
ARTICLE REVIEW

Environmental Factors Associated with Sarcopenia: A Systematic Review

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ABSTRACT

Introduction	Elderly is a vulnerable population that is prone for sarcopenia which is associated with the loss of muscle mass, strength and function which are one the diseases that affects elderly. Association between environmental factors with sarcopenia should be explored as it has the potential to influence the health and disability of a person. At present, limited research is conducted to investigate the association which could be attributed to the complex interaction between the human and environmental interactions. Hence this review is conducted to identify the environmental factors associated with sarcopenia.
Methods	A systematic review was conducted using PubMed, SCOPUS, Web of Science and manual search following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) criteria. We used articles that have been written in English and relevant articles were then screened, duplicates were removed, eligibility criteria were applied, and studies that met the criteria were reviewed. The keywords environmental factors, pollutants food environment, neighbourhood environment, locality and sarcopenia were included.
Results	Initial search generated 934 publications and 12 articles were included after inclusion and exclusion criteria for this review. In this review, environmental factors associated with sarcopenia are divided into 3 themes that comprises of food environment (availability and physical access, economic access and food quality and safety), neighbourhood environment and pollutants.
Conclusion	This systematic review revealed association between the food environment, neighbourhood environment and pollutants with sarcopenia. The findings are salient as it could aid the the policy makers to formulate the necessary strategy to reduce the morbidity and mortality associated with sarcopenia especially with the increase in ageing population globally.
Keywords	Environmental Factors - Elderly - Sarcopenia.

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INTRODUCTION

With increasing age, elderly is prone to myriad of health problems that affects their daily lives. The inevitable aging process comprises changes towards both physical and mental health of the elderly.¹ Loss of muscle mass and muscle strength is one of condition that is observed in the elderly.² The aforementioned changes may increase the tendency of the elderly to suffer from sarcopenia.

The term sarcopenia was instigated by Rosenberg³ in 1997 and spurred the research globally. The significance of sarcopenia was further invigorated by the listing of sarcopenia as disease in the 10th Edition of the International Classification of Diseases.⁴ Based on the latest revised consensus available^{2,5} sarcopenia is a disease defined as a gradual decrease in muscle mass, strength and/ or low physical performance.

In terms of the burden of the disease, sarcopenia prevalence globally ranges from 10% till 27%.⁶ At the Asian level, the prevalence of sarcopenia are reported to be in the range of 5.5% till 25.7%² with male predominance. Apart from that, sarcopenia also resulted in higher cost in the healthcare⁷ and with the inevitable increase in ageing population especially in the developing nations,⁸ emphasise on sarcopenia is pertinent.

Findings from studies conducted globally revealed that sarcopenia has a negative impact on the quality of life of the elderly.^{9,10} Apart from that, this disease also associated with falls and fractures and impacts the metabolic health of the elderly.^{11,12} Besides that, studies performed by Hwang&Park,¹³ Kim et al¹⁴ and Sazlina et al¹⁵ shows that sociodemographic factors such as age, gender and occupation has been also associated with sarcopenia. While the aforementioned factors are explored globally, it is also important to investigate the association of environmental factors with sarcopenia as it could influence the health and disability of a person.¹⁶ According to,¹⁷ environmental factors are described as the physical, social and attitudinal environment in which people live and conduct their lives which could be either barriers to or facilitators of the person's functioning. This shows that, environmental factors could have substantial impact on sarcopenia and exploring the association is crucial. However, research that focuses on the association of environmental factors with sarcopenia is limited which could be attributed due to the complex interaction that exist between the human and environmental interactions.¹⁸ In view of that, this systematic review is conducted with the aim to identify the association between the environmental factors and sarcopenia.

MATERIAL AND METHOD

This systematic review is prepared according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) updated guideline.¹⁹

The objective of this review is to identify the environmental factors associated with sarcopenia. We used PEO (population, exposure, outcome) concept in framing the research question.²⁰ Population in this review refers to elderly population, exposure refers to the environmental factors and outcome is sarcopenia.

