**Review Paper:**

Effects of Extracorporeal Shockwave Therapy on Clinical and Neurophysiological Indices of Spasticity Inpatients With Upper Motor Neuron Lesions: A Systematic Review and Meta-analysis

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**Objective:** Spasticity is one of the components of an Upper Motor Neuron (UMN) lesion that occurs usually after a period of flaccidity in the form of velocity-dependent resistance to passive stretch. Spasticity is a significant cause of limited mobility and disability in neurological diseases. There are several clinical approaches to control spasticity. Recently, Shock Wave Therapy (SWT) has been reported to be a new, safe, and effective method for reducing spasticity for people with upper motor neuron lesions. We conducted a meta-analysis of relevant clinical trials to assess the effect of applying SWT on spasticity in UMN lesions.

**Materials & Methods:** An electronic search was performed in PubMed, ISI Web of Science, Scopus, Science Direct, MEDLINE, and Google scholar from January 2005 to January 2020. Studies were included if they measured spasticity with the Modified Ashworth Scale (MAS) or/and neurophysiological indices in patients with stroke, multiple sclerosis, and cerebral palsy. The keywords of muscle hypertonia or spasticity, extracorporeal shock wave therapy, stroke, multiple sclerosis, and cerebral palsy were used. Two independent researchers searched articles, screened eligible studies against the inclusion criteria, and assessed the methodological quality of included studies. The methodological quality of studies was evaluated using the Downs and Black tool. The difference between the means was considered as the effect size in the MAS and Hoffman reflex/motor response (H/M) ratio before and after the intervention with 95% CI in random-effects models. Analyzes were performed using STATA software version 11.

**Results:** The initial search led to the retrieval of 98 studies based on the inclusion and exclusion criteria, of which 24 full-text articles were reviewed and 14 articles were included in the meta-analysis process. All 14 articles had examined the effects of shockwave on the MAS. Four studies with 120 patients had examined the effects of shockwave therapy on the H/M ratio. Significant reduction in MAS grade was observed immediately ($I^2 = 100\%, P<0.001, SMD=1.38$ with 95%CI: (0.80, 1.87)) and three months after SWT ($I^2 = 100\%, P<0.001, SMD=1.13$ with 95%CI: (0.50, 1.76)) in comparison with the baseline values. ESWT had no significant effects on the H/M ratio ($I^2 = 97.5\%, P<0.001, SMD=1.09$ with 95%CI: (-0.54, 2.73)).

**Conclusion:** SWT can improve spasticity based on the MAS. The lack of SWT effects on the neurophysiological parameter of spasticity supports this opinion that SWT acts on the non-neural component of spasticity. Differences observed in studies in terms of treatment sessions, intervals of treatment sessions, energy density, number of shocks, and follow-up duration need to be examined more closely. More randomized clinical trials are needed in the future to analyze the impact of these factors on the efficacy of SWT for spastic patients.

**Keywords:**
Spasticity, Cerebral palsy, Stroke, Multiple sclerosis, Extracorporeal shock wave therapy

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Extended Abstract

Introduction

Spasticity is one of the symptoms of upper motor neuron damage that usually appears after a period of muscle relaxation as an increase in speed-dependent resistance during passive movement with the intensification of tendon reflexes [1]. This movement disorder is commonly seen in patients with cerebral palsy, hemiplegia, multiple sclerosis, and spinal cord injuries. Neural and non-neural mechanisms can lead to increased resistance to passive movement in upper motor neuron injury. Nervous mechanisms are due to the removal of inhibition of the corticospinal pyramidal pathway and extra-pyramidal pathways (rubrospinal and vestibulospinal) from the brain stem and spinal cord [6], but non-neural mechanisms are associated with muscle stiffness and high levels of collagen and connective tissue in the spastic muscle [2]. Prolonged spasticity can cause changes in the structural properties of the involved muscle and adjacent muscles in a short time or muscle fibrosis, which causes abnormal control of the position of the limb and as a result, movement disorder in the limb [7].

Pharmacotherapy and rehabilitation interventions, especially those that focus on connective tissue flexibility, are non-invasive treatments to reduce spasticity [8]. Shock Wave Therapy (SWT) is one of the most promising methods to reduce spasticity today, but it has not yet been used as a common treatment [9, 10]. Shockwaves are high-energy sound waves (100 MPA) that are produced in a very short time (10 microseconds) and at high pressure [11]. Shockwaves have been reported in the treatment of orthopedic lesions, such as nonunion in long bones, inflammation of the plantar fascia, calcified shoulder tendons, inflammatory tendon diseases, and spasticity [12]. SWT can be used in both focal and radial forms. Focal shockwaves are generated by electromagnetic, hydroelectric, and piezoelectric methods, while radial shockwaves are generated pneumatically. In addition, the penetration depth of radial shockwaves is less than focal shockwaves [11].

So far, no precise mechanism has been proposed to justify the effects of SWT in reducing spasticity. A group of studies believes that “shockwave” shock waves can have a direct effect on fibrosis muscles and non-reflex components of spastic muscle. This mechanism of shock wave effect can be explained by the results of some studies on the positive effects of SWT on the tendon and musculoskeletal problems in patients with hypertension [13]. Some studies have shown that shockwaves at the muscle level can alter the sensory flow of the muscle, which by acting on free nerve terminals, reduces muscle excitability at the spinal cord level and ultimately reduces spasticity [14]. Studies on non-human specimens have shown that shockwaves delay neuromuscular transmission at the neuromuscular junction and is a possible mechanism for reducing muscle pain and tonicity [15]. There are various clinical tools and neurophysiological methods for assessing spasticity. Evaluation of neurophysiological responses of spastic muscle is possible by examining tendon reflex, F wave, M wave, and Hoffman reflex [16, 17].

