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Review

The effect of muscle electrical stimulation on muscle stiffness problems and musculoskeletal pain caused by muscle imbalance: A systematic review

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Abstract. Whole Body Electrical Stimulation (WB-EMS) is a relatively new training method that has been used extensively in recent years, however, the lack of consensus on the efficacy of Whole Body Electrical Stimulation exists, and the aim of this study is to investigate the effects of this method on postural structure problems and musculoskeletal pain. Summary of articles by ISC, Google Scholar , American Journal of Sports Medicine , PubMed Journal of Rehabilitation Medicine , Cochrane , and Sports Medicine Journals between 2000 and 2019 were studied to identify all studies that report electrical stimulation applied simultaneously to the upper and lower limbs. Keywords: Electrical stimulation, Electrical muscle stimulation, Functional electrical stimulation, Whole body electrical stimulation, Wearable sensors, Electrotherapy, Electrode vest, Electrode vest for treatment and rehabilitation, E-fit, Electronic muscle stimulation , Whole body electronic muscle stimulation, Electronic Stimulation, Electronic Suit, Wearable Sensor, and Electrotherapy were used to obtain relevant articles and finally, 22 articles were compared according to the set criteria of 107 papers. Based on the results of studies on the effects of Whole Body Electrical Stimulation, this tool is based on parameters such as muscle strength, muscle size, body composition, obesity, sarcopenia, sarcopenia- induced obesity and pain reduction in non-specific chronic low back pain patients, have a significant positive effect. Due to the lack of studies on the effects of Whole Body Electrical Stimulation and the inconsistency between studies and the lack of similar consensus, further research is needed.

Keywords: Whole Body Electrical Stimulation, Static Structure, Electrical stimulation, Muscle stimulation.

Introduction

In today's society we see many people who are struggling with problems such as back pain, neck pain, knee pain, chronic back pain, and so on. Such problems at an early age may be common due to bone resumption, muscle andjoint swelling, although these are less common with an older lifestyle, but today we find that most young people are involved with skeletal and structural problems that are the main cause of such technological and inertia problems that can cause postural problems (1). Posture or body posture is how different parts of the body are positioned. The shape and position of the human spine depends on the effective functioning of the muscles and ligaments, and therefore any weakness in the spinal cord muscles may cause distortion in the human posture and cause musculoskeletal disorders and disorders (2) Having a good physical condition is effective in improving motor function while inappropriate posture can in addition

to the physical appearance of the body and produce specific psychological effects, cause multiple body organs (3).

Electromyostimulation (EMS) has been used for physical therapy practice as a method to rehabilitate muscles after an injury or surgery. In the 1960s, EMS was often used to prevent the atrophy that occurs when skeletal muscle is denervated. With advances in EMS technology, its use became increasingly popular for treating patients who sustained central nervous system impairment secondary to brain injury. Since the 1980s, researchers have developed units with an improved ability to modulate a variety of electrical wave forms resulting in an electrical current that can be effectively used to stimulate innervated muscles (4). It has been commonly used to strengthen the extremities ofpatients who have had orthopedic surgery. The use of EMS can also prevent people from injuries, especially for those inclined to injuries in the lower back, knees, shoulders, and muscles. EMS is very gentle on the joints and reduces the risk of injury due to the absence of weights (5). These impulses cause involuntary contraction in the muscles, thereby causing the use of fast-twitch fibers (4). The major difference between the involuntary mechanism of muscle contraction and the voluntary contraction of EMS- induced muscle contraction in motile muscle fibers. In order to move the muscle fiber, there must be a level of stimulation that can activate the muscle fiber. In the case of spontaneous muscle contraction, a small low threshold motor unit must first be activated. During EMS, impulses are transmitted through electrodes on the skin close to dermis tissue for stimulation. These impulses cause involuntary contractions of the muscles and thereby recruit fast-twitch fibers (6). The major difference between the mechanisms of involuntary muscle contraction and voluntary muscle contraction induced by EMS is in muscle fiber mobilization. In order to mobilize muscle fiber, there must be a level of stimulation that can be activated. In the case of spontaneous muscle contraction, a small motor unit with low threshold is activatedfirst. In the case of muscle contraction due to EMS, the motors unit under the control of the larger nerve is activated, and muscle fibers with high threshold are easily mobilized (4), resulting in positive effects on muscle strength (7).

