Sarcopenia in the elderly-A narrative review

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Abstract

The biggest impact of Taiwan's population aging on society is the increase in the demand for geriatric medical care and the increase in the burden of social and economic welfare. It will have an impact on domestic consumption, domestic demand and labor supply, and changes in the demographic structure will also have an impact on the economy. There will be a series of changes in consumer demand and infrastructure as the workforce shrinks and productivity weakens. The negative effects of sarcopenia in obese or osteoporotic populations are greater than those in the general healthy population, and sarcopenia is additive to the effects of obesity and osteoporosis on metabolism and physical activity. The increase of adipose tissue in the elderly can also lead to an increase in chronic inflammation in the body, increase insulin resistance, reduce muscle synthesis and increase muscle breakdown, resulting in an increase in the prevalence of sarcopenic obesity in the elderly. Studies have shown that sarcopenia increases the risk of falls in the elderly, and also causes obese elderly people to easily lose muscle under a calorie-restricted diet. It can be seen from the above that nutritional supplementation and moderate aerobic and resistance exercise can reduce the risk of sarcopenia and falls in the obese elderly. Falls and their related injuries represent one major health care issue in the elderly population. Falls are a common event among older adults and are associated with increased morbidity and disability. It has been estimated that, in such population, two-thirds of the death from unintentional injuries are related to a fall event. And improve the mobility of the elderly, so pay attention to the problems of sarcopenia and frailty in the elderly, and early and active intervention can prevent subsequent disability and the disadvantages of sarcopenia and frailty.

Key words:

Sarcopenia; Malnutrition; Falls; Frailty; Geriatric syndrome; Osteosarcopenia .

**Introduction:**

 Falls in the elderly are an important issue, especially in patients with sarcopenia and osteoporosis, and falls are a major cause of disability and bedridden. Sarcopenia is an age-related chronic inflammation, changes in body composition, and hormonal imbalances. Global has entered an aging society. Due to the aging process, motor nerve degeneration, reduced protein synthesis, insufficient nutrient supply, sedentary inactivity or chronic disease bed rest and inflammatory reactions are all causes of sarcopenia [1]. Frailty is characterized by a diminished response to stress, which triggers a decline in the physiological function of various systems. The frailty typical of older adults is often associated with reduced quality of life and mobility [2]. Falls are often associated with reduced mobility and the ability to perform common functions of daily living, as well as increased hospitalization days. When an elderly person has both obesity and muscle deficiency, it is called sarcopenia obesity [3]. In addition, muscle mass loss associated with altered muscle composition, increased visceral fat, and altered infiltration and innervation of muscle cells by fat, as well as increased fat mass, have a multiplicative effect on increased cardiovascular risk [4]. The risk of falls in elderly women is about 1.5-2 times than that of elderly men. The elderly over the age of 65 will fall about 28-35% every year, and it will increase to 32-42% over the age of 70. The incidence of falls is 30-40%, and the incidence of falls can be as high as 50% for the elderly over 80 years old, and the incidence of falls in the elderly in long-term care institutions is even higher, even as high as 50% per year. There are many literatures related to the pathophysiology of sarcopenia and frailty and its sarcopenia, osteoporosis and falls in the elderly.