The Ashworth scale is a common tool for the clinical assessment of spasticity, which is based on the assessment of tendon resistance [18]. Most studies on the effects of SWT on muscle tone have used the clinical scale of Ashworth or biomechanical scales and only in two studies, evaluation was performed by measuring ultrasound of muscle architecture [19, 20].

Due to the need for spasticity treatment in neurological patients and because in clinical studies on the effect of SWT on the reduction of spastic muscle tone, no specific treatment protocol has been used, and also because systematic reviews and meta-analysis are tools for summarizing the available evidence accurately and reliably [21], the present study was done to analyze the available clinical trial studies on the effectiveness of SWT in reducing spastic muscle tone at the time immediately and three months after shockwave application in patients with upper motor neuron lesions.

Materials and Methods

In this study, databases, including PubMed, ISI Web of Science, ScienceDirect, MEDLINE, Scopus, and Google Scholar search engine were searched using the keywords of muscle hypertension or spasticity, cerebral palsy, stroke, multiple sclerosis, and shockwave therapy. All clinical trials published from January 2005 to January 2020 were enrolled. Studies examining spasticity with a modified Ashworth Scale (MAS) and/or neurophysiological parameters in patients with stroke, cerebral palsy, and multiple sclerosis were selected. Two independent researchers searched and reviewed eligible studies in terms of inclusion criteria and assessed the methodological quality of selected studies.

First, the abstracts were reviewed, and then, the full text of the articles was reviewed based on the inclusion criteria. Studies unavailable in their full-text form, those published in a non-English language, and studies, in which shockwave had been used for purposes other than spasticity treatment were excluded from the study. Articles with the following characteristics were selected for meta-analysis: 1. Original research articles; 2. Clinical trial studies with...
a control group or pre-test/post-test design; 3. Studies using the MAS to assess spasticity (at least two times, one immediately after the intervention and the other, 3 months after SWT; and 4. studies using neurophysiological indicators to assess spasticity. The methodological quality of the selected studies was assessed using the Downs and Black Scale. This scale consists of 27 items and is designed to evaluate the methodological quality of random and non-random studies [22].

**Statistical analysis**

The difference between the means was considered as the effect size in the scores of the joint Ashworth scale before, immediately, and three months after the intervention for meta-analysis. Another meta-analysis was performed on the differences in means in neurophysiological indices before and after the intervention. Heterogeneity was assessed (presence or absence of homogeneity) between studies using the F index. Due to the confirmation of heterogeneity of studies (P>50%) using the Ashworth scale and neurophysiological indices, the random-effects model of the meta-analysis was used. This model shows the mean difference of each study and the value of the combined mean difference as well as their confidence intervals. Emission bias was also assessed using Egger’s test. Data were analyzed using MATLAB software version 11. Values of p less than 0.05 were considered statistically significant.

**Results**

Using the above keywords, a total of 98 articles were selected in the first stage, which after deleting 31 unrelated articles and 43 duplicate articles, 24 articles remained. Among these articles, the full text of two articles was not found, and three articles were clinical trials on animals. The other five articles were omitted for the following reasons: three studies did not report mean values and Standard Deviation (+ SD) and two articles used the MAS. A total of 14 articles were included in the systematic review and meta-analysis. The flowchart of the selection process of studies is shown in Figure 1. All related studies were analyzed in terms of patient characteristics, treatment sessions, muscles examined, intensity and number of treatment pulses, evaluation methods, and finally the results obtained (Table 1). The quality of the studies entered varied. Based on the Downs and Black score, one excellent study, two good studies, seven relatively good low-quality, and four low-quality studies were determined. The mean score of methodological quality in all studies was 17 and in the range of 10-27. Table 1 shows the qualitative scores of all studies.

**Systematic review findings**

As shown in Table 1, the observed differences between the articles are in the type of disease, the number of treatment sessions, the muscles examined, and the energy applied. Out of 14 articles included in the study, 11 articles had examined the effect of shockwave in stroke patients, one study in multiple sclerosis patients, and 3 studies in cerebral palsy patients, which is probably due to the higher prevalence of stroke patients in the community. The number of treatment sessions in 7 studies was one and in other studies, the duration of treatment lasted between 3 and 6 weeks. The highest number of sessions was found in the study by Wang et al. with one session of treatment per week for 3 months and a total of 12 sessions [23]. In terms of the duration of the therapeutic effects of shockwave, Moon et al. concluded that the effect of SWT decreases over time [24]. While studies by Manganotti et al. [25] and Amelio et al. [26] confirmed the long-term effects of shockwave. In terms of examined muscles, the gastrocolic muscle had been studied in eight studies, wrist and finger flexor muscles in 5 studies, and biceps muscle in one study. The difference in the parameters of the shock wave device in terms of energy intensity used varied from 0.03mJ/mm² to 0.32mJ/mm². In most studies, low energy intensities had been used in the treatment, but no reason had been provided by the researcher in choosing the intensity of application.

A total of 12 studies had evaluated the effect of SWT on the scores of the MAS. Among these articles, 3 studies had evaluated the effect of SWT three months after treatment using this scale [25-27]. Manganotti simultaneously evaluated two groups of forearm flexor and intrinsic hand muscles [25]. In his study, Wang evaluated the right and left gastrocnemius muscles separately [23]. Li examined the intrinsic muscles of the hand in 2 groups and the forearm flexor muscles in 2 groups [27].

