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Literature review

The effects of transcutaneous electrostimulation in patients in the intensive care unit

Os efeitos da eletroestimulação transcutânea em pacientes na unidade de terapia intensiva

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RESUMO | INTRODUÇÃO: A fraqueza muscular adquirida em internações prolongadas é comum em cerca de 50 -80% dos pacientes onde apresentam evidências eletrofisiológicas de disfunção neuromuscular. A mobilização e a reabilitação precoce têm demonstrado melhorar os resultados funcionais e a qualidade de vida e neste contexto, a estimulação elétrica neuromuscular (NMS) tem positivas evidências auxiliando na preservação da síntese proteica e na prevenção de atrofia muscular durante o período de imobilização. **OBJETIVO:** Analisar os benefícios proporcionados pela eletroestimulação em pacientes internados na unidade de terapia intensiva. **METODOLOGIA:** Para realizar esta revisão, foi realizada uma busca nas seguintes bases de dados: SciELO, Medline, Lilacs, PEDro, PubMed e Cochrane, no período de junho a dezembro de 2018. Foram encontrados 106 artigos e 99 excluídos por não estarem de acordo com nossos descritores. No final, 7 artigos se enquadram nos critérios para a análise final. Os estudos foram selecionados primeiro pelo título, resumos e metodologias. Os critérios de inclusão dos estudos foram: comparador (es): parâmetros da EENM utilizados, força muscular e tempo de terapia por sessão, indivíduos maiores de 18 anos, homens e mulheres, necessitando de ventilação mecânica invasiva por mais de 24 horas. Estudos: Ensaios clínicos, coorte transversal, coorte longitudinal com esse tema. Não foram selecionados estudos de caso, artigos de revisão sistemática, resumos de congressos sobre o assunto, estudos fora do intervalo de tempo escolhido e outras técnicas de mobilização precoce. **RESULTADOS:** O número total de participantes incluídos nos estudos foi de 594 adultos, 323 em grupos experimentais e 271 em grupos controle, e todos os estudos investigaram os efeitos da NMS em pacientes críticos. Os estudos foram em adultos com diversos diagnósticos, houve grande variabilidade entre os protocolos NMS, número e tempo de sessão realizada. **CONCLUSÃO:** O NMS tem resultados significativos no aumento da força muscular, melhora a independência funcional, encurta o tempo de internação hospitalar, o tempo do uso de ventilação mecânica invasiva e níveis mais baixos de sedação. No entanto, ainda há necessidade de mais estudos com uma metodologia mais bem descrita para realmente investigar com mais precisão sobre o efeito isolado de NMS em pacientes críticos.

PALAVRAS-CHAVE: Estimulação elétrica transcutanea. Terapia intensiva. Fisioterapia. Mobilização precoce. Reabilitação precoce.

ABSTRACT | INTRODUCTION: Acquired muscle weakness in prolonged hospitalizations is common in approximately 50 -80% of hospitalized patients where all present electrophysiological evidence of neuromuscular dysfunction. Mobilization and early rehabilitation have been shown to improve functional results and quality of life and in this context, neuromuscular electrical stimulation (NMS) has positive evidences aiding in the preservation of protein synthesis and in the prevention of muscle atrophy during the immobilization period. **OBJECTIVE:** To analyze the benefits of electrostimulation in patients in the intensive care unit. **METHODOLOGY:** To carry out this review a search was performed in the following databases: SciELO, Medline, Lilacs, PEDro, PubMed and Cochrane, in the period from June to December 2018. 106 articles were found and 99 were excluded because they were not in accordance with our descriptors. In the end, 7 articles fit the criteria for the final analysis. The studies were selected first by the title, abstracts and methodologies. The criteria for inclusion of the studies were: comparator (es): NMS parameters used, muscle strength and therapy time per session, individuals over 18 years old, male and female, requiring invasive mechanical ventilation for more than 24 hours. Studies: Clinical trials, cross-sectional cohort, longitudinal cohort with this theme. No case studies, Systematic review articles, congress summaries on the subject, studies outside the chosen time interval, and other early mobilization techniques were selected. **RESULTS:** The total number of participants included in the studies was 594 adults, 323 in experimental groups and 271 in control groups, and all studies investigated the effects of NMS in critical patients. The studies were in adults with diverse diagnoses, there was great variability between the NMS protocols, number and time of session performed. **CONCLUSION:** The NMS has significant results in the increase of muscle strength, Improves functional independence, shortens hospital admission time, shortens time for invasive mechanical ventilation and lower levels of sedation. However, there is still a need for further studies with a better described methodology to actually investigate more accurately about the isolated effect of NMS in critical patients.

