Review Article
Benefits of Equine-Assisted Therapies in People with Multiple Sclerosis: A Systematic Review

Ana Myriam Lavín-Pérez,1 Daniel Collado-Mateo,1 Alejandro Caña-Pino,2 Santos Villafaina,3,4 José Alberto Parraca,4,5 and María Dolores Apolo-Arenas2

1Centre for Sport Studies, Rey Juan Carlos University, 28943 Fuenlabrada, Madrid, Spain
2Department of Medical Surgical-Therapy, Medicine Faculty, Extremadura University, 06006 Badajoz, Spain
3Faculty of Sport Sciences, University of Extremadura, Cáceres, Avenida de la Universidad s/n, Cáceres 10003, Extremadura, Spain
4Departamento de Desporto e Saúde, Escola de Saúde e Desenvolvimento Humano, Universidade de Évora, Évora, Portugal
5Comprehensive Health Research Center (CHRC), University of Évora, Évora, Portugal

Correspondence should be addressed to Alejandro Caña-Pino; alejandrocp@unex.es

Received 18 September 2021; Accepted 4 April 2022; Published 27 April 2022

Academic Editor: Pablo Herrero

Copyright © 2022 Ana Myriam Lavín-Pérez et al. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

This systematic review aimed to provide an up-to-date analysis of the effects of equine-assisted therapies (EAT) in people with multiple sclerosis (PwMS). The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were followed to conduct this systematic review. PubMed and Web of Science databases were employed in the search, which ended in February 2022. The risk of bias analysis was performed using the Evidence Project tool. After removing duplicates, thirty-nine studies were identified. However, only ten fulfilled the inclusion criteria and were included in this systematic review. Therefore, a total of 195 PwMS, aged between 40.3 and 51.3, were included in this systematic review. EAT-based interventions had a mean length of 13.6 weeks with a session’s frequency ranging from ten to once a week. All sessions involved real horses and lasted a mean of 34.4 min. Among the included articles, four were randomized controlled trials (RCT), four did not perform randomization, and two employed a prepost design without a control group. RCTs showed positive effects on quality of life, fatigue, balance, spasticity, and gait speed. Furthermore, non-RCT showed improvements in balance, spasticity, and postural control (postural control was not assessed in RCT studies). Importantly, significant effects were only observed when the comparison group was inactive or followed usual care. Therefore, EAT is a promising and effective therapy to improve quality of life, fatigue, balance, spasticity, and gait speed in PwMS. However, since comparison groups are heterogeneous, results could vary depending on the research design. Moreover, the inclusion of noncontrolled studies (in order to have a wide perspective of the state of art) could increase the risk of bias and make the results be taken with caution.

1. Introduction

Multiple sclerosis (MS) is a chronic disease characterized by a progressive demyelination and an axonal loss across the central nervous system. MS symptoms can be manifested singly or combined and include several manifestations such as fatigue, paraesthesia, stiffness, muscle spasms, tremors, weakness, dizziness, gait disturbance, or pain [1]. These symptoms significantly reduce the health-related quality of life (HRQoL) of people with MS (PwMS) [2, 3]. Furthermore, previous studies have shown that PwMS often showed less postural control and, consequently, a higher risk of falling [4, 5]. This is relevant, since falls are associated with injuries, lower participation, and increased fear of falling in this population [6]. Despite the benefits of pharmacological and nonpharmacological treatments, rehabilitation programs are encouraged to improve both physical health and mental health of PwMS.

Complementary and alternative treatments emerged to reduce the severity of symptoms and to enhance the HRQoL
of PwMS. However, evidence about the efficacy of these therapies has sometimes been questioned [7]. In this regard, complementary and alternative therapies have been included in less than half of the clinical practice guidelines for PwMS [8]. Therefore, there is a need to review studies that provide more evidence and clarify which therapies should be recommended to reach higher benefits and reduce the symptoms’ limitations [8].

Previous studies in the field of animal-assisted interventions reported positive benefits in mental and physical health [9, 10]. Equine-assisted therapies (EATs), which are part of animal-assisted intervention, have shown positive benefits in older adults [11], autism [12], children with attention-deficit/hyperactivity disorder [13], cerebral palsy [14], or chronic pain populations [15]. The physical mechanism underlying the physical benefits of riding a horse is related to the rider’s movement induced by the horse during walking. This movement pattern has some similarities with the human gait, generating a bilateral and continuous stimulus that leads to voluntary and involuntary muscular activity. This pattern has been shown to help improve or maintain control of posture balance [16]. Furthermore, some psychological benefits have also been observed after EAT, including improvements in self-esteem, self-regulation, HRQoL, competency, emotional wellbeing, and social support [17, 18].

A previous review, in 2010, aimed to systematically review the evidence for hippotherapy as a therapy to improve balance [19]. Although only three studies were included in that review, the authors concluded that hippotherapy has a positive effect on balance in PwMS. However, due to the variety of terms used to inadequately refer to EAT (such as equine-assisted therapy, horse-riding, horseback riding, or therapeutic riding), we believed that further evidence might not have been included. Furthermore, no other review has been conducted specifically to evaluate the effects of EAT (including more search terms related to EAT) or to evaluate other health-related variables in PwMS such as fatigue, HRQoL, or walking performance. Therefore, the current systematic review aimed to provide an up-to-date analysis of the effects of EAT in different health-related variables of PwMS.

2. Methods

This systematic review was performed according to the Preferred Reporting Items for Systematic Review and Meta-analysis (PRISMA) guidelines [20]. This study was registered in the International Prospective Register of Systematic Reviews (PROSPERO) with the following identification number: CRD42020220433.

2.1. Data Sources and Search Strategy. PubMed and Web of Science databases (including Current Contents Connect, Derwent Innovations Index, Korean Journal Database, Medline, Russian Science Citation Index, and Scielo Citation Index) were used to identify potential studies.

A wide variety of terms describing equine-assisted interventions can be found regarding context, country, or type of intervention such as hippotherapy, equine-assisted intervention, or therapeutic horseback riding. This represented a huge source of confusion, since these terms are used interchangeably [21]. Therefore, taking this variety into account, we have followed the definition of EAT made by the Professional Association of Therapeutic Horsemanship International (PATH) to include and analyze the articles. In this regard, EAT has been considered as an intervention that can incorporate equines or equine environments for rehabilitation goals directed by professionals in the field. Thus, the following search string was employed: (“multiple sclerosis”) AND (“hippotherapy” OR “equine-assisted” OR “horse-riding” OR “horseback riding” OR “therapeutic riding”). Year, type of design, and language restrictions were not applied in the search. The search process ended in February 2022. Duplicated studies were excluded and articles’ titles, abstracts, and full texts were carefully screened by two of the authors (A.M.L-P. and A.C.P.).

Studies were included in the systematic review if they fulfilled the following criteria: (1) participants suffered from MS; (2) the article analyzed the effects of EAT on physical or mental health–related outcomes; (3) the study conducted an EAT intervention; and (4) they were randomized or non-randomized controlled trials with prepost data. Moreover, the studies were excluded when: (1) they were written in a different language from English or Spanish; (2) they were a review, study protocol, conference abstract, or a case report; (3) the article was not focused on PwMS.

The study selection was performed by one author, A.C.P., and checked by another, A.M.L-P. Disagreements between these authors were solved through discussion with D.C-M.

2.2. Risk of Bias Assessment. The Evidence Project tool [22] was employed to evaluate the risk of bias of the selected studies. This tool is composed of eight items that cover study design, the participants’ representativeness, and the equivalence of comparison groups. In this regard, the study design includes items referring to cohort, control, or comparison group and prepost intervention data. Participants’ representativeness includes items that analyze the random assignment of participants to the intervention, random selection of participants for assessment, and follow-up rate of 80% or more. Lastly, the comparison groups’ equivalence is assessed with items concerning the equivalent on sociodemographics and the equivalent at baseline. This scale allows evaluating both randomized and nonrandomized trials.

2.3. Data Extraction. According to PRISMA methodology [20], participants, intervention, comparison treatments, outcomes, and study design (PICOS) data were extracted. Accordingly, information concerning participants’ characteristics, study design, sample size, age, years from MS diagnosis, disability level, and body composition were exported from each article. Moreover, intervention characteristics such as intervention length, treatment frequency, duration of the sessions, setting where the EAT was carried...
out, type of exercise performed, and its description were analyzed. For each variable the "pre-," "post-," and the change between pre- and post- data were extracted, reporting means and standard deviations as well as the reported effects (within- and between-group differences) for each article. The extraction process was conducted by two authors (A.M.L.-P. and A.C.P.). Regarding the reported data, specific statistical calculations were performed according to each trial design. First, the Standardized Mean Differences between control and equine-assisted therapy groups were calculated by utilizing the ReviewManager Software (Rev-Man, 5.3) [23]. The selected method was the inverse variance with random effects and a 95% confidence interval (CI) [24]. In randomized control trials (RCT), results were calculated taking into account the data after intervention. Meanwhile, in non-RCT, changes from baseline results were the data selected. Moreover, in that non-RCT without enough change from baseline data, Cohen’s effect size and its corresponding confidence interval (95%) were calculated [25].