**Meta-analysis findings**

A. Analysis of the results of studies included in the meta-analysis by examining the effect of shockwave on the scores of the modified Ashworth scale:

A total of 18 interventions that evaluated the effect of shockwave on the MAS scores before and after treatment and 7 studies that examined the effect of shockwave on the MAS scores before and three months after SWT were included in the meta-analysis.

The results of the meta-analysis showed a significant decrease in the MAS immediately after treatment; however, the Ashworth scale scores decreased by 1.38 with a 95%
| Author/Year of Publication | Type of Disease/Number of Patients | Treatment Dose (Number of Shots)/Treated Muscles | Number of Treatments/Treatment Methods | Article Quality Score | Applied Energy (mJ/mm²) | Mean±SD | Hoffman Reflex/Motor Response (H/M) Ratio |
|----------------------------|-----------------------------------|-----------------------------------------------|----------------------------------------|----------------------|------------------------|----------------|------------------------------------------|
| Manganotti et al. 2005 [25]| Stroke/20                         | 1500/forearm flexor muscles, 3200/fingertips   | An active shockwave session            | 13                   | 0.030                  | 3.04±0.7    | 3.2±0.6                                  |
|                            |                                   |                                               | All patients received a placebo shock 1 week before active treatment. |                      |                        | 2.0±0.9     | 0.8±0.4                                  |
|                            |                                   |                                               |                                        |                      |                        | 3.0±0.5     | 1.8±0.7                                  |
| Bae et al. [37]            | Stroke/32                         | 1200/Biceps muscle                             | One session per week and a total of 3 sessions | 15                   | 0.12                   | 3.3±0.49    | 1.8±0.38                                  |
|                            |                                   |                                               |                                        |                      |                        | 2.8±0.57    |                                          |
| Amelio et al. 2010 [26]    | Cerebral palsy/12                 | 1500/Gastrocnemius                             | One placebo treatment session and after 6 weeks, one active shock wave treatment session | 10                   | 0.1                    | 2.6±1.15    | 1.22±1.03                                 |
|                            |                                   |                                               |                                        |                      |                        | 2.98±5.63   | 3.12±5.78                                |
| Sohn et al. 2011 [33]      | Stroke/10                         | 1500/Gastrocnemius                             | One shockwave treatment session on the inner head of the gastrocnemius | 13                   | 0.89                   | 2.5±0.67    | 1.41±0.67                                 |
| Moon et al. 2013 [24]      | Stroke/30                         | 1500/Gastrocnemius                             | One session of placebo treatment and then, 3 sessions of shockwave treatment (1 session per week) on the junction of internal and external gastrocnemius muscle | 14                   | 0.1                    | 3.5±1       | 2.1±1.1                                   |
| Santamato et al. 2014 [38] | Stroke/23                         | 1500/Gastrocnemius                             | An active shockwave session            | 13                   | 0.23                   | 3.4±0.4     | 2.1±0.6                                   |
| Fouda et al. 2015 [39]     | Stroke/30                         | 1500/Hand and finger flexors, 3200/Intrinsic hand | Patients were randomly and equally divided into two groups. The first group received the usual physiotherapy treatments with placebo shockwave therapy and the second group received the usual physiotherapy treatments with active shockwave therapy (one session per week for 5 weeks). | 17                   | 0.32                   | 3.4±0.4     |                                          |
confidence interval. \[I^2 = 100\%; P<0.001, \text{SDM}=1.38 \text{With} \] 95\%CI: (0.80, 1.87). Figure 2 of the Forest Plot diagram shows the extent of changes in the Ashworth scale before and immediately after SWT in general and separately for all studies. With a confidence interval of 95%, the difference between the mean before and immediately after the Ashworth scale was equal to 0.80 and 1.87, respectively, which

