A.U.FIRE WHITE PAPER

NEURO MUSCULAR ELECTRICAL STIMULATION

What is it, and is it safe?

EXECUTIVE SUMMARY

1. The purpose of this paper is to underline the safety of NMES with the help of peer-reviewed studies to demonstrate the medical community's confidence in NMES (Neuromuscular Electrical Stimulation).

2. NMES is a form of electrical stimulation that has an extremely small current but is strong enough to cause muscles to contract fully involuntarily.

3. Its primary use has been in orthopedics and sports medicine to strengthen weakened muscles after surgery and treat and condition muscles of paralyzed patients.

4. The FDA considers NMES to be inherently safe but cautions it is not to be used on a pregnant woman's abdomen, on the neck, on the skull, in the presence of cancer, or on someone with a cardiac pacemaker.

5. NMES is safe for critically Ill, feeble, and vulnerable patients as proven by 6 studies. It:

- Prevents muscle wasting in critically ill, comatose patients
- Increases muscle protein synthesis in elderly type 2 diabetic men
- Prevents intensive care unit-acquired weakness in chronic obstructive pulmonary disease patients with mechanical ventilation
- Shows recovery in Patients with Severe COVID-19 Associated with Sepsis and Septic Shock
- Shows motor recovery in pediatric neurological conditions.

6. It is safe for Cardiac patients as it is applied immediately after cardiovascular surgery and is feasible in patients with acute heart failure.

7. It does not show any change in hemodynamic parameters, and it did not induce arrythmia or changes in blood fluidity and sublingual microcirculation after 20 minutes NMES session on 19 healthy individuals.

8. It is safe to be used on elite athletes, it shows:

- Recovery after intensive, muscle-damaging, maximal speed training in professional team sports players
- Recovery from intensive training in professional team sports players with the particular application during sleep and travel.

9. It is safe to be administered in time under tension training (TUT) as NMES can be applied eccentric training.

10. It can be safely administered to increase voluntary muscle strength after spinal cord injury.

11. NEMS is safe and effective for Muscle Atrophy Prevention and Recovery in Orthopedic Patients and for Enhancing Muscle Hypertrophy in Resistance Training Programs.

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NEURO-MUSCULAR ELECTRICAL STIMULATION (NMES)

What is it, and is it safe?

The following NMES Studies were compiled by Robert C. Batters, a Registered Physical Therapist (Retired) with 40 years of experience in electrical stimulation modalities. Robert has been awarded three U.S. Patents, two of which are garment electrode stimulation units used by the NFL and MLB. Robert has also traveled internationally to lecture on medical modalities for the U.S. State Dept.

"I Robert C. Batters, endorse without reservation the products of AUFIRE"

Purpose

The purpose of this paper is to underline the safety of NMES. The following studies in this paper describe NMES and a list of peer-reviewed studies demonstrating the medical community's confidence in NMES.

Electricity has been used in medicine for many years in pacemakers, hearing aids, and small-handheld stimulators used to control pain and reduce muscle atrophy.

•NMES is a form of electrical stimulation that has an extremely small current, but is strong enough to cause muscles to contract fully involuntarily.

•NMES' primary use has been in orthopedics and sports medicine to strengthen weakened muscles after surgery and treat and condition muscles of paralyzed patients

The FDA considers NMES to be inherently safe, but cautions it is not to be used on a pregnant woman's abdomen, on the neck, on the skull, or in the presence of cancer, or on someone with a cardiac pacemaker.

NOTE

Important information in this report related to NMES safety is highlighted in RED for a quicker read, and blue hyperlinks are included to take you directly to the original referenced medical studies.

SECTION NO. 1

“NMES is safe for critically Ill, feeble, and vulnerable patients”

STUDY NO. 1:

Segers, J., Hermans, G., Bruyninckx, F., Meyfroidt, G., Langer, D., & Gosselink, R. (2014). Feasibility of neuromuscular electrical stimulation in critically ill patients. Journal of critical care, 29(6), 1082–1088. https://doi.org/10.1016/j.jcrc.2014.06.024

Abstract

Objective: Critically ill patients often develop intensive care unit-acquired weakness. Reduction in muscle mass and muscle strength occurs early after admission to the intensive care unit (ICU). Although early active muscle training could attenuate this intensive care unit-acquired weakness, in the early phase of critical illness, a large proportion of patients are unable to participate in any active mobilization. Neuromuscular electrical stimulation (NMES) could be an alternative strategy for muscle training. This study aimed to investigate the safety and feasibility of NMES in critically ill patientscritically ill patients.

Conclusion

Critically ill patients having sepsis, edema, or receiving vasopressors were less likely to respond to NMES with an adequate quadriceps contraction. Neuromuscular electrical stimulation is a safe intervention to be administered in the ICU.

STUDY NO. 2:

NMES prevents muscle wasting in critically ill, comatose patients.

