Effectiveness of hippotherapy and therapeutic horseback riding on balance in hemiparetic patients after stroke

Efetividade da hipoterapia e da equoterapia terapêutica no equilíbrio de pacientes hemiparéticos pós-acidente vascular cerebral

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Abstract

Introduction: Stroke is one of the leading causes of disability and death worldwide. Individuals who suffered stroke present numerous functional limitations. Hippotherapy (HPOT) is proposed as capable of promoting the recovery of postural balance in patients with neurological impairment. **Objective:** To analyze published articles, seeking the effects of HPOT on changes in postural balance, through the Berg Balance Scale (BBS), in individuals with stroke. **Methods:** We conducted a systematic review and meta-analysis of studies published on the electronic databases PubMed, VHL, SCIELO, Cochrane, SCOPUS, WoS, and Cinahl. Keywords: "hippotherapy", "horseback riding" and "stroke" linked by the OR and AND boolean operators. The research was restricted to clinical trials in an adult population with a history of stroke. **Results:** Four articles were included in this meta-analysis, which used HPOT as an intervention to improve postural balance. Three studies used a mechanical device (horseback riding), and the horse. The age ranged from 61 to 71 years, being more predominant the male sex. Sessions ranged from 6 to 12 weeks of 20 to 30 minutes per session. Quality analysis using the PEDro scale demonstrated scores ranging from 6 to 8 points in the selected studies. Overall, treatment with mechanical and conventional therapy resulted in an improvement in the total BBS score. As compared with conventional therapy just studies with horseback riding was superior to conventional therapy to improve postural balance in hemiparetic stroke patients. **Conclusion:** There are few studies of high quality; then, it is not possible to evaluate the effectiveness of HPOT using a horse or a mechanic simulator in patients with stroke when compared with conventional therapy. Future studies could clarify if HPOT has potential benefits as a complementary therapeutic strategy to conventional physiotherapy to promote the improvement of postural balance after stroke.

Keywords: Mechanical horseback riding. Equine-assisted therapy. Hippotherapy. Stroke. Postural balance.

Resumo

Introdução: *O acidente vascular encefálico (AVE) é uma das principais causas de incapacidade e morte em todo o mundo. Existem diferentes prospostas terapêuticas para melhorar o equilíbrio postural de hemiparéticos após AVE, mas a efetividade de técnicas como a hipoterapia ainda está por ser esclarecida.* ***Objetivo:*** *Avaliar através da Escala de Equilíbrio de Berg (EEB) a efetividade da hipoterapia para melhorar o equilíbrio postural em pacientes hemiparéticos após acidente vascular encefálico em comparação à terapia convencional* ***Métodos:*** *Uma revisão sistemática foi conduzida com buscas nas bases de dados eletrônicas PubMed, BVS, SCIELO, Cochrane, SCOPUS, WoS e Cinahl. Palavras-chave: "hippotherapy", "horseback riding" e "stroke" ligadas pelos operadores booleanos OR e AND. A pesquisa foi restrita a ensaios clínicos numa população adulta com histórico de AVE.* ***Resultados:*** *Após a análise dos estudos, foram incluídos nessa metanálise quatro artigos que utilizaram a hipoterapia como intervenção para melhora do controle postural e equilíbrio postural. Três artigos utilizaram hipoterapia com simulador mecânico e um estudo realizou com cavalos. O grupo de comparação foi a fisioterapia convencional. A idade variou de 61 a 71 anos, sendo mais predominante o sexo masculino. As sessões, com duração de 20 a 30 minutos, variaram entre 6 e 12 semanas. A análise de viés dos estudos com a escala PEDro revelou pontuações de 6 a 8 pontos. O resultado de três dos quatro ensaios clínicos sugere que o simulador mecânico e convencional resultou em melhora estatisticamente significativa do escore total da EEB.* ***Conclusão:*** *Uma vez que há poucos estudos de alta qualidade, não é possível estabelecer a efetividade da hipoterapia utilizando cavalos ou simulador mecânico para promover a melhoria no equilíbrio postural em pacientes sobreviventes após AVE quando comparada ao tratamento convencional. Estudos futuros podem esclarecer se a hipoterapia pode ser considerada um tratamento complementar para melhoria do equilíbrio postural após AVE.*

Palavras-chave: *Terapia assistida por cavalos. Hipoterapia. Simulador de terapia assistida por cavalos. Acidente vascular encefálico. Equilíbrio postural.*

Introduction

The neurological deficit from stroke results from the central nervous system injury of vascular origin due to a lack of tissue oxygenation.[1] It is the most prevalent cause of disability and death worldwide, and its incidence increased around 42% in the world population between the years 1990 and 2010. The number of deaths and disability due to this disease increased by approximately 20% and 16%, respectively.[2]

In Brazil, according to statistics from 2016, the number of deaths caused by stroke was 102,965, of which 51,753 were deaths in men and 51,198 in women.[3] The prevalence of disability after stroke was 29.5% for men and 21.5% for women in 2013.[4] Mortality and disability rates are at least ten times higher in low- and middle-income countries than in economically more developed nations. One of the reasons for this is the lack of disease monitoring and rehabilitation programs.[5]

