Therapeutic Effects of Horseback Riding Interventions

A Systematic Review and Meta-analysis

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Objective: Equine-assisted therapies, such as therapeutic riding and hippotherapy, are believed to have positive physical and emotional effects in individuals with neuromotor, developmental, and physical disabilities. The purpose of this review was to determine whether therapeutic riding and hippotherapy improve balance, motor function, gait, muscle symmetry, pelvic movement, psychosocial parameters, and the patients' overall quality of life.

Design: In this study, a literature search was conducted on MEDLINE, CINAHL, MBASE, SportDiscus, Cochrane Database of Systematic Reviews, Cochrane Controlled Trials Register, PEDro, DARE, Google Scholar, and Dissertation Abstracts. Only studies with a control/comparison group or self-controlled studies performing preintervention and postintervention assessment were included. Excluded were (1) studies not providing data on baseline score or end-point outcome, (2) single-subject studies, (3) studies providing only qualitative data, and (4) studies that used a mechanical horse. Sixteen trials were included. The methodologic quality of each study was evaluated using Downs and Black quality assessment tool.

Results: Most of the studies showed a trend toward a beneficial effect of therapeutic riding and hippotherapy on balance and gross motor function. The meta-analysis showed improvement in both the Berg Balance Scale and the Gross Motor Function Measure in therapeutic riding and hippotherapy programs.

Conclusion: Programs such as therapeutic riding and hippotherapy are a viable intervention option for patients with balance, gait, and psychomotor disorders.

Key Words: Therapeutic Horseback Riding, Hippotherapy, Cerebral Palsy, Multiple Sclerosis, Neuromuscular Disease, Elderly, Stroke, Neuromotor, Developmental, Physical Disabilities

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The terms *neuromuscular diseases*, *neuromotor*, *developmental*, and *physical disabilities* are used to describe a broad group of conditions characterized by some form of motor dysfunction, which is the target group for this article with regard to the therapeutic effects of horseback riding interventions.[1] This group includes conditions due to a central nervous system etiology, such as cerebral palsy (CP), stroke, multiple sclerosis (MS), or spinal cord injury, or lower motor neuron disorders, including conditions such as spinal muscular atrophy, peripheral nerve disorders such as Charcot-Marie-Tooth disease, neuromuscular junction disorders such as congenital myasthenia gravis or myasthenic syndromes, and disorders of muscle fibers such as myopathies and muscular dystrophies, and sarcopenia associated with aging.[2,3] Conditions affecting the motor cortex are the most common of these, creating vulnerabilities to disturbances of both posture and mobility.[4] Many times, coexisting disorders of mental abilities, emotional development, perception, speech, communication, and sensory abilities are also present.[1,4,5]

Individuals with neuromotor, developmental, and physical disabilities have abnormal gait patterns owing to abnormal muscle tone, reduced control of their muscles, incoordination, asymmetry between agonist and antagonist muscles, and poor equilibrium reflexes.[4,6]

Physical activity provides many benefits to these individuals, including the improvement of functional abilities, including balance, and may delay progression of some disorders, ultimately leading to reduced morbidity and reduced premature mortality. The psychologic benefits of such a program are also important.[1,6,7] The introduction of sports as a form of therapy in the early formative years may also have a significant impact on accelerating the rehabilitation of individuals suffering from such forms of neuromotor, developmental, and physical disabilities.[8] According to the literature, equine-assisted therapies are exercise therapies that can have positive physical effects on coordination, muscle tone, postural alignment, stiffness/flexibility, endurance, and strength, correcting abnormal movement patterns and improving gait and balance.[9,10]

The terms used in this article to refer to a therapeutic activity with the help of the horse are *therapeutic riding* (TR) and *hippotherapy* (HT). TR is the adaptive or modified sport (sport as therapy) of equitation. The purpose is to contribute

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positively to cognitive, physical, emotional, and social well-being of people with disabilities. TR provides benefits in the areas of therapy, education sport, and recreation and leisure.[11] According to Sterba et al,[8] "sports therapy" is the enjoyment of any sport that results in improvements in gross motor function for participants with neuromotor, developmental, and physical disabilities.[8,12] As horseback riding rhythmically moves the rider's body in a manner similar to a human gait, riders with physical disabilities often show improvement in flexibility, balance, and muscle strength. In addition to the therapeutic benefits, TR also provides recreational opportunities for such individuals to enjoy the outdoors.[11] HT is the use of the movement of the horse by health professionals with HT qualifications to address impairments, functional limitations, and disabilities in participants with neuromotor, developmental, and physical disabilities. As part of an integrated rehabilitation treatment program, HT can be prescribed to achieve improvements in posture, balance, mobility, walking energy expenditure, function, and sensory abilities.[5,10,11,13,14] Moreover, the term *equine-assisted activities and therapies* is the terminology used to describe these two types of riding.[15]

In recent years, TR and HT have systematically been used as part of integrated rehabilitation treatment programs, with significant positive impacts.[14,16] The purpose of this study was to assess the improvements that TR and HT can exert on balance, motor function, posture, gait, muscle symmetry, pelvic movement, psychosocial parameters, and the patients' overall quality of life, using the evidence gathered from found in international literature. Although there are a significant number of studies that discuss the positive impacts of TR and HT, few studies use a control group and include quantitative data. The systematic review and meta-analysis conducted in this article provide a quantitative overview of recent developments and findings, enhancing and contributing to up-to-date literature in this scientific field.

METHOD

The study has been designed and the results have been reported based on the Preferred Reporting Items for Systematic Review and Meta-analysis statement. The Preferred Reporting Items for Systematic Review and Meta-analysis is an evidence-based minimum set of items for reporting in systematic reviews and meta-analyses and focuses especially on the reporting of reviews evaluating randomized trials.[17] This study conforms to all Preferred Reporting Items for Systematic Review and Meta-analysis guidelines and reports the required information accordingly (see Supplementary Checklist, http://links.lww.com/PHM/A404).[18]

Eligibility Criteria

The studies included in this review concern published trials (in the English language) involving children, adults, and the elderly with diagnoses associated with impairments in motor function, focusing on the intervention effects of HT or TR on postural control, balance, gait, and spasticity as well as overall quality of life indicators. A main criterion for selecting studies to be included in this review was that the effects of HT and TR were assessed in a quantitative manner.

