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ORIGINAL ARTICLE

Objectively measured far vision impairment and sarcopenia among adults aged ≥ 65 years from six low- and middle-income countries

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Abstract

Background There are currently no studies on visual impairment and sarcopenia. We investigated the cross-sectional association between objectively measured far vision impairment and sarcopenia in a nationally representative sample of older adults aged 65 years and over from six low- and middle-income countries (LMICs).

Methods Cross-sectional, community-based data from the study on global ageing and adult health (SAGE) were analyzed. Far vision acuity was measured using the tumbling E LogMAR chart and classified as: no vision impairment (6/12 or better); mild vision impairment (6/18 or better but worse than 6/12); moderate vision impairment (6/60 or better but worse than 6/18); severe vision impairment (worse than 6/60). Sarcopenia was defined as having low skeletal muscle mass and either a slow gait speed or a weak handgrip strength. Associations were assessed with multivariable logistic regression.

Results Fourteen thousand five hundred and eighty five individuals aged ≥ 65 years were included in the analysis [mean (SD) age 72.6 (11.5) years; 54.1% females]. After adjustment for multiple potential confounders, compared to those with no vision impairment, the OR (95% CI) for sarcopenia in those with mild, moderate, and severe vision impairment were 1.10 (0.87–1.40), 1.69 (1.25–2.27), and 3.38 (1.69–6.77), respectively. The estimates for females and males were similar.

Conclusions The odds for sarcopenia increased with increasing severity of far vision impairment among older people in LMICs. The mere co-occurrence of these conditions is concerning, and it may be prudent to implement interventions to address/prevent sarcopenia in those with far vision impairment through the promotion of physical activity and appropriate nutrition.

Keywords Sarcopenia · Visual impairment · Low- and middle-income countries · Older adults · Far vision impairment

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Introduction

Sarcopenia may be categorised as a progressive loss of muscle mass and function and is a common physiological change often associated with ageing [1]. A recent review including 35 articles and 58,404 individuals concluded that the overall estimates of global prevalence of sarcopenia was 10% [95% confidence interval (CI) 8–12%] in men and 10% (95% CI 8–13%) in women [2]. Since sarcopenia is associated with numerous health complications such high levels on a global scale is a cause for concern. One umbrella review summarized the evidence regarding sarcopenia as a risk factor for unfavourable health outcomes in older people, and identified seven conditions that were associated with sarcopenia, and a highly suggestive evidence was found for mortality, disability and falls [3]. Moreover, sarcopenia has been estimated to represent about 1.5% of total health expenditure in the US [4]. It is clear that interventions to curb the high prevalence of sarcopenia are required.

To inform targeted interventions to reduce the prevalence of sarcopenia, correlates of this condition need to be identified. Correlates can either be modifiable (e.g., lifestyle behaviours) or non-modifiable (e.g., participants demographics). A plethora of literature exists on correlates of sarcopenia in older adults, and these include for example clinical correlates, nutrition, and physical activity [5–9]. However, one understudied but potential correlate of sarcopenia is visual impairment. It is plausible to assume that older adults with visual impairment are at higher risk of sarcopenia when compared to normal seeing counterparts, owing to several reasons. First, visual impairment is associated with a higher risk of overall disability, disease, and mortality per se [10–12]. Next, those with visual impairment tend to report lower levels of physical activity [13–15] than those without and participation in physical activity is associated with lower levels of sarcopenia [16]. Finally, those with visual impairment are more likely to consume an unhealthy diet [17] and a poor diet is also associated with a higher prevalence of sarcopenia [8]. However, to date, there are currently no studies on vision impairment and sarcopenia.

Owing to this background, the aim of the present study is to investigate the cross-sectional association between objectively measured far vision impairment and objectively measured sarcopenia in a large sample of older adults aged 65 years and over from six low- to middle-income countries (LMICs). LMICs are an appropriate setting to assess this association as the prevalence of visual impairment has been reported to be high [18].

Methods

The survey

Data from the study on global ageing and adult health (SAGE) were analyzed. These data are publicly available through http://www.who.int/healthinfo/sage/en/. This survey was undertaken in China, Ghana, India, Mexico, Russia, and South Africa between 2007 and 2010. Based on the World Bank classification at the time of the survey, all countries were LMICs.

