

Assistive Devices for Personal Mobility in Parkinson's Disease: A Systematic Review of the Literature

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Abstract: Background: Gait abnormalities are a hallmark of Parkinson's disease and contribute to falling risk. As disease symptoms progress, assistive devices are often prescribed. However, there are no guidelines for choosing appropriate ambulatory devices for gait impairment.

Objective: To review the scientific evidence on assistive devices for gait impairment in Parkinson's disease.

Methods: We performed a systematic literature review for articles relating to parkinsonian gait impairment and assistive devices. We assessed the studies' methodological quality and risk of bias using the PEDro scale.

Results: Seventeen articles were reviewed. Four articles (23.53%) showed that canes and standard and two-wheeled walkers without visual cues decreased gait speed and stride length, with no significant effects on freezing of gait or falls. Instead, improvements were observed with the use of visual [seven articles (41.18%)] and auditory cues [three articles (17.65%)], including decreased number of freezing episodes and increased stride length.

Conclusions: Although assistive devices seem to improve confidence, there is still limited information about the efficacy of assistive devices on gait parameters and functional disability in Parkinson's disease. Further, longitudinal, multicenter, randomized, blinded, and controlled studies using assistive devices in a free-living context are required to provide the best scientific evidence

Parkinson's disease (PD) is the second most frequent neurodegenerative disease, with a prevalence that is progressively increasing along with the continuous aging of the population. Recent studies estimated that the number of PD cases doubled between 1990 and 2015, reaching 6.2 million people worldwide, and is expected to double by 2040.¹ As PD progresses, disorders of posture, gait, and balance are common and debilitating, even more in atypical parkinsonism.^{2,3} Parkinsonian gait disorder is characterized by slowness, shortening of stride length, a reduction in the distance between the ground and the feet, and decreased arm swing. Approximately 40–70% of people with PD fall yearly, and one-third repeatedly fall,^{4,5} twice as likely as the healthy elderly population.⁶ An increase in step cadence and freezing are common, causing a tendency

to lean forward,⁷ inability to turn, and postural imbalances that contribute to causing falls.⁸ All these gait disturbances have a significant physical and psychological impact resulting in increased fear of falling and sedentary lifestyles.⁹ As a consequence, gait impairment in PD favors the risk for dependence, social isolation, institutionalization, and decreased quality of life, causing a significant impact on social and health care costs.¹⁰

Although no available therapies modify the underlying neurodegenerative process, symptomatic therapies can improve patient quality of life in PD.¹ However, when pharmacological treatment is insufficient as the disease progresses, support products or assistive devices are traditionally recommended for gait impairment. These assistive devices in PD aim to maintain patients'

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Keywords: Parkinson's disease, self-help devices, canes, walkers, gait disorders.

³Composition of Multidisciplinary Telemedicine Group is specified in Supplemental File S1.

Received 12 January 2022; revised 12 August 2022; accepted 28 August 2022.

Published online 7 October 2022 in Wiley Online Library (wileyonlinelibrary.com). DOI: 10.1002/mdc3.13568

balance, increase their confidence and security, and maintain their independence for as long as possible.¹¹

A wide variety of assistive products might facilitate walking for PD patients. Some of them are standard products commonly used in geriatrics, such as canes, crutches, or walkers, among many others. In addition, other devices have been developed specifically for people with PD, including various add-ons or modifications, such as the introduction of visual guides.¹²

The prescription of assistive devices may vary according to different clinical practices and health environments. Standard guideline practices recommend that the prescription of assistive products should be performed by qualified professionals, such as neurologists, occupational therapists, or physical therapists.¹³ However, there are no scientific-based guidelines for choosing appropriate ambulatory devices in PD. In addition, it is often difficult to determine which device is appropriate for patients with PD based on their needs and functional impairment. Therefore, this article aims to review the best available scientific evidence on using assistive devices in patients affected by PD with gait impairment.

Methods

Design

This systematic review was conducted following the PRISMA guidelines,¹⁴ including the checklist.