Survivors from stroke commonly have disabilities associated with impairments, especially motor impairments, which are the most prevalent.[6] Limitations on mobility, particularly in postural balance, are associated with low ambulatory activity and low levels of cardiovascular fitness, and balance-related inactivity could contribute to deconditioning.[7] Participation and autonomy five years after stroke are limitated on domains that required high levels of physical, social, and cognitive abilities.[8]

Hemiparesis is a common post-stroke impairment often associated with postural balance deficits on stability and alignment. Berg Balance Scale (BBS), a standardized clinical instrument, evaluates static and dynamic postural balance, and it is one of the most used to test clinical interventions directed to stroke patients.[9]

Postural balance impairment is one of the common clinical signals in patients after stroke. The impairment of postural control is related to alteration of postural reactions, early postural adjustments, and abnormal muscular synergies. Other alterations, such as asymmetry in the discharge of weight between the lower limbs, lower surface stability, increased body oscillation, and body inclination, are also present.[10]

Clinically, stroke patients with impairment on postural balance present flexed trunk and head posture, both in orthostatic and sitting positions.[11,12] These compensatory strategies can be related to motor disturbances, sensory and perceptual deficits, alteration in spatial cognition, or peripherical impairments. Verheyden and colleagues[12] argue that altered postural alignment was related to trunk control and functional postural balance. As a consequence, physical therapy interventions must

maintain focus on improving lower trunk mobility in the chronic stage after stroke.

There is strong evidence in favor of high repetitive task-oriented and task-specific training.[13] Although, systematic reviews identified limited evidence based on high methodological quality about the effectiveness of rehabilitation interventions for improving postural balance in stroke patients.[14] The better evidence available seems to be an immediate beneficial effect on postural balance measured by standardized instruments like the BBS.[15]

The protocols of the field of rehabilitation have on task repetitive training as principal foundation, such as gait or functional training, associated or not with musculoskeletal intervention or cardiopulmonary intervention,[15] sensory retraining of the leg,[16] and trunk exercises.[17] Similarly, hippotherapy is a therapeutic alternative in the recovery of postural balance in patients with some neurological impairment[18-20] and older adults.[21] Hippotherapy works with the three-dimensional movement of the horse, which simulates the movement of a person's pelvis during the human gait, providing sensory input of a precise and repetitive pattern of movement and causing the practitioner to respond reciprocally. Hippotherapy benefits are the development of postural control of head and trunk, as well as cognitive, social, and emotional benefits.[22, 23]

Despite this rationale in favor of using hippotherapy in hemiparetic patients after a stroke, the effectiveness of this approach has not been established by a structured literature review. Therefore, we undertook a systematic review and meta-analysis of randomized clinical trials to determine if the hippotherapy, in comparison with conventional therapy, is superior to improve the postural balance in hemiparetic stroke patients.

Methods

Research strategy

We could describe the research question of this systematic review using the PICO acronym as following: Is the hippotherapy (intervention) effective to improve postural balance measured by clinical measurements (outcome) on hemiparetic patients after stroke (population) in comparison with conventional rehabilitation (control)?

This systematic review follows recommendations of Cochrane handbook[24] and attended the criteria described in the items of reports for systematic reviews (PRISMA).[25] The protocol was registered in the database PROSPERO under the number: CRD42018083647.

Purpose of the evaluation criteria

The review focused on published studies in any language, with no time limit, in a population of adults diagnosed with a stroke. Changes on postural balance were the outcome do evaluate the results of hippotherapy. The studies included reliable assessment tools to avoid bias risks. All studies analyzed were randomized clinical trials.

Data source

We searched the following electronic databases: Pubmed (1991 to 2017), BVS (2012 to 2016), SCIELO (2010 to 2016), Cochrane (2014 to 2016), SCOPUS (2012 to 2017), Web of Science (2010) and CINAHL (2013 to 2017). The keywords used were "hippotherapy", "horseback riding," and "stroke" and "balance", "postural balance" linked by booleans operators OR and AND. We use the following descriptors for (i) intervention: ["Hippotherapy" (Mesh) OR "Horseback riding" (All Fields) OR "Mechanical horseback riding"].

The search strategy used in Pubmed Medline was: ("Equine-assisted therapy" [MeSH Major Topic] OR "Mechanical horseback riding" [Title/Abstract] OR Hippotherapy [Title/Abstract] OR "Horseback Riding Therapy" [Title/Abstract]) AND (Stroke [MeSH Major Topic] OR "Cerebrovascular Accident" [Title/Abstract] OR "Cerebrovascular stroke" [Title/Abstract] OR "Hemiparetic patients" [Title/Abstract]) AND ("Postural balance" [MeSH Major Topic] OR "Posturography" [Title/Abstract]). Similar PICO strategies were used on the others scientific databases.

Two evaluators independently selected the studies based on the titles, excluding those that were not related to the subject of the review. And, in case of disagreement, a third evaluator was consulted to decide on the inclusion of the studies.

After this selection, the evaluators read the abstracts of the selected articles to identify those that met the inclusion criteria. In the sequence, the included studies were analyzed in their entirety through a structured

script with the contemplation of the following items: author/year, sample, design of the research, evaluated outcomes, intervention, instruments, and effects found.