Details of the survey methodology have been published elsewhere [19]. Briefly, to obtain nationally representative samples, a multistage clustered sampling design method was used. The sample consisted of adults aged ≥ 18 years with oversampling of those aged ≥ 50 years. Trained interviewers conducted face-to-face interviews using a standard questionnaire. Standard translation procedures were undertaken to ensure comparability between countries. The survey response rates were: China 93%; Ghana 81%; India 68%; Mexico 53%; Russia 83%; and South Africa 75%. The response rates were lowest in Mexico. This was partly due to the short time available for field work in this country which did not allow sufficient time for multiple re-visits in cases where the respondent was not at home. Sampling weights were constructed to adjust for the population structure as reported by the United Nations Statistical Division. Ethical approval was obtained from the WHO Ethical Review Committee and local ethics research review boards. Written informed consent was obtained from all participants.

Sarcopenia

Following the criteria used in a previous publication using the same dataset [20], sarcopenia was defined as having low skeletal muscle mass (SMM) as reflected by lower skeletal mass index (SMI) and either a slow gait speed or a weak handgrip strength [21]. Skeletal muscle mass (SMM) was calculated as the appendicular skeletal muscle mass (ASM) based on the equation proposed by Lee and colleagues: $ASM = 0.244 \times weight + 7.8 \times height + 6.6 \times sex - 0.098 \times age + race - 3.3$ [where female = 0 and male = 1; race = 0 (White and Hispanic), race = 1.9 (Black) and race = − 1.6 (Asian)] [22]. ASM was further divided by BMI based on measured weight and height to create a skeletal muscle mass index (SMI) [23]. Low SMM was defined as the lowest quintile of the SMI based on sex-stratified values. Gait speed was based on a 4 m timed walk and was measured by asking the participant to walk at a usual pace. The interviewer recorded the time to

completion of the 4 m walk. Slow gait speed referred to the lowest quintile of walking speed based on height, age, and sex-stratified values [24, 25]. Weak handgrip strength was defined as < 30 kg for men and < 20 kg for women using the average value of the two handgrip measurements of the dominant hand [26].

Visual impairment

Visual acuity was measured using the tumbling E LogMAR chart separately for each eye. The interviewer was instructed to check that the vision charts are well lit and to make sure that the surface did not reflect glare. Furthermore, the respondent was instructed to use glasses or contact lenses if they usually wore them. Based on the WHO criteria, we categorized far vision into the following levels of severity: no vision impairment (6/12 or better); mild vision impairment (6/18 or better but worse than 6/12); moderate vision impairment (6/60 or better but worse than 6/18); severe vision impairment (worse than 6/60).

Control variables

The selection of the control variables included in this study was based on past literature [27–29] and included sex, age (years), wealth quintiles based on income, highest level of education achieved (primary, secondary, tertiary), smoking (never, past, current), physical activity, cognition, obesity, and chronic physical conditions (at least one of angina, arthritis, diabetes, or stroke). Moderate-to-vigorous physical activity in min/week was assessed by the global physical activity questionnaire [30]. Cognitive function was assessed with two questions: Overall in the last 30 days, how much difficulty did you have (a) with concentrating or remembering things? and (b) in learning a new task (for example, learning how to get to a new place, learning a new game, learning a new recipe)? Each item was scored on a five-point scale: none (score = 1), mild (score = 2), moderate (score = 3), severe (score = 4), and extreme/cannot do (score = 5). Since these answer options were an ordered categorical scale, as in previous SAGE studies, we conducted factor analysis with polychoric correlations to incorporate the covariance structure of the answers provided for individual questions measuring a similar construct [31, 32]. The principal component method was used for factor extraction, while factor scores were obtained using the regression scoring method. These factor scores were later converted to scores ranging from 0 to 100 to create a cognitive function scale with higher values representing worse cognitive function. A stadiometer and a routinely calibrated electronic weighting scale were used to measure height and weight, respectively. Obesity was defined as body mass index ≥ 30 kg/m^2. Arthritis, diabetes, and stroke were based on self-reported lifetime diagnosis. For angina, in addition to a self-reported diagnosis, a symptom-based diagnosis based on the rose questionnaire was also used [33].