Searching Strategy

Literature search was conducted on PubMed, Web of Science, Scopus, and manual search for studies published from January 2012 to January 2023. Search terms that were used in this systematic literature review are “environmental factors” OR “pollutants” OR “food environment” OR “neighbourhood environment” OR “locality” AND “sarcopenia”. The search was then conducted following the PRISMA flow, as shown in the diagram (Figure1).

Eligibility Criteria

All searches were restricted to English-language studies. All studies conducted on the environmental factors associated with sarcopenia with all full-text English language, published between January 1 2012 until January 2023 are included in this systematic review. Studies with inadequate data on desired information and non-primary articles are excluded. All duplicate studies were deleted, and the full text of the papers was manually and electronically searched using databases.

Study selection

Three reviewers determined individual article eligibility based on a review of the title, abstract, and full text. The third reviewer was assigned to resolve any disagreements which arise between the other two reviewers.

Quality Appraisal and Data Extraction

Quality appraisal was conducted using the Mixed Method Appraisal Tool (MMAT). The MMAT evaluates the quality of qualitative, quantitative, and mixed method studies. It focuses on methodological criteria and includes five core quality criteria for each of the following five categories of study designs that comprises of quantitative, qualitative, randomized controlled, nonrandomized, and mixed methods.²¹ The following information was then gathered and documented on a standardised form to document related items with the research information such as authors, title, year of publication, study design, sample size and the environmental factors associated with sarcopenia.

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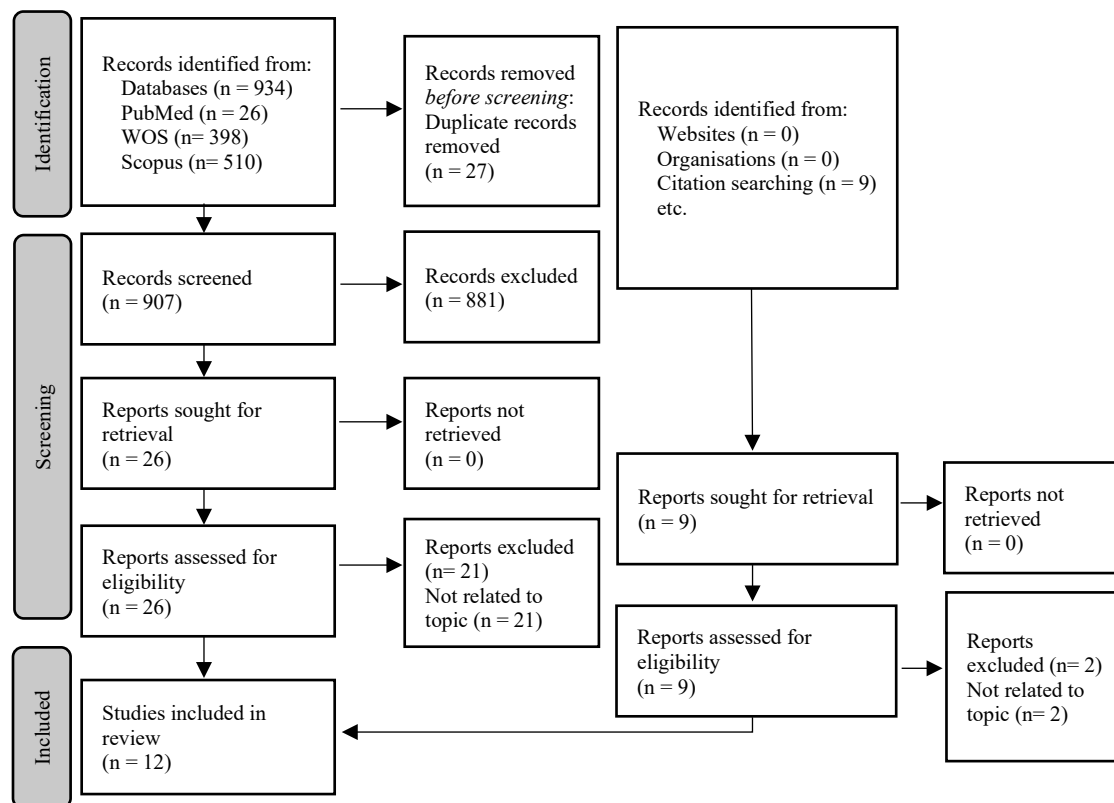