Search Strategy

The search was performed using the databases Web of Science, ScienceDirect, PubMed, Scopus, and Cochrane, searching in the title, abstract, and keywords the following MeSH terms: “*Parkinson Disease*,” “*Self-Help Devices*,” “*Canes*,” “*Walkers*,” “*Gait Disorders*” and “*Parkinsonian Disorders*” from January first, 1992, to May first, 2022. We combined the following terms: (Parkinson Disease AND Self-Help Devices) OR (Parkinson Disease AND Canes) OR (Parkinson Disease AND Walkers) OR (Gait Disorders AND Self-Help Devices) OR (Gait Disorders AND Canes) OR (Gait Disorders AND Walkers) OR (Parkinsonian Disorders AND Self-Help Devices) OR (Parkinsonian Disorders AND Canes) OR (Parkinsonian Disorders AND Walkers).

Inclusion and Exclusion Criteria

The identified articles were considered for review if they included patients with idiopathic PD, with a Hoehn and Yahr (HY) stage <5, an assistive device was applied as a primary or secondary variable of interest, and gait or balance outcomes were given. We excluded trials published in languages other than English or Spanish.

Review Process

The eligibility of identified trial reports was reviewed by all authors independently. Full texts were obtained if there was a need. The study eligibility was resolved by discussion and adjudicated by the lead author (AG).

Quality Assessment of the Studies

The studies' methodological quality and risk of bias were assessed using the PEDro scale¹⁵ shown in Table 1, which evaluated the internal validity and the statistical information. When available, the PEDro rating scores were obtained from the PEDro database, ranging from 0 (worst quality) to 10 (highest quality), and classified as poor or fair, indicating a lack of methodological quality with scores ranging from 0 to 3, acceptable methodology with scores from 4 to 5, good methodology with scores from 6 to 8, and excellent with scores from 9 or 10. In other instances, controversial opinions about study eligibility were resolved by discussion and adjudicated by the lead author (AG) as required.

Study Analysis

Two of the following contributors (AGB, FVS) extracted data on study design, sample characteristics, intervention design, and outcomes (study qualities and gait device characteristics). The studies were described in terms of trial design (sample size, the PEDro total score), sample demographic and clinical characteristics [HY stage,¹⁶ the Unified Parkinson's Disease Rating Scale (UPDRS) or MDS-UPDRD Part III¹⁷], study quality (the PEDro scale), intervention component (type of assistive device), and efficacy outcomes including freezing of gait, falls, balance, and gait parameters such as walking speed, cadence, stride time, stride length, swing time, double stance phase, and stance period.

Results

Articles Selection

Figure 1 shows the flow diagram of the eligible articles with the inclusion and exclusion criteria and data extraction. The study selection filter was initially based on the information in the title and subsequently on the abstract and full text when the abstracts did not contain the necessary information. In the full-text pre-analysis phase, the articles were checked to see if they met the inclusion criteria for this review.

Quality Assessment

Table 1 shows the PEDro scores. Most of the articles included in this review (88.23%) obtained a score of 5 to 6, indicating an acceptable-good methodology. Most articles were open-label

TABLE 1 Assessment of the articles using the PEDro scale

	Items											Total
	1 ^a	2	3	4	5	6	7	8	9	10	11	
Boonsinsukh R, et al. ¹⁹	1	0	0	1	0	0	0	1	1	1	1	5
Buatoed W et al. ²⁰	1	0	0	1	0	0	0	1	1	1	1	5
Bryant M et al. ²¹	1	1	0	1	0	0	0	1	1	1	1	6
Asahi T et al. ²²	0	0	0	0	0	0	0	0	0	0	0	0
Kegelmeyer DA et al. ²³	1	1	0	1	0	0	0	1	1	1	1	6
Dotov D et al. ²⁴	1	0	0	1	0	0	0	1	1	1	1	5
McCandless PJ et al. ²⁵	1	0	0	1	0	0	0	1	1	1	1	5
Bryant MS et al. ²⁶	1	0	0	1	0	0	0	1	1	1	1	5
Kim M and Lim B ²⁶	1	0	0	1	0	0	0	1	1	1	1	5
Zhao Y et al. ²⁸	1	0	0	1	0	0	0	1	1	1	1	5
Bryant M et al. ²⁶	1	0	0	1	0	0	0	1	1	1	1	5
Zhang M et al. ²⁹	1	0	0	1	0	0	0	1	1	1	1	5
Bunting-Perry L et al. ³⁰	1	0	0	1	0	0	0	1	1	1	1	5
Donovan S et al. ³¹	1	1	0	1	0	0	0	1	1	1	1	6
Egerton C et al. ³²	0	0	0	1	0	0	0	1	1	1	1	5
León Ruiz M et al. ³³	0	0	0	0	0	0	0	0	0	0	0	0
Cubo E et al. ³⁴	1	1	0	1	0	0	0	1	1	1	1	6

