Association between age-related sensory impairment with sarcopenia and its related components in older adults: a systematic review

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Abstract

Sensory impairments and sarcopenia are both highly prevalent age-related conditions, with the former having been postulated to contribute to the pathogenesis of the latter condition. Confirming this hypothesis may therefore help to better inform strategies for early treatment and intervention of sarcopenia. We performed a systematic review of the current literature examining the relationships between four major sensory impairments [vision (VI), hearing (HI), smell (SI), and taste (TI)] with (i) sarcopenia; and (ii) its associated components (low handgrip strength, slow gait speed, and low muscle mass). PubMed, EMBASE, CINAHL, and Cochrane Library databases were searched for observational studies investigating the relationship of VI, HI, SI, and TI with sarcopenia, low handgrip strength, slow gait speed, and low muscle mass, in adults aged 50 years or older, from inception until 24 May 2021. The risk of bias of the included studies was assessed using the Newcastle-Ottawa Scale. This study was registered with PROSPERO, reference CRD42021247967. Ten cross-sectional and three longitudinal population-based studies of community-dwelling adults ($N = 68\ 235$) were included, with five studies investigating more than one sensory impairment. In total, 8, 6, 3, and 1 studies investigated the relationship between VI, HI, SI, and TI and sarcopenia and its related components, respectively. Follow-up duration for the longitudinal studies ranged from 4 to 11 years. All studies had a low or moderate risk of bias. We found that the presence of VI and SI, but not TI, independently increased the odds of sarcopenia. In addition, VI and SI were each independently associated with low muscle mass; and VI, HI, and SI were each independently associated with slow gait speed. However, we found inconclusive evidence for the associations between VI, HI and SI, and low handgrip strength. Our systematic review suggests a potential association between the presence of single or multiple sensory impairments and a greater likelihood of sarcopenia and/or deficits in its associated components, especially for VI, HI, and SI. Prospective studies are needed to untangle the relationship between sensory impairment and sarcopenia to better inform clinical guidelines for disease prevention and management.

Keywords   Sarcopenia; Sensory impairment; Visual impairment; Hearing impairment; Taste impairment; Smell impairment

Introduction

The world is undergoing an ageing demographic shift, with 1 in 6 people anticipated to be aged ≥65 years by 2050, up from 1 in 11 in 2019.[1] As such, there is growing demand for the development and implementation of interventions to prevent or delay the detrimental consequences of age-related health conditions contributing to disability and

dependence in older adults.[2] Research into sarcopenia, a skeletal muscle disorder that produces a progressive decline in skeletal muscle mass and function, is increasingly gaining traction, with the World Health Organization classifying it as a geriatric syndrome in 2016.[3,4] The global prevalence of sarcopenia in community-dwelling older adults ranged between 10% and 40% depending on the definition used.[5] The most widely accepted one requires clinical findings of low muscle mass, plus low muscle strength, and/or low physical performance.[6,7] The adverse consequences of sarcopenia on the individual and society include physical disabilities, frailty, falls, cognitive impairment, depression, decreased quality of life (QoL), nursing home admission, and even death.[8–11] Although a recent systematic literature review of RCTs has shown potential improvements in the component measures of sarcopenia, that is, muscle mass, strength, and/or physical function via exercise and nutritional interventions in sarcopenic older adults,[12] it remains unclear whether sarcopenia itself can be prevented or reversed by early detection and interventions. Therefore, a better understanding of other potential modifiable risk factors for sarcopenia and its component measures is vital for informing novel alternating strategies to prevent, delay, or even reverse it.

Age is an established risk factor for declines in the visual, auditory, olfactory, and gustatory systems.[13] The global prevalence of these sensory losses are high, with up to 40%, 37%, and 41% of adults aged ≥60 years estimated to have visual impairment (VI), hearing impairment (HI) and smell impairment (SI), respectively.[14–16] Although there are no global data on taste impairment (TI), a US study measuring the full spectrum of age-related sensory impairments reported that TI (74%) was the most prevalent, suggesting a correspondingly high global prevalence.[17] Individuals with sensory impairments are at high risk of profound consequences including cognitive impairment, frailty, falls, reduced QoL, poor nutrition, mobility dysfunction, and mortality.[18–21] Given the high prevalence rates of sarcopenia and sensory impairment in older adults, their associations with other geriatric syndromes and the presence of several shared health-related risk factors.[5,14–17] A direct relationship between the two has been hypothesized.[22,23] Establishing this relationship is important, as sensory impairments can be managed effectively with sensory interventions such as cataract surgery, provision of glasses and hearing aids, and olfactory management.[24–27] Specifically, cross-sectional[22,28–31] and longitudinal[32–34] studies have documented the association between sensory impairments and the associated components of sarcopenia. As such, sensory impairments may represent an early indicator and modifiable risk factor of sarcopenia. However, there is no comprehensive review on the relationship between sensory impairments and the presence of sarcopenia and its components.

