



*Review article*

## **Impact of Physical Activity on Frailty Status and How to Start a Semiological Approach to Muscular System**

**Maximiliano Smietniansky \*, Bruno R. Boietti, Mariela A. Cal, María E. Riggi, Giselle P.Fuccile, Luis A. Camera, and Gabriel D. Waisman**

Department of Internal Medicine and Geriatrics, Hospital Italiano de Buenos Aires (HIBA), Buenos Aires, Argentina.

\* **Correspondence:** E-mail: [maximiliano.smietniansky@hospitalitaliano.org.ar](mailto:maximiliano.smietniansky@hospitalitaliano.org.ar); Tel/Fax: +5411-4958-5560.

**Abstract: Introduction:** The world population is aging, and this demographic fact is associated with an increased prevalence of sedentary lifestyles, sarcopenia and frailty; all of them with impact on health status. Biologic reserve determination in the elderly with comorbidity poses a challenge for medical activities. Frailty is an increasingly used concept in the geriatric medicine literature, which refers to an impairment in biologic reserve. There is a close and multidirectional relationship between physical activity, the muscular system function, and a fit status; decline in this dimensions is associated with poor outcomes. The aim of this article is to make a narrative review on the relationship between physical activity, sarcopenia and frailty syndrome. **Results:** The low level of physical activity, sarcopenia and frailty, are important predictors for development of disability, poor quality of life, falls, hospitalizations and all causes mortality. For clinical practice we propose a semiological approach based on measurement of muscle performance, mass and also level of physical activity, as a feasible way to determine the biologic reserve. This evidence shows us that the evaluation of muscle mass and performance, provides important prognostic information because the deterioration of these variables is associated with poor clinical outcomes in older adults followed up in multiple cohorts. **Conclusions:** Low activity is a mechanism and at the same time part of the frailty syndrome. The determination of biologic reserve is important because it allows the prognostic stratification of the patient and constitutes an opportunity for intervention. The clinician should be aware of the clinical tools that evaluate muscular system and level of physical activity, because they place us closer to the knowledge of health status.

---

**Key words:** elderly; muscular system; sarcopenia; frailty; physical activity

---

## 1. Introduction

For 2025 11% of the world population will be over 65 years and in developed countries this proportion could reach 21% [1]. Data from the last census in Argentina [2] showed that is the third aged country in the region and, with a forecast for 2050 of 1 every 5 Argentines over 64 years. Aging is associated with an increased prevalence of many diseases and disabilities. It is also associated with impaired functional and physiologic reserve in multiple organ systems, and a gradual limitation on the personal and social resources [3]. Frailty is a biologic syndrome of decreased reserve and resistance to stressors, resulting from cumulative declines across multiple physiologic systems, and increased the risk of falls, hospitalizations, disability, and death [47]. Impairment of muscle performance is one of the central components of the frailty syndrome, and the rate of loss of muscle mass is about 8% from 50 to 70 years [5]. The prevalence of sarcopenia syndrome, characterized by loss of strength and muscle mass, reaches 30% in people over 80 years [6]. Physical activity has a role on maintaining the function of different organ systems, and mainly on mass and muscle performance; in addition, inactivity is another key component of frailty syndrome [4]. At this point, it seems clear that there is a close and multidirectional relationship between physical activity, the muscular system vitality, and frailty syndrome; but specifically exploring strengths and holes in the current knowledge and published literature about this relationship, is beyond the objectives of this article.

For starting a practical and semiological approach to measure frailty, we propose the novel concept of “muscle language”. We think muscular system performance talks us about the entire body health status and learning this language is a first clinical step to hear the voice of the biologic reserve.

