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Research Article

Effects of Intramuscular Electrical Stimulation on Pain and Dysfunction Following Upper Trapezius Trigger Points

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ABSTRACT

Introduction: The purpose of the present study was to investigate the effects of single-session intramuscular electrical stimulation (IMES) on pain and dysfunction following active trigger points in the upper trapezius muscle.

Materials and Methods: Volunteers (30 females) with active trigger points in the upper trapezius muscle were randomly divided into two IMES and placebo groups. For the IMES group, a needle was inserted into the trigger point, and electrical stimulation was applied to generate a pain-free contraction. For the placebo group, the intervention procedure was exactly the same, but there was no electrical stimulation. Pain by visual analog scale (VAS), pain pressure threshold (PPT), range of motion (ROM), and disability by neck disability index (NDI) were assessed as main outcome measures before, immediately after, and one week after conducting intervention by another blinded researcher.

Results: The VAS scales were improved in both groups but were significantly lower in the IMES group one week after treatment. The PPT and ROM scores were substantially higher in the IMES group one week after the treatment. The NDI indexes significantly reduced for both groups, with no significant differences between them.

Conclusion: IMES effectively improves pain, PPT, ROM, and NDI, following trigger points in the upper trapezius muscle. Further studies are required to investigate the IMES's long-term effects.

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1. Introduction

Clinical disorders are divided into two articular and non-articular groups. One of the most prevalent non-articular disorders is myofascial pain syndrome (MPS) [1]. About one-third of the patients with musculoskeletal disorders meet the diagnostic criteria for this syndrome [2]. The prevalence of this disorder is up to 85% [3]. MPS is characterized by sensitive areas called trigger points [1, 4, 5]. The prevalence of these points is high; they are associated with many disorders that exacerbate and simulate symptoms [1, 6-17]. Trigger points are among disorders that are usually overlooked [18]. The most common definition for a trigger point is "a sensitive point in the muscular taut band, and painful with pressure, stretch, overload, and contraction that cause referral pain to areas away from that site" [4, 5]. The trigger points have the following side effects: pain, limited Range of Motion (ROM), motor dysfunction, cramp, muscular fatigue, and local tenderness [6, 19].

Different interventions are used for trigger point management. These interventions include manual therapy, ischemic pressure, electrical stimulation, acupuncture, magnetic therapy, ultrasound therapy, laser therapy, injection, and muscle stretch. Among these interventions, manual therapy and some physiotherapy modalities have demonstrated promising clinical results. In many cases, more research is needed to determine the effects of placebo, appropriate dosage, and long-term effects of therapies [17, 20-25]. Another popular trigger point treatment is dry needling. This intervention has been compared with other interventions. In some cases, its effect is better, and in some, it has equal or lower effects [22, 26]. Further studies are required to detect the best intervention for trigger points [17, 21, 23, 24, 26].

Another relatively new treatment to reduce muscle pain is intramuscular electrical stimulation (IMES). In some cases, the effectiveness of this intervention has been studied and held promising results [27-34]. These studies have examined the effects of this intervention on low back pain, shoulder pain, thoracic pain, and MPS. Only a few studies are available on the effectiveness of this intervention on trigger points and its placebo effects [29, 31-33]. Most of these studies lacked a control group or placebo to evaluate the effectiveness of this intervention. Thus, further studies are required in this regard. The current study investigated the effect of IMES by dry needling on pain and dysfunction caused by trigger points in the upper trapezius muscle compared with the placebo effect.

2. Materials and Methods

This research was a double-blind, randomized controlled trial. It was conducted at the University of Medical Sciences, … City, …, in 2017. The Ethics Committee of the University of Medical Sciences approved this study. All participants were aware of the nature of the study and signed informed consent. The registration number of this trial is XXXXX.