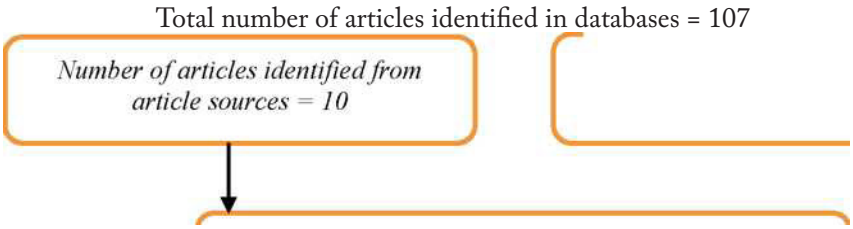
Many studies applied EMS locally with single electrodes to defined muscle groups (8). With further technical developments, EMS progressed from a local stimulation to a whole body-EMS (WB-EMS) method where several muscle groups were targeted simultaneously through an electrode belt and vest system (i. e., Miracle Suit, Seoul, Korea). More recently, Miracle Suit has upgraded its functions and capabilities and has overcome limitations and inconveniences from past systems. For example, the cumbersome process of spraying water or wearing wet clothes to allow electrical currents to pass through the body has been replaced by inserting a silicone conductive pad into the garment. In addition, wires connecting the electrodes to the EMS machine have been replaced with wireless sensors via Bluetooth technology to enable a wider range of activity that can be adjusted within 40 m. This advanced WB-EMS system allows for more comfort, ease of use, andfaster results in rehabilitating patients with musculoskeletal diseases as well as improving body composition and muscle function in normal people as shown in previous studies (8-14). However, to avoid WB-EMS-related side effects, guidelines for efficacy and safety were established, which included the control of electrical strength, consideration of subject health, and the training of instructors (10). Recently, researchers have used the recommended WB-EMS protocol (20 min, bipolar, 85 Hz, 350 sec, rectangular, 6 sec of current, 4 sec of rest) for healthy men (12-15). It was reported that using the WB-EMS protocols in their studies can prevent rhabdomyolysis and corresponding renal, hepatic, and cardiac problems. In particular, there are no reports of the effects of WB-EMS on psychiatric factors. The most important aspect of EMS is time saving. Improving the performance that is difficult to achieve in the traditional 3-minute EMS exercise is only possible in 2 to 5 minutes in the EMS training method. The combination of traditional exercises and EMS can enhance intramuscular coordination to improve motor skills.

Research has shown that electrical stimulation is effective in treating some of the musculoskeletal disorders, as well as helping people who are injured, sedentary or athletes looking to strengthen their muscles to improve their function and prevent injury. Pardos & Veiga (16) also concluded that EMS training had a

positive effect on specific muscle groups in adolescent female athletes; also Filipovic et al. (17) concluded that whole body electrical stimulation for People with chronic nonspecific low back pain significantly reduce pain, significantly improve the disability index and significantly improve the NASS and Stengel et al. (18). It was concluded that whole-body electrical stimulation had significant positive effects on muscle mass and muscle strength (16). Ray observed psychological factors and improved heart and lung variables such as oxygen uptake using whole body electrical stimulation. Now, given the above, and with the advances in technology and the mechanization of life that have led to erroneous motor habits and disruptions in the muscular balance of people, especially teenagers and young people, and causing a variety of skeletal abnormalities - Is it possible to see muscle using electrical stimulation as a complementary tool to other exercises? The question is, can this tool be used to strengthen muscles, improve posture and prevent or treat injury, given the emergence of whole-body electrical stimulation that simultaneously affects muscle groups? Given that the number of studies on whole body electrical stimulation is limited, it does not allow us to obtain a definitive conclusion on its effects, and further investigations on whole body electrical stimulation are necessary.