Reading the full text was possible to evaluate the eligibility of articles. The data extracted were: characteristics of the participants, methods, results related to the defined objective and outcome for each of the studies included in this review. Since the effectiveness of treatment changes from stroke to other neurological diseases, this was a criterion to exclude studies. Besides, we exclude studies with different variables than the proposal registered on PROSPERO, and other study designs as well.

Quality (risk of bias) and evaluation of publication bias

Two researchers assessed the quality of the studies and the risk of bias using the PEDro scale and the Kappa coefficient alone. The PEDro scale presents the following items to be evaluated: eligibility criteria, randomization, allocation concealment, the similarity in baseline data, blinding of subjects, therapist blinding, evaluator blinding, adequate follow-up, intention to treat analysis, analysis between groups and use of measures. On this scale, the maximum possible score is 10, but the "blindness of all therapists" and "blindness of all subjects" were considered irrelevant when comparing the group in the therapy of the control group without exercise; thus, the maximum score established is 7.[26]

Types of studies and participants

The inclusion criteria of the studies were: adult subjects with a diagnosis of stroke, who evaluated postural control and postural balance through BBS and clinical trials in which the experimental group used hippotherapy as an intervention in comparison with the control group, that used conventional physiotherapy as an intervention.

Types of intervention and outcomes

The intervention considered in the experimental group was hippotherapy with horses or mechanical device (horseback riding) that reproduced the three-dimensional movements of the animal and could be associated with conventional physiotherapy. Within the treatment parameters, we observed duration, frequency (times a week), number, and duration of sessions.

The outcome of the studies should be postural control and postural balance. The standard test used to measure this variable was BBS, which consists of a functional evaluation of the postural balance performance based on 14 activity daily items that assess postural control, dynamic postural balance, and flexibility. The BBS has a maximum score of 56 that can be achieved, each item having an ordinal scale of five alternatives ranging from 0 to 4 points. The test is simple, easy to administer, and safe for the evaluation of elderly patients. It only requires a stopwatch and a ruler as equipment, and its execution takes about 15 minutes.[9]

Data extraction

All data relevant to the study were extracted. A single researcher performed the extraction procedure, and a second researcher examined them.

Data analysis

As mentioned above, the variable of interest used on meta-analysis was the total score of BBS using the means and standard deviation of group control and intervention (hippotherapy). The BBS total score was analyzed as a continuous data.

As all the pooled studies used the same evaluation scale to analyze the result, the mean differences (DM) with 95% confidence interval (CI) were calculated. The heterogeneity was evaluated through the value of the I^2 statistic, with a value less than 50% indicating low heterogeneity. If there were acceptable levels of heterogeneity, the fixed-effect model would be used instead of the random one.[24] All statistical analyzes were performed with R Software - Meta Package.

Results

Selection and evaluation of studies

The initial survey resulted in 69 articles. Initially, 36 searches that repeatedly appeared in more than one database were excluded. Of the remaining 33 studies, 20 were excluded due to the lack of adequacy of the title to the proposed theme. The analysis of the abstract

eliminated three articles because they did not address patients with stroke and presented other study designs. There were considered ten studies for analysis of the full text, but six of these studies show different variables and outcomes. We follow the strategy previously registered on PROSPERO. The findings related to gait were described here instead.

Laboratory measurements of postural balance as based on electromyographic measures as primary or secondary outcomes on randomized clinical trial studies were included in this study. The final selection resulted in the inclusion of four articles for a complete analysis (Figure 1): three studies used mechanical therapy combined with physical therapy,[27-29] and one study used hippotherapy with horse.[30]

Studies included in the systematic review

The publication dates of included studies ranged from 2012 to 2015, involving a total of 117 patients, with a mean age of 65.7 ± 3.6 years, of which 73 were male (62.4%) and 44 were female (37.6%). The stroke time was mentioned only in the studies of Han et al.[27] and Lee and Kim,[28,29] resulting in a time greater than six months of injury.

In all studies, participants should have sufficient cognition to follow verbal instructions and understand the content and purpose of the study, which was assessed by the Mental State Mini Exam (MMSE) with scores higher than 24. In the studies of Han et al.,[27] Lee and Kim[28,29] and Lee et al.,[30] patients would need to be able to sit upright without support for 30 minutes and the subjects of Lee and Kim[28,29] and Lee et al.[30] were included in the study if they could walk 10 meters independently without walking assisted devices.

The duration of the program of the intervention of hippotherapy ranged from 6 to 12 weeks, 2 to 5 times a week, and 24 to 30 sessions lasting from 20 to 30 minutes.

The mean frequency of the therapy was 3.75 ± 1.5 days per week, with a mean duration of the session of 27.5 ± 5 minutes, a mean number of sessions of 27 ± three times, and mean duration of the program of 8 ± 2.82 weeks. The heterogeneity between the studies was low (I^2 39%), so we decided to use the fixed effect (Figure 2). The z score for fixed model was 2.7642 [2.0652; 3.4633] 7.75; ($p < 0.0001$), while for random-effects model was 2.5821 [1.5316; 3.6325] 4.82, ($p < 0.0001$). From the forest plot, the diamond was on the right side of the vertical line and did not intersect with the line. If considering the small sample size of studies included in the meta-analysis, we just suggest that there is a difference of BBS total score in favor of hippotherapy (diamond at right side). For this same reason, it was not possible to run a subgroup analysis for mechanical or horse hippotherapy.

