

Dysfunction in Olfactory Identification and Physical Function Decline in Older Adults

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IMPORTANCE Few longitudinal studies have examined the association of olfactory dysfunction with future decline in physical function.

OBJECTIVE To examine cross-sectional and longitudinal associations between olfaction and physical function among older adults (age ≥ 65 years).

DESIGN, SETTING, AND PARTICIPANTS This cohort study used data from the Atherosclerosis Risk in Communities (ARIC) study, a prospective cohort study that enrolled 15 792 adults aged 45 to 64 years from 4 US communities. In the present study, we used data from visits 5 (2011-2013), 6 (2016-2017), and 7 (2018-2019). Data were analyzed July 16, 2025.

EXPOSURE Olfaction was measured using the 12-item Sniffin' Sticks Odor Identification Test (total score range, 0-12) at visit 5 and categorized as good (11-12 [reference]), moderate (9-10), and poor (0-8).

MAIN OUTCOMES AND MEASURES Physical function was assessed using the Short Physical Performance Battery (SPPB) overall score (range, 0-12); SPPB subscale scores (range, 0-4) for balance, 4-m usual pace walk, and chair stand; and gait speed at visits 5 (baseline), 6, and 7. Grip strength was assessed at visits 5 and 7.

RESULTS In the analytic sample of 5474 participants (mean [SD] age, 75.3 [5.0] years; 3163 [57.8%] female), the estimated mean difference in total SPPB scores was -0.14 (95% CI, -0.28 to -0.01) among those with moderate vs good olfaction and -0.49 (95% CI, -0.63 to -0.35) among those with poor vs good olfaction. In longitudinal analyses, compared with participants with good olfaction, the estimated mean annual difference in SPPB score was -0.05 (95% CI, 0.08 to -0.02) among those with moderate olfaction and -0.11 (95% CI, -0.14 to -0.08) among those with poor olfaction. Consistent trends were observed across SPPB subscales (eg, balance score: estimated mean difference in poor vs good olfaction, -0.18 [95% CI, -0.02 to -0.12]), gait speed (-0.06 [95% CI, -0.07 to -0.04] m/s), and grip strength (-1.50 [95% CI, -1.98 to -1.01] kg).

CONCLUSIONS AND RELEVANCE In this cohort study, poor olfaction in older adults was associated with a decline in physical functioning. These findings may have clinical implications for identifying older adults at elevated risk. Future research should investigate biologic mechanisms linking olfactory dysfunction with functional aging.

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The sense of smell plays an important role in well-being, quality of life, nutrition, and safety.¹ Olfactory loss is common among older adults, with more than 40% of US adults older than 65 years experiencing some degree of olfactory dysfunction. The prevalence of poor olfaction increases with age.²⁻⁴ Olfaction is a multifaceted process that involves both sensory and cognitive processing.⁵ Age-related olfactory decline may reflect structural and functional changes in the olfactory epithelium, olfactory bulb, or multiple olfactory cortical regions, such as the anterior olfactory nucleus, piriform cortex, and entorhinal cortex.⁵⁻⁷

Poor olfactory function has been established as an early marker of neurodegenerative diseases, such as Alzheimer disease, and is associated with increased mortality.^{5,8} Emerging evidence links olfactory dysfunction to a wide range of other age-related chronic conditions, including diabetes, kidney dysfunction, pneumonia, and cardiovascular diseases.^{3,4,9-13} These potentially broad associations raise the possibility that poor olfaction is a marker of accelerated biologic aging.^{14,15}

Decline in physical functioning, manifested by limited mobility, frailty, and loss of independence, is a hallmark of aging.^{16,17} If poor olfaction reflects systemic aging processes,¹⁵ it may serve as a sentinel preclinical marker of physical function decline. Several US-based cross-sectional and longitudinal studies have demonstrated that among older adults, olfactory impairment is associated with reduced mobility, balance, fine motor function, and manual dexterity as well as increased risk of frailty.¹⁸⁻²⁰ However, 2 studies in older Japanese adults did not find significant associations between olfaction and physical performance.^{21,22} Limited longitudinal studies to date have shown that poor olfaction is associated with faster physical function decline and increased risk of frailty in older adults.^{8,23-26} Most of these studies were from the Health, Aging, and Body Composition (Health ABC) study,²³⁻²⁵ which included well-functioning participants aged 70 to 80 years at enrollment. We performed both cross-sectional and longitudinal analyses to assess whether there were associations between olfaction and physical function among older adults with wider age and physical function representation in the Atherosclerosis Risk in Communities (ARIC) study.

Methods

Study Population

This cohort study used data from the prospective ARIC study, which was designed to investigate cardiovascular disease etiology and risk factors. Detailed information on ARIC study design and cohort characteristics has been described elsewhere.²⁷ In brief, from 1987 to 1989, the ARIC study enrolled 15 792 adults aged 45 to 64 years from 4 US communities: Forsyth County, North Carolina; Jackson, Mississippi; northwestern suburbs of Minneapolis, Minnesota; and Washington County, Maryland. Participants were followed up through multiple in-person clinic visits, annual (semiannual since 2012) telephone interviews, and surveillance of hospitalizations. For the present analysis, we used data from visits

Key Points

Question Is poor olfaction associated with poor physical functioning in older adults?

Findings In this cohort study of 5474 older adults (age ≥ 65 years), poor vs good olfaction was associated with worse lower-extremity muscle strength, balance, gait speed, and grip strength and faster annual declines in those physical functions.

Meaning Poor olfaction may be associated with poor physical functioning in older adults.

5 (2011-2013), 6 (2016-2017), and 7 (2018-2019). Olfaction was assessed during visit 5; the Short Physical Performance Battery (SPPB) was administered during visits 5, 6, and 7; and grip strength was assessed during visits 5 and 7. This study was approved by the Johns Hopkins Medicine institutional review board, serving as the single institutional review board for this study. All participants provided written informed consent. This study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guideline.

Exposure Measure

Olfaction was assessed at visit 5 using the 12-item Sniffin' Sticks Odor Identification Test.²⁸ Participants were asked to smell 12 common odorants from odor-embedded pens and identify the correct odor from 4 choices presented in a multiple-choice format. One point was awarded for each correct identification, resulting in a total score ranging from 0 to 12. The olfaction score was categorized into 3 levels, consistent with the cut points used in previous studies²⁶: good (11-12), moderate (9-10), and poor (0-8).