The present study is a review by investigating internal and external articles related to research variables. The process of selecting articles consists of several steps, the first step being searching for articles in specialized databases, SID, Google Scholar, American Journal of Sports Medicine, PubMed and Journal of Sports Medicine between years 2000 to 2019 to identify all studies that applied electrical stimulation concurrently in the upper and lower extremities. Keywords, Electrical stimulation, Electrical muscle stimulation, Functional electrical stimulation, Whole body electrical stimulation, Wearable sensors, Electrotherapy, Electrode vest, Electrode vest for treatment and rehabilitation, E-fit, Electronic muscle stimulation, Whole body electronic muscle stimulation, Electronic Stimulation, Electronic suit, Wearable sensor and Electrotherapy were used to obtain related articles. Subsequently, related articles were reviewed based on title and abstract Only studies that analyzed human subjects without limiting their sex, age or physical condition were taken into account. The participants of these studies could have a good health status or suffer from a disease for which WB-EMS was applied as a possible treatment; afterwards, an analysis of the effect of its application on the symptoms of this disease was performed. In addition, the studies included in this review should apply whole-body electrical stimulation in the lower and upper limbs simultaneously as an intervention in at least one group of the sample population. Also, for a more thorough search of the study, the sources of articles were reviewed to find relevant studies. Exclusion criteria also included studies where the full text of the article was not available, duplicate articles, articles with no specific sample, method of implementation were unclear, and articles unrelated to the subject under study, ultimately out of 107 articles, 23 article was used.

stimulation as well as in a study by Kammler et al. (11, 12). Significant changes were observed in fat mass reduction. According to a study by Flipovich et al. (15,17), whole body electrical stimulation is effective in enhancing physical strength as well as improving athletic skills, also in a study by Kammler et al. (11) Showed that people who used whole body electrical stimulation had a higher calorie burn rate than people who used low intensity strength training, and whole body electrical stimulation as a tool focused on body composition and power parameters (13). According to Kammler et al. (12) Whole Body Electrical Stimulation for elderly people or those who have Sarcopenia or can't, or are unwilling to perform strength exercises to maintain muscle mass, can be used as a good tool for maintaining mass exercise muscle, muscle strength and body composition, also Kammler et al. (10) showed that whole body electrical stimulation is effective in increasing muscle strength and volume in older women, as well as whole body electrical stimulation is a suitable training tool for individuals low back pain is chronic (13) and also according to a study (12), whole body electrical stimulation is a good tool to increase upper body strength in people with chronic low back pain. Whole-body electrical stimulation research has identified at least a link between electrical stimulation and anthropometric parameters (16-20).



Results

In a study by Kammler et al. (10), an increase in muscle mass was observed in people who used whole body electrical

