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The Relationship Between the Elemental Status of the Elderly and Senile Population and Sarcopenia: A Review

Gulmira A. Umarova, Gulnara A. Batyrova, Ayagul S. Zhubaniyazova

West Kazakhstan Marat Ospanov Medical University, Aktobe, Republic of Kazakhstan

ABSTRACT

The elemental status plays a key role in maintaining the vital balance in the body and deviations in which lead to the development of a particular pathology. Sarcopenia—an age-related condition characterized by a decrease in muscle mass, strength, and functionality, is a serious public health problem, especially against the background of global population aging. One of the significant but little-studied factors influencing the development of sarcopenia is the elemental status of the body of elderly and senile people. Macro- and microelements such as zinc, magnesium, selenium, iron, and calcium play an important role in regulating muscle metabolism, antioxidant protection, and anti-inflammatory activity. Deficiency of these elements can significantly accelerate the development of sarcopenia, worsen the general condition of elderly patients and increase the risk of disability. Studying the relationship between the level of vital trace elements and the manifestations of sarcopenia allows us to better understand the pathogenesis of this condition, develop methods for early diagnosis and reasonably apply nutritional correction. Conducting research in this area is an important step towards developing personalized prevention and treatment strategies that help improve quality of life and reduce the burden of chronic age-related diseases.

Keywords: macronutrients; trace elements; sarcopenia; elderly and senile age.

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Связь элементного статуса населения пожилого и старческого возраста с саркопенией: научный обзор

Г.А. Умарова, Г.А. Батырова, А.С. Жубаниязова

Западно-Казахстанский медицинский университет имени Марата Оспанова, Актобе, Республика Казахстан

АННОТАЦИЯ

Элементный статус организма играет ключевую роль в поддержании физиологического гомеостаза, а его нарушения могут способствовать развитию различных патологических состояний. Саркопения — возраст-ассоциированное атрофическое дегенеративное изменение скелетной мускулатуры, характеризующееся снижением мышечной массы, силы и функциональной активности, — представляет значимую медико-социальную проблему в условиях стареющего населения. Одним из потенциальных, но недостаточно изученных факторов, влияющих на её развитие, является обеспеченность макро- и микроэлементами у лиц пожилого и старческого возраста. Такие элементы, как цинк, магний, селен, железо, кальций, участвуют в регуляции процессов мышечного метаболизма, обеспечивают антиоксидантную защиту, поддерживают противовоспалительные механизмы. Их дефицит может способствовать ускоренной утрате мышечной ткани, снижению физической работоспособности и увеличению риска функциональных нарушений и инвалидизации. Установление взаимосвязей между содержанием жизненно важных микроэлементов и клиническими проявлениями саркопении открывает перспективы для более точной диагностики и целенаправленной нутритивной коррекции. Актуальность исследований в этой области обусловлена необходимостью разработки персонализированных профилактических и лечебных подходов, направленных на замедление прогрессирования саркопении и повышение качества жизни. Таким образом, изучение взаимосвязи между элементным статусом пожилого населения и саркопенией является важной областью современной геронтологии, диетологии и общественного здравоохранения.

Ключевые слова: макроэлементы; микроэлементы; саркопения; пожилой и старческий возраст.

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老年及高龄人群元素状况与肌少症的关系：科学综述

Gulmira A. Umarova, Gulnara A. Batyrova, Ayagul S. Zhubaniyazova

West Kazakhstan Marat Ospanov Medical University, Aktobe, Republic of Kazakhstan

摘要

机体的元素状况在维持生理稳态中起着关键作用，其紊乱可能促发多种病理状态。肌少症是一种与年龄相关的骨骼肌萎缩性退行性变化，表现为肌肉质量、肌力及功能活动水平的下降，随着人口老龄化的加剧，已成为一项重要的医学和社会问题。老年及高龄人群中宏量元素和微量元素的供给水平，是影响其发生和发展的潜在但尚未被充分研究的因素之一。锌、镁、硒、铁、钙等元素参与肌肉代谢过程的调控，具有抗氧化活性，并支持抗炎机制。上述元素的缺乏可能加速肌肉组织的流失，降低身体功能水平，并增加功能障碍与致残的风险。明确关键微量元素含量与肌少症临床表现之间的关系，有助于实现更为精准的诊断与有针对性的营养干预。该领域研究的现实意义在于推动个体化的预防和治疗策略开发，以延缓肌少症的进展、改善生活质量。因此，探讨老年人元素状况与肌少症之间的关联，已成为当前老年医学、营养学与公共卫生研究的重要方向。