Patients recruitment

The patients with pain following trigger points in the upper trapezius muscle aged 18-40 years were enrolled in the study. The inclusion criteria were as follows: 1) active trigger points with a specific bundle in the upper trapezius muscle, 2) pain associated with trigger points greater than 3 based on the Visual Analog Scale (VAS) (moderate pain), [35], 3) an age of 18-40 years, 4) being under no treatment in the last month, 5) no history of muscle disorders including fibromyalgia and myopathy, 6) no malignancy or susceptibility to infection, 7) no neurological disorders or history of migraine, 8) no radicular pain or history of neck surgery, 9) no history of allergic reactions to acupuncture or dry needling, 10) not being pregnant, 11) not using anticoagulants, 12) no significant fear of needles, 13) no vascular disease or history of diabetes, and 14) not being a physiotherapist. Individuals were excluded from the study if they 1) had a history of muscle disorder including fibromyalgia and myopathy, 2) had malignancy or susceptibility to infection, 3) had neurological disorders or a history of migraine, 4) had radicular pain or history of neck surgery, 5) had a history of allergic reactions to acupuncture or dry needling, 6) was pregnant, 7) used anticoagulants, 8) had a significant fear of needles, 8) had vascular disease or history of diabetes 9) was a physiotherapist, 10) refused to cooperate, 11) felt discomfort, or 12) showed intolerance and abnormal reactions to the intervention.

To determine the sample size, a pilot study was performed on 8 patients with a statistical power of 90% and a confidence interval of 95%. The sample size was calculated based on pain measurement (VAS) as 15 subjects for each group.

In this study, balanced block randomization by SBT was used to allocate the volunteers. The main researcher (MH) and assessor (MB) were blind about random allocation. The patients were randomly assigned to the IMES and placebo groups. Participants were blind to random allocation.

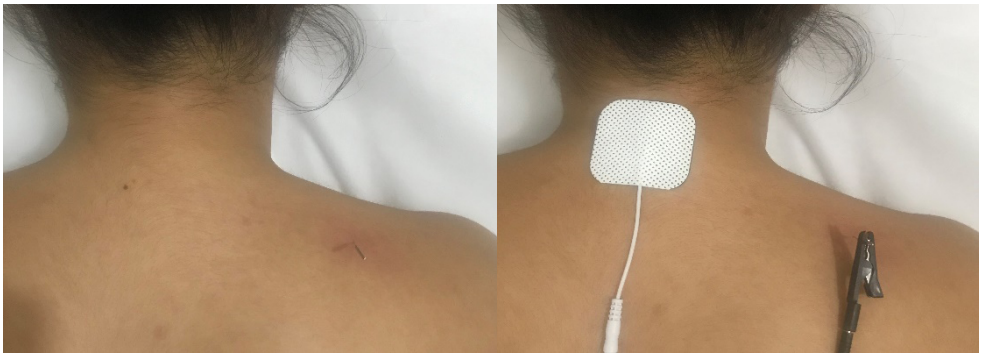

Figure 1. Intervention procedure

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A: Needle inserted toward trigger point; B: Electrical stimulation added

Intervention procedure

In the IMES group, the subjects were in the prone position, with their hands positioned adjacent to the body, their head in the midline, and a roll applied under the forehead. Then, the muscle was touched with pincer palpation, and the needle was inserted toward the trigger point and therapist's finger [36]. The cathode electrode was connected to the needle by clip electrodes, and the anode electrode was placed over the C7 spinous process with adhesive electrodes. A burst current with a frequency of 2 Hz and a pulse duration of 200 µs was added to the needle [37]. The intensity was increased to the point where painless contractions were created. The current was applied for 10 minutes [37] (Figure 1). The device used in this study (ES-160 by ITO (…)) was calibrated (Figure 2).

In the placebo group, the needle was inserted similarly to the IMES group. Electrode placement was the same as the IMES group, but the current intensity was zero. The other channel was turned on to generate current sound. The subject remained in this position for 10 minutes.

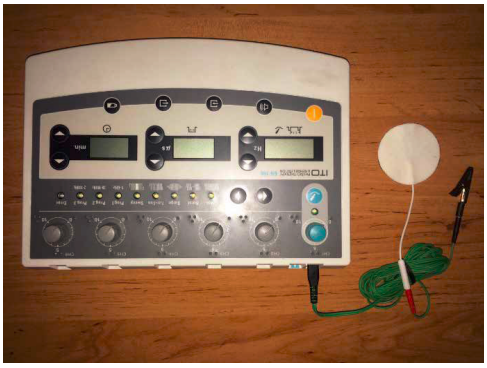

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Figure 2. Electrical stimulator device (ES-160 by ITO (2018))

Outcome measures

In this study, the severity of pain and disability were measured as primary outcome measures. Pressure pain threshold (PPT) and the active range of cervical lateral flexion were measured as secondary outcome measures by another blinded researcher. These variables were measured before, immediately after the intervention, and one week later.