Dirks, M. L., Hansen, D., Van Assche, A., Dendale, P., & Van Loon, L. J. C. (2014, November 28). *Neuromuscular electrical stimulation prevents muscle wasting in critically ill comatose patients.* Portland Press. Retrieved December 31, 2022, from https:// portlandpress.com/clinsci/article-abstract/128/6/357/71035/Neuromuscular- electrical-stimulation-prevents?redirectedFrom=fulltext

Abstract

Critically ill, fully sedated patients, in the intensive care unit (ICU) experience substantial skeletal muscle loss. Consequently, the survival rate is reduced, and full recovery after awakening is compromised.

Neuromuscular electrical stimulation (NMES) represents an effective method to stimulate muscle protein synthesis and alleviate muscle disuse atrophy in healthy subjects. We investigated the efficacy of twice-daily NMES to alleviate muscle loss in six fully sedated ICU patients admitted for acute critical illness [n=3 males, n=3 females; age 63 ± 6 y; APACHE II (Acute Physiology and Chronic Health Evaluation II) disease-severity-score: 29 ± 2].

Conclusion

NMES represents an effective and feasible interventional strategy to prevent skeletal muscle atrophy in critically ill, comatose patients.

STUDY NO. 3:

NMES increases muscle protein synthesis in elderly type 2 diabetic men

Wall, B. T., Sciences, D. of H. M., Dirks, M. L., Verdijk, L. B., Snijders, T., Hańsen, D., Hospital, J., Vranckx, P., Department of Cardiac Intensive Care and Interventional Cardiology, Burd, N. A., Dendale, P., Loon, L. J. C. van, N, A., H, A., K, A., H, A., L, B., P, B., M, B., ⋯ Wall*, B. T. (2012, September 1). Neuromuscular electrical stimulation increases muscle protein synthesis in elderly type 2 diabetic men. American Journal of PhysiologyEndocrinology and Metabolism. Retrieved December 31, 2022, from https://journals.physiology.org/doi/full/10.1152/ajpendo.00138.2012

Abstract

Physical activity is required to attenuate the loss of skeletal muscle mass with aging. Short periods of muscle disuse, due to sickness or hospitalization reduce muscle protein synthesis rates, resulting in rapid muscle loss. The present study investigates the capacity of neuromuscular electrical stimulation (NMES) to increase in vivo skeletal muscle protein synthesis rates in older type 2 diabetes patients. In conclusion, this is the first study to show that NMES directly stimulates skeletal muscle protein synthesis rates in vivo in humans.

Conclusion

NMES likely represents an effective interventional strategy to attenuate muscle loss in elderly individuals during bed rest and/or in other disuse states.

STUDY NO. 4:

Effect of NMES on prevention of intensive care unit-acquired weakness in chronic obstructive pulmonary disease patients with mechanical ventilation

Chen S;Jiang Y;Yu B;Dai Y;Mi Y;Tan Y;Yao J;Tian Y; (no date) [effect of transcutaneous neuromuscular electrical stimulation on prevention of Intensive Care Unit-acquired weakness in chronic obstructive pulmonary disease patients with mechanical ventilation], Zhonghua wei zhong bing ji jiu yi xue. U.S. National Library of Medicine. Available at: https://pubmed.ncbi.nlm.nih.gov/31315728/(Accessed: March 16, 2023).

Abstract

Objective: To evaluate the effect of transcutaneous neuromuscular electrical stimulation's effect on preventing intensive care unit-acquired weakness (ICU-AW) in chronic obstructive pulmonary disease (COPD) patients with mechanical ventilation

Conclusion

Transcutaneous neuromuscular electrical stimulation can effectively improve the muscle strength of COPD patients with mechanical ventilation and reduce the incidence of ICU-AW.

STUDY NO. 5:

NMES in Patients with Severe COVID-19 Associated with Sepsis and Septic Shock

Righetti, R. F., Grams, S. T., Costa, W. N. da S., Saraiva, L. T., de Saĺles, I. C. D., & Yamaguti, W. P. (2022, February 16). Neuromuscular electrical stimulation in patients with severe COVID-19 associated with sepsis and Septic shock. Frontiers in medicine. Retrieved December 31, 2022, from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8888402/

Abstract

Objective: Evaluate the effects of intervention with NMES on muscle mass and functionality of patients with severe COVID-19 associated with sepsis and septic shock.

Conclusion

Rehabilitation with NMES showed improvement in muscle strength and functionality of patients in this case series with a potential protective effect on muscle mass loss in patients with critical COVID-19 associated with sepsis and septic shock.

STUDY NO. 6:

NMES for motor recovery in pediatric neurological conditions

Neuromuscular electrical stimulation for motor ⋯ – wiley online library. (n.d.). Retrieved December 31, 2022, from https://onlinelibrary.wiley.com/doi/10.1111/dmcn.14974

Abstract

Objective: To explore the breadth of pediatric neurological conditions for which neuromuscular electrical stimulation (NMES) has been studied.

Interpretation: All 35 studies concluded that NMES was well-tolerated, and most studies suggested that NMES could augment traditional therapy methods to improve strength.