关键词：宏量元素；微量元素；肌少症；老年及高龄人群。

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INTRODUCTION

Kazakhstan is seeing a steady increase in the elderly population. It is expected that the proportion of people aged 60 and older will increase from 12% to 20% by 2050. Population aging in Kazakhstan will be driven by a gradual decline in birth rates and higher life expectancy. The ratio of working-age population (25–64 years) to population over 65 years will drop by half (from 7.0 to 3.5) by 2050. Increasing life expectancy requires high quality of life, preventive actions, and conditions for active and healthy aging[1] [1]. With age, the body experiences complex metabolic and epigenetic changes accompanied by health deterioration [2]. It is known that in aging, the bioelement homeostasis dysregulates, which is associated with some macro- and micronutrient deficiency. However, data on the age-related bioelemental changes in the human body are controversial; only a few studies prove the hypothesis of a universal and linear decrease in their levels with age. Review of literature indicates multidirectional age-related changes in the elemental homeostasis, which can manifest as both a deficiency and an excess of individual bioelements in old age [3].

Assessing micro- and macronutrient adequacy in the elderly population is a pressing public health issue, especially in regions with adverse environmental conditions, such as Western Kazakhstan. There is observed risk of both essential nutrient deficiency and excessive intake of toxic and potentially toxic substances that can have adverse health effects in the elderly population. Considering the importance of this issue for geriatric practice, the review of publications studying the elemental status of older people and its relationship with sarcopenia is relevant and reasonable.

METHODS

The relevant literature was searched using PubMed and Google Scholar search engines, MEDLINE and Cochrane Library databases, and official government websites. A total of 292 publications were found. We selected 31 sources related to the studied issue based on the criterion of review depth (over the past 5 years). We used the data analysis method (see Fig. 1).

IMPORTANCE OF BIOELEMENS FOR ELDERLY POPULATION

Many studies of the elderly and senile populations emphasize the importance of macro- and micronutrients for health [4]. They have showed age-related changes in levels of nutrients, such as selenium, iron, manganese, and lead [5]. Micronutrient content fluctuations in the elderly can affect enzyme activity and key biochemical pathways, contributing to various conditions, including chronic diseases and cancer [6]. Higher plasma selenium, magnesium, and iron have been shown to reduce the premature death risk in the elderly population [7]. Assessment of the relationship between the level of macro- and micronutrients in hair and the cardiovascular risk over 10 years in healthy people over 60 years of age showed that low hair sodium is characteristic of the low-risk group. In addition, a negative correlation was found between the content of cobalt, uranium, and mercury with the degree of risk [8]. The studies describe the role of zinc in hematopoiesis in elderly and senile populations. Moreover, micronutrients are important for cognitive modulation in the elderly. Associations have been identified between the levels of copper [9], arsenic, aluminum, vanadium, barium [10], cadmium, and selenium [11] and the cognitive dysfunction risk.

In Kazakhstan, micronutrient status is largely determined by nutrition. Dietary patterns observed in the elderly population are characterized by excessive calorie intake, macronutrient imbalances, and prevalence of high-carbohydrate foods. There is evidence that sodium, calcium, and magnesium intake decreases with age. However, there are various complex risk factors and causes of micronutrient deficiency in the elderly population, including socioeconomic difficulties (poverty among them), low appetite, age-related metabolic and sensory disorders (taste and smell), chewing problems due to poorly fitting dentures, limited mobility, and polypharmacy (when people take many medications) [13]. Taken together, these factors are major barriers to maintaining optimal micronutrient balance in the elderly population.