**Frailty and sarcopenia:**

Sarcopenia is defined as a decrease in muscle mass and strength, a phenomenon that occurs naturally with age [5]. In 1997, American scholar Rosenberg first used the Greek word "Sarcopenia" to name this phenomenon and called it sarcopenia [6]. Sarcopenia is mainly manifested as a decline in muscle strength, which reduces the mobility of the elderly, making it difficult for the elderly to complete daily activities such as walking, sitting, and lifting heavy objects, and even lead to balance disorders and easy falls. In 2001, the scholar Fried proposed five main clinical indicators of frailty (Fried frailty phenotype), and based on this to define frailty; these clinical indicators include unintentional weight loss, self-reported fatigue, decreased muscle strength, walking slower speed and lower physical activity [7,8]. The Taiwan Nutrition and Health Status Survey from 2014 to 2015 found that the prevalence of frailty among Taiwanese aged 65 and over was 7.8%, and the prevalence of pre-frailty was 50.8%. Compared with normal people, patients with sarcopenia have significantly lower body weight and lean body mass, significantly lower grip strength, and significantly weakened lower extremity flexors, so the elderly often fall frequently [9]. Sarcopenia is associated with poor physical fitness, lack of exercise, slowed gait speed, and decreased mobility; these manifestations also represent common features of frailty and together lead to an increased risk of falls. Sarcopenia, obesity, and sarcopenic obesity are associated with many negative health outcomes such as high risk of falls and low health-related quality of life in older adults [10].

**Dental chewing problems in the elderly lead to a vicious cycle between malnutrition and sarcopenia:**

The present study shows that chewing ability is related to sarcopenia, which is equal to the relationship with the known factor of age. Poor oral status as determined by the number of natural teeth, chewing ability, articulatory oral motor skill, tongue pressure, and subjective difficulties in eating and swallowing significantly predicted future physical weakening (new onsets of physical frailty, sarcopenia, and disability). The investigated physical, mental, and social factors affecting community-dwelling elderly individuals, to identify whether poor oral status affected risks for physical weakening, and to examine whether accumulation of oral frailty could predict adverse health outcomes. The results suggest that poor status in oral measures may potentially predict new onsets of physical frailty, sarcopenia, and subsequent requirement for long-term care. Results also demonstrate that baseline oral frailty status, as significantly predicted susceptibility to physical frailty, sarcopenia, the subsequent need for mortality, although there was no significant association between oral frailty status and chronic conditions at baseline. Possibly, subjective difficulties in eating and swallowing are more likely to be related to habitual poor food intake than objective

measures. In fact, a previous study reported that both subjective and objective assessments should be undertaken. Because most oral frailty components, except the number of teeth, were reversible, early awareness of declining oral health and prompt treatment of impaired oral function may be effective in preventing adverse health outcomes. Firstly, preventing tooth mortality is essential. The preventive effects of education in oral self-care and professional mechanical tooth cleaning on tooth mortality have been recognized. Furthermore, an oral health education program, including an exercise for promoting oral functions, was shown to be effective in

improving articulatory oral motor skill, functional performance of the tongue, and swallowing function among disability-free elderly individuals. These programs could be useful for improving chewing ability and subjective difficulties in eating because occlusal force and self-reported masticatory ability are also likely to be improved. Taken together, oral frailty could be prevented by proper oral self-care, habitual exercise for oral functions, and periodic professional checkups, which requires evaluation.