3. Results

3.1. Study Selection. A total of 63 publications were identified in the electronic databases: 22 studies in PubMed and 41 in the Web of Science. After removing duplicates, 39 studies were screened by reading the title and abstract. Twenty-six studies were excluded because they were reviews (thirteen studies), conference abstracts (four studies), protocols (one study), not focused on PwMS (six studies), or not written in English or Spanish (two studies). Thirteen studies were assessed for eligibility. However, three studies did not fulfill the inclusion criteria, since one was a case report, one was an observational study, and one included another type of disease apart from MS. Therefore, our systematic review included ten studies (Figure 1).

3.2. Characteristics of the Participants. Table 1 shows the study design, sample size, age, years from MS diagnosis, disability level, and body composition for each article. A total sample size of 195 participants was included in this systematic review. 104 participants were included in the equine-assisted therapy group (EATG) and 91 in the CG, of which 63 were inactive participants and 28 performed a different type of exercise performed, and its description for each article. The EAT interventions assessed in this systematic review had a mean length of 13.6 weeks with a standard deviation of 5.6. Four interventions performed the treatment twice a week [27–31] and four performed the treatment once a week [28, 32–34], while one conducted the intervention ten times per week [35]. EAT sessions lasted a mean of 34.4 min with a standard deviation of 8.9. However, some of the interventions made a progression in the sessions’ duration throughout the program [30, 32, 36]. Two studies did not describe the characteristics of their intervention.

Regarding sessions characteristics, most of the EAT interventions performed a warm-up and a cool-down with a duration from 5 [28, 29, 31, 34] to 10 minutes [36], based on upper and lower extremities stretching or slow walking while connecting with the horse. EAT exercises (with a mean duration of 30 minutes) were focused on balance, mobility, changes in direction and speed [29, 31, 34, 35], progressive difficulty of tracks [28, 29] based on riders’ motor skills [32], and postural control on the horse by the employment of different riding techniques [36].

EATG participants were also enrolled in physiotherapy sessions in only one study as its CG [32]. Also, Frevel et al. (2015) and Menezes et al. (2013) included active CGs, performing home-based exercises focused on balance, postural control, strength [30], pilates, swimming, or weightlifting [36]. The rest of the studies, except two [31, 35], included CGs that followed standard care routines [27–29, 32, 33]. In relation to EAT safety, only one article [27] reported that one participant fell off the therapy horse and was able to continue therapy. Moreover, two participants experienced, at the beginning of the intervention, an MS relapse accompanied by painful muscle contractions. The other two articles employed two side-walkers in order to reduce risks [29, 34].

3.3. Characteristics of the Interventions. Table 2 depicts the intervention length, treatment frequency, duration of the sessions, setting where the EAT was carried out, type of exercise performed, and its description for each article. The EAT interventions assessed in this systematic review had a mean length of 13.6 weeks with a standard deviation of 5.6. Four interventions performed the treatment twice a week [27–31] and four performed the treatment once a week [28, 32–34], while one conducted the intervention ten times per week [35]. EAT sessions lasted a mean of 34.4 min with a standard deviation of 8.9. However, some of the interventions made a progression in the sessions’ duration throughout the program [30, 32, 36]. Two studies did not describe the characteristics of their intervention.

Regarding sessions characteristics, most of the EAT interventions performed a warm-up and a cool-down with a duration from 5 [28, 29, 31, 34] to 10 minutes [36], based on upper and lower extremities stretching or slow walking while connecting with the horse. EAT exercises (with a mean duration of 30 minutes) were focused on balance, mobility, changes in direction and speed [29, 31, 34, 35], progressive difficulty of tracks [28, 29] based on riders’ motor skills [32], and postural control on the horse by the employment of different riding techniques [36].

EATG participants were also enrolled in physiotherapy sessions in only one study as its CG [32]. Also, Frevel et al. (2015) and Menezes et al. (2013) included active CGs, performing home-based exercises focused on balance, postural control, strength [30], pilates, swimming, or weightlifting [36]. The rest of the studies, except two [31, 35], included CGs that followed standard care routines [27–29, 32, 33]. In relation to EAT safety, only one article [27] reported that one participant fell off the therapy horse and was able to continue therapy. Moreover, two participants experienced, at the beginning of the intervention, an MS relapse accompanied by painful muscle contractions. The other two articles employed two side-walkers in order to reduce risks [29, 34].

3.4. Health Variables Evaluated. Different health outcomes were assessed before and after the interventions. HRQoL was studied using King’s Health Questionnaire (KHQ) [33], the Multiple Sclerosis Quality of Life-54 (MSQOL-54) [33] and its mental and physical health subscales [27], the Short Form 36 (SF-36) and its dimensions [35], the Hamburg Quality of Life Questionnaire in Multiple Sclerosis (HAQUAMS) [30], and the Functional Assessment of Multiple Sclerosis Quality of Life (FAMS). [28]. Four studies analyzed fatigue using the Fatigue Severity Scale (FSS) [27, 28, 30], the Fatigue Impact Scale (FIS) [33], and the Modified Fatigue Impact Scale (MFIS) [27, 28]. Five articles analyzed balance [27, 30, 31, 34, 35] using the Berg Balance Scale for static balance [27, 30, 31, 34, 35] and the Dynamic Gait Index (DGI) for dynamic balance [30]. Moreover, four studies assessed the benefits in mobility using the Performance Oriented Mobility Assessment (POMA) [32, 34] and the Timed Up and Go test [28, 35] and two articles studied the spasticity through the Numeric Rating Scale (NRS) [27] and the
3. Effects of Equine-Assisted Therapy on HRQoL and Physical Outcomes. Table 3 summarizes the results in HRQoL, fatigue, balance, mobility, spasticity, walking performance, gait performance, disability, pain physical functioning, and postural control. Regarding HRQoL, significant within-group differences were found in two articles [28, 33], whereas Hammer et al. (2005) did not find significant differences. Between-group differences were observed in both physical and mental health dimensions \( (p < 0.001) \) [27]. However, when comparing EAT to Internet-based home training, Frevel et al. (2015) did not find significant differences [30].

As for participants’ fatigue perception, when the effects of EAT were compared to an inactive CG, significant between-group differences emerged \( (p = 0.002) \) [27] and \( p = 0.017 \) [28]. In contrast, when the CG performed Internet-based home training, significant differences were not reached [30]. Moreover, three of the studies found a significant decrease in fatigue in the EATG after the intervention \( (p < 0.001 \) [28, 33] and \( p < 0.05 \) [30]).

Results in physical outcomes showed that static balance significantly improved after EAT intervention in comparison to an inactive CG \( (p = 0.047) \) [26v] and \( p = 0.04 \) [34]. However, Frevel et al. (2015) did not find significant between-group differences (EATG versus home-based training group); however, significant within-group improvements were found in the EATG [30]. In this regard, Lindroth et al. (2015) did not find differences after the EAT intervention in balance [31].