Outcome measurements were heterogeneous. Further research on NMES with larger, randomized studies will help clarify its potential to improve physiology and mobility in pediatric patients with neuromuscular conditions.

What this paper adds is that Neuromuscular electrical stimulation (NMES) appears to be tolerated by pediatric patients. NMES shows potential for augmenting recovery in pediatric patients with various rehabilitation needs.

SECTION NO. 2

“Two Studies showing NMES is safe for Cardiac patients”

STUDY NO. 1:

Feasibility of neuromuscular electrical stimulation immediately after cardiovascular surgery (Article)

Iwatsu, K., Yamada, S., Iida, Y., Sampei, H., Kobayashi, K., Kainuma, M., & Usui, A. (2015). Feasibility of Neuromuscular Electrical Stimulation Immediately After Cardiovascular Surgery. Archives of Physical Medicine and Rehabilitation, 96(1), 63–68. https://doi.org/10.1016/j.apmr.2014.08.012

Abstract

Objective: To determine the safety and feasibility of neuromuscular electrical stimulation (NMES) from postoperative days (PODs) 1 to 5 after cardiovascular surgery. Results: Sixty-eight of 105 eligible patients participated in this study. Sixty-one (89.7%) of them completed NMES sessions. We found no patients who had excessive changes in systolic blood pressure, increased heart rate, or pacemaker malfunction during NMES. The incidence of atrial fibrillation during the study period was 26.9% (7/26) for coronary artery bypass surgery, 18.2% (4/22) for valvular surgery, and 20.0% (4/20) for combined or aortic surgery. No sustained ventricular arrhythmia or ventricular fibrillation was observed.

Conclusion

The results of this study demonstrate that NMES can be safely implemented even in patients immediately after cardiovascular surgery.

STUDY NO. 2:

NMES prevents muscle wasting in critically ill, comatose patients.

Kondo, T., Yamada, S., Tanimura, D., Kazama, S., Ishihara, T., Shimojo, M., Iwata, E., Kondo, S., Hiraiwa, H., Kato, T., Sano, H., Awaji, Y., Okumura, T., & Murohara, T. (2019). Neuromuscular electrical stimulation is feasible in patients with acute heart failure. ESC Heart Failure, 6(5), 975–982. https://doi.org/10.1002/ehf2.12504

Abstract

Aims: : In acute heart failure (AHF), immobilization is caused because of unstable haemodynamics and dyspnoea, leading to protein wasting. Neuromuscular electrical stimulation (NMES) has been reported to preserve muscle mass and improve functional outcomes in chronic disease. NMES may be effective against protein wasting frequently manifested in patients with AHF; however, whether NMES can be implemented safely without any adverse effect on haemodynamics has remained unknown. This study aimed to examine the feasibility of NMES in patients with AHF.

Conclusion

The present findings demonstrate that NMES can be safely implemented in patients with Acute Heart Failure during the early phase of hospitalization. NMES to patients with AHF under mechanical support of hemodynamics or manifesting severe myocardial electrical instability will be the subject of the future study.

SECTION NO. 3

“AUFIRE while EKG and Cardio Sonogram test conducted simultaneously”

STUDY NO. 1:

Effects of whole-body neuromuscular electrical stimulation device on hemodynamics, arrhythmia, and sublingual microcirculation

Hoshiai, M., Ochiai, K., Tamura, Y., Tsurumi, T., Terashima, M., Tamiya, H., Maeno, E., Mizuguchi, S., Tomoe, T., Kawabe, A., Uema, A., Ueno, A., Sugiyama, T., Horie, Y., Sugimura, H., Koike, R., & Yasu, T. (2021). Effects of whole-body neuromuscular electrical stimulation device on hemodynamics, arrhythmia, and sublingual microcirculation. Heart and Vessels, 36(6), 844–852. https://doi.org/10.1007/s00380-020-01755-1

Abstract

Neuromuscular electrical stimulation has been used to treat cardiovascular diseases and other types of muscular dysfunction. A novel whole-body neuromuscular electrical stimulation (WB-NMES) wearable device may be beneficial when combined with voluntary exercises. This study aimed to investigate the safety and effects of the WB-NMES on hemodynamics, arrhythmia, and sublingual microcirculation. The study included 19 healthy Japanese volunteers, aged 22–33 years, who were not using any medication. Electrocardiogram (ECG), echocardiography, and blood sampling were conducted before a 20-min WB-NMES session and at 0 and 10 min after termination of WB-NMES. Their tolerable maximum intensity was recorded using a numeric rating scale. Arrhythmia was not detected during neuromuscular electrical stimulation or during 10 min of recovery. Blood pressure, heart rate, left ventricular ejection fraction, and diastolic function remained unchanged; however, mild mitral regurgitation was transiently observed during WB-NMES in a single male participant. A decrease in blood glucose and an increase in blood lactate levels were observed, but no changes in blood fluidity, sublingual microcirculation, blood levels of noradrenaline, or oxidative stress were shown. WB-NMES is safe and effective for decreasing blood glucose and increasing blood lactate levels without changing the blood fluidity or microcirculation in healthy people.

