al,. 2022.

Group	Side	Before (X ± σ) [seconds]	After (X ± σ) [seconds]	*p*-value	Test power
Control	Dominant	3.16 (± 0.28)	3.13 (± 0.29)	.279	0.0593
	Non-dominant	3.26 (± 0.29)	3.24 (± 0.31)	.7418	0.0537
Experimental	Dominant	3.25 (± 0.18)	3.10 (± 0.18)	.0002	0.6098
	Non-dominant	3.34 (± 0.19)	3.19 (± 0.21)	.0002	0.521

The benefits of telerehabilitation including interactive web-based programs, home-based systems for physical activity monitoring, or online communities (Khan et al., 2015), for instance, could monitor and motivate patients over time, whilst potentially improving the accessibility and quality of physiotherapy services (Marziniak et al., 2018).

CONCLUSIONS

This systematic review highlighted the significant potential of technology in enhancing hand rehabilitation for pwMS Technological advancements provided accurate parameters for assessing hand function and dexterity, ensured high treatment adherence, and increased patient satisfaction. These tools also enabled more intensive exercise programs and eliminated physical barriers by allowing remote rehabilitation under professional supervision.

However, the review identified a critical gap: there was no comprehensive tool specifically designed for measuring individual finger strength in pwMS. This limitation underscored the need for future research and development to address this gap and create versatile devices that could adapt to the diverse needs of pwMS at different stages of the disease.

Regarding rehabilitation strategies, the review emphasized that combining conventional therapies with innovative technologies, such as exoskeletons, motion sensors and augmented reality systems, yielded better outcomes compared to traditional methods alone. Strategies that incorporated visual and auditory feedback, as well as engaging tools like serious games and virtual reality, were shown to improve adherence and satisfaction among patients. Telerehabilitation also emerged as a promising approach, particularly for patients with mobility challenges, as it allowed them to access therapy from home while maintaining effective supervision.

Despite these advantages, the review also highlighted certain limitations in the use and implementation of technology and telerehabilitation for pwMS. One major limitation was the lack of extensive studies demonstrating the short- and long-term effectiveness of these systems. Additionally, current devices were often focused on specific tasks and lacked versatility, while more comprehensive systems were prohibitively expensive, limiting accessibility. The review also emphasized the challenges of working with patients at different stages of the disease, as their abilities varied significantly. This highlighted the need for devices and rehabilitation strategies to be adaptable and easy to use, ensuring they could be applied to a wide range of patients without requiring excessive effort for adjustments.

Future efforts should focus on developing adaptable and personalized rehabilitation tools that could cater to the varying needs of pwMS. Additionally, further studies were required to validate the long-term effectiveness of these technologies and establish standardized guidelines for their implementation in clinical practice.

AUTHOR CONTRIBUTIONS

All authors meet the criteria for authorship in accordance with established ethical guidelines. Contributions are specified according to the CRediT (Contributor Roles Taxonomy) as follows:

Conceptualization, Pacheco Sanchez-Aguilar, PJ, Virto, N., Mendez-Zorrilla A. Methodology, Pacheco Sanchez-Aguilar, PJ, Virto, N., Mendez-Zorrilla A. Formal Analysis: Pacheco Sanchez-Aguilar, PJ, Virto, N. Investigation: Pacheco Sanchez-Aguilar, PJ, Virto, N. Writing—original draft preparation, Pacheco Sanchez-Aguilar, PJ, Virto, N. Writing—review and editing, Pacheco Sanchez-Aguilar, PJ, Virto, N., Mendez-Zorrilla A. Supervision: Mendez-Zorrilla A. All authors have critically reviewed and approved the final version of the manuscript and agree to be accountable for all aspects of the work.

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The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this manuscript.

AI USE DISCLOSURE

In accordance with current publishing ethics and transparency recommendations, artificial intelligence (AI) tools were used solely to assist with translation and language editing, with the aim of improving clarity and readability. No AI tools were used in the generation of scientific content, including the study design, data collection, analysis, interpretation of results, or the formulation of conclusions. The authors retain full responsibility for the content of the manuscript and confirm its originality, integrity, and accuracy.

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