| Author/Year of Publication | Type of Disease/Number of Patients | Treatment Dose (Number of Shots)/Treated Muscles | Number of Treatments/Treatment Methods | Article Quality Score | Applied Energy (mJ/mm²) | Ashworth Modified Scale Score Before | Ashworth Modified Scale Score Immediately After | Hoffmann Reflex/Motor Response (H/M) Ratio Before | Hoffmann Reflex/Motor Response (H/M) Ratio Immediately After |
|---------------------------|----------------------------------|-----------------------------------------------|----------------------------------------|----------------------|-------------------------|-------------------------------------|---------------------------------------------|---------------------------------------------|---------------------------------------------|
| Gawad et al. 2015 [34]    | Cerebral palsy/30                | 700/Gastrocnemius and soleus                  | 3 sessions of active shockwave treatment during a week | 17                   | Not mentioned           | 3.75±1.08                           | 1.95±0.06                                  | Not mentioned                             | Not mentioned                             |
| Marinelli et al. 2015 [35]| Multiple Sclerosis/68            | 2000/Gastrocnemius                            | 4 sessions of treatment once a week, and control group: placebo treatment | 22                   | Not mentioned           | 0.5±0.26                            | 0.56±0.24                                  | Not mentioned                             | Not mentioned                             |
| Radinmehr et al. 2016 [32]| Stroke/12                       | 1500/Inner gastrocnemius                    | An active shockwave treatment session on planter flexor muscles | 17                   | Not mentioned           | 0.45±0.25                           | 0.4±0.25                                   | Not mentioned                             | Not mentioned                             |
| Wang et al. 2016 [23]     | Cerebral palsy/34 Control group/32 | 1500/Gastrocnemius                           | One active shockwave treatment session per week for three months | 27                   | 0.30                    | 1.9±0.7                            | Right 2.6±1 Left 1.9±1                   | Right 1.9±1 Left                           | Right 1.9±1 Left                           |
| Dymarek et al. 2016 [40]  | Stroke/20                       | 1500/Wrist flexors, carpal flexor ulnaris and radialis | An active shock wave treatment session                            | 19                   | 0.30                    | 2.1±0.9                            | 1.5±0.8                                   | Not mentioned                             | Not mentioned                             |
| Li et al. 2016 [27]       | Stroke/60                       | 4000/Intrinsic muscles of the hand           | Patients were randomly divided into three groups. The first group received one active shockwave treatment session per week for 3 consecutive weeks. The second group received only one shockwave treatment session and the third group received 1 placebo shock treatment session per week for 3 weeks | 17                   | Not mentioned           | 3.3±0.22                           | 1.5±0.5 Ga 1.5±0.15 Ga 1.9±0.5 Ga       | 3.1±0.26 Ga 1.5±0.15 Ga 2.2±0.8 Ga       | 3.1±0.19 Ga 1.2±0.12 Ga 2.9±0.14 Ga       |
| Li et al. 2016 [27]       | Stroke/60                       | 1500/Carpal flexor ulnaris and radialis      | Patients were divided into two equal groups: the treatment group received one active shockwave treatment session and the control group received placebo treatment. | 17                   | Not mentioned           | 2.9±1.6                            | 0.5±0.1 Ga 1.75±0.6 Ga 2.9±0.14 Ga      | 3.1±0.19 Ga 1.2±0.12 Ga 2.9±0.14 Ga       | 3.1±0.19 Ga 1.2±0.12 Ga 2.9±0.14 Ga       |
| Lee et al. 2019 [19]      | Stroke/9 Control group/9         | 2000/Gastrocnemius                            | Patients were divided into two equal groups: the treatment group received one active shockwave treatment session and the control group received placebo treatment. | 20                   | 0.1                     | 2.2±1.09                           | 0.1±78.89                                 | Not mentioned                             | Not mentioned                             |
shows that the mean of the Ashworth scale before and immediately after the intervention was significantly different.

The results of the meta-analysis also showed that three months after the intervention, the scores of the MAS decreased significantly. \( [I^2 = 100\%, \ p <0.001, \ SMD = 1.13 \text{ with 95\%CI: (0.50, 1.76)}] \). Figure 3 of the Forest Plot diagram shows the rate of changes in the scale of Ashworth scale before and 3 months after SWT in general and separately for all studies.

With a 95\% confidence interval, the mean difference in comparison between before and 3 months after the Ashworth Scale was equal to 0.50 and 1.76, respectively, which shows that the mean Ashworth Scale before and 3 months after the intervention was significantly different.

B- Analyzing the results of studies included in the meta-analysis by examining the effect of shockwave on the Hoffman reflex/motor response (H/M) ratio:

Four studies with a total of 120 patients had evaluated the effects of SWT on the H/M ratio. Figure 4 shows the Forest plot diagram of changes in H/M ratio before and after SWT in general and separately for all studies. With a 95\% confidence interval, the mean difference in comparison with

Figure 1. Flowchart of the steps for study selection in a systematic review and meta-analysis

Figure 2. Forest plot diagram estimating the rate of decrease in Ashworth scale before and immediately after treatment
before and after the ratio of H/M was 0.54 and 2.73, respectively, which indicates that the mean index of the H/M ratio before and after the intervention was not significantly different.

Discussion and Conclusion

In general, one of the most important goals of meta-analysis studies is to solve problems caused by controversial results of previous studies. In these studies, by combining several studies with specific characteristics, the sample size increases, which reduces the confidence interval of measurements. As a result, a valid result can be presented from previous studies [28].

The results of the present study showed that the degree of the Ashworth scale decreased significantly after shockwave application. In this meta-analysis, the effects of shockwave on the reduction of spasticity at follow-up (3 months after treatment) were also significant. So far, several systematic reviews and meta-analyses have been performed to evaluate the effect of SWT on spasticity in patients with upper motor neuron lesions. However, no study has been performed on the simultaneous evaluation of the effects of SWT on the clinical and neurophysiological symptoms of spasticity in patients with upper motor neuron lesions with different etiologies.

The results of other review studies that have examined the effect of SWT on the severity of spasticity are consistent with the results of the present study. Lee et al. (2014) reviewed 5 studies (3 studies in patients with partial paralysis and 2 studies in patients with cerebral palsy) and stated that the MAS score immediately and 4 weeks after SWT significantly improved compared with the baseline values [29].

Guo et al. (2017) in their systematic review and meta-analysis and based on data from 6 studies on stroke patients, analyzed the effects of SWT in reducing spasticity and reported significant differences between baseline values of the Ashworth scale immediately and 4 weeks after treatment [30].

Xiang et al. (2018) in their systematic review and meta-analysis of 8 clinical trials on stroke patients reported that there is a high level of evidence to confirm the positive effects of SWT in reducing spasticity immediately after treatment. Ashworth, Tardio scale, H/M ratio, and joint range of motion were analyzed in this study [31].

A systematic review and meta-analysis conducted in 2020 by Cabanas-Valdés et al. obtained similar results to the results of the present study. In two separate articles, the author examined the effects of SWT on reducing spasticity of the lower and upper limb muscles in patients with partial paralysis and reported that SWT has significant effects on improving the MAS, range of motion, and Fugl Meyer criteria in the short and long term [10].