Inclusion and Exclusion Criteria

Only studies with a control/comparison group or self-controlled studies performing preintervention and postintervention assessment have been included. The studies excluded (1) studies not providing data on baseline score or end-point outcome, (2) single subject studies, (3) studies providing only qualitative data, and (4) studies that used a mechanical horse. Exclusion criteria were set for cointerventions such as medication or surgery that might have influenced the outcome. To increase the reliability of citation selection, all potentially relevant citations were reviewed independently by two investigators.

Information Sources and Search Strategy

A literature search was conducted in the databases MEDLINE, CINAHL, MBASE, SportDiscus, Cochrane Database of Systematic Reviews, Cochrane Controlled Trials Register, PEDro, DARE, Google Scholar, Scopus, ISI Web of Science, and Dissertation Abstracts using the following search terms to record studies on HT or TR published February 29, 2016. The search algorithm used was *"therapeutic riding" OR "therapeutic horse riding" OR "therapeutic horseback riding" OR "horse riding" OR "horseback riding" OR hippotherapy OR "equine-assisted therapy" OR "equine-assisted movement therapy" OR "equine therapy" OR "equine movement therapy" OR "developmental riding therapy" OR "riding for the disabled*." The search was limited to English-language articles. Hard copies of *Pediatric Physical Therapy*, *Gait and Posture*, *Developmental Medicine and Child Neurology*, *American Journal of Physical Medicine & Rehabilitation*, *Archives of Physical Medicine and Rehabilitation*, and *Physiotherapy Theory and Practice* were also searched. In addition, abstracts of the *Gait and Posture* conference and the American Academy of Cerebral Palsy and Developmental Medicine were also searched for relevant articles. Finally, the reference lists of the included articles were also searched for additional studies and any already published systematic review or meta-analysis was cross-checked for studies that were potentially missed out.

Data Extraction

The following information from each eligible scientific article was extracted: first author, year of publication, country, total sample size and sample size per type of disorder, characteristics and statistics of participants in the intervention programs (e.g., mean age of participants), interventions per type of disorder, TR program, duration of interventions, outcomes, follow-up duration, measures used to evaluate the efficacy of interventions, and baseline and end-point measurements. Moreover, any adjuvant interventions that were administered were recorded. Data extraction was performed by the lead author and was checked by one of the coauthors.

Methodologic Quality Assessment of Research Articles

The methodologic quality of each study was evaluated independently by two of the coauthors and differences were resolved by a third. Evaluation was performed using Downs and Black quality assessment tool. The Downs and Black checklist consists of 27 items categorized into four sections: reporting (10 items), external validity (3 items), internal validity (bias: 7 items, and confounding: 6 items), and power (1 item). Twenty-five items were scored as yes = 1 point, no = 0, or unable to determine = 0; item 5 was scored as yes = 2 partially = 1, no = 0; and lastly, item 27 was scored from 0 to 5 points, and therefore, each study was attributed a total Downs and Black score (range from 0 to 32). The mean (SD) Quality Index Score for randomized controlled trials was 14.0 (6.39) (skewness, −0.07) and for nonrandomized studies was 11.7 (4.64) (skewness, −1.10).[19] The kappa statistic was used to determine the interrater reliability, a measurement of the extent to which data collectors (raters) assign the same score to the same variables.[20,21]

Statistical Analysis

A meta-analysis of the mean differences of the Berg Balance Scale (BBS)[22] or Pediatric Balance Scale (PBS)[23] and the Gross Motor Function Measure (GMFM)[24] between intervention and control groups was conducted for the studies included. The analysis aimed at estimating the pooled effect size of HT and TR on participants. Both fixed and random effects meta-analysis were used. The meta-analysis was based on the inverse variance method for weighting and the Dersimonian and Laird estimator[25] for the random effects meta-analysis model was used. Cochran's Q test statistic[26] was used to assess heterogeneity. The degree of heterogeneity was assessed using the formula: $I^2 = 100\% * \frac{Q-(k-1)}{Q}$, where k represents the number of studies included. The I^2 statistic ranges from 0% to 100%, and cutoff values of 25%, 50%, and 75% indicate low, moderate, and high degrees of heterogeneity respectively. The analysis was conducted with the use of Stata version 13 (College Station, TX).

RESULTS

The literature review and the application of the eligibility and inclusion/exclusion criteria led to the detailed assessment of 16 studies (Fig. 1).

Quality Assessment

Agreement between the two raters was 85.2% and the interrater reliability kappa statistic[28] was equivalent to 0.72 (standard error, 0.034), indicating substantial agreement.

Of the 16 studies reviewed, few have a low Downs and Black score, whereas 8 studies had higher scores and qualified for inclusion in the formal meta-analysis that followed. The lowest score was noted for Kim et al.,[29] with a score of 15, and the highest was noted for Davis et al.,[30] with a score of 28. More specifically, one study scored 27 on the Downs and Black scale, two studies scored 24, three studies scored 21, one study scored 20, four scored 19, and three scored 17.

Cerebral Palsy

Eight studies assessed the effect of HT and TR in children with CP. The total number of participants (children) studied was 343, of which 170 participants were in the HT and TR intervention group and 158 participants were in a control group. In the study of Kang et al.,[31] a group of 15 participants (physical therapy group) were considered in a control and intervention group. The common outcome measure was the GMFM,[24]