**Falls are highly associated with sarcopenia:**

In recent years, sarcopenia has been gradually valued by the public, health sports centers, nutrition associations and experts in geriatric medicine; it has been defined internationally: in 2018, the European Working Group on Sarcopenia (EWGSOP) proposed the definition of sarcopenia as "progressive". Decreased muscle mass and muscle function (muscle strength and physiological activity) may lead to a syndrome of increased disease incidence, reduced quality of life, and even death” [11]. Diagnosis and Grading Criteria: Contains three components: low muscle mass, low muscle strength, and low physical performance. Many literatures discuss falls in the elderly, but the fall caused by sarcopenia is rarely discussed. There are many individual reasons for sarcopenia and falls, and it is difficult to prove their causal relationship, especially since most of the studies are cross-sectional A cross-sectional study, therefore it is not possible to determine whether sarcopenia is a risk factor for falls, and future prospective studies are needed to determine whether sarcopenia causes falls in older adults; in short, sarcopenia defined by muscle mass, muscle strength, and physical performance, it is positively associated with falls in older adults [12,13]. Interventions to prevent sarcopenia may be important in preventing falls in older adults. Sarcopenia is a geriatric syndrome characterized by decreased muscle mass and strength, as well as decreased physical function. Sarcopenia may be one of the important risk factors for falls. Sarcopenia and frailty are common geriatric syndromes around us. As we get older, muscle and bone mass will gradually lose, and the risk of sarcopenia will gradually increase. After the age of 30, muscle mass decreases by 8% every ten years. After muscle mass declines, weakness, fatigue, falls, and symptoms such as weight loss [14]. Whereas medical care in the past focused on prevention, early diagnosis, and long-term care, current trends tend to view age as a background cause of frailty, interacting with multiple factors including age-related physiological changes, environment, various diseases, and medications [15]. This leads to debilitating symptoms in the elderly, and there are many factors that can be summarized as endocrine system diseases and systemic inflammation. Body composition changes in the skeletal musculature may be nutrient deficiencies, of which sarcopenic obesity has drawn more attention. Many physiological mechanisms are considered to be related to frailty, among which sarcopenia is considered to be highly correlated with frailty, and it can almost be said that sarcopenia and frailty are two sides of the same [16]. If obesity is combined at the same time, it will also lead to metabolic deterioration problems such as blood sugar and blood pressure, because muscle is closely related to the storage of human protein and the regulation of blood sugar and other metabolism. If the elderly have both muscle deficiency and obesity, it is called sarcopenic obesity, and sarcopenic obesity may be more likely to cause cardiovascular disease or falls than obesity or sarcopenia alone, and even increase mortality. According to recent research, approximately 6% of all medical expenditures for older Americans are related to falls, and 5% of older adults who fall require hospitalization [17].

**Sarcopenic osteoporosis:**

Sarcopenic osteoporosis is also known as ‘’osteosarcopenia’’, which is osteopenia or osteoporosis combined with sarcopenia [18]; sarcopenia and osteoporosis are generally related since 2001, some people have studied the relationship between muscle and bone in the elderly; recent studies have found that muscle mass can predict bone density for both elderly men and women, and the evidence for postmenopausal women is that stronger than in men [19]. Therefore, the synergistic relationship between sarcopenia and osteoporosis may be better viewed as an interaction of five indicators of muscle mass, muscle strength, bone mineral density (BMD), fractures, and quality of life [20]. After the age of 50, the muscle mass decreases by about 1-2% per year, and the muscle strength decreases by 1.5-3% per year. Some literatures believe that it is caused by the decline of estrogen after menopause [21]. In addition to the effects of sex hormones, insulin-like growth factor and growth hormone also affect bones and muscles. Because muscles and bones are mutually reinforcing [42], sarcopenia and osteoporosis are also often Combination occurs, resulting in osteopenia syndrome. EWGSOP defines sarcopenia as not only a decrease in muscle mass, but also an impact on muscle strength and physical performance [22]; recent studies have found that people with osteoporosis are often also people with sarcopenia, so sarcopenia is associated with osteoporosis is co-existing and closely related.

**Physiological factors affecting balance:**

Falls have many different causes; some risk factors that predispose older adults to falls are classified as intrinsic or extrinsic [23]. Intrinsic factors include those related to function and health conditions such as physiological dysfunction, balance disorders. Extrinsic factors include: adverse drug reactions, use of restraints, and environmental factors such as poor lighting or lack of safety equipment in bathrooms. Physiological functions include: 1.degeneration of the nervous system: the nerve conduction speed in the elderly becomes slower, the sensation is slower, and the reaction time is prolonged; the degeneration of the optic nerve affects vision, and lesions of the vestibular nerve, cerebellum, brain stem and basal ganglia (stroke, Parkinson's disease) Symptoms) and so on will affect the balance of the elderly. 2. degeneration of skeletal joints and muscular systems, such as joint pain, deformation, contracture, etc., causing by lower limb or spondyloarthritis, affects the stability and symmetry of the patient's gait, and makes the patient prone to falls. Compared with young people, the total muscle mass and number of muscle fibers of the elderly show a significant decrease, and aging causes muscle atrophy; from the age of 60 to 90, the average muscle strength decreases by 20-30%. All of the above reasons make the elderly unable to cope with the occurrence of falls. 3. Concomitant medical diseases such as arrhythmia, postural hypotension, inappropriate hypoglycemic and hypertensive drugs, antihistamines and sedatives, etc., may affect the sense of balance and make the elderly more prone to falls [24].