Another finding of this study showed was no significant changes in alpha motor neuronal excitability (H/M ratio) in patients with upper motor neuron lesions after SWT.

This finding contradicts the findings of a review study by Guo et al. [30]. A noteworthy point in their study was that the effects of SWT on H/M ratio were assessed only by meta-analysis of one study, while in the present study meta-

Figure 3. Forest plot diagram estimating the rate of Ashworth scale reduction compared with before and 3 months after treatment.
analysis was performed according to the inclusion criteria of 4 articles. Therefore, this could be a justification for the discrepancy between the findings of the present study and their study.

In this context, based on inclusion criteria, four articles that had investigated the immediate effects of spastic muscle SWT on the H/M ratio were included in this study. Radinmehr et al. (2016) reported that by performing a shockwave session on the gastrocnemius muscle of 12 stroke patients and recording the H/M ratio immediately and one hour after treatment, despite the reduction of the H-reflex latency, no change in the H/M ratio was observed [32]. Shon et al. (2011) in their study on 10 stroke patients reported that one session of SWT on the gastro-soleus muscle did not show significant changes in the H/M ratio compared with before treatment [33]. Gawad et al. (2015), observed a significant decrease in the H/M ratio after 3 sessions of treatment in patients with cerebral palsy [34]. Marinelli et al. (2015) reported that 4 sessions of SWT could significantly reduce electrophysiological parameters in patients with multiple sclerosis [35].

A significant consideration in studies that have examined the H/M ratio of spasticity is the time interval between the onset of upper motor neuron lesions. However, the H/M ratio is a reliable measure of the excitability of upper motor neurons. However, studies using the H/M ratio to assess spasticity did not indicate the onset of upper motor neuron lesions in patients with the disease. Hiersemenzel et al. (2000) reported that the H/M ratio reaches its maximum value at least 2 to 6 months after the onset of upper motor neuron lesion and then, remains constant [36], thus, the H/M ratio may not be stable before this time. Therefore, it seems that the evaluation of patients in terms of the H/M ratio concerning the time of onset of the complication is an important factor in the evaluation result and can affect the results of the study. Therefore, it is recommended that studies that use this ratio to evaluate the effects of different therapies on spasticity consider the time elapsed since the onset of upper motor neuron lesion. Although the results of all studies confirm the positive effects of SWT in reducing spasticity based on the Ashworth scale, it seems that many questions must be answered before this method can be recommended to patients as a common method of reducing spasticity.

First, to determine the independent effect of shockwave on spasticity, it is necessary to limit the use of any other treatment that can affect the severity of spasticity to avoid confusion in the expression of results. For example, Gawad et al. (2015) in their study used exercise therapy protocol in the control and treatment groups along with SWT [34]. Wang et al. (2016) used Chinese massage and electrical stimulation along with SWT [23]. Sohn et al. (2011) used antispasmodics with a shock wave in their study [33]. On the other hand, differences in the number of treatment sessions, treatment session intervals, energy density and number of shocks applied, and follow-up time need to be examined more closely. The existence of these differences significantly increases the level of heterogeneity in studies. Therefore, because of the lack of adequate data from the main articles for meta-analysis of the above variables in any of the reviews and meta-analyses, the effect of SWT with different shocks and intensities and the duration of different treatments was not analyzed. Therefore, in future studies, it is recommended to conduct clinical trials considering the following items: 1. Patients should be divided into different groups based on the characteristics of the shock wave, the number of treatment sessions, and the duration of follow-
up; 2. The samples should be matched in terms of the Ashworth scale; 3. Factors related to spasticity (type of upper motor neuron lesion and even type of stroke) should also be considered in the selection of patients.

One of the limitations of this study is the small number of well-designed clinical trials, considering that the mechanism of effectiveness of SWT on spasticity is not yet fully understood, and on the other hand, there is no integrated protocol in the treatment of spasticity by SWT; thus, more trials with appropriate designs are needed in the future.

The results of this review study showed that SWT is a non-invasive method that can be easily used in spastic muscles of the lower and upper limbs in patients with upper motor neuron lesions and has beneficial effects on improving the clinical scale of spasticity assessment. Because there is still no single instruction for treating patients in terms of the number of treatment sessions, energy intensity, and several shocks applied, and on the other hand, none of the studies provided a documented reason for choosing the number of sessions and pulse intensity as a common method of reducing spasticity, conducting high-quality randomized clinical trials is suggested to analyze the factors affecting SWT on spasticity.

Ethical Considerations

Compliance with ethical guidelines

All ethical principles are considered in this article.

Funding

This article has been done with the financial support of the Vice Chancellor for Research and Technology of Shahid Beheshti University of Medical Sciences.

Authors’ contributions

Conceptualization and project management: Nahid Tahan; Research: Nahid Tahan and Farideh Dehghan Manshadi; Data collection: Nahid Tahan and Fereshteh Poursaid; Editing and writing – review & editing: All authors; Statistical analysis: Alireza Akbarzadeh Baghban.

Conflict of interest

The authors declared no conflict of interest.