With respect to mobility, significant between-groups differences were not found. However, two studies showed significant within-group results in mobility [28, 34]. Spasticity results showed that EAT interventions could significantly reduce this aspect when compared to the CG [27, 33]. Considering walking and gait performance, Moraes et al. (2020) revealed significant differences between \( (p < 0.001) \) and within \( (p < 0.001) \) groups in all the tests performed (6MWT, gait velocity, and gait cadence) [29]. However, Flever et al. (2015), in walking performance, and Muñoz-Lasa et al. (2011), in walking performance and gait, did not show positive results [30, 32]. Regarding postural control, Menezes et al. (2013), Moraes et al. (2021) and Lindroth et al. (2015) showed that EAT can improve the amplitude of the anterior-posterior center of pressure \( (p < 0.01) \), mean
Table 1: Characteristics of the participants included in the systematic review.

| Study                    | Randomization | Group   | Sample size (% of females) | Age (SD) | Years from diagnosis (SD) | Disability level (SD) | Body composition data (SD) |
|--------------------------|---------------|---------|-----------------------------|----------|--------------------------|-----------------------|---------------------------|
| *Moraes (2020) and Moraes (2021)* | Yes (RCT)     | EATG    | n = 17 (94.18%)             | 45.5 (9.7) | 9 (6.1)                  | EDSS (median): 2      | H: 162 (4.2)/W: 67 (13.1)/BCD: 25.5 |
|                          |               | ICG     | n = 16 (93.75%)             | 44.8 (8.8) | 8.8 (5.7)                | EDSS (median): 1.75   | H: 163 (6.6)/W: 68.7 (13.4)/BCD: 25.9 |
| *Muñoz-Lasa (2019)*     | No (non-RCT)  | EATG    | n = 6 (50%)                 | 41.3 (3.3) | 15.5 (5)                 | NR                    | NR                        |
|                          |               | ICG     | n = 4 (25%)                 | 51.3 (4.6) | 17.5 (7.3)               | NR                    | NR                        |
| *Vermoehlen (2017)*     | Yes (RCT)     | EATG    | n = 30 (90%)                | 50 (median); R (45–53) | 16.5 (median) R (11–20) | EDSS < 5:10          | W: 67 (10.3)              |
|                          |               | CG      | n = 37 (72.97%)             | 51 (median); R (47–56) | 17.6 (median) R (11–27) | EDSS < 5:11          | EDSS ≥ 5:26               |
| *Frevel (2015)*         | Yes (RCT)     | EATG    | n = 9 (88.8%)               | 46.9 (7.6) | 22.3 (8.3)               | EDSS: 3.8 (1.1)       | H: 167.9 (9.0)/W: 72.5 (12.3)/BCD: 25.7 |
|                          |               | ACG     | n = 9 (77.77%)              | 44.3 (8.1) | 16.1 (11.3)              | EDSS: 3.8 (1.5)       | H: 168.2 (8.2)/W: 65.0 (8.9)/BCD: 23.03 |
| *Lindroth (2015)*       | No (non-RCT)  | EATG    | N = 3 (66.66%)              | 52.33 (13.28) | 14 (13.89)               | 4 (1.32)              | NR                        |
|                          |               | EATG    | n = 7 (85.71%)              | 44 (9.1)   | 8.6 (9.6)                | NR                    | H: 162 (1)/W: 68.1 (16.6)/BCD: 25.9 (5.3) |
| *Menezes (2013)*        | No (non-RCT)  | ACG     | n = 4 (50%)                 | 40.3 (15.9) | 8.2 (5.6)                | NR                    | H: 142 (6.2)/W: 72 (34.2)/BCD: 25.2 (25) |
| *Muñoz-Lasa (2011)*     | No (non-RCT)  | EATG    | n = 12 (58.33%)             | 44.8. Range: 34–59 | 8.3 (7)              | EDSS: 5.2 (1.2)       | NR                        |
|                          |               | ACG     | n = 15 (60%)                | 46.2. Range: 38–64 | 7.8 (7)               | EDSS: 4.9 (1.3)       | NR                        |
| *Silwood-Sherer (2007)* | No (non-RCT)  | EATG    | n = 9 (55.55%)              | 42.4 (14.2) | 9.9 (8.2)                | NR                    | NR                        |
|                          |               | ICG     | n = 6 (66.66%)              | 47.7 (14.1) | 12.7 (6.6)               | NR                    | NR                        |
| *Hammer (2005)*         | No (non-RCT)  | EATG    | n = 11 (81.8%)              | 47.9 (8.4) | 10 (7)                   | 5 (6)                 | NR                        |

EATG: equine-assisted therapy group; ICG: control group; NR: not reported; SD: standard deviation; EDSS: Extended Disability Status Scale; H: height (cm); W: weight (kg); BCD: body composition data; R: range; ACG: active control group.
| Study                       | Group | Duration | Frequency | Sessions duration | Setting                                              | Type of exercise                                                                 |
|-----------------------------|-------|----------|-----------|-------------------|------------------------------------------------------|-----------------------------------------------------------------------------------|
| Moraes (2020) and Moraes (2021) | EATG  | 8 weeks  | 2 days/week | 35 min  | Military Police Hippotherapy Center in Brasilia, Brazil | Hippotherapy                                                                      |
|                             | ICG   |          |           |                   |                                                      |                                                                                  |
| Muñoz-Lasa (2019)           | EATG  | 24 weeks | 1 day/week | From 20 to 40 min | MHG foundation equestrian therapy team               | Hippotherapy                                                                      |
|                             | ICG   |          |           |                   |                                                      |                                                                                  |
| Vermöhlen (2017)            | EATG  | 12 weeks | 1 day/week | 30 min (EAT)     | Multicenter (five centers in Germany)                | Developed following the guidelines for hippotherapy of Deutsches Kuratorium für Therapeutisches Reiten. |
|                             | ICG   |          |           |                   |                                                      |                                                                                  |
| Frevel (2015)               | EATG  | 12 weeks | 2 days/week | 20–30 min   | Hospital with therapeutic riding center “Gut Uttingshof, Bad Mergentheim” | Hippotherapy                                                                      |
|                             | ICG   |          |           |                   |                                                      |                                                                                  |
| Lindroth (2015)             | EATG  | 6 weeks  | 2 days/week | 40 min  | Adaptive riding center                                 | Hippotherapy                                                                      |
|                             | ICG   |          |           |                   |                                                      |                                                                                  |
| Menezes (2013)              | EATG  | 16 weeks | 2 days/week | 50 min  | Association of PwMS of Santa Maria, Brazil            | Hippotherapy                                                                      |
|                             | ACG   |          |           |                   |                                                      |                                                                                  |
|                             | EATG  | 20 weeks on and 4 weeks off in between | 1 day/week | 30–40 min (EAT) | Fundación Caballo Amigo in Villanueva de la Cañada (Madrid) | Therapeutic horseback riding and conventional physiotherapy |
|                             | ACG   |          |           |                   |                                                      |                                                                                  |

Exercise description:
- Stretching and warming-up exercises on the horse (5 min); EAT (28 min): balance, mobility, and functional exercises. Thirteen progressive tasks were performed (from “serpentine movement throwing hoops on cone” to “short obstacle courses”); calm down (2 min): relaxation with the horse always in motion.

- Development following the guidelines for hippotherapy of Deutsches Kuratorium für Therapeutisches Reiten.

- EAT: riding forward, backward, side-ways, changes in horse’s speed from slow to moderate, diagonal change of direction, sudden stops and starts.

- Balance exercises and movements on the horse: trunk rotations, arm lifting with eyes open and closed (lying on the horse’s back with the front or rear, sitting sideways or backward).

- Balance, postural control, and strength exercises for the main muscle groups of the lower limbs, trunk, and shoulder girdle. 8–15 repetitions. 2–3 sets of moderate intensity (Borg Scale: 11–14).

- 5-min warm-up with the participant sitting forward on the horse with no stirrups, followed by 30 min of individualized intervention (balance exercises in different positions) and a 5-min cool-down.

- Stretching and contact with the horse (10 min).

- Horse walking (30 min): use of different driving techniques and postures with postural control. The level of difficulty was gradually increased.

- Cool-down (10 min): exercise and stretching.

- EAT: exercises based on rider’s motor skills, balance, and body posture in a slow steady horse gait (four-beat walk).

- Physiotherapy: aerobic, balance, strength, and flexibility exercises.
| Study                | Group          | Duration                      | Frequency | Sessions’ duration | Setting                     | Type of exercise               | Exercise description                                                                 |
|---------------------|----------------|-------------------------------|-----------|--------------------|-----------------------------|--------------------------------|-------------------------------------------------------------------------------------|
| Muñoz-Lasa (2011)   | ACG            | 20 weeks on and 4 weeks off in between | 1 day/week | 40 min             | ADEMM in Madrid             | Conventional physiotherapy     | Aerobic, balance, strength, and flexibility exercises.                                |
|                     |                |                               |           |                    |                             |                                | Warm-up (5 min): slow pace (90–100 steps/min) and stretching on the horse, progressively increasing to moderate pace (125–130 steps/min). |
|                     |                |                               |           |                    |                             |                                | Individualized EAT (30 min): trunk rotations in sitting forward position, anticipatory challenges, change of direction exercises, sudden stops and starts, and speed changes from slow pace to trot (150 steps/min). |
| Silkwood-Sherer (2007) | EATG          | 14 weeks                     | 1 day/week | 40 min             | NR                          | Therapeutic horseback riding   | Cool-down (5 min): stretching and moderate pace.                                      |
|                     |                |                               |           |                    |                             |                                |                                                                                     |
|                     | ICG            | NR: no rehabilitation program with the chance of participating in the intervention after the follow-up evaluation |           |                    |                             |                                |                                                                                     |
| Hammer (2005)       | EATG           | 11 weeks                     | 10 sessions/week | 30 min             | NR                          | Therapeutic riding             | Trunk rotation exercises, for example, reaching the ears or tail of the horse with one hand, reaching the opposite knee or diagonally, towards the ceiling. The exercises involved balance and driving skills. |