**Improve diet and regular exercise to prevent falls in older adults:**

During the process of muscle loss, adipose tissue also slowly accumulates. This phenomenon is a state of excessive fat accumulation and reduced muscle mass, also known as musculoskeletal atrophic obesity. If the elderly population is combined with muscle atrophy and obesity, it will have a multiplicative negative impact on health, and accelerate the physical disability, morbidity and mortality of the elderly [25]. Sarcopenia, obesity, and sarcopenic obesity are associated with many negative health outcomes such as higher risk of falls and lower health-related quality of life in older adults. Vitamin D supplementation appears to reduce the risk of falls by more than 20 percent in stable ambulatory or hospitalized older adults [26]. Studies have found that 400 IU of vitamin D did not significantly reduce fracture risk, while trials using 700-800 IU/day of vitamin D did find a significant reduction in observed fractures, and further studies should be considered to examine the effects of alternative types of vitamin D and their calcium dose of the role of supplements and effects in men [27]. Musculoskeletal aging is a major public health problem and stress in Taiwan due to significant demographic changes with aging, and frailty, sarcopenia, and a high risk of falls, and loss of autonomy in the elderly are associated with institutionalized health outcomes [28], This pathological state is therefore also associated with high morbidity rates and health care expenditures. Bone mass, muscle mass, and strength increase in late adolescence and early adulthood, but decrease significantly from age 50 and are closely related. It is increasingly accepted that bone and muscle tissue are endocrine organs that interact through paracrine and endocrine signaling [29]. The mineral content of bone is closely related to muscle mass during growth, there is some evidence that osteoporosis and sarcopenia share common pathophysiological factors, and that low bone mineral density in both men and women is associated with a correlation exists between sarcopenia [30]. Typical elderly sarcopenia and osteoporosis are often closely related, and are also highly related to frailty. These syndromes lead to an increased risk of falls in the elderly; according to research, falls in long-term care institutions are an important factor in disability and death for the elderly, according to Studies have investigated that ''environmental factors'' account for the largest proportion of falls in the elderly, as high as 50% [31]. And older people living in the community, due to various internal (age, gender, ethnicity, physical health problems, medical, cognitive impairment and physical inactivity), and external (vision, polypharmacy, inappropriate shoes, inappropriate accessories furniture and bathrooms, lack of grab bars, poor lighting, uneven stairs or slippery surfaces) risk factors, more than one-third of seniors fall at least once a year, and among seniors living in the community, 30-50% of falls are due to environmental factors caused [43].

**Prescriptions for balance-promoting exercise for the elderly:**

Due to lack of exercise, the walking speed of some elderly people is slower, the pace is smaller, the walking pause time is longer, the swinging time of the hands during walking is shortened, the foot lift is not high, and the range of motion of each joint of the leg is small during walking. Lack of sufficient exercise can cause muscle atrophy and joint stiffness and contracture. Muscle atrophy refers to the reduction of muscle size, muscle tension and muscle strength. Usually, symptoms of muscle weakness will appear after 1-2 days of bed rest. The more the frail, the lower the activity tolerance, the less the amount of exercise, and the more reluctance to move because of the weakness. In this vicious cycle, the muscles begin to atrophy [32]. The gait and balance problems of the elderly are related to the stability of the elderly when walking and standing, and the walking posture is different due to common elderly diseases, which are all factors that cause the elderly to fall. The body needs to be coordinated by 3 systems to maintain balance: 1.vestibular system: sensory organs that regulate balance force (balance force perception), directional information related to head position (internal gravity, linear and angular acceleration). 2.somatosensory system: joint proprioception and kinematic sensation, information from skin and joints (pressure and vibration sensations); spatial position and motion relative to supporting surfaces; motion and position of different body parts relative to each other. 3.vision system: refer to the verticality of body and head movements, relative to the spatial position of the object [33]. Once the elderly fall, they will be more afraid of walking, stay in bed or sit in a wheelchair all day, and the muscles and joints will gradually degenerate, forming a vicious circle [34]. When practicing Tai Chi, you need to focus on muscle control, which can help enhance the strength of the upper and lower limbs and the overall balance and stability, so that the elderly can reduce the risk of falling. Some studies have pointed out that practicing Tai Chi can reduce the risk of falling by as much as 50% within 12 months. [35].