Outcome Measure

The SPPB is a tool to evaluate lower-extremity function in older adults and consists of 3 timed components: balance, 4-m usual pace walk, and chair stand.²⁹ The balance test evaluates individuals' ability to maintain standing posture for 10 seconds with 3 different feet positions: side-by-side, semi-tandem, and full tandem. The 4-m walk measures the individual's usual walking speed with or without assistive devices, and the faster record of 2 trials was used. The chair stand test measures time to complete 5 consecutive chair stand-ups and sitting down with arms crossed over the chest. The detailed procedure and scoring mechanism for each test are described elsewhere.³⁰ A score of 0 was assigned to any task if the participant was physically unable to complete it or it was unsafe to do so. Each subscale was scored from 0 to 4 and summed to create the total SPPB score ranging from 0 to 12, with a higher score indicating better physical function.³⁰ A score over 2 for each SPPB subscale and a score over 6 for total SPPB denoted good physical function.^{31,32}

Continuous gait speed (meters per second), measured in the 4-m usual pace walk test, was an additional indicator of lower-extremity function. A gait speed of 0.8 m/s and above was defined as fair or good, and slower than 0.8 m/s was defined as poor.³³ Grip strength, an indicator of upper-extremity muscle strength, was assessed using a handheld

dynamometer to measure the maximum force in kilograms exerted by the participants' preferred hand.³⁴ Grip strength was assessed twice per visit approximately 15 to 20 seconds apart, and the higher of the 2 measurements was used in our analysis. Grip strength was recorded in kilograms, with a higher value indicating stronger upper-extremity muscle strength. We defined grip strength (kilograms) as high vs low using the cutoffs of sex and body mass index (BMI; calculated as weight in kilograms divided by height in meters squared) proposed by Fried et al³⁵ (men: 29 kg for BMI \leq 24; 30 kg for BMI >24 to 28; and 32 kg for BMI >28; women: 17 kg for BMI \leq 23; 17.3 kg for BMI >2 to 26; 18 kg for BMI >26 to 29; and 21 kg for BMI >29). Although grip strength cutoffs are usually considered in the context of sex, absolute grip strength is also influenced by body size.³⁶ Studies have found an improved fit to normative data with the addition of BMI, and BMI-specific thresholds may better reflect relative muscle weakness rather than absolute strength to reduce the impact of body composition variability on muscle strength.³⁶⁻³⁸

Baseline Covariates

We used a directed acyclic graph to identify potential confounders based on previous literature and knowledge.²⁴ Covariates assessed at visit 1 included sex, self-reported race (Black, White), field center, and educational level (operationalized as completed high school or higher education vs less than high school). Given that the racial composition differs markedly by ARIC field center, we created a combined race and center variable with 5 categories: Black race in Mississippi and North Carolina and White race in North Carolina (reference), Minnesota, and Maryland. Only Black and White participants were included in the analysis because of small sample sizes of other racial and ethnic groups. Covariates assessed at visit 5 included age, smoking (ever vs never), alcohol consumption (ever vs never), BMI (modeled using linear spline with knots at 25 and 30, as those are cut points for overweight and obesity, respectively),³⁹ systolic and diastolic blood pressure, total and high-density lipoprotein cholesterol levels, and prevalent chronic conditions, including diabetes, hypertension, coronary heart disease, stroke, heart failure, any cancer, and dementia.

Statistical Analysis

Baseline characteristics were summarized using means and SDs for continuous variables and proportions for categorical variables. We used multiple imputation by chained equations⁴⁰ with 5 imputations to account for missing covariates in all regression models.

For cross-sectional analyses of olfaction and physical function at visit 5, we conducted linear regression models using generalized linear models with good olfaction as the reference. We fitted 3 nested models, sequentially adjusting for 3 sets of potential confounders: model 1 adjusted only for age and age squared, model 2 additionally adjusted for demographics (sex, educational level, and race and center), and model 3 further adjusted for behavioral factors (smoking, alcohol consumption), metabolic indicators (BMI, systolic and diastolic blood pressure, and total and high-density lipoprotein cholesterol lev-

els), and chronic conditions (prevalence of diabetes, hypertension, coronary heart disease, stroke, heart failure, and cancer). We used linear regression coefficients with 95% CIs to quantify mean differences in physical function between moderate or poor olfaction vs good olfaction. To compare the magnitude of associations across different physical function outcomes, we *z* standardized all outcome variables and repeated the aforementioned analyses. We additionally fitted logistic regression models and reported odds ratios using dichotomized outcome measures.

For longitudinal analyses of olfaction and changes in physical function, we fitted linear mixed-effects models using information on physical function outcomes at visits 5, 6, and 7 (with the exception of grip strength, which was assessed only at visits 5 and 7). Visit 5 was considered the baseline in the longitudinal analysis. To account for potential biases from informative missingness and attrition from visit 5 to visits 6 and 7 due to death or nonparticipation, we used stabilized inverse probability of censoring weights⁴¹ derived from logistic regression models adjusted for age, age squared, demographics, behavioral and metabolic risk factors, and chronic conditions. Time was calculated as the number of days from visit 5 (baseline) to visits 6 and 7 divided by 365.25. We modeled olfaction as a categorical variable, comparing moderate and poor olfaction groups with the good olfaction group. In the models, the main effect size term for olfaction groups quantified baseline mean differences in physical function, and the interaction term between olfaction and time estimated the mean differences in annual rate of decline in physical function. In exploratory analyses, we examined olfaction score as a continuous variable. Physical function outcomes were *z* standardized, and the olfaction score was modeled using a cubic spline function to capture potential nonlinearity in the relationship with knots at 6, 8, and 10, which constitute cut points for anosmia, hyposmia, and moderate olfaction, respectively.⁴² We estimated the annual rate of decline in standardized physical function across the range of olfaction scores to evaluate a potential dose-response relationship. This approach preserves information, improves statistical efficiency, and allows visualization of potential nonlinear associations that cannot be captured using categorical exposures alone.

In sensitivity analyses, we repeated all cross-sectional and longitudinal models among participants without dementia or Parkinson disease at visit 5. We also conducted subgroup analyses stratified by age (\geq 75 and <75 years; based on the median baseline age), sex, and race. Furthermore, we performed an analysis among participants who had another olfaction assessment at visit 6 that additionally controlled for olfaction change from visit 5 to visit 6. We conducted all analyses using SAS, version 9.4 (SAS Institute Inc) and used R, version 4.4.2 (R Foundation for Statistical Computing) to construct plots. Data were analyzed July 16, 2025.

