DOI: 10.1590/1809-2950/18046327022020

ORIGINAL RESEARCH

Effects of neuromuscular electrostimulation of quadriceps on the functionality of fragile and pre-frail hospitalized older adults: randomized clinical trial

Efeitos da eletroestimulação neuromuscular de quadríceps sobre a funcionalidade de idosos frágeis e pré-frágeis hospitalizados: ensaio clínico randomizado

Efectos de la electroestimulación neuromuscular del cuádriceps sobre la funcionalidad de ancianos frágiles y prefrágiles hospitalizados: un ensayo clínico aleatorizado

Luísa Tiecker Reidel[1], Betina Cecchele[2], Amanda Sachetti[3], Leonardo Calegari[4]

ABSTRACT | This work aimed to evaluate the effects of neuromuscular electrostimulation (NMES) on the functionality of frail and pre-frail hospitalized older adults. It is a randomized clinical trial that dealt with 17 hospitalized people. Anthropometric, socioeconomic and clinical data were evaluated, followed by the scale proposed by Fried to identify the frailty syndrome. In addition, we evaluated thigh perimetry and lower limb strength according to the Medical Research Council (MRC) as well as conducted the sit-to-stand test (STST). Patients were allocated to the control group (CG; n=9), aged 67.7±6.9 years and intervention group (IG; n=8), aged 71.2±5.6 years. Both groups received conventional physiotherapy care. The NMES protocol was applied only in the intervention group. The groups were similar in terms of sociodemographic, anthropometric profile, clinical characteristics and continuous use of medications. There were significant effects of NMES when compared to CG for right thigh perimetry (p=0.03); number of repetitions in STST (p=0.004) and quadriceps muscle strength (p=0.01) evaluated by the MRC scale. The quadriceps muscle training with the aid of NMES was effective in frail and pre-frail hospitalized people, promoting increased strength and functional performance.

KEYWORDS | Age; Electric Stimulation; Muscle Strength; Frailty.

RESUMO | Este artigo teve como objetivo avaliar os efeitos da eletroestimulação neuromuscular (EENM) sobre a funcionalidade de idosos frágeis e pré-frágeis hospitalizados. Trata-se de um ensaio clínico randomizado com 17 idosos hospitalizados. Foram avaliados dados antropométricos, socioeconômicos e clínicos, seguido da escala proposta por Fried para identificação da síndrome da fragilidade. Além disso, foram avaliados a perimetria da coxa e a força de membros inferiores pelo Medical Research Council (MRC) e teste de sentar e levantar (TSL). Os pacientes foram randomizados em grupo-controle (GC; n=9), com idade de 67,7±6,9 anos e grupo intervenção (GI; n=8), com idade de 71,2±5,6 anos. Ambos os grupos receberam atendimento de fisioterapia convencional. O protocolo de EENM foi aplicado somente no grupo intervenção. Os grupos foram semelhantes quanto ao perfil sociodemográfico, antropométrico, quanto às características clínicas e quanto ao uso contínuo de medicamentos. Houve efeitos significativos da EENM quando comparados ao GC para perimetria da coxa direita (p=0,03); para o número de repetições no TSL (p=0,004) e para a força muscular do quadríceps (p=0,01), avaliados pela escala MRC. O treinamento muscular de quadríceps com a EENM foi efetivo nos idosos frágeis e

Study developed at Hospital São Vicente de Paulo (HSVP) – Passo Fundo (RS), Brazil.
[1]University of Passo Fundo – Passo Fundo (RS), Brazil. E-mail: luisa_treidel@hotmail.com. Orcid: 0000-0001-5198-8694
[2]University of Passo Fundo – Passo Fundo (RS), Brazil. E-mail: betina.cecchele@gmail.com. Orcid: 0000-0002-6449-0382
[3]School of Health – Passo Fundo (RS), Brazil. E-mail: amandasachetti@gmail.com. Orcid: 0000-0001-9991-0001
[4]Faculty Specialized in Health in Rio Grande do Sul (Fasurgs) – Passo Fundo (RS), Brazil. E-mail: profcalega@gmail.com. Orcid: 0000-0003-0758-3467