Figure 1 PRISMA

Table 2 The details of the MMAT assessment: Quantitative Descriptive

No	Author	Types of study	1.1 Is the sampling strategy relevant to address the research question?	1.2 Is the sample representative of the target population	1.3 Are the measurements appropriate?	1.4 Is the risk of nonresponse bias low?	1.5 Is the statistical analysis appropriate to answer the research question?
1.	Smith et al ²²	Quantitative descriptive	Yes	Yes	Yes	Yes	Yes
2.	Papaioannou et al ²³	Quantitative descriptive	Yes	Yes	Yes	Can't tell	Yes
3.	Jeng et al ²⁴	Quantitative descriptive	Yes	Yes	Yes	Yes	Yes
4.	Swan et al ²⁵	Quantitative descriptive	Yes	Yes	Yes	Can't tell	Yes
5.	Kuczmariski et al. ²⁶	Quantitative descriptive	Yes	Yes	Yes	Yes	Yes
6.	Na et al ²⁷	Quantitative descriptive	Yes	Yes	Yes	Yes	Yes
7.	Seo et al ²⁸	Quantitative descriptive	Yes	Yes	Yes	Yes	Yes
8.	Okuyama et al ²⁹	Quantitative descriptive	Yes	Yes	Yes	Yes	Yes
9.	Wu et al ³⁰	Quantitative descriptive	Yes	Yes	Yes	Yes	Yes
10.	Yang et al ³¹	Quantitative descriptive	Yes	Yes	Yes	Yes	Yes
11.	Yoo et al ³²	Quantitative descriptive	Yes	Yes	Yes	Yes	Yes

Table 3 The details of the MMAT assessment: Qualitative

No	Author	Types of study	1.1	1.2	1.3	1.4	1.5
			Is the qualitative approach appropriate to answer the research question?	Are the qualitative data collection methods adequate to address the research question?	Are the findings adequately derived from the data?	Is the interpretation of results sufficiently substantiated by data?	Is there coherence between qualitative data sources, collection, analysis and interpretation?
12.	Herrema et al ³³	Qualitative	Yes	Yes	Yes	Yes	Yes

RESULTS

The search yielded 26 articles from PubMed, 510 from SCOPUS, 398 from WOS and 9 from manual searching resulting in 943 unique hits. After rigorous selection screening, only 12 articles were included in the full-text assessment, as shown in the PRISMA flow diagram (Figure 1). A descriptive summary of the included studies in this review regarding the study design, sample size and the environmental factors associated with sarcopenia are presented in Table 2. In this review, environmental factors associated with sarcopenia are divided into 3 themes that comprises of i) food environment, ii) neighbourhood environment and iii) pollutants.

Food environment

Out of total 12 articles in this review, 7 articles are associated with food environment. The studies conducted on food environment are divided into the three key elements of the food environment that comprises of i) availability and physical access, ii) economic access and iii) food quality and safety.

Availability and physical access

Study conducted by Smith et al²² that involved six low and middle income countries (LMIC) revealed that severe food insecurity that comprises of frequency of eating and lack of food associated with 2.05 (95% confidence interval (1.12, 3.73) times higher odds for sarcopenia. Besides that, another study in this review performed by Herrema et al³³ highlighted that, convenience in consumption that comprises of the product and the packaging as an important factor to be considered for the 33.3 % of the participants in the study to consume high protein diet.

Economic access

A cross sectional study performed by Jeng et al²⁴ shows that, males with income less than \$20,000 were 2.78 times more likely to have sarcopenic obesity than males with an annual income of \$60,000 or more. Another separate study Swan et al²⁵ reveals that, elderly living in a disadvantaged

socioeconomic position(SEP) is associated with 1.48 (95% CI (1.17, 1.87) times higher odds for probable sarcopenia among the elderly compared to those from high SEP.