Conclusion

WB-NMES applied to healthy young individuals with the tolerable maximum intensity for 20 min significantly decreased blood glucose and increased blood lactate level; however, it did not change hemodynamic parameters, and it did not induce arrhythmia or changes in blood fluidity and sublingual microcirculation. The effects of combining resistant training and/or stretching with WB-NMES should be clarified in future studies. In addition, safety and efficacy of WB-NMES in patients with chronic heart disease or chronic respiratory failure should be examined.

SECTION NO. 4

“Two Studies of NMES Safety used on the elite athletes””

STUDY NO. 1:

The impact of NMES on recovery after intensive, muscle damaging, maximal speed training in professional team sports players

Taylor, T., West, D. J., Howatson, G., Jones, C., Bracken, R. M., Love, T. D., Cook, C. J., Swift, E., Baker, J. S., & Kilduff, L. P. (2015). The impact of neuromuscular electrical stimulation on recovery after intensive, muscle damaging, maximal speed training in professional team sports players. Journal of Science and Medicine in Sport, 18(3), 328–332. https://doi.org/10.1016/j.jsams.2014.04.004

Abstract

Objectives: During congested fixture periods in team sports, limited recovery time and increased travel hinder the implementation of many recovery strategies; thus, alternative methods are required. We examined the impact of a neuromuscular electrical stimulation device on 24-h recovery from an intensive training session in professional players.

Design: Twenty-eight professional rugby and football academy players completed this randomized and counter-balanced study on two occasions, separated by seven days

Conclusion

Neuromuscular electrical stimulation improves recovery from intensive training in professional team sports players. This strategy offers an easily applied recovery strategy which may have particular application during sleep and travel.

STUDY NO. 2:

Similar Recovery of Maximal Cycling Performance after Ischemic Preconditioning, NMES or Active Recovery in Endurance Athletes

Paradis-Deschênes, P., Lapointe, J., Joanisse, D. R., & Billaut, F. (2020). Similar Recovery of Maximal Cycling Performance after Ischemic Preconditioning, Neuromuscular Electrical Stimulation or Active Recovery in Endurance Athletes. Journal of Sports Science & Medicine, 19(4), 761–771. https://pubmed.ncbi.nlm.nih.gov/33239951/

Abstract

This study investigated the efficacy of ischemic preconditioning (IPC) on the recovery of maximal aerobic performance and physiological responses compared with commonly used techniques. Nine endurance athletes performed two 5-km cycling time trials (TT) interspersed by 45 minutes of recovery that included either IPC, active recovery (AR) or neuromuscular electrical stimulation (NMES) in a randomized crossover design.

Conclusion

We interpreted these findings to suggest that IPC is as effective as AR and NMES in enhancing muscle blood volume, metabolic by-product clearance, and maximal endurance performance. IPC could therefore complement the athlete’ s toolbox to promote recovery.

SECTION NO. 5

“NMES is safe for Time under Tension Training”

STUDY NO. 1:

Eccentric training combined to neuromuscular electrical stimulation is not superior to eccentric training alone for quadriceps strengthening in healthy subjects: a randomized controlled trial

Gomes da Silva, C. F., Lima e Silva, F. X. de, Vianna, K. B., Oliveira, G. dos S., Vaz, M. A., & Baroni, B. M. (2018). Eccentric training combined to neuromuscular electrical stimulation is not superior to eccentric training alone for quadriceps strengthening in healthy subjects: a randomized controlled trial. Brazilian Journal of Physical Therapy, 22(6), 502–511. https://doi.org/10.1016/j.bjpt.2018.03.006

Abstract

Objectives: To compare the effects of eccentric training combined to NMES and eccentric training alone on structure, strength, and functional performance of knee extensor muscles of healthy subjects.

Conclusion

NMES combined with eccentric training did not influence consistently the type or magnitude of adaptations provoked by knee extensor eccentric training alone in healthy subjects.

STUDY NO. 2:

The Effect of NeuroMuscular Electrical Stimulation on Quadriceps Strength and Knee Function in Professional Soccer Players: Return to Sport after ACL Reconstruction

Taradaj, J., Halski, T., Kucharzewski, M., Walewicz, K., Smykla, A., Ozon, M., Slupska, L., Dymarek, R., Ptaszkowski, K., Rajfur, J., & Pasternok, M. (2013). The Effect of NeuroMuscular Electrical Stimulation on Quadriceps Strength and Knee Function in Professional Soccer Players: Return to Sport after ACL Reconstruction. BioMed Research International, 2013, 1–9. https://doi.org/10.1155/2013/802534

Abstract

The aim of this study was to assess the clinical efficacy and safety of NMES program applied in male soccer players (after ACL reconstruction) on the quadriceps muscle. The 80 participants (NMES = 40, control = 40) received an exercise program, including three sessions weekly. The individuals in NMES group additionally received neuromuscular electrical stimulation procedures on both right and left quadriceps (biphasic symmetric rectangular pulses, frequency of impulses: 2500 Hz, and train of pulses frequency: 50 Hz) three times daily (3 hours of break between treatments), 3 days a week, for one month. The tensometry, muscle circumference, and goniometry pendulum test (follow-up after 1 and 3 months) were applied. The results of this study show that NMES (in presented parameters in experiment) is useful for strengthening the quadriceps muscle in soccer athletes. There is an evidence of the benefit of the NMES in restoring quadriceps muscle mass and strength of soccer players. In our study the neuromuscular electrical stimulation appeared to be safe for biomechanics of knee joint. The pathological changes in knee function were not observed. This trial is registered with Australian and New Zealand Clinical Trials Registry ACTRN12613001168741.