Conventional prevention or treatment approaches to sarcopenia are mainly focused on exercise, adequate protein intake, and amino acid supplementation. The role of macro- and micronutrients in the pathogenesis of sarcopenia is still less studied. However, contemporary data indicate the role of iron, magnesium, and selenium in its development, including skeletal muscle mass, strength, and performance deterioration [14]. Micronutrient status disturbances, including low serum iron and zinc, have been shown to be associated with muscle mass loss, low muscle strength, and low functional performance in the elderly [15]. Their deficiency is considered as a factor of the development and progression of sarcopenia [16]. In addition, iron deficiency may be involved in its pathogenesis by reducing the synthesis of hemoglobin and myoglobin, causing a decrease in skeletal muscle mitochondria and disrupting the regulation of the mitochondrial respiratory chain. It is suggested that calcium contributes to sarcopenia by modulating calpains, which are cysteine proteases responsible for key myogenesis processes regulation [17]. In skeletal muscle, zinc affects myogenesis and muscle regeneration through muscle cell activation, proliferation, and differentiation [18]. Its deficiency is considered as a predictor of age-related loss of skeletal muscle mass in the elderly population [19]. In turn, zinc deficiency is

[1] Demographic trends in Kazakhstan and their economic impact (presentation). URL: https://www.enpf.kz/upload/iblock/51e/86nhwoamp5h2plcb3bt3f2lakqngb4nu.pdf?. Accessed on September 24, 2024.

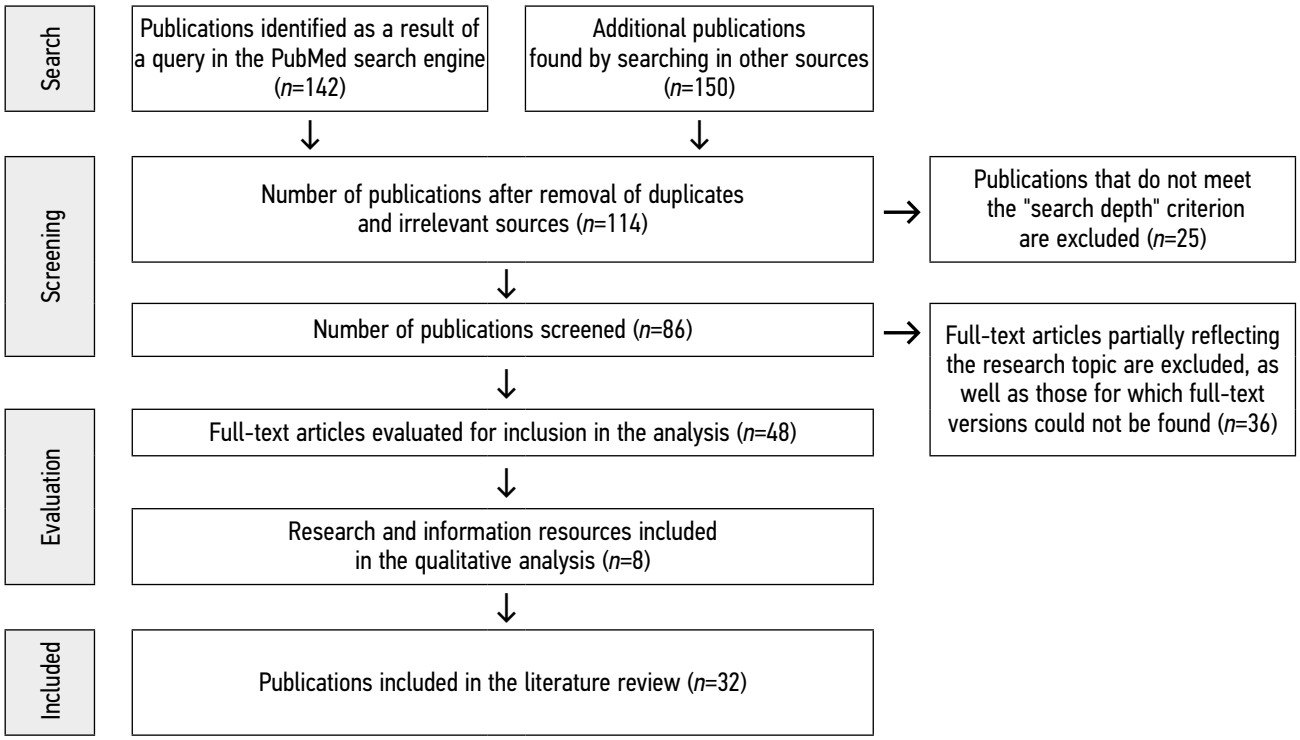

Fig. 1. The strategy of search and selection of sources.