Results

Of 6538 participants attending visit 5 of the ARIC study, we excluded 465 with missing olfaction assessment, 565 with miss-

Table 1. Descriptive Statistics of Baseline Covariates in Older Adults by Olfaction Function

Characteristic	Participants ^a			
	Total (N = 5474)	Olfaction		
		Good (n = 2058)	Moderate (n = 1840)	Poor (n = 1576)
Age, mean (SD), y	75.3 (5.04)	74.5 (4.76)	75.2 (4.9)	76.6 (5.3)
Completed high school or higher education				
Total	4741 (86.6)	1883 (91.7)	1596 (86.8)	1262 (80.3)
Missing, No.	9	4	1	4
Sex				
Female	3163 (57.8)	1354 (65.8)	1051 (57.1)	758 (48.1)
Male	2311 (42.2)	704 (34.2)	789 (42.9)	818 (51.9)
Race				
Black	1172 (21.4)	229 (11.1)	403 (21.9)	540 (34.3)
White	4302 (78.6)	1829 (88.9)	1437 (78.1)	1036 (65.7)
Race and center				
Black, Mississippi	1089 (19.9)	207 (10.1)	368 (20.0)	514 (32.6)
Black, North Carolina	83 (1.5)	22 (1.1)	35 (1.9)	26 (1.7)
White, North Carolina	1100 (20.1)	474 (23.0)	344 (18.7)	282 (17.9)
White, Minnesota	1648 (30.1)	723 (35.1)	560 (30.4)	365 (23.2)
White, Maryland	1554 (28.4)	632 (30.7)	533 (29.0)	389 (24.7)
Ever smoker				
Total	2975 (58.4)	1051 (54.8)	1036 (60.3)	888 (61.1)
Missing, No.	383	139	122	122
Ever alcohol drinker				
Total	4288 (79.1)	1657 (81.3)	1431 (78.5)	1200 (76.9)
Missing, No.	51	19	19	16
BMI				
Mean (SD)	28.70 (5.55)	28.69 (5.53)	28.84 (5.44)	28.54 (5.70)
Missing, No.	14	4	1	9
Blood pressure, mean (SD), mm Hg				
Systolic	130.03 (17.93)	129.87 (17.71)	129.86 (17.66)	130.45 (18.53)
Diastolic	66.16 (10.59)	66.22 (10.21)	66.13 (10.59)	66.12 (11.05)
Missing, No.	15	4	3	8
Cholesterol level, mean (SD), mg/dL				
Total	181.5 (42.0)	184.8 (42.3)	182.1 (41.4)	176.5 (41.7)
HDL	52.1 (13.9)	53.2 (14.0)	51.9 (13.7)	50.7 (14.0)
Missing, No.	34	7	8	19
Diabetes				
Total	1743 (32.2)	576 (28.2)	595 (32.7)	572 (36.6)
Missing, No.	52	17	21	14
Hypertension				
Total	4013 (73.9)	1482 (72.3)	1348 (73.8)	1183 (76.1)
Missing, No.	43	9	13	21
Prevalent coronary heart disease				
Total	796 (14.8)	269 (13.3)	264 (14.6)	263 (17.0)
Missing, No.	92	32	29	31
Prevalent stroke				
Total	197 (3.6)	58 (2.8)	63 (3.4)	76 (4.8)
Missing, No.	9	5	3	1

(continued)

Table 1. Descriptive Statistics of Baseline Covariates in Older Adults by Olfaction Function (continued)

Characteristic	Participants ^a			
	Total (N = 5474)	Good (n = 2058)	Moderate (n = 1840)	Poor (n = 1576)
Prevalent heart failure	666 (12.2)	194 (9.4)	216 (11.7)	256 (16.2)
Prevalent cancer				
Total	1219 (22.5)	459 (22.5)	391 (21.5)	369 (23.7)
Missing, No.	55	19	19	18
Dementia	169 (3.1)	10 (0.5)	23 (1.3)	136 (8.6)
Parkinson disease	287 (5.2)	47 (2.3)	91 (5.0)	149 (9.5)

Abbreviations: BMI, body mass index (calculated as weight in kilograms divided by height in meters squared); HDL, high-density lipoprotein; NA, not applicable.

SI conversion factor: To convert total and HDL cholesterol to millimoles per liter, multiply by 0.0259.

^a Data are presented as number (percentage) of participants unless otherwise indicated.

Table 2. Cross-Sectional Analysis of Olfaction Categories and Measures of Physical Function in 5474 Older Adults

Measure, olfaction category ^a	β Coefficient (95% CI)		
	Model 1 ^b	Model 2 ^c	Model 3 ^d
SPPB score (range, 0-12)			
Moderate	-0.25 (-0.40 to -0.11)	-0.15 (-0.30 to -0.02)	-0.14 (-0.28 to -0.01)
Poor	-0.77 (-0.92 to -0.62)	-0.54 (-0.69 to -0.39)	-0.49 (-0.63 to -0.35)
Balance score (range, 0-4)			
Moderate	-0.06 (-0.12 to 0.00)	-0.03 (-0.09 to 0.03)	-0.02 (-0.08 to 0.04)
Poor	-0.26 (-0.33 to -0.20)	-0.20 (-0.27 to -0.14)	-0.18 (-0.02 to -0.12)
4-m Walk score (range, 0-4)			
Moderate	-0.07 (-0.12 to -0.03)	-0.04 (-0.09 to 0.00)	-0.04 (-0.08 to 0.00)
Poor	-0.23 (-0.28 to -0.18)	-0.17 (-0.22 to -0.12)	-0.15 (-0.20 to -0.10)
Chair stand score (range, 0-4)			
Moderate	-0.12 (-0.20 to -0.05)	-0.08 (-0.16 to -0.01)	-0.08 (-0.15 to 0.00)
Poor	-0.28 (-0.36 to -0.20)	-0.16 (-0.25 to -0.08)	-0.16 (-0.24 to -0.07)
Continuous gait speed, m/s			
Moderate	-0.03 (-0.04 to -0.02)	-0.02 (-0.04 to -0.01)	-0.02 (-0.03 to -0.01)
Poor	-0.08 (-0.09 to -0.07)	-0.06 (-0.07 to -0.04)	-0.06 (-0.07 to -0.04)
Grip strength, kg			
Moderate	1.29 (0.65 to 1.94)	-0.56 (-1.01 to -0.11)	-0.53 (-0.98 to -0.09)
Poor	2.22 (1.54 to 2.90)	-1.62 (-2.11 to -1.13)	-1.50 (-1.98 to -1.01)

Abbreviation: SPPB, Short Physical Performance Battery.

^a The olfaction score was categorized as good (11-12), moderate (9-10), and poor (0-8), with good as the reference category.

^b Adjusted for age and age squared.

^c Adjusted for demographics (age, age squared, sex, educational level, and race and center).

^d Adjusted for demographics (age, age squared, sex, educational level, and race and center), behavioral factors (smoking, alcohol consumption), metabolic factors (body mass index, systolic blood pressure, diastolic blood pressure, and total and high-density lipoprotein cholesterol levels), and medical history (diabetes, hypertension, coronary heart disease, stroke, heart failure, and cancer).