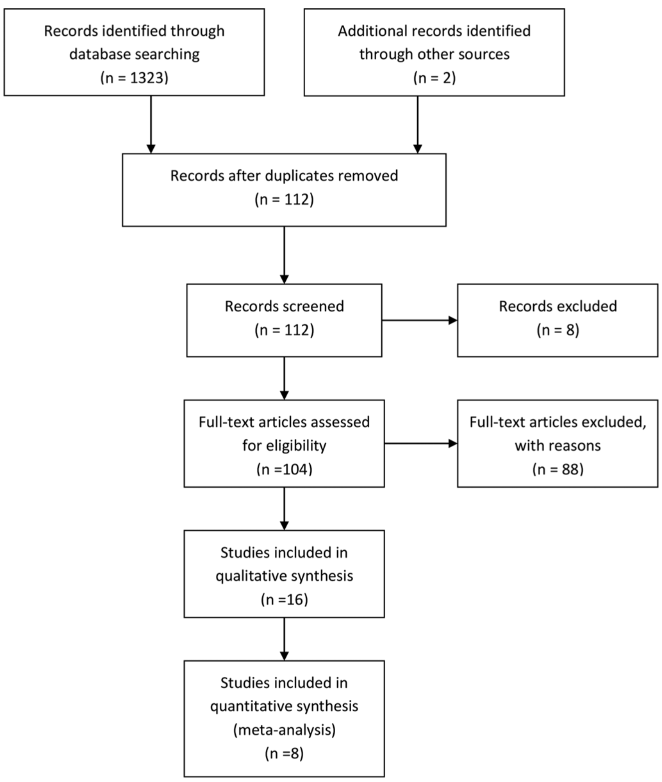

FIGURE 1. Preferred Reporting Items for Systematic Review and Meta-analysis 2009 flow diagram.[27]

but also fine motor function, balance, posture, gait, muscle symmetry, pelvic movement, psychosocial parameters, and quality of life were measured.

Davis et al.[30] did not find a significant improvement in 35 children who participated in a TR program. Only two significant differences (P = 0.04) were found between the scores in the intervention and control groups (KIDSCREEN parent report[32] and family relations domain of the Child Health Questionnaire[33]).

Kwon et al.[34] found that the stride length increased significantly, with no change in cadence in the 16 participants of the intervention group (HT plus physical therapy). In contrast, in the control group (which undertook only physical therapy treatment), cadence increased. Statistically significant interactions between interventions were noted in the scores for dimension E (walking, running, jumping) of the GMFM,[24] GMFM-66,[35] and PBS.[23] In the intervention group, a decrease in the average pelvic anterior tilt was noted during gait, at terminal stance, and at initial contact.

Park et al.[36] did not find significant differences between the 34 participants of the HT intervention group and the 21 participants of the control groups in terms of the mean baseline total scores of GMFM-66, GMFM-88, or Pediatric Evaluation of Disability- Inventory Functional Skills Scale.[37] After the 8-wk intervention program, mean GMFM-66 and GMFM-88[35] scores significantly improved in both groups. The HT group had significantly greater improvement in dimension E and GMFM-66 total score than the control group did. The total Pediatric Evaluation of Disability-Inventory Functional Skills Scale score and the subscores of its three domains were significantly higher in the HT intervention group, but not in the control group.

Kwon et al.[38] found a statistically significant difference in the 45 participants of the HT intervention group in GMFM-66, GMFM-88, and GMFM dimensions B (sitting), C (crawling and kneeling), D (standing), and E (walking, running, jumping). No statistically significant results were found in the 46 participants of the control group. Also, significant results were found in PBS in the HT intervention group in contrast with the control group, where no statistically significant difference was noted.

In the study of Benda et al.,[39] in the HT intervention group, a significant improvement was noted in the symmetry of muscle activity, in those muscle groups displaying the highest asymmetry before HT (P = 0.051).

Kang et al.[31] reported that the sway pathway and velocity of the center of pressure on the force plate, when sitting, significantly decreased in the HT intervention group ($P < 0.05$) compared with the physical therapy group and the control group. This indicates that the HT intervention group had improvement in sitting balance.

MacKinnon et al.[40] found a significant difference in Skill A (grasping) of Fine Motor Control[41] (P = 0.006). Subsequent analyses showed a significant improvement (P = 0.045) between the moderate-CP intervention and moderate-CP control groups.

Finally, Baik et al.[42] noted an overall improvement in the knee muscle tone and hip joint range of motion after treatment with TR but they did not find statistically significant differences between the HT intervention group and the control group.

Elderly Individuals

Four randomized clinical trials assessed the use of equine-assisted therapy for mobility improvement in the elderly population. The total number of participants was 90 (elderly individuals), 43 in the intervention group and 47 in the control group. The common outcome was the timed up and go test[43] and the BBS.[22]

de Araújo et al.[44] presented a statistically significant increase in BBS and 30 chair stand test [45] in the HT intervention group (P = 0.003 and P = 0.032, respectively), indicating an improvement in the balance and muscle strength of the lower limbs. In timed up and go, no statistically significant difference was noted.

Homnick et al.[46] did not note statistically significant results because of the small sample size, the relatively high initial balance scores of the participants, and the tendency of the members of the control group to increase their physical activities, which most likely influenced the outcomes of the study.

Araujo et al.[47] found statistically significant results in stabilometry data after the treatment in the variables center of pressure anterio-posterior[48] area (P = 0.02), center of pressure anterio-posterior mean, and area means. A significant effect was also shown in the mean results of the timed up and go test (P = 0.04).

Kim and Lee[29] measured subjects' static balance ability before and after the intervention, using a Balance Plate, and found that the step length increased significantly ($P < 0.05$) in the HT intervention group and the sway path length decreased significantly in the HT intervention group in comparison to the control group ($P < 0.05$).

Multiple Sclerosis

Three studies assessed the effect of HT and TR on individuals with MS. One study did not include a control group. The total number of participants was 52, 32 in the intervention group and 20 in the control group. Of the 52 participants, 12 were diagnosed with relapsing-remitting MS; 6, with secondary progressive MS; 5, with primary progressive MS; 3 were unknown in Silkwood-Sherer and Warmbier[49]; and 26 were not stated in the Muñoz-Lasa et al.[9] research. The common outcome measures were the Tinetti Performance Oriented Mobility Assessment (POMA),[50] the BBS, and gait speed (meters per second).

