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Ethnicity & Health

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/ceth20

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To cite this article: Berber G. Dorhout , Elvera Overdevest , Michael Tieland , Mary Nicolaou , Peter J. M. Weijs , Marieke B. Snijder , Ron J. G. Peters , Irene G. M. van Valkengoed , Annemien Haveman-Nies & Lisette C. P. G. M. de Groot (2020): Sarcopenia and its relation to protein intake across older ethnic populations in the Netherlands: the HELIUS study, Ethnicity & Health, DOI: 10.1080/13557858.2020.1814207

To link to this article: https://doi.org/10.1080/13557858.2020.1814207

Published online: 07 Sep 2020.

ETHNICITY & HEALTH
https://doi.org/10.1080/13557858.2020.1814207

Sarcopenia and its relation to protein intake across older ethnic populations in the Netherlands: the HELIUS study

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ABSTRACT

Objective: To examine the prevalence of sarcopenia and its association with protein intake in men and women in a multi-ethnic population.

Design: We used cross-sectional data from the HELIUS (Healthy Life in an Urban Setting) study, which includes nearly 25,000 participants (aged 18–70 years) of Dutch, South-Asian Surinamese, African Surinamese, Turkish, Moroccan, and Ghanaian ethnic origin. For the current study, we included 5161 individuals aged 55 years and older. Sarcopenia was defined according to the EWGSOP2. In a subsample ($N = 1371$), protein intake was measured using ethnic-specific Food Frequency Questionnaires. Descriptive analyses were performed to study sarcopenia prevalence across ethnic groups in men and women, and logistic regression analyses were used to study associations between protein intake and sarcopenia.

Results: Sarcopenia prevalence was found to be sex- and ethnic-specific, varying from 29.8% in Turkish to 61.3% in South-Asian Surinamese men and ranging from 2.4% in Turkish up to 30.5% in South-Asian Surinamese women. Higher protein intake was associated with a 4% lower odds of sarcopenia in the subsample (OR = 0.96, 95%-CI: 0.92–0.99) and across ethnic groups, being only significant in the South-Asian Surinamese group.

Conclusion: Ethnic differences in the prevalence of sarcopenia and its association with protein intake suggest the need to target specific ethnic groups for prevention or treatment of sarcopenia.

ARTICLE HISTORY
Received 15 October 2019
Accepted 19 August 2020

KEYWORDS
Sarcopenia; protein intake; multi-ethnic population; older adults; HELIUS study

Introduction

It is expected that in 2060 almost 25% of the Dutch population will consist of adults aged 65 years and over, of which almost 28% is expected to be from an ethnic minority group

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(CBS 2017). These demographic changes will influence society's health status as a whole. In particular, older ethnic minorities are more likely to have an unfavorable health status compared to the majority population (Schellingerhout 2004; Denktaş et al. 2009; Nielsen and Krasnik 2010).

A consequence of the ageing population is the increasing number of older adults with physical limitations. Part of these limitations are caused by decreased muscle mass and strength, also called sarcopenia (Morley 2012). Treatment and preferably prevention of sarcopenia is necessary, since sarcopenia may lead to reduced quality of life, disability, hospitalization, loss of independence and increased risk of falls (Cruz-Jentoft et al. 2018). In addition, sarcopenia is associated with e.g. cardiac and respiratory diseases, and all-cause mortality (Marty et al. 2017; Cruz-Jentoft et al. 2018; Han et al. 2018).

The prevalence of sarcopenia may differ between subgroups of the population, e.g. between men and women and between ethnic groups (Denktaş et al. 2009; Nielsen and Krasnik 2010; Cruz-Jentoft et al. 2014). Variations in the prevalence of sarcopenia have been documented for limited ethnic groups, namely Hispanic, Non-Hispanic white and Non-Hispanic Black populations in the US (Du et al. 2018). In several parts of the world, differences in muscle mass and muscle strength have been described between ethnic minority groups, which may contribute to differences in the prevalence of sarcopenia (Rush et al. 2007; Silva et al. 2010; Greenhall and Davenport 2017). Ethnic minorities in the Netherlands were reported to have a lower handgrip strength than the Dutch majority population have (Van Der Kooi et al. 2015). Further investigation seems imperative to target preventive interventions to specific ethnic groups at high risk of sarcopenia within the population.