## 2. A Clinical Integrated Vision of Three Major Dimensions: Physical Activity, Muscle Vitality and Biologic Reserve

It is very important for clinical practice to be aware of the close association between these three dimensions, because from this model, we can establish risk factors, prognostic stratification and levels for evaluation and treatment. The evidence for this relationship is abundant. Regular physical activity has been shown to protect against various components of frailty syndrome [7], it improves energy levels and reduces the fatigue [8,9], reduces the risk of sarcopenia and sarcopenic obesity [10], increases walking speed [11,12] and muscle strength [13]; and also decreases the risk of functional decline and reduce mortality [14,15]. These benefits are also seen in frail patients [16]. Different types of physical activity have benefits in other organ systems: improved cardiovascular and respiratory efficiency, improved body composition and promote healthy metabolic changes, and also increased muscle endurance [17–22]. Following some periods of disuse that occur with frequency in the elderly,

for example, due to illness or hospitalization, the rate of sarcopenic muscle loss is accelerated [23]. It is no wonder then, that the most important cause of sarcopenia is inactivity. This has particular implications for older adults where there is a high prevalence of a low level of physical activity. Both the low level of physical activity [24], sarcopenia [25] and frailty [4], are important predictors for development of disability, poor quality of life, falls, hospitalizations and all cause mortality. The close relationship between sarcopenia and frailty is given because, even though they are two different entities, there is an important overlapping and a bidirectional dynamics established between them; where sarcopenia is a component of the frailty syndrome and at the same time it plays a decisive role in its development by the deterioration of the functional reserve [26]. In addition, frailty syndrome impacts through different mechanisms in muscle mass and performance, such as level of physical activity, inflammatory mediators, malnutrition, etc. [27,28].

### **3. A Semiological Approach to the Muscle Language and What the Muscle Tell us about Patient's Health Status**

From the aspects described in the preceding paragraphs sections, it is clear the relevance of measuring mass and muscle performance, and not only for what it tells us about the muscle, but also for what the muscle tell us about health status. Thus, a semiological approach to muscle language, in order to get information for daily and sometimes complex decision making processes, is relevant in the elderly [29,30]. Several tools are available for valid and reliable measurements of muscle mass, strength, and performance in clinical settings. Magnetic resonance Imaging (MRI), computed tomography (CT), Dual-energy X-ray (DXA) and a 4-compartment (4-C) model are gold standards for assessment of muscle mass. For a home-setting BIA (bioelectrical impedance), although its validity is not optimal, handheld dynamometry for measurement of muscle strength and gait speed or a Short Physical Performance Battery (SPPB) are the most valid, reliable, and feasible [31]. Interestingly, the information provided by these tools is beyond of what they are specifically measuring; for instance, in people aged 80 and older, physical performance is a strong predictor of mortality, hospitalization, and disability, and muscle strength is a strong predictor of mortality and hospitalization [32]. Elderly outpatients with a higher handgrip strength or knee extension strength were significantly more likely to be able to maintain standing balance for 10 seconds [33]. 5-m gait speed is an incremental predictor of mortality and major morbidity in elderly patients undergoing cardiac surgery, associated with a 2- to 3-fold increase in risk [34]. The SPPB includes standing balance, gait speed, and chair rises (sit to stand); and subjects with scores  $\leq 10$  at baseline had significantly higher odds of mobility disability at 3-year follow-up [35]. For muscle mass measurement, many other studies had found associations with poorer outcomes [36] that interestingly includes surgical cohorts [37]. Finally, there is also a relationship between body mass index, muscle strength and physical performance in older adults. Data from the eight HALCyon cohorts [38] were used in a recent published analysis that showed that older men and women with weak muscle

strength and high BMI have considerably poorer performance than others associations<sup>39</sup>. This evidence shows us that the evaluation of muscle mass and performance, provides important prognostic information because the deterioration of these variables is associated with poor clinical outcomes in older adults followed up in multiple cohorts. These results bring us back to the concept of biological reserve, main theoretical line of frailty syndrome, for which, from a clinical care perspective, the described tools allow us to start a reasonable approach. Ultimately, we state the need to shift from a model prognosis and weighting health based on classical comorbidity, to another multidimensional, that incorporates among other variables those which here are described, and that can be assessed daily in clinical practice.