KEYWORDS: Transcutaneous electrostimulation. Intensive care. Physical therapy. Physiotherapy. Early mobilization. Early rehabilitation.

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Introduction

The acquisition of neuromuscular dysfunction after hospitalization in the intensive care unit (ICU) has been greatly described in the last decade. This dysfunction is characterized by a decrease in strength, usually associated with muscle atrophy, with acute onset, diffuse, symmetrical and generalized.It develops after the onset of a critical disease, with no other identifiable cause. Acquired ICU weakness usually manifests in the limbs with hyporeflexia or arreflexia and the preservation of the cranial nerves[1].

Critical patient neuromyopathy (CINM) is a term used for neuromuscular disorders associated with critical diseases, including critical disease polyneuropathy (PCI), critical disease myopia (MIC) and neuromuscular junction disorders[2]. The differentiation between CIP and CIM usually requires electrophysiology and / or direct muscle stimulation; Although the amplitudes of the potential of compound muscular action are reduced in both conditions, the amplitudes of the potential of action of the sensitive nerve are reduced or absent in the CIP, but normal in the CIM. In addition, creatine kinase levels are increased in about 50% of the patients with MCI, but normal in those with CIP. The MIC can also be divided into four histological subtypes: necrotizing, cachetic, acute rhabdomyolysis and loss of thick filaments.The necrotizing subtype is associated with worse prognosis.As PCI and MIC occur frequently at the same time, they are often treated as an entity: CINM.The CINM pathophysiology is complex and includes bed rest sequels, the effects of cytokine production induced by critical disease, and possibly drug interaction such as neuromuscular blockers and corticosteroids[3,12].

Neuromuscular weakness in the ICU is common approximately 50% of patients hospitalized in ICU with sepsis, multiple organ failure or prolonged mechanical ventilation present electrophysiological evidence of neuromuscular dysfunction. More than 25% of ICU patients submitted to mechanical ventilation for seven or more days present clinical evidence of weakness upon awakening, the marked diaphragmatic atrophy can be observed 18 hours after the beginning of mechanical ventilation[4]. The differential diagnosis of acquired neuromuscular weakness is broad, and includes laboratory tests, radiographic images and electromyography[5].

With the development of clear criteria and diagnoses, several forms of treatment were developed to inhibit the development of acquired ICU weakness, no medical therapy is available once the condition has developed. Neuromuscular blocking agents and corticosteroids are usually avoided to decrease the risk of weakness acquired in the IC[6]. Insulin therapy reduces the catabolic syndrome of prolonged critical disease because of its anabolic properties, including stimulation of muscle protein synthesis and attenuation of protein degradation[7]. High-dose sedatives may mask symptoms or delay the identification of acquired ICU weakness, The daily awakening with the interruption of sedative agents and the limitation of administration and dosage have beneficial results in critical patients[8].

In addition, the strategies of physical rehabilitation and prevention of acquired weakness have been a primary therapy for these patients, mainly by remedying neuromuscular deficiencies during the recovery process and the reduction of sequelae associated with unconditioning.