^aItem 1: eligibility criteria; Item 2: random allocation; Item 3: concealed allocation; Item 4: Group homogeneity; Item 5: patient blinding; Item 6: therapist blinding; Item 7: rater blinding; Item 8: key outcome collection; Item 9: intervention allocation; Item 10: between-group statistical comparisons; Item 11: key outcome measures report. Item 1 influences external validity but not internal validity. This item is not used to calculate the PEDro score.

trials,^{20,25–30} with a randomized design in 4/17 (23.52%).^{21,23,31,34} Two articles (11.76%)^{32,33} obtained a PEDro score of 0, because they were reports of individual cases. The items with lower scores were 2, 3, 4, 5, and 6. Regarding item 2 (random allocation), only 4/17 articles (23.53%) used random distribution. Regarding item 3 (concealed allocation), none of the articles mentioned any blinding technique in the distribution of participants. Regarding items 5 (patient blinding), 6 (therapist blinding), and 7 (rater blinding), none of the articles met these criteria. Table 2 in File S2 shows a summary of the main aspects of each article.^{19–34}

Sample and PD Characteristics

The included trials involved a total of 276 patients with a mean age of 67.38 years, 182 males (65.95%), 62 females (22.46%), and 32 participants (11.59%) whose gender was not specified. The range of PD duration of participants was from 1 to 27 years.

In 12/17 articles (70.59%), PD patients were assessed using the MDS-UPDRS part III, with a mean total score of 28.73, ranging from 18.00 to 39.00. In 7/17 articles (41.18%), the overall mean HY stage was <3, and in 5/17 articles (29.41%), the mean HY stage was ≥3, and in 5/17 (29.41%) the HY stage was

missing. Only two articles (11.76%) reported the patient's motor state (Off vs. On state).

Assistive Devices and Gait Assessment

Most articles compared different assistive devices, including canes and walkers, with or without sensory cues. One or more types of canes were evaluated in 10 out of 17 articles (58.82%) [7/10 (70%) evaluated the standard cane, 3/10 (30%) the cane with laser or visual cues, and 1/10 (10%) an adapted cane]. Different types of walkers were evaluated in 7/17 articles (41.18%), including standard, two-wheeled and four-wheeled walkers, the U-Step walkers, and motorized walkers. In addition, wheeled walkers with and without visual cues were evaluated in 5/17 articles (29.41%). Other assistive devices using sound or vibration metronomes, smart glasses, or other rhythmic cues stimuli were evaluated in 4/17 (23.53%) articles.

Most trials were exclusively conducted in a laboratory environment. Video cameras, sensors, and other assessment tools were used to analyze gait parameters. GAITRite[®] was the most frequent assessment for gait disturbances using a portable single-layer pressure-sensitive walkway that measured temporal and spatial parameters.^{21,23,26,27}