The severity of pain was measured by VAS (with a 100-mm ruler). Subjects marked their pain level based on the assumption that 0 indicates no pain and 100 means the most imaginable pain. The high reliability of this tool for measuring acute pain has already been reported [29, 31, 38-40]. An algometer was used to determine PPT. Algometer was placed vertically on the trigger point, and the hen pressure was slowly increased. The subjects reported the pain onset. For more precision, the mean score of two measurements was recorded [41]. A goniometer was used to measure the ROM. For this measurement, the subjects were seated upright, and movements were taught. The goniometer axis was placed on the C7 spinous process. The fixed arm of the goniometer was perpendicular to the ground, and its flexible arm was located in the posterior midline of the skull. Each subject performed the movement, then the movable arm's degree was recorded [42]. The Neck Disability Index (NDI) was used to measure disability. This index is one of the oldest and most used tools for exploring disability [43, 44]. In this study, the … version of this tool was used. This version is a reliable and useful tool for assessing functional conditions in … speakers [45].

Statistical analysis

In this study, within-group and between-group comparisons were analyzed. The Kolmogorov–Smirnov test was used to check the normality of the data. For within-group comparisons, If data were normal, repeated measures analysis of variance (ANOVA) was used, and if data were not normal, the Friedman test was used. For between-group comparisons, ANOVA was used if the data was normal, and the Kruskal-Wallis was used if the data was not normal.

3. Results

This study was conducted in 2017 (from September 6 to October 30). Overall, 38 participants voluntarily participated in the research. Eight subjects were not included in the study (because of not meeting the inclusion criteria or refusing to participate in the intervention). Finally, 30 subjects entered the study and were randomly divided into two groups (15 females in each group) (Figure 3). The subjects' demographic data, including age and complication duration, are presented in Table 1. There was