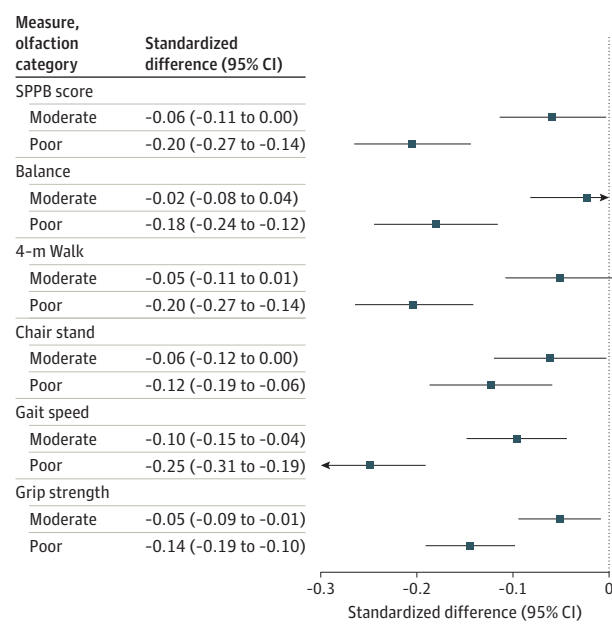
ing SPPB measures, and 22 Black participants from the Minnesota and Washington County field centers and 12 participants from racial groups other than Black or White due to small sample sizes, leading to the final analytic sample of 5474 participants (eFigure in Supplement 1). Among these participants (mean [SD] age, 75.3 [5.0] years), 1172 (21.4%) were Black, 4302 (78.6%) were White, 2311 (42.2%) were male, and 3163 (57.8%) were female. A total of 2058 (37.6%) had good olfaction, 1840 (33.6%) had moderate olfaction, and 1576 (28.8%) had poor olfaction (Table 1). Those with moderate or poor olfaction, compared with those with good olfaction, were older on average and more likely to be male, Black, and ever smokers. They were also less likely to have completed high school education and to be classified as ever drinkers of alcohol, and they had a higher prevalence of chronic conditions.

Cross-Sectional Analysis

After adjusting for all a priori specified covariates, individuals with moderate and poor olfaction tended to have lower SPPB

total scores compared with those with good olfaction (Table 2). The estimated mean difference in SPPB scores was -0.49 (95% CI, -0.63 to -0.35) for the poor vs good olfaction groups and -0.14 (95% CI, -0.28 to -0.01) for the moderate vs good olfaction groups. Consistent patterns were observed across subscales of SPPB (eg, balance score: estimated mean difference in poor vs good olfaction, -0.18 [95% CI, -0.02 to -0.12]), continuous gait speed (-0.06 [95% CI, -0.07 to -0.04] m/s), and grip strength (-1.50 [95% CI, -1.98 to -1.01] kg). Logistic regression models using dichotomized physical function outcomes yielded consistent findings (eTable 1 in Supplement 1), with both moderate and poor olfaction associated with lower odds of having good physical function compared with good olfaction. Individuals with moderate and poor olfaction had consistently lower physical function across all domains compared with those with good olfaction (Figure 1). When comparing the magnitude of associations on the same scale using z-standardized physical function outcomes, the association of poor vs good olfaction with total SPPB score

Figure 1. Dot-and-Whisker Plot of Cross-Sectional Analysis of Olfaction and Physical Function Outcomes



Standardized difference with 95% CI for each physical function measure was derived from generalized linear models, with good olfaction as the reference. Adjustment factors are described in the Statistical Analysis subsection of the Methods section. The olfaction score was categorized as good (11-12), moderate (9-10), and poor (0-8). SPPB indicates Short Physical Performance Battery.

($\beta = -0.20$; 95% CI, -0.27 to -0.14) was slightly larger than that for grip strength ($\beta = -0.14$; 95% CI, -0.19 to -0.10).

Longitudinal Analysis

Individuals with moderate and poor olfaction, compared with those with good olfaction, experienced greater declines in nearly all physical function outcomes (Table 3). After adjusting for all covariates, compared with those with good olfaction at baseline, individuals with moderate olfaction had a faster annual change in SPPB score of -0.05 (95% CI, -0.08 to -0.02), while the corresponding estimate for individuals with poor olfaction was -0.11 (95% CI, -0.14 to -0.08). The association pattern was supported by cubic spline models, which demonstrated a positive dose-response relationship between olfaction dysfunction and decline rate (Figure 2).

Sensitivity Analysis

In both cross-sectional and longitudinal analyses excluding participants with dementia or Parkinson disease at visit 5 ($n = 5074$), results were similar to those of the main analyses (eTables 2 and 3 in Supplement 1). Subgroup analyses stratified by age, sex, and race also showed results consistent with those of the main analyses (eTables 2 and 3 in Supplement 1), although some estimates were no longer statistically significant due to decreased sample size. In the analysis of 3085 participants who had another olfaction assessment at visit 6 that additionally controlled for olfaction change from visit 5 to visit 6, the association patterns remained similar to those in the main analysis (eTable 4 in Supplement 1).

Discussion

In this large cohort study of 5474 community-dwelling older adults, olfactory dysfunction was associated with poor physical function and with physical function decline observed over approximately 7 years. Associations were also found across multiple physical function measures even after adjusting for potential confounders and accounting for potential selection bias due to cohort attrition. The findings remained robust in sensitivity analyses restricted to participants without prevalent dementia and across subgroups defined by age, sex, and race.

Several prior cross-sectional and longitudinal studies have shown that individuals with poor olfaction tend to perform poorly on physical function assessments.^{18,19,23-26} Our findings extend the literature by demonstrating a gradient pattern in the associations across all physical function outcomes, including total SPPB score, SPPB subscale scores, and grip strength. The absolute differences between poor and good olfaction groups were -0.49 (95% CI, -0.63 to -0.35) for total SPPB score and -0.06 (95% CI, -0.07 to -0.04) m/s for continuous gait speed, both exceeding thresholds of small but clinically meaningful differences in physical function.⁴³ Compared with the cross-sectional findings from the Health ABC cohort,²⁴ our study showed a consistent pattern but observed larger estimates. The observed discrepancy may reflect differences in study population characteristics and analytic approaches. Notably, the Health ABC study adjusted for a broader set of covariates, some of which were likely mediators rather than confounders, including dementia, Parkinson disease, and depressive symptoms; these were not controlled for in our analyses. The standardized cross-sectional difference between poor and good olfaction was largest for continuous gait speed among all the assessed outcomes, whereas the difference in grip strength was the smallest. This suggests that olfactory dysfunction may be more strongly associated with lower extremity strength than with upper extremity strength. While both upper and lower limb functions are crucial for mobility and overall health, evidence suggests that age-related muscle strength reduction tends to be more pronounced in legs than in the arms.⁴⁴ As people age, there is a shift in muscle activity patterns, with decreased lower limb and increased upper limb activity,⁴⁵ which may explain the disproportionate association of olfactory dysfunction with lower body performance.