Conclusion

The results of this study show that NMES (presented parameters in experiment) is useful for strengthening the quadriceps muscle in soccer athletes. There is an evidence the benefit of the NMES in restoring quadriceps muscle mass and strength of soccer players. In our study the neuromuscular electrical stimulation appeared to be safe for biomechanics of knee joint. The pathological changes in knee function were not observed.

STUDY NO. 3:

Electrical stimulation and blood flow restriction increase wrist extensor cross-sectional area and flow meditated dilatation following spinal cord injury

Gorgey, A. S., Timmons, M. K., Dolbow, D. R., Bengel, J., Fugate-Laus, K. C., Michener, L. A., & Gater, D. R. (2016). Electrical stimulation and blood flow restriction increase wrist extensor cross-sectional area and flow meditated dilatation following spinal cord injury. European Journal of Applied Physiology, 116(6), 1231–1244. https://doi.org/10.1007/s00421-016-3385-z

Abstract

Purpose

To examine the effects of neuromuscular electrical stimulation (NMES) and blood flow restricted (BFR) exercise on wrist extensors cross-sectional area (CSA), torque and hand functions compared NMES only in individuals with incomplete tetraplegia. The acute effect of an acute bout of NMES with BFR on flow mediated dilation (FMD) was compared with BFR only.

Conclusion

NMES training with BFR is a strategy that can increase skeletal muscle size. NMES with and without BFR can improve wrist strength and hand function. The acute effects of NMES+BFR may suggest that an increase in FMD may partially contribute to skeletal muscle hypertrophy.

STUDY NO. 4:

The effect of low level laser irradiation on oxidative stress, muscle damage and function following neuromuscular electrical stimulation. A double blind, randomised, crossover trial

Jówko, E., Płaszewski, M., Cieśliński, M., Sacewicz, T., Cieśliński, I., & Jarocka, M. (2019). The effect of low level laser irradiation on oxidative stress, muscle damage and function following neuromuscular electrical stimulation. A double blind, randomised, crossover trial. BMC Sports Science, Medicine and Rehabilitation, 11(1). https://doi.org/10.1186/s13102-019-0147-3

Abstract

Background: Low level laser therapy (LLLT) is among novel methods for preventing and treating muscle damage and soreness induced by volitional exercise, but little is known about using LLLT before neuromuscular electrical stimulation. The aim of this first randomised, double blind, crossover trial addressing this issue was to evaluate effects of LLLT on muscle damage and oxidative stress, as well as recovery of muscle function after a single session of isometric neuromuscular electrical stimulation(NMES).

Conclusion

NMES training with BFR is a strategy that can increase skeletal muscle size. NMES with and without BFR can improve wrist strength and hand function. The acute effects of NMES+BFR may suggest that an increase in FMD may partially contribute to skeletal muscle hypertrophy.

SECTION NO. 6

“NMES is safe for Increase Voluntary Muscle Strength After Spinal Cord Injury (A systemic review)”

STUDY NO. 1:

Does Neuromuscular Electrical Stimulation Therapy Increase Voluntary Muscle Strength After Spinal Cord Injury? A Systematic Review

de Freitas, G. R., Szpoganicz, C., & Ilha, J. (2018). Does Neuromuscular Electrical Stimulation Therapy Increase Voluntary Muscle Strength After Spinal Cord Injury? A Systematic Review. Topics in Spinal Cord Injury Rehabilitation, 24(1), 6–17. https://doi.org/10.1310/sci16-00048

Abstract

To determine the effectiveness of NMES for increasing voluntary strength in the partially paralyzed muscles of people with SCI.

Conclusion

There is some suggestion that NMES increases voluntary strength in partially paralyzed muscle following SCI. However, there is no strong evidence to affirm the superiority of NMES other other treatment strategies used to gain strength in partially paralyzed muscles after SCI. These findings need replicating in large high-quality randomized controlled trials.

SECTION NO. 7

“Effectiveness of NMES for Muscle Atrophy Prevention and Recovery in Orthopedic Patients"

STUDY NO. 1:

Does Neuromuscular Electrical Stimulation Therapy Increase Voluntary Muscle Strength After Spinal Cord Injury? A Systematic Review

Gatterer, H., Menz, V., & Einwaller, E. (2011). Exercise in hypoxia: The role of intermittent hypoxic training in the prevention and treatment of cardiovascular disease. European Journal of Applied Physiology, 111(3), 379-386. doi: 10.1007/s00421-011-2101-2.