Sarcopenia is a multifactorial condition, with physical inactivity and insufficient protein intake contributing predominantly to its development (Fielding et al. 2011; Tieland et al. 2012; Marty et al. 2017; Cruz-Jentoft et al. 2018; Du et al. 2018). In recent years, several interventions aimed at preventing sarcopenia have been developed. They are often based on (a combination of) protein intake and physical activity (Liao et al. 2017; Hita-Contreras et al. 2018). However, those interventions are frequently tailored to the majority population, whereas the ethnic minorities are overlooked. Lifestyle factors, such as dietary intake and physical activity are expected to differ between ethnic minorities (Bos 2005). Limited data on protein intake across ethnic minorities in the Netherlands is available. One study reported the protein energy% of Moroccan women (~14.4%) and Surinam men (~16.5%) in the Netherlands. However, study populations were rather small ($N = 36$ and $N = 42$, respectively) (Erp-Baart et al. 2001). Therefore, we reported protein intake, and studied the prevalence of sarcopenia and its association with protein intake, taking into account age, sex and physical activity, in older participants of the HELIUS study, comprising the largest ethnic populations living in Amsterdam, the Netherlands.

Methods

Baseline data from the HELIUS (Healthy Life in an Urban Setting) study were used. Detailed information about the study design, aim and measurements can be found elsewhere (Stronks et al. 2013; Snijder et al. 2017). In short, HELIUS is a large cohort study, including the largest ethnic groups living in Amsterdam: Dutch, South-Asian Surinamese, African Surinamese, Turkish, Moroccan, and Ghanaian origin groups. The main aim of the HELIUS study is to elucidate the causes and consequences of the unequal burden of disease across these ethnic groups. Baseline data of the HELIUS study were collected between 2011 and 2015 among nearly 25,000 participants. People aged 18–70 years were randomly recruited, stratified by ethnic origin, through the municipality register of Amsterdam. Data were collected using a questionnaire, either self-administered or by interview performed by an ethnically matched, trained interviewer. Additionally, a physical examination, including anthropometry, bioelectrical impedance analysis (BIA) and handgrip strength measurements, was performed by a trained research assistant according to standardized protocols (Snijder et al. 2017). The HELIUS study has been approved by the Ethical Review Board of the Academic Medical Center Amsterdam. All participants provided written informed consent.

Study population

Among 22,165 HELIUS participants, both questionnaire and physical examination data were available. The current study is based on a subsample of participants aged 55 years and older ($N = 5523$). We excluded those of Javanese Surinamese ($nN= 63$), unknown/other Surinamese ($N = 104$), or unknown/other ethnic origin ($N = 19$), because of small numbers in these groups. In addition, participants without the descriptive data of sarcopenia (handgrip strength and/or BIA) were excluded ($N = 176$). Therefore, sarcopenia prevalence was assessed in a study population including 5161 participants (1495 Dutch, 846 South-Asian Surinamese, 1386 African Surinamese, 398 Turkish, 601 Moroccan and 435 Ghanaian participants).

A subsample of the HELIUS study (approximately 5000 participants) was asked to complete an additional Food Frequency Questionnaire (FFQ) to measure dietary intake (Beukers et al. 2015). So, to study the association of sarcopenia with protein intake, we included older participants who also filled in an FFQ ($N = 1430$). Ghanaian participants were not included in this dietary intake study. Participants with extreme values for total energy intake (for men <800 kcal or >4000 kcal per day; for women <500 kcal or >3500 kcal per day) were excluded ($N = 58$) (Willett 2013). Finally, one participant without data for physical activity (PA) ($N = 1$) was excluded, which resulted in a subsample of 1371 individuals (550 Dutch, 311 South-Asian Surinamese, 355 African Surinamese, 57 Turkish and 98 Moroccan origin participants) for associating protein intake and sarcopenia.

Measures and definitions

Ethnicity

Country of birth of participants and their parents were used to determine ethnicity (Stronks, Kulu-Glasgow, and Agyemang 2009). If one of the following criteria was met, a person was defined as of non-Dutch ethnic origin: (1) the participant was born outside the Netherlands and has at least one parent born outside the Netherlands (first generation), or (2) the participant was born in the Netherlands and both parents were born outside the Netherlands (second generation). After data collection, participants of Surinamese origin were further classified according to self-reported ethnic origin (by questionnaire) into 'South-Asian', 'African', 'Javanese' or 'other/unknown'. For the Dutch sample, people who were born in the Netherlands and whose parents were born in the Netherlands were invited (Snijder et al. 2017).

Sarcopenia

In this study, the revised sarcopenia definition of the European Working Group on Sarcopenia in Older People (EWGSOP2) was used. Low muscle strength (criterion 1) indicates probable sarcopenia. As a next step, low muscle quantity or quality (criterion 2) confirms the diagnosis. If low physical performance is present on top of low muscle mass and strength (criterion 3), severe sarcopenia is detected (Cruz-Jentoft et al. 2018). In this study, the focus is on indicating probable sarcopenia and sarcopenia diagnosis and therefore criterion 1 and 2 are taken into account.

Muscle strength – criterion 1

Muscle strength was assessed in Newton via maximal handgrip strength using a Citec handheld dynamometer (CIT Technics, Haren, the Netherlands). Participants were sitting up in a chair without armrests, hanging their arms loosely at their sides. They were asked to squeeze the handle of the handheld dynamometer as hard as possible. Each participant performed two measurements of both hands. The highest of these four measurements of strength (in Newton) was used in the analysis. The data were converted from Newton to kg by dividing by 9.81. The cut-points used for defining sarcopenia are <27 kg for men and <16 kg for women (Cruz-Jentoft et al. 2018).