EATG: equine-assisted therapy group; ICG: inactive control group; EAT: equine-assisted therapy; NR: not reported; ACG: active control group; PwMS: people with multiple sclerosis; EDSS: Extended Disability Status Scale.
Table 3: Effects of equine-assisted therapy intervention on the assessed instrument.

| Study                      | Tool                          | Groups         | Mean (SD) Before intervention | Mean (SD) After intervention | Effect size [CI 95%] | Differences (p value) | Between-group |
|---------------------------|-------------------------------|----------------|-------------------------------|-----------------------------|----------------------|-----------------------|---------------|
| **HEALTH-RELATED QUALITY OF LIFE** |                               |                |                               |                             |                      |                       |               |
| Moraes (2021)            | FAMS (total)                  | EATG           | 133.4 (35.2)                  | 151.4 (38.3)                | 0.11 [−0.57, 0.80]SMD | p < 0.001             | p = 0.283      |
|                           |                               | ICG            | 143.2 (27.2)                  | 138.7 (27.2)                | 1.38 [0.1, 2.6]d      | p < 0.001             | p = 0.360      |
| Muñoz-Lasa (2019)        | FAMS                          | EATG           | 34.83 (16.15)                 | 17.7 (6.95)                 | −0.08 [−1.5, 1.3]d    | p = 0.033             | NSD            |
|                           |                               | ICG            | 32.36 (19.99)                 | 34 (21.73)                  | 0.02 [−1.4, 1.4]d     | p = 0.011             | NSD            |
| Vermöhlen (2017)         | KHQ                           | EATG           | 2.85 (0.9)                    | 3.55 (0.61)                 | −0.85 [−2.0, 0.3]d    | p < 0.001             | NSD            |
|                           |                               | ICG            | 2.63 (1.3)                    | 2.61 (1.05)                 | 0.36 [−0.12, 0.85]SMD | p < 0.001             | NSD            |
| Frevel (2015)            | HAQUAMS total                 | EATG           | 13.6 (2.3)                    | 14.5 (2.1)                  | 0.38 [−0.62, 1.37]d   | p < 0.001             | NSD            |
|                           |                               | ICG            | 11.5 (4.1)                    | 13.0 (4.9)                  | 0.38 [−0.62, 1.37]d   | p < 0.001             | NSD            |
| Hammer (2005)            | SF-36 (general health)        | EATG           | 54.5 (21.62)                  | 53.8 (19.26)                | NA                    | NA                    | NA             |
|                           |                               | SF-36 (mental health) | 54.5 (21.62) | 53.8 (19.26) | NA                    | NA                    | NA             |
| **FATIGUE**              |                               |                |                               |                             |                      |                       |               |
| Moraes (2021)            | FSS                           | EATG           | 5.0 (1.6)                     | 4.0 (1.7)                   | −0.17 [−0.86, 0.51]SMD | p < 0.001             | p = 0.335      |
|                           |                               | ICG            | 4.5 (1.7)                     | 4.3 (1.7)                   | 0.38 [−1.4, 2.5]d     | p < 0.001             | p = 0.461      |
| Muñoz-Lasa (2019)        | FIS                           | EATG           | 44.2 (19.0)                   | 32.3 (18.5)                 | −0.86 [−1.57, −0.14]SMD | p < 0.001             | p = 0.017      |
|                           |                               | ICG            | 48.1 (10.3)                   | 45.9 (11.5)                 | 0.38 [−1.4, 1.4]d     | p < 0.001             | NSD            |
| Vermöhlen (2017)         | FSS (sum score of FSS)        | EATG           | 51.80 (10.5)                  | 42.6 (11.4)                 | −0.38 [−0.86, 0.11]SMD | p < 0.001             | NA             |
|                           |                               | ICG            | 47.8 (11.9)                   | 46.8 (10.6)                 | 0.38 [−0.86, 0.11]SMD | p < 0.001             | NA             |
| Frevel (2015)            | FSS                           | EATG           | 5.40 (0.80)                   | 4.4 (1)                     | 0.24 [−0.75, 1.22]SMD | p < 0.05              | NSD            |
|                           |                               | ICG            | 4.50 (1.90)                   | 4.00 (2.00)                 | 0.24 [−0.75, 1.22]SMD | p < 0.05              | NSD            |
| **BALANCE**              |                               |                |                               |                             |                      |                       |               |
| Vermöhlen (2017)         | BBS                           | EATG           | 40.60 (11.50)                 | 47.0 (8.7)                  | 0.19 [−0.29, 0.67]SMD | p < 0.05              | p = 0.047      |
|                           |                               | ICG            | 42.10 (10.90)                 | 45.10 (10.90)               | 0.19 [−0.29, 0.67]SMD | p < 0.05              | p = 0.047      |
| Frevel (2015)            | BBS                           | EATG           | 40.30 (9.80)                  | 45.8 (8.3)                  | −0.08 [−1.06, 0.90]SMD | p < 0.05              | p < 0.05       |
|                           |                               | ICG            | 43.50 (9.90)                  | 46.50 (9.00)                | −0.08 [−1.06, 0.90]SMD | p < 0.05              | p < 0.05       |
| Silkwood-Sherer (2007)   | BBS                           | EATG           | 39.38 (16.87)                 | 56 (15.1)                   | 1.31 [0.04, 2.58]†    | p < 0.05              | p < 0.05       |
| Lindroth (2015)          | BBS                           | EATG           | 42 (1.73)                     | 46 (0)                      | NA                    | NA                    | NA             |
| Hammer (2005)            | BBS                           | EATG           | 40.5 (24.57)                  | 31 (26.06)                  | NA                    | NA                    | NA             |
| Study                        | Tool                                | Before intervention | After intervention | Effect size [CI 95%] | Differences (p value) Within-group | Differences (p value) Between-group |
|-----------------------------|-------------------------------------|---------------------|--------------------|----------------------|-------------------------------------|--------------------------------------|
| **MOBILITY**                |                                     |                     |                    |                      |                                     |                                      |
| Moraes (2021)               | Timed up and go test                | EATG 9.9 (3.1)      | 7.5 (2.2)          | −0.27 [−0.95, 0.42]SMD | p < 0.001                           | p = 0.108                            |
|                            | ICG 8.7 (2.5)                       |                     | 8.09 (2.13)        |                      |                                     |                                      |
| Muñoz-Lasa (2011)           | POMA                                | EATG 16 (6.1)       | 19.3 (3.6)         | 1.23 [0.38, 2.08]†   | p < 0.001                           | NSDACG                              |
|                            | ICG 17.3 (6.8)                      |                     | 17.1 (6.7)         |                      |                                     |                                      |
| Silkwood-Sherer (2007)      | POMA                                | EATG 18.44 (6.45)   | 22.11 (4.82)       | −2.05 [−3.51, −0.59]† | NR                                  | p = 0.078                            |
|                            | ICG 19.33 (3.9)                     |                     | 18.83 (3.98)       |                      |                                     |                                      |
| Hammer (2005)               | Timed up and go test                | EATG 14.85 (7.52)   | 14.82 (7.75)       | NA                   | NA                                  | NA                                   |
| **SPASTICITY**              |                                     |                     |                    |                      |                                     |                                      |
| Muñoz-Lasa (2019)           | Modified Ashworth Scale             | EATG 1.25 (0.25)    | 0.5 (0.55)         | 3.40 [1.11, 5.69]†   | p = 0.01                            | NSDACG                              |
|                            | ICG 1.12 (0.58)                     |                     | 0.82 (0.48)        |                      |                                     |                                      |
| Vermöhlen (2017)            | NRS                                 | EATG 4.6 (2.1)      | 3.2 (2.4)          | −0.25 [−0.74, 0.23]SMD | NR                                  | p = 0.031                            |
|                            | ICG 4.4 (2.2)                       |                     | 3.8 (2.3)          |                      |                                     |                                      |
| **WALKING PERFORMANCE**     |                                     |                     |                    |                      |                                     |                                      |
| Moraes (2020)               | Walking endurance (6-minute WT (m))| EATG 459.06 (118.34)| 503.59 (126.38)    | 0.06 [−0.63, 0.74]SMD | p = 0.144                           | p < 0.001                            |
|                            | ICG 513.00 (101.97)                 |                     | 497.13 (88.88)     |                      |                                     |                                      |
| Frevel (2015)               | 2-minute WT                         | EATG 130.3 (22.5)   | 141.3 (28.8)       | 0.24 [−0.75, 1.22]SMD | NSDACG                              | NSDACG                              |
|                            | ICG 128.6 (50.7)                    |                     | 130.0 (57.1)       |                      |                                     |                                      |
| **GAIT SPEED**              |                                     |                     |                    |                      |                                     |                                      |
| Moraes (2020)               | Speed (cm/s)                        | EATG 97.84 (25.94)  | 114.93 (31.20)     | 0.29 [−0.39, 0.98]SMD | p = 0.001                           | p < 0.001                            |
|                            | ICG 110.95 (33.35)                  |                     | 105.95 (28.61)     |                      |                                     |                                      |
| Muñoz-Lasa (2011)           | Speed (m/s)                         | EATG 0.44 (0.11)    | 0.48 (0.10)        | −0.38 [−1.2, 0.4]†   | NR                                  | NSDACG                              |
| Lindroth (2015)             | FGA                                 | EATG 14 (4.36)      | 18 (6.24)          | NA                   | NA                                  | NA                                   |
| **DISABILITY**              |                                     |                     |                    |                      |                                     |                                      |
| Muñoz-Lasa (2011)           | EDSS                                | EATG 5.2 (1.2)      | 5.2 (1.1)          | 0 [−0.8, 0.8]d       | NSDACG                              | NSDACG                              |
|                            | ICG 4.9 (1.3)                       |                     | 5 (1.3)            |                      |                                     |                                      |
| **PAIN**                    |                                     |                     |                    |                      |                                     |                                      |
| Vermöhlen (2017)            | VAS                                 | EATG 32.2 (29.9)    | 24.9 (27.6)        | 0.05 [−0.43, 0.54]SMD | p < 0.05                            | p < 0.05                            |
|                            | ICG 24.7 (29.3)                     |                     | 23.4 (27.0)        |                      |                                     |                                      |
| **PHYSICAL FUNCTIONING INDEPENDENCE LEVEL** |            |                     |                    |                      |                                     |                                      |
| Muñoz-Lasa (2011)           | Barthel Index                       | EATG 89.6 (10.5)    | 90.4 (8.9)         | −0.08 [−0.9, 0.7]d   | NSDACG                              | p = 0.055                            |
|                            | ICG 90.3 (10.9)                     |                     | 90.7 (11.3)        |                      |                                     |                                      |
Table 3: Continued.