Quality analysis using the PEDro scale demonstrated scores ranging from 6 to 8 points in the selected studies. The level of agreement between the reviewers, calculated with the Kappa coefficient, was 0.95 (95% CI: 0.88 to 1.0).

Considering the risk of bias, the two evaluators agreed that the most frequent source of bias was the 5, 6, and 7 items of PEDro Scale of initial ten studies included in the initial phase of a systematic review. This fact indicates that the absence of blinding is the source of bias. The bias reported to evaluators is related to studies blinding of all subjects, all assessors who measured at least one key outcome, and, finally, all therapists who administered the therapy. The authors failed to report other sources of risk of bias.

Hippotherapy in postural balance

In general, treatment with mechanical therapy (horseback riding) and with a horse resulted in a significant improvement in the total BBS score. The pool of data showed that there was a difference in the weighted mean [WMD] = 2.76, 95% CI: [2.07; 3.46]. In the isolated analysis, the study that used the horse as a therapeutic resource did not present a significant difference between the control and intervention groups (1 study, n = 30 patients, WMD = 1, 95% CI: 2.5, 4.5).

Table 1 presents information from the studies included in the systematic review of the author and year of publication of the articles, average age of the study population, intervention and frequency of treatment, equipment used, evaluation instrument, variable analyzed, and outcomes. None of the studies have described the side and area of brain injury.

The control groups underwent conventional physiotherapy, which is described in studies such as neurological therapy, which includes stretching, strengthening and proprioception exercises, except for the study by Lee et al.,[30] in which the participants walked on the treadmill.

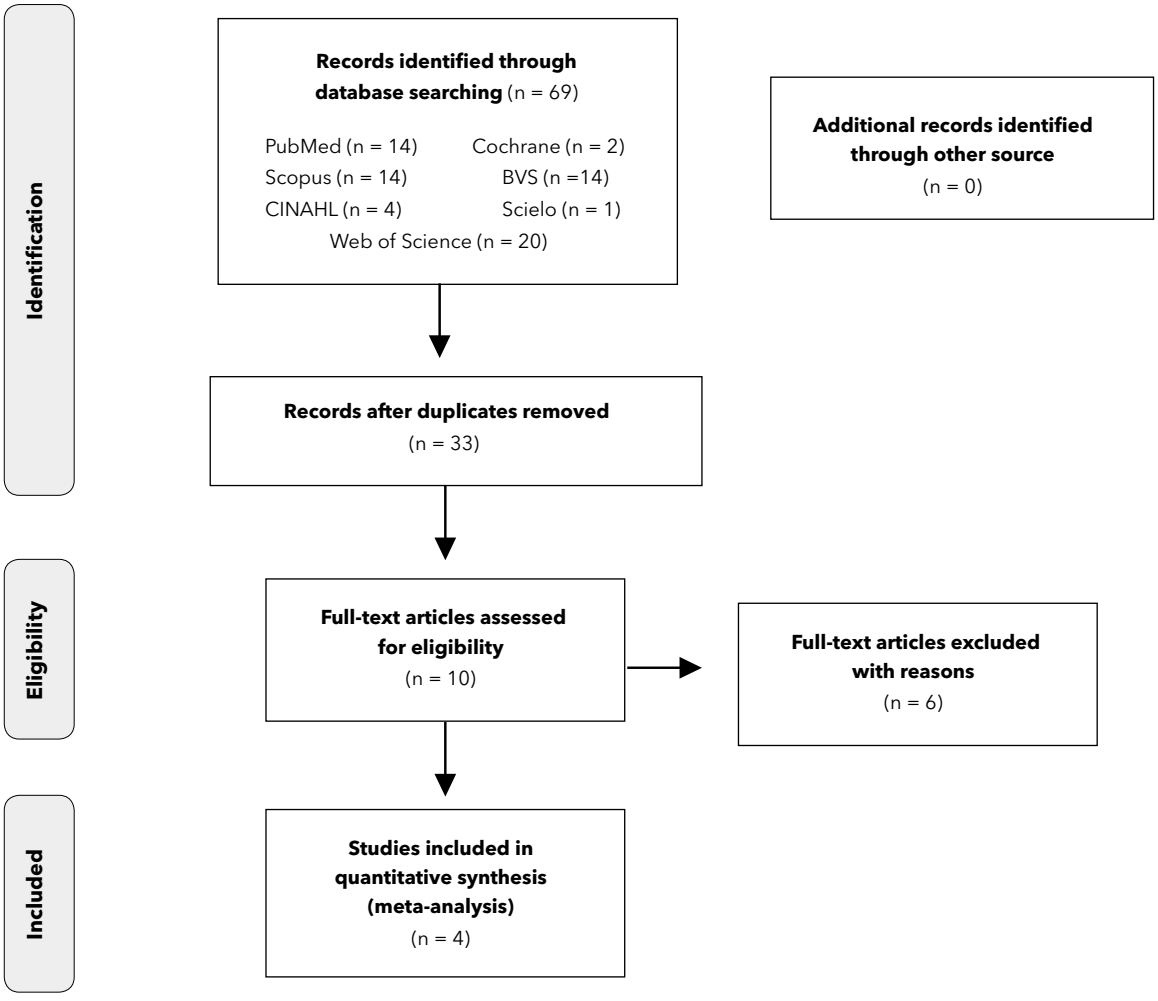

Figure 1 - Electronic search flowchart.