Food quality and safety

A study performed by Herrema et al³³ also highlighted interesting findings on food quality and safety. According to this qualitative study, attraction, taste and satisfied feeding are reported to facilitates the elderly to consume high protein diet with the following percentage of 38.8%, 94.4% and 33.3%. In a separate study performed by Fanelli Kuczumski et al²⁶ shows that, high alcoholic beverage consumption associated with 2.62 (95% CI(1.22, 5.62) times higher odds for sarcopenia compared with healthy diet. Apart from that, study by Papaioannou et al²³ revealed that significant main effect observed($p < 0.05$) where those with highest Healthy Diet Score(HDS) tertile associated with lower sarcopenia risk compared to those with lowest tertile. Besides that, according to the study conducted by Na et al²⁷ shows that, poor diet quality is associated with 1.8 times (95% CI(1.00, 3.25) times higher odds for sarcopenia compared with those with good diet quality identified as a factor associated with sarcopenia.

Neighbourhood environment

Study by Seo&Kim²⁸ that involved 1778 participants, shows that no public transportation (OR = 2.04; 95% CI = 1.19, 3.48), poor recreational facilities access (OR = 1.39; 95% CI = 1.01, 1.90), absence of destination (OR = 1.53; 95% CI = 1.06, 2.20), many hilly hazards (OR = 1.36; 95% CI = 1.03, 1.78), and lack of traffic safety(OR = 1.35; 95% CI = 1.02, 1.78) are associated with sarcopenia. The role of distance to the facility and the density of a population was identified as the factors associated with sarcopenia in the study conducted by Okuyama et al²⁹ that shows that, male who are living at far distance from the community center has a less decline in skeletal muscle mass index(SMI) (β : 0.04, 95% CI 0.01, 0.07) compared to those living

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close distance and females from higher residential density had a less decline in grip strength (β : 0.13, 95% CI 0.02, 0.24) compared to those living in lower residential density. Apart from that, findings from the studies conducted by Wu et al³⁰ shows that, elderly from rural area is 1.47(95% CI (1.29, 1.69) times higher odds for sarcopenia compared to elderly from urban area. Another study by Yang³¹ also highlighted the influence of the location of living where women from rural areas are more prone for sarcopenia 21.72% compared to men 12.93% (p value<0.001).

Pollutants

In this review, one article investigated the role of pollutants in the sarcopenia. According to the study by Yoo et al³² that involved 704 participants, shows that, high levels of blood lead OR=1.32(95% CI (0.47, 3.68), mercury OR=3.25(95% CI (1.42, 7.44) and cadmium OR= 1.42 95%CI (0.64, 3.16) associated with increase in sarcopenia among male and high levels of blood lead OR=3.36(95% CI (0.56, 20.04), mercury OR=5.26(95% CI (1.07, 25.80) and cadmium OR= 4.41(95%CI (0.75, 26.04) associated with increase in sarcopenia among female.