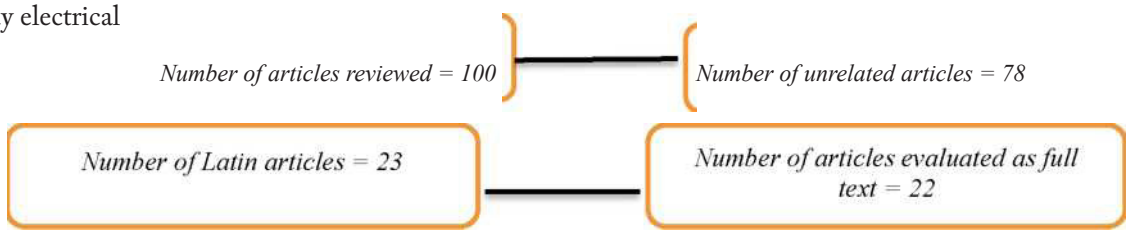


Fig.1. Flow chart of study selection

Discussion

The purpose of this review is to determine the effects of whole body electrical stimulation (WB-EMS) on posture and body composition problems, particularly on muscle strength to prevent muscle imbalance and prevent injury. In recent years, this study method, a study that confirms the knowledge gained so far on the topic, is needed to clarify the status of the subject, and studies on WB-EMS are on the rise. Too many to use this educational tool that can be very dangerous if used improperly. However, our knowledge in this area is scarce, and existing studies lack the evidence to conclude on the effectiveness of WB- EMS training and adequate technical guidance. It is used and managed in a variety of contexts and needs, as well as most studies in specific groups with special needs. According to the findings of the present study, whole body electrical stimulation in most cases increases muscle strength. Regarding the effects on power, only two studies examined the effect of WB-EMS at RM1, which showed a significant increase in power (12-14). Flipovich et al. (15,19) also confirmed this increase in strength in a study. In this regard, Kemmalr et al. (14) came to the conclusion that the electrical stimulation of the body that increases foot BES, BES and improve the back and can be used as a way to improve strength and body composition in front of his high intensity resistance training. However, in other studies using a similar approach for local EMS, a smaller increase in lower extremity dynamic strength was observed after training for three days per week for 12 weeks (20). Wirts et al. (22) also found in a study that stimulation The whole body electrically increases the maximum strength in the muscles. Hosseini Sharifabad (23), in a study comparing local electrical stimulation (EMS) and strength training, found that both increased quadriceps muscle strength but increased strength training compared to EMS. He concluded that EMS increases quadriceps muscle strength in older patients but this increase is less than isometric exercise. Filipovic et al. (18), in their systematic review of the effects of electrical stimulation, show a high correlation between current intensity and EMS effects. In his review, Filipovic et al. (17) concludes that a current of 50 Hz is sufficient for type II muscle activation and working with power. In fact, previous studies have shown that the need to minimize the frequency of flow is possible because its increase is associated with increased muscle fatigue. Therefore, it seems that the electrical stimuli selected in some studies are not usually recommended for patients with atrophy of the muscular system and sedentary lifestyle.

Table 1. whole body electrical stimulation studies

Row	the writer Year	Title	Sample	Research tools	Research tools
1	Ahadi 2011	Comparison of the effect of 6 weeks of strength training and electrical stimulation on 4-leg muscle strength in Ahvaz female basketball players	24	1.Weights for measuring and performing strength exercises. 2.Fixed bicycle for heating, made in Taiwan. 3.Faradayek electrical stimulation device manufactured by Novin Company in Iran. 4.Digital weighing scale for weighing subjects with 0.001 kg accuracy, made in China. 5.Digital height meter to measure subjects height, made by Iran.	Both strength training and electrical stimulation methods increased the 4-legged muscle strength of female basketball players, but there was a significant difference between the two exercises, so that 1.5 times more strength training than electrical stimulation exercises increase the strength basketball players' quadriceps
2	Abdoli 2009	The simultaneous effect of active training and electrical stimulation on the degree of freedom change Knee articulation in the oscillatory phase of patients with pneumonia	12		The results showed that the simultaneous execution of active exercises and electrical stimulation altered the degree of knee freedom during the oscillation phase of patients with pubic palsy. As a result, they are able to bend the knee more frequently and cross these barriers when faced with obstacles in the walking path and reduce the risk of potential falls.
3	Shujaud din et al 2013	The Effect of a Selected Exercise Program Course with and without Applying Electrical Stimulation (APS) on Pain and Spinal Function of Young Girls with Chronic Low Back Pain	24	Electrical Stimulation Device (APS)	Selected exercises with and without electrical stimulation (APS) resulted in improved performance and reduced pain in patients. Although this improvement was more pronounced in the APS group, the two groups were not significantly superior to each other.
4	Hosseini Sharifabad 2009	Comparison of voluntary isometric exercise and electrical stimulation in quadriceps muscle strengthening after knee immobilization in subjects over 40 years old.	40	Electrical Stimulator, Manufactured by Modern Medical Engineering Company - Isfahan - Iran.	Increased muscle strength in four groups of electrical stimulation (28%) was significantly lower than isometric group (40%) . However, there was no significant difference between the two treatments in terms of mean hip circumference (P = 0.96). This study showed that although electrical stimulation is an effective alternative to increase quadriceps muscle strength in middle - aged and elderly patients following knee immobilization , it is not more effective than voluntary isometric exercise .