To address this gap, we performed a systematic review of observational studies evaluating the associations between sensory impairments (VI, HI, SI, and TI) with sarcopenia and associated components, including handgrip strength, muscle mass, and gait speed. We hypothesize that sensory impairment is an independent risk factor of sarcopenia and its associated components. We also identify key knowledge gaps and suggest future research directions.

Methods

Search strategy

The PubMed, EMBASE, Cumulative Index to Nursing and Allied Health Literature (CINAHL), and Cochrane Library databases were searched for English language research articles published from inception until 24 May 2021. Searches were conducted systematically by using pre-determined controlled vocabulary terms [e.g. Medical Subject Headings (MeSH) term used in PubMed] and keywords based on the two health conditions: sensory impairment (i.e. VI, HI, SI, and TI) and sarcopenia and its component measures (low muscle mass, weak muscle strength, and reduced physical performance). We chose handgrip strength and gait speed as proxy measures for muscle strength and physical performance, respectively, because they are strongly recommended by the International Clinical Practice Guidelines for Sarcopenia as feasible and valid measurements of these two components.[35] Relevant references identified from the bibliographies of pertinent articles were also retrieved. Our full search strategy and Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) checklist are reported in the Supporting Information, *Data* S1 and S2. The review protocol is available on PROSPERO (http://www.crd.york.ac.uk/prospero/, reference CRD42021247967).

Eligibility criteria

Our inclusion criteria were (i) study design: observational studies (cross-sectional, longitudinal, and case–control); (ii) population: adults aged ≥50 years within well-defined populations (community-dwelling, hospital, and nursing home/geriatric settings); (iii) exposure: sensory impairment (VI, HI, SI, or TI) measured objectively (e.g. Snellen chart, pure-tone audiometry, sniffing sticks, and taste solutions of varying concentrations) as well as self-report (e.g. answering a question about whether they have VI); (iv) outcomes: sarcopenia and its component measures, including low muscle mass, weak handgrip strength and slow gait speed. Studies that included continuous measures of muscle mass [e.g. appendicular skeletal muscle mass (ASM), ASM/height[2]], handgrip strength or gait speed were also included, and no other restrictions were placed on the definition of sarcopenia or the methods used to measure its defining components for

this review; (v) studies published in English and; (vi) studies that included human participants.

Studies were excluded if they (i) were literature reviews, qualitative studies, letters, editorials, commentaries, economic evaluations, guidelines, protocols, and book chapters, (ii) focused on specific subpopulations/risk groups (e.g. individuals with cancer or cardiovascular disease), (iii) investigated disease-specific instead of sensory-specific associations (e.g. cataract or glaucoma instead of VI).

Selection process

Studies were retrieved by one author (K. C. H.) and independently verified by a second co-author (P. G.). All discrepancies were resolved by consensus, and in cases where no consensus could be reached, the senior author (E. L.) was consulted.

Data extraction and data synthesis

Using a pre-identified form, data extraction and risk of bias assessment were performed by one author (K. C. H.) and vetted by a co-author (P. G.). Information extracted included author, year of publication, journal of publication, country, study design, number of study participants, age range, type of population, sex distribution, definitions of sensory impairment and sarcopenia and its components (including measurement methods and cut-points), prevalence of sensory impairment/sarcopenia in sample (percentage/number of participants), and reported risk estimates [e.g. odds ratio (OR)] between sensory impairment and sarcopenia and its components). Authors' conclusions were also extracted.

Risk of bias assessment and data analysis

Risk of bias of the included studies was assessed by one author (K. C. H.) and vetted by co-author (P. G.) using the Newcastle-Ottawa Scale (NOS).[36] Studies were categorized as high (<5 stars), moderate (5–7 stars), or low risk of bias (≥8 stars) on a scale of 0 to 10 for cross-sectional studies and 0 to 9 for longitudinal studies.[37] Where necessary, authors of included studies were contacted for clarification of study design to inform risk of bias. Authors were allowed 2 weeks to respond with a follow-up email for another 2 weeks, after which the best available information was used if no reply was obtained. Due to the heterogeneity of included studies such as population characteristics, definitions and measurements of exposures and outcomes, analysis methods and effect estimates, it was not possible to pool the results statistically, and therefore a meta-analysis was not undertaken.

Results

Overview of included studies

After all citations were merged and duplicates were removed, our search produced 3175 unique records, of which, 21 full-text reports were assessed (PRISMA flow diagram; *Figure* 1). In total, 10 cross-sectional and three longitudinal population-based studies of community-dwelling adults (N = 68 235) were included. The characteristics of these studies are summarized in *Table* 1. Briefly, with some studies (n = 5) investigating more than one sensory impairment, 8, 6, 3, and 1 studies investigated the relationship between VI, HI, SI, and TI and sarcopenia and its related components, respectively. Follow-up duration for the longitudinal studies ranged from 4 to 11 years. Sample sizes ranged between 141 and 34 129. All were population-based studies of community dwelling adults. Four studies drew from Asian populations, seven from Caucasian populations and two from a combination of multiple ethnicities from six low- and middle-income countries (LMIC). Two studies[30,38] had a moderate (NOS 5–7) and the remaining[22,23,28,29,31–34,39–41] (n = 11) had a low (NOS ≥ 8) risk of bias (*Table* 2 for longitudinal studies; *Table* 3 for cross-sectional studies).