Corresponding address: Luísa Tiecker Reidel – Avenida Sete de Setembro, 1452, Vila Rodrigues – Passo Fundo (RS), Brazil – Zip Code: 99010-120. E-mail: luisa_treidel@hotmail.com –
Funding source: nothing to declare – Conflict of interests: nothing to declare – Presentation: Dec. 12th, 2018– Accepted for publication: Apr. 14th 2019 – Approved by the Research Ethics Committee: Protocol No. 2,642,892 – Brazilian Registry of Clinical Trials (Rebec): No. 9xg5qs.

pré-frágeis hospitalizados, promovendo aumento da força e do desempenho funcional.
Descritores | Idoso; Estimulação Elétrica; Força Muscular; Fragilidade.

RESUMEN | Este artículo tuvo como objetivo evaluar los efectos de la electroestimulación neuromuscular (EENM) sobre la funcionalidad de ancianos frágiles y prefrágiles hospitalizados. Es un ensayo clínico aleatorizado en el cual participaron 17 ancianos hospitalizados. Se evaluaron los datos antropométricos, socioeconómicos y clínicos, seguidos de la escala propuesta por Fried para identificar el síndrome de fragilidad. Además, se evaluaron la perimetría del muslo y la fuerza de las extremidades inferiores utilizando el Medical Research Council (MRC) y el test de sentarse y levantarse (TSL). Los pacientes se asignaron aleatoriamente a un grupo de control (GC; n=9), con promedio de 67,7±6,9 años, y al grupo de intervención (GI; n=8), con 71,2±5,6 años. Ambos grupos recibieron fisioterapia convencional. El protocolo de EENM se aplicó solo al grupo de intervención. Los resultados de los grupos fueron similares en relación a las características sociodemográficas, antropométricas, clínicas y de uso continuo de medicamentos. Hubo efectos significativos de la EENM en comparación al GC para la perimetría del muslo derecho (p=0,03); para el número de repeticiones en el TSL (p=0,004) y para la fuerza muscular del cuádriceps (p=0,01), evaluados por la escala MRC. El entrenamiento muscular del cuádriceps con la EENM fue eficaz en los ancianos frágiles y prefrágiles hospitalizados, pues promovió un aumento de la fuerza y el rendimiento funcional.
Palabras clave | Anciano; Estimulación Eléctrica; Fuerza Muscular; Fragilidad.

INTRODUCTION

Aging is a natural biological process, which involves a decline in systemic physiological functions, resulting in varying degrees of decreased functionality[1]. Population aging is now a worldwide occurrence, and in Brazil the older population exceeded 14.5 million in 2000; it is estimated that in 2030 they will be 18.6% of Brazilians, and in 2060, 33.7%[2,3]. In Brazil, there have been significant changes in age structures in recent decades, with a decrease in fertility levels and in mortality, increasing life expectancy and population longevity[3,4].

According to Arantes et al.[5] frailty is a clinical syndrome of multifactorial nature, characterized by a state of physiological vulnerability due to decreased energy reserves and the ability to maintain or recover homeostasis after an event. Frailty indicates conditions of high risk of falls, hospitalization, disability, institutionalization and death[6]. Thus, the study of this syndrome in hospitalized older adults has clinical relevance. Therefore, the investigation of its presence allows health professionals to make an appropriate intervention, avoiding its harmful consequences to health.

In hospitalized older people, the diagnosis of frailty was associated with an increase in the number of hospitalized days and high mortality rates[7]. Identification of the stage that precedes the most serious manifestations, known as pre-frailty, has preventive potential. After the phenomenon onset, the therapeutic approach aims to prevent, postpone or mitigate the harmful effects of frailty on functional capacity and quality of life [7,8].

Interest and research on muscle mass loss associated with loss of muscle function—strength or physical performance—in older adults has gradually increased since the publication of the European working group on sarcopenia in this population in 2010[9]. Secondary sarcopenia due to illness or nutritional status may be related to the frailty syndrome[10]. Hospitalization for treatment of a disease can lead to a rapid decline in muscle mass and function, triggered by increased inflammation and combined with decreased muscle activity, which can cause some older people to become sarcopenic[10]. The term "acute sarcopenia" was used to refer to the acute loss of muscle mass and function associated with hospitalization[10].