In the Silkwood-Sherer and Warmbier[49] study, statistically significant differences in scores for the BBS (P = 0.012) and the POMA (P = 0.006) were found in the HT intervention group consisting of nine participants. The most significant change occurred between the preterm and midterm tests in BBS (P = 0.016) and POMA (P = 0.016). No statistically significant changes in any of the items of BBS (14 items were tested) were observed in the physical therapy control group of six participants (they undertook only physical therapy). In contrast, the mean rank change of the alternating stool touch task (12th item of BBS) showed significant change (P = 0.037) for the HT intervention group. Also, a statistically

TABLE 1. Studies included in meta-analysis in BBS/PBS and GMFM

			Study Group			Control Group				
Meta-analysis ID	**Author**	**Year**	**Mean**	**SD**	***N***	**Mean**	**SD**	***N***	**Patients**	**Intervention**
Studies included in meta-analysis BBS/PBS										
1	Araujo	2013	54.58	2.11	12	54.13	2.34	16	Elders	HT
1	Homnick	2012	55.9	**0.3**	9	54.7	**1.5**	6	Elders	TR
2	Silkwood-Sherer	2007	45.44	12.42	9	40.17	7.91	6	MS	HT
2	Beinotti	2010	49	13	10	45.1	14.2	10	Stroke	HT
3	Kwon et al.	2011	45.8	8.6	16	41.5	10.6	16	CP	HT
3	Kwon et al.	2015	28.9	18.8	45	27.1	18.3	46	CP	HT
Studies included in meta-analysis GMFM										
4	Davis et al.	2009	73	17	35	74	18	37	CP	TR
4	Kwon et al.	2011	73.7	8.3	16	70.1	8.1	16	CP	HT
4	Park et al.	2014	61.43	14.78	34	62.46	21.7	21	CP	HT
4	Kwon et al.	2015	63.5	15.8	45	61.8	15	46	CP	HT

significant difference was found between the posttest BBS scores ($P = 0.043$), but not for the POMA index ($P = 0.070$).

The Muñoz-Lasa et al.[9] study showed a significant improvement in balance on the POMA index in the TR intervention group ($P < 0.005$), whereas the Expanded Disability Status Scale[51] and Barthel index[52] did not significantly change. In the TR intervention group, a significant reduction in stride time ($P < 0.04$) and a significant increase ($P < 0.01$) in the ground reaction forces[53] was observed after the treatment (except in the minimum in midstance).

In the Hammer et al.[54] study, treatment with TR/HT seemed to benefit the subjects differently. The BBS and "Role-Emotional," a dimension of the Short-Form 36 of Health-Related Quality of Life,[55,56] most often improved.

Stroke

Only one randomized clinical trial assessing the effect of HT on post-stroke individuals was identified in Beinotti et al.[57] The total number of participants in the study was 20, 10 participants in the HT intervention group and 10 in the control group.

According to Beinotti et al.,[57] the Fugl-Meyer assessment[58] showed significant improvement concerning the symptoms of motor impairment in the lower limbs for all participants ($P = 0.01$) and a significant difference between the two groups was observed ($P = 0.01$). When the groups were separately compared, the intervention group showed significant improvement ($P = 0.004$) but the control group did not improve ($P = 1.000$) in the last assessment. Regarding the balance subscale, there was significant improvement in both groups ($P = 0.19$). As concerns BBS, the experimental group showed a greater tendency of improvement than the control group.

Meta Analysis

BBS and PBS

A total of six studies investigating the effects of HT measured in terms of the BBS and PBS satisfied the meta-analysis inclusion criteria: two studies were conducted in elderly individuals, two studies focused on individuals with neuromotor disabilities, and two studies focused on participants (children) with CP. The subgroup of participants with neuromotor disabilities included two studies (MS, stroke). A meta-analysis was performed for each of the three groups of participants. The PBS is an adapted scale of BBS for children (Tables 1 and 2, Fig. 2)

For the elderly individuals group, no significant heterogeneity was observed ($Q = 0.51$; $P = 0.47$), so the fixed effect model was used. The analysis showed a mean difference (improvement) of 0.94 points in the BBS score but was not statistically significant ($P = 0.06$). The estimated 95% confidence interval for the pooled mean difference is −0.04 to 1.92).

For the participants with neuromotor disabilities, no significant heterogeneity was observed, and the Q statistic was found to be 0.03 ($P = 0.87$), so the fixed effect model was used. The analysis on participants with neuromotor disabilities showed that there was improvement, with a mean difference of 4.69 points on the BBS, but this was not statistical significant ($P = 0.24$). The estimated 95% confidence interval for the pooled mean difference is −3.11 to −12.48.

TABLE 2. Results of meta-analyses

Group	**Studies**	***Q* Value**	**Heterogeneity *P***	I^2	***P* of Meta-analysis**	**Mean Difference (95% CI)**
BBS (elders)	2	0.51	0.47	0.00%	0.06	0.94 (−0.04 to 1.92)
BBS (neuromotor disabilities)	2	0.03	0.87	0.00%	0.24	4.69 (−3.11 to 12.48)
PBS (cerebral palsy)	2	0.23	0.63	0.00%	0.21	3.21 (−1.82 to 8.24)
GMFM (cerebral palsy)	4	1.11	0.77	0.00%	0.37	1.61 (−1.92 to 5.14)