Sensory impairments and sarcopenia

Two studies investigated the association between objectively measured sensory impairment measurements and sarcopenia (*Table* 1). In a cross-sectional study of adults aged ≥65 years in six LMIC, Smith and associates[41] reported that subjects with moderate (OR 1.69; 95% CI: 1.25 to 2.27; $P < 0.001$), and severe (OR 3.38; 95% CI: 1.69 to 6.77; $P < 0.001$), but not mild VI (OR 1.10; 95% CI: 0.87–1.40; $P > 0.05$), had higher odds of having sarcopenia compared with those with no VI in multivariate analyses. Results were similar in sensitivity analyses using different ways of defining sarcopenia [e.g. weak handgrip vs. (weak handgrip + low muscle mass) vs. (weak handgrip + low muscle mass + slow gait)]. Similarly, in a cross-sectional study of Japanese adults aged ≥65 years, Harita and co-workers[23] found that individuals with SI had higher odds of sarcopenia (OR 47.8; 95% CI: 1.13–2016; $P = 0.04$) after adjusting for potential confounders. Interestingly, sex-stratified analyses revealed that this association was only significant in women (OR 36.2; 95% CI: 1.01–1406; $P = 0.048$), and no significant association was found between TI and sarcopenia.

Sensory impairments and muscle mass

Two studies showed evidence of significant associations between objectively measured sensory impairment parameters
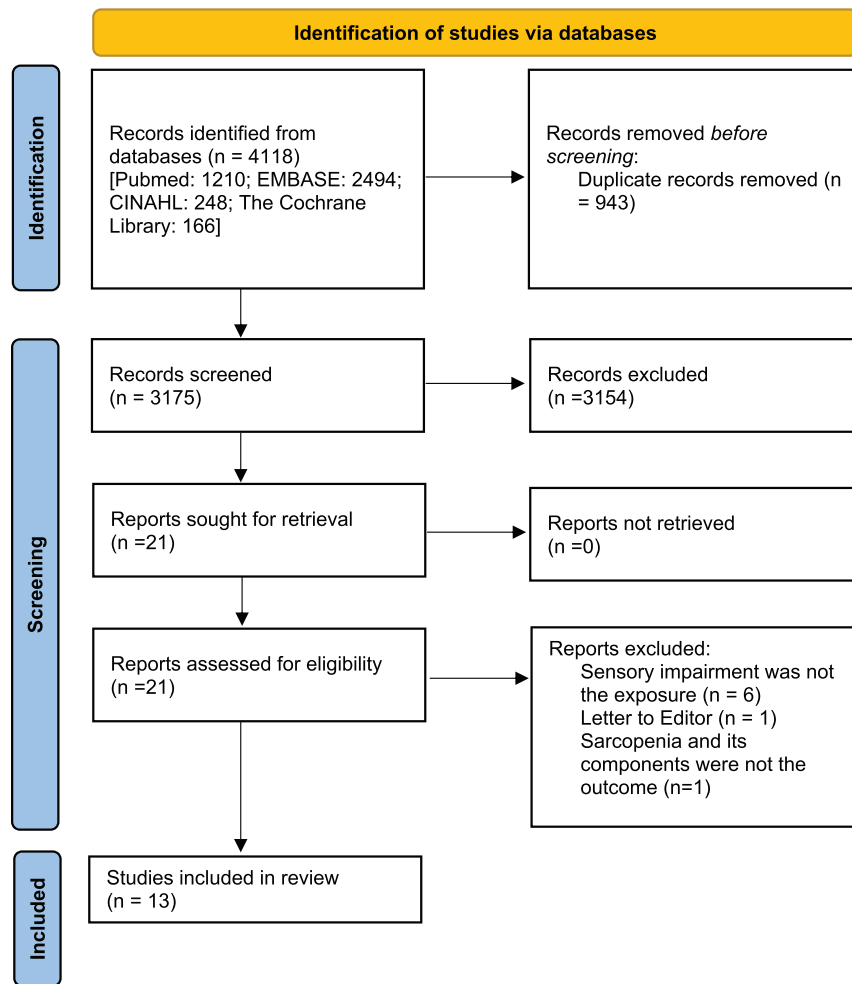
Identification of studies via databases

Identification

Records identified from databases (n = 4118) [Pubmed: 1210; EMBASE: 2494; CINAHL: 248; The Cochrane Library: 166]

→ Records removed *before screening*: Duplicate records removed (n = 943)

Screening

Records screened (n = 3175) → Records excluded (n = 3154)

Reports sought for retrieval (n = 21) → Reports not retrieved (n = 0)

Reports assessed for eligibility (n = 21) → Reports excluded: Sensory impairment was not the exposure (n = 6) Letter to Editor (n = 1) Sarcopenia and its components were not the outcome (n=1)