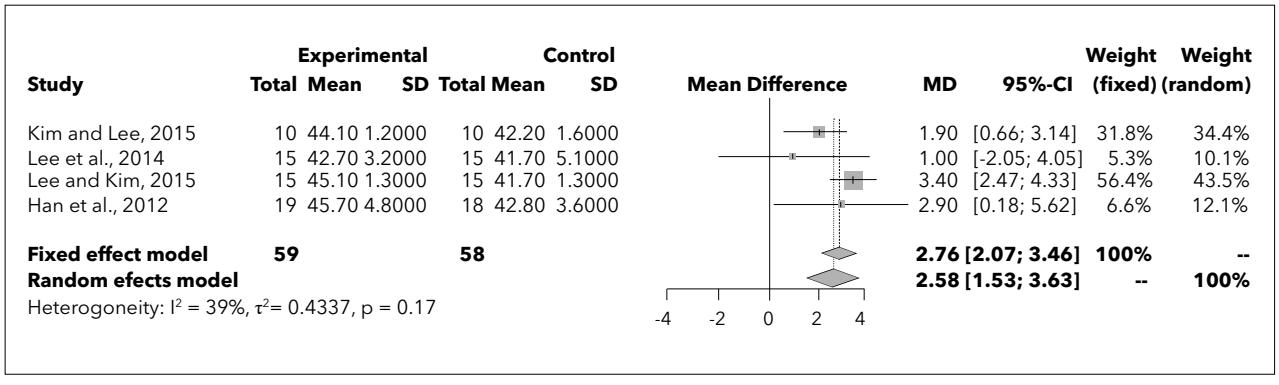

Figure 2 - Comparison of balance in conventional hippotherapy and combined mechanical therapy with physical therapy compared to the control group.

Table 1 - Characteristics of the individuals, intervention and outcome

Studies	Population		Intervention			Comparison	Outcome	
	Participants in the EG	Participants in the CG	Training frequency*	Experimental Group	Instrument used and therapy	Control Group	Evaluation and variable	Results related to balance
Han et al., 2012[27]	19 (M13/ F6) Age: 61,1 Time post stroke: > 6 months Side of hemiparesis: NS	18 (M11/ F7) Age: 62,2 Time post stroke: > 6 months Side of hemiparesis: NS	12 weeks, 2x/week, 24 sessions, 20 minutes	Mechanical horseback riding therapy + Conventional physical therapy	Joba EU6441. A cycle is a set of movements: swing back and forth, left and right, and back to the starting position. The speed of movement varies from level 1 (0.62 Hz) to level 7 (1.21 Hz). There are three preset slope levels: basic conditioning (flat), forward tilt and backward tilt.	Conventional physical therapy	BBS; Balance	Balance parameters improved significantly in the experimental group at 12 weeks post treatment (p = 0,001). When comparing the groups, the dynamic balance category of BBS in post treatment showed significant difference (p = 0.02).
Lee et al., 2014[30]	15 (M11/F4) Age: 63,8 Time post stroke: NS Side of hemiparesis: NS	15 (M12/F3) Age: 64,3 Time post stroke: NS Side of hemiparesis: NS	8 weeks, 3x/ week, 24 sessions, 30 minutes	Hippotherapy	During each hippotherapy session, the horse walked around a circle 30 meters in diameter 30 times clockwise and 30 counter-clockwise for 30 minutes.	Walk on the treadmill	BBS; Balance	There was no significant improvement between the groups, but there was significance between pre and post treatment in experimental group (p < 0,05)
Lee and Kim, 2015[28]	15 (M8/F7) Age: 68,4 Time post stroke: > 6 months Side of hemiparesis: R7/L8	15 (M8/F7) Age: 67,0 Time post stroke: > 6 months Side of hemiparesis: R6/L9	6 weeks, 5x/ week, 30 sessions, 30 minutes	Mechanical horseback riding therapy + Conventional physical therapy	Joba EU7200**	Conventional physical therapy	BBS; Balance	The balance improved significantly after treatment with mechanical horseback riding therapy (p < 0,05)
Kim and Lee, 2015[29]	10 (M5/F5) Idade: 71,1 Time post stroke: > 6 months Side of hemiparesis: R5/L5	10 (M5/ F5) Idade: 69,2 Time post stroke: > 6 months Side of hemiparesis: R5/L5	6 weeks, 5x/week, 30 sessions, 30 minutes	Mechanical horseback riding therapy + Conventional physical therapy	Joba EU7200. It offers 5 types of movements: twist, slide from top to bottom, slide from front to back, rotate from front to back and rotate from left to right (three-dimensional movements). Based on level, adaptability and motor ability, subjects were asked to start at level 1 and continue at level 4. The subjects were able to control their posture by holding the hand loops and maintaining the correct posture.	Conventional physioal therapy	BBS; Balance	Significant improvement in the balance of the experimental group after training with mechanical horseback riding therapy (p < 0,05). The experimental group showed significant differences in balance, gait, and ADLs compared with in the control group.