Statistical analysis

The statistical analysis was performed with Stata 14.1 (Stata Corp LP, College station, Texas). The analysis was restricted to those aged ≥ 65 years as sarcopenia is an age-related condition. The difference in sample characteristics by severity of far vision impairment was tested by Chi-squared tests and Kruskall Wallis tests for categorical and continuous variables, respectively. We conducted multivariable binary logistic regression with far vision impairment as the exposure variable and sarcopenia as the outcome. The analysis was conducted using the overall sample and sex-stratified samples. We also conducted sex-stratified analysis as it is indeed possible that the association between sarcopenia and objective vision will differ by sex, owing to sex differences within exposure and outcome variables. For example, certain eye conditions such as cataract that cause vision impairment have been found to be more common in women than men [34]. Furthermore, the prevalance of sarcopenia has been reported to be higher in men than women [35]. The regression analysis was adjusted for sex, age, wealth, education, smoking, physical activity, cognition, obesity, chronic conditions and country with the exception of the sex-stratified analysis which was not adjusted for sex. Adjustment for country was done by including dummy variables for each country in the model as in previous SAGE publications [36, 37]. We also conducted sensitivity analysis to assess the robustness of our findings when employing a different definition of sarcopenia. Specifically, following the definitions based on the European working group on sarcopenia in older people (EWGSOP) 2 [38], we defined sarcopenia in three different ways: (a) low handgrip strength only; (b) low handgrip strength and low SMM; (c) low handgrip strength, low SMM, and slow gait.

All variables were included in the models as categorical variables with the exception of age, physical activity, and cognition (continuous variables). The sample weighting and the complex study design were taken into account in the analyses to generate nationally representative estimates. Results from the regression analyses are presented as odds ratios (ORs) with 95% confidence intervals (CIs). The level of statistical significance was set at $p < 0.05$.

Results

A total of 14,585 individuals aged ≥ 65 years were included in the analysis (China 5360; Ghana 1975; India 2441; Mexico 1375; Russia 1950; South Africa 1484). The sample

Table 1 Sample characteristics (overall and by severity of far vision impairment)

Far vision impairment						
Characteristic	Overall	None	Mild	Moderate	Severe	*p* value[a]
Sarcopenia						
No	83.8	88.2	84.6	74.9	52.5	< 0.001
Yes	16.2	11.8	15.4	25.1	47.5	
Sex						
Male	45.9	49.0	44.2	41.3	38.6	0.001
Female	54.1	51.0	55.8	58.7	61.4	
Age (years)						
Mean (SD)	72.6 (11.5)	71.1 (10.6)	72.8 (11.6)	74.1 (11.7)	77.0 (11.8)	< 0.001
Wealth						
Poorest	22.1	19.6	22.0	26.5	50.0	< 0.001
Poorer	21.4	21.6	20.8	21.5	23.5	
Middle	20.0	18.5	19.1	24.1	9.7	
Richer	17.6	18.7	19.2	14.2	6.9	
Richest	18.9	21.6	18.9	13.7	9.9	
Education						
Primary	66.3	62.4	68.1	71.5	98.2	0.004
Secondary	28.3	30.7	26.6	25.8	1.5	
Tertiary	5.4	6.8	5.3	2.7	0.3	
Smoking						
Never	61.2	60.3	62.7	61.4	68.6	0.090
Current	30.7	30.7	29.4	32.1	17.8	
Past	8.2	8.9	7.9	6.6	13.7	
Physical activity[b]						
Median (IQR)	390 (40–1080)	420 (70–1200)	360 (30–980)	315 (0–960)	90 (0–630)	< 0.001
Cognition[c]						
Median (IQR)	41 (20–60)	41 (0–58)	41 (20–60)	50 (31–60)	50 (41–60)	< 0.001
Obesity						
No	90.6	90.2	89.4	92.2	98.8	0.046
Yes	9.4	9.8	10.6	7.8	1.2	
Chronic condition						
None	53.5	55.6	53.4	48.8	62.2	0.049
Yes	46.5	44.4	46.6	51.2	37.8	