Table 4 Summary of included articles

No	Author	Study type	Sample size	Themes	Environmental factors associated with sarcopenia
1.	Smith et al ²²	Cross sectional	14 585	Food environment (Availability and physical access)	Severe food insecurity that comprises of frequency of eating and lack of food associated with 2.05 (95% CI (1.12, 3.73) times higher odds for sarcopenia.
2.	Papaioannou et al ²³	Cross sectional	252	Food environment (Food quality and safety)	Significant main effect observed(p<0.05) where those with highest Healthy Diet Score(HDS) tertile associated with lower sarcopenia risk compared to those with lowest tertile.
3.	Jeng et al ²⁴	Cross sectional	10 325	Food environment (Economic access)	Male with males with income less than \$20,000 were 2.78 times more likely to have sarcopenic obesity than males with an annual income of \$60,000 or more.
4.	Swan et al ²⁵	Cross sectional	3342	Food environment (Economic access)	Disadvantaged socioeconomic position(SEP) is associated with 1.48 (95% CI (1.17, 1.87) times higher odds for probable sarcopenia among the elderly compared to those from high SEP.
5.	Herrema et al ³³	Qualitative	18	Food environment (Availability and physical access)	33.3 % of the participants reported that convenience in consumption is an important driver to for them to consume high protein diet.
				(Food quality and safety)	Attraction, taste and satisfied feeding are reported to facilitates the elderly to consume high protein diet with the following percentage of 38.8%, 94.4% and 33.3%.
6.	Kuczmarski et al ²⁶	Cross sectional	2176	Food environment (Food quality and safety)	High alcoholic beverage consumption associated with 2.62 (95% CI(1.22, 5.62) times higher odds for sarcopenia compared with healthy diet.
7.	Na et al ²⁷	Cross sectional	3373	Food environment (Food quality and safety)	Poor diet quality is associated with 1.8 times(95% CI(1.00, 3.25) times higher odds for sarcopenia compared with those with good diet quality.
8.	Seo et al ²⁸	Cohort	1778	Neighbourhood environment	No public transportation (OR = 2.04; 95% CI = 1.19, 3.48), poor recreational facilities access (OR = 1.39; 95% CI = 1.01, 1.90), absence of destination (OR = 1.53; 95% CI = 1.06, 2.20), many hilly hazards (OR = 1.36; 95% CI = 1.03, 1.78), and lack of traffic safety(OR = 1.35; 95% CI = 1.02, 1.78) are associated with sarcopenia.
9.	Okuyama et al ²⁹	Cohort	2526	Neighbourhood environment	Male who are living at far distance from the community center has a less decline in skeletal muscle mass index(SMI) (β : 0.04, 95% CI 0.01, 0.07) compared to those living close distance and females from higher residential density had a less decline in grip strength (β : 0.13, 95% CI 0.02, 0.24) compared to those living in lower residential density.
10.	Wu et al ³⁰	Cohort	61	Neighbourhood environment	Elderly from rural area is 1.47(95% CI (1.29, 1.69) times higher odds for sarcopenia compared to elderly from urban area.
11.	Yang et al ³¹	Cross sectional	1105	Neighbourhood environment	Women from rural areas are more prone for sarcopenia 21.72% compared to men 12.93% (p value<0.001)
12.	Yoo et al ³²	Cross sectional	704	Pollutants	High levels of blood lead OR=1.32(95% CI (0.47, 3.68), mercury OR=3.25(95% CI (1.42, 7.44) and cadmium OR= 1.42(95%CI (0.64, 3.16)associated with increase in sarcopenia among male. High levels of blood lead OR=3.36(95% CI (0.56, 20.04), mercury OR=5.26(95% CI (1.07, 25.80) and cadmium OR= 4.41(95%CI (0.75, 26.04) associated with increase in sarcopenia among female

DISCUSSION

In this systematic review, discussion is divided into 3 themes that comprises of food environment, neighbourhood environment and pollutants.

Food Environment

Food availability and physical access is one of the key elements of food environment, identified as the environmental factors associated with sarcopenia. Similar findings are demonstrated by another study in which association between food availability and sarcopenia is determined by the food insecurity.³⁵ The study comprises of 3632 participants and revealed that, elderly with food insecurity have higher tendency of being identified with probable sarcopenia compared to those with adequate food security. The aforementioned study shows that; the unavailability of the food leads to poor diet pattern in the elderly that subsequently leads to sarcopenia. Elderly are vulnerable population and the direct interaction that is observed between the availability of the food and the diet pattern should be highlighted as these factors are modifiable. Apart from that, the role of aging should be considered as well as the aging process causes muscle loss and in combination with unavailability of the food, elderly facing this hurdle are at higher risk of developing sarcopenia.³⁶ Besides that, a qualitative study conducted also revealed that aging causes the elderly to reduce their food volume due to various factors such as biological, psychological and social age-related changes.³⁷ Hence it is understandable when diet optimisation in the elderly is proven imperative in the in the prevention and management of sarcopenia.³⁸