Included

Studies included in review (n = 13)

Figure 1 Preferred reporting items for systematic review and Meta-analyses flow diagram showing the study selection process.

and low muscle mass. In a cross-sectional study of Koreans aged ≥65 years, Moon and colleagues demonstrated that VI was associated with a 1.6-fold higher odds of low muscle mass (OR 1.60; 95% CI 1.02 to 2.50; $P = 0.04$).[22] Similarly, in a longitudinal study of US adults ≥70 years by Purdy and associates, individuals with SI at baseline experienced a greater annual decline in total lean mass (-139 g/year, 95% CI: -236 to -43; $P < 0.05$) compared with those without SI at baseline.[32]

Sensory impairments and handgrip strength

The association between sensory impairments and handgrip strength was equivocal. In a cross-sectional study of Australians aged ≥65 years, Gopinath and colleagues[39] reported that women with two to three concomitant sensory impairments (VI, HI, and/or SI) had 1.1 kg lower mean handgrip strength compared with those with no sensory loss

($P = 0.05$). However, these associations were not observed in men. Interestingly, no significant difference in handgrip strength was observed in individuals with a single sensory impairment compared with no impairment. Two other studies[38,40] also found no association between VI (both self-reported and objectively measured) and weak handgrip strength; however, Vancampfort and associates[38] reported that individuals with HI (based on an interviewer's observation during the survey) had higher odds of weak handgrip strength (OR 1.40; 95% CI: 1.16 to 1.70; $P < 0.001$).

Sensory impairments and gait speed

We found strong evidence of an independent association between sensory impairment parameters, particularly, HI[28–30,33] and VI,[28,31,34] and slow gait speed. For instance, Chen and co-workers[33] in an 11-year longitudinal study of US adults aged ≥70 years found that subjects with HI had slower slow gait

Table 1 Study characteristics included in the literature review (n = 13)

Study, design	Participants' characteristics	Measure of sensory impairment (exposure)	Measure of sarcopenia/ muscle mass/grip strength/ gait speed (outcome)	Covariates	Key findings
Outcome: Sarcopenia (n = 2)					
Harita et al.,[23] cross-sectional	141 community-dwelling adults aged ≥65 years in Japan	SI was defined as ≤7 times correctly identify the 12 odours in the Open Essence test. TI was defined as the first concentrations required to recognize salty and sweet tastes in the 1-mL whole-mouth gustatory test	Sarcopenia was defined as both (i) ASM index measured by BIA divided by height squared with cut-off values <7.0 kg/m^2 for men and <5.7 kg/m^2 for women; and (ii) grip strength measured by a Smedley's hand dynamometer with cut-off values <26 kg for men and <18 kg for women	Age, sex, heart disease, digestive disease and bone/joint disease, BMI, body fat mass index and body mineral index	Individuals with SI had higher odds of having sarcopenia (OR 47.8; 95% CI: 1.13 to 2016; P = 0.04). After stratification by sex, this independent association was only significant in women (OR 36.2; 95% CI: 1.01 to 1406; P = 0.048). No significant association was found between TI and sarcopenia
Smith et al.,[41] cross-sectional	14 585 community dwelling adults aged ≥65 years in six low- and middle-income countries[a]	VI was defined as presenting visual acuity of the better eye worse than 6/12 using the tumbling E LogMAR chart. Level of severity: mild (<6/12 and ≥6/18); moderate (<6/18 and ≥6/60); severe (<6/60)	Sarcopenia was defined as having (i) lowest quintile skeletal muscle mass (calculated as the ASM divided by BMI, where ASM was calculated based on weight, height, sex, age and race); and (ii) either a slow gait speed of a 4 m walk (lowest quintile based on height, age, and sex-stratified values) or a weak handgrip strength (<30 kg for men and <20 kg for women)	Age, wealth, education, smoking, physical activity, obesity, chronic conditions, and country of residence	Compared with those with no VI, individuals with moderate (OR 1.69; 95% CI: 1.25 to 2.27; P < 0.001) and severe VI (OR 3.38; 95% CI: 1.69 to 6.77; P < 0.001) had higher odds of having sarcopenia, but the association was not observed in those with mild VI (OR 1.10; 95% CI: 0.87–1.40; P > 0.05)
Outcome: Muscle mass (n = 2)					
Purdy et al.,[32] longitudinal study (7-year follow-up)	2390 community-dwelling adults aged ≥70 years in the USA	SI was defined as ≤8 times correctly identifying the 12 odours in the Brief Smell Identification Test	Decline in total lean mass was measured by DXA over a 7-year period	Age, sex, race, height, education, clinic site, family income, smoking status, physical activity, self-reported health status, cancer, depression, dementia, cardiovascular diseases, diabetes, and hypertension	Individuals with SI had a greater annual decline in total lean mass (−139 g, 95% CI: −236 g to −43 g; P < 0.05) compared with those without SI
Moon et al.,[22] cross-sectional	1733 community-dwelling adults aged ≥65 years in Korea	VI was defined as best-corrected visual acuity of the better eye <6/12 at a 4 m distance using Jin's vision chart	Low muscle mass was defined as ASM index measured by DXA divided by height squared with cut-off values of <6.43 kg/m^2	Age, smoking status, alcohol consumption, frequency of physical activity, educational level, the status of basic livelihood security recipient and history of stroke	Individuals with VI had higher odds of low muscle mass (OR 1.60; 95% CI: 1.02 to 2.50; P = 0.04), compared with those without VI