Data are % unless otherwise stated

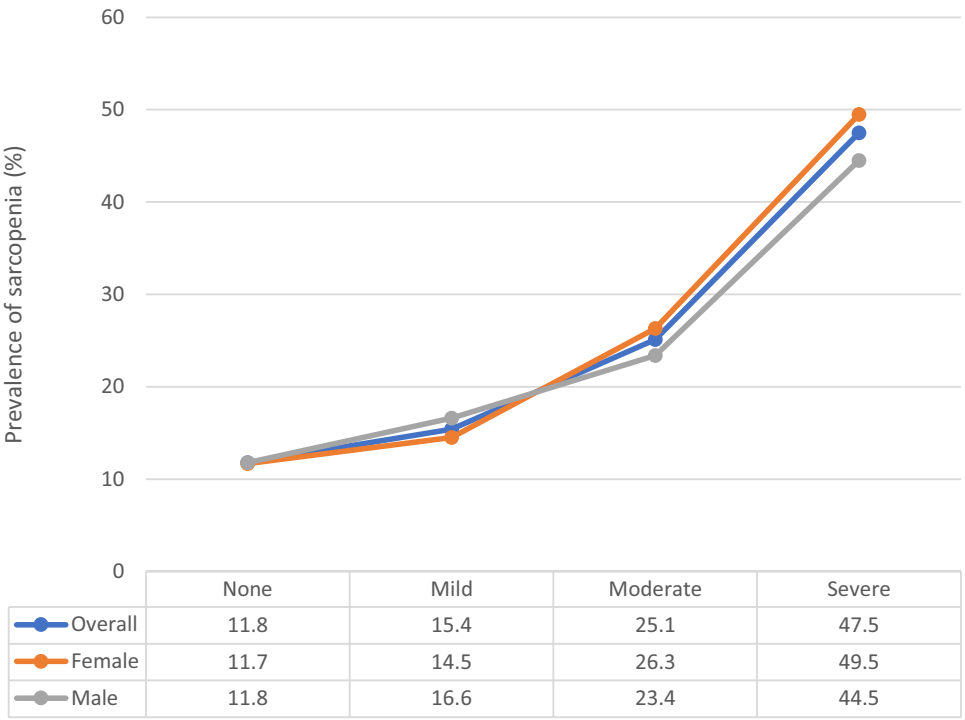
SD standard deviation, *IQR* interquartile range

[a]*p* value was calculated by chi-squared test and Kruskal Wallis tests for categorical and continuous variables, respectively

[b]Physical activity referred to moderate-to-vigorous physical activity in min/week

[c]Cognition was a score ranging from 0 to 100 with higher scores corresponding to worse cognitive function

characteristics are provided in Table 1. The mean (SD) age was 72.6 (11.5) years and 54.1% were females. The prevalence of sarcopenia was 16.2%, while the prevalence of mild, moderate, and severe far vision impairment was 51.8, 23.1, 24.3, and 0.8%, respectively. The prevalence of sarcopenia increased with increasing severity of far vision impairment in the overall sample and also in sex-stratified samples (Fig. 1). For example, in the overall sample, while the prevalence of sarcopenia was only 11.8% among those with no vision impairment, this figure increased to 47.5% among those with severe vision impairment. The association between far vision impairment and sarcopenia estimated by multivariable logistic regression is shown in Table 2. In the overall sample, compared to those with no vision impairment, the OR (95% CI) for sarcopenia in those with mild, moderate, and severe vision impairment were 1.10 (0.87–1.40), 1.69 (1.25–2.27), and 3.38 (1.69–6.77), respectively. The estimates for females and males were similar. The results of the sensitivity analysis using different definitions for sarcopenia were similar (Appendix Table).



	None	Mild	Moderate	Severe
Overall	11.8	15.4	25.1	47.5
Female	11.7	14.5	26.3	49.5
Male	11.8	16.6	23.4	44.5

Fig.1 Prevalence of sarcopenia by severity of far vision impairment

Discussion

In this large sample of older adults from six LMICs, after adjustment for multiple potential confounders, we found that the odds for sarcopenia increased with increasing severity of far vision impairment for the overall sample and for males and females separately. Specifically, in the overall sample, the odds for sarcopenia was substantially increased (OR = 3.38) in those with severe visual impairment vs no vision impairment. To the authors' knowledge, this is the first study to investigate the association between vision impairment and sarcopenia.

Although it is not possible to compare directly our findings with previous literature, as the specific association between visual impairment and sarcopenia has not been investigated to date, our study results are in line with previous studies which have investigated the association between visual impairment and conditions that are related to sarcopenia such as low handgrip strength and frailty. For example, in one study carried out in a sample of the US population with visual impairment, it was found that those with visual impairment were more likely to be prefrail and frail than those without visual impairment [28]. Another study found that older adults in England with poor self-rated eyesight have lower levels of physical function compared with those with good eyesight [29].