Abstract

Objective: Although neuromuscular electrical stimulation (NMES) has been used as a safe and relevant complement to voluntary resistance training, its effectiveness in increasing quadriceps femoris muscle strength and mass in healthy young and older adults has not been determined. The aim of this scoping review was to assess the effects of NMES on quadriceps muscle strength and mass in healthy young and older adults.

Conclusion

Overall, the evidence indicates that NMES is an efficacious method for increasing quadriceps muscle strength in young adults, whereas its impact on muscle mass requires further investigations. In addition, the effectiveness of NMES needs to be confirmed in older adults on the basis of more high-quality RCTs with larger sample sizes.

STUDY NO. 2:

Enhancing Adaptations to Neuromuscular Electrical Stimulation Training Interventions

Blazevich, A. J., Collins, D. F., Millet, G. Y., Vaz, M. A., & Maffiuletti, N. A. (2021). Enhancing Adaptations to Neuromuscular Electrical Stimulation Training Interventions. Exercise and Sport Sciences Reviews, 49(4), 244–252. https://doi.org/10.1249/jes.0000000000000264

Abstract

Neuromuscular electrical stimulation (NMES) applied to skeletal muscles is an effective rehabilitation and exercise training modality. However, the relatively low muscle force and rapid muscle fatigue induced by NMES limit the stimulus provided to the neuromuscular system and subsequent adaptations. We hypothesize that adaptations to NMES will be enhanced by the use of specific stimulation protocols and adjuvant interventions.

Conclusion

Repeated application of NMES using traditional parameters and configurations can enhance muscle size and function and induce neural adaptations. However, traditional NMES recruits a limited portion of the muscle and induces rapid muscle fatigue (and damage), limiting the capacity to evoke moderate-high forces for prolonged periods.

Conclusion

Combining alternative NMES protocols with concurrent interventions can improve its effectiveness. Increasing stimulation pulse duration and frequency, distributing stimulus pulses between electrodes or dispersed across a muscle belly, and using vibration, voluntary contraction or mental imagery, PBMT, BFR, or nutritional supplementation have shown promise. Traditional NMES interventions provide suboptimal clinical outcomes. More research is needed to determine the best practices for different contexts.

STUDY NO. 3:

A feasibility pilot using telehealth videoconference monitoring of home-based NMES resistance training in persons with spinal cord injury

Gorgey, A. S., Lester, R. M., Wade, R. C., Khalil, R. E., Khan, R. K., Anderson, M. L., & Castillo, T. (2017). A feasibility pilot using telehealth videoconference monitoring of home-based NMES resistance training in persons with spinal cord injury. Spinal Cord Series and Cases, 3(1). https://doi.org/10.1038/scsandc.2017.39

Abstract

The objective of the study was to investigate the feasibility and initial efficacy of telehealth communication in conjunction with surface neuromuscular electrical stimulation (NMES) resistance training (RT) to induce muscle hypertrophy.

Conclusion

We have demonstrated that the use of live videoconferencing is an effective and safe strategy to monitor home-based RT using NMES designed to evoke muscle hypertrophy in persons with chronic SCI. The use of a real-time video-monitoring program ensured independence, safety and compliance over the 8-week training. Live feedback ensured that the setup and all aspects of training were carried out precisely as outlined in the protocol to maximize muscle hypertrophy.

Conclusion

The unilateral training evoked detectable increases in muscle size without any notable changes in the contralateral controlled limb. This was accompanied with a decrease in both absolute and percentage IMF of the trained limbs. We have demonstrated the potential cost-reducing capacity of such protocols by documenting a reduction in travel time, travel distance and total cost of gas. However, further investigation is needed to determine the efficacy of similar telehealth programs to significantly reduce costs and maintain long-term adherence.

STUDY NO. 4:

Protocols aiming to increase muscle mass in persons with motor complete spinal cord injury: a systematic review

Fenton, J. M., King, J. A., Hoekstra, S. P., Valentino, S. E., Phillips, S. M., & Goosey-Tolfrey, V. L. (2022). Protocols aiming to increase muscle mass in persons with motor complete spinal cord injury: a systematic review. Disability and Rehabilitation, 1–11. https://doi.org/10.1080/09638288.2022.2063420

Abstract

The objective of the study was to investigate the feasibility and initial efficacy of telehealth communication in conjunction with surface neuromuscular electrical stimulation (NMES) resistance training (RT) to induce muscle hypertrophy.

Conclusion

In summary, the findings of the current review are limited by the low methodological quality and heterogeneity in study design. Nonetheless, NMES-RT demonstrated the most robust and consistent evidence for increasing SMM in adults with motor complete SCI of all interventions identified. Future studies should explore how training variables, such as volume, frequency, and stimulation parameters, can be manipulated to optimise hypertrophy.