Note: M = Male; F = Female; R = Right; L = Left; NS = Not Specified; BBS = Berg Balance Scale; CG = Group Control; EG = Experimental Group. *Equal in both groups; **Same apparatus described in the Kim and Lee´s study.[29]

The BBS scores presented significant relevance, varying between 39.9 and 45.7 ($p < 0.05$). In the study of Lee et al.,[30] which used the horse as a therapeutic resource, there was no significant difference between the control and intervention groups. Still, the other studies showed a significant difference between both groups.

The studies of Lee and Kim[28,29] and Lee et al.[30] presented only the values of the general BBS score, not differentiating between the categories of the same. One the other hand, Han et al.[27] separated the values of BBS´s categories, such as sitting, static, and dynamic, in addition to the general score. Adverse effects were not related by the authors of the studies included in this review.

Discussion

This meta-analysis aimed to evaluate the effect on postural balance in patients with stroke when undergoing the hippotherapy and horseback riding intervention. The review of the literature for this article revealed that there are few randomized clinical trials on hippotherapy in individuals with stroke. However, we observed that mechanical and horse riding can offer benefits to postural control and postural balance of this population.

Hippotherapy focuses on trunk stability, posture, and pelvic mobility to improve postural balance in patients with neurological problems.[23] During equestrian, a practitioner's pelvis moves smoothly, rhythmically and repetitively, a movement similar to a human pelvis during normal walking.[20] Repetitive stimulation improves postural coordination, and rhythmic stimulation allows reciprocal movement. Also, riding on a horse can improve postural control through the stimulation of normal postural balance reactions.[31,32] However, hippotherapy is not a readily applicable therapy because of fear of the animal, difficulty in riding a horse, and other problems.[27] Based on these considerations, mechanical therapy becomes a good alternative for patients with neurological problems.[32]

During movement in patients with stroke, activation of the erector spinae increases, and activation of the paretic rectus abdominis decreases.[33-35] Increased activation of the spinal erector during the movement represents the greater recruitment of motor units to compensate for the reduction induced by the stroke, and this activation also contributes to the movement of the trunk and maintenance of postural balance during gait.[35,36]

The study of An and Shaughnessy[37] evaluated the effectiveness of gait training in increasing the postural balance of post-stroke patients, its results demonstrated the effectiveness of the therapy in less than one hour of postural balance training with 30 minutes of gait training, three to five times a week. Similar results were observed in this meta-analysis, with session time ranging from 20 to 30 minutes and frequency of 2 to 5 times a week.

Regarding the evaluation instrument used in the studies of this meta-analysis, BBS presents strong reliability, validity, and responsiveness to change. The test is useful and easy to administer without expensive equipment or extended evaluation time.[33,34] In the study of Han et al.[27] there was an 81.6% increase in the dynamic postural balance score between the groups. In other studies, static or dynamic equilibrium is not described, which impairs the interpretation and analysis of the data.[38,39]

Kim and colleagues[40] compared conventional therapy with mechanical equine therapy (horseback riding). They observed that simulated hippotherapy might be an effective alternative to increase trunk and hip muscle activation and improve postural control and postural balance, especially among the elderly, when conventional hippotherapy is not possible. Other studies referred only to horseback therapy and its benefits alone, without comparison with conventional hippotherapy.[41-43] Both treatments showed a significant improvement in the pre- and post-test postural balance; however, there was no significant difference between the control and intervention groups, only in the study that used hippotherapy.[30] How to explain this difference in results from three studies evolving training with simulator from the only study using equine-assisted therapy?

One possible explanation for this difference between the results of studies using horseback riding from the results of the study of hippotherapy[30] could be related to low variability of training used on equine-assisted therapy (the horse walked around a circle with 30 meters). High variability of training seems to be more effective in promoting motor learning needed to promote long term changes in the structure and function of the central nervous system in parallel with improvements in motor performance.[44]

There is a considerable difference between the intervention in the control group across the four studies. The interventions vary from mat exercises to non-destructive testing (NDT) and treadmill training. The use

of treadmill training could be considered a high demand training and could explain the absence of difference in favor of hippotherapy.

We have limited the sample size of the intervention and control groups that were small to draw reliable conclusions and the reduced amount of studies that use the horse in its natural habitat to perform the therapy, which may generate possible risks of bias. Another limitation was the small number of studies showing the effects of equine therapy on postural balance. Also, the authors lack to present sources of bias in their studies. It is necessary to develop studies using the same outcomes of gait and postural balance to clarify if hippotherapy is superior to conventional treatment to improve balance and gait in stroke survivors. The principal clinical message is that the result of small randomized clinical trials suggest positive effects of hippotherapy and horseback riding on postural balance in hemiparetic patients after stroke.