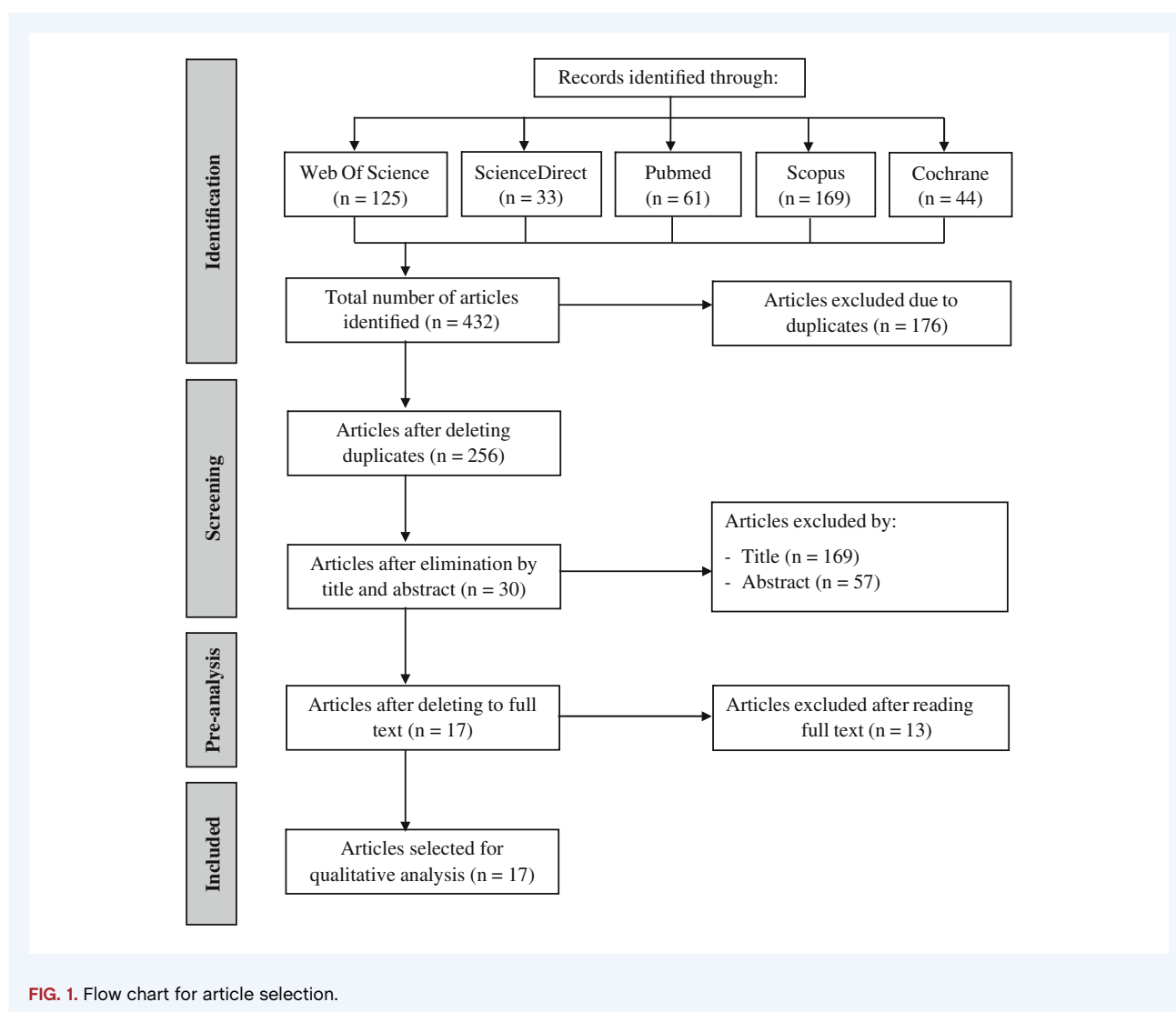


FIG. 1. Flow chart for article selection.

Efficacy Outcomes

Table 3 in File S3 shows the main efficacy outcomes for each article, including statistical figures.

Gait Speed

Gait speed, commonly assessed in centimeters/second, was one of the most assessed efficacy outcomes, in 10/17 articles (58.82%). Several studies showed that using assistive devices including canes,²⁷ and wheeled walkers,^{26,27,34} decreased gait speed compared to unassisted walking. In contrast, no differences in gait speed were found between standard, two-wheeled, four-wheeled walkers, and U-Step walker.²³ Boonsinsukh et al.¹⁹ neither found significant differences in gait speed between walking with and without a standard cane.

On the other hand, the results were very different when canes with visual cues were used. Buated et al.²⁰ observed that gait

speed was faster using a laser light cane compared to a standard cane during the “off” state, and this improvement was observed in patients with mild and moderate PD. On the contrary, Bryant et al.²¹ found no significant differences, and patients’ gait speed during the “off state” was similar regardless of whether they used a standard cane or a red or green laser light cane.