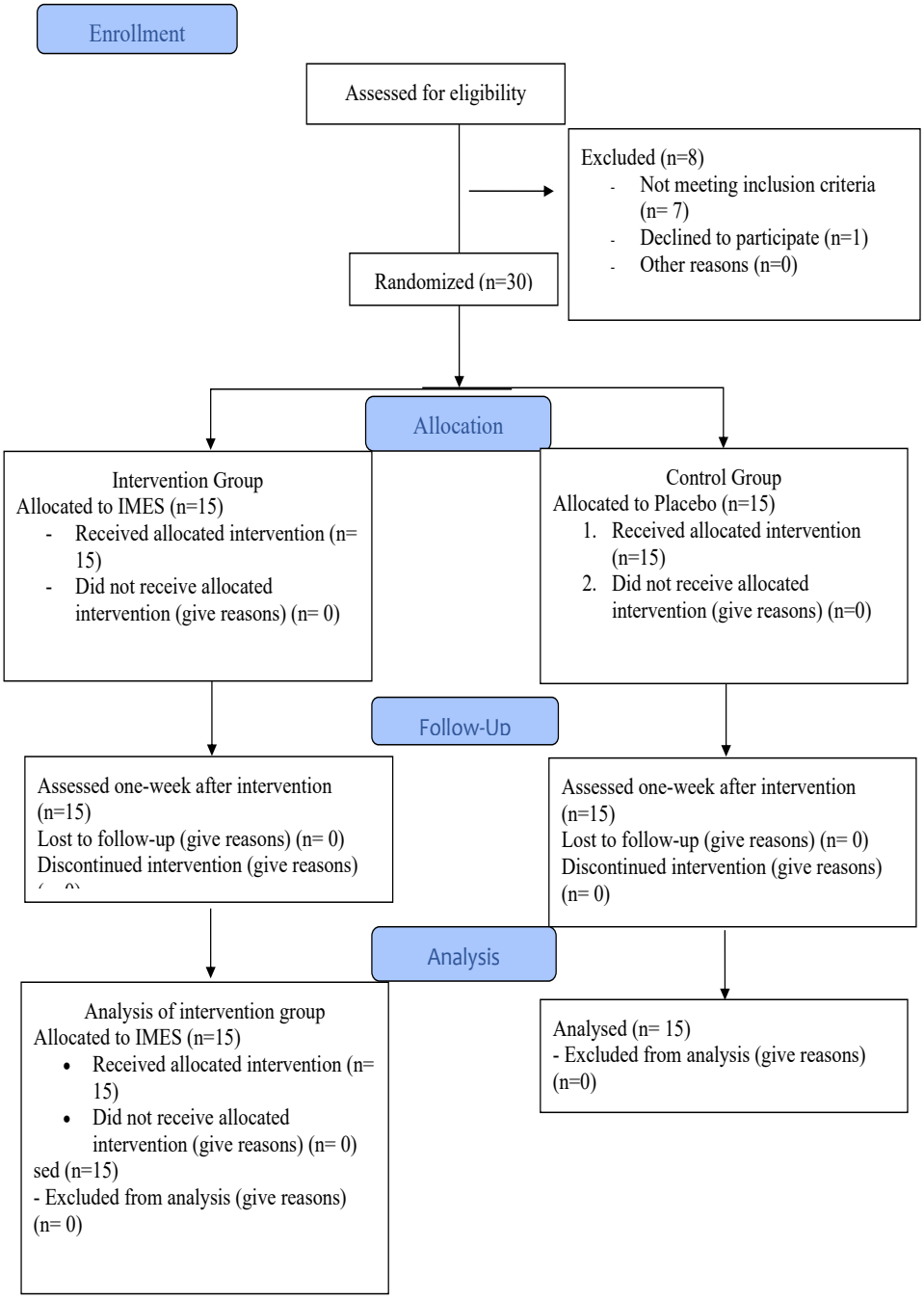

Figure 3. Flow diagram

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Table 1. Baseline characteristics of participants

Characteristics	Group	Mean±SD	Median	Min	Max	P
Age (y)	Total (30)	24.13±5.14	23	18	40	>0.05
	IMES (15)	23.33±4.93	23	18	40	
	Placebo (15)	24.93±5.39	23	20	40	
Duration of symptoms (mo)	Total (30)	19.46±17.51	12	1	60	
	IMES (15)	17.73±19.07	7	1	60	
	Placebo (15)	21.20±16.27	12	1	60	

IMES: Intramuscular electrical stimulation.

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no significant difference between the two groups regarding baseline information.

The outcome measures in both groups are listed in Table 2 for all 3 measurements before, immediately after the intervention, and one week later. There was no significant difference between the two groups in terms of outcome measures before the intervention. In both groups, all participants completed the treatment and measurement sessions.

Outcome measures in each of the three measurement steps were evaluated for each group in terms of normal distribution. The pain intensity and range of motion variables in both groups had a normal distribution. There was no normal distribution of PPT and disability in the IMES group; however, the placebo group had a normal distribution.

Pain intensity

The pain in the IMES group decreased in the triple steps of measurement, and this decrease was significant between all measurement stages (P<0.05). The pain also decreased in the placebo group. However, this difference was only significant between the two measurements before and immediately after receiving the intervention. Moreover, this decrease was not significant one week after the intervention.

There was no significant difference in pain reduction immediately after the intervention. Meanwhile, both interventions reduced the pain. However, pain reduction one week after the intervention in the IMES group was more than that in the placebo group. This difference was significant between the two groups (Table 3).

PPT

The PPT in the IMES group increased one week after the intervention. However, these changes were not significant (P>0.05) between the three measurements before, immediately after the intervention, and one week later. This variable decreased in the placebo group during measurement times; however, these changes were not significant.