| Study          | Tool                              | Before intervention | After intervention | Effect size | Differences (p value) | Within-group | Between-group |
|----------------|-----------------------------------|---------------------|--------------------|-------------|-----------------------|--------------|---------------|
|                |                                   | Mean (SD)           | Mean (SD)          |             |                       |              |               |
|                |                                   |                     |                    |             |                       |              |               |
| **POSTURAL CONTROL** |                                   |                     |                    |             |                       |              |               |
|                | CoP Speed (cm/s), stable surface, eyes open |                     |                    |             |                       |              |               |
| Moraes (2021) | EATG                              | 1.2 (0.4)           | 0.7 (0.4)          | −1.21 [-1.96, −0.46] | SMD | p < 0.001 | p = 0.004 |
|                | ICG                               | 1.4 (0.7)           | 1.4 (0.7)          |             |                       |              |               |
|                |                                   |                     |                    |             |                       |              |               |
|                | CoP Speed (cm/s), stable surface, eyes closed |                     |                    |             |                       |              |               |
|                | EATG                              | 1.6 (0.6)           | 1.1 (0.6)          | −0.98 [-1.70, −0.25] | SMD | p < 0.001 | p = 0.013 |
|                | ICG                               | 2.0 (1.1)           | 1.7 (0.6)          |             |                       |              |               |
|                |                                   |                     |                    |             |                       |              |               |
|                | CoP Speed (cm/s), foam surface, eyes open |                     |                    |             |                       |              |               |
|                | EATG                              | 2.7 (0.9)           | 1.6 (0.9)          | −0.80 [-1.51, −0.09] | SMD | p < 0.001 | p = 0.019 |
|                | ICG                               | 2.8 (1.1)           | 2.3 (0.8)          |             |                       |              |               |
|                |                                   |                     |                    |             |                       |              |               |
|                | CoP Speed (cm/s), foam surface, eyes closed |                     |                    |             |                       |              |               |
|                | EATG                              | 5.9 (2.2)           | 2.6 (1.6)          | −1.14 [-1.88, −0.40] | SMD | p < 0.001 | p < 0.001 |
|                | ICG                               | 6.4 (2.7)           | 5.10 (2.6)         |             |                       |              | p = 0.005 |
| **Menezes (2013)** |                                   |                     |                    |             |                       |              |               |
|                | AMPap (cm), eyes open             |                     |                    |             |                       |              |               |
|                | EATG                              | 2.85 (0.93)         | 2.28 (0.68)        | 0.70 [-0.4, 1.8] | d | p < 0.01 | p < 0.01 |
|                | ICG                               | 1.58 (0.35)         | 1.89 (0.99)        |             |                       |              |               |
|                | AMPap (cm), eyes closed           |                     |                    |             |                       |              |               |
|                | EATG                              | 3.91 (1.70)         | 3.02 (0.84)        | 0.66 [-0.4, 1.7] | d | p < 0.01 | p < 0.01 |
|                | ICG                               | 2.39 (1.71)         | 2.61 (1.37)        |             |                       |              |               |
|                | AMPml (cm), eyes open             |                     |                    |             |                       |              |               |
|                | EATG                              | 2.2 (1.19)          | 1.66 (0.76)        | 0.54 [-0.5, 1.6] | d | NSD | p < 0.01 |
|                | ICG                               | 0.96 (0.43)         | 0.96 (0.63)        |             |                       |              |               |
|                | AMPml (cm), eyes closed           |                     |                    |             |                       |              |               |
|                | EATG                              | 3.28 (2.21)         | 2.17 (0.99)        | 0.65 [-0.4, 1.7] | d | NSD | p < 0.01 |
|                | ICG                               | 1.41 (0.67)         | 1.08 (0.67)        |             |                       |              |               |
|                | Msap (cm/s), eyes open            |                     |                    |             |                       |              |               |
|                | EATG                              | 1.44 (0.56)         | 1.48 (0.46)        | −0.08 [-1.1, 1.0] | d | NSD | p < 0.01 |
|                | ICG                               | 0.83 (0.19)         | 0.97 (0.28)        |             |                       |              |               |
|                | Msap (cm/s), eyes closed          |                     |                    |             |                       |              |               |
|                | EATG                              | 1.91 (0.79)         | 1.85 (0.70)        | 0.08 [-1.0, 1.1] | d | NSD | p < 0.01 |
|                | ICG                               | 0.99 (0.27)         | 1.33 (0.35)        |             |                       |              |               |
|                | MSml (cm/s), eyes open            |                     |                    |             |                       |              |               |
|                | EATG                              | 1.30 (0.75)         | 1.19 (0.59)        | 0.16 [-0.9, 1.2] | d | p = 0.02 | p < 0.01 |
|                | ICG                               | 0.62 (0.30)         | 0.72 (0.28)        | −0.34 [-1.7, 1.1] | d | NSD | p < 0.01 |
|                | MSml (cm/s), eyes closed          |                     |                    |             |                       |              |               |
|                | EATG                              | 1.70 (0.99)         | 1.19 (0.41)        | 0.57 [-0.4, 1.8] | d | p = 0.02 | p < 0.01 |
|                | ICG                               | 0.69 (0.26)         | 0.84 (0.15)        | −0.71 [-2.1, 0.7] | d | NSD | p < 0.01 |

SD: standard deviation; EATG: equine-assisted therapy group; ICG: inactive control group; NR: not reported; ACG: active control group; NSD: not significant differences; † within group Cohen's d value with an interval confidence of 95%; SMD: Standardized Mean Difference results of randomized trials (calculated with after intervention data); ‡ Standardized Mean Difference results of nonrandomized trials (calculated with change from baseline data); NA: not applied; MSQOL-54: Multiple Sclerosis Quality of Life-54; HAQUAMS: Hamburg Quality of Life Questionnaire in Multiple Sclerosis; FAMS: Functional Assessment of Multiple Sclerosis Quality of Life; SF-36: Short Form 36; KHQ: King's Health Questionnaire; WURS: Wurzburg Restless Legs Scale; VAS: Visual Analogue Scale; BBS: Berg Balance Scale; CSID: Clinical Scale for Impaired Daily Living; SOT: Sensory Organization Test; EATG: equine-assisted therapy group; ICG: inactive control group; NR: not reported; ACG: active control group; NSD: not significant differences; SMD: Standardized Mean Difference results of randomized trials (calculated with after intervention data); † Standardized Mean Difference results of nonrandomized trials (calculated with change from baseline data); NA: not applied; MSQOL-54: Multiple Sclerosis Quality of Life-54; HAQUAMS: Hamburg Quality of Life Questionnaire in Multiple Sclerosis; FAMS: Functional Assessment of Multiple Sclerosis Quality of Life; SF-36: Short Form 36; KHQ: King's Health Questionnaire; WURS: Wurzburg Restless Legs Scale; VAS: Visual Analogue Scale; BBS: Berg Balance Scale; CSID: Clinical Scale for Impaired Daily Living; SOT: Sensory Organization Test.
medial-lateral velocity (p = 0.02), and the speed of the center of pressure in stable and foam superfi cies (p < 0.001) [28] and a positive trend was observed in the SOT [31]. Concerning activities of daily living, pain, or physical independence, EAT interventions did not show significant benefits when compared to the CG [27,32].