The observed association between far vision impairment and sarcopenia may be explained by several plausible pathways. As previously mentioned, those with visual impairment tend to engage in lower levels of physical activity and have a poorer diet (specifically, low fruit and vegetable consumption and low protein intake) than their normal seeing counter parts and both physical activity and poor diet are associated with the onset of sarcopenia. Although the current study adjusted for physical activity, this variable was only on current levels of physical activity and may not reflect physical activity levels during the life course which is more likely to be correlated with risk for sarcopenia. Next, it has recently been suggested that oxidative stress, chronic inflammation, and mitochondrial dysfunction play important roles in age-related muscle atrophy including sarcopenia [39]. Importantly, those with visual impairment have higher levels of oxidative stress, particularly older adults [40, 41], and some visual impairments share common antecedents with chronic inflammation [42]. Moreover, mitochondrial dysfunction and mitochondrial disorders have been implicated in the onset of visual impairment [43, 44]. It is important to highlight the finding that the more severe the visual impairment the greater the risk of sarcopenia, demonstrating biological gradient. It is likely that more severe visual impairment results in a higher exposure to the above discussed risk factors and thus greater risk of sarcopenia. For example, literature has shown that those with the severest forms of vision impairment exhibit the lowest levels of physical activity [45].

The present study has clear strengths that include the use of large nationally representative datasets. However, it is important to highlight the limitations of the present

Table 2 Association of far vision impairment and covariates with sarcopenia estimated by multivariable logistic regression

Characteristic	Overall		Female		Male	
	OR	95% CI	OR	95% CI	OR	95% CI
Visual impairment						
None	1.00		1.00		1.00	
Mild	1.10	[0.87, 1.40]	1.04	[0.72, 1.49]	1.27	[0.90, 1.79]
Moderate	1.69***	[1.25, 2.27]	1.75*	[1.09, 2.82]	1.74*	[1.12, 2.70]
Severe	3.38***	[1.69, 6.77]	3.87**	[1.70, 8.84]	3.17*	[1.26, 7.97]
Sex						
Male	1.00					
Female	0.86	[0.68, 1.08]				
Age (years)	1.12***	[1.10, 1.14]	1.14***	[1.11, 1.17]	1.09***	[1.07, 1.12]
Wealth						
Poorest	1.00		1.00		1.00	
Poorer	0.68**	[0.51, 0.90]	0.63	[0.38, 1.02]	0.84	[0.54, 1.29]
Middle	0.62**	[0.44, 0.89]	0.68	[0.42, 1.11]	0.67	[0.43, 1.05]
Richer	0.59**	[0.43, 0.82]	0.51**	[0.33, 0.81]	0.78	[0.48, 1.26]
Richest	0.43***	[0.29, 0.62]	0.39**	[0.20, 0.75]	0.53**	[0.33, 0.85]
Education						
Primary or less	1.00		1.00		1.00	
Secondary	0.86	[0.64, 1.17]	0.94	[0.58, 1.51]	0.70*	[0.50, 0.98]
Tertiary	0.70	[0.43, 1.14]	0.57	[0.21, 1.53]	0.56	[0.31, 1.01]
Smoking						
Never	1.00		1.00		1.00	
Current	0.92	[0.69, 1.21]	1.20	[0.73, 1.97]	0.76	[0.54, 1.05]
Past	1.19	[0.83, 1.72]	0.77	[0.38, 1.59]	1.20	[0.79, 1.81]
Moderate to vigorous physical activity (min/week)	1.00	[1.00, 1.00]	1.00	[1.00, 1.00]	1.00	[1.00, 1.00]
Cognition[a]	1.01**	[1.00, 1.01]	1.01***	[1.01, 1.02]	1.00	[0.99, 1.01]
Obesity						
None	1.00		1.00		1.00	
Yes	2.75***	[1.90, 4.00]	1.44	[0.85, 2.42]	10.89***	[5.51, 21.53]
Chronic conditions						
None	1.00		1.00		1.00	
Yes	1.10	[0.87, 1.38]	1.01	[0.75, 1.36]	1.23	[0.92, 1.66]

Models are mutually adjusted for all variables in the respective columns and country