Among the most varied forms of muscle training, neuromuscular electrostimulation (NMES) consists of the application of an electric current, of low or medium frequency, over the muscle, aiming at muscle re-education and atrophy prevention[11]. The NMES application is related to maintaining and increasing muscle strength and endurance, in addition to increased exercise tolerance, improved balance and functionality[11,12]. In short, the loss of muscle strength

in hospitalized older adults is widely described in the literature[9,10] and NMES is a safe and viable therapeutic strategy to be used in the hospital[13].

Within this context, the objective of this study was to evaluate the effects of NMES on the functionality of frail and pre-frail hospitalized older adults.

METHODOLOGY

This is a randomized clinical trial with older patients admitted to a highly complex hospital, registered under the Brazilian Registry of Clinical Trials (Rebec No. 9xg5qs). All participants signed the Informed Consent Form, and the study was approved by the Research Ethics Committee of the institution under opinion No. 2,642,892.

Casuistry

Older adults were allocated into two groups by means of randomization using the online GraphPad *software*: control group (CG) and intervention group (IG). The study included older people aged 60 years or over, with a length of stay equal to or greater than two days and equal to or less than 10 days, classified as frail or pre-frail according to the criteria of Fried et al.[14]. Exclusion criteria were: hemodynamically unstable patients; patients with bone fractures that made intervention impossible; patients with neuromuscular diseases; patients unable to obey simple commands; patients using sedation and/or neuromuscular blockers and patients contraindicated to receive NMES.

Procedures

A questionnaire adapted by the authors was applied based on the subjective assessment of the frailty of Fried et al.[14], which has been used in studies to identify hospital frailty[15],with socioeconomic identification data, evaluation of frailty syndrome, perimeter of the thigh muscles, Medical Research Council (MRC) and sit-to-stand test (STST).

The assessment of quadriceps muscle strength was obtained using the MRC scale, quantifying the degree of muscle strength throughout the range of motion in values ranging from 0 (absence of muscle contraction) to 5 (performs the movement against maximum resistance)[16]. A physical therapist received training and applied the manual muscle strength test, which was standardized in the two groups studied[16]. The STST evaluated the strength and resistance of lower limbs. The number of times the patient got up from the chair in 30 seconds was counted without assistance and without hand support[17]. In addition, with the patient in the supine position, measurements of the thigh circumference were performed at the midpoint between the inguinal line and the upper edge of the patella[18]. These assessments were carried out before and after the NMES protocol.

Both control and intervention groups received assistance from the hospital's physical therapy service, which consisted of walking, passive stretching exercise, strengthening of lower and upper limbs and kinesiotherapy, according to each patient's needs[19]. The consultations were performed once a day, lasting approximately 20 minutes, making an average of eight physical therapy sessions in both groups.

In the IG, NMES was performed with an Ibramed® electric stimulator, model Neurodyn II, 4 channels, São Paulo/Brazil. After cleaning the skin, two Arktus® silicone electrodes, size 5×9 cm, were placed on the quadriceps, the anode being 4 cm above the upper edge of the patella. The cathode positioning was guided by the determination of the motor point on the upper lateral surface of the quadriceps muscle. The motor area of greatest muscle contraction was used to position the cathode[20,21]. During electrostimulation, patients were supine, with their knees at 30º of flexion, being encouraged to perform isometric contractions concomitantly with the electrical stimulus[12]. All sessions lasted 30 minutes, with a frequency of 50 Hertz (Hz), pulse duration of 300 microseconds, rise time of 1 second, stimulus time (ON) of 5 seconds, descent time of 1 second and time of 10 seconds of relaxation (OFF)[12,20]. Intensity was adjusted according to the patient's tolerance, with approximately 100 contractions per session.

