JAMDA xxx (2017) 1–3

JAMDA

journal homepage: www.jamda.com

Editorial

Muscle Power Training: A Hallmark for Muscle Function Retaining in Frail Clinical Setting

Eduardo Lusa Cadore PhD [a], Mikel Izquierdo PhD [b,*]

[a] Exercise Research Laboratory, Physical Education School, Universidade Federal do Rio Grande do Sul, Porto Alegre, RS, Brazil
[b] Department of Health Sciences, Public University of Navarre, CIBER de Fragilidad y Envejecimiento Saludable (CB16/10/00315), Tudela, Navarre, Spain

What Is the Rationale to Include Muscle Power Training in the Elderly Routine?

Functional ability, and retaining autonomy and independence, as people age is the cornerstone of healthy aging, a term established by World Health Organization in its first world report on aging and health.[1] Physical function parameters, therefore, are currently being proposed as biomarkers of aging in humans; are predictive of adverse health events, disability, and mortality; and are commonly used as functional outcomes for clinical trials.[2,3] Among the main physical function outcomes, muscle power output preservation will be in the palestra for counteracting the age-related decline of functional capacity.[4–7]

With increasing age, loss of neuromuscular function (ie, sarcopenia) and declines in cardiorespiratory fitness result in an impaired capacity to perform daily activities and maintain independent functioning. Although there is a marked decrease in muscle strength, skeletal muscle power decreases at a greater rate of muscle strength with advancing age,[4,8,9] and is a more discriminant predictor of functional performance in older adults.[4] It is now increasingly recognized that recommendations for managing functional status should include muscle power training, mainly for the lower extremity muscle. Furthermore, exercise interventions that have included muscle power training have been well tolerated, safe, and effective even among frail older adults.[7,10–12] In league with the current scientific evidence, we therefore suggest that improvements in muscle power are greater with resistance training (RT) interventions that emphasize high versus low muscle contraction velocity. In addition, there is emerging evidence that higher-velocity, lower-intensity RT, and several types of exercise programs performed at high velocity, can improve physical functioning in older adults to a greater extent than traditional slow-velocity RT.[4]

Evidence of Power Training Benefits in Elderly Populations?

The prescription of explosive RT and its positive effects on neuromuscular function in the elderly has been shown in several studies.[10,11,13,14] There are important arguments to justify the inclusion of explosive RT in the elderly. Muscle power output and rate of force development are strongly associated with the capacity to perform daily living activities in elderly populations.[4,5,15–17] Indeed, strong associations between functional capacity test performance and muscle power output or rate of force development has been previously shown in the healthy elderly.[4,16,17] More recently, it was found that muscle power and explosiveness are also associated with functional capacity and incidence of falls in the oldest old populations, including the frail institutionalized oldest old.[5,18]

Some studies and meta-analysis have shown that RT aimed to improve muscle power output (ie, explosive RT) is more effective to improve functional abilities (ie, sit-to-stand, walking ability, stairs climbing) than traditional RT (ie, slow controlled velocity of concentric actions).[19–24] In a meta-analysis by Steib et al,[24] explosive RT was significantly more effective than traditional RT in improving sit-to-stand ability, and approached significance for stair climbing performance. As expected, explosive RT induced greater increases in maximal power than traditional RT, along with similar strength increases when compared with traditional RT (ie, slower muscle actions). Recently, Straight et al[25] performed a meta-analysis including 12 RCTs assessing lower-body muscle power and showed that explosive RT is more effective than traditional RT in improving lower-body muscle power. Interestingly, no effects of training intensity was observed in the lower-body muscle power. In fact, one interesting characteristic of explosive-type RT prescription in the elderly is that marked maximal strength and power, as well as muscle size and functional performance enhancements, are achieved at low to moderate intensities (ie, 40%-60% of 1RM).[7,22,26] It can be explained because performing concentric muscle actions at the highest velocity requires the recruitment of fast-type muscle fibers.[27]

Therefore, several RCTs and also meta-analyses have provided evidences that explosive RT using moderate intensities (ie, 40%-60% of 1RM) induces increases in maximal strength, muscle power output, muscle mass, and functional capacity.[7,19–24] More importantly that to stimulate muscle hypertrophy, to improve neuromuscular function needs to be focused when prescribing exercise in elderly, and explosive RT seems to be the most effective intervention in order to provide this benefit.

Can Explosive RT Be Prescribed in Physically Frail Oldest Old?

Based in scientific evidence, the answer is yes. Exercise interventions have been highlighted as one of the main cornerstones of prevention and treatment of frailty.[28–30] Indeed, it has been widely

The authors declare no conflict of interest.