OR odds ratio, *CI* confidence interval

[a]Cognition was a score ranging from 0 to 100 with higher scores corresponding to worse cognitive function

*$p < 0.05$

**$p < 0.01$

***$p < 0.001$

work. First, this study is cross-sectional in nature. Therefore, causality of temporal associations cannot be established. Second, six LMICs with large populations were included, however, the present work is not representative of all LMICs. Third, ASM was based on a population equation that has been validated against gold standard methods such as magnetic resonance imaging and dual-energy X-ray absorptiometry in diverse populations, and concordance rates have been reported to be good [22, 46]. As these gold standard methods are costly, they would be impractical for population-based surveys, especially from LMICs. Nevertheless, direct estimates would had yielded results that are more accurate. In addition, the measurement of visual acuity was conducted at the participant's home. Although the interviewer was instructed to check that the vision charts are well lit, it is possible that the level of illumination differed by household and this could have led to some level of misclassification. Next, our

Table 3 Association of far vision impairment with different definitions of sarcopenia estimated by multivariable logistic regression

Sarcopenia	Visual impairment	Overall		Female		Male	
		OR	95% CI	OR	95% CI	OR	95% CI
Weak handgrip	None	1.00		1.00		1.00	
	Mild	1.25*	[1.04, 1.51]	1.13	[0.88, 1.47]	1.44**	[1.14, 1.82]
	Moderate	1.70***	[1.28, 2.25]	1.51**	[1.12, 2.04]	2.05**	[1.28, 3.27]
	Severe	3.98***	[1.75, 9.02]	6.33***	[2.14, 18.71]	2.42	[0.83, 7.03]
Weak handgrip + low SMM	None	1.00		1.00		1.00	
	Mild	1.17	[0.91, 1.50]	1.11	[0.76, 1.61]	1.31	[0.91, 1.88]
	Moderate	1.62***	[1.22, 2.14]	1.59*	[1.03, 2.46]	1.76*	[1.13, 2.75]
	Severe	3.81***	[1.88, 7.73]	3.98**	[1.65, 9.62]	3.87**	[1.56, 9.60]
Weak handgrip + low SMM + slow gait	None	1.00		1.00		1.00	
	Mild	1.85**	[1.25, 2.73]	1.66	[0.87, 3.18]	2.13*	[1.18, 3.86]
	Moderate	3.26***	[1.78, 5.99]	2.79*	[1.27, 6.15]	3.85***	[1.93, 7.68]
	Severe	7.11**	[2.14, 23.64]	2.51	[0.61, 10.30]	22.61***	[4.42, 115.51]

Models are adjusted for age, wealth, education, smoking, physical activity, obesity, chronic conditions, and country. Overall analysis is additionally adjusted for sex

OR odds ratio, *CI* confidence interval, *SMM* skeletal muscle mass

*$p < 0.05$

**$p < 0.01$

***$p < 0.001$

measure on physical activity was based on self-report and only reflected current levels of physical activity and this may have introduced bias in the analysis. Future studies should consider use of data on past patterns of physical activity and objectively measured levels of physical activity. Furthermore, we did not have data on nutritional status and/or food intake, and thus, the influence of these factors on the association between vision impairment and sarcopenia could not be assessed. Finally, participants in nursing homes or other institutions, who may be at higher risk for sarcopenia and visual impairment, were not included in our study. Thus, our study results may not be generalizable to the entire population.

In conclusion, in this large sample of older adults from six LMICs, it was found that the odds for sarcopenia increased with increasing severity of far vision impairment for the overall sample, and for males and females separately. Before concrete recommendations can be made for policy and practice, future longitudinal and intervention studies are needed to understand the mechanism that underlies the association between vision impairment and sarcopenia, and to assess whether addressing visual impairment can lead to lower risk of future development of sarcopenia. However, the mere co-occurrence of these conditions observed in our study is concerning as both of these conditions are associated with a myriad of adverse health outcomes. Thus, it may be prudent to implement interventions to address/prevent sarcopenia in those with visual impairment possibly through the promotion of physical activity and appropriate nutrition.

Appendix

See Table 3.

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Availability of data and materials Data are available from https://www.who.int/healthinfo/sage/en/

Declarations

Conflict of interest None.

Ethics approval Ethical approval was obtained from the WHO Ethical Review Committee and local ethics research review boards.

Consent to participate Written informed consent was obtained from all participants.

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