Statistical analysis

Microsoft Excel was used to tabulate the data, and the Statistical Package for the Social Sciences (SPSS - version 19) was used for statistical analysis. The Winpepi program (version 11.43) was used To calculate the sample size. The sample size was calculated in eight patients in each group,

considering statistical power of 80% and significance level of 5% to detect an average difference between the groups of 2 ± 1.3 repetitions in the sit-to-stand test[21]. The Kolmogorov-Smirnov test was used to analyze the data distribution. In the comparisons between the groups and the pre and post-intervention times, analysis of variance (ANOVA) with repeated measures was used, followed by the Holm-Sidak post-hoc test. Comparisons between groups for body weight, age and BMI were performed using the Student's *t* test for independent samples. Categorical variables were analyzed using the chi-square test. Values of $p<0.05$ were considered statistically significant.

RESULTS

Twenty-four hospitalized older adults from May to September 2018 were evaluated, as Figure 1 shows.

Table 1 shows that the groups are similar in terms of demographic, anthropometric, clinical characteristics and continuous use of medications.

Anova revealed significant effects of NMES when compared to the CG for perimetry of the right thigh ($p=0.03$); for the number of repetitions in the STST ($p=0.004$); and for quadriceps muscle strength ($p=0.01$), assessed by the MRC scale, as shown in Table 2.