widespread in this age group. Selenium deficiency is associated with impaired antioxidant protection and high oxidative stress with the resulting muscle inflammation. Animal studies have shown that selenium supplementation improves muscle performance by modulating calcium metabolism and mitochondrial biogenesis [20]. F. Petermann-Rocha et al. [21] found that high calcium intake is associated with lower odds of sarcopenia; the authors also found an inverse relationship between magnesium intake and this condition. A study by S. ter Borg et al. [22] showed that elderly people with sarcopenia had low magnesium intake. A study of the relationship between blood manganese and sarcopenia risk showed a U-shaped relationship with an inflection at a blood manganese level of 13.45 μg/l [23]. C. van Dronkelaar et al. [24] studied how phosphorus and potassium affect sarcopenia, but they had controversial results. Identifying the potential of micro- and macronutrients for the prevention and treatment of sarcopenia in the elderly population, including by increasing their intake to recommended daily intakes, is a promising area for developing effective strategies aimed at maintaining muscle function, improving the quality of life, and promoting healthy aging [24]. In addition, researchers note that the use of hair micronutrient test is an accessible, affordable, and informative method for assessing the elemental status of the elderly population [5, 8].

NUTRITION AND SARCOPENIA RISK IN THE ELDERLY POPULATION

Micronutrient inadequacy in the elderly population is considered as a factor contributing to the development of sarcopenia. As life expectancy increases, age-related changes, including loss of muscle mass and strength and low physical performance, are becoming more pressing medical and social issues. Sarcopenia is a geriatric syndrome associated with a progressive decrease in muscle strength, mass, and performance. It increases the disability, hospitalization, and mortality risks and leads to low quality of life of elderly patients [25].

Numerous studies have been investigating the prevalence of sarcopenia risk factors [26–28]. In its 2019 consensus statement, The Asian Working Group for Sarcopenia (AWGS) recommended various actions to identify patients with undiagnosed sarcopenia [26]. J. Sun et al. [27] assessed its prevalence and risk factors in the elderly people living in a nursing home based on the AWGS 2019. The cross-sectional study included 583 participants. A multivariate analysis identified predictors associated with a higher sarcopenia risk:

- Old age;
- Malnutrition risk;
- Good care;
- Low physical activity (exercise less than three times a week);
- Osteoporosis.

In this case, sarcopenia risk was reduced by food supplements.

B.G. Dorhout et al. [28] studied the prevalence of sarcopenia and its association with protein intake in a multi-ethnic male and female population. Cross-sectional data from the HELIUS (Healthy Life in an Urban Setting) study were used, including approximately 25,000 participants aged 18 to

70 years of Dutch, South Asian Surinamese, African Surinamese, Turkish, Moroccan, and Ghanaian ethnic origins. The study involved 5,161 participants aged 55 years and older. It was found that the prevalence of sarcopenia depends on sex and ethnic origin:

- 29.8% in Turkish males to 61.3% in South Asian Surinamese males;
- 2.4% in Turkish females to 30.5% in South Asian Surinamese females.

Higher protein intake was associated with a 4% lower probability of sarcopenia [odds ratio 0.96 (95% confidence interval (CI) 0.92–0.99)] with statistical significance only seen in the South Asian Surinamese subgroup. The findings highlight the need for ethnic approaches to the prevention and treatment of sarcopenia.