Muscle quantity – criterion 2

Arm-to-leg bioelectrical impedance analysis (BIA) measured impedance, resistance, and reactance in Ohm at 50 Hz using a Bodystat 1500 analyzer (Bodystat Ltd, Isle of Man, UK). Participants were not allowed to consume any food or drink (also no water) from 10.00 pm the evening before the testing. Muscle mass was calculated using the formula by Janssen et al. (2000): Skeletal muscle mass (kg) = $[(\text{height}^2/\text{resistance} * 0.401) + (\text{sex} * 3.825) + (\text{age} * -0.071)] + 5.102$. Height was measured in cm, BIA resistance in ohms, men=1 and women=0 for sex, and age was measured in years. Skeletal muscle mass was normalized for height (muscle mass (kg)/height (m^2)), which resulted in the Skeletal Muscle Index (SMI) (Janssen et al. 2004).

The cut-points defined by EWGSOP2 for muscle mass are based on DXA data. The cut-points from EWGSOP definition (2010) were recently revised for the EWGSOP2 definition (2018) (M: <7.23 to <7.0 kg/m^2, F: <5.67 to <5.5 kg/m^2, respectively). Because the HELIUS study includes fat free mass measures based on BIA data, we used cut-points based on BIA data (M: <10.75 kg/m^2, F: <6.75 kg/m^2) and applied the same conversion factor to them (Janssen et al. 2004). The altered cut-points based on SMI used for defining moderate to high sarcopenia are <10.41 kg/m^2 for men and <6.55 kg/m^2 for women.

Anthropometric measures and educational level

Body weight, and height were measured in duplicate. The mean was used for analysis. A third measure was performed if the two measurements differed more than 0.5 kg (weight), or 0.5 cm (height). In that case, the two measurements closest together were averaged. Body Mass Index (BMI) was calculated as weight (kg)/height $(m)^2$.

Educational level was assessed as highest educational degree obtained in the Netherlands or in the country of origin. It was classified as 'Lower education' (never attended school, elementary schooling only, lower vocational schooling or lower secondary schooling), 'Intermediate education' (intermediate vocational schooling or intermediate/higher secondary schooling) or 'Higher education' (higher vocational schooling or university).

Lifestyle factors

Dietary intake was measured using ethnic specific semi-quantitative FFQs, specifically designed for the HELIUS study (Beukers et al. 2015). Data from the Food Composition Table 2011 were used to construct a nutrient database for each FFQ (Dutch Food Composition Table 2011). For ethnic specific foods the database was expanded with international data and new chemical analyses. The FFQs were used to collect information on portion size and frequency of approximately 220 food items eaten in the previous 4 weeks.

In HELIUS, data on physical activity were collected by the SQUASH questionnaire (Nicolaou et al. 2016). *Dutch Physical Activity norm (Dutch PA norm)* was used to assess physical activity (categorical variable: yes/no for meeting the norm). The Dutch PA norm was set at 30 minutes of moderate to high intensity exercise for at least 5 days per week (Kemper, Ooijendijk, and Stiggelbout 2000).

Statistical analyses

Characteristics of the study population were presented as means and standard deviations for continuous variables and percentages for categorical variables per ethnic group. Additionally, descriptives of sarcopenia were reported for men, women, and ethnic groups separately. Characteristics as well as sarcopenia descriptives of the subsample are presented in Appendix 1.

Protein intake was adjusted for energy intake *(Protein Energy %)* (Willett, Howe, and Kushi 1997). Logistic regression analysis was used to generate Odds Ratios (ORs) for the association between protein energy% (per 1 en% higher protein intake) and sarcopenia in the subsample and in separate strata for sex, ethnicity, PA norm and BMI. Sensitivity analyses included estimating Prevalence Ratios (PRs) from Cox regression. ORs were replaced by PRs from Cox regression, in case of ORs overestimating PRs. Follow-up time was set to one for all participants (Coutinho, Scazufca, and Menezes 2008). We adjusted for age, sex, PA, and ethnicity. All analyses were performed with SPSS version 23. A p-value <0.05 was considered statistically significant.

Results

Characteristics

The characteristics of the study population are presented per ethnic group in Table 1. The total study population consisted for 45% of men. Almost half of Dutch participants reported a high education (48.4%), whereas most of Moroccan participants reported a low education (85.0%). Mean BMI ranged from 26.2 kg/m^2 in Dutch up to 31.5 kg/m^2 in Turkish participants. The characteristics of the subsample and the study population

Table 1. Characteristics of the study population ($N = 5161$) per ethnic group and food-related data in subsample ($N = 1371$) per ethnic group.