As rehabilitation and early mobilization in ICU has shown to improve functional results in the short term and potentially in the long term, the use of physiotherapeutic strategies to combat skeletal muscle weakness and atrophy by disuse has been exponentially promoted in the last years[9,13]. The technique performed with transcutaneous electrical stimulation (NMS), consists of generating visible muscle contractions with portable devices connected to surface electrodes, has been shown to be effective in the treatment of compromised muscles, because it has the potential to preserve muscle protein synthesis and prevent muscle atrophy during prolonged periods of immobilization[10,14]. Neuromuscular electrical stimulation (NMS) in ICU has recently been introduced for the treatment of acquired muscle weakness as it does not require active patient cooperation, has an acute beneficial systemic effect on muscle microcirculation and seems to provide some structural and functional benefits for critical patients[11,14].

Although early active muscle training can alleviate this weakness acquired in the intensive care unit, in the early stages of critical disease, a large proportion of patients are unable to participate in any active mobilization.The NMS can be an alternative strategy for muscle training[9,13,14].

The objective of this study is to evaluate the major benefits of transcutaneous electrostimulation in critically ill patients in intensive care unit evaluating the increase in muscle strength, functional independence, decreased hospitalization, mechanical ventilation and sedation.

Methodology

Review study on the use of transcutaneous electrostimulation as part of the early mobilization of inpatients in ICU. In order to carry out this review, the following question was used: What are the benefits of using NTMS in critical patients in the intensive care unit?

Three researchers were independently selected to search for all titles and abstracts of the article, according to the guidelines for systematic review of Preferred Reporting items for Systematic Reviews and Meta-Analyses (PRISMA). Then, articles considered relevant were acquired in full text for evaluation, thus identifying those eligible.

A form was developed divided into 13 stages on the general information of the respective studies: Author/ Year; the type of study; population; age group; cause of ICU admission; IOT; Early Mobilization and Mobilization Early Rehabilitation and Rehabilitation EENM; the parameters used; Time of use; Time of IOT; Conclusion of the Study. After data extraction, they were grouped in tables to allow the specification of items to facilitate the comparative analysis of the studies favoring the identification of the variability between them.

The initial search strategy, considering the databases CINAHL, EMBASE, Medline (PubMed), The Cochrane Library, SciELO, PEDro and Lilacs, selected studies for evaluation clinical trials, cross- sectional cohort, longitudinal cohort with this theme, in Portuguese, English and Spanish. Case studies, literature review, conference abstracts on the subject, out of time studies and other early mobilization techniques were not selected, The search returned 106 titles and summaries. The first examiner identified six possible articles, and the second identified four. After reading the summaries, the ten articles were selected for reading in full, being included in this review, a meta-analysis was not possible due to the heterogeneity of the included studies. The descriptors used were: Transcutaneous Electric, Intensive Care, Respiration, randomized Controlled trial, Physical Therapy, Physiotherapy.

Results

A total of 7 articles, performed between 2007 and 2018, were included. The total number of participants included in the studies was 594 adults, 323 in experimental groups and 271 in control groups, the number of weekly sessions ranged from two to seven sessions per week, with a minimum estimated time of 10 minutes and a maximum of 1 hour, ranging from one to twice a day, and all studies investigated the effects of transcutaneous electrostimulation in critical patients.

The intervention time varied from June 2007 to July 2017, the participants included in the studies were adults with differentiated diagnoses, ranging between cardiac, respiratory, renal, metabolic and musculoskeletal pathologies, with varying severity and sequel, aged between 18 and 65 years. The eligibility criteria involved different conditions of mechanically ventilated patients such as: > 24 hours in mechanical ventilation, septic patients, pre and postoperative heart surgery, heart failure, melitus diabetes decompensation, septic shock, acute or chronic renal failure and trauma.

The evaluations and interventions varied among the studies, but always divided into control group and experimental group by randomization. Peripheral electrostimulation occurred in all selected articles, with different exercises and protocols (Table 1).

Discussion

The transcutaneous electrical stimulation has been the target of several studies published in recent years, including several types of protocols, being used in muscles of lower limbs or diaphragm, associated with rehabilitation sessions. However, the lack of consensus between the parameters used makes possible comparisons more difficult. In addition, many authors correlate transcutaneous electrical stimulation with beneficial effects in the period of rehabilitation of the critical patient.