A cross-sectional study conducted in nursing homes in Hunan Province (China) by N. Hua et al. [29] investigated the relationship between the nutritional status and sarcopenia in 386 elderly participants. The analysis included a brief nutritional screening to identify risk of malnutrition, a dietary diversity assessment, and a mental health assessment to determine the cognitive status. In addition, the authors collected sociodemographic data (age, sex, and education), health data (dietary habits, self-care level, medication intake), body composition data (body mass index, protein content, body fat mass, body fat percentage, skeletal muscle index, and total body water), and anthropometric parameters (calf circumference, upper arm circumference, grip strength, and walking speed). The study showed that 32.4% of participants were at risk of malnutrition and 49.7% had sarcopenia. Nutritional status positively correlates with:

- Age (risk ratio [RR]: 1.03);
- Sarcopenia (RR = 1.88);
- Tooth loss affecting food intake (RR = 1.45);
- Poor self-care (RR = 1.82);
- Moderate/insufficient dietary diversity (RR = 2.04).
- Nutritional status negatively correlates with:
- Having one child (RR = 0.27);
- Body mass index (RR = 0.82);
- Protein content (RR = 0.76);
- Body fat mass (RR = 0.91);
- Body fat percentage (RR = 0.94);
- Skeletal muscle index (RR = 0.65);
- Total body water (RR = 0.94);
- Calf circumference (RR = 0.89);
- Upper arm circumference (RR = 0.86).

Thus, the factors associated with the malnutrition risk in older people in nursing homes were age, number of children, sarcopenia, dietary habits, self-care level, dietary diversity, and body composition. To identify vulnerable populations, it is advisable to focus on body composition parameters as an accessible and informative screening tool [29].

Sociodemographic factors, lifestyle, and comorbidities associated with sarcopenia according to the updated classification of the European Working Group on Sarcopenia in Older People 2 (EWGSOP2) are still poorly understood. This is why F. Petermann-Rocha et al. [21] analyzed the factors associated with sarcopenia risk based on EWGSOP2 criteria. The cross-sectional study included 396,283 participants (52.8% females) aged 38–73 years. Potential factors of sarcopenia were divided into four groups:

- Sociodemographic (sex, age, education, income, and professional qualifications);
- Anthropometric (nutritional status, abdominal obesity, body fat, and birth weight);
- Lifestyle (physical activity, smoking, sleep, time spent sitting, watching TV, alcohol, and diet);
- Health (self-reported chronic diseases).

The analysis showed the significant association of age, sex (female), low level of education, unfavorable socioeconomic conditions, underweight, low birth weight, and chronic diseases (rheumatoid arthritis, chronic bronchitis, and osteoporosis) with a higher probability of sarcopenia. However, overweight, obesity, high energy, protein, vitamin (B12 and B9), and mineral (potassium, calcium, and magnesium) intake are associated with its low probability. Thus, women over 65 years of age, underweight individuals, and patients with chronic inflammatory diseases have a high probability of sarcopenia. Given the expected increase in the elderly population, sarcopenia may become a more significant public health issue. Identification of risk factors allows for early detection of individuals predisposed to the disease and preventive interventions [21].

The medical care for patients with sarcopenia faces some problems, including [30]:

- Poor awareness of medical professionals of contemporary diagnostic criteria and treatment methods;
- No clear standards of care;
- Limited use of a multidisciplinary approach, which is key in the treatment and rehabilitation of elderly patients.

In turn, it requires a systematic approach and includes the following key aspects [31]:

- Early diagnosis;
- Multidisciplinary approach;
- Social support;
- Staff training, awareness programs for medical professionals and the patient's family.

Integration of evidence-based approaches allows for the optimization of healthcare resources by reducing the incidence of sarcopenia-related complications (falls, hospitalizations) and increasing the functional independence of patients. Thus, the elderly population with sarcopenia tend to have a lower quality of life mainly due to low physical performance [32].

Medical care for patients with sarcopenia should be based on the principles of evidence-based medicine and the characteristics of patients. High awareness and understanding the mechanisms underlying this disease is important for

further development of standard treatments and diagnostic options, leading to better care and improved quality of life for geriatric patients [33].