* Address correspondence to Mikel Izquierdo, PhD, Public University of Navarra, Department of Health Sciences, Av. Tarazona s/n, 31500 Tudela, Navarra, Spain.
E-mail address: mikel.izquierdo@gmail.com (M. Izquierdo).

https://doi.org/10.1016/j.jamda.2017.12.010
1525-8610/

shown that multicomponent exercise interventions including RT, balance exercises, and gait retraining improve muscle strength, gait ability, balance, and incidence of falls in the frail elderly.[28–30] Although with less evidence in frail population, explosive RT seems to be a feasible exercise mode even in the institutionalized oldest old, frail individuals.[7,26] It has been reported that 12 weeks of multicomponent exercise training including explosive RT improved muscle power output (96%-116%), strength (24%-144%), muscle cross-sectional area, and muscle fat infiltration (4%-8%), as well as functional outcomes and dual task performance (7%-58%) in frail institutionalized nonagenarians.[7] In another study, it has been shown that 4 weeks of high-speed RT combined with walking, cognitive, and balance exercises improved gait ability, balance, and muscle strength (15%-30%) and reduced the incidence of falls in frail patients with dementia after long-term physical restraint used in their nursing care.[26] Another interesting perspective is the inclusion of RT also composed by explosive muscle actions in acute hospitalized elderly patients.[31] A recent systematic review has shown that exercise in early hospitalization may be an interesting resource to avoid rehospitalization, accelerates hospital discharge, reduces personal and public health costs, and also avoids the functional decline associated with iatrogenic nosocomial disability.[32]

In line with this, the European Union (EU) has included several initiatives to recommend physical exercise in aging individuals. The Vivifrail Project, for example, an EU-funded project as part of the Erasmus+ program, aims to provide training on how to promote and prescribe physical exercise in elderly to maintain physical functioning and autonomy as much as possible (http://www.vivifrail.com).[33] The focus of Vivifrail is the enhancement of knowledge that how to develop and implement of good practice, as well as the design of materials that can enable us to define physical exercise prescription as a way to effectively enhance health in elderly within their environment, creating synergies among sport and health and social care services.[33]

How to Manage Power Training Intervention in Nonresponder Individuals

There is a considerable interindividual variability in response to exercise interventions that has not been clarified in elderly populations.[34–37] This means that under the same stimulus, some subjects achieve positive effects after exercise interventions (ie, responders), whereas others present unchanged physical parameters (ie, cardiorespiratory, neuromuscular).[36,37] Notwithstanding, it has been demonstrated that RT is an effective intervention with a very low rate of nonresponders in, at least, one neuromuscular parameter. Indeed, it has been shown that non-responsiveness to months of RT was not apparent because every participant experienced a positive adaptive response in at least 1 training outcome. In this case, the term *nonresponder* is more about semantics because the authors demonstrate a nonresponse in some of the chosen response variables (eg muscle fiber size, lean body mass, leg strength) across participants.[38] Therefore, in some cases, training prescription adjustments should be done (ie, increasing or decreasing intensity and volume, changing intrasession exercise order during combined resistance and endurance training) in order to achieve the expected neuromuscular, cardiorespiratory, and functional improvements. In addition, some individuals will also need more time to present such improvements.[38]

Clinical Application of Muscle Power Training: From Health Elderly to Institutionalized and Hospitalized Oldest Old Patients

There are some aspects that should be taken into consideration when prescribing explosive RT in elderly individuals. Explosive RT should be performed with the concentric phase as fast as possible followed by a controlled slower eccentric phase, and emphasized in lower limbs.[10–12] The sets using explosive muscle actions can be performed alone,[7,20,22] or combined with traditional RT (ie, slow concentric muscle actions) during the training organization, but always avoiding concentric failure.[10–12] The training intensity should range from 30% to 60% of 1RM load because maximal power output is maximized at these intensities.[8] Several studies have used standard free weights and weight machines for power training,[7,10–12,20,22] but there are studies that used pneumatic machines for this type of RT,[6,39] and similar neuromuscular and functional improvements have been observed.[40] Explosive RT doesn't necessarily need to be performed using free weights or machines. In the absence of devices to train, the use of own body as resistance, and, the raise from a chair exercise, for example, may be a nice intervention. It could start with slower execution and another person's assistance, but progresses until the patient can perform alone, and as fast as possible. This strategy may be easily performed in hospital rooms or geriatric residence. Although a volume progression should be performed, this type of exercise could be done every day and even twice a day, especially if the intervention is the only one physical activity performed by the patient during the hospitalization. When working with patients with cognitive impairments, attention needs to be paid to emotional aspects, such as reassurance, respect, and empathy toward the participants as described in patient-centered techniques that were developed for communication with these individuals.[41] The simple structure of the instructions, haptic support, and use of mirror techniques rather than complex oral instructions supported the progress of training. It is also nice to create a familiar, empathetic training atmosphere with the patients. Independent of the type of patients, care needs to be taken to ensure that the exercises are executed appropriately.