With regard to the protocols of electrostimulation exercises, the studies approached stimulation in the muscular region of quadriceps, only two of the studies used stimulation in muscles associated with quadriceps, one being in brachial biceps and the other in diaphragm both using the Fes modality[15,16]. Rodriguez 2012[15], used the transcutaneous electrostimulation protocol in brachial biceps and quadriceps, conducted the study with fourteen patienst, using a frequency of 100 Hz, pulse width of 300 us, time on 2 seconds, time off 4 seconds, Variing the sessions between 30 and 60 minutes[15]. Leite 2018[16], performed the NMS in quadriceps and diaphragm, conducted the study with sixty- seven patienst, using a frequency of 50 Hz, time on 8 seconds and time off 30 seconds in muscle quadriceps, and time on 1 second and time off 20 seconds in diaphragm, lasting 45 minutes[16].

Two studies approached electrostimulation only in an experimental group, in the Medrinal 2018[17] nineteen patients used four early rehabilitation techniques. The sessions were arranged ten minutes of exercise on the bed: ten minutes of passive exercises to legs, ten minutes of electrical stimulation in quadriceps, ten minutes of passive ergometric bicycle and ten minutes of cycling plus FES using a frequency of 35 Hz, pulse width of 300 us, for 20 minutes, not describing the on and off time used, with therapy lasting fifty minutes twice a day during the week[17]. In Rodriguez 2012[15], study fourteen patients used muscle electrostimulation in brachial biceps, where the electrodes were positioned in the medial portion of the muscle and in the motor point, and in the quadriceps muscle was utilized the same positioning, the therapy was performed in only one hemibody, and the patient was its own control group against lateral, two daily sessions lasting between thirty and sixty minutes were used during all days of the week[15].

In the study conducted by Fossat 2018[18], two hundred of forty-five patients were randomly divided into two groups, in the experimental group (n= 125) conventional physiotherapy (FC) was performed it being a fifteen-minute session of exercise in the bed in an ergometer cycle plus a fifty-minute electrical stimulation session in the quadriceps muscle, not describing the nms parameters used, in the control group (n= 120) conventional physiotherapy was performed, Both therapies were performed once a day throughout the week[18].

Sixty-seven patients were selected in the study of Leite 2018[16], where they were divided into three random groups, and a control group (n= 26) that received conventional physiotherapy twice a day weekly, the experimental group was subdivided into quadriceps group (n= 24) which in addition to conventional therapy received once daily electrostimulation in the quadriceps muscle, with the positioning of one of the channels in the medial portion, and the other canal in the lateral and rectus femoral region. The diaphragm group (n= 17) also received conventional physiotherapy plus electrostimulation in the diaphragm muscle once a day, lasting forty-fiveminutesaweek[16].

In the study of Cerqueira 2018[19], fifty-nine patients were divided into experimental groups (n=26) who underwent conventional physiotherapy plus electrostimulation in the quadriceps and gastrocnemic muscles in the postmarketing periodimmediate surgery, using a frequency of 50 Hz, pulse width of 400 us, time on 3 seconds, time off 3 seconds, for 30 minutes they were submitted twice a day, totaling ten sessions per patient. The control group participants (n=33) received regular physiotherapeutic care twice a day[19].

Dos Santos 2018[20], conducted a study with thirty-three participants, where they were divided into four groups, the control group (n= 7) received care of passive mobilization, stretching and positioning, the exercise group (n=9) performed active exercises- assisted, active exercises and exercises resisted with elastic, from the main muscle groups, the group of electrostimulation (n=8) had two electrodes positioned in each muscle being: femoral rectum, vastlateral, vast medial, using the following parameters, frequency 45 Hz, pulse width 400us, time in 8 seconds, time in 6 seconds, for 55 minutes. The group of combined therapies (n=9) used the electrostimulation techniques and active exercises simultaneously, all groups performed the activities twice a day, weekly[20].

