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Editor's Choice

Brief Report

Olfaction Is Related to Motor Function in Older Adults

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Abstract

Background: Among older adults, both olfaction and motor function predict future cognitive decline and dementia, suggesting potential shared causal pathways. However, it is not known whether olfactory and motor function are independently related in late life.

Methods: We assessed cross-sectional associations of olfaction with motor and cognitive function, using concurrent data on olfactory function, mobility, balance, fine motor function, manual dexterity, and cognition in 163 Baltimore Longitudinal Study of Aging participants aged 60 and older without common neurological diseases (n = 114 with available cognitive data). Using multiple linear regression, we adjusted for age, sex, race, smoking history, height, and weight for mobility and balance, and education for cognition. We used multiple linear regression to test whether olfaction-motor associations were independent of cognition and depressive symptoms.

Results: Olfactory scores were significantly associated with mobility (usual gait speed, rapid gait speed, 400-m walk time, and Health ABC Physical Performance Battery score), balance, fine motor function, and manual dexterity (all $p < .05$). In those with available cognitive data, additional adjustment for depressive symptoms, verbal memory, or visuoperceptual speed demonstrated especially strong independent relationships with challenging motor tasks such as 400-m walk and nondominant hand manual dexterity ($p < .005$)

Conclusions: This study demonstrates for the first time that, in older adults, olfactory function is associated with mobility, balance, fine motor function, and manual dexterity, and independent of cognitive function, with challenging upper and lower extremity motor function tasks. Longitudinal studies are needed to determine if olfactory performance predicts future mobility and functional decline.

Keywords: Smell—Lower and upper extremity function—Usual aging

The brain is changing years before the diagnosis of Alzheimer's disease (AD) and Parkinson's disease (PD). The earliest and most severely involved regions include the limbic system (1). Since the limbic system has ties to the olfactory system, olfactory deficits may be one of the earliest detectable signs of neuropathology (2). Olfactory dysfunction is associated with neurodegenerative pathologies in nondemented individuals (3,4) and predicts cognitive decline over and beyond memory performance (5). Olfactory dysfunction also occurs years before motor symptoms of PD (6,7). Olfactory changes may be an early indicator of neurodegeneration, well before clinical signs become apparent.

Although the capacity of olfactory function to predict future cognitive decline, AD, and PD is established, the relationship between olfactory function and motor dysfunction of aging is unknown. Among nondemented older individuals, olfactory deficits are associated with smaller areas of the perirhinal and entorhinal cortices, somatosensory cortex, and with lower microstructural integrity of the corpus callosum and superior longitudinal fasciculus (8). Olfactory tracts are known to project to the orbitofrontal cortex and cerebellum (9). These areas influence movement planning, spatial navigation, and sensorimotor integration and are also associated with mobility and gait (10,11). If olfactory and motor function are related cross-sectionally, then longitudinal studies to explore the sequence of events and associated brain changes would be justified. Ultimately, such a novel predictive role for olfaction could lead to olfactory clinical screening for future movement problems of aging, as well as to new studies of underlying mechanisms.

We use a validated olfactory test in a well-characterized sample of community-dwelling adults without common neurological diseases. Our goal is to take the first step toward evidence regarding olfaction and movement in aging. We examine the cross-sectional associations between olfactory function and a variety of motor function

assessments and determine if the relationships are independent of cognition and depressive symptoms.

Methods

Study Population

Data on olfactory function were collected in 196 participants from the Baltimore Longitudinal Study of Aging (BLSA). Of these participants, 187 lacked diagnoses of mild cognitive impairment, AD, PD, and stroke. Diagnoses of mild cognitive impairment and AD follow standard BLSA procedures (12). Diagnoses of PD and stroke are self-reported. All 187 (N = 163 aged 60 and older) had concurrent motor measures; Concurrent manual dexterity and cognition data were available for 132 (n = 114 aged 60 or older) participants due to a scoring lag.

All provided written informed consent. This study was approved by the Institutional Review Board, National Institute on Aging.

Olfaction

Olfactory function was measured using a 16-item Sniffin' Sticks Identification Test (13).

Motor Function

Motor assessments include mobility (usual gait speed, rapid gait speed, 400-m time, and Health ABC Physical Performance Battery (HABCPPB) score), total standing balance time, fine motor function (finger tapping time), and manual dexterity (Purdue Pegboard Test) (12).