Acknowledgments

The authors thank the Vice Chancellor for Research and Technology of Shahid Beheshti University of Medical Sciences.
تأثیر شاک ویو درمانی بر شاخص‌های بالینی و تورفوپزیولوژی اسپاستیسیتی در بیماران دارای آسیب نورون محرکه فوقانی (مرون سیستماتیک و متاآنالیز)

عبیرا الهی، نازنین متین، سونیا اکبرزاده، علیرضا انقلابی، نیکی نوروزی، بهار میروف، نازنین طلایی، الهی، و همکاران

آسیب نورون محرکه فوقانی بیماران مختلف، به خصوص دچار سکته مغزی، میتواند راههای درمانی را ربط به بیماران کاهش دهد و آسیب را پیش‌برداری نماید. شاک ویو یکی از راههای درمانی این بیماران است که می‌تواند در کاهش شاخص‌های بالینی و تورفوپزیولوژی اسپاستیسیتی به کار رود.

در این مقاله مورد بررسی قرار گرفت که چگونگی اثرات شاک ویو درمانی بر شاخص‌های بالینی و تورفوپزیولوژی اسپاستیسیتی در بیماران دارای آسیب نورون محرکه فوقانی است. برای ارزیابی این اثرات، مراجعه به تحقیقات مربوطه و استانداردهای علمی و پژوهشی انجام شد.

عملکرد شاک ویو درمانی برای کاهش شاخص‌های بالینی و تورفوپزیولوژی اسپاستیسیتی در بیماران دارای آسیب نورون محرکه فوقانی باعث بهبود شاخص‌های بالینی و رفع محدودیت حرکتی شده است. 

کلیدواژه‌های: اسپاستیسیتی، فلج مغزی، سکته مغزی، مولتیپل اسکلروز، شاک ویو درمانی.
در سطح بالین اختلال تغییر در جریان حسی عضلانی مشاهده می‌شود. مکانیسم‌های عصبی و غیرعصبی موثر انجام می‌شود. درمان اسپاستیتی در بیماران فلج مغزی با توجه به ضرورت درمان بیماران فلج مغزی، مولتیپل اسکلروز و شاک ویودرمانی برای جست‌وجو انتخاب شدند. این انتخاب با توجه به طور معمول در بیماران فلج مغزی، این مطالعات برای کاهش تون عضله اسپاستیک فاقد پروتکل اینکه مرور سیستماتیک و متای آنالیز ابزاری برای خلاصه کردن مدارک و شواهد موجود درمورد اثبات شاک ویودرمانی در مشکلات تاندونی و مکانیسم‌های فیبروز عضلات شاک ویودرمانی به کمکی از مقیاس بالینی آشورت و مولتیپل اسکلروز بررسی شدند. این انتخاب با اعتبار بالای شاک ویودرمانی در کاهش تون عضله اسپاستیک در بیماران شاک ویودرمانی مشاهده می‌شود. این مطالعات به عنوان یکی از مراحل مشاهداتی در سرپرستی بالینی انتخاب می‌شود. این انتخاب با اعتبار بالای شاک ویودرمانی در کاهش تون عضله اسپاستیک در بیماران شاک ویودرمانی مشاهده می‌شود.

شک ویودرمانی می‌تواند در دو شکل فوکال و رادیال استفاده نماید. امواج شک ویو فوکال می‌توانند اثرات فیبروزی و اجزای غیررفلکسی عضله اسپاستیک داشته باشند. امواج ضربه‌ای شک ویو می‌تواند تأثیر مستقیمی بر عضلات فیبروزی و اجزای غیررفلکسی عضله اسپاستیک داشته باشد. این مکانیسم اثر شاک ویودرمانی، با توجه به نتایجی که برخی از مطالعات درباره اثرات مثبت شاک ویودرمانی در مشکلات تاندونی و مقیاس بالینی آشورت گرفته‌اند که امواج ضربه‌ای شک ویو می‌تواند تأثیر مستقیمی بر عضلات فیبروزی و اجزای غیررفلکسی عضله اسپاستیک داشته باشد.

کف پا، تاندونیت کلسیفیه شانه، بیماری‌های التهابی تاندون و عدم جوش خوردگی در استخوان‌های بلند، التهاب فاشیای، استفاده از شک ویو در درمان ضایعات ارتوپدی از قبیل تاندونیت کلسیفیه شانه، بیماری‌های التهابی تاندون و عدم جوش خوردگی در استخوان‌های بلند، التهاب فاشیای، استفاده از شک ویو در درمان ضایعات ارتوپدی از قبیل تاندونیت کلسیفیه شانه، بیماری‌های التهابی تاندون و عدم جوش Khوردن به شمار می‌رود. به همین دلیل، شک ویو به عنوان یکی از روش‌های امیدبرنگین برای درمان ضایعات ارتوپدی استفاده می‌شود. امواج ضربه‌ای شک ویو می‌تواند تأثیر مستقیمی بر عضلات فیبروزی و اجزای غیررفلکسی عضله اسپاستیک داشته باشد.

در مطالعه‌های بالینی، اثبات شک ویودرمانی در کاهش تون عضله اسپاستیک مشاهده می‌شود. این مطالعات به عنوان یکی از مراحل مشاهداتی در سرپرستی بالینی انتخاب می‌شود. این انتخاب با اعتبار بالای شاک ویودرمانی در کاهش تون عضله اسپاستیک در بیماران شاک ویودرمانی مشاهده می‌شود. این مطالعات به عنوان یکی از مراحل مشاهداتی در سرپرستی بالینی انتخاب می‌شود. این انتخاب با اعتبار بالای شاک ویودرمانی در کاهش تون عضله اسپاستیک در بیماران شاک ویودرمانی مشاهده می‌شود.
کمال طور در جدول ۱ در همان شکل است. تکثیر مقاله,