In the study of Koutsioumpa 2018[21], eighty patients participated in the study, being the experimental group (n=38) where they performed daily conventional physiotherapy for forty-five minutes plus electrostimulation in the quadriceps muscle for sixty minutes, using a frequency 50 Hz, pulse width 500us, not describing the on and off time used, while the control group (n=42) received only conventional physiotherapy, Both groups started the study from the 4th day of hospitalization.

As regards the results observed in the studies, the patients who participated in the experimental groups presented superior effects on the outcomes analyzed as compared to the control groups. The performance of the ergometric bicycle plus FES, increased cardiac output and produced sufficient intensity of muscle work to constitute an effective intervention of early rehabilitation[17], in addition to increased muscle strength stimulated, functional independence, and length of[15,16] and decreased duration of mechanical ventilation and sedation[20].

Of the seven studies, only three showed no significant improvement in comparison between control and experimental groups[18], observed improvement in functional independence in daily life activities, without increased muscle strength[19] on the other hand, did not observe any significant difference between the groups in relation to the distance covered on TC6, walking speed, muscle strength, functional independence and quality of life, is justified by the short stay of patients in hospital[21] concluded that electrostimulation had no significant impact on myopathy in critical patients. In summary, in a total of seven articles, four obtained significant results in the experimental group[15,17,20] and three articles did not achieve equivalent improvements by both groups[18,19,21]. The studies presented important limitations, as to the used electrostimulation protocols, different muscle groups, different NMS parameters, time of therapy, and frequency of sessions, thus obtaining different results.

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Table 1 (to be continued)

AUTHOR/YEAR	TYPE OF STUDY	METHOD OF ASSESSMENT	POPULATION	AVERAGE AGE AGE RANGE	CAUSE OF ADMISSION UTI	MECHANICAL VENTILATION SYSTEM	PROTOCOLS USED	FREQUENCY	WIDTH OF THE WRIST	TIME ON/OFF	TIME OF USE	STIMULATED MUSCLE	CONCLUSION OF THE STUDY
Medrinal, C. et al 2018	Randomised and controlled crossover study conducted in an 18-bed ICU	Cardiac output during exercise, being measured at the beginning and every 3 minutes during exercise using cardiac Doppler ultrasound.	Men (13) Women (6)	65,3 years	Pneumonia; sepsis; COPD exacerbation; Heart Failure; Drug Overdose; Intra-abdominal sepsis with surgery	Over 24h in VM pressure support and Ramsay 4	4 sessions of 10 min of exercise on the bed: 10 min of MMII passive exercises; 10 min of electric stimulation of the quadriceps, 10 min of passive ergometric bicycle and 10 min of cycling FES	35 HZ	300 US	NOT DESCRIBED	20 MINUTES	Quadriceps	FES-associated cycling increased cardiac output for effective early rehabilitation intervention
Fossat, G. et al 2018	Randomised clinical trial of a single centre with adult ICU patients in a 1100-bed hospital in France.	Overall muscle strength evaluated by the Medical Research Council's classification system (MRC); Functional autonomy evaluated by the UTI Mobility Scale.	Men accounted for 65% of those involved.	66 years	Chronic arterial hypertension, type II diabetes; Alcoholism; Chronic Respiratory insufficiency; COPD; Immunocompromised conditions.	Between 48h to 72h VM	FC (a 15-minute session of exercise in the bed) in an ergometer cycle + a 50-minute electrical stimulation session of the muscles of the quadriceps.	NOT DESCRIBED	NOT DESCRIBED	NOT DESCRIBED	50 MINUTES	Quadriceps	Early mobilization exercises and electrical stimulation of quadriceps muscles did not improve overall muscle strength at ICU discharge.
Rodriguez, P.O et al 2012	Randomised clinical trial with septic patients who needed VM	Brachial biceps thickness in the midline using a 7.5-MHz linear ultrasound transducer. Bending force of the forearm and knee extension using MRC	Men (7) Women (7)	72 years	Infections of the respiratory and abdominal tract.	Above 24h in VM	2 daily sessions of EENM in the biceps brachial and vast medial (quadriceps) unilateral.	100 HZ	300 US	ON 2 SEG/ OFF 4 SEG	30 TO 60 MINUTES	Brachial biceps and Quadriceps	The EENM increased the muscle strength of quadriceps
Leite, M.A. et al 2018	A randomized prospective pilot study was conducted in individuals admitted to the 14-bed adult ICU of the Western Paraná University Hospital	Peripheral muscle strength (MRC); Respiratory muscle strength (manovacuometer); Functional independence (ADL and FSS-ICU)	Men (53); Women (14)	44,16 years	Head trauma; Emergency surgery and electives.	Above 24h in VM	FC 2X/day ; Group quadriceps + FC once daily + one daily EENM session ; Diaphragm group + FC once daily + one daily EENM session	50 HZ	NOT DESCRIBED	ON 8 SEG/ OFF 30 SEG(QUADRICEPS) ON 1 SEG/ OFF 20 SEG (DIAPHRAGM)	45 MINUTES	Quadriceps and diaphragm	NMCE increased peripheral muscle strength and functional independence, decreasing hospital stay time compared to the control group