#### **4. Measuring Intensity of Physical Activity in Clinical Practice: Another Way to Approach Frailty**

At this point, it is worth remembering, that inactivity is a risk factor while a component of the frailty syndrome [4], and this is a major risk factor for the development of disability, loss of autonomy and death. From this it follows that while we have clinical tools to measure physical activity level we could be able to measure the weighting of a risk factor for frailty and indeed one of the core components of the syndrome. This is of central relevance for clinical practice. From a practical point of view, questionnaires for physical activity intensity could seem at the first reliable tools if correlates with frailty or other poor outcomes. A study examined leisure time physical activity (LTPA) at middle life using a systematic questionnaire for common activities during the past year such as reading, watching television, walking, cycling, running, competitive exercise, etc, and subjects then were stratified in four categories based on intensity. The cohort was reassessed at 2000 and resulted that the men with high LTPA in midlife had up to 80% lower risk of frailty compared with the men with sedentary lifestyle; in addition, decline in physical activity during the 26 years of follow-up was associated with a higher prevalence of frailty in old age [40]. Not only the time spent performing physical activity, but also a sedentary behavior is seems to be associated with poor health outcomes; for instance, the actual sitting time, using the administration of a detailed lifestyle questionnaire that included sedentary lifetime dose measurement, has recently also been independently related to increased risk for all-cause and cardiovascular disease (CVD) mortality [41]. An example of a more practical and less time consuming tool is the 4-levelSaltin-Grimby Physical Activity Level Scale (SGPALS) [42] that uses a single question for self reported level of physical activity: “How much do you move and exert yourself physically during leisure time?”, and four options are given as possible answers. A study using this scale showed that self reported physical activity level, according to the SGPALS, was negatively associated with traditional cardiovascular risk factors [43]. For a busy consulting room, the authors of this study propose the present tool for routine risk assessment to identify inactive individual, with a higher risk profile.

## 5. Reasons for Proactive Medical Attitudes to Deal with Sedentary Lifestyles

The percentage of elderly persons who are inactive is very high; for example, in the United States, over 50% of older adults do not meet the recommended physical activity goals [44]. If we remember the multidirectional relationship between inactivity, sarcopenia, frailty and also disability, we could rapidly imagine the huge impact of sedentary lifestyle for public health. The first step for establishing a multidimensional approach, that should undoubtedly consider the clinical practice matter, is to have uniform definitions of some key concepts. Leisure time physical activities are that performed by a person that are not required as essential activities of daily living, and baseline physical activities refers to daily activities such as sitting, standing, walking slowly, etc. For the last category of physical activity, people are considered inactive [45]. It should be known that the concept of physical activity not only includes the endurance component, but also balance, coordination and flexibility, and that each one have overlapped and different benefits; in addition even moderate levels of physical activity reduce the risk of physical limitations or the onset of frailty [46]. The clinician should be acquainted with these concepts, for then, based on the patient and contextual diagnoses, started an individualized prescription of physical activity that should always include variables of quality, duration, frequency and intensity. Several studies have brought evidence to support the conclusions of theoretical models and developments regarding the benefits of physical activity in relation to frailty. For instance, the LIFE-P Study, a randomized controlled trial enrolling 424 community-dwelling persons (mean age = 76.8 years) with sedentary lifestyle and at risk of mobility disability, showed that regular physical activity may reduce frailty, especially in individuals at higher risk of disability [47]; and that even older adults with sarcopenia, who represent a vulnerable segment of the elder population, are capable of improvements in physical performance after a physical activity intervention [48]. In the past years, some meta analysis that assessed the impact of physical activity in outcomes extremely related to frailty were published. In one of them exercise was shown to improve normal gait speed and SPPB in community dwelling frail older adults [49]; and in other training induced increases in muscle size and strength in people older than 75 years [50]. The benefits of physical activity were also showed in nursing home residents and cancer patients [51,52]. Ultimately, other relevant aspects for the implementation of an interventional program for inactivity must be considered: motivation and self-efficacy, attitudes, barriers, cultural aspects and local considerations.