To our knowledge, limited studies have provided evidence that olfactory dysfunction is associated with accelerated physical decline.^{8,23-25} Our longitudinal findings revealed a dose-response relationship, which suggests that poor olfaction is associated with faster physical decline among older adults. While physical decline was observed in the full study sample, including participants with good olfaction, individuals with moderate and poor olfaction experienced greater declines. This pattern supports the hypothesis that olfactory dysfunction may be an early marker of accelerated aging.⁵ Several mechanisms may underlie the observed association between olfactory dysfunction and accelerated physical

Table 3. Longitudinal Analysis of Olfaction Categories and Measures of Physical Function in Older Adults

Measure, olfaction category ^a	β Coefficient (95% CI)		
	Model 1 ^b	Model 2 ^c	Model 3 ^d
SPPB score			
Time, y	-0.14 (-0.16 to -0.12)	-0.14 (-0.16 to -0.12)	-0.14 (-0.16 to -0.12)
Olfaction \times time, y			
Moderate	-0.05 (-0.08 to -0.03)	-0.05 (-0.08 to -0.03)	-0.05 (-0.08 to -0.02)
Poor	-0.12 (-0.16 to -0.09)	-0.12 (-0.15 to -0.09)	-0.11 (-0.14 to -0.08)
Balance score			
Time, y	-0.05 (-0.06 to -0.04)	-0.05 (-0.06 to -0.04)	-0.05 (-0.06 to -0.04)
Olfaction \times time, y			
Moderate	-0.02 (-0.04 to -0.01)	-0.02 (-0.04 to -0.01)	-0.02 (-0.03 to -0.01)
Poor	-0.03 (-0.05 to -0.02)	-0.03 (-0.05 to -0.02)	-0.03 (-0.04 to -0.01)
4-m Walk score			
Time, y	-0.02 (-0.03 to -0.01)	-0.02 (-0.03 to -0.01)	-0.02 (-0.03 to -0.01)
Olfaction \times time, y			
Moderate	-0.01 (-0.02 to 0.00)	-0.01 (-0.02 to 0.00)	-0.01 (-0.02 to 0.00)
Poor	-0.03 (-0.04 to -0.02)	-0.03 (-0.04 to -0.02)	-0.03 (-0.04 to -0.02)
Chair stand score			
Time, y	-0.07 (-0.08 to -0.06)	-0.07 (-0.08 to -0.06)	-0.07 (-0.08 to -0.06)
Olfaction \times time, y			
Moderate	-0.02 (-0.03 to 0.00)	-0.02 (-0.03 to 0.00)	-0.02 (-0.03 to 0.00)
Poor	-0.05 (-0.07 to -0.03)	-0.05 (-0.06 to -0.03)	-0.04 (-0.06 to -0.03)
Continuous gait speed			
Time, y	-0.008 (-0.009 to -0.006)	-0.008 (-0.009 to -0.006)	-0.008 (-0.010 to -0.006)
Olfaction \times time, y			
Moderate	-0.002 (-0.005 to 0.000)	-0.002 (-0.005 to 0.000)	-0.002 (-0.004 to 0.000)
Poor	-0.002 (-0.005 to 0.000)	-0.002 (-0.005 to 0.000)	-0.001 (-0.004 to 0.001)
Grip strength			
Time, y	-0.06 (-0.61 to -0.52)	-0.06 (-0.61 to -0.51)	-0.57 (-0.62 to -0.52)
Olfaction \times time, y			
Moderate	-0.08 (-0.15 to -0.01)	-0.07 (-0.14 to 0.00)	-0.07 (-0.14 to 0.00)
Poor	-0.16 (-0.23 to -0.08)	-0.13 (-0.21 to -0.05)	-0.13 (-0.21 to -0.05)

Abbreviation: SPPB, Short Physical Performance Battery.

^a The olfaction score was categorized as good (11-12), moderate (9-10), and poor (0-8), with good as the reference category.

^b Adjusted for age and age squared.

^c Adjusted for demographics (age, age squared, sex, educational level, and race and center).

^d Adjusted for demographics (age, age squared, sex, educational level, and race and center), behavioral factors (smoking, alcohol consumption), metabolic factors (body mass index, systolic blood pressure, diastolic blood pressure, and total and high-density lipoprotein cholesterol levels), and medical history (diabetes, hypertension, coronary heart disease, stroke, heart failure, and cancer).