For other types of assistive products, Bryant et al.²⁶ found that patients with PD walked faster with an auditory pacer than without it, at baseline and after 1 week. Similarly, Zhao et al.²⁸ analyzed the effects of three types of external cues, a metronome, a flashing light, and an optical flow. Compared to no-cues, the metronome was the external cue more frequently associated with a significant improvement in walking speed, but only during a specific run involving turning 90°, walking through an open door, and turning 180° to return to the starting point. In contrast, Zhang et al.²⁹ found that walking speed was faster with unassisted walking than using a motorized walker with haptic cues with medium speed.²⁹

Step and Stride Lengths

Step and stride lengths, commonly assessed in centimeters, were also frequently reported efficacy outcomes. At least one of them was assessed in 11/17 articles (64.71%). However, the results were very diverse. In this regard, several authors found no significant differences in step length between using or not using a cane,^{19,27} in contrast other studies found a worsening of stride length using a cane and a wheeled walker compared to unassisted walking.^{19,26,27} Moreover, Kegelmeyer et al.²³ found no significant differences between unassisted walking compared to walking with a cane, a four-wheeled walker, or a U Step walker, but the stride length was improved in the unassisted walking compared to using a standard walker or a two-wheeled walker.

Several studies have reported the efficacy of laser light in assistive products with similar results. In this regard, Buated et al.²⁰ found an improvement in stride length during the “off” state using a laser light cane compared to a standard cane in patients with mild and moderate PD. Similarly, Bryant et al.²¹ found that using a cane with light (especially green) improved stride length compared to using a standard cane without a light, both during the “Off” and “On” states.

For auditory paces, Bryant et al.²⁶ showed that PD patients walking with an auditory pacer had a longer stride length compared to unassisted walking at baseline and after 1 week. Interestingly, Zhao et al.²⁸ found that the metronome was the only guide significantly associated with improving stride length, while optic flow and flashing light decreased the stride length. In contrast, Zhang et al.²⁹ reported a decrease in stride length using the motorized walker with haptic cues compared to unassisted walking, both with medium and high-speed cues.

Cadence

Cadence, commonly assessed in steps/minute, was assessed in 6/17 articles (35.29%). Most studies showed that using support products did not improve walking cadence. In this regard, Bryant et al.²⁶ did not find any significant difference in cadence between unassisted walking compared to walking with canes,²⁶ wheeled walkers (with and without visual cues) during the “On” and “Off” states,²⁰ nor using a standard cane or a cane with a light, regardless of whether the light was red or green.²¹ Similar findings were observed using an auditory pacemaker.²⁶ On the opposite, Kim and Lim,²⁷ showed that walking without any support improved walking cadence compared to using a cane and a two-wheeled walker.

Freezing of Gait

The number of gait freezes while walking as an efficacy outcome was used in 8/17 articles (47.06%). Overall, freezing of gait was more frequently observed using a standard walker compared to walking with a wheeled walker (3.9 ± 4.7 vs. 2.5 ± 3.8 ; $P = 0.0041$) and unassisted walking.³⁴

In other studies, including patients with mild and moderate PD, using a cane with visual cues reduced the number of

freezing gait episodes during the “Off” state compared to the standard cane.²⁰ Similarly, walking with a cane with a green light reduced the number of gait freezes during the “Off” state, compared to walking with a walker without a light and with a red light, both in a straight line as well as in a 180° turn.²¹ Laser light was the most effective support product in reducing the percentage of freezing episodes compared to unassisted walking, sound and vibration metronomes, and standard canes.^{25,31} Similarly, Zhao et al.²⁸ showed that during walks that included 360° turns, fewer freezing episodes occurred with a metronome compared to unassisted walking. In contrast, other authors did not find any significant differences in the number of freezes comparing walking using a wheeled walker with and without laser light.^{25,30}

Reduction of Falls

This efficacy outcome was used only in 1/17 article (5.88%).³¹ With the use of laser lights in standard canes and walkers, these authors found a reduction in the percentage of falls and frequency of weekly falls (3.23 ± 1.31 vs. 2.12 ± 0.92 ; $P = 0.02$).³¹

Discussion

A wide variety of assistive products can facilitate walking for PD patients. However, clinical experience denotes that patients' safety can be compromised using the wrong device by favoring anomalous arm swings, back posture, and falls if they are not adequately tested or adjusted. These assistive devices are often standard products commonly used in the elderly population, such as canes, crutches, or walkers, among many others. In PD, other devices have been specifically developed, including various add-ons or modifications with the introduction of visual guides.¹² At present, patients can get these devices from health personnel prescriptions, social media advertisements, or non-health personnel recommendations.

This article aimed to examine the best available scientific evidence for using personal mobility aids in patients with PD. Although these products are top-rated and used among patients with PD, the scientific evidence is scarce, based on few publications, with contradictory results.