**Conclusion:**

Aging is associated with the gradual decline of the body's physiological functions. An important body part affected by aging is muscle tissue [36]. The world's population is aging, and increases in life expectancy are often unhealthy. In particular , musculoskeletal aging, which leads to sarcopenia and osteoporosis, has a variety of causes; such as changes in body composition, inflammation, and hormonal imbalances. Sarcopenia, osteoporosis, and sarcopenic obesity are often closely associated with frailty, often leading to the development of geriatric syndromes [37]. Frailty increases the risk of immobility or falls during daily activities, and increases cardiovascular disease, cancer, and death [38]. As the geriatric population continues to increase, it is most important to identify the elderly at risk of frailty early and treat or prevent their poor prognostic factors [39], and to develop interventions that can promote successful aging. The complexity and heterogeneity of sarcopenia and frailty require a comprehensive geriatric assessment, such as nutritional interventions, regular physical activity and psychosocial well-being, and regular review of medication intake, which appear to prevent and affect life expectancy and quality of life, thereby reducing mortality [40,41]. Falls and sarcopenia are interrelated. If there is no effective prevention and interventional treatment, the disability of the elderly may come early, which will bring more burdens to patients and caregivers. Of course, more foundations are required. And clinical research to understand the complex physiology of sarcopenia, osteoporosis, and frailty leading to falls in the elderly, and to take effective clinical interventions at a young age to prevent and treat sarcopenia [42,43].

Reference:

1.Dupuy C, Lauwers‐Cances V, Guyonnet S, et al. Searching for a relevant definition of sarcopenia: results from the cross‐sectional EPIDOS study. Journal of Cachexia, Sarcopenia and Muscle. 2015 Jun;6(2):144-54.

2.Dawson-Hughes B, Bischoff-Ferrari H. Considerations concerning the definition of sarcopenia. Osteoporosis international. 2016; 27(11):3139-44.

3.Kalinkovich A, Livshits G. Sarcopenic obesity or obese sarcopenia: a cross talk between age-associated adipose tissue and skeletal muscle inflammation as a main mechanism of the pathogenesis. Ageing research reviews 2017; 35: 200-21.

4.Migliaccio S, Greco EA, Wannenes F, et al. Adipose, bone and muscle tissues as new endocrine organs: role of reciprocal regulation for osteoporosis and obesity development. Hormone molecular biology and clinical investigation 2014; 17(1): 39-51.

5.Cruz-Jentoft AJ, Sayer AA. Sarcopenia. The Lancet 2019; 393(10191):2636-46.

6.Marzetti E, Calvani R, Tosato M, et al. Sarcopenia: an overview. Aging clinical and experimental research 2017; 29(1):11-7.

7.Fried LP, Tangen CM, Walston J, et al. Frailty in older adults: evidence for a phenotype. The Journals of Gerontology Series A: Biological Sciences and Medical Sciences 2001; 56(3): M146-M157.

8.Von Haehling S, Morley JE, Anker SD. An overview of sarcopenia: facts and numbers on prevalence and clinical impact. Journal of cachexia, sarcopenia and muscle. 2010;1(2):129-33.