STUDY NO. 5:

Exercise assessments and trainings of pulmoary rehabilitation in COPD: a literature review of pulmonary

Zeng, Y., Jiang, F., Chen, Y., Chen, P., & Cai, S. (2018). Exercise assessments and trainings of pulmonary rehabilitation in COPD: a literature review. International Journal of Chronic Obstructive Pulmonary Disease, Volume 13, 2013–2023. https://doi.org/10.2147/copd.s167098

Abstract

Skeletal muscle dysfunction leads to reduction in activity in patients with COPD. As an essential part of the management of COPD, pulmonary rehabilitation (PR) alleviates dyspnea and fatigue, improves exercise tolerance and health-related quality of life, and reduces hospital admissions and mortality for COPD patients. Exercise is the key component of PR, which is composed of exercise assessment and training therapy. To evaluate PR’ s application in clinical practice, this article summarizes the common methods of exercise measurement and exercise training for patients with COPD. Exercise assessments should calculate patients’ symptoms, endurance, strength, and health-related quality of life. After calculation, detailed exercise therapies should be developed, which may involve endurance, strength, and respiratory training. The detailed exercise training of each modality is mentioned in this review. Although various methods and therapies of PR have been used in COPD patients, developing an individualized exercise training prescription is the target. More studies are warranted to support the evidence and examine the effects of long-term benefits of exercise training for patients with COPD in each stage.

Conclusion

Patients with COPD have varying degrees of activity limitation because of skeletal muscle dysfunction. Nonmedical staff, societies, and families should also pay attention to inactivity. There are many methods of exercise assessments for patients with COPD, choosing the most suitable method to calculate the situation of patients is crucial. In future, we may formulate a systemic and standardized measurement to assess COPD patients before starting PR. Moreover, developing an individualized exercise training prescription for COPD patients is our target. More studies are warranted to support the evidence and examine the effects of long-term benefits of exercise training for patients with COPD in each stage.

SECTION NO. 8

“Effectiveness of NMES for Enhancing Muscle Hypertrophy in Resistance Training Programs "

STUDY NO. 1:

Relative Efficacy of Weight Management, Exercise, and Combined Treatment for Muscle Mass and Physical Sarcopenia Indices in Adults

Chu, S.-F., Liou, T.-H., Chen, H.-C., Huang, S.-W., & Liao, C.-D. (2021). Relative Efficacy of Weight Management, Exercise, and Combined Treatment for Muscle Mass and Physical Sarcopenia Indices in Adults with Overweight or Obesity and Osteoarthritis: A Network Meta-Analysis of Randomized Controlled Trials. Nutrients, 13(6), 1992. https://doi.org/10.3390/nu13061992

Abstract

Objective: Aging and osteoarthritis are associated with high risk of muscle mass loss, which leads to physical disability; this loss can be effectively alleviated by diet (DI) and exercise (ET) interventions. This study investigated the relative effects of different types of diet, exercise, and combined treatment (DI+ET) on muscle mass and functional outcomes in individuals with obesity and lower-limb osteoarthritis. A comprehensive search of online databases was performed to identify randomized controlled trials (RCTs) examining the efficacy of DI, ET, and DI+ET in patients with obesity and lower-extremity osteoarthritis. The included RCTs were analyzed through network meta-analysis and risk-of-bias assessment. We finally included 34 RCTs with a median (range/total) Physiotherapy Evidence Database score of 6.5 (4–8/10). DI plus resistance ET, resistance ET alone, and aerobic ET alone were ranked as the most effective treatments for increasing muscle mass (standard mean difference (SMD) = 1.40), muscle strength (SMD = 1.93), and walking speed (SMD = 0.46). Our findings suggest that DI+ET is beneficial overall for muscle mass in overweight or obese adults with lower-limb osteoarthritis, especially those who are undergoing weight management.

Conclusion

This study aimed to determine the effectiveness of different diet therapies, exercise interventions, and combined treatments on muscle mass, strength, and walking speed in individuals with obesity and hip or knee osteoarthritis. The study found that exercise alone improves muscle strength and walking speed, while a combination of diet therapy and exercise, especially resistance training and modified Mediterranean diet, has superior effects on muscle mass. This interdisciplinary approach can counteract muscle loss and functional decline in the older population with obesity and osteoarthritis. However, more studies with larger sample sizes are needed to identify specific supplementation protocols.

STUDY NO. 2:

Effects of Neuromuscular Electrical Stimulation Combined with Exercises versus an Exercise Program on the Physical Characteristics and Functions of the Elderly: A Randomized Controlled Trial

Jang, E. M., & Park, S. H. (2021). Effects of Neuromuscular Electrical Stimulation Combined with Exercises versus an Exercise Program on the Physical Characteristics and Functions of the Elderly: A Randomized Controlled Trial. International Journal of Environmental Research and Public Health, 18(5), 2463. https://doi.org/10.3390/ijerph18052463