5	Roshan et al 2008	The effect of a four- week course of electrotherapy and selected motor therapy on pain and range of motion of the frozen shoulder.	19	Using the tensile apparatus (for the purpose of vibration and mobility of muscles) in both normal and impact form, The use of a hot bag (aimed at raising the temperature of the stance and subsequently reducing the stiffness and pain in the soft tissue of the joint) between the two modes using the TENS device and the ultrasound device (with the aim of increasing the soft tissue stretching ability and reducing Pain level.	The results showed that elective movement therapy was more effective than electrotherapy in alleviating pain and reducing range of motion in frozen shoulder.
6	Shariati et al 2016	Evaluation of the Effectiveness of the Spinal Muscle Comprehensive Protocol with and without Functional Electrical Stimulation in Elderly People with Functional Hyperkyphosis.	45	4 Surface electrodes measuring 5.5 by 6.5 cm.	There was a significant difference in the degree of kyphosis with the control group after a period of comprehensive training with and without functional electrical stimulation. Also, the results showed that there was no significant difference between the control group and functional electrical stimulation. It was functional without electrical stimulation According to the findings of the study, it is suggested that comprehensive training exercises to improve the angle of kyphosis and prevent its complications in this segment of the community, be included along with other therapeutic programs.
7	Faridz Ahmad et al 2015	The effect of electrical stimulation of muscles on skeletal muscle volume in men	15	X Body from Hungary with German technology	Using EMS increases muscle strength and size, this method can improve athletes' strength so it can be used in sports science.
8	Prigel J. et al 2018	The effect of eight weeks of electrical stimulation of muscles on contractile activity in adolescent athlete girls	19		EMS training has a positive effect on specific muscle groups in adolescent female athletes.
9	Konrad et al 2018	Whole body electrical stimulation for people with chronic non¬specific low back pain	49	Miha bodytec (Series 1, German Technology)	Feelings of pain were significantly reduced. The disability index improved significantly. The NASS has improved significantly.
10	Kemmler et al 2017	The effect of whole body electrical stimulation on non-specific chronic low back pain	23	Miha bodytec (Series 1, German Technology)	Whole-body electrical stimulation appears to be an appropriate tool for non-specific chronic low back pain, however further studies are needed.

11	Filipovic et al 2012	- Systematic review of the effects of different EMS methods on power parameters in trained and elite individuals	89		Improve strength, speed, fitness,
12	Kemmler et al 2010	The effect of whole body electrical stimulation on body metabolism, body composition and maximal strength of postmenopausal women	30	Miha bodytec (Series 1, German Technology)	The effect of whole-body electrical stimulation exercises is far greater than endurance and resistance training individually, and for older people who are unable to exercise, electrical stimulation exercises may be helpful in maintaining muscle mass.
13	Stengel et al 2015	Whole body electrical stimulation to combat osteoporosis in older women		Miha bodytec (Series 1, German Technology)	Whole-body electrical stimulation is effective in increasing muscle mass but has less effect on bone than muscle but can be used as a way to maintain muscle mass.
14	Kemmler et al 2018	Effect of whole body electrical stimulation and protein supplementation on muscle / local fat distribution in men with obesity and sarcopenia	33	Miha bodytec (Series 1, German Technology)	Increase the volume of lean thigh muscles Reduce body fat Improved lower extremity function Improved walking speed
15	Rodrigue z et al 2019	Systematic review of the effect of whole body electrical stimulation on body health and function	21		Increase power More energy consumption than aerobic exercise alone Increased isometric resistance Reduce adipose tissue
16	Kemmler et al 2018	Evaluation of the effectiveness of whole body electrical stimulation as a post-workout recovery method	9	Miha bodytec (Miha II, German Technology)	Whole-body electrical stimulation is not an appropriate recovery method because it does not provide the power to reconstitute physiological and psychological variables over other active and inactive resting methods.
17	Kemmler et al 2016	The effects of whole body electrical stimulation versus high intensity resistance training on body composition and strength	48	Miha bodytec (Germany)	Increase fat burning Improves the power of leg extensions Improved power of back extensions Whole-body electrical stimulation can be used as a way to improve strength and body composition against high-intensity resistance training.