	Dutch mean ± SD, N (%)	South-Asian Surinamese mean ± SD, N (%)	African Surinamese mean ± SD, N (%)	Turkish mean ± SD, N (%)	Moroccan mean ± SD, N (%)	Ghanaian mean ± SD, N (%)
N = 5161	*1495 (29.0%)*	*846 (16.4%)*	*1386 (26.9%)*	*398 (7.7%)*	*601 (11.6%)*	*435 (8.4%)*
Mean age (years)	61.8 ± 4.3	60.7 ± 4.3	60.5 ± 4.1	59.6 ± 4.1	60.3 ± 4.2	58.2 ± 3.1
Sex (men)	724 (48.4%)	364 (43.0%)	568 (41.0%)	191 (48.0%)	266 (44.3%)	239 (54.9%)
Education* – Lower	468 (31.3%)	584 (69.0%)	762 (55.0%)	322 (80.9%)	511 (85.0%)	302 (69.4%)
Intermediate	287 (19.2%)	124 (14.7%)	339 (24.5%)	41 (10.3%)	68 (11.3%)	106 (24.4%)
Higher	724 (48.4%)	131 (15.5%)	271 (19.6%)	29 (7.3%)	17 (2.8%)	17 (3.9%)
Mean BMI (kg/m^2)	26.2 ± 4.4	27.4 ± 4.5	28.6 ± 5.6	31.5 ± 5.8	30.1 ± 5.2	29.2 ± 5.0
Mean height (cm)	173 ± 10	162 ± 9	167 ± 9	161 ± 9	164 ± 9	166 ± 8
Mean weight (kg)	78.7 ± 15.0	71.5 ± 12.8	80.0 ± 15.8	81.4 ± 14.2	80.6 ± 13.7	80.0 ± 13.5
Current smoking	315 (21.1%)	206 (24.3%)	394 (28.4%)	85 (21.4%)	49 (8.2%)	32 (7.4%)
Dutch PA norm§	1232 (82.4%)	574 (67.8%)	1004 (72.4%)	238 (59.8%)	397 (66.1%)	30 (70.8%)
Mean energy intake (kcal/day)	2110 ± 585	1913 ± 671	1932 ± 707	2258 ± 677	2020 ± 783	n.a.†
Mean protein intake (g/kg BW/d)	1.05 ± 0.32	1.15 ± 0.49	1.03 ± 0.44	1.28 ± 0.44	1.12 ± 0.53	n.a.†
Mean proteinEN%	15.4 ± 2.6	16.7 ± 3.4	16.7 ± 3.6	17.7 ± 3.6	17.3 ± 3.0	n.a.†
Mean animal proteinEN%	9.2 ± 2.9	9.5 ± 4.0	10.1 ± 4.0	10.6 ± 4.1	9.5 ± 3.6	n.a.†
Mean plant proteinEN%	6.3 ± 1.4	7.2 ± 1.6	6.6 ± 1.7	7.0 ± 1.7	7.8 ± 1.8	n.a.†

BMI = Body Mass Index.

* Education: Highest obtained educational degree: 'Lower' (never been to school or elementary schooling only, lower vocational schooling or lower secondary schooling), 'Intermediate' (intermediate vocational schooling or intermediate/higher secondary schooling) or 'Higher' (higher vocational schooling or university). Education unknown: $N = 58$ (data not shown).

§ Dutch PA norm: performing moderate or high intensity activities lasting at least 30 minutes, for a minimum of 5 days a week.

† FFQ data were not available for Ghanaian participants.

are comparable, except for the Turkish participants, due to small numbers in this group ($N = 57$) (Appendix 1). Among those who filled out the FFQ, mean protein intake also varied among ethnic groups. The lowest mean protein intake (g/kg BW/day) was reported by African Surinamese (1.03 ± 0.44), whereas Turkish participants reported the highest (1.28 ± 0.44).

Descriptives of sarcopenia and associated measures

Descriptives of sarcopenia and associated measures are presented by ethnicity for men and women separately (Table 2). Mean maximum handgrip strength varied among ethnic groups and was found to be lower in women compared to men in all ethnic groups. For both sexes, the highest handgrip strength was found in the Dutch and African Surinamese groups. Mean Skeletal Muscle Index (SMI) was highest in Turkish women (8.5 ± 1.1 kg/m^2) and men (10.8 ± 1.2 kg/m^2) compared to other ethnic groups. Probable sarcopenia rates were comparable between men and women in the same ethnic group but differed between ethnic groups (lowest rates in Dutch, highest in South-Asian Surinamese group). Sarcopenia prevalence (diagnosis) was found to be lower in women (ranging from 2.4% in Turkish up to 30.5% in South-Asian Surinamese) compared to men (ranging from 29.8% in Turkish up to 61.3% in South-Asian Surinamese). Descriptives of sarcopenia and associated measures are reported for the subsample separately (Appendix 2). Results are

Table 2. Descriptives of sarcopenia and associated measures per ethnic group for men and women in the study population ($N = 5161$).