Apart from the availability of the food, the economic access that dictates the affordability is also associated with sarcopenia. In a cross sectional study conducted in Tehran, low socioeconomic status has direct implication on the food consumption among the elderly which leads to higher likelihood of developing sarcopenia.³⁹ In another study conducted in United States, elderly from a lower income are shown to be more prone for food insecurity.⁴⁰ To further aggravate the issue of socioeconomic inequality, the COVID-19 pandemic has caused disruption in the food chain globally, that causes alteration in the food environment that subsequently leads to food insecurity and poverty.⁴¹ Hence, elderly with low purchasing power is prone for malnutrition due the inadequate food and inevitably higher tendency of suffering from sarcopenia.

Food quality and safety is another key element of food environment along with food availability and economic access that is associated with sarcopenia. The ingredient, texture, taste and the manner the food is produced influences the quality of the food and proven to be the facilitating factor for the elderly to maintain a healthy diet.^{33,42}

It is also important to note that, food availability and economic access or affordability does influence the food quality and the interaction that exists between these factors needs to be appreciated, as it interrelated.⁴³ Furthermore it is important to take note that, about 3 billion people globally unable to fulfil the minimum recommendation of the healthy diet due to the cost involved.⁴⁴ Interestingly, another key element of food environment that comprises of promotion, advertising and information, are not identified as a factor associated with sarcopenia in this review.⁴²

Neighbourhood Environment

The components of the neighbourhood environment comprises of density and connectivity within the community, safety, accessibility to the recreational centres, neighbourhood aesthetics and the arrangement of the physical features in an area.⁴⁵ The interplay between this elements have shown to play a role as determinant in elderly health such as the physical activity which has also been associated with sarcopenia.^{46,47} A cross sectional study conducted in Japan revealed that car driving status that determines the connectivity and along with the living environment of the elderly are associated with sarcopenia. Apart from the neighbourhood environment, the location where the elderly lives also related to sarcopenia in this review. A study conducted in Korea generated similar findings as rural areas are associated with a low muscle function which makes the elderly susceptible for sarcopenia.⁴⁸

Pollutants

Even though limited result was generated, the role of pollutant is also explored in this review. As pollutants are harmful in nature, it is important to identify the pollutants associated with sarcopenia to avert the undesired outcome implicated with the pollutants. A study conducted in United Kingdom reveals that ambient air pollution exposure could be a risk factor of sarcopenia.⁴⁹ Besides that, in a cross sectional study performed in Taiwan that involved 530 elderly, it was shown that long term exposure to the fine particulates are associated with reduced skeletal muscle mass and increased body fat mass among elderly.⁵⁰

Strength and Limitations

This systematic review was conducted using more than two databases and included manual search that widen the search result. However, only one article was found under the theme of pollutant which is an important factor to be considered under the environmental factors. Future researchers may utilise more key words to generate broader findings. Despite the aforesaid limitation, this systematic review illustrated the key elements of the environmental factors and its association with

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sarcopenia which may aid in better understanding of this disease.

Recommendation

As elderly are vulnerable population, efforts need to intensified to ensure foods are affordable, accessible and good quality in nature. Apart from the government, private sectors such as the major players under retail sector should ensure affordable food prices are provided to the elderly.

Besides that, house developers should consider and implement neighbourhood environment that are friendly in nature for the elderly in their housing projects. Prior to the project launch, careful planning should be done with the supervision from the local government. House developers who are successful in the implementation needs to be given recognition to promote and encourage other house developers to emulate the effort.

Apart from law enforcement for the offenders, monitoring of potential pollutants could be done by incorporating the pollution monitoring system that comprises of measurement and predictive analysis. By doing this, preventive measures could be taken to curtail the impact of this pollutants.

CONCLUSION

This systematic review revealed association between the food environment, neighbourhood environment and pollutants with sarcopenia. The findings are salient as it could aid the the policy makers to formulate the necessary strategy to reduce the morbidity and mortality associated with sarcopenia especially with the increase in ageing population globally.

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