(Continues)

Table 1 (continued)

Study, design	Participants' characteristics	Measure of sensory impairment (exposure)	Measure of sarcopenia/ muscle mass/grip strength/ gait speed (outcome)	Covariates	Key findings
Outcome: Handgrip strength (n = 3)					
Gopinath et al.,[39] cross-sectional	947 community-dwelling adults aged ≥65 years in Australia	VI was defined as best-corrected visual acuity of the better eye <6/12 using a retro-illuminated chart. HI was defined as average pure-tone air conduction threshold at 500; 1000; 2000; and 4000 Hz in the better ear >25 dB HL. SI was defined as <6 times correctly identifying the eight odours in the San Diego Odour Identification Test	Handgrip strength of the dominant hand was measured with a Jamar hand dynamometer	Age, living alone, admission to hospitals, and walking disability	Women with two or three sensory impairments had 1.1 kg lower mean handgrip strength compared with those with no sensory impairment (17.47 ± 0.5 kg vs. 18.59 ± 0.3; P = 0.05), but the association was not observed in men. No associations were observed between individuals with one sensory impairment and handgrip strength in both men and women
Ho et al.,[40] cross-sectional	780 community-dwelling adults aged ≥65 years in Singapore	VI was defined as presenting visual acuity of the better eye <6/12 at a 3 m distance using the tumbling E LogMAR chart	Weak handgrip strength of the dominant hand was measured by the Smedley's hand dynamometer with cut-off value of <26 kg for men and <18 kg for women	Age, sex, ethnicity, and cognition	No significant association was found between VI and weak grip strength (OR − 0.5; 95% CI −1.4 to 0.3; P > 0.05)
Vancampfort et al.,[38] cross-sectional	34 129 community dwelling adults aged ≥50 years in 6 low-and middle-income countries[a]	VI was defined as having 'extreme difficulty' in seeing and recognizing a person that the participant knows from about 20 metres. Responses included none, mild, moderate, severe, or extreme. HI was defined based on an interviewer's observation during the survey	Weak handgrip strength of the dominant hand was measured by the Smedley's hand dynamometer, with cut-off value of <30 kg for men and <20 kg for women	Age, sex, wealth, education, marital status, BMI, physical activity, smoking, depression, other chronic conditions, and country of residence	No significant association was found between VI and weak handgrip strength (OR 1.33; 95% CI: 0.83 to 2.13; P > 0.05). Individuals with HI had a higher odd of weak handgrip strength (OR 1.40; 95% CI: 1.16 to 1.70; P < 0.001), compared with those without HI
Outcome: Gait speed (n = 6)					
Verghese et al.,[34] longitudinal study (4-year follow-up)	2306 community-dwelling adults aged ≥65 years in the USA	VI was defined as self-reported 'fair' or 'poor' ability to see objects at far or near distances. Responses included	Slow gait speed of a 2.5 m walk was defined as 0.57 m/s, 0.49 m/s and 0.38 m/s in women aged <70, 70–79 and ≥80 years, respectively. In men, it was	Age, sex, education, muscle weakness, cognitive impairment, alcohol consumption, pain, falls, poor sleep quality, physical inactivity, obesity, arthritis,	Individuals with VI had a higher risk of incident slow gait speed (RR 1.36 95% CI: 1.03 to 1.80; P < 0.05), compared with those without VI

(Continues)

Table 1 (continued)