9.Guirguis-Blake JM, Michael YL, Perdue LA, Coppola EL, Beil TL. Interventions to Prevent Falls in Older Adults: Updated Evidence Report and Systematic Review for the US Preventive Services Task Force. JAMA. 2018; 319(16): 1705-16.

10.Ensrud KE, Ewing SK, Taylor BC, et al. Comparison of 2 frailty indexes for prediction of falls, disability, fractures, and death in older women. Archives of internal medicine 2008; 168(4): 382-9.

11.Cruz-Jentoft AJ, Baeyens JP, Bauer JM, et al. Sarcopenia: European consensus on definition and diagnosisReport of the European Working Group on Sarcopenia in Older PeopleA. J. Cruz-Gentoft et al. Age and ageing 2010; 39(4): 412-23.

12.Chen LK, Woo J, Assantachai P, et al. Asian Working Group for Sarcopenia: 2019 consensus update on sarcopenia diagnosis and treatment. Journal of the American Medical Directors Association. 2020; 21(3): 300-7.

13.Moncada LVV, Mire LG. Preventing falls in older persons. Am Fam Physician. 2017; 96(4): 240-7.

14.Cruz-Jentoft AJ, Landi F, Topinková E, Michel JP. Understanding sarcopenia as a geriatric syndrome. Current Opinion in Clinical Nutrition & Metabolic Care 2010; 13(1):1-7.

15.Visser M, Schaap LA. Consequences of sarcopenia. Clinics in geriatric medicine 2011; 27(3): 387-99.

16.Morley JE. Diabetes, sarcopenia, and frailty. Clinics in geriatric medicine. 2008 Aug 1;24(3):455-69.

17.Chuang SY, Hsu YY, Chen RC, Liu WL, Pan WH. Abdominal obesity and low skeletal muscle mass jointly predict total mortality and cardiovascular mortality in an elderly Asian population. Journals of Gerontology Series A: Biomedical Sciences and Medical Sciences. 2016 Aug 1;71(8):1049-55.

18.Ormsbee MJ, Prado CM, Ilich JZ, et al. Osteosarcopenic obesity: the role of bone, muscle, and fat on health. Journal of cachexia, sarcopenia and muscle 2014; 5(3): 183-92.

19.Greco EA, Pietschmann P, Migliaccio S. Osteoporosis and sarcopenia increase frailty syndrome in the elderly. Frontiers in endocrinology 2019; 10: 255-35.

20.Gielen E, Bergmann P, Bruyère O, et al. Osteoporosis in frail patients: a consensus paper of the Belgian bone club. Calcified tissue international 2017; 101(2): 111-31.

21.Yeung SS, Reijnierse EM, Pham VK, et al. Sarcopenia and its association with falls and fractures in older adults: a systematic review and meta‐analysis. Journal of cachexia, sarcopenia and muscle 2019; 10(3): 485-500.

22.Marques A, Queirós C. Frailty, sarcopenia and falls. In Fragility Fracture Nursing Springer 2018: 15-26 (Cham p.1-169).

23.Panel on Prevention of Falls in Older Persons, American Geriatrics Society and British Geriatrics Society. Summary of the Updated American Geriatrics Society/British Geriatrics Society clinical practice guideline for prevention of falls in older persons. J Am Geriatr Soc. 2011; 59(1): 148-57.

24.Phelan EA, Mahoney JE, Voit JC, Stevens JA. Assessment and management of fall risk in primary care settings. Med Clin North Am. 2015; 99(2): 281-93.

25.Öztürk ZA, Türkbeyler İH, Abiyev A, et al. Health‐related quality of life and fall risk associated with age‐related body composition changes; sarcopenia, obesity and sarcopenic obesity. Internal medicine journal 2018;48(8): 973-81.