To summarize, between-groups differences were only observed when comparing EAT with an inactive CG [27–29, 33, 34, 36]. Therefore, between groups, significant differences were not observed when EAT was compared to an active CG [30, 32].

3.6. Risk of Bias. The mean score of the risk of bias analysis with the Evidence Project tool was 5.7 out of 8 with a standard deviation of 1.57 and scores ranged from 3 to 7 (Table 4). Higher scores corresponded to RCT studies (7/8) [27–30] where assignment to experimental groups was randomized. Item-by-item analysis showed that assessment of the quality of the study design (items 1 and 3) was satisfactorily reached by all the studies. However, in the participants’ representativeness evaluation, more heterogeneous results were found. Item 4, which assessed the “random assignment of participants to the intervention,” was only fulﬁ lled by three studies, while item 5 (“random selection of participants for assessment”) was not reached for any of the studies, whereas all the studies positively scored item 6 (“follow-up rate of 80% or more”). Besides, in the equivalence of comparison groups, except for three studies on item 8 (referred to the “comparison groups equivalent at baseline on outcome measures”) and two studies in item 7, all the studies fulﬁ lled the requirements. However, the total scores and the section analysis were inﬂ uenced in their low results by the inclusion of two studies with no CG [31, 35].

4. Discussion

This systematic review analyzed the effects of EAT in PwMS. Ten articles were included in this systematic review: three were RCTs, and seven did not perform randomization. RCTs showed positive effects of EAT on HRQoL, fatigue, balance, spasticity, and gait speed. Furthermore, non-RCTs showed improvements in balance, spasticity, and postural control (postural control was not assessed in RCTs studies). Importantly, signifi cant effects were only observed when the comparison group was inactive or followed their usual care. Furthermore, taking into account the fact that non-RCTs studies are more prone to bias and the heterogeneity among the selected studies (mainly due to the inclusion of articles focused on different health-related outcomes and articles with active and inactive CGs), results might be taken with caution.

Results of this systematic review showed that signifi cant improvements can be reached with EAT when comparing its effects to an inactive CG or a CG that followed usual care. This is congruent with previous studies that showed the potential of physical activity to increase the HRQoL and physical function of PwMS [27, 37, 38]. Thus, physical activity is considered a useful therapy against MS-related impairments when EAT cannot be performed. This is relevant, since EAT is usually expensive due to animal care or displacement. Thus, previous studies have analyzed the effects of horse-riding simulators in special populations [11, 39]. These simulators mimic horse movements, leading to postural responses [38] with fewer costs than real horses [40]. However, the emotional response of riding a horse [41], even the temperature (higher than humans which could have a benefi cial eﬀ ect on spasticity), or the outdoor environment could add some benefi ts to EAT [17,42]. Thus, future studies should try to isolate the eﬀ ects of EAT.

Positive results were found in the HRQoL [27, 28, 33] and fatigue [27, 28, 30, 33] after EAT in PwMS. The observed improvements could be considered clinically signifi cant, since a difference of at least 0.45 points on the FSS or 4 points on the MFIS has been reached [43]. Fatigue is one of the main causes of impaired HRQoL among PwMS, although it is poorly understood [44]. However, diﬀ erent mechanisms, including proinfl ammatory cytokines (TNF-α), endocorties influences, and axonal loss, have been proposed [44]. TNF-α mRNA expression is increased among PwMS with fatigue [45, 46]. In this regard, previous studies have shown that animal-assisted intervention had hormonal eﬀ ects, such as an increase in oxytocin release. This is quite relevant, since a previous study showed that oxytocin treatment decreases TNF-α [47]. Thus, future studies should explore if fatigue reduction after animal-assisted intervention could be related to oxytocin releases.

Regarding HRQoL, benefi ts could be related to the improvement of physical function (balance, postural control, mobility, walking, and gait performance). However, both the physical and the mental dimensions of the MSQoL-54 have been improved, reaching the minimum clinically important difference [27]. Therefore, the signifi cant increase in the mental dimension of MSQoL, and the total HRQoL with the FAMS questionnaire [28], indicated that changes were not limited to physical benefi ts. Furthermore, other benefi ts such as the reduction of fatigue [28, 30, 33] or pain [15, 27] may have a signifi cant impact on HRQoL. However, controversial results were found, since Frel vel et al. [30] only reported improvements in the cognition, lower limb, and mood subscales but not in the overall score of the Hamburg Quality of Life Questionnaire in Multiple Sclerosis. These disagreements in results may be explained by the use of diﬀ erent tools to assess HRQoL, which cover diﬀ erent dimensions that infl uence the fi nal score [58, 59]. Nevertheless, taking into account the obtained results and the large impact of MS on HRQoL, EAT could be a potential therapy to enhance not only the physical dimension of the HRQoL, but also the mental dimension. This can be considered one of the major fi ndings of the current review.

In relation to the physical eﬀ ects of EAT interventions on PwMS, there is consensus among the analyzed studies showing benefi ts on balance. These changes can be considered clinically important, since Berg Balance Scale increased more than three points [51]. Nevertheless, taking into account the p values, signifi cant between-group diﬀ erences were observed when the group that received EAT

Evidence-Based Complementary and Alternative Medicine 11
was compared to an inactive CG [27, 34]. In this way, only within-group differences were observed in balance, postural control, and strength when EAT intervention was compared with a group that performs Internet-based home training [30]. Moreover, previous studies in the field of EAT have shown significant benefits in trunk/head stability [15, 47, 52–54], which positively influences balance [27, 30, 34]. This is relevant, since improvements in balance can considerably reduce the risk of falling [30, 53, 55], being a major limitation in PwMS [6]. Therefore, according to the results summarized in this systematic review, a 30-minute session per week for 12 sessions may be enough to achieve improvements in balance [27], since the improvements are found when the EAT was received once a week [27, 34], like when there were twice [30].

Mobility and walking performance of PwMS improved after EAT interventions [29, 30, 32, 34]. Improvements in walking performance may be related to the reduction in the stance time and double support time as well as the increase in balance time [29]. Benefits in gait parameters after EAT may be due to a physical stimulus induced by the movement of the horse. In this regard, horses perform a three-dimensional rhythmic movement, being patients’ pelvis movements similar to the movement produced during human gait. Thus, riding a horse leads to bilateral, continuous, and symmetrical movement patterns that stimulate muscle fibers and positively affect the control of posture and balance [43]. Furthermore, its practice requires the participation of the whole body and, therefore, it contributes to changes in muscle tone and motor coordination [56]. For this reason, this type of therapy has been used as a complementary strategy to reduce spasticity and improve motor skills [32].

This systematic review has some limitations. First, only studies in Spanish and English were included. Second, due to the heterogeneity of the studies included in the systematic review (in terms of interventions, CGs, participants, and outcomes), a meta-analysis was not possible. Concerning participants’ heterogeneity, only four of the ten studies included in this systematic review used a scale to evaluate the disability level. Thus, future studies should incorporate specific scales for PwMS, such as EDSS, to characterize the participants. Third, some studies were not randomized, which could have affected the obtained results due to an increase of risk of bias in these studies. Therefore, RCTs with homogeneous populations are encouraged to assess the effect of EAT in PwMS to ensure that the groups are equivalent at baseline. Lastly, only one article detailed the side effects of this therapy [27] and two studies reported safety strategies to reduce risks [30, 34]. Future studies are encouraged to detail any side effects detected or to report that no side effects were identified.