Table 2. Results of within-group comparisons in imes and placebo groups (n=15)

	IMES					Placebo				
	Mean±SD			F	P	Mean±SD			F	P
	Baseline	Immediately After	One-week After			Baseline	Immediately After	One-week After		
VAS	50.33±13.65	27.13±14.83	15.40±14.07	7.26	0.00*	49.06±15.26	37.46±19.36	39.06±21.68	4.44	0.02*
PPT	10.56±3.99	10.48±2.58	12.11±4.01	-	0.16**	13.13±5.25	11.25±6.17	11.71±3.24	1.60	0.21*
ROM	27.84±5.80	31.86±6.33	33.66±4.75	9.82	0.00*	28.77±7.35	27.50±6.45	27.40±6.97	0.74	0.48*
NDI	24.52±6.77	-	13.59±8.75	-	0.00**	25.99±8.85	-	20.67±9.04	4.19	0.06*

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*Repeated measures ANOVA P-value; **Friedman test P-value; VAS: Visual analog scale; PPT: Pain pressure threshold; ROM: Range of Motion; NDI: Neck Disability Index.

Table 3. Between-group comparisons of changes immediately and one week after interventions

Variables		Mean±SD		P*
		IMES Group	Placebo Group	
VAS	Immediate changes	-23.20 (9.74)	-11.60 (12.81)	0.09
	One-week changes	-34.93 (12.57)	-10 (15.71)	0.00
PPT	Immediate changes	-.08 (2.90)	-1.88 (3.34)	0.12
	One-week changes	1.55 (2.45)	-1.41 (3.77)	0.01
ROM	Immediate changes	4.02 (4.21)	-1.26 (4.50)	0.02
	One-week changes	5.82 (5.67)	-1.36 (5.75)	0.02
NDI	One-week changes	-10.93 (7.59)	-5.31 (10.05)	0.09

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Immediate change: Immediately after intervention-Baseline; One-week change: One-week after intervention-Baseline.

*ANOVA P.

There was no significant difference between the two groups in terms of PPT changes immediately after the intervention. However, one week after the intervention, the PPT increased in the IMES group and decreased in the placebo group. Furthermore, the difference between the two groups was significant (P<0.05) (Table 3).

ROM

The cervical ROM increased in the IMES group during the three measurements. In addition, these changes were significant immediately after and one week after the intervention. The ROM in the placebo group decreased during the three measurements, but these changes were not significant (P>0.05).

The increase in the ROM immediately after the intervention was higher in the IMES group. In addition, these changes were significant compared with the placebo group (P<0.05). One week after the intervention, the ROM in the IMES group increased more than that in the placebo group, and this difference was significant between the two groups (P<0.05) (Table 3).

Disability

Disability in the IMES group decreased one week after the intervention, and these changes were significant (P<0.05). In the placebo group, disability decreased, but the changes were not significant (P>0.05).

Comparing the two groups, the disability in the IMES group decreased more than in the placebo group, but this difference was not significant between the two groups (Table 3).

4. Discussion

Pain sensation decreased in both groups. The pain reduction in the IMES group was higher than the placebo group, and this difference was significant one week after the intervention. IMES intervention was significantly more effective than the placebo in increasing the PPT one week after the intervention. The range of neck-side flexion increased in the IMES group immediately and one week after the intervention. These changes were significant in comparison with the placebo group. IMES intervention reduced disability more in one week after the intervention. However, this change was not significant in comparison to the placebo group. There were no identified harms and or unintended effects following both interventions.

The mechanisms that create trigger points cause sarcoplasmic reticulum damage and, as a result, increase calcium concentration in the area, which leads to permanent muscle fibers contraction in that area [36, 46, 47]. This contraction causes hypoxia in the affected area and leads to cellular damage that results in the release of the substance P and triggers the pain receptors [47]. Additionally, based on the integrated theory, abnormal depolarization in the postsynaptic membrane causes an energy crisis that leads to hypoxia in the affected area [18, 48]. A local twitch response eliminates the common noise in that area and indicates the inactivity of trigger points [49]. Local twitch response appears to reduce the concentration of substances around trigger points [50]. The loss of concentration of substances around the trigger points will likely be due to an increase in local blood flow in that area [51].

Like a burst current that leads to muscle contraction, electrical currents can increase the blood flow in the area and reduce the static state of blood flow [52-55]. Increasing blood flow probably reduces the concentration of substances around the trigger point and, as a result, reduces the free nerve endings of pain receptors stimulation and pain. In addition, increased circulation in the area caused by electrical stimulation can break the defective cycle and permanent contraction caused by hypoxia, resulting in decreased localized contracture of the area, which may lead to an increase in the ROM. Another possible mechanism for reducing the symptoms of IMES is that the stimulation frequencies of 2-4 Hz can release endorphins and encephalin [56]. The frequency used in this study was 2 Hz, which is probably a reason for pain relief by the effect of IMES. The release of endorphins and encephalin may have caused analgesic function in this therapeutic intervention.