The present study is the first systematic review investigating the effectiveness of hippotherapy and horseback riding on postural balance in hemiparetic patients. However, we suggest to carry out studies with a larger sample number for future standardized analyzes of gait and postural balance, and using the horse in its natural habitat to understand better the motor and behavioral changes that this therapy implies in these individuals.

Conclusion

Since there are few studies of high quality, it is not possible to evaluate the effectiveness of hippotherapy and horseback riding in patients with stroke. The motor performance improved on three studies using horseback riding and on the study using hippotherapy. Future studies could clarify if the hippotherapy is a complementary therapeutic strategy to conventional physiotherapy to promote the improvement of postural balance.

Authors´ contributions

SBCAS and ACCBH were responsible for the conception and design, and data acquisition. JCL, for the analysis and interpretation of data. MLS, for the conception and design, drafting of the manuscript, critical revisions and supervision. AGM and LPSP were responsible for the critical revisions and supervision of the work.

References

1. Sacco RL, Kasner SE, Broderick JP, Caplan LR, Connors JJ, Culebras A, et al. An updated definition of stroke for the 21st century: a statement for healthcare professionals from the American Heart Association/American Stroke Association. Stroke. 2013;44(7):2064–89. DOI

2. Krishnamurthi R V., Feigin VL, Forouzanfar MH, Mensah GA, Connor M, Bennett DA, et al. Global and regional burden of first-ever ischaemic and haemorrhagic stroke during 1990-2010: findings from the Global Burden of Disease Study 2010. Lancet Glob Heal. 2013;1(5):e259-81. DOI

3. Brasil. Ministério da Saúde. DATASUS; 2018 [cited 2020 Feb 15]. Available from: http://www2.datasus.gov.br

4. Bensenor IM, Goulart AC, Szwarcwald CL, Vieira MLFP, Malta DC, Lotufo PA. Prevalence of stroke and associated disability in Brazil: National Health Survey - 2013. Arq Neuropsiquiatr. 2015;73(9):746–50. DOI

5. Norrving B, Kissela B. The global burden of stroke and need for a continuum of care. Neurology. 2013;80(3 Suppl 2): S5–12. DOI

6. Carvalho-Pinto BPB, Faria CDCM. Health, function and disability in stroke patients in the community. Braz J Phys Ther. 2016;20(4):355–66. DOI

7. Michael KM, Allen JK, Macko RF. Reduced ambulatory activity after stroke: the role of balance, gait, and cardiovascular fitness. 2005;86(8):1552–6. DOI

8. Palstam A, Sjödin A, Sunnerhagen KS. Participation and autonomy five years after stroke: a longitudinal observational study. PLoS One. 2019;14(7):e0219513. DOI

9. Bambirra C, Rodrigues MCB, Faria CDCM, Paula FR. Clinical evaluation of balance in hemiparetic adults: a systematic review. Fisioter Mov. 2015;28(1):187–200. DOI

10. Tasseel-Ponche S, Yelnik AP, Bonan IV. Motor strategies of postural control after hemispheric stroke. Neurophysiol Clin. 2015;45(4–5):327–33. DOI

11. Iyengar YR, Vijayakumar K, Abraham JM, Misri ZK, Suresh BV, Unnikrishnan B. Relationship between postural alignment in sitting by photogrammetry and seated postural control in post-stroke subjects. NeuroRehabilitation. 2014;35(2):181–90. DOI

12. Verheyden G, Ruesen C, Gorissen M, Brumby V, Moran R, Burnett M, et al. Postural alignment is altered in people with chronic stroke and related to motor and functional performance. J Neurol Phys Ther. 2014;38(4):239–45. DOI

13. Veerbeek JM, van Wegen E, van Peppen R, van der Wees PJ, Hendriks E, Rietberg M, et al. What is the evidence for physical therapy poststroke? A systematic review and meta-analysis. PLoS One. 2014;9(2):e87987. DOI

14. Arienti C, Lazzarini SG, Pollock A, Negrini S. Rehabilitation interventions for improving balance following stroke: an overview of systematic reviews. PLoS One. 2019;14(7):e0219781. DOI

15. Hugues A, Di Marco J, Ribault S, Ardaillon H, Janiaud P, Xue Y, et al. Limited evidence of physical therapy on balance after stroke: a systematic review and meta-analysis. PLoS One. 2019;14(8): e0221700. DOI

16. Chia FSF, Kuys S, Choy NL. Sensory retraining of the leg after stroke: systematic review and meta-analysis. Clin Rehabil. 2019;33(6):964–79. DOI

17. Souza DCB, Santos MS, Ribeiro NMS, Maldonado IL. Inpatient trunk exercises after recent stroke: An update meta-analysis of randomized controlled trials. NeuroRehabilitation. 2019;44(3):369–77. DOI

18. Stergiou A, Tzoufi M, Ntzani E, Varvarousis D, Beris A, Ploumis A. Therapeutic effects of horseback riding interventions a systematic review and meta-analysis. Am J Phys Med Rehabil. 2017;96(10):717–25. DOI

19. Bronson C, Brewerton K, Ong J, Palanca C, Sullivan SJ. Does hippotherapy improve balance in persons with multiple sclerosis: a systematic review. Eur J Phys Rehabil Med. 2010;46(3):347–53. Full text link