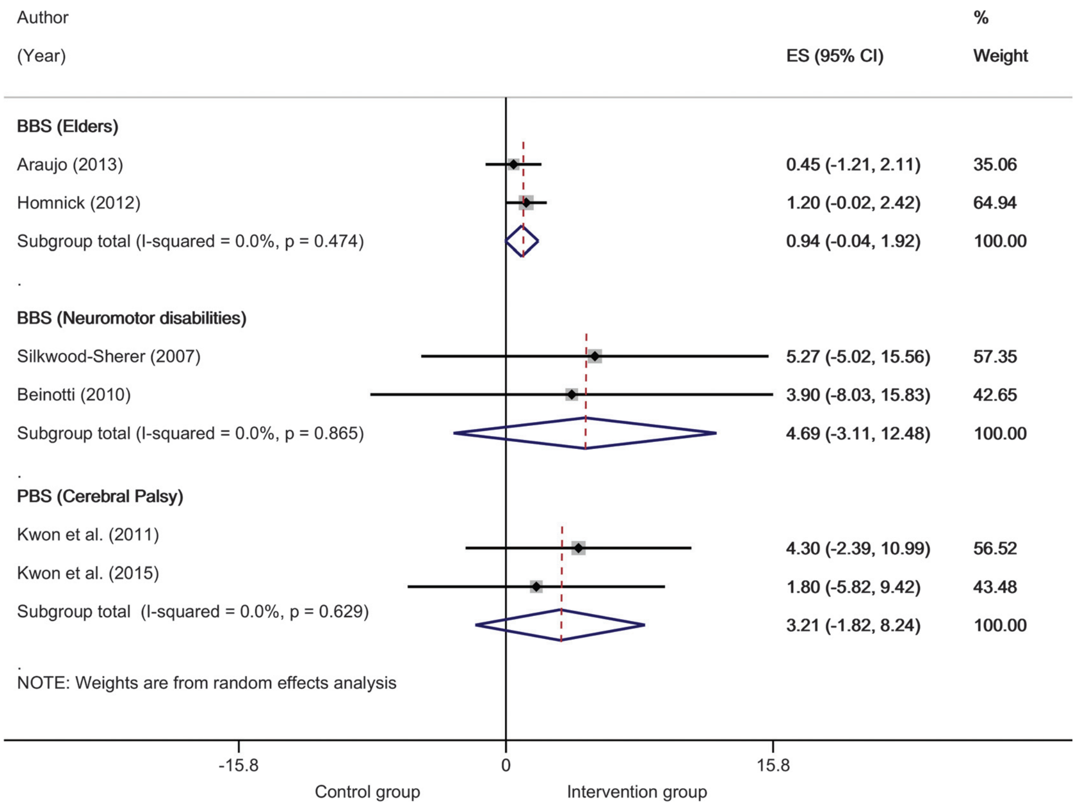

FIGURE 2. Subgroup synthesis forest plot. Meta-analysis of BBS/PBS.

For participants with CP, the *Q* value for heterogeneity was 1.11 ($P = 0.77$), so the fixed effects model was used. The analysis on participants with CP showed that there was improvement with a mean difference of 3.21 points on BBS, but this was not statistically significant ($P = 0.21$). The estimated 95% confidence interval for the pooled mean difference is −1.82 to 8.24.

Gross Motor Function Measure

Reported results from four studies were used to examine the effect of HT intervention on participants with CP. For participants with CP no significant heterogeneity was observed, the *Q* statistic was equivalent to 1.11 ($P = 0.77$) and the I^2 was found equal to 0%, indicating that there was no heterogeneity between the studies. Therefore, a fixed effect model was

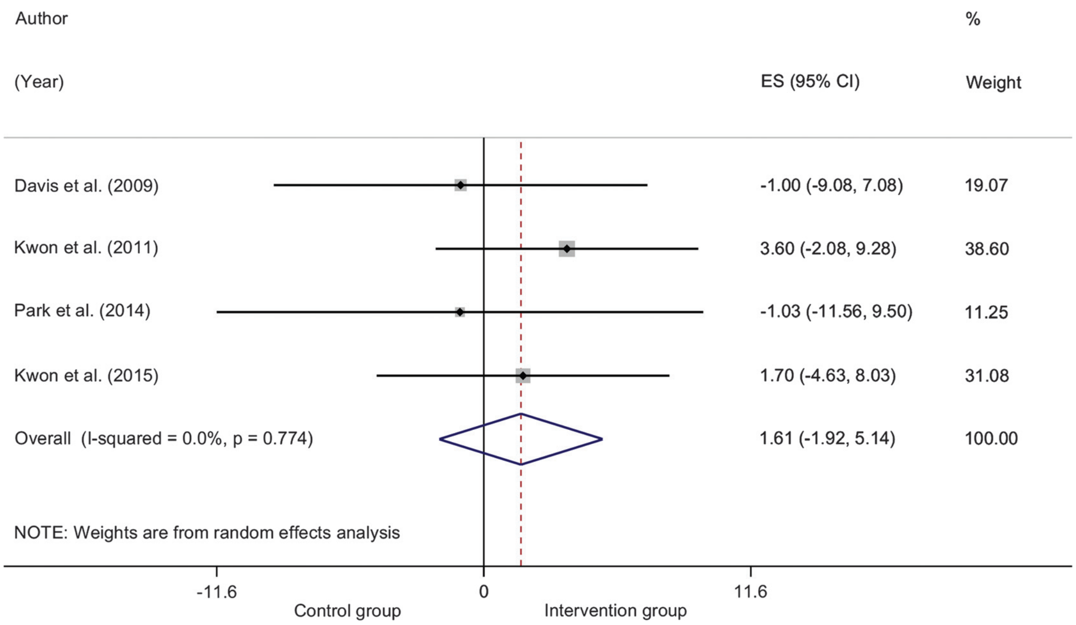

FIGURE 3. Subgroup synthesis forest plot. Meta-analysis of GMFM.

used. The results of the data synthesis table (Fig. 3) show that between the intervention and nonintervention groups, there was a mean difference (improvement) of 1.61, although this was not statistically significant and therefore the GMFM 66 score seems to be roughly equal for the two groups ($P = 0.37$). The estimated 95% confidence interval for the pooled mean difference is −1.92 to 5.14 (Tables 1 and 2, Fig. 3)

DISCUSSION

The literature review conducted for this article revealed that there are very few studies about TR and HT in the international literature. Furthermore, in most studies, the sample size of the intervention group was too small to draw reliable conclusions. From the existing literature, a total of 16 trials were chosen, which fulfilled the requirements of the inclusion criteria of this review. Of the 16 trials, only 8 included appropriate data for further comparative meta-analysis. In eight studies, the participants were children with CP; in three studies, the participants were adults with MS; one study included post-stroke participants; and four studies were about elderly individuals with multiple health problems. The eight trials included in the meta-analysis were divided as follows: in four studies, the participants were children with CP; in one study, the participants were adults with MS; one study has post-stroke participants; and two studies were about elderly individuals with multiple health problems. Although no statistically significant improvement was observed in the HT and TR intervention groups, all studies and meta-analysis showed increased scores concerning the impact of HT and TR. The review shows that the intervention has positive results even though these may be of small magnitude. The heterogeneity of the population studies may require more specific measures for each condition to optimally detect benefits. Generally, it was observed that TR and HT have a significantly positive impact on adults with neuromotor disabilities (including both MS and stroke) and children with CP, as well as elderly individuals with multiple health problems and disabilities. More specifically, TR and HT significantly improve the balance, motor function, posture, gait, muscle symmetry, pelvic movement, psychosocial parameters, and the patients' overall quality of life. The meta-analysis that included only BBS/PBS did not show statistically significant benefits of TR versus other forms of therapy. For the GMFM, although there are significantly positive impacts of TR and HT on individual dimensions (A—lying and rolling, B—sitting, C—crawling and kneeling, D—standing, and E—walking, running, jumping), it was not possible to conduct a meta-analysis separately for each dimension, as the results for these were not given in the individual studies. Thus, the total score was used in the meta-analysis and these significantly positive impacts do not reflect in the results as they are averaged out.