26.Kim J, Lee Y, Kye S, Chung YS, Lee O. Association of serum vitamin D with osteosarcopenic obesity: Korea National Health and Nutrition Examination Survey 2008-2010. Journal of cachexia, sarcopenia and muscle. 2017; 8(2): 259-66.

27.Thanapluetiwong S, Chewcharat A, Takkavatakarn K, et al. Vitamin D supplement on prevention of fall and fracture: a meta-analysis of randomized controlled trials. Medicine 2020; 99(34): 1-12.

28.Fhon JRS, Rodrigues RAP, Neira WF, et al. Fall and its association with the frailty syndrome in the elderly: systematic review with meta-analysis. Revista da Escola de Enfermagem da USP 2016; 50: 01005-013.

29.Konopka AR, Harber MP. Skeletal muscle hypertrophy after aerobic exercise training. Exercise and sport sciences reviews 2014; 42(2): 53-61.

30.Gandham A, Mesinovic J, Jansons P, et al. Falls, fractures, and areal bone mineral density in older adults with sarcopenic obesity: A systematic review and meta‐analysis. Obesity reviews 2021; 22(5): e13187.

31.Vlaeyen E, Coussement J, Leysens G, et al. Characteristics and effectiveness of fall prevention programs in nursing homes: a systematic review and meta-analysis of randomized controlled trials. J Am Geriatr Soc. 2015; 63(2): 211-21.

32.Marzetti E, Calvani R, Tosato M, et al. Physical activity and exercise as countermeasures to physical frailty and sarcopenia. Aging clinical and experimental research. 2017;29(1):35-42.

33.Kelsey JL, Berry SD, Procter‐Gray E, et al. Indoor and outdoor falls in older adults are different: the maintenance of balance, independent living, intellect, and Zest in the Elderly of Boston Study. Journal of the American Geriatrics Society 2010; 58(11): 2135-41.

34.Cruz-Jentoft AJ. Perspective: protein and exercise for frailty and sarcopenia: still learning. Journal of the American Medical Directors Association 2013; 14(1): 69-71.

35.Schleicher MM, Wedam L, Wu G. Review of Tai Chi as an effective exercise on falls prevention in elderly. Research in Sports Medicine 2012; 20(1): 37-58.

36.Conte M, Vasuri F, Trisolino G, et al. Increased Plin2 expression in human skeletal muscle is associated with sarcopenia and muscle weakness. PLoS One 2013; 8(8): e73709.

37.Huo YR, Suriyaarachchi P, Gomez F, et al. Comprehensive nutritional status in sarco-osteoporotic older fallers. The journal of nutrition, health & aging 2015; 19(4): 474-80.

38.Lana LD, Schneider RH. The frailty syndrome in elderly: a narrative review. Revista Brasileira de Geriatria e Gerontologia 2014; 17: 673-80.

39.Lang T, Streeper T, Cawthon P, et al. Sarcopenia: etiology, clinical consequences, intervention, and assessment. Osteoporosis international 2010; 21(4): 543-59.

40.Hernández Morante JJ, Gómez Martínez C, Morillas-Ruiz JM. Dietary factors associated with frailty in old adults: a review of nutritional interventions to prevent frailty development. Nutrients 2019; 11(1): 102-15.

41.Tanimoto Y, Watanabe M, Sun W, et al. Sarcopenia and falls in community-dwelling elderly subjects in Japan: Defining sarcopenia according to criteria of the European Working Group on Sarcopenia in Older People. Archives of gerontology and geriatrics 2014; 59(2): 295-9.

42.Bian A, Ma Y, Zhou X, et al. Association between sarcopenia and levels of growth hormone and insulin-like growth factor-1 in the elderly. BMC Musculoskeletal Disorders 2020; 21(1): 1-9.

43.Murakami M, Hirano H, Watanabe Y, et al. Relationship between chewing ability and sarcopenia in J apanese community‐dwelling older adults. Geriatrics & gerontology international 2015; 15(8): 1007-12.