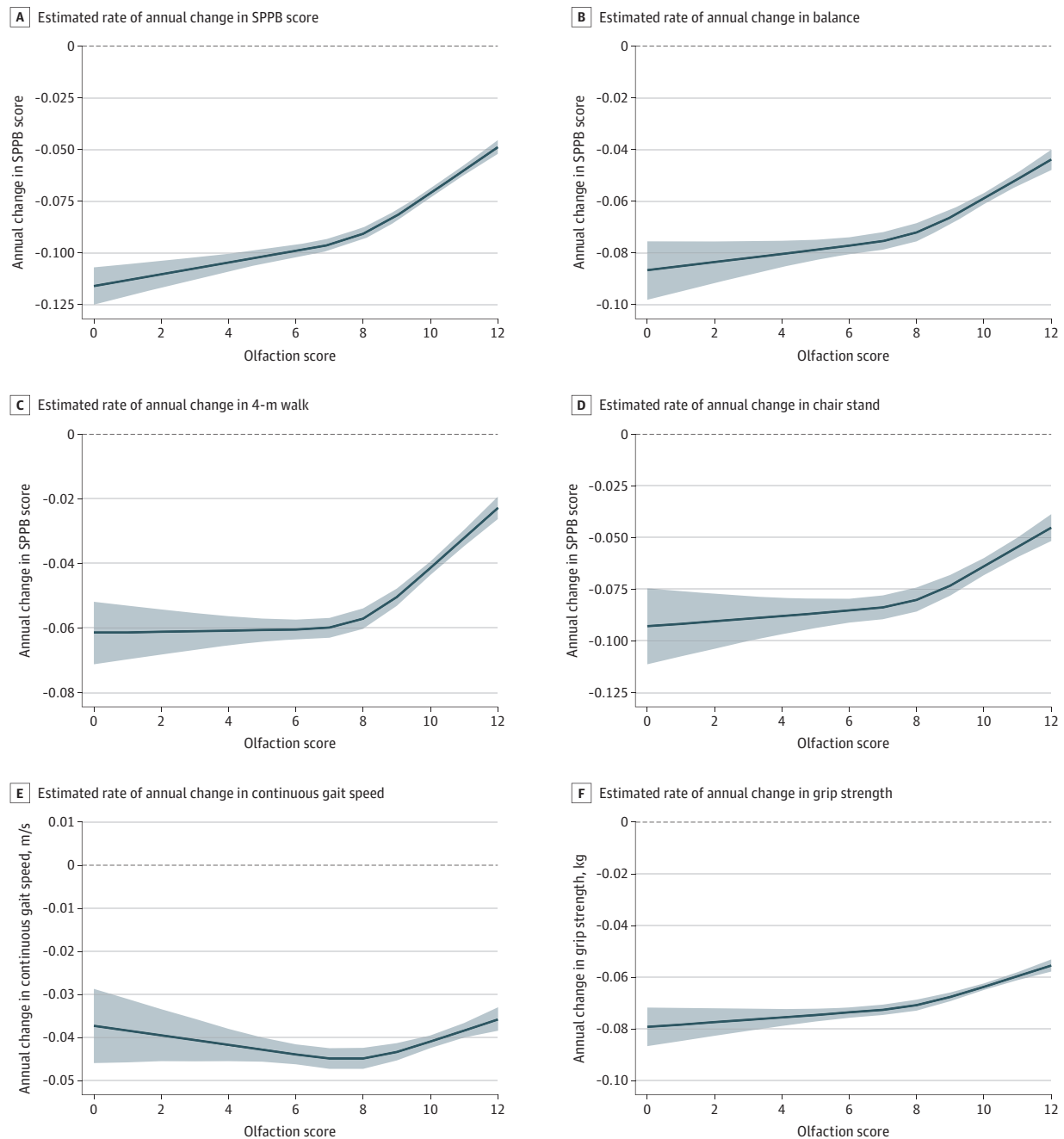
decline. First, olfactory dysfunction shares common pathophysiological pathways with other hallmarks of aging, including neurodegeneration,^{46,47} systemic inflammation,⁷ and impaired sensory processing.⁴⁸ Impaired olfaction is a well-established prodromal symptom of neurodegenerative disorders, such as Alzheimer and Parkinson diseases,⁴⁹ which are characterized by early motor impairment and physical decline.^{50,51} Second, olfactory dysfunction may have downstream behavioral and psychosocial consequences that contribute to accelerated functional decline. A diminished sense of smell reduces appetite and food enjoyment,⁵² leading to lower overall food intake or shifted diet.⁵³ Olfactory dysfunction may also impair individuals' social interaction and participation in daily activities.⁵⁴ These disruptions can result in poor nutrition and reduced physical activity, both of which are known contributors to age-related losses in muscle mass and strength.⁵⁵⁻⁵⁸ Therefore, olfactory dysfunction may be both a biologic indicator and a behavioral marker of accelerated aging. Our longitudinal analysis demonstrated that poor

olfaction was associated with annual declines across all physical function domains examined in a dose-response pattern, suggesting the potential utility of olfaction as a continuous marker of future physical decline.

Strengths and Limitations

Our study has several strengths, including a focus on a large community-based population, a longitudinal design, and rigorous statistical methods with extensive sensitivity analyses. Nevertheless, we acknowledge several limitations. First, while olfaction typically declines with age, we used olfaction measurement only at the study baseline (visit 5). We were unable to conclude whether olfaction decline after visit 5 may have biased the results. However, the sensitivity analysis of participants who had another olfaction assessment at visit 6 revealed that the association patterns remained similar to those in the main analyses. Second, the study population was limited to older adults; therefore, findings may not be generalizable to younger populations. Third, despite adjusting for a list

Figure 2. Line Graphs of Estimated Rate of Annual Change in Physical Function Outcomes



Estimated annual change rate in each physical function measure was estimated in linear mixed-effect models. All physical function outcomes were standardized, and olfaction score was modeled using a cubic spline function with knots at 6, 8, and 10. Adjustment factors are described in the Statistical

Analysis subsection of the Methods section. The olfaction score was categorized as good (11-12), moderate (9-10), and poor (0-8), with good as the reference category. Shading represents 95% CIs. SPPB indicates Short Physical Performance Battery.

of potential confounders, residual confounding may remain due to unreported impairment in lung function, nutrition status, and rhinosinusitis.⁵⁸⁻⁶⁰ Fourth, the 12-item Sniffin' Sticks Odor Identification Test assesses higher-order olfactory processing and does not solely reflect peripheral olfactory function because successful item identification also depends on cognitive domains, such as semantic memory and naming. To

address this concern, we performed a sensitivity analysis excluding participants with dementia or Parkinson disease at baseline, and the associations between olfactory identification performance and physical function outcomes remained similar to those in the main analyses, suggesting that the observed associations were not greatly confounded by neurological diseases.

Conclusions

In this cohort study, poor olfaction in older adults was associated with a decline in physical functioning. This finding may have clinical implications for identifying older

adults at elevated risk of physical function decline. Future research should investigate the biologic mechanisms linking olfactory dysfunction with functional aging and explore whether olfactory function could serve as an early intervention target to preserve functional independence in later life.