In summary, explosive RT must be prescribed in healthy and frail elderly individuals, at least in combination with traditional RT, because this type of training optimizes functional abilities gains, and reduces incidence of falls, improves muscle strength and power output, and stimulates muscle hypertrophy. RT can be also prescribed in hospitalized patients, using even the body mass as resistance if no RT device is available. Although there are older individuals who can nonrespond satisfactorily in the short term, training adjustments and long-term training may provide positive benefits, and special care is needed to prescribe resistance in this type of subjects (ie, nonresponders).

References

1. Beard JR, Officer A, de Carvalho IA, et al. The world report on ageing and health: A policy framework for healthy ageing. Lancet 2016;387:2145–2154.
2. Justice JN, Cesari M, Seals DR, et al. Comparative approaches to understanding the relation between aging and physical function. J Gerontol A Biol Sci Med Sci 2016;71:1243–2153.
3. Odden MC, Peralta CA, Haan MN, Covinsky KE. Rethinking the association of high blood pressure with mortality in elderly adults: The impact of frailty. Arch Intern Med 2012;172:1162–1168.
4. Reid KF, Fielding RA. Skeletal muscle power and functioning in older adults. Exerc Sport Sci Rev 2012;40:1–12.
5. Casas-Herrero A, Cadore EL, Zambom-Ferraresi F, et al. Functional capacity, muscle fat infiltration, power output and cognitive impairment in institutionalized frail oldest-old. Rejuvenation Res 2013;16:396–403.
6. Fielding RA, LeBrasseur NK, Cuoco A, et al. High-velocity resistance training increases skeletal muscle peak power in older women. J Am Geriatr Soc 2002; 50:655–662.
7. Cadore EL, Casas-Herrero A, Zambom-Ferraresi F, et al. Multicomponent exercises including muscle power training enhance muscle mass, power output, and functional outcomes in institutionalized frail nonagenarians. Age (Dordr) 2013;36:773–785.
8. Izquierdo M, Ibañez J, Gorostiaga E, et al. Maximal strength and power characteristics in isometric and dynamic actions of the upper and lower extremities in middle-aged and older men. Acta Physiol Scand 1999;167:57–68.
9. Izquierdo M, Aguado X, Gonzalez R, et al. Maximal and explosive force production capacity and balance performance in men of different ages. Eur J Appl Physiol Occup Physiol 1999;79:260–267.
10. Izquierdo M, Häkkinen K, Ibañez J, et al. Effects of strength training on muscle power and serum hormones in middle-aged and older men. J Appl Physiol 2001;90:1497–1507.
11. Häkkinen K, Kallinen M, Izquierdo M, et al. Changes in agonist-antagonist EMG, muscle CSA, and force during strength training in middle-aged and older people. J Appl Physiol 1998;84:1341–1349.