Table 1 (conclusion)

Cerqueira, T.C.F. et al	Randomised, parallel, controlled clinical trial, in adult patients in the preoperative period following reconstruction and / or replacement of the heart valve.	Six-minute walk test (TC6); 10-meter Walk Speed Test; MRC; MIF and NHP	men and women	55,5 years	Heart valve reconstruction and / or replacement or replacement of bioprostheses	Above 24h in VM	FC 2x/day. FC + EENM quadriceps muscle and gastrocnemic, bilaterally, 2x/day.	50 HZ	400 US	ON 3 SEG/ OFF 9 SEG	30 MINUTES	Quadriceps	There was no statistically significant difference between the groups
Dos Santos F.V. et al 2018	Um ensaio clínico aleatório duplamente cego em UTI de um hospital terciário	RASS; Glasgow Coma Score; Duration in VM (counted from admission up to 48 hours after extubation without need of vm).	Men accounted for 69% of those involved.	53,2 years	Acute pulmonary injury; Pneumonia; sepsis; Vascular encephalic accident	Less than 72h in VM	FC 2x/day; Assisted Active Exercises - Active Exercise + Resistant Exercise with Theraband, twice a day; Exercise Group + EENM (N= 9) Active MMII + EENM in the Femoral Rectal Muscle, vast lateral and vast medial 2x/daily with a period of 55 minutes.	45 HZ	400 US	ON 8 SEG/ OFF 6 SEG	55 MINUTES	Quadriceps	Less duration of VM and duration sedation compared to conventional treatment
Koutsioumpa, E. et al;	Randomised controlled clinical trial at the General Hospital in Larissa, Greece.	Incidence of histologically diagnosed myopathy; CRM; Duration of mechanical ventilation; Length of permanence in ICU	men and women	Older than 18 years	Neurosurgeries, pneumonia, septic shock, COPD, heart failure, Diabetes mellitus	above 96 hours in VM and stay in ICU	FC daily for 45 minutes; FC daily for 45 minutes + EENM in muscle quadriceps for 60 minutes.	50 HZ	500 US	NOT DESCRIBED	60 MINUTES	Quadriceps	Higher MRC in the EENMS group compared to the control group, but no difference was observed in the incidence of myopathy.

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Conclusion

Transcutaneous electric neuromuscular stimulation has significant results in increasing muscle strength, improving functional independence, decreasing hospital stay time, decreases time in invasive mechanical ventilation and lower levels of sedation. There is no doubt that there is a need for studies with a better described methodology to investigate in fact more accurately about the effect of transcutaneous electrical estimulation isolated in critical patients.

Author contributions

Nascimento JMR and Moraes AV participated in the study conception and design, interpretation of the results, writing of the scientific article. Costa JS participated in the literature review, study design, data analysis, interpretation of results, and writing of the scientific article.

Competing interests

No financial, legal or political competing interests with third parties (government, commercial, private foundation, etc.) were disclosed for any aspect of the submitted work (including but not limited to grants, data monitoring board, study design, manuscript preparation, statistical analysis, etc.).

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