The common therapies that are applied to individuals with CP are physical therapy, occupational therapy, and speech therapy. Some studies[59–61] have shown that there are many other interventions that could help children with CP regarding motor function, posture, balance, quality of life, and generally in their everyday life. Verschuren et al.[59] have stated that children with CP may benefit from improved exercise programs that focus on lower extremity muscle strength and cardiovascular fitness. Dewar et al.[10] stated that there is moderate evidence to support the use of treadmill training with no–body weight support, trunk-targeted training, reactive balance training, and gross motor task training as interventions for CP. Also, Anttila et al.,[60,61] in their review, refer to the effectiveness of interventions such as comprehensive physical therapy, strength training programs, upper extremity treatments, sensorimotor training programs, constraint-induced movement therapy, balance training, soft tissue treatment, hydrotherapy, and conductive education in children with CP. In this review, it was observed that TR helps in the improvement of muscle activity symmetry,[39] sitting balance,[31] walking speed, stride length, and pelvic kinematics (average pelvic anterior tilt, pelvic anterior tilt at initial contact, pelvic anterior tilt at terminal stance); in GMFM (dimension E: walking, running, and jumping); in balance[34]; and in Skill A (grasping) of Fine Motor Control.[40]

In elderly individuals, exercise interventions were associated with a small to moderate reduction in fear of falling immediately after intervention.[62] According to Schoene et al.,[63] step training improves step velocity (reaction time, movement time), step accuracy, and static and dynamic balance measures; balance board training can improve performance in balance batteries (e.g., BBS and POMA) between baseline and reassessment; balance board and aerobic training in combination improved static and dynamic balance and mobility; and aerobic programs should improve balance and mobility in older people. Howe et al.[64] also mention that there is weak evidence that some types of exercise (gait, balance, coordination and functional tasks; strengthening exercise; 3D exercise and multiple exercise types) are moderately effective, immediately after intervention, in improving clinical balance outcomes in older people. According to this review, HT in elderly individuals showed improvements in balance and muscle strength of lower limbs.

The exercise therapy such as resistance training, endurance training, and water Ai-Chi can potentially reduce depressive symptoms in individuals with MS.[65] Also, significant effects on reducing the impact or severity of patient-reported fatigue are the aquatic exercise, resistance training, and vestibular rehabilitation.[66] The evidence of efficacy of yoga on MS remains unclear, according to Cramer et al.[67] In this review, it was noticed that TR improves balance,[9,49,68] reduces the stride time, and ground reaction forces.[9]

Cardiorespiratory training helps individuals after a stroke to improve their mobility and balance. There is sufficient evidence to incorporate cardiorespiratory and mixed training, involving walking, within post-stroke rehabilitation programs, to improve the speed and tolerance of walking.[69] Moderate-quality evidence-based studies have showed a beneficial effect of constraint-induced movement therapy, mental practice, mirror therapy, interventions for sensory impairment, virtual reality, and a relatively high dose of repetitive task practice. Also, it has been indicated that unilateral arm training may be more effective than bilateral arm training.[70] In this review, only one RCT[57] studying TR in stroke participants was found that observed significant improvements in motor impairment regarding the lower limbs and balance.

Overall, although the literature reports the positive impacts of TR programs on participants with neuromotor, developmental, and physical disabilities, there is a need to quantify the efficacy of such programs on the daily activity and participation level of such individuals, as well as the increase in their self-competence and quality of life. This meta-analysis including only specific balance (BBS/PBS) and gross motor function (GMFM) measures did not show significant differences between people with an impairment receiving TR or HT and those who did not. Equine-assisted activities and therapies potentially provide advantage for cognitive, emotional and social well-being; individuals who participate have the opportunity to simultaneously experience, benefit and enjoy the outdoors, which might not otherwise be readily available. TR and HT are likely viable intervention options for participants with impairments in balance, gross and fine motor function, gait, spasticity and coordination.

STUDY LIMITATIONS

The limitations of this study were (1) that there are few clinical trials with control group, (2) more quantitative study results are needed to assess the outcome of the intervention, and (3) it is necessary to provide more details and demonstrate all the results in the publications; for example, for the GMFM, although there are significantly positive impacts of TR and HT on individual dimensions (A–E), it was not possible to conduct a meta-analysis separately for each dimension as the results for these were not given in each of the individual studies. As a result, in this review article, only the total score was used in the meta-analysis, which cannot reflect the significant positive results in the individual dimensions because these are averaged out. Finally, it would be useful for the various studies conducted in this field to define common measurements that could then be used in a meta-analysis.

CONCLUSIONS

There is a lack of published articles assessing the effects of TR and HT intervention programs on participants with neuromotor, developmental, and physical disabilities. Although TR and HT are used for neuromotor, developmental, and physical disabilities, the overall effectiveness of TR for many of the indications is unclear and more research has been recommended. It will be useful in future studies to give the results of all dimensions (A, B, C, D, and E) of the GMFM to make it possible to conduct a separate meta-analysis for each of these, in addition to the total score that was assessed in this study.

Overall, programs such as TR and HT and generally the use of the horse as a therapeutic tool are clearly a viable intervention option for participants with impairments in balance, gross and fine motor function, gait, spasticity, and coordination. Also, TR and HT provide cognitive, emotional, and social well-being, and individuals who attend such a therapy program have the opportunity to simultaneously experience, benefit, and enjoy the activity outdoors.