Study, design	Participants' characteristics	Measure of sensory impairment (exposure)	Measure of sarcopenia/muscle mass/grip strength/gait speed (outcome)	Covariates	Key findings
		excellent, very good, good, fair, or poor.	defined as 0.62, 0.56, and 0.45 m/s for those aged <70, 70–79, and ≥80 years, respectively	stroke, diabetes, hypertension, heart condition and depression	Individuals with moderate or worse HI had slower gait speed than participants with no HI at Visit 1 (1.18 m/s 95% CI: 1.16 to 1.21 vs. 1.22 m/s 9 5% CI: 1.20 to 1.23; P < 0.05). Visit 5 (1.08 m/s 95% CI: 1.06 to 1.10 vs. 1.11 m/s 95% CI: 1.09 to 1.13; P < 0.05), and Visit 11 (0.80 m/s 95% CI: 0.77 to 0.84 vs. 0.88 m/s 95% CI: 0.86 to 0.91; P < 0.01) No significant association was found between mild HI and slow gait speed in any visit.
Chen et al.,[33] longitudinal study (11-year follow-up)	2190 community-dwelling adults aged ≥70 years in the USA	HI was defined as average pure-tone air conduction threshold at 500, 1000, 2000, and 4000 Hz in the better ear >25 dB HL. Level of severity: mild (>25 and ≤40 dB HL); moderate or great (>40 dB HL)	Gait speed of a 3, 4, or 6 m walk was measured. Mean gait speed was compared between groups	Age, sex, race, education, study site, smoking status, hypertension, diabetes, and stroke	
Li et al.,[29] cross-sectional	1180 community-dwelling adults aged ≥50 years in the USA	HI was defined as average pure-tone air conduction threshold at 500, 1000, 2000, and 4000 Hz in the better ear >25 dB HL	Slow gait speed of a 6.1 m walk was defined as <1.0 m/s.	Age, sex, race, and education. Cardiovascular risk factors, including smoking status, hypertension, diabetes mellitus, and stroke	Individuals with HI had higher odds of slow gait speed (OR 2.0; 95% CI: 1.2 to 3.2; P < 0.01), compared with those without HI.
Mikkola et al.,[30] cross-sectional	848 community-dwelling adults aged ≥75 years in Finland	HI was defined as self-reported 'major difficulty' when conversing with another person in a noisy environment. Responses included no difficulty, sometimes, some difficulty, major difficulty	Gait speed of a 2.4 m walk was measured. Mean gait speed was compared between groups	Age, years of education, cognitive functioning, cardiac, circulatory, locomotor diseases	Individuals with major HI had significantly slower walking speed than those with no HI (0.80 m/s vs. 0.88 m/s; P = 0.008)
Huang et al.,[28] cross-sectional	4197 community-dwelling adults aged ≥50 years in the UK	VI was defined as self-reported 'fair' or 'poor' for eyesight. Responses included excellent, very good, good, fair, poor, or registered blind HI was measured by 2 pure pure-tone air conduction at 3000 Hz with 3	Gait speed of a 2.4 m walk was measured. Mean gait speed was compared between groups	Age, sex, education level, cigarette smoking, alcohol drinking, physical activity, hearing aid, depressive symptoms, heart attack, hypertension, diabetes, arthritis, and osteoporosis	Compared with those who self-reported 'excellent' or 'very good' vision, individuals with VI had a slower gait speed (−0.03 m/s 95% CI: −0.06 to −0.01; P = 0.03) Compared with those with no HI, individuals with HI had a slower gait speed *(Continues)*

Table 1 (continued)

Study, design	Participants' characteristics	Measure of sensory impairment (exposure)	Measure of sarcopenia/ muscle mass/grip strength/ gait speed (outcome)	Covariates	Key findings
		thresholds: 75, 55, and 35 dB HL and at 1000 Hz with 3 thresholds: 55, 35, and 20 dB HL for each ear. Level of severity: moderate (heard 3 to 5 tones at either ear), and severe (heard 0 to 2 tones at either ear). DSI was defined as having both VI and severe HI			with a mean difference as −0.03 m/s (95% CI: −0.05 to −0.02; $P < 0.001$) and −0.07 m/s (95% CI: −0.11 to −0.04, $P < 0.001$) for moderate and severe HI, respectively Compared with those with no DSI, individuals with DSI had a slower gait speed with a mean difference as −0.08 m/s (95% CI: −0.14 to −0.02, $P = 0.01$) for DSI
Miyata et al.,[31] cross-sectional	2809 community-dwelling adults aged ≥70 years in the UK	VI was defined as best-corrected visual acuity of the better eye <6/12 at a 5 m distance using a Landolt ring chart	Slow gait speed of a 10 m walk was defined as <1.0 m/s and an additional cut-off at ≤0.8 m/s was also analysed	Age, gender, BMI, current smoking, and number of other health conditions	Individuals with VI had higher odds of having slow gait speed <1.0 m/s (OR 4.50; 95% CI: 1.87 to 10.85; $P = 0.001$) and ≤0.8 m/s (OR 3.51; 95% CI: 1.21 to 10.15; $P = 0.02$)

ASM, appendicular skeletal muscle mass; BIA, bioelectrical impedance analysis; BMI, body mass index; CI, confidence interval; dB HL, decibel hearing loss; DSI, dual sensory impairment; DXA, dual-energy X-ray absorptiometry; HI, hearing impairment; LogMAR, logarithm of the minimum angle of resolution; OR, odds ratio; RR, relative risk; SI, smell impairment; TI, taste impairment; VI, vision impairment.
[a]Six low- and middle-income countries include China, Ghana, India, Mexico, Russia, and South Africa.