## 6. Conclusions

Inactivity and one of the main consequences, sarcopenia, are factors strongly associated with the development of the frailty syndrome, which is highly prevalent in the elderly. All three conditions have a multidirectional relationship, and are associated with an increased incidence of falls, hospitalizations, disability and death. There are clinical tools for quantifying physical activity

levels, muscle mass and performance, that correlates with biological reserve. This is important because the detection of impairment in these dimensions change the prognostic stratification of the patient, and also constitutes an opportunity for intervention. The prevalence of inactivity in the elderly is also high, and physical inactivity is an endemic situation with costly consequences for patients and the health system. Clinicians should address this important issue and promote lifestyle changes in the patient; for this, a methodic art for exercise prescription should be part of health care skills. In a wider dimension this reality imposes the need to promote and establish efficient public policies to counter it.

## Conflict of Interest

Authors declare no conflict of interest.

## References

1. Nations U (2013) World Population Ageing. Available from: <http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:World+Population+Ageing+2013#7>.
2. Censo (2010) Argentina. Available from: <http://www.censo2010.indec.gov.ar/>.
3. Bettelli G (2011) Preoperative evaluation in geriatric surgery : comorbidity, functional status. *Minerva anestesologica* 77: 637-646.
4. Fried LP, Tangen CM, Walston J, et al. (2001) Frailty in older adults: evidence for a phenotype. *J Gerontol A Biol Sci Med Sci* 56: M146-156.
5. Grimby G, Saltin B (1983) The ageing muscle. *Clin Physiol* 3: 209-218.
6. Morley JE (2008) Sarcopenia: Diagnosis and treatment. *J Nutr Heal Aging* 12: 452-456.
7. Peterson MJ, Giuliani C, Morey MC, et al. (2009) Physical activity as a preventative factor for frailty: The health, aging, and body composition study. *J Gerontol Ser A Biol Sci Med Sci* 64: 61-68.
8. Puetz TW (2006) Physical activity and feelings of energy and fatigue: Epidemiological evidence. *Sport Med* 36: 767-780.
9. Puetz TW, Flowers SS, O'Connor PJ (2008) A randomized controlled trial of the effect of aerobic exercise training on feelings of energy and fatigue in sedentary young adults with persistent fatigue. *Psychother Psychosom* 77: 167-174.
10. Baumgartner RN, Koehler KM, Gallagher D, et al. (1998) Epidemiology of sarcopenia among the elderly in New Mexico. *Am J Epidemiol* 147: 755-763.
11. Henwood TR, Riek S, Taaffe DR (2008) Strength versus muscle power-specific resistance training in community-dwelling older adults. *J Gerontol A Biol Sci Med Sci* 63: 83-91.
12. Englund U, Littbrand H, Sundell A, et al. (2005) A 1-year combined weight-bearing training program is beneficial for bone mineral density and neuromuscular function in older women. *Osteoporos Int* 16: 1117-1123.