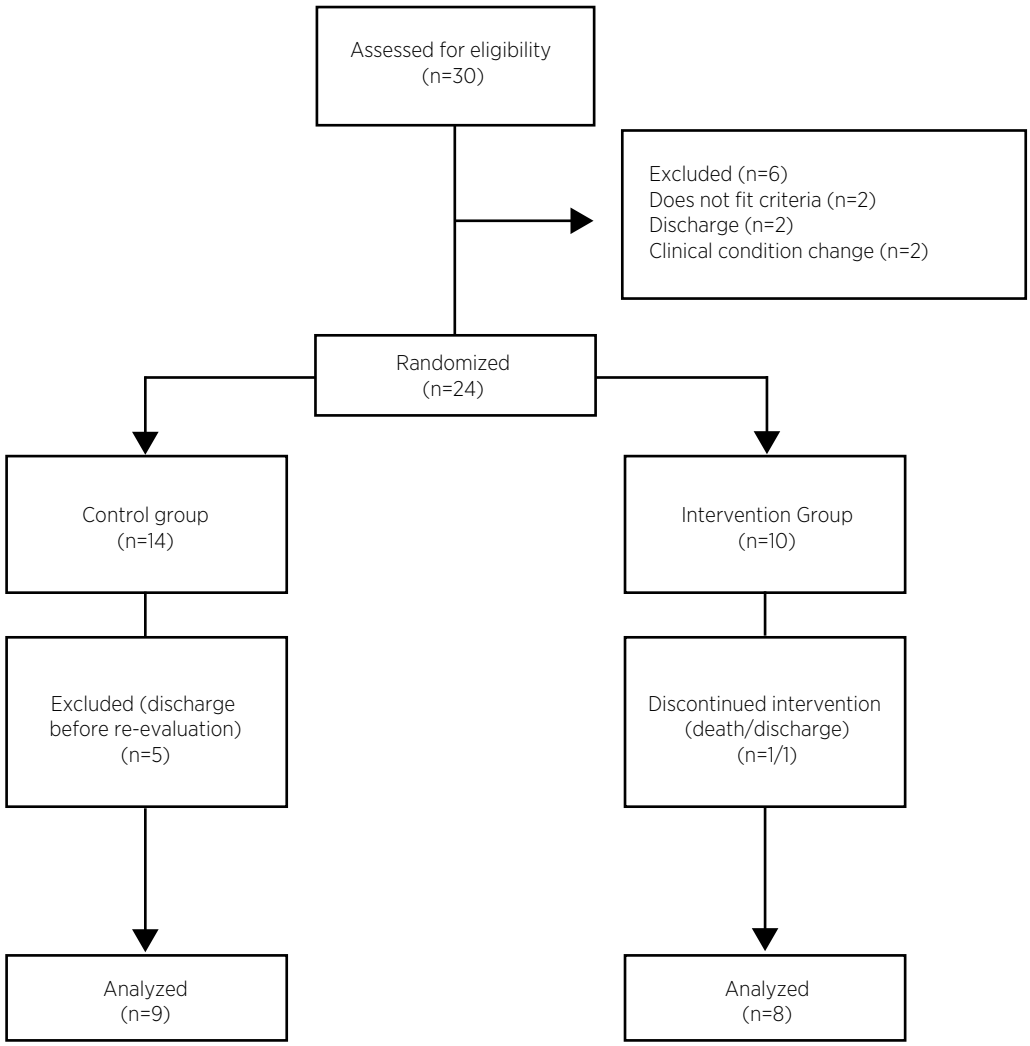

Figure 1. Flowchart of patients and composition of groups

Table 1. Anthropometric and sociodemographic data of the sample

	IG	CG	*p*
Age (years) (±SD)	71.2±5.6	67.7±6.9	0.27
BMI (kg /m2) (±SD)	27.3±5.1	25.2±4.7	0.39
Height (m) (±SD)	163.8±9.5	161.4±7.1	0.55
Sex			0.77
Female	3 (37.5%)	4 (44.4%)	
Male	5 (62.5%)	5 (55.6%)	
Frailty Assessment			0.85
Frail	5 (62.5%)	6 (66.6%)	
Pre-frail	3 (37.5%)	3 (33.4%)	
Reason for hospitalization			0.27
Gastrointestinal tract	2 (25%)	1 (11.1%)	
Respiratory	2 (25%)	3 (33.3%)	
Oncological	-	3 (33.3%)	
Cardiological	1 (12.5%)	1 (11.1%)	
Neurological	1 (12.5%)	-	
Renal	2 (25%)	-	
Orthopedic	-	1 (11.1%)	
Medications in continuous use*			0.31
Absence	-	1 (11.1%)	
1-2	1 (12.5%)	2 (22.2%)	
3-5	3 (37.5%)	5 (55.6%)	
>5	4 (50.0%)	1 (11.1%)	

IG: intervention group; CG: control group; BMI: muscle mass index; *: amount of medication in continuous use at the time of hospitalization.

Table 2. Effects of functional electrical stimulation on muscle strength in hospitalized older adults

	IG			CG			Difference between groups	*p*
	Pre	Post	Δ	Pre	Post	Δ		
HGS (kg/*f*)	26.2±7.7	21.6±10.1	5.4±2.9	24.2±6	22.4±7	1.7±3.2	0.8±0.5	0.32
Perimetry D (cm)	46.0±7.67	48.5±6.4	2.5±1.4	44.6±6.7	43.8±7.2	0.7±2.6	4.7±3.3*	0.03*
Perimetry E (cm)	47.2±5	48.3±6.4	1.1±2.8	44.2±6.4	43.7±7	0.5±2.6	4.6±3.2	0.06
STST (number of repetitions)	8.3±2.26	9.6±2.9	1.2±1.4	6.4±1.8	6.0±1.5	0.4±1.3	3.6± 2.5*	0.004*
MRC	4.1±0.64	4.7±7.0	0.6±0	3.5±0.5	3.5±0.5	-	1.2±0.8*	0.01*
Walking speed (m/s)	0.61±0.23	0.75±0.37	0.14±0.29	0.48±0.11	0.46±0.09	0.02±0.07	0.29± 0.2	0.18

Data presented as mean and standard deviation. IG: intervention group; CG: control group; HGS: hand grip strength; MRC: Medical Research Council; STST: sit and stand test; Δ: intra-group difference; *: difference between groups (p<0.05).

DISCUSSION

The main findings of this study showed increased strength of the lower limbs after NMES protocol in frail and pre-frail hospitalized older adults. The use of NMES proved to be an effective resource in the context of hospital physical therapy applied to Geriatrics. Similarly, other results obtained in other clinical situations, such as chronic obstructive pulmonary disease and heart failure[13,22], reported that a short-term NMES protocol also promoted improvement in muscle strength and exercise tolerance in hospitalized patients.