5. Conclusion

This systematic review is the first to evaluate the benefits of EAT on PwMS. Promising and positive results were achieved for HRQoL, fatigue, balance, and gait. However, large heterogeneity was also observed between the included studies. Thus, more RCTs are needed to evaluate the effects of EAT on those variables.

Data Availability

The data supporting this systematic review are from previously reported studies and datasets, which have been cited.

Disclosure

The funder has not been involved in the manuscript writing, editing, approval, or the decision to publish.

Conflicts of Interest

The authors declare no conflicts of interest.

Authors’ Contributions

A.C.-P. and M.D.A.-A. contributed to conceptualization; A.M.L.-P. and D.C.-M. contributed to methodology; A.M.L.-P., S.V., and D.C.-M. contributed to formal analysis;
A.C.-P., S.V., and J.A.P. contributed to investigation; A.M.L.-P., S.V., and D.C.-M. contributed to resources; A.M.L.-P. and D.C.-M. contributed to data curation; D.C.-M., A.M.L.-P., A.C.-P., and S.V. contributed to writing—original draft preparation; S.V., D.C.-M., and A.M.L.-P. contributed to writing—review and editing; J.A.P. and S.V. contributed to supervision; D.C.-M. contributed to project administration. All authors have read and agreed to the published version of the manuscript.

Acknowledgments

The author SV was supported by a grant from the Universities Ministry of Spain and the European Union (NextGenerationUE) “Ayuda del Programa de Recualificación del Sistema Universitario Español, Modalidad de ayudas Margarita Salas para la formación de jóvenes doctores” (MS-03).

References

[1] K. Faguy, “Multiple sclerosis: an update,” Radiologic Technology, vol. 87, no. 5, pp. 529–550, 2016.
[2] K. Rosiak and P. Zagośdzon, “Quality of life and social support in patients with multiple sclerosis,” Psychiatry Polska, vol. 51, no. 5, pp. 923–935, 2017.
[3] A. Ochoa-Morales, T. Hernández-Mojica, F. Paz-Rodríguez et al., “Quality of life in patients with multiple sclerosis and its association with depressive symptoms and physical disability,” Multiple Sclerosis and Related Disorders, vol. 36, Article ID 101386, 2019.
[4] M. H. Cameron and S. Lord, “Postural control in multiple sclerosis: implications for fall prevention,” Current Neurology and Neuroscience Reports, vol. 10, no. 5, pp. 407–412, 2010.
[5] J. E. Freund, D. M. Stetts, and S. Vallabbajosula, “Relationships between trunk performance, gait and postural control in persons with multiple sclerosis,” NeuroRehabilitation, vol. 39, no. 2, pp. 305–317, 2016.
[6] M. H. Cameron and Y. Nilsagard, “Balance, gait, and falls in multiple sclerosis,” Handbook of Clinical Neurology, vol. 159, pp. 237–250, 2018.
[7] S. B. Claffin, I. A. F. van der Mei, and B. V. Taylor, “Complementary and alternative treatments of multiple sclerosis: a review of the evidence from 2001 to 2016,” Journal of Neurology, Neurosurgery & Psychiatry, vol. 89, no. 1, pp. 34–41, 2018.
[8] J. Y. Ng and V. Kishimoto, “Multiple sclerosis clinical practice guidelines provide few complementary and alternative medicine recommendations: a systematic review,” Complementary Therapies in Medicine, vol. 56, Article ID 102395, 2021.
[9] S. Muñoz Lasa and F. Franchignoni, “The role of animal-assisted therapy in physical and rehabilitation medicine,” European Journal of Physical and Rehabilitation Medicine, vol. 44, no. 1, pp. 99–100, 2008.
[10] S. Muñoz Lasa, G. Ferriero, E. Brigatti, R. Valero, and F. Franchignoni, “Animal-assisted interventions in internal and rehabilitation medicine: a review of the recent literature,” Panminerva Medica, vol. 53, no. 2, pp. 129–136, 2011.
[11] C. Hilliere, D. Collado-Mateo, S. Villafaina, P. Duque-Fonseca, and J. A. Parraça, “Benefits of hippotherapy and horse riding simulation exercise on healthy older adults: a systematic review,” PM&R, vol. 10, no. 10, pp. 1062–1072, 2018.
[12] B. C. McDaniel Peters and W. Wood, “Autism and equine-assisted interventions: a systematic mapping review,” Journal of Autism and Developmental Disorders, vol. 47, no. 10, pp. 3220–3242, 2017.
[13] J. Pérez-Gómez, H. Amigo-Gamero, D. Collado-Mateo et al., “Equine-assisted activities and therapies in children with attention-deficit/hyperactivity disorder: a systematic review,” Journal of Psychiatric and Mental Health Nursing, vol. 28, no. 6, pp. 1079–1091, 2021.
[14] S.-H. Tseng, H.-C. Chen, and K.-W. Tam, “Systematic review and meta-analysis of the effect of equine assisted activities and therapies on gross motor outcome in children with cerebral palsy,” Disability & Rehabilitation, vol. 35, no. 2, pp. 89–99, 2013.
[15] D. Collado-Mateo, A. M. Lavin-Pérez, J. P. Fuentes García, M. A. García-Gordillo, and S. Villafaina, “Effects of equine-assisted therapies or horse-riding simulators on chronic pain: a systematic review and meta-analysis,” Medicina, vol. 56, no. 9, p. 444, 2020.
[16] R. Funakoshi, K. Masuda, H. Uchiyama, and M. Ohta, “A possible mechanism of horseback riding on dynamic trunk alignment,” Helyon, vol. 4, no. 9, Article ID e00777, 2018.
[17] S. White-Lewis, “Equine-assisted therapies using horses as healers: a concept analysis,” Nursing Open, vol. 7, no. 1, pp. 58–67, 2020.
[18] V. X.-L. Tan and J. G. Simmonds, “Parent perceptions of psychosocial outcomes of equine-assisted interventions for children with autism spectrum disorder,” Journal of Autism and Developmental Disorders, vol. 48, no. 3, pp. 759–769, 2018.
[19] C. Bronson, K. Brewerton, J. Ong, C. Palanca, and S. J. Sullivan, “Does hippotherapy improve balance in persons with multiple sclerosis: a systematic review,” European Journal of Physical and Rehabilitation Medicine, vol. 46, no. 3, pp. 347–353, 2010.
[20] A. Liberati, D. G. Altman, J. Tetzlaff et al., “The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration,” PLoS Medicine, vol. 6, no. 7, Article ID e1000100, 2009.
[21] M. De Santis, L. Contalbrigo, M. Borgi et al., “Equine assisted interventions (EAI)s: methodological considerations for stress assessment in horses,” Veterinary Sciences, vol. 4, no. 4, p. 44, 2017.
[22] C. E. Kennedy, V. A. Fonner, K. A. Armstrong et al., “The Evidence Project risk of bias tool: assessing study rigor for both randomized and non-randomized intervention studies,” Systematic Reviews, vol. 8, no. 1, p. 3, 2019.
[23] R. RevMan, The Nordic Cochrane Centre, the Cochrane Collaboration. Book Computer Program. Version, 2014.
[24] F. L. Schmidt, I.-S. Oh, and T. L. Hayes, “Fixed- versus random-effects models in meta-analysis: model properties and an empirical comparison of differences in results,” British Journal of Mathematical and Statistical Psychology, vol. 62, no. 1, pp. 97–128, 2009.
[25] M. K. Campbell, S. Thomson, C. R. Ramsay, G. S. MacLennan, and J. M. Grimshaw, “Sample size calculator for cluster randomized trials,” Computers in Biology and Medicine, vol. 34, no. 2, pp. 113–125, 2004.
[26] J. F. Kurtzke, “Rating neurologic impairment in multiple sclerosis: an expanded disability status scale (EDSS),” Neurology, vol. 33, no. 11, p. 1444, 1983.
[27] V. Vermöhlen, P. Schiller, S. Schickendantz et al., “Hippotherapy for patients with multiple sclerosis: a multicenter
randomized controlled trial (MS-HIPPO),” Multiple Sclerosis Journal, vol. 24, no. 10, pp. 1375–1382, 2018.

[28] A. G. Moraes, S. G. R. Neri, R. W. Motl et al., “Effects of hippotherapy on postural balance, functional mobility, self-perceived fatigue, and quality of life in people with relapsing-remitting multiple sclerosis: secondary results of an exploratory clinical trial,” Multiple Sclerosis and Related Disorders, vol. 52, Article ID 102948, 2021.