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REFERENCES

- Doty RL, Kamath V. The influences of age on olfaction: a review. *Front Psychol*. 2014;5:20. doi:10.3389/fpsyg.2014.00020
- Attems J, Walker L, Jellinger KA. Olfaction and aging: a mini-review. *Gerontology*. 2015;61(6):485-490. doi:10.1159/000381619
- Patel ZM, Holbrook EH, Turner JH, et al. International consensus statement on allergy and rhinology: olfaction. *Int Forum Allergy Rhinol*. 2022;12(4):327-680. doi:10.1002/ialr.22929
- Whitcroft KL, Altundag A, Balungwe P, et al. Position paper on olfactory dysfunction: 2023. *Rhinology*. 2023;61(33):1-108. doi:10.4193/Rhin22.483
- Olofsson JK, Ekström I, Larsson M, Nordin S. Olfaction and aging: a review of the current state of research and future directions. *Iperception*. 2021;12(3):20416695211020331. Published online June 26, 2021. doi:10.1177/20416695211020331
- Kondo K, Kikuta S, Ueha R, Suzukawa K, Yamasoba T. Age-related olfactory dysfunction: epidemiology, pathophysiology, and clinical management. *Front Aging Neurosci*. 2020;12:208. doi:10.3389/fnagi.2020.00208
- Xie Y, Wang S, Cha X, et al. Aging and chronic inflammation: impacts on olfactory dysfunction—a comprehensive review. *Cell Mol Life Sci*. 2025;82(1):199. doi:10.1007/s00018-025-05637-5
- Ruane R, Lampert O, Larsson M, Vetrano DL, Laukka EJ, Ekström I. Olfactory deficits and mortality in older adults. *JAMA Otolaryngol Head Neck Surg*. 2025;151(6):558-566. doi:10.1001/jamaoto.2025.0174
- Chamberlin KW, Yuan Y, Li C, et al. Olfactory impairment and the risk of major adverse cardiovascular outcomes in older adults. *J Am Heart Assoc*. 2024;13(12):e033320. doi:10.1161/JAHA.123.033320
- Catamo E, Tornese G, Concas MP, Gasparini P, Robino A. Differences in taste and smell perception between type 2 diabetes mellitus patients and healthy controls. *Nutr Metab Cardiovasc Dis*. 2021;31(1):193-200. doi:10.1016/j.numecd.2020.08.025
- Wang K, Luo Z, Li C, et al. Olfaction and kidney function in community-dwelling older adults. *PLoS One*. 2022;17(2):e0264448. doi:10.1371/journal.pone.0264448
- Nagururu NV, Bernstein IA, Voegtline K, Olson S, Agrawal Y, Rowan NR. The association of peripheral and central olfaction with frailty in older adults. *J Gerontol A Biol Sci Med Sci*. 2023;78(7):1276-1283. doi:10.1093/gerona/glac237
- Yuan Y, Luo Z, Li C, et al. Poor olfaction and pneumonia hospitalisation among community-dwelling older adults: a cohort study. *Lancet Healthy Longev*. 2021;2(5):e275-e282. doi:10.1016/S2666-7568(21)00083-0
- Dan X, Yang B, McDevitt RA, et al. Loss of smelling is an early marker of aging and is associated with inflammation and DNA damage in C57BL/6J mice. *Aging Cell*. 2023;22(4):e13793. doi:10.1111/acel.13793
- Van Regemorter V, Hummel T, Rosenzweig F, Mouraux A, Rombaux P, Huart C. Mechanisms linking olfactory impairment and risk of mortality. *Front Neurosci*. 2020;14:140. doi:10.3389/fnins.2020.00140
- Stolz E, Mayerl H, Muniz-Terrera G, Gill TM. Terminal decline in physical function in older adults. *J Gerontol A Biol Sci Med Sci*. 2024;79(1):glad119. doi:10.1093/gerona/glad119
- Layne AS, Hsu FC, Blair SN, et al; LIFE Study Investigators. Predictors of change in physical function in older adults in response to long-term, structured physical activity: the LIFE study. *Arch Phys Med Rehabil*. 2017;98(1):11-24.e3. doi:10.1016/j.apmr.2016.07.019
- Tian Q, Resnick SM, Studenski SA. Olfaction is related to motor function in older adults. *J Gerontol A Biol Sci Med Sci*. 2017;72(8):1067-1071.
- Yesanharao LV, Vohra V, Cheng M, et al. Olfactory dysfunction and balance dysfunction are associated with increased falls in older adults. *Laryngoscope*. 2023;133(8):1964-1969. doi:10.1002/lary.30733
- Cheng MZ, Vohra V, Wang H, et al. The association between olfactory subdomains and frailty: a prospective case-control study investigation. *Int Forum Allergy Rhinol*. 2024;14(10):1598-1606. doi:10.1002/ialr.23398
- Kose Y, Hatamoto Y, Tomiga-Takae R, et al. Olfaction, ability to identify particular olfactory clusters and odors, and physical performance in community-dwelling older adults: the Yanai Study. *Exp Gerontol*. 2022;163:111793. doi:10.1016/j.exger.2022.111793
- Kose Y, Hatamoto Y, Takae R, et al. Association between the inability to identify particular odors and physical performance, cognitive function, and/or brain atrophy in community-dwelling older adults from the Fukuoka Island City study. *BMC Geriatr*. 2021;21(1):421. doi:10.1186/s12877-021-02363-y
- Yuan Y, Chamberlin KW, Li C, et al. Olfaction and mobility in older adults. *JAMA Otolaryngol Head Neck Surg*. 2024;150(3):201-208. doi:10.1001/jamaoto.2023.4375
- Yuan Y, Li C, Luo Z, Simonsick EM, Shiroma EJ, Chen H. Olfaction and physical functioning in older adults: a longitudinal study. *J Gerontol A Biol Sci Med Sci*. 2022;77(8):1612-1619. doi:10.1093/gerona/ab233
- Vohra V, Simonsick EM, Kamath V, Banteen-Roche K, Agrawal Y, Rowan NR. Physical