REFERENCES

1. McCrory MA, Kim HR, Wright NC, et al: Energy expenditure, physical activity, and body composition of ambulatory adults with hereditary neuromuscular disease. *Am J Clin Nutr* 1998;67:1162–9
2. Driscoll SW, Skinner J: Musculoskeletal complications of neuromuscular disease in children. *Phys Med Rehabil Clin N Am* 2008;19:163–94, viii
3. Cup EH, Pieterse AJ, Ten Broek-Pastoor JM, et al: Exercise therapy and other types of physical therapy for patients with neuromuscular diseases: A systematic review. *Arch Phys Med Rehabil* 2007;88:1452–64
4. Gage JR: *Gait Analysis in Cerebral Palsy. Clinics in Developmental Medicine*, London, McKeith Press, 1991
5. McGibbon NH, Andrade CK, Widener G, et al: Effect of an equine-movement therapy program on gait, energy expenditure, and motor function in children with spastic cerebral palsy: A pilot study. *Dev Med Child Neurol* 1998;40:754–62
6. Krivickas LS: Exercise in neuromuscular disease. *J Clin Neuromuscul Dis* 2003;5:29–39
7. Kilmer DD: Response to resistive strengthening exercise training in humans with neuromuscular disease. *Am J Phys Med Rehabil* 2002;81(suppl):S121–6
8. Sterba JA, Rogers BT, France AP, et al: Horseback riding in children with cerebral palsy: Effect on gross motor function. *Dev Med Child Neurol* 2002;44:301–8
9. Muñoz-Lasa S, Ferriero G, Valero R, et al: Effect of therapeutic horseback riding on balance and gait of people with multiple sclerosis. *G Ital Med Lav Ergon* 2011;33:462–7
10. Dewar R, Love S, Johnston LM: Exercise interventions improve postural control in children with cerebral palsy: A systematic review. *Dev Med Child Neurol* 2015;57:504–20
11. PATH International. Available at: http://www.pathintl.org/. Accessed January 19, 2013
12. Sterba JA: Does horseback riding therapy or therapist-directed hippotherapy rehabilitate children with cerebral palsy? *Dev Med Child Neurol* 2007;49:68–73
13. Meregillano G: Hippotherapy. *Phys Med Rehabil Clin N Am* 2004;15:843–54, vii
14. Zadnikar M, Kastrin A: Effects of hippotherapy and therapeutic horseback riding on postural control or balance in children with cerebral palsy: A meta-analysis. *Dev Med Child Neurol* 2011;53:684–91
15. Tseng SH, Chen HC, Tam KW: Systematic review and meta-analysis of the effect of equine assisted activities and therapies on gross motor outcome in children with cerebral palsy. *Disabil Rehabil* 2013;35:89–99
16. Bronson C, Brewerton K, Ong J, et al: Does hippotherapy improve balance in persons with multiple sclerosis: A systematic review. *Eur J Phys Rehabil Med* 2010;46:347–53
17. Moher D, Shamseer L, Clarke M, et al: Preferred Reporting Items for Systematic Review and Meta-analysis Protocols (PRISMA-P) 2015 statement. *Syst Rev* 2015;4:1
18. Moher D, Liberati A, Tetzlaff J, et al: Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *PLoS Med* 2009;6:e1000097
19. Downs SH, Black N: The feasibility of creating a checklist for the assessment of the methodological quality both of randomised and non-randomised studies of health care interventions. *J Epidemiol Community Health* 1998;52:377–84
20. McHugh ML: Interrater reliability: The kappa statistic. *Biochem Med (Zagreb)* 2012;22:276–82
21. Landis JR, Koch GG: The measurement of observer agreement for categorical data. *Biometrics* 1977;33:159–74
22. La Porta F, Caselli S, Susassi S, et al: Is the Berg Balance Scale an internally valid and reliable measure of balance across different etiologies in neurorehabilitation? A revisited Rasch analysis study. *Arch Phys Med Rehabil* 2012;93:1209–16
23. Franjoine MR, Gunther JS, Taylor MJ: Pediatric Balance Scale: A modified version of the Berg Balance Scale for the school-age child with mild to moderate motor impairment. *Pediatr Phys Ther* 2003;15:114–28
24. Russell DJ, Rosenbaum PL, Cadman DT, et al: The Gross Motor Function Measure: A means to evaluate the effects of physical therapy. *Dev Med Child Neurol* 1989;31:341–52
25. DerSimonian R, Laird N: Meta-analysis in clinical trials. *Control Clin Trials* 1986;7:177–88
26. Hardy RJ, Thompson SG: Detecting and describing heterogeneity in meta-analysis. *Stat Med* 1998;17:841–56
27. Moher D, Liberati A, Tetzlaff J, et al: Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *BMJ* 2009;339:b2535
28. Cohen J: A coefficient of agreement for nominal scales. *Educ Psychol Meas* 1960:37–46
29. Kim SG, Lee CW: The effects of hippotherapy on elderly persons' static balance and gait. *J Phys Ther Sci* 2014;26:25–7
30. Davis E, Davies B, Wolfe R, et al: A randomized controlled trial of the impact of therapeutic horse riding on the quality of life, health, and function of children with cerebral palsy. *Dev Med Child Neurol* 2009;51:111–9, discussion 88
31. Kang H, Jung J, Yu J: Effects of hippotherapy on the sitting balance of children with cerebral palsy: A randomized control trial. *J Phys Ther Sci* 2012;24:833–6
32. Ravens-Sieberer U, Gosch A, Rajmil L, et al: KIDSCREEN-52 quality-of-life measure for children and adolescents. *Expert Rev Pharmacoecon Outcomes Res* 2005;5:353–64
33. Waters E, Salmon L, Wake M, et al: The Child Health Questionnaire in Australia: Reliability, validity and population means. *Aust N Z J Public Health* 2000;24:207–10
34. Kwon JY, Chang HJ, Lee JY, et al: Effects of hippotherapy on gait parameters in children with bilateral spastic cerebral palsy. *Arch Phys Med Rehabil* 2011;92:774–9
35. Alotaibi M, Long T, Kennedy E, et al: The efficacy of GMFM-88 and GMFM-66 to detect changes in gross motor function in children with cerebral palsy (CP): A literature review. *Disabil Rehabil* 2014;36:617–27
36. Park ES, Rha DW, Shin JS, et al: Effects of hippotherapy on gross motor function and functional performance of children with cerebral palsy. *Yonsei Med J* 2014;55:1736–42
37. Steenbeek D, Gorter JW, Ketelaar M, et al: Responsiveness of Goal Attainment Scaling in comparison to two standardized measures in outcome evaluation of children with cerebral palsy. *Clin Rehabil* 2011;25:1128–39
38. Kwon JY, Chang HJ, Yi SH, et al: Effect of hippotherapy on gross motor function in children with cerebral palsy: A randomized controlled trial. *J Altern Complement Med* 2015;21:15–21