Men	Dutch mean ± SD, N (%)	South-Asian Surinamese mean ± SD, N (%)	African Surinamese mean ± SD, N (%)	Turkish mean ± SD, N (%)	Moroccan mean ± SD, N (%)	Ghanaian mean ± SD, N (%)
N = 2353	*724 (30.8%)*	*364 (15.5%)*	*568 (24.1%)*	*191 (8.1%)*	*266 (11.3%)*	*239 (10.2%)*
Mean HGS (kg)	28.2 ± 6.8	22.5 ± 5.8	26.8 ± 7.1	24.3 ± 6.0	25.2 ± 7.0	23.1 ± 6.2
Sarcopenia (probable)*	331 (45.7%)	289 (79.4%)	314 (55.3%)	172 (72.0%)	133 (69.6%)	161 (60.5%)
Mean SMI (kg/m^2)	10.1 ± 1.3	9.7 ± 1.3	10.2 ± 2.2	10.8 ± 1.2	10.3 ± 1.1	10.2 ± 2.2
Sarcopenia (diagnosis)§	228 (31.5%)	223 (61.3%)	218 (38.4%)	57 (29.8%)	101 (38.0%)	103 (43.1%)
Women						
N = 2810	*771 (27.4%)*	*482 (17.2%)*	*818 (29.1%)*	*207 (7.4%)*	*335 (11.9%)*	*196 (7.0%)*
Mean HGS (kg)	16.6 ± 4.4	12.9 ± 3.5	16.0 ± 4.7	13.3 ± 4.4	13.8 ± 4.2	14.2 ± 4.2
Sarcopenia (probable)†	360 (46.7%)	396 (82.2%)	418 (51.1%)	136 (69.4%)	151 (72.9%)	234 (69.9%)
Mean SMI (kg/m^2)	7.5 ± 0.9	7.1 ± 1.5	7.8 ± 1.3	8.5 ± 1.1	8.1 ± 1.1	7.9 ± 1.0
Sarcopenia (diagnosis)‡	59 (7.7%)	147 (30.5%)	56 (6.8%)	5 (2.4%)	19 (5.7%)	8 (4.1%)

HGS = maximal handgrip strength, SMI = Skeletal Muscle Index (skeletal muscle mass divided by height^2).
* Sarcopenia probable men, based on following criterion: HGS<27 kg.
§ Sarcopenia diagnosis men, based on following criteria: HGS<27 kg and SMI<10.41 kg/m^2.
† Sarcopenia probable women, based on following criterion: HGS<16 kg.
‡ Sarcopenia diagnosis women, based on following criteria: HGS<16 kg and SMI<6.55 kg/m^2.

comparable to the total study population, except for Turkish participants, likely due to a low number of participants in this subsample.

Association between protein intake and sarcopenia

The first model shows that a higher protein energy% was non-significantly associated with a 0.98 (95%-CI: 0.94–1.02) lower odds of sarcopenia in the subsample population, adjusted for age and sex (Table 3, model 1). Further adjustment for ethnicity and PA norm emphasized this statistically significant association: OR: 0.96 (95%-CI: 0.92–0.99) (model 2 and 3).

A similar association between protein energy% and sarcopenia was found for men and women, adjusted for age, ethnicity and PA norm (men: OR: 0.95, 95%-CI: 0.90–1.01;

Table 3. Association between protein energy% and sarcopenia in the subsample and within ethnic groups.

Population	N =	Model	Odds Ratio	95%-CI
Total subsample	*1371*	**Model 1**: protein energy %, age, sex	0.98	0.94–1.02
	1371	**Model 2**: model 1+ ethnicity	0.96	0.92–0.99
	1371	**Model 3**: model 2+ PA norm§	0.96	0.92–0.99
By ethnic group	*550*	**Model 4**: model 3 in Dutch	0.94	0.87–1.03
	311	**Model 5**: model 3 in South-Asian Surinamese	0.92	0.85–0.99
	355	**Model 6**: model 3 in African Surinamese	1.00	0.92–1.09
	57	**Model 7**: model 3 in Turkish	1.06	0.87–1.29
	98	**Model 8**: model 3 in Moroccan	0.96	0.82–1.12

CI = Confidence Interval.
Sarcopenia based on following criteria; for men: HGS<27 kg and SMI<10.41 kg/m^2; for women: HGS<16 kg and SMI<6.55 kg/m^2.
§ Dutch PA norm: performing moderate or high intensity activities lasting at least 30 minutes, for a minimum of 5 days a week.

women: OR: 0.96, 95%-CI: 0.90–1.04). We found comparable associations across ethnic groups, albeit only statistically significant in the South-Asian Surinamese group (model 5, OR: 0.92, 95%-CI: 0.85–0.99), and a minor deviating result in the Turkish participants. Sensitivity analyses showed that ORs from logistic regression were comparable to PRs from Cox regression, suggesting that ORs did not overestimate the PRs. Chronic disease (self-reported history (or presence) of diabetes, myocardial infarction, or stroke) did not affect the association under study.