Only four prior studies have investigated the effects of IMES on the symptoms of trigger points in the upper trapezius muscle [29, 31-33]. A study in 2004 by Chu et al. investigated the effects of IMES on MPS in a soccer player with low back pain. The researchers reported this intervention as potentially effective in reducing pain and increasing the ROM in patients with low back pain. The results of their study, although presented as a case report, are in line with this study [27]. Chu et al. examined the effect of this intervention on 12 patients with low back pain and reported the results of the treatment promising; however, the results were not statistically significant [28]. A study in 2008 examined the impact of this intervention on upper trapezius muscle and levator scapulae trigger points and reported positive effects of this intervention in reducing symptoms. The results of their study, although lacking a control group, are consistent with the present study results [29]. Other researchers investigated the effects of this intervention on the pain of the thoracic region, and its positive effects on pain relief were reported [30]. In 2015, another study investigated the effects of this intervention on the trigger points of the upper trapezius muscle. The researchers reported positive effects of exercise training for this intervention. Additionally, they reported positive effects for low-level laser treatments. Their results are consistent with the present study [31]. Another study reported the positive effects of this intervention on trigger points with paraspinal muscle stimulation [32]. Another case study examined the effects of this intervention on a patient with low back pain and indicated its promising results [33]. Other studies that examined the effects of this intervention on some disorders, such as MPS, knee osteoarthritis, and migraine, also reported its positive effects [34, 57, 58].

In general, in previous studies that investigated the effect of IMES on the symptoms of trigger points, three studies lacked a control group [29, 32, 33], and another study overlooked the placebo effects [31].

We investigated the effects of IMES alone on the severity of pain, the PPT, the active range of side bending of the neck, and disability due to trigger points in the upper trapezius muscle. To the best of our knowledge, this study is the first research to compare the effects of this treatment with a placebo on myofascial trigger points in the upper trapezius muscle.

Limitations

There were a few identified limitations of this study. The long-term effects of the intervention were disregarded in this study. Moreover, gender impact cannot be studied through this research since the study was conducted just on women. Finally, it was impossible to carefully monitor the quality of lifestyle of the volunteers, since there was a one-week interval between interventions and re-evaluation of the volunteers.

5. Conclusion

The obtained results of this study revealed that the IMES could be effective in reducing pain intensity, increasing ROM, and reducing disability in female patients with trigger points in the upper trapezius muscle. Further research is suggested to identify a more accurate investigation of the effects of the IMES on active trigger points. Furthermore, the most comprehensive objective measurement methods can be considered to assess the effects of the IMES on lifestyle and disability in individuals with an upper trapezius trigger point. In addition, the long-term effects of similar interventions can enhance the depth of relevant knowledge for the clinicians who work on the IMES.

Suppliers

Needle; DONG BANG medical co., LTD. Size: 0.30×50

Adhesive electrode; 40×40mm (Everyway Medical Instruments, made in Taiwan)

Electrical stimulator; ES-160 by ITO (2018)

Algometer; FG-5020 by Taiwan

Goniometer; SAEHAN Stainless Steel Goniometer.

Ethical Considerations

Compliance with ethical guidelines

This study was approved by Ethics Committee of Tehran University of Medical Sciences (Code of IR.TUMS.FNM.REC.1396.2216).

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Authors' contributions

Carried out the literature search and review, data extraction, wrote the initial draft, submitted the manuscript and coordinated revisions: Monavar Hadizadeh; Contributed to the literature search, search design and review, coordinated the appraisal, contributed to data analysis, synthesized the results, critical appraisal and manuscript revisions: Siamak Basharddoust Tajali; Contributed to the search design and review, coordinated the appraisal, and contributed to manuscript revisions: Behrouz Attarbashi Moghadam; Contributed to the search strategy, and synthesized the results: Shohreh Jalaei; Contributed to data extraction: Mahnaz Bazzaz; All authors read and approved the article.

Conflict of interest

The authors declared no conflict of interest.

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