39. Benda W, McGibbon NH, Grant KL: Improvements in muscle symmetry in children with cerebral palsy after equine-assisted therapy (hippotherapy). *J Altern Complement Med* 2003;9:817–25
40. Mackinnon JR, Noh S, Lariviere J, et al: A study of therapeutic effects of horseback riding for children with cerebral palsy. *Phys Occup Ther Pediatr* 1995;15:17–34
41. Stokes NA, Deitz JL, Crowe TK: The Peabody Developmental Fine Motor Scale: An interrater reliability study. *Am J Occup Ther* 1990;44:334–40
42. Baik K, Byeun JK, Baek JK: The effects of horseback riding participation on the muscle tone and range of motion for children with spastic cerebral palsy. *J Exerc Rehabil* 2014;10:265–70
43. Sebastião E, Sandroff BM, Learmonth YC, et al: Validity of the timed up and go test as a measure of functional mobility in persons with multiple sclerosis. *Arch Phys Med Rehabil* 2016;97:1072–7
44. de Araújo TB, de Oliveira RJ, Martins WR, et al: Effects of hippotherapy on mobility, strength and balance in elderly. *Arch Gerontol Geriatr* 2013;56:478–81
45. Jones CJ, Rikli RE, Beam WC: A 30-s chair-stand test as a measure of lower body strength in community-residing older adults. *Res Q Exerc Sport* 1999;70:113–9
46. Homnick TD, Henning KM, Swain CV, et al: The effect of therapeutic horseback riding on balance in community-dwelling older adults: A pilot study. *J Appl Gerontol* 2015;34:118–26
47. Araujo TB, Silva NA, Costa JN, et al: Effect of equine-assisted therapy on the postural balance of the elderly. *Rev Bras Fisioter* 2011;15:414–9
48. Fujimoto C, Murofushi T, Chihara Y, et al: Assessment of diagnostic accuracy of foam posturography for peripheral vestibular disorders: Analysis of parameters related to visual and somatosensory dependence. *Clin Neurophysiol* 2009;120:1408–14
49. Silkwood-Sherer D, Warmbier H: Effects of hippotherapy on postural stability, in persons with multiple sclerosis: A pilot study. *J Neurol Phys Ther* 2007;31:77–84
50. Tinetti ME, Williams TF, Mayewski R: Fall risk index for elderly patients based on number of chronic disabilities. *Am J Med* 1986;80:429–34
51. Kurtzke JF: Rating neurologic impairment in multiple sclerosis: An Expanded Disability Status Scale (EDSS). *Neurology* 1983;33:1444–52
52. Mahoney FI, Barthel DW: Functional Evaluation: The Barthel Index. *Md State Med J* 1965;14:61–5
53. White SC, Yack HJ, Tucker CA, et al: Comparison of vertical ground reaction forces during overground and treadmill walking. *Med Sci Sports Exerc* 1998;30:1537–42
54. Hammer A, Nilsagard Y, Forsberg A, et al: Evaluation of therapeutic riding (Sweden)/ hippotherapy (United States). A single-subject experimental design study replicated in eleven patients with multiple sclerosis. *Physiother Theory Pract* 2005;21:51–77
55. Persson LO, Karlsson J, Bengtsson C, et al: The Swedish SF-36 Health Survey II. Evaluation of clinical validity: Results from population studies of elderly and women in Gothenborg. *J Clin Epidemiol* 1998;51:1095–103
56. Sullivan M, Karlsson J: The Swedish SF-36 Health Survey III. Evaluation of criterion-based validity: Results from normative population. *J Clin Epidemiol* 1998;51:1105–13
57. Beinotti F, Correia N, Christofoletti G, et al: Use of hippotherapy in gait training for hemiparetic post-stroke. *Arq Neuropsiquiatr* 2010;68:908–13
58. Yu L, Xiong D, Guo L, et al: A remote quantitative Fugl-Meyer assessment framework for stroke patients based on wearable sensor networks. *Comput Methods Programs Biomed* 2016;128:100–10
59. Verschuren O, Ketelaar M, Takken T, et al: Exercise programs for children with cerebral palsy: A systematic review of the literature. *Am J Phys Med Rehabil* 2008;87:404–17
60. Anttila H, Autti-Rämö I, Suoranta J, et al: Effectiveness of physical therapy interventions for children with cerebral palsy: A systematic review. *BMC Pediatr* 2008;8:14
61. Anttila H, Suoranta J, Malmivaara A, et al: Effectiveness of physiotherapy and conductive education interventions in children with cerebral palsy: A focused review. *Am J Phys Med Rehabil* 2008;87:478–501
62. Kendrick D, Kumar A, Carpenter H, et al: Exercise for reducing fear of falling in older people living in the community. *Cochrane Database Syst Rev* 2014;(11):CD009848
63. Schoene D, Valenzuela T, Lord SR, et al: The effect of interactive cognitive-motor training in reducing fall risk in older people: A systematic review. *BMC Geriatr* 2014;14:107
64. Howe TE, Rochester L, Neil F, et al: Exercise for improving balance in older people. *Cochrane Database Syst Rev* 2011:CD004963
65. Dalgas U, Stenager E, Sloth M, et al: The effect of exercise on depressive symptoms in multiple sclerosis based on a meta-analysis and critical review of the literature. *Eur J Neurol* 2015;22:443–e34
66. Asano M, Finlayson ML: Meta-analysis of three different types of fatigue management interventions for people with multiple sclerosis: Exercise, education, and medication. *Mult Scler Int* 2014;2014:798285
67. Cramer H, Lauche R, Azizi H, et al: Yoga for multiple sclerosis: A systematic review and meta-analysis. *PloS One* 2014;9:e112414
68. Silkwood-Sherer DJ, Killian CB, Long TM, et al: Hippotherapy—an intervention to habilitate balance deficits in children with movement disorders: A clinical trial. *Phys Ther* 2012;92:707–17
69. Saunders DH, Sanderson M, Brazzelli M, et al: Physical fitness training for stroke patients. *Cochrane Database Syst Rev* 2013:CD003316
70. Pollock A, Farmer SE, Brady MC, et al: Interventions for improving upper limb function after stroke. *Cochrane Database Syst Rev* 2014;11:CD010820