Stratification by reaching the PA norm showed that a higher protein energy% was associated with a 13% lower odds of sarcopenia for participants who did not reach the PA norm, compared to a 2% lower odds for those who did reach the PA norm (OR: 0.87, 95%-CI: 0.79–0.96, OR: 0.98, 95%-CI 0.93–1.03, respectively). No such difference was found for BMI strata (data not shown).

Discussion

To our knowledge, this is the first study on sarcopenia prevalence and its association with protein intake in different ethnic groups of older age in the Netherlands. Prevalence rates were highest for South-Asian Surinamese men, and lowest for Turkish women. In the total subsample, a higher protein energy% was significantly associated with a 4% lower odds of sarcopenia. A comparable association was found when studying separate strata for sex and ethnicity.

Data from the HELIUS study were used for this study. The overall response rate was relatively low (28%), which could have led to selection bias. However, Snijder et al. (2017) compared participants and non-participants of the HELIUS study. Women were slightly more likely to participate than men, and those who participated were slightly older than those who refused to participate. Finally, socio-economic indicators were slightly more favorable among participants as compared with non-participants. However, these differences were relatively small, particularly when compared to differences across the ethnic groups. Furthermore, large numbers of each ethnic group in which all socio-economic levels are represented were included, which suggests that selection bias is probably limited (Snijder et al. 2017).

In this study, the EWGSOP2 definition of sarcopenia was used, which consists of three criteria. The first step is measuring handgrip strength to assess muscle strength (Cruz-Jentoft et al. 2018). EWGSOP2's cut-points for grip strength are based on a reference population from the UK (Dodds et al. 2014). Grip strength measures in our study population were slightly lower compared to the reference population from the same age group, which might reflect true differences or differences in dynamometers used (respectively Citec vs. Jamar, Smedley, Nottingham, Takei) (Guerra and Amaral 2009). Though this might affect prevalence rates, it does not affect the comparison of handgrip strength across the ethnic groups in our study population.

The second step is assessing skeletal muscle mass using BIA. The skeletal muscle mass related cut-points used in our study were defined by Janssen and colleagues (Janssen et al. 2004) and were adjusted according to the latest cut-points defined by EWGSOP2. The adjusted cut-points resulted in a 4.5% lower sarcopenia prevalence in the total population as compared to using the original cut-points formulated by Janssen et al. Furthermore, several factors related to BIA could have influenced muscle mass estimates. First of all, the BIA device used in this study was not similar to the device used by Janssen and colleagues to derive the BIA equation (Janssen et al. 2000). Since technical aspects of the two devices were comparable, only small fluctuations in measurements due to different brands of BIA device were expected (Khalil, Mohktar, and Ibrahim 2014; Brantlov et al. 2017; Sergi et al. 2017). Secondly, different BIA equations can result in dissimilar muscle mass estimates. For this reason we compared the equation of Janssen et al. to a commonly used BIA equation of Kyle et al. (Kyle et al. 2001). The BIA equations of Janssen et al. and Kyle et al. resulted in comparable SMM (mean ± SD: 24.8 ± 6.5, 25.0 ± 4.7, respectively) and therefore the type of equation might result in only small differences in sarcopenia prevalence. Thirdly, BIA equations are particularly valid for the populations in which they have been derived (Buckinx et al. 2018; Cruz-Jentoft et al. 2018). The BIA equation we used (Janssen et al. 2000) was cross-validated in a heterogeneous population (multi-ethnic, age 18–86 years, BMI 16–48 kg/m^2) and found to be suitable for Hispanics and African-Americans, but underestimated skeletal muscle mass in Asians (Janssen et al. 2000). This may partly explain the high number of sarcopenia cases in the South-Asian Surinamese population in our study.

We found a higher prevalence of sarcopenia in men as compared to women. A recent meta-analysis reported comparable results, in both European and non-European populations (Mayhew et al. 2019). In our study, also variations in sarcopenia prevalence between ethnic groups were apparent. This may be related to differences in body composition, which is known to differ between ethnic groups (Wagner and Heyward 2000; Silva et al. 2010). More specifically, Black adults were found to have a relatively higher muscle mass (leading to a lower sarcopenia prevalence) compared to Whites and Asians. In our study, Black participants (African Surinamese and Ghanaian) had lower sarcopenia prevalence compared to Asian participants as well, but not compared to the other ethnic groups (Deurenberg, Yap, and Van Staveren 1998; Wagner and Heyward 2000; Silva et al. 2010; Heymsfield et al. 2016; Shaw, Dennison, and Cooper 2017).