20. 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(8):684–91. DOI

21. Hilliere C, Collado-Mateo D, Villafaina S, Duque-Fonseca P, Parraça JA. Benefits of hippotherapy and horse riding simulation exercise on healthy older adults: a systematic review. PM R. 2018;10(10):1062–72. DOI

22. Koca TT, Ataseven H. What is hippotherapy? The indications and effectiveness of hippotherapy. North Clin Istanb. 2016;2(3):247–52. DOI

23. Meregillano G. Hippotherapy. Phys Med Rehabil Clin N Am. 2004;15(4):843-54. DOI

24. Higgins JPT, Green S (editors). Cochrane Handbook for Systematic Reviews of Interventions Version 5.1.0. The Cochrane Collaboration; 2011 [cited 2019 Nov 5]. Available from: https://handbook-5-1.cochrane.org

25. Liberati A, Altman DG, Tetzlaff J, Mulrow C, Gøtzsche PC, Ioannidis JPA, et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate healthcare interventions: explanation and elaboration. BMJ. 2009;339:b2700. DOI

26.Fitzpatrick RB. PEDro: A physiotherapy evidence database. Med Ref Serv Q. 2008;27(2):188–97. DOI

27. Han JY, Kim JM, Kim SK, Chung JS, Lee HC, Lim JK, et al. Therapeutic effects of mechanical horseback riding on gait and balance ability in stroke patients. Ann Rehabil Med. 2012;36(6):762–9. DOI

28. Lee DK, Kim EK. The influence of horseback riding training on the physical function and psychological problems of stroke patients. J Phys Ther Sci. 2015;27(9):2739–41. DOI

29. Kim YN, Lee DK. Effects of horse-riding exercise on balance, gait, and activities of daily living in stroke patients. J Phys Ther Sci. 2015;27(3):607–9. DOI

30. Lee CW, Kim SG, Yong MS. Effects of hippotherapy on recovery of gait and balance ability in patients with stroke. J Phys Ther Sci. 2014;26(2):309–11. DOI

31. Herrero P, Asensio A, García E, Marco A, Oliván B, Ibarz A, et al. Study of the therapeutic effects of an advanced hippotherapy simulator in children with cerebral palsy: a randomised controlled trial. BMC Musculoskelet Disord. 2010;16:11:71. DOI

32. Bertoti DB. Effect of therapeutic horseback riding on posture in children with cerebral palsy. Phys Ther. 1988;68(10):1505–12. Full text link

33. Dickstein R, Heffes Y, Laufer Y, Ben-Haim Z. Activation of selected trunk muscles during symmetric functional activities in poststroke hemiparetic and hemiplegic patients. J Neurol Neurosurg Psychiatry. 1999;66(2):218–21. DOI

34. Dickstein R, Shefi S, Marcovitz E, Villa Y. Electromyographic activity of voluntarily activated trunk flexor and extensor muscles in post-stroke hemiparetic subjects. Clin Neurophysiol. 2004;115(4):790–6. DOI

35. Winzeler-Merçay U, Mudie H. The nature of the effects of stroke on trunk flexor and extensor muscles during work and at rest. Disabil Rehabil. 2002;24(17):875–86. DOI

36. Cromwell RL, Aadland-Monahan TK, Nelson AT, Stern-Sylvestre SM, Seder B. Sagittal plane analysis of head, neck, and trunk kinematics and electromyographic activity during locomotion. J Orthop Sports Phys Ther. 2001;31(5):255–62. DOI

37. An M, Shaughnessy M. The effects of exercise-based rehabilitation on balance and gait for stroke patients: A systematic review. J Neurosci Nurs. 2011;43(6):298–307. DOI

38. Harris JE, Eng JJ, Marigold DS, Tokuno CD, Louis CL. Relationship of balance and mobility to fall incidence in people with chronic stroke. Phys Ther. 2005;85(2):150–8. Full text link

39. Andersson AG, Kamwendo K, Seiger A, Appelros P. How to identify potential fallers in a stroke unit: validity indexes of four test methods. J Rehabil Med. 2006;38(3):186–91. DOI

40. Kim MJ, Kim TY, Oh S, Yoon BC. Equine exercise in younger and older adults: simulated versus real horseback riding. Percept Mot Skills. 2018;125(1):93–108. DOI

41. Park J, Lee S, Lee J, Lee D. The effects of horseback riding simulator exercise on postural balance of chronic stroke patients. J Phys Ther Sci. 2013;25(9):1169-72. DOI

42. Kang KY. Effects of mechanical horseback riding on the balance ability of the elderly. J Phys Ther Sci. 2015;27(8):2499–500. DOI

43. Lee D, Lee S, Park J. Effects of indoor horseback riding and virtual reality exercises on the dynamic balance ability of normal healthy adults. J Phys Ther Sci. 2014;26(12):1903–5. DOI

44. Hornby TG, Henderson CE, Plawecki A, Lucas E, Lotter J, Holthus M, et al. Contributions of stepping intensity and variability to mobility in individuals poststroke. Stroke. 2019; 50(9):2492–9. DOI