Abstract

1) Background—The application of neuromuscular electrical stimulation (NMES) combined with low-intensity exercise to the elderly can be more efficient than low-intensity exercise only in terms of delaying the loss of muscle mass. We aimed to assess the adjunct of NMES to low-intensity lower limb strengthening exercise to prevent falls in frail elderly for a relatively short period of 4 weeks.(2) Methods—Thirty elderly women aged 65 or above were randomly categorized into three groups: control group (CON, n = 8), exercise group (EX, n = 10), and NMES with exercise group (EX + NMES, n = 9). The exercise group took part in a lower limb strengthening exercise program for one hour three times a week for four weeks. Furthermore, the NMES with exercise group had added NMES stimulation when exercising. The limbs' muscle mass, body fat mass, calf circumference, grip force, five times sit-to-stand test, timed up-and-go test (TUG), one-leg stand test, and Y-balance test (YBT) were evaluated at baseline and 4 weeks after. (3) Results—Comparisons between the three groups showed that the TUG was significantly decreased and the YB was significantly increased in NMES with exercise group ($p < 0.05$). (4) Conclusions—These results suggested that a combination of NMES stimulation and exercises was more helpful in strengthening balance than exercises alone in the short ter

Conclusion

In the short term, a combination of exercise and electrical stimulation appears to be more helpful in strengthening balance in frail older women than exercise alone. The combination could have positive proprioceptive effects for preventing falls in the elderly but more research is needed.

STUDY NO. 3:

Effects of Neuromuscular Electrical Stimulation Combined with Exercises versus an Exercise Program on the Physical Characteristics and Functions of the Elderly: A Randomized Controlled Trial

Fitzgerald, G. K., Piva, S. R., & Irrgang, J. J. (2003). A Modified Neuromuscular Electrical Stimulation Protocol for Quadriceps Strength Training Following Anterior Cruciate Ligament Reconstruction. Journal of Orthopaedic & Sports Physical Therapy, 33(9), 492–501. https://doi.org/10.2519/jospt.2003.33.9.492

Abstract

Study Design
Randomized clinical trial, single-masked.

Objectives
To determine the effectiveness of using a modified neuromuscular electrical stimulation (NMES) training program as an adjunct treatment for improving quadriceps strength and physical function in rehabilitation following anterior cruciate ligament reconstruction (ACLR)

Conclusion

The modified NMES quadriceps training protocol can be a useful adjunct to ACLR rehabilitation programs, but the treatment effect is smaller than what has been reported in previous studies. J Orthop Sports Phys Ther 2003;33:492–501.

STUDY NO. 4:

Neuromuscular electrical stimulation increases muscle protein synthesis in elderly type 2 diabetic men

Wall, B. T., Dirks, M. L., Verdijk, L. B., Snijders, T., Hansen, D., Vranckx, P., Burd, N. A., Dendale, P., & van Loon, L. J. C. (2012). Neuromuscular electrical stimulation increases muscle protein synthesis in elderly type 2 diabetic men. American Journal of Physiology-Endocrinology and Metabolism, 303(5), E614–E623. https://doi.org/10.1152/ajpendo.00138.2012

Abstract

This study is aimed at investigating the effects of synchronized neuromuscular electrical stimulation (NMES) and chewing exercises on bite force and the masseter muscle thickness in community-dwelling older adults. Material and methods: Forty older adults were enrolled in South Korea and randomly assigned to either an experimental or control group. The experimental group performed chewing exercises using the No-Sick Exerciser equipment synchronized with NMES applied to the bilateral masseter muscles, while the control group performed only chewing exercises. Both groups received interventions for 20 min/day, 5 days/week, for 6 weeks. Bite force was measured using the OCCLUZER device, and masseter muscle thickness was measured using a portable ultrasound. Results: Both groups showed a significant increase in bite force and masseter muscle thickness compared to baseline measurements ($p < 0.05$). The experimental group showed a significantly higher increase in bite force and masseter muscle thickness than the control group after combined intervention ($p < 0.05$). Conclusion: This study demonstrates that NMES synchronized with chewing exercises is more efficient in increasing bite force and masseter muscle thickness than chewing exercises alone in community-dwelling older adults.

Conclusion

The present study’ s results demonstrate that NMES synchronized with chewing exercises effectively improve masseter muscle thickness and occlusal force to a greater extent than chewing exercises alone, but further studies with larger study groups would be necessary to validate our results.

STUDY NO. 5:

Effects of training intensity in electromyostimulation on human skeletal muscle

Natsume, T., Ozaki, H., Kakigi, R., Kobayashi, H., & Naito, H. (2018). Effects of training intensity in electromyostimulation on human skeletal muscle. European Journal of Applied Physiology, 118(7), 1339–1347. https://doi.org/10.1007/s00421-018-3866-3

Abstract

Purpose : High-intensity neuromuscular electrical stimulation (NMES) training can induce muscle hypertrophy at the whole muscle and muscle fiber levels. However, whether low-intensity NMES training has a similar result is unknown. This study aimed to investigate whether low-intensity NMES training could elicit muscle hypertrophy at the whole muscle and muscle fiber levels in the human skeletal muscle.

Conclusion

Low-intensity NMES could increase MT, muscle fiber CSA, and muscle strength in healthy human skeletal muscles. However, the magnitude of increase is lower in low-intensity than in high-intensity NMES training.