18	Wirts et al 2016	The effect of squat training with and without electrical stimulation on body function	20	Miha bodytec (Germany)	Squat training with electrical stimulation increases maximum strength and improves jumping ability in different sports. Improves leg muscles and hamstring strength.
19	Filipovic et al 2015	The effect of whole body electrical stimulation on the red blood cell deformability	15	Miha bodytec (Germany)	Increase maximum resistance in the training group with whole body electrical stimulation and increase red blood cell deformability to absorb more oxygen and promote more general force in high performance exercise.
20	Kemmler et al 2012	The effect of whole body electrical stimulation on energy consumption during exercise	19	Miha bodytec (Germany)	Energy consumption and calorie burn through resistance training combined with whole body electrical stimulation are higher than resistance training alone, so whole body electrical stimulation can be a time-saving tool for people who are unwilling to exercise.

On the other hand, what has been shown in studies with local EMS is the effectiveness of training with EMS as a tool for improving performance in the elderly population (24), which prompts new research in the case of WB-EMS in this population should be tailored to the specific needs of this group. There is considerable evidence that low-frequency WB-EMS (less than 100 Hz) significantly increases health-related parameters in middle-aged and untrained middle-aged groups to non-athletes, the most prominent being WB-EMS. Impact on body composition, in this context sarcopenia and obesity due to sarcopenia in the elderly can be one of the most promising targets for WB-EMS use, given the

magnitude of the effects of WB-EMS, a study with men a trained middle-aged (8) reported that WB-EMS had a positive effect on body composition (ie, muscle mass and fat), muscle strength, and Cardiac and metabolic outcomes are similar to high- intensity resistance exercises that the elderly or injured cannot use so they can use WB-EMS instead of high-intensity resistance exercises, so low - frequency WB-EMS is minimized. It can be considered as a safe training technology, at least under the close supervision of a trained technician (14). The use of WB-EMS is typically done in sports or beauty centers, which take up to 20 minutes of training sessions. This is a controversial issue (18). In some studies, 20 minutes of exercise is too stressful and a sufficient period of time to increase the level of strength and physical skills resulting from it, while another study concludes that a classic 20-minute training session does not seem appropriate. The best way to improve sports skills or injury rehabilitation (6). It should be borne in mind that depending on the flow parameters, the muscle fatigue that occurs is very different (24). The use of WB-EMS is increasing in different centers, and this increase in interest is not only due to the availability of this tool, but mainly due to a personal trainer and a 2-person training (14). Given the great interest in using this tool, WB-EMS sports should always be under the supervision and guidance of a trained and up-to-date technologist to avoid the risks of overuse and Profitability, to be used (17).

Conclusion

From this study it can be concluded that the use of whole body electrical stimulation in most cases increases muscle strength and consequently increases the agonist and antagonist muscles strength and increases their support for joints and prevention of injury, but

the findings of this study indicate that further studies are needed to include populations without special needs to influence the effects produced by various parameters present in WB-EMS. A limited number of studies on WB-EMS are available. Much of the existing research has been done with specific demographic groups with special needs and is therefore often unreliable. Many existing studies lack the amount of scientific evidence needed to validate the effects of WB-EMS. Many studies have focused on body composition and fat burning, and studies on muscle strength improvement and follow-up or treatment of injury are limited, so due to the growing development of this tool and the increased interest in people using it, research is needed. There is more research into the effects of WB-EMS on the body.

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