[29] A. G. Moraes, S. G. R. Neri, R. W. Motl et al., “Effect of hippotherapy on walking performance and gait parameters in people with multiple sclerosis,” Multiple Sclerosis and Related Disorders, vol. 43, Article ID 102203, 2020.

[30] D. Frevel and M. Mäurer, “Internet-based home training is capable to improve balance in multiple sclerosis: a randomized controlled trial,” European Journal of Physical and Rehabilitation Medicine, vol. 51, no. 1, pp. 23–30, 2015.

[31] J. L. Lindroth, J. L. Sullivan, and D. Silkwood-Sherer, “Does hippotherapy effect use of sensory information for balance in people with multiple sclerosis?” Physiotherapy Theory and Practice, vol. 31, no. 8, pp. 575–581, 2015.

[32] S. Muñoz-Lasa, G. Ferriero, R. Valero, F. Gomez-Muñiz, A. Rabini, and E. Varela, “Effect of therapeutic horseback riding on balance and gait of people with multiple sclerosis;” G Ital Med Lav Ergon, vol. 33, no. 4, pp. 462–467, 2011.

[33] S. Muñoz-Lasa, C. López de Silianes, M. Á. Atín-Aratibel, C. Bravo-Llatas, S. Pastor-Jimeno, and N. Máximo-Bocanegra, “Effects of hippotherapy in multiple sclerosis: pilot study on quality of life, spasticity, gait, pelvic floor, depression and fatigue,” Medicina Clinica, vol. 152, no. 2, pp. 55–58, 2019.

[34] D. Silkwood-Sherer and H. Warmbier, “Effects of hippotherapy on postural stability, in persons with multiple sclerosis: a pilot study,” Journal of Neurologic Physical Therapy, vol. 31, no. 2, pp. 77–84, 2007.

[35] A. Hammar, Y. Nilsagård, A. Forsberg, H. Pepa, E. Skargren, and B. Öberg, “Evaluation of therapeutic riding (Sweden)/ hippotherapy (United States). A single-subject experimental design study replicated in eleven patients with multiple sclerosis,” Physiotherapy Theory and Practice, vol. 21, no. 1, pp. 51–77, 2005.

[36] K. M. Menezes, F. Copetti, M. J. West, C. M. Trevisan, and A. F. Silveira, “Efeito da equoterapia na estabilidade postural de portadores de esclerose múltipla: estudo preliminar,” Fisioterapia e Pesquisa, vol. 20, no. 1, pp. 43–49, 2013.

[37] A. E. Latimer-Cheung, L. A. Pilutti, A. L. Hicks et al., “Effects of exercise training on fitness, mobility, fatigue, and health-related quality of life among adults with multiple sclerosis: a systematic review to inform guideline development,” Archives of Physical Medicine and Rehabilitation, vol. 94, no. 9, pp. 1800–1828, 2013.

[38] F. Halabchi, Z. Alizadeh, M. A. Sahraian, and M. Abolhasani, “Exercise prescription for patients with multiple sclerosis: potential benefits and practical recommendations,” BMC Neurology, vol. 17, no. 1, p. 185, 2017.

[39] J. G. Dominguez-Romero, A. Molina-Aroca, J. A. Moral-Munoz, C. Luque-Moreno, and D. Lucena-Anton, “Effectiveness of mechanical horse-riding simulators on postural balance in neurological rehabilitation: systematic review and meta-analysis,” International Journal of Environmental Research and Public Health, vol. 17, no. 1, p. 165, 2020.

[40] M. B. S. Borges, M. J. D. S. Werneck, M. D. L. D. Silva, L. Gandolfi, and R. Pratesi, “Therapeutic effects of a horse riding simulator in children with cerebral palsy,” Arquivos de Neuro-Psiquiatria, vol. 69, no. 5, pp. 799–804, 2011.

[41] S. Villafaina, C. Cordón-González, D. Collado-Mateo et al., “Influence of horseback riding and horse simulator riding on heart rate variability: are there differences?” Applied Sciences, vol. 9, no. 11, p. 2194, 2019.

[42] A. C. Granados and I. F. Agis, “Why children with special needs feel better with hippotherapy sessions: a conceptual review,” Journal of Alternative & Complementary Medicine, vol. 17, no. 3, pp. 191–197, 2011.

[43] B. A. Garber and B. R. Rigby, “Human pelvic motions when walking and when riding a therapeutic horse,” Human Movement Science, vol. 39, pp. 121–137, 2015.

[44] T. J. Braley and R. D. Chervin, “Fatigue in multiple sclerosis: mechanisms, evaluation, and treatment,” Sleep, vol. 33, no. 8, pp. 1061–1067, 2010.

[45] M. K. Sharief and R. Hentges, “Association between tumor necrosis factor-α and disease progression in patients with multiple sclerosis,” New England Journal of Medicine, vol. 325, no. 7, pp. 467–472, 1991.

[46] C. Heesen, L. Nawrat, C. Reich, N. Bauer, K.-H. Schulz, and S. M. Gold, “Fatigue in multiple sclerosis: an example of cytokine mediated sickness behaviour?” Journal of Neurology, Neurosurgery & Psychiatry, vol. 77, no. 1, pp. 34–39, 2006.

[47] J. L. L. Encheff, Kinematic Gait Analysis of Children with Neurological Impairments Pre and Post Hippotherapy Intervention, University of Toledo, Toledo, OH, USA, 2008.

[48] B. G. Vickrey, R. D. Hays, R. Harooni, L. W. Myers, and G. W. Ellison, “A health-related quality of life measure for multiple sclerosis,” Quality of Life Research, vol. 4, no. 3, pp. 187–206, 1995.

[49] S. M. Gold, C. Heesen, H. Schulz et al., “Disease specific quality of life instruments in multiple sclerosis: validation of the Hamburg Quality of Life Questionnaire in Multiple Sclerosis (HAQUAMS),” Multiple Sclerosis Journal, vol. 7, no. 2, pp. 119–130, 2001.

[50] J. A. Opara, K. Jaracz, and W. Brola, “Quality of life in multiple sclerosis,” Journal of medicine and life, vol. 3, no. 4, pp. 352–358, 2010.

[51] E. Gervasoni, J. Jonsdottir, A. Montesano, and D. Cattaneo, “Minimal clinically important difference of Berg balance scale in people with multiple sclerosis,” Archives of Physical Medicine and Rehabilitation, vol. 98, no. 2, pp. 337–340, 2017.

[52] H. S. Kim, C.-W. Lee, and I.-S. Lee, “Comparison between the effects of horseback riding exercise and trunk stability exercise on the balance of normal adults,” Journal of Physical Therapy Science, vol. 26, no. 9, pp. 1325–1327, 2014.

[53] T. L. Shurtleff, J. W. Standeven, and J. R. Engsberg, “Changes in dynamic trunk/head stability and functional reach after hippotherapy,” Archives of Physical Medicine and Rehabilitation, vol. 90, no. 7, pp. 1185–1195, 2009.

[54] T. B. de Araújo, R. J. de Oliveira, W. R. Martins, M. de Moura Pereira, F. Copetti, and M. P. Safons, “Effects of hippotherapy on mobility, strength and balance in elderly,” Archives of Gerontology and Geriatrics, vol. 56, no. 3, pp. 478–481, 2013.

[55] Y. E. Nilsagård, L. K. von Koch, M. Nilsson, and A. S. Forsberg, “Balance exercise program reduced falls in people with multiple sclerosis: a single-group, pretest-posttest trial,” Archives of Physical Medicine and Rehabilitation, vol. 95, no. 12, pp. 2428–2434, 2014.

[56] T. Mutoh, T. Mutoh, H. Tsunoe et al., “Impact of long-term hippotherapy on the walking ability of children with cerebral palsy and quality of life of their caregivers,” Frontiers in Neurology, vol. 10, 2019.
[57] D. Cattaneo, K. Rasova, E. Gervasoni, G. Dobrovodská, A. Montesano, and J. Jonsdottir, “Falls prevention and balance rehabilitation in multiple sclerosis: a bi-centre randomised controlled trial,” Disability & Rehabilitation, vol. 40, no. 5, pp. 522–526, 2018.

[58] S. Rooney, D. A. McFadyen, D. L. Wood, D. F. Moffat, and P. L. Paul, “Minimally important difference of the fatigue severity scale and modified fatigue impact scale in people with multiple sclerosis,” Multiple Sclerosis and Related Disorders, vol. 35, pp. 158–163, 2019.

[59] J. A. Opara, K. Jaracz, and W. Brola, “Quality of life in multiple sclerosis.” The Journal of Medicine and Life, vol. 3, no. 4, pp. 352–358, 2010.