توابع نخستینی

7. Wang 8. Moon 9. Manganotti 10. Amelio

98 تفاوت میانگین ها با دو مقاله و یک مقاله غیرانگلیسی چاپ شده بودند. از مقالات مورد بررسی برای اجرای آزمون `random effects model` استفاده شد. داده‌ها با استفاده از نرم‌افزار STATA تهیه شد. مقادیر P کمتر از ۰/۰۵ به عنوان مختار

97 نتایج نشان داده شد که اثر شاک ویو درمانی بر شاخص های نوروفیزیولوژیکی اسپاستیسیتی در بیماران دارای آسیب نورون محرک فوق‌العاده

95 مقالات که از مقیاس آشورت برای ارزیابی اسپاستیسیتی، تجربیات دقیق در مورد تفاوت‌های میانگین و انحراف معیار در شاخص‌ها (حداقل در ۵۰%) پوشش یافته بودند، به صورت رئالیستی برای ارزیابی اسپاستیسیتی استفاده کردند. بدین‌طور که این مقالات متألفین با ارزیابی اسپاستیسیتی تجربیات زیادی داشتند.

93 تفاوت میانگین ها به عنوان اندازه اثر بر انجام آزمون `random effects model` با استفاده از کلمات کلیدی مذکور، در مجموع ۳۱ مقاله

92 یافت و در نهایت نتایج به دست آمده مورد نشان داده

91 "اشکال-ویو" برای اهدافی غیر از ارزیابی تشخیصی همان طور که در آمار و بستگی به زبان و زبان، مطالعات غیرانگلیسی چاپ شده بودند و از شاک ویو برای اهداف غیر از ارزیابی تشخیصی استفاده کرده بودند، از مقاله کمیت مطالعاتی که به صورت کارآزمایی بالینی با گروه کنترل یا پیش از آزمون سرمایه طراحی شده بود، مقالاتی که اکنون استنت intra clase correlation coefficient و اکنون استنت intra clase correlation coefficient و در مطالعه یانگ و همکاران

90 اکنون استنت intra clase correlation coefficient و در مطالعه یانگ...
| جلسه | شاک ویو | فعال | بر روی کنار | فعال | دَز درمان | روش | کیفیت | نمره مقیاس اصلاح شده آشورت | انحراف معیار | نمره مقیاس اصلاح شده آشورت | انحراف معیار | نمره مقیاس اصلاح شده آشورت | انحراف معیار |
|-------|---------|------|------------|------|-----------|-----|------|----------------|-------------|----------------|-------------|----------------|-------------|
| 1     |         |      |            |      |           |     |      | 131313131313 | ±0000000000 | ±0000000000 | ±0000000000 | ±0000000000 | ±0000000000 |
| 2     |         |      |            |      |           |     |      | 131313131313 | ±0000000000 | ±0000000000 | ±0000000000 | ±0000000000 | ±0000000000 |
| 3     |         |      |            |      |           |     |      | 131313131313 | ±0000000000 | ±0000000000 | ±0000000000 | ±0000000000 | ±0000000000 |

* تعداد جلسات درمان/ روش 3 جلسه درمان/ روش 1500 نگه نشده و خارجی 1200 نگه نشده. در حال حاضر فلکسور ساعد، گاستروکنمیوس/ عضله/ عضله انگشتی دست 3200 تعداد بیماران سکته مغزی 30/ فلج مغزی 30/ سال انتشار 2014/ نیروکونی نیروکونی 2010/ همکاران Amelio/ Fouda/ 2011 بای طلسم.
نتایج در مطالعات وارد شده به متا آنالیز با بررسی تأثیر شاک ویو درمانی بر شاخص های بالینی و نوروفیزیولوژیک اسپاستیتی در بیماران دارای آسیب نورون محرکه فوقانی

در مجموع 18 مداخله تا کنون گروه شاکوپلیوس را در دو گروه درمان و درمان پلاسما بررسی کردند که در نتیجه این مطالعات گروه درمان شاکوپلیوس کاهش شد. در آخرین نسخه سمینار بین‌المللی تخصصی شکل‌گیری و تغییرات مغزی (۷۲) این موضوع مطرح شد.
تصویر ۱. فلورتار مراحل ورود مطالعات به مور سیستماتیک و متا‌انالیز

اصلاح‌شده آشورت را قبل و بعد از درمان و هفت مطالعه که تأثیر شاک‌ویو بر نمرات مقیاس اصلاح‌شده آشورت را قبل و سه ماه پس از شاک‌ویو درمانی مورد بررسی قرار داده بودند در متا‌انالیز وارد شدند.

نتایج متا‌انالیز نشان داد که میانگین بهبود ۸۹٪ تفاوت در مقایسه قبل و بعد در مقیاس آشورت به دست آمده که آشکار است که میانگین بهبود در مقیاس آشورت قبل و بعد از درمان در زیر: ۱۸۴۴ نفر در این مطالعه به دست آمده که تفاوت قبل و بعد در مقیاس آشورت به دست آمده بود.