As far as it is known, this is the first randomized clinical trial that aimed to investigate the effects of NMES in frail and pre-frail hospitalized older adults. Strength gain through NMES can be attributed to increased muscle and neural activation, which, when associated with voluntary contractions, can optimize muscle recruitment arising from NMES[11]. The association of NMES with kinesiotherapy showed an improvement in the strength of lower limbs and an increase in the ability to walk in hospitalized older women[23]. Although an increase in muscle strength is observed after NMES, the length of hospital stay did not differ between the intervention group and the control group, despite the improvement in functional performance in the STST.

Our results showed an increase in the perimetry of the right thigh in the NMES group, when compared

to the control. Benavent-Caballer et al.[12] reported an increase in the cross-sectional area of the rectus femoris muscle after NMES protocol associated with isometric contraction in the elderly. However, other studies do not corroborate our findings[21,24]. Studies using more accurate methods, such as magnetic resonance, computed tomography or ultrasonography, may confirm the changes in muscle volume induced by NMES[12].

NMES has the potential to be used especially in individuals who cannot perform intense exercises that guarantee adequate strengthening, such as frail older people and hospitalized patients[25,26]. Voluntary isometric contraction should also be requested whenever possible so that there is greater muscle activation. Both resistance training and NMES are effective options for the prevention and treatment of sarcopenia in institutionalized and hospitalized older adults, and are preferably indicated[27].

Our results showed an increase in muscle strength and endurance, results evaluated by performance in the STST and corroborating other studies of NMES in hospitalized older adults who used NMES in patients with chronic obstructive pulmonary disease, in the cardiac postoperative period, with osteoarthritis and with severe heart failure[13,21,27,28]. The increase in the number of repetitions in the STST of the intervention group suggests an improvement in muscle endurance in a functional movement widely used in daily life. Another result that confirms the strength gain in the NMES group was the improvement in the MRC scores, a scale widely used and currently recommended as a method for diagnosing muscle weakness acquired in intensive care units[16].

A systematic review with meta-analysis showed significant effects of NMES on muscle strength, assessed by the MRC scale in critically ill patients[24]. Frail older people have a higher risk of hospitalization when compared to other non-frail people, and sarcopenia is closely linked to frailty and hospitalization[15,29]. It was observed that frailty is associated with muscle decline, especially in individuals with long periods of hospital stay[30]. The presence of low mass and muscle function during acute illness is associated with increased health costs, length of stay, rehabilitation costs and the need for institutional care or post-discharge social assistance. In this context, the prevention of acute sarcopenia brings broader economic benefits, as well as benefits to patients[10]. Therefore, strategies to reduce adverse events resulting from disuse and hospitalization, such as NMES, can attenuate the loss of muscle mass and improve functionality in hospitalized older adults.

It should be noted that this study has some limitations. We recognize the heterogeneity of subjects at the time of hospitalization and the wide variety of pathologies as a reason for hospitalization. Furthermore, there was no follow-up after the patient was discharged to verify the long-term treatment effectiveness.

CONCLUSION

This study provides evidence from NMES on improving muscle strength of lower limbs in frail and pre-frail hospitalized older adults. These results suggest that NMES can be a useful therapeutic strategy for hospitalized older people.