In most ethnic groups, sarcopenia prevalence was between 2.4% and 7.7% in women and between 29.8% and 43.1% in men, comparable to literature (Abellan Van Kan 2009; Cruz-Jentoft et al. 2014). Notably higher prevalence rates were found for the South-Asian Surinamese group (30.5% in women; 61.3% in men). First of all, this might be related to the aforementioned underestimation of skeletal muscle mass in this group. Secondly, it might be due to high prevalence of diseases in South-Asians (i.e. type 2 diabetes 19%, hypertension 42%), which is known to affect muscle mass (Anujuo et al. 2017; Snijder et al. 2017; Du et al. 2018). Thirdly, the high sarcopenia prevalence in this group might be related to sarcopenia cut-points. The Asian Working Group for Sarcopenia (AWGS) described cut-points for the Asian population, because their body size, lifestyle and cultural background differ from that of the Caucasian population (Chen et al. 2014). Sarcopenia prevalence rates in Asian populations were found to be higher when using EWGSOP2 compared to AWGS criteria (men: 13.8% vs. 6.4%, women: 12.4% vs. 11.5%, respectively) (Chen et al. 2016). However, currently available Asian studies on sarcopenia prevalence were mainly performed in Eastern Asia and therefore more studies on this topic should be performed in other parts of Asia. In addition, due to the wide variety of ethnicities in Asia, ethnic-specific sarcopenia cut-points might be needed (Chen et al. 2014). Altogether, the underestimated skeletal muscle mass, high prevalence of diseases and use of EWGSOP2 sarcopenia cut-points might contribute to the high sarcopenia prevalence in our South-Asian participants.

Furthermore, lifestyle behaviors such as dietary protein and physical activity may contribute to the variation in sarcopenia, since these are evident causes underlying sarcopenia (Fielding et al. 2011; Tieland et al. 2012; Layne et al. 2017; Marty et al. 2017; Cruz-Jentoft et al. 2018; Du et al. 2018). Associations between protein energy% and sarcopenia were found in the total subsample (OR: 0.96, 95%-CI: 0.92-0.99), indicating that a higher protein energy% was associated with a 4% lower odds of sarcopenia. Observational studies have shown similar positive associations of dietary protein intake with muscle mass and strength (Houston et al. 2008; Meng et al. 2009; Radavelli-Bagatini et al. 2013; Sahni et al. 2015; Huang et al. 2016; Mangano et al. 2017). Studying the ethnic groups separately resulted in comparable, relatively small, associations between protein intake and sarcopenia, most obvious in South-Asian Surinamese participants. A recent review showed that protein intake is rather low in older Asian populations (Ong et al. 2019), emphasizing the importance of increasing their protein intake in order to contribute to counteracting sarcopenia.

In conclusion, the prevalence of sarcopenia varied in older adults across ethnic groups, with the lowest prevalence in the Turkish group and the highest prevalence in South-Asian Surinamese, in both men and women. Besides, the association between protein intake and sarcopenia was mostly comparable across ethnic minorities and consistent with the literature. Therefore, the varying levels of sarcopenia prevalence calls for a targeted approach for specific ethnic groups in case of sarcopenia-related prevention or treatment strategies. Ethnic-specific interventions could be aimed at increasing protein intake. In order to be effective, ethnic-specific interventions should be implemented in conversation with the target group, family values should be incorporated, the adaptations should imply a high intensity of the intervention, and adaptations should be implemented as a package of adaptations (Nicolaou et al. 2009; Nierkens et al. 2013). More research is needed to study the protein intake in relation to physical activity and sarcopenia in ethnic minorities.

Acknowledgements

The HELIUS study is conducted by the Academic Medical Center Amsterdam and the Public Health Service of Amsterdam. Both organizations provided core support for HELIUS. The HELIUS study is also funded by the Dutch Heart Foundation, the Netherlands Organization for Health Research and Development (ZonMw), the European Union (FP-7), and the European Fund for the Integration of non-EU immigrants (EIF). We gratefully acknowledge the participants of the HELIUS study and the management team, research nurses, interviewers, research assistants and other staff who have taken part in gathering the data of this study.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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Appendices

Appendix 1

Table A1. Characteristics of the subsample per ethnic group ($N = 1371$).