13. Liu C-J, Latham NK (2009) Progressive resistance strength training for improving physical function in older adults. *Cochrane Database Syst Rev*: CD002759.
14. Rantanen T, Guralnik JM, Foley D, et al. (1999) Midlife hand grip strength as a predictor of old age disability. *JAMA* 281: 558-560.
15. Pate RR, Pratt M, Blair SN, et al. (1995) Physical activity and public health. A recommendation from the centers for disease control and prevention and the american college of sports medicine. *JAMA*: 402-407.
16. Rydwick E, Lammes E, Frändin K, et al. (2008) Effects of a physical and nutritional intervention program for frail elderly people over age 75. A randomized controlled pilot treatment trial. *Aging Clin Exp Res* 20: 159-170.
17. King M, Sibbald B, Ward E, et al. (2000) Randomised controlled trial of non-directive counselling, cognitive-behaviour therapy and usual general practitioner care in the management of depression as well as mixed anxiety and depression in primary care. *Health Technol Assess* 4.
18. Cress ME, Buchner DM, Questad K a, et al. (1999) Exercise: effects on physical functional performance in independent older adults. *J Gerontol A Biol Sci Med Sci* 54: M242-248.
19. Ettinger WH, Burns R, Messier SP, et al. (1997) A randomized trial comparing aerobic exercise and resistance exercise with a health education program in older adults with knee osteoarthritis. *FAST*: 25-31.
20. Messier SP, Loeser RF, Mitchell MN, et al. (2000) Exercise and weight loss in obese older adults with knee osteoarthritis: a preliminary study. *J Am Geriatrics Soc* 48: 1062-1072.
21. Miszko T a, Cress ME, Slade JM, et al. (2003) Effect of strength and power training on physical function in community-dwelling older adults. *J Gerontol A Biol Sci Med Sci* 58: 171-175.
22. Gauchard GC, Gangloff P, Jeandel C, et al. (2003) Physical activity improves gaze and posture control in the elderly. *Neurosci Res* 45: 409-417.
23. Paterson DH, Jones GR, Rice CL (2007) Ageing and physical activity: evidence to develop exercise recommendations for older adults. *Can J public Heal Rev* 98 Suppl: 2.
24. Kortebein P, Ferrando A, Lombeida J, et al. (2007) Effect of 10 days of bed rest on skeletal muscle in healthy older adults. *JAMA* 297: 1772-1774.
25. Cruz-Jentoft AJ, Baeyens JP, Bauer JM, et al. (2010) Sarcopenia: European consensus on definition and diagnosis. *Age Ageing* 39: 412-423.
26. Freiburger E, Sieber C, Pfeifer K (2011) Physical activity, exercise, and sarcopenia—future challenges. *Wien Med Wochenschr* 161: 416-425.
27. Clegg A, Young J, Iliffe S, et al. (2013) Frailty in elderly people. *Lancet* (London, England) 381: 752-762.
28. Felicio DC, Pereira DS, Assumpção AM, et al. (2014) Inflammatory mediators, muscle and functional performance of community-dwelling elderly women. *Arch Gerontol Geriatr* 59: 549-553
29. Smietniansky M, Perrota M, Saadi JM (2015) Impacto de una Consulta Geriátrica en el Proceso de Toma de Decisiones en Pacientes con Cáncer Ginecológico. *Congreso Argentino de*

*Ginecología Oncológica*: 289-296.