Table 2 NOS for risk of bias assessment of included longitudinal studies

Study	Domains[a]			Results[b]	
	Selection (4)	Comparability (2)	Outcome (3)	Score	Risk
Purdy et al.[32]	4	3	2	9	Low
Verghese et al.[34]	3	3	2	8	Low
Chen et al.[33]	4	3	1	8	Low

[a]Domains of Newcastle-Ottawa Scale (NOS): Selection (representativeness of the exposed cohort; selection of the non-exposed cohort; ascertainment of exposure and demonstration that outcome of interest was not present at start of study); Comparability (principal factor and any additional factor); and Outcome (assessment of outcome; if the follow-up was long enough for outcomes to outcome occurs; and adequacy of follow-up of cohorts).
[b]Studies were categorized as high (<5), moderate ($5–7$), or low risk of bias ($≥8$) on the scale of 0 to 9 for longitudinal studies.

Table 3 NOS for risk of bias assessment of included cross-sectional studies

Study	Domains[a]			Results[b]	
	Selection (5)	Comparability (2)	Outcome (3)	Score (10)	Risk
Harita et al.[23]	3	2	3	8	Low
Smith et al.[41]	3	2	2	7	Low
Moon et al.[22]	3	2	3	8	Low
Gopinath et al.[39]	3	2	3	8	Low
Ho et al.[40]	3	2	3	8	Low
Vancampfort et al.[38]	1	2	3	6	Moderate
Li et al.[29]	3	2	3	8	Low
Mikkola et al.[30]	1	2	3	6	Moderate
Huang et al.[28]	2	2	3	7	Low
Miyata et al.[31]	3	2	3	8	Low

[a]Domains of Newcastle-Ottawa Scale (NOS): Selection (representativeness of the sample; sample size; non-respondents; and ascertainment of the exposure); Comparability (confounding factors are controlled); and Outcome (assessment of outcome; and statistical test).
[b]Studies were categorized as high (<5), moderate ($5–7$), or low risk of bias ($≥8$) on the scale of 0 to 10 for cross-sectional studies.

speed than those with no HI. Individuals with moderate or greater HI had significantly slower gait speeds ($P < 0.05$) at all visits where gait speed was measured (*Table* 1). Similarly, Verghese and colleagues[34] reported a significantly higher risk of incident slow gait speed (RR 1.36 95% CI: 1.03 to 1.80; $P < 0.05$) in US adults aged $≥65$ years with self-reported VI than those without over the 4-year follow up periods. Corroborating these findings, Miyata and associates[31] observed independent associations between VI and slow gait speed based on two commonly used gait speed cut-offs: <1.0 m/s (OR 4.50; 95% CI: 1.87 to 10.85; $P = 0.001$) and $≤0.8$ m/s (OR 3.51; 95% CI: 1.21 to 10.15; $P = 0.02$). Critically, presence of dual sensory impairment (DSI), which refers to the co-occurrence of VI and HI, was also reported as a risk factor for slow gait speed. For instance, Huang and associates[28] reported that, compared with those with no DSI, individuals with DSI had a slower gait speed, with a mean difference of -0.08 m/s (95% CI: -0.14 m/s to -0.02 m/s, $P = 0.01$) for DSI.

Discussion

In our systematic review, we found 13 studies investigating the association between sensory impairment parameters

and sarcopenia ($n = 2$), muscle mass ($n = 2$), handgrip strength ($n = 3$) and gait speed ($n = 6$). Overall, we found that the presence of VI and SI (only in women), but not TI, independently increased the odds of having sarcopenia; the association between VI, HI, and SI, and low handgrip strength was inconsistent across studies; VI and SI were each independently associated with low muscle mass; and VI, HI, and DSI were all associated with slow gait speed. Early detection and intervention to prevent the onset of sensory impairment may lower the risk of the development and progression of sarcopenia and its related components. However, given the small number of studies on the sensory impairment-sarcopenia relationship, coupled with the cross-sectional nature of most of these studies, there is currently insufficient evidence to indicate a reliable and valid independent association between sensory impairment and sarcopenia and its related components. More longitudinal investigations are warranted to validate current consensus and confirm causality.

Current hypotheses suggest that sensory impairment contributes to decreased physical activity[29,42–46] and poor nutrition[19,47,48] leading to aggregate physiological dysfunction, in turn, leading to decreased muscle mass, strength and/or gait speed as well as sarcopenia.[4,7] For instance, VI and HI can lead to difficulty in balance control and mobility,[29,42–46] resulting in decreased levels of physical activ-

ity and slower gait speed. Similarly, VI,SI and/or TI can alter older adults' long-term food consumption patterns including a decline in appetite and food intake,[19] leading to suboptimal diet and poor nutritional status.[49,50] Similarly, physical activity and nutrition are critical to maintaining muscle strength and mass in the elderly, with exercise and nutritional interventions demonstrating efficacy in improving muscle mass gain, strength, and gait speed in patients with sarcopenia.[12]

The association between sensory impairment and sarcopenia in older adults may be explained by several psychosocial factors.[47,48,51] For instance, individuals with DSI have markedly worse psychosocial outcomes, such as depressive symptoms, low self-efficacy, social isolation, and loneliness, compared with those with no sensory impairment.[51] Fear of falling is also commonly reported in individuals with VI and/or HI.[47,48] All these psychosocial factors have been linked, either directly or indirectly, with a greater risk of sarcopenia in older adults.[52–55] As such, it is surprising that only two studies assessing the relationship between VI, SI, TI, and sarcopenia were found, with no studies evaluating the associations between HI and sarcopenia or the associated underpinning mechanisms of action.