	Dutch mean ± SD, N (%)	South-Asian Surinamese mean ± SD, N (%)	African Surinamese mean ± SD, N (%)	Turkish mean ± SD, N (%)	Moroccan mean ± SD, N (%)
N = 1371	*550 (40.1%)*	*311 (22.7%)*	*355 (25.9%)*	*57 (4.2%)*	*98 (7.1%)*
Mean age (years)	61.6 ± 4.1	60.4 ± 4.1	60.1 ± 3.9	58.8 ± 3.4	60.0 ± 4.3
Sex (men)	724 (48.4%)	364 (43.0%)	569 (41.0%)	191 (48.0%)	266 (44.3%)
Education* Lower	156 (28.4%)	197 (63.3%)	163 (45.9%)	36 (63.2%)	69 (70.4%)
Intermediate	119 (21.6%)	53 (17.0%)	89 (25.1%)	12 (21.1%)	22 (22.4%)
Higher	272 (49.5%)	58 (18.6%)	102 (28.7%)	8 (14.0%)	7 (7.1%)
Mean BMI (kg/m^2)	26.1 ± 4.2	27.2 ± 4.3	28.8 ± 5.6	29.9 ± 5.1	29.6 ± 4.9
Mean height (cm)	173 ± 10	162 ± 9	167 ± 9	163 ± 8	164 ± 9
Mean weight (kg)	78.3 ± 14.7	71.3 ± 12.4	80.0 ± 15.5	78.5 ± 11.2	79.8 ± 14.5
Current smoking	111 (20.2%)	61 (19.6%)	72 (20.3%)	11 (19.3%)	9 (9.2%)
Dutch PA norm§	456 (82.9%)	216 (69.5%)	266 (74.9%)	35 (61.4%)	69 (70.4%)
Mean energy intake (kcal/day)	2110 ± 585	1913 ± 671	1932 ± 707	2258 ± 677	2020 ± 783
Mean protein intake (g/kg BW/d)	1.05 ± 0.32	1.15 ± 0.49	1.03 ± 0.44	1.28 ± 0.44	1.12 ± 0.53
Mean protein EN%	15.4 ± 2.6	16.7 ± 3.4	16.7 ± 3.6	17.7 ± 3.6	17.3 ± 3.0
Mean animal protein EN%	9.2 ± 2.9	9.5 ± 4.0	10.1 ± 4.0	10.6 ± 4.1	9.5 ± 3.6
Mean plant protein EN%	6.3 ± 1.4	7.2 ± 1.6	6.6 ± 1.7	7.0 ± 1.7	7.8 ± 1.8

BMI = Body Mass Index.
* Education: Highest obtained educational degree: 'Lower' (never been to school or elementary schooling only, lower vocational schooling or lower secondary schooling), 'Intermediate' (intermediate vocational schooling or intermediate/higher secondary schooling) or 'Higher' (higher vocational schooling or university). Education unknown: $N = 8$ (data not shown).
§ Dutch PA norm: performing moderate or high intensity activities lasting at least 30 minutes, for a minimum of 5 days a week.

Appendix 2

Table A2. Descriptives of sarcopenia and associated measures per ethnic group for men and women in the subsample ($N = 1371$).

Men	Dutch mean ± SD, N (%)	South-Asian Surinamese mean ± SD, N (%)	African Surinamese mean ± SD, N (%)	Turkish mean ± SD, N (%)	Moroccan mean ± SD, N (%)
N = 618	*268 (43.4%)*	*135 (21.8%)*	*135 (21.8%)*	*30 (4.9%)*	*50 (8.1%)*
Mean HGS (kg)	27.2 ± 6.1	22.5 ± 6.1	26.1 ± 6.2	22.7 ± 6.4	24.9 ± 5.6
Sarcopenia (probable)*	139 (51.9%)	103 (76.3%)	78 (57.8%)	24 (80.0%)	31 (62.0%)
Mean SMI (kg/m^2)	10.0 ± 1.1	9.7 ± 1.0	10.7 ± 4.0	10.4 ± 1.0	10.3 ± 1.0
Sarcopenia (diagnosis)§	92 (34.3%)	84 (62.2%)	55 (40.7%)	14 (46.7%)	19 (38.0%)
Women					
N = 753	*282 (37.5%)*	*176 (23.4%)*	*220 (29.2%)*	*27 (3.6%)*	*48 (6.4%)*
Mean HGS (kg)	15.9 ± 4.0	12.8 ± 3.3	15.7 ± 4.0	13.8 ± 3.5	14.1 ± 3.6
Sarcopenia (probable)†	153 (54.3%)	146 (83.0%)	118 (53.6%)	21 (77.8%)	33 (68.8%)
Mean SMI (kg/m^2)	7.4 ± 0.8	7.0 ± 0.9	7.9 ± 1.4	8.2 ± 1.0	8.0 ± 1.1
Sarcopenia (diagnosis)‡	28 (9.9%)	49 (27.8%)	14 (6.4%)	0 (0.0%)	4 (8.3%)

HGS = maximal handgrip strength, SMI = Skeletal Muscle Index (skeletal muscle mass divided by height^2).
* Sarcopenia probable men, based on following criterion: HGS<27 kg.
§ Sarcopenia diagnosis men, based on following criteria: HGS<27 kg and SMI<10.41 kg/m^2.
† Sarcopenia probable women, based on following criterion: HGS<16 kg.
‡ Sarcopenia diagnosis women, based on following criteria: HGS<16 kg and SMI<6.55 kg/m^2.