30. Smietniansky M, Cal M (2015) Impact of a geriatric consultation in decision-making in elderly patients with severe aortic stenosis candidates for TAVI. *An Sci Meeting AGS*.
31. Mijnders DM, Meijers JMM, Halfens RJG, et al. (2013) Validity and reliability of tools to measure muscle mass, strength, and physical performance in community-dwelling older people: A systematic review. *J Am Med Dir Assoc* 14: 170-178.
32. Legrand D, Vaes B, Matheï C, et al. (2014) Muscle strength and physical performance as predictors of mortality, hospitalization, and disability in the oldest old. *J Am Geriatr Soc* 62: 1030-1038.
33. Bijlsma AY, Pasma JH, Lambers D, et al. (2013) Muscle strength rather than muscle mass is associated with standing balance in elderly outpatients. *J Am Med Dir Assoc* 14: 493-498.
34. Afilalo J, Eisenberg MJ, Morin J-F, et al. (2010) Gait speed as an incremental predictor of mortality and major morbidity in elderly patients undergoing cardiac surgery. *J Am Coll Cardiol* 56: 1668-1676.
35. Vasunilashorn S, Coppin AK, Patel K V, et al. (2009) Use of the short physical performance battery score to predict loss of ability to walk 400 meters: Analysis from the InCHIANTI study. *J Gerontol-Ser A Biol Sci Med Sci* 64: 223-229.
36. Spruit MA, Sillen MJH, Groenen MTJ, et al. (2013) New Normative values for handgrip strength: results from the uk biobank. *J Am Med Dir Assoc* 14: 775.e5-e11
37. Hasselager R, G genur I (2014) Core muscle size assessed by perioperative abdominal CT scan is related to mortality, postoperative complications, and hospitalization after major abdominal surgery: A systematic review. *Langenbeck's Arch Surg*: 1-9.
38. Cooper R, Hardy R, Sayer A, et al. (2011) Age and gender differences in physical capability levels from mid-life onwards: The harmonisation and meta-analysis of data from eight UK cohort studies. *PLoS One* 6.
39. Hardy R, Cooper R, Aihie Sayer A, et al. (2013) Body mass index, muscle strength and physical performance in older adults from eight cohort studies: the halcyon programme. *PLoS One* 8: e56483. Available from: <http://dx.plos.org/10.1371/journal.pone.0056483>.
40. Savela SL, Koistinen P, Stenholm S, et al. (2013) Leisure-time physical activity in midlife is related to old age frailty. *J Gerontol-Ser A Biol Sci Med Sci* 68: 1433-1438.
41. Katzmarzyk PT, Church TS, Craig CL, et al. (2009) Sitting time and mortality from all causes, cardiovascular disease, and cancer. *Med Sci Sports Exerc* 41: 998-1005.
42. Saltin B, Grimby G (1968) Physiological analysis of middle-aged and old former athletes. Comparison with still active athletes of the same ages. *Circulation* 38: 1104-1115.
43. Rödger L, Jonsdottir IH, Rosengren A, et al. (2012) Self-reported leisure time physical activity: A useful assessment tool in everyday health care. *BMC Public Health* 12: 693.
44. Centers for Disease Control and Prevention. U.S. Physical Activity Statistics. 2007. Department of Health and Human Services. Available from:



- <http://apps.nccd.cdc.gov/PASurveillance/StateSumResultV.asp?CI=&Year=2007&State=0#data>.
45. US Department of Health & Human Services. Physical guidelines for American. 2010. Available at: <http://www.healthypeople.gov/default.htm>. Accessed August 28th 2010.
  46. Keysor JJ (2003) Does late-life physical activity or exercise prevent or minimize disablement? A critical review of the scientific evidence. *Am J Prev Med* 25: 129-136.
  47. Cesari M, Vellas B, Hsu F-C, et al. (2015) A physical activity intervention to treat the frailty syndrome in older persons-results from the LIFE-P study. *J Gerontol A Biol Sci Med Sci* 70: 216-222.
  48. Liu CK, Leng X, Hsu FC, et al. (2014) The impact of sarcopenia on a physical activity intervention: The lifestyle interventions and independence for elders pilot study (LIFE-P). *J Nutr Heal Aging* 18: 59-64.
  49. Giné-Garriga M, Roqué-Fíguls M, Coll-Planas L, et al. (2014) Physical exercise interventions for improving performance-based measures of physical function in community-dwelling, frail older adults: A systematic review and meta-analysis. *Arch Phys Med Rehabil* 95: 753-769.
  50. Stewart VH, Saunders DH, Greig CA (2014) Responsiveness of muscle size and strength to physical training in very elderly people: A systematic review. *Scand J Med Sci Sports* 24: e1-10.
  51. Fiatarone MA, O'Neill EF, Ryan ND, et al. (1994) Exercise training and nutritional supplementation for physical frailty in very elderly people. *The New England J Med* 330: 1769-1775.
  52. Galvão DA, Taaffe DR, Spry N, et al. (2010) Combined resistance and aerobic exercise program reverses muscle loss in men undergoing androgen suppression therapy for prostate cancer without bone metastases: A randomized controlled trial. *J Clin Oncol* 28: 340-347.



AIMS Press

© 2016 Maximiliano Smietniansky et al., licensee AIMS Press.  
This is an open access article distributed under the terms of the  
Creative Commons Attribution License  
(<http://creativecommons.org/licenses/by/4.0>)