Evidence for an association between the four sensory impairments and the components defining sarcopenia were equally sparse and, in the case of handgrip strength, findings were equivocal. Specifically, Gopinath and colleagues did not find any association between single sensory impairment and low handgrip strength, but women who had two to three sensory impairments had lower mean handgrip strength compared with those who had one or no sensory impairment.[39] This finding may suggest a sex-based disparity in the relationship between sensory impairment and weak handgrip strength. Previous studies have also shown that predictors of handgrip strength are different for men and women.[56] For example, occupation was a predictor of handgrip strength in men, but not women, while the opposite was observed that body weight was a predictor of handgrip strength in women, but not men.[56] Further investigations are needed to confirm whether sensory impairment is associated with low handgrip strength and there is a sex-based disparity.

Notwithstanding the current lack of evidence and a need for more research in this area, our results suggest a potential relationship between sensory impairment and sarcopenia component measures, which may warrant screening for early detection of sarcopenia in those with sensory impairment. However, rather than using dual-energy X-ray absorptiometry (DXA), which is the gold standard for measurement of muscle mass but is seldom available or used in clinics, screening questionnaires could be used. For example, the SARC-F questionnaire,[57] which include five components: Strength, Assistance with walking, Rise from a chair, Climb stairs, and Falls, has been developed as a possible rapid diagnostic test for sarcopenia. The questionnaire has been validated against

several sets of diagnostic criteria (e.g. diagnostic criteria of EWGSOP2) in different populations.[58–61] The use of such brief and self-complete tools may facilitate early detection and intervention for sarcopenia in those with sensory impairment.

Importantly, several aspects of the sensory impairment-sarcopenia relationship remain unknown due to limited number of studies investigating this association, the general paucity of longitudinal studies and the wide variation in definitions and measurement techniques of both sensory impairment and sarcopenia adopted across studies. Moreover, it is still unclear whether there are race- or sex-based disparities in the relationships between sensory impairment and sarcopenia. Moreover, the temporality and direction of the sensory impairment-sarcopenia relationship is uncertain: rather than a causal relationship, the link between sensory impairment and sarcopenia could be due to a common factor, that is, a common cause hypothesis. For example, oxidative stress, an imbalance between the production of reactive oxygen species and the detoxification of their reactive intermediates,[62] has been reported as a risk factor of VI,[63] HI,[64] SI,[65] and sarcopenia.[66] Other factors such as age-related chronic metabolic disorders include obesity, type 2 diabetes mellitus, cardiovascular disease and neurodegenerative diseases have been linked to VI,[67] HI,[68] SI,[69] TI,[70] and sarcopenia.[71] Even once causality has been established, more research to examine the factors involved in mediating the sensory impairment-sarcopenia relationship is needed. Last, a consistent definition and standardized measurement techniques for sensory impairment, sarcopenia, and sarcopenia components should also be used to allow for the comparison across studies and aggregation of data from multiple studies to perform meta-analyses.

Strengths of our study include a rigorous search strategy with a comprehensive list of search term among multiple electronic databases and involvement of two experienced researchers to assess the risk of bias of the included studies. Nonetheless, our study has several limitations. First, the small number of studies, particularly those of longitudinal design, limit our ability to infer causality and demonstrate the need for more well-designed cohort studies. Second, we excluded non-English publications which may have resulted in some publication bias. Third, the inconsistency in measurement techniques [e.g. bioelectrical impedance analysis (BIA) vs. DXA in measuring muscle mass] and definitions [e.g. presenting visual acuity (VA) vs. best-corrected VA in defining VI] of sensory impairment, and sarcopenia and its associated components across studies have precluded our ability to compare across studies and perform a meta-analysis. Fourth, we have only included studies which defined weak muscle strength and low physical functions based on handgrip strength and slow gait speed. Although they are most used measures, our analyses would not apply to studies using other clinical measures for muscle strength and physical functions. Last, the general senses (touch, pressure, pain, temperature, etc.)

were not considered in this review, as they are composite senses with a complex range of pathology that require separate consideration.

In conclusion, notwithstanding the limited studies on the relationship between sensory impairment and sarcopenia and its associated components, our systematic review suggests a potential association between the presence of single or multiple sensory impairments and a greater likelihood of sarcopenia and/or deficits in its associated components, especially for VI, HI, and SI. These findings suggest the need for early detection and intervention to prevent the onset of sensory impairment which, in turn, may reduce the risk of the development and progression of sarcopenia. However, further prospective studies to untangle the relationship between sensory impairment on sarcopenia and its associated components are needed to better inform clinical guidelines for disease prevention and management.

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Conflict of interest

The authors declare that they have no conflict of interest.

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Online supplementary material

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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