Overall, standard canes, walkers, and wheeled walkers, except for four-wheeled walkers,²³ seem to reduce walking speed and cadence. When using these assistive devices, stride length does not improve or even worsens. Two-wheeled walkers seem to decrease walking speed and stride length more than canes.²⁷ No effect on freezing of gait was observed, except when using standard walkers without wheels, which further increased the frequency of freezing of gait.

Visual cues, especially those incorporated into standard canes, appear to increase walking speed and stride length compared to using the same assistive products without visual guides. In addition, visual guides also seem to contribute to reducing freezing gait episodes and the frequency of falls.³¹ On the other hand,

metronomes and auditory pacemakers improve gait in PD patients by increasing stride speed and stride length, maintaining gait cadence, and reducing the number of freezing gait episodes.

At present, it is still challenging to determine which device or devices are appropriate to improve gait parameters, freezing, or decrease falls in PD. In order to obtain an adequate level of evidence, we need to consider several methodological aspects: Firstly, the population target. The ability to walk in patients with PD can be influenced by several aspects such as disease severity, aging, and confounding variables such as cognitive impairment and other comorbidities. Secondly, good scientific evidence is derived from trials using a randomized, controlled, double-blinded clinical trial design. In this regard, because blindness in research using assistive devices is challenging, a good solution could be using an objective single-blind rater assessments provided by wearable technology. However, the accuracy of these wearable sensors against validated motor and gait outcome measures in PD, the influence of sensor characteristics, and their location (for instance, lower extremity vs. hip) are still controversial.³⁵ Likewise, the duration of the benefits associated with these devices in gait parameters is still unknown.

Thirdly, selecting meaningful gait, disability, quality of life outcomes, and cost-effective devices is crucial. In this systematic review, we have summarized the data on kinematic gait outcomes such as slowness, cadence, and shortening of stride length; and dysfunction and disability outcomes such as falls and episodes of freezing of gait. However, none included information on disability and quality of life assessments or other aspects such as cost-effectiveness.

Fourthly, the environment where these research studies might also influence the results. In this regard, clinical observations have found that patients with PD walk better under certain conditions, such as “white lab coat stimuli.” Consequently, ecological studies are strongly recommended to analyze the gait improvement and functional capacity of these patients while performing their daily living activities in a free-living context.

We are aware that this systematic review has some limitations. In particular, we have not included articles published in other languages besides English or Spanish. However, on the other hand, given the small number of published articles, we have provided exhaustive information on the current information about these assistive devices for PD.

Conclusion

This review confirms that there is limited information on the efficacy and safety of assistive device products to improve gait parameters and decrease functional disability related to gait dysfunction in PD. Further, longitudinal, blinded, multicenter, randomized, controlled studies conducted in a free-living context are required to provide the best therapeutic recommendations for this disabling condition in PD.

Acknowledgment

We want to thank the Parkinson's disease research community.

Author Roles

1. Research project: A. Conception; B. Organization; C. Execution. 2. Analysis: A. Design; B. Execution; C. Review and Critique. 3. Manuscript Preparation: A. Writing of the first draft; B. Review and Critique.

AGB: 1A, 1B, 1C, 2A, 2B, 2C, 3A, 3B.

FVS: 2A, 2B, 2C, 3C.

MAR: 2A, 2B, 2C, 3C.

JGS: 3A, 3B.

EC: 1A, 1B, 1C, 2C, 3A, 3B.

Rest of Multidisciplinary Telemedicine Group: 3A, 3B.

Disclosures

Ethical Compliance Statement: It was not necessary for the study to be approved by any ethics committee because it was a systematic review of the literature. Informed patient consent was not necessary for this work. We confirm that we have read the Journal's position on issues involved in ethical publication and affirm that this work is consistent with those guidelines.

Funding Sources and Conflicts of Interest: This work was supported by the project PI19/00670 of the Ministerio de Ciencia, Innovación y Universidades, Instituto de Salud Carlos III, Spain. The authors declare that there are no additional disclosures to report relevant to this work.

Financial Disclosures for the Previous 12 Months: The authors declare that there are no additional disclosures to report relevant to this work. ■

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Supporting Information

Supporting information may be found in the online version of this article.

File S1. Appendix: Multidisciplinary Telemedicine Group.

File S2. Table 2. Summary of articles included in the systesx4atic review.

File S3. Table 3. Efficacy outcomes of articles included in the systematic review.