REFERENCES

1. Tiedemann A, Sherrington C, Lord SR. The role of exercise for fall prevention in older age. Motriz: Rev Educ Fis. 2013;19(3):541-7. doi: 10.1590/S1980-65742013000300002
2. Allendorf DB, Schopf PP, Gonçalves BC, Closs VE, Gottlieb MGV. Idosos praticantes de treinamento resistido apresentam melhor mobilidade do que idosos fisicamente ativos não praticantes. Rev Bras Ciênc Mov. 2016;24(1):134-44. doi: 10.18511/0103-1716/rbcm.v24n1p134-144
3. Instituto Brasileiro de Geografia e Estatística. Caracteristica da população brasileira. Rio de Janeiro: IBGE; 2015.
4. Berlezi EM, Farias AM, Dallazen F, Oliveira KR, Pillatt AP, Fortes CK. Analysis of the functional capacity of elderly residents of communities with a rapid population aging rate. Rev Bras Geriatr Gerontol. 2016;19(4):643-52. doi: 10.1590/1809-98232016019.150156
5. da Silva SLA, Vieira RA, Arantes P, Dias RC. Avaliação de fragilidade, funcionalidade e medo de cair em idosos atendidos em um serviço ambulatorial de geriatria e gerontologia. Fisioter Pesqui. 2009;16(2):120-5. doi: 10.1590/S1809-29502009000200005
6. Lana LD, Schneider RH. Síndrome de fragilidade no idoso: uma revisão narrativa. Rev Bras Geriatr Gerontol. 2014;17(3):673-80. doi: 10.1590/1809-9823.2014.12162
7. Chong E, Ho E, Baldevarona-Llego J, Chan M, Wu L, Tay L. Frailty and risk of adverse outcomes in hospitalized older adults: A comparison of different frailty measures. J Am Med Dir Assoc. 2017;18(7):638.e7-638.e11. doi: 10.1016/j.jamda.2017.04.011
8. Freitas CV, Sarges ESNF, Moreira KECS, Carneiro SR. Avaliação de fragilidade, capacidade funcional e qualidade de vida dos idosos atendidos no ambulatório de geriatria de um hospital universitário. Rev Bras Geriatr Gerontol. 2016;19(1):119-28. doi: 10.1590/1809-9823.2016.14244
9. Cruz-Jentoft AJ, Baeyens JP, Bauer JM, Boirie Y, Cederholm T, Landi F, et al. Sarcopenia: European consensus on definition and diagnosis: Report of the European Working Group on

Sarcopenia in older people. Age Ageing 2010;39(4):412-23. doi: 10.1093/ageing/afq034