- function trajectories and mortality in older adults with multisensory impairment. *JAMA Otolaryngol Head Neck Surg.* 2024;150(3):217-225. doi:10.1001/jamaoto.2023.4378
26. Pleasants H, Yuan Y, Chamberlin K, et al. Longitudinal association of olfactory function with frailty in older adults: the Atherosclerosis Risk in Communities study. *J Gerontol A Biol Sci Med Sci.* 2025;80(4):glaf018. doi:10.1093/gerona/018
27. Wright JD, Folsom AR, Coresh J, et al. The ARIC (Atherosclerosis Risk in Communities) study: JACC Focus Seminar 3/8. *J Am Coll Cardiol.* 2021;77(23):2939-2959. doi:10.1016/j.jacc.2021.04.035
28. Hummel T, Sekinger B, Wolf SR, Pauli E, Kobal G. 'Sniffin' sticks': olfactory performance assessed by the combined testing of odor identification, odor discrimination and olfactory threshold. *Chem Senses.* 1997;22(1):39-52. doi:10.1093/chemse/22.1.39
29. Guralnik JM, Simonsick EM, Ferrucci L, et al. *Short Physical Performance Battery.* APAPsycTests; 1994.
30. Riskowski JL, Hagedorn TJ, Dufour AB, Hannan MT. Functional foot symmetry and its relation to lower extremity physical performance in older adults: The Framingham Foot Study. *J Biomech.* 2012;45(10):1796-1802. doi:10.1016/j.jbiomech.2012.04.019
31. Rocco LLG, Fernandes TG. Validity of the Short Physical Performance Battery for screening for frailty syndrome among older people in the Brazilian Amazon region: a cross-sectional study. *Sao Paulo Med J.* 2020;138(6):537-544. doi:10.1590/1516-3180.2020.0264.r1.14092020
32. Kumagai KI, Yamauchi K, Hagiwara R, et al. Abstract WP161: Early Short Physical Performance Battery (SPPB) score can predict functional independence and death for acute stroke. *Stroke.* 2017;48(suppl 1). doi:10.1161/str.48.suppl_1.wp161
33. Windham BG, Parker SB, Zhu X, et al. Endurance and gait speed relationships with mild cognitive impairment and dementia. *Alzheimers Dement (Amst).* 2022;14(1):e12281. doi:10.1002/dad2.12281
34. Bohannon RW. Grip strength: an indispensable biomarker for older adults. *Clin Interv Aging.* 2019;14:1681-1691. doi:10.2147/CIA.S194543
35. Fried LP, Tangen CM, Walston J, et al; Cardiovascular Health Study Collaborative Research Group. Frailty in older adults: evidence for a phenotype. *J Gerontol A Biol Sci Med Sci.* 2001;56(3):M146-M156. doi:10.1093/gerona/56.3.M146
36. González Arnáiz E, López Gómez JJ, Ariadel Cobo D, et al. Absolute and adjusted hand grip strength values in obese patients. *Endocrinol Diabetes Nutr (Engl Ed).* 2025;72(5):501560. doi:10.1016/j.endien.2025.501560
37. Chun SW, Kim W, Choi KH. Comparison between grip strength and grip strength divided by body weight in their relationship with metabolic syndrome and quality of life in the elderly. *PLoS One.* 2019;14(9):e0222040. doi:10.1371/journal.pone.0222040
38. Sallinen J, Stenholm S, Rantanen T, Heliövaara M, Sainio P, Koskinen S. Hand-grip strength cut points to screen older persons at risk for mobility limitation. *J Am Geriatr Soc.* 2010;58(9):1721-1726. doi:10.1111/j.1532-5415.2010.03035.x
39. Body mass index. Wikipedia. Accessed July 7, 2025. https://en.wikipedia.org/w/index.php?title=Body_mass_index&oldid=1297493091
40. Li P, Stuart EA, Allison DB. Multiple imputation: a flexible tool for handling missing data. *JAMA.* 2015;314(18):1966-1967. doi:10.1001/jama.2015.15281
41. Seaman SR, White IR. Review of inverse probability weighting for dealing with missing data. *Stat Methods Med Res.* 2013;22(3):278-295. doi:10.1177/0962280210395740
42. Shrestha S, Zhu X, Kucharska-Newton AM, et al. Characterizing the olfaction and dementia association in the community-based ARIC study. *Alzheimers Dement.* 2025;21(2):e14613. doi:10.1002/alz.14613
43. Perera S, Mody SH, Woodman RC, Studenski SA. Meaningful change and responsiveness in common physical performance measures in older adults. *J Am Geriatr Soc.* 2006;54(5):743-749. doi:10.1111/j.1532-5415.2006.00701.x
44. Amaral JF, Alvim FC, Castro EA, Doimo LA, Silva MV, Novo Júnior JM. Influence of aging on isometric muscle strength, fat-free mass and electromyographic signal power of the upper and lower limbs in women. *Braz J Phys Ther.* 2014;18(2):183-190. doi:10.1590/S1413-35552012005000145
45. Ferrreira L, Gobbi S, Gobbi LTB. An explanatory mechanism for the different decline in limb strength in older women. *Arch Gerontol Geriatr.* 2009;49(3):373-377. doi:10.1016/j.archger.2008.12.002
46. Bhatia-Dey N, Heinbockel T. The olfactory system as marker of neurodegeneration in aging, neurological and neuropsychiatric disorders. *Int J Environ Res Public Health.* 2021;18(13):6976. doi:10.3390/ijerph18136976
47. Chen YN, Kostka JK. Beyond anosmia: olfactory dysfunction as a common denominator in neurodegenerative and neurodevelopmental disorders. *Front Neurosci.* 2024;18:1502779. doi:10.3389/fnins.2024.1502779
48. Hong S, Baek SH, Lai MKP, Arumugam TV, Jo DG. Aging-associated sensory decline and Alzheimer's disease. *Mol Neurodegener.* 2024;19(1):93. doi:10.1186/s13024-024-00776-y
49. Ielo A, Bonanno L, Brunati C, et al. Structural and functional connectomics of the olfactory system in Parkinson's disease: a systematic review. *Parkinsonism Relat Disord.* 2025;132:107230. doi:10.1016/j.parkreldis.2024.107230
50. Buchman AS, Bennett DA. Loss of motor function in preclinical Alzheimer's disease. *Expert Rev Neurother.* 2011;11(5):665-676. doi:10.1586/ern.11.57
51. Katsuno M, Sahashi K, Iguchi Y, Hashizume A. Preclinical progression of neurodegenerative diseases. *Nagoya J Med Sci. Article in Japanese.* 2018;80(3):289-298.
52. Marin C, Alobod I, Fuentes M, López-Chacón M, Mullol J. Olfactory dysfunction in mental illness. *Curr Allergy Asthma Rep.* 2023;23(3):153-164. doi:10.1007/s11882-023-01068-z
53. Stevenson RJ, Mahmut MK, Horstmann A, Hummel T. The aetiology of olfactory dysfunction and its relationship to diet quality. *Brain Sci.* 2020;10(11):769. doi:10.3390/brainsci10110769
54. Blomkvist A, Hofer M. Olfactory impairment and close social relationships: a narrative review. *Chem Senses.* 2021;46:bjab037. doi:10.1093/chemse/bjab037
55. Oikawa SY, Holloway TM, Phillips SM. The impact of step reduction on muscle health in aging: protein and exercise as countermeasures. *Front Nutr.* 2019;6:75. doi:10.3389/fnut.2019.00075
56. Robinson SM, Reginster JY, Rizzoli R, et al; ESCEO Working Group. Does nutrition play a role in the prevention and management of sarcopenia? *Clin Nutr.* 2018;37(4):1121-1132. doi:10.1016/j.clnu.2017.08.016
57. Distefano G, Goodpaster BH. Effects of exercise and aging on skeletal muscle. *Cold Spring Harb Perspect Med.* 2018;8(3):a029785. doi:10.1101/cshperspect.a029785
58. Vohra V, Leland EM, Schlosser RJ, Kamath V, Rowan NR. Association of frailty status and dietary patterns in a nationally representative sample of United States adults with olfactory dysfunction. *Nutrients.* 2022;14(6):1238. doi:10.3390/nu14061238
59. Kim JS, Park JO, Lee DH, Chang KH, Kim BG. Association of olfactory and pulmonary function in middle-aged and older adults: the Korea National Health and Nutrition Examination Survey. *J Clin Med.* 2021;10(7):1535. doi:10.3390/jcm10071535
60. LaFever BJ, Imamura F. Effects of nasal inflammation on the olfactory bulb. *J Neuroinflammation.* 2022;19(1):294. doi:10.1186/s12974-022-02657-x