CONCLUSION

Sarcopenia is a progressive degenerative change of skeletal muscle accompanied by its low mass, strength, and function. It is recognized as a leading cause of disability, low quality of life, and high mortality rates in the elderly population. In the context of global population aging and the growing proportion of people over 60 years of age, the issue of sarcopenia is becoming particularly relevant, requiring revised approaches to its prevention and treatment. Macro- and micronutrient status, i.e. the content of essential macro- and micronutrients, is a key, albeit understudied, factor of sarcopenia. Zinc, magnesium, selenium, iron, calcium, and vitamin D are essential for muscle function, protein metabolism, and antioxidant protection. Elemental imbalances common in the elderly population may contribute to decreased muscle protein synthesis, impaired neuromuscular transmission, higher oxidative stress, and chronic systemic inflammation. Age-related changes in metabolism, loss of appetite, taste disorders, chronic diseases, and polypharmacy contribute to micronutrient deficiency. In the premises, there is a pressing need for a personalized approach to the diagnosis and management of elemental status disorders. There is growing interest in the potential of dietetics and nutritional support as part of a comprehensive strategy for preventing and slowing the progression of sarcopenia. Research aimed at identifying specific micronutrient deficiencies in the elderly population contributes to a better understanding of the pathogenesis of the disease and the development of personalized treatment and prevention programs. Early diagnosis of elemental imbalance can predict the risk of sarcopenia and help reduce the disability rate and healthcare costs and can improve functional independence and social activity in the elderly population.

Thus, the study of the relationship between the elemental status and sarcopenia in the elderly population is an important area of contemporary gerontology, dietetics, and public health. These data may be the basis for updated clinical guidelines, including assessment and management of elemental status as an integral part of preventing age-related changes and improving the quality of life of the elderly population.

ADDITIONAL INFORMATION

Author contributions: G.A. Umarova: investigation, formal analysis, writing—original draft, writing—review & editing; G.A. Batyrova: investigation, formal analysis, writing—original draft; A.S. Zhubaniyazova: investigation, formal analysis, writing—original draft. All the authors approved the version of the manuscript to be published and agreed to be accountable for all aspects of the work, ensuring that issues related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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Этическая экспертиза. Неприменимо.

Источники финансирования. Данное исследование финансирует Комитет науки Министерства науки и высшего образования Республики Казахстан (ИРН № AP26199833).

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Оригинальность. При создании настоящей работы авторы не использовали ранее опубликованные сведения (текст, иллюстрации, данные).

Доступ к данным. Редакционная политика в отношении совместного использования данных к настоящей работе не применима.

Генеративный искусственный интеллект. При создании настоящей статьи технологии генеративного искусственного интеллекта не использовали.

Рассмотрение и рецензирование. Настоящая работа подана в журнал в инициативном порядке и рассмотрена по обычной процедуре. В рецензировании участвовали два внешних рецензента, член редакционной коллегии и научный редактор издания.

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AUTHORS' INFO

*** Gulmira A. Umarova,** PhD;
address: 68 Maresyev st, Aktobe, Republic of Kazakhstan, 030019;
ORCID: 0000-0001-7637-113X;
eLibrary SPIN: 9146-3959;
e-mail: uga_80@mail.ru

Gulnara A. Batyrova, PhD;
ORCID: 0000-0001-7970-4059;
eLibrary SPIN: 8584-5024;
e-mail: g.batyrova@zkmu.kz

Ayagul S. Zhubaniyazova;
ORCID: 0000-0002-0285-5462;
eLibrary SPIN: 6337-1280;
e-mail: a.zhubaniyazova@zkmu.kz

ОБ АВТОРАХ

*** Умарова Гульмира Арыстангалиевна;**
адрес: Республика Казахстан, 030019, Актобе, ул. Маресьева, д. 68;
ORCID: 0000-0001-7637-113X;
eLibrary SPIN: 9146-3959;
e-mail: uga_80@mail.ru

Батырова Гульнара Арыстангалиевна;
ORCID: 0000-0001-7970-4059;
eLibrary SPIN: 8584-5024;
e-mail: g.batyrova@zkmu.kz

Жубаниязова Аягуль Саясатовна;
ORCID: 0000-0002-0285-5462;
eLibrary SPIN: 6337-1280;
e-mail: a.zhubaniyazova@zkmu.kz

* Corresponding author / Автор, ответственный за переписку