10. Welch C, K. Hassan-Smith Z, A. Greig C, M. Lord J, A. Jackson Thomas. Acute sarcopenia secondary to hospitalisation: An emerging condition affecting older adults. Aging Dis. 2018;9(1):151-64. doi: 10.14336/ad.2017.0315
11. Langeard A, Bigot L, Chastan N, Gauthier A. Does neuromuscular electrical stimulation training of the lower limb have functional effects on the elderly?: A systematic review. Exp Gerontol. 2017;91:88-98. doi: 10.1016/j.exger.2017.02.070
12. Benavent-Caballer V, Rosado-Calatayud P, Segura-Ortí E, Amer-Cuenca JJ, Lisón JF. Effects of three different low-intensity exercise interventions on physical performance, muscle CSA and activities of daily living: A randomized controlled trial. Exp Gerontol. 2014;58:159-65. doi: 10.1016/j.exger.2014.08.004
13. Chaplin EJL, Houchen L, Greening NJ, Harvey-Dunstan T, Morgan MD, Steiner MC, et al. Neuromuscular stimulation of quadriceps in patients hospitalised during an exacerbation of COPD: A comparison of low (35 Hz) and high (50 Hz) frequencies. Physiother Res Int. 2013;18(3):148-56. doi: 10.1002/pri.1541
14. Fried LP, Tangen CM, Walston J, Newman AB, Hirsch C, Gottdiener J, et al. Frailty in older adults: Evidence for a phenotype. J Gerontol A Biol Sci Med Sci. 2001;56(3):146-57. doi: 10.1093/gerona/56.3.m146
15. Oliveira DR, Bettinelli LA, Pasqualotti A, Corso D, Brock F, Erdmann AL. Prevalência de síndrome da fragilidade em idosos de uma instituição hospitalar. Rev Latino-Am. Enfermagem. 2013;21(4):1-8. doi: 10.1590/S0104-11692013000400009
16. Parry SM, Berney S, Granger CL, Dunlop DL, Murphy L, El-Ansary D, et al. A new two-tier strength assessment approach to the diagnosis of weakness in intensive care: An observational study. Crit Care. 2015;19(52):1-10. doi: 10.1186/s13054-015-0780-5
17. dos Santos RG, Tribess S, Meneguci J, da G Bastos LLA, Damião R, Virtuoso Júnior JS. Força de membros inferiores como indicador de incapacidade funcional em idosos. Motriz Rev Educ Fis. 2013;Suppl 19(3):35-42. doi: 10.1590/S1980-65742013000700006
18. Heyward VH. Avaliação da composição corporal aplicada. 12 ed. São Paulo: Manole; 2000.
19. Said CM, Morris ME, Woodward M, Churilov L, Bernhardt J. Enhancing physical activity in older adults receiving hospital based rehabilitation: A phase II feasibility study. BMC Geriatr. 2012;12(26):12-6. doi: 10.1186/1471-2318-12-26
20. Bohórquez IJR, de Souza MN, Pino AV. Influência de parâmetros da estimulação elétrica funcional na contração concêntrica do quadríceps. Rev Bras Eng Biomed. 2013;29(2):153-65. doi: 10.4322/rbeb.2013.012
21. Schardong J, Kuinchtner GC, Sbruzzi G, Plentz RDM, da Silva AMV. Functional electrical stimulation improves muscle strength and endurance in patients after cardiac surgery: A randomized controlled trial. Braz J Phys Ther. 2017;21(4):268-73. doi: 10.1016/j.bjpt.2017.05.004
22. Groehs RV, Antunes-Correa LM, Nobre TS, Alves MJNN, Rondon MUPB, Barreto ACP, et al. Muscle electrical stimulation improves neurovascular control and exercise tolerance in hospitalised advanced heart failure patients. Eur J Prev Cardiol. 2016;23(15):1599-608. doi: 10.1177/2047487316654025
23. Maggioni MA, Cè E, Rampichini S, Ferrario M, Giordano G, Veicsteinas A, et al. Electrical stimulation versus kinesitherapy in improving functional fitness in older women: A randomized controlled trial. Arch Gerontol Geriatr. 2010;50(3):e19-25. doi: 10.1016/j.archger.2009.04.015
24. Wageck B, Nunes GS, Silva FL, Damasceno MCP, de Noronha M. Application and effects of neuromuscular electrical stimulation in critically ill patients: Sistematic review. Med Intensiva. 2014;38(7):444-54. doi: 10.1016/j.medin.2013.12.003
25. Maffiuletti NA, Gondin J, Place N, Stevens-Lapsley J, Vivodtzev I, Minetto MA. Clinical use of neuromuscular electrical stimulation for neuromuscular rehabilitation: What are we overlooking? Arch Phys Med Rehabil. 2018;99(4):806-12. doi: 10.1016/j.apmr.2017.10.028
26. Paillard T. Muscle plasticity of aged subjects in response to electrical stimulation training and inversion and/or limitation of the sarcopenic process. Ageing Res Rev. 2018;46:1-13. doi: 10.1016/j.arr.2018.05.002
27. Cadore EL, Pinto RS, Reischak-Oliveira Á, Izquierdo M. Explosive type of contractions should not be avoided during resistance training in elderly. Exp Gerontol. 2018;102:81-3. doi: 10.1016/j.exger.2017.12.003
28. Sacilotto MCB, Lavagnoli CFR, Silveira-Filho LM, Vilarinho KAS, de Oliveira ES, de Carvalho DD, et al. A simpler and shorter neuromuscular electrical stimulation protocol improves functional status and modulates inflammatory profile in patients with end-stage congestive heart failure. Int J Cardiovasc Sci. 2017;30(6):484-95. doi: 10.5935/2359-4802.20170064
29. Fragala MS, Dam TTL, Barber V, Judge JO, Studenski SA, Cawthon PM, et al. Strength and function response to clinical interventions of older women categorized by weakness and low lean mass using classifications from the Foundation for the National Institute of Health Sarcopenia project. J Gerontol A Biol Sci Med Sci. 2015;70(2):202-9. doi: 10.1093/gerona/glu110
30. Khandelwal D, Goel A, Kumar U, Gulati V, Narang R, Dey AB. Frailty is associated with longer hospital stay and increased mortality in hospitalized older patients. J Nutr Health Aging. 2012;16(8):732-5. doi: 10.1007/s12603-012-0369-5