| Study ID | % Weight | ES (95% CI) |
|----------|-----------|-------------|
| Manganotti et al | * | 1.40 (1.33, 1.47) | 5.56 |
| Manganotti et al | | 2.40 (2.37, 2.43) | 5.56 |
| Bae et al | | 1.30 (1.25, 1.35) | 5.56 |
| Amelio et al | * | 1.50 (1.47, 1.53) | 5.56 |
| Sohn et al | | 1.45 (1.42, 1.48) | 5.49 |
| Moon et al | | 1.09 (1.05, 1.13) | 5.56 |
| Santarotto et al | | 1.40 (1.31, 1.49) | 5.55 |
| Fouda et al | * | 1.80 (1.79, 1.81) | 5.55 |
| Fouda et al | | 1.30 (1.28, 1.32) | 5.56 |
| Wang et al | | 0.70 (0.70, 0.70) | 5.56 |
| Wang et al | | 1.10 (1.04, 1.16) | 5.56 |
| Dynarek et al | | 0.60 (0.56, 0.74) | 5.56 |
| Li et al | | 0.60 (0.56, 0.74) | 5.56 |
| Li et al | | 2.40 (2.40, 2.40) | 5.56 |
| Li et al | | 1.90 (1.90, 1.90) | 5.56 |
| Li et al | | 1.60 (1.59, 1.61) | 5.56 |
| Li et al | | 2.25 (2.23, 2.27) | 5.56 |
| Lee et al | | 0.33 (0.23, 0.43) | 5.55 |
| Overall (I-squared = 100.00, p = 0.000) | 1.38 (0.89, 1.87) | 100.00 |

NOTE: Weights are from random effects analysis

پیوسته: Forest plot
تفاوت معنی‌دار دارد.

نتایج مطالعات همچنین نشان داد که سه ماه پس از مداخله، نمرات مقیاس اصلاح شده آشورت به طور قابل توجهی کاهش پیدا کردند (I2 = 100%, p<0.001, SMD=1.13 with 95% CI: (0.50, 1.76).

بیشتر تغییرات قبل و سه ماه بعد مقیاس آشورت قبل و سه ماه بعد از مداخله تفاوت معنی‌دار ندارند (H/M نسبت قبل و بعد از مداخله).

گزارش می‌شود که نسیمی دارد.

در نتیجه مطالعات اصلاح شده آشورت به طور قابل توجهی کاهش پیدا کردند (I2 = 100%, p<0.001, SMD=1.13 with 95% CI: (0.50, 1.76).

تغییرات قبل و بعد از مداخله میانگین شاخص H/M به طور کلی و جداگانه برای تمام مطالعات نشان داده است. با قابلیت اطمینان 95 درصد، تفاوت میانگین در مقایسه قبل و سه ماه بعد میانگین شاخص H/M قبل و بعد از مداخله معنی‌دار بود.

بیشتر تغییرات قبل و بعد از مداخله میانگین شاخص H/M نسبت قبل و بعد از شاک ویودرمانی ارزیابی کردند.
به طور کلی یکی از محدوده‌های اعمد مطالعات متاآنالیز حل مشکلات ناشی از نتایج احتقانی مطالعات که گذشته است در این مطالعات با ترکیب دو مطالعه یا مطالعه‌های مشخص و جمع‌نامه‌های ارزش‌الامیده که این امر خود به خود کاهش اساسی امکان‌پذیر نداشته‌اند. این مطالعات شامل ارزیابی جمله در مطالعه‌های مواد نورونیه به همراه موردی قابل اعتماد از تحریک پذیری نورون محرکه فوقانی است، اما بر شدت قرار گرفتند، بنابراین این امر می‌تواند توجیهی بر وجود مغایرت معیارهای ورود چهار مقاله مورد تجزیه و تحلیل اثباتی از یک ضایعات نورون محرکه فوقانی پس از درمان با شاک ویو وجود. منابعی مطالعه حاصل نشان داد که در زمینه مطالب امکان‌پذیر نیست.

تعداد بیماران در این مطالعه در ماله‌ها گزارش شده و همکاران گزارش کرده اند که قابل اعتماد از تحریک پذیری نورون محرکه فوقانی در فضای تازه‌سازی توانایی یک متاآنالیز پایدار نیست، بنابراین به نظر می‌رسد ارزیابی بیماران قبل از این‌زمان و همکاران گزارش کرده اند که قابل اعتماد از تحریک پذیری نورون محرکه فوقانی است، اما بر شدت قرار گرفتند، بنابراین این امر می‌تواند توجیهی بر وجود مغایرت معیارهای ورود چهار مقاله مورد تجزیه و تحلیل اثباتی از یک ضایعات نورون محرکه فوقانی پس از درمان با شاک ویو وجود. منابعی مطالعه حاصل نشان داد که در زمینه مطالب امکان‌پذیر نیست.

در اثری بر روی امکان میزان ظرفیت و ضایعات نورونیه در داخل درمانی گزارش شده، همکاران گزارش کرده اند که قابل اعتماد از تحریک پذیری نورون محرکه فوقانی است، اما بر شدت قرار گرفتند، بنابراین این امر می‌تواند توجیهی بر وجود مغایرت معیارهای ورود چهار مقاله مورد تجزیه و تحلیل اثباتی از یک ضایعات نورون محرکه فوقانی پس از درمان با شاک ویو وجود. منابعی مطالعه حاصل نشان داد که در زمینه مطالب امکان‌پذیر نیست.

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از نظر شاک ویودرمانی با توجه به زمان شروع عارضه، عامل $H/M$ از نظر شاخص نسبت مهمی در نتیجه ارزیابی باشد و می‌تواند نتایج مطالعه را تحت تأثیر قرار دهد. توصیه می‌شود که مطالعه‌های که این نسبت به سایر ارزیابی‌های مطلوب سطح کاملاً استقلال معنی‌دار باشد، مطالعاتی که از نظر سطح کاملاً استقلال مستقل ارزیابی باشند، مطالعاتی که از نظر اثراتی از مراحل فعلی ارزیابی باشند، یا مطالعاتی که از نظر زمان جلسات روش درمانی باشند.
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