12. Häkkinen K, Kraemer WJ, Newton RU, Alen M. Changes in electromyographic activity, muscle fibre and force production characteristics during heavy resistance/power strength training in middle-aged and older men and women. Acta Physiol Scand 2001;171:51–62.
13. Jozsi AC, Campbell WW, Joseph L, et al. Changes in power with resistance training in older and younger men and women. J Gerontol A Biol Sci Med Sci 1999;54:591–596.
14. Skelton DA, Young A, Greig CA, Malbut KE. Effects of resistance training on strength, power, and selected functional abilities of women aged 75 and older. J Am Geriatr Soc 1995;43:1081–1087.
15. Bassey EJ, Fiatarone MA, O'Neill EF, et al. Leg extensor power and functional performance in very old men and women. Clin Sci (Lond) 1992;82:321–327.
16. Lopez P, Wilhelm EN, Rech A, et al. Echo intensity independently predicts functionality in sedentary older men. Muscle Nerve 2017;55:9–15.
17. Rech A, Radaelli R, Goltz FR, et al. Echo intensity is negatively associated with functional capacity in older women. Age (Dordr) 2014;36:9708.
18. Martinikorena I, Martínez-Ramírez A, Gómez M, et al. Gait variability related to muscle quality and muscle power output in frail nonagenarian older adults. J Am Med Dir Assoc 2015;17:162–167.
19. Bean JF, Kiely DK, LaRose S, et al. Increased velocity exercise specific to task training versus the National Institute on Aging's Strength Training Program: Changes in limb power and mobility. J Gerontol A Biol Sci Med Sci 2009;64:983–991.
20. Bottaro M, Machado SN, Nogueira W, et al. Effect of high versus low-velocity resistance training on muscular fitness and functional performance in older men. Eur J Appl Physiol 2007;99:257–264.
21. Miszko TA, Cress ME, Slade JM, et al. Effect of strength and power training on physical function in community-dwelling older adults. J Gerontol A Biol Sci Med Sci 2003;58:171–175.
22. Ramirez-Campillo R, Castillo A, de la Fuente C, et al. High-speed resistance training is more effective than low-speed resistance training to increase functional capacity and muscle performance in older women. Exp Gerontol 2014;58:51–57.
23. Tschopp M, Sattelmayer MK, Hilfiker R. Is power training or conventional resistance training better for function in elderly persons? A meta-analysis. Age Ageing 2011;40:549–556.
24. Steib S, Schoene D, Pfeifer K. Dose-response relationship of resistance training in older adults: A meta-analysis. Med Sci Sports Exerc 2010;42:902–914.
25. Straight CR, Lindheimer JB, Brady AO, Dishman RK. Effects of resistance training on lower-extremity muscle power in middle-aged and older adults: A systematic review and meta-analysis of randomized controlled trials. Sports Med 2016;46:353–364.
26. Cadore EL, Moneo ABB, Mensat MM, Muñoz AR. Positive effects of resistance training in frail elderly patients with dementia after long-term physical restraint. Age (Dordr) 2014;36:801–811.
27. Aagaard P, Suetta C, Caserotti P, et al. Role of the nervous system in sarcopenia and muscle atrophy with aging: Strength training as a countermeasure. Scand J Med Sci Sports 2010;20:49–64.
28. Cadore EL, Rodríguez-Mañas L, Sinclair A, Izquierdo M. Effects of different exercise interventions on risk of falls, gait ability and balance in physically frail older adults. A systematic review. Rejuvenation Res 2013;16:105–114.
29. Lopez P, Izquierdo M, Radaelli R, et al. Effectiveness of multimodal training on functional capacity in frail older people: A meta-analysis of randomized controls trials. J Aging Phys Act 2017;27:1–36.
30. Lopez P, Pinto RS, Radaelli R, et al. Benefits of resistance training in physically frail elderly: A systematic review. Aging Clin Exp Res; 2017 Nov 29. https://doi.org/10.1007/s40520-017-0863-z.
31. Martínez-Velilla N, Casas-Herrero A, Zambom-Ferraresi F, Suárez N. Functional and cognitive impairment prevention through early physical activity for geriatric hospitalized patients: Study protocol for a randomized controlled trial. BMC Geriatr 2015;15:112.
32. Martínez-Velilla N, Cadore L, Casas-Herrero Á, et al. Physical activity and early rehabilitation in hospitalized elderly medical patients: Systematic review of randomized clinical trials. J Nutr Health Aging 2016;20:738–751.
33. Izquierdo M, Rodriguez-Mañas L, Sinclair AJ; Vivifrail Investigators Group. What is new in exercise regimes for frail older people: How does the Erasmus Vivifrail Project take us forward? J Nutr Health Aging 2016;20:736–737.
34. Bouchard C, Rankinen T. Individual differences in response to regular physical activity. Med Sci Sports Exerc 2001;33:446–451.
35. Sisson SB, Katzmarzyk PT, Earnest CP, et al. Volume of exercise and fitness nonresponse in sedentary, postmenopausal women. Med Sci Sports Exerc 2009;41:539–545.
36. Alvarez C, Ramírez-Campillo R, Ramírez-Vélez R, Izquierdo M. Effects and prevalence of non-responders after 12 weeks of high-intensity interval or resistance training in adult woman with insulin resistance: A randomized trial. J Appl Physiol 2017;122:985–996.
37. Karavirta L, Häkkinen A, Sillanpää E, et al. Effects of combined endurance and strength training on muscle strength, power and hypertrophy in 40-67-year-old men. Scand J Med Sci Sports 2011;21:401–411.
38. Churchward-Venne TA, Tieland M, Verdijk LB, et al. There are no non-responders to resistance-type exercise training in older men and women. J Am Med Dir Assoc 2015;16:400–411.
39. Reid KF, Martin KI, Doros G, et al. Comparative effects of light or heavy resistance power training for improving lower extremity power and physical performance in mobility-limited older adults. J Gerontol A Biol Sci Med Sci 2015;70:374–380.
40. Balachandran AT, Gandia K, Jacobs KA, et al. Power training using pneumatic machines vs. plate-loaded machines to improve muscle power in older adults. Exp Gerontol 2017;98:134–142.
41. Kitwood T. The dialectics of dementia: With particular reference to Alzheimer's disease. Ageing Soc 1990;10:177–196.