Cognition

Cognitive assessments include verbal memory (California Verbal Learning Test [CVLT]), visuoperceptual speed (Digit Symbol Substitution Test [DSST]), executive function (Trail Making Test part B [TMT-B]), and attention (TMT-A) (12). This study also includes depressive symptoms (Center for Epidemiologic Studies Depression Scale [CES-D]) and global mental status (Mini-Mental State Exam [MMSE]) (12).

Covariates

Basic covariates include age, sex, race, smoking history, height, and weight for mobility and balance, and education for cognitive outcomes. Additional covariates include depressive symptoms, verbal memory, and visuoperceptual speed.

Statistical Analysis

In adults aged 60 and older, univariate associations between olfactory scores and sample characteristics were examined using Pearson correlation coefficients or independent t tests as appropriate.

Univariate associations of olfactory scores with CES-D and MMSE were examined using Spearman correlation coefficients. Cross-sectional associations between olfactory scores and each motor and cognitive measure were examined using linear regression. Models were adjusted for basic covariates. To examine whether the relationship was independent of depressive symptoms, memory, or visuoperceptual speed, models were additionally adjusted for each. We report models using CVLT immediate recall; results were unchanged with delayed recall (Supplementary Appendix 1).

Results

In adults aged 60 and older (Table 1), age ranged from 60 to 100 years and olfactory scores from 1 to 16. In unadjusted models, lower olfactory scores were associated with all motor and cognitive measures except TMT-B (Table 2). The relationships between olfaction and mobility, balance, manual dexterity measures remained significant after basic adjustment (Table 2). The relationship after basic adjustment remained significant for simple tapping time by the dominant hand, but became marginal for the nondominant hand and complex tapping time (Table 2).

In those with cognition data, after basic adjustment, lower olfactory scores were associated with lower CVLT delayed recall and DSST scores (Table 2). Since this sample size is smaller, we rechecked olfactory-motor cross-sectional analyses to determine if effects were consistent. Some associations lost significance, in part due to the smaller sample, while the associations with 400-m time and HABCPPB scores remained significant (Table 3).

With adjustment for CES-D, CVLT immediate recall, or DSST scores, associations with 400-m time and HABCPPB remained significant (Table 3). Simple tapping time was significantly associated

Table 1. Sample Characteristics in Adults Aged 60 and Older

	Mean ± *SD* or *N* (%)
Characteristics	Total (N = 163)
Age (y)	77.4 ± 8.5
Female	88 (52.4)
Black	33 (20.1)
Education (y)	17.0 ± 2.5
Height (cm)	166.6 ± 8.8
Weight (kg)	75.2 ± 14.9
Smokers[a]	1 (0.6)
Olfaction score, ranged 0–16	11.27 ± 2.69
Mobility	
Usual gait speed (m/s)	1.06 ± 0.24
Rapid gait speed (m/s)	1.54 ± 0.34
400-m time (s)	297.6 ± 75.7 (n = 150)
Health ABC Physical Performance Battery score	2.7 ± 0.7
Balance	
Total standing balance time (s)	71.3 ± 22.4
Fine motor	(n = 147)
Complex tapping time (s/tap)	0.17 ± 0.05
Simple tapping dominant hand (s/tap)	0.19 ± 0.03
Simple tapping nondominant hand (s/tap)	0.20 ± 0.03
	Cognitive subset (n = 114)
Manual dexterity	
Pegboard dominant hand	11.8 ± 2.2
Pegboard nondominant hand	11.5 ± 2.2
Memory	
CVLT immediate	50.9 ± 11.6
CVLT short-delay	10.0 ± 3.5
CVLT long-delay	10.5 ± 3.5
Visuoperceptual speed	
Digit symbol substitution test	38.2 ± 10.5
Executive function	
Trail Making Test part B (s)	90.8 ± 48.2
Attention	
Trail Making Test part A (s)	35.0 ± 14.6
Depressive symptoms	
Center for Epidemiologic Studies Depression Scale	5.32 ± 5.62
Global mental status	
Mini-Mental State Exam	28.4 ± 1.2

Note: CVLT = California Verbal Learning Test.
[a]Current/recent versus never/former.

Table 2. Associations Between Olfaction and Motor or Cognitive Function in Adults Aged 60 and Older

	Unadjusted	Model 1: Basic Adjustment
	β (95% CI); *p* Value (*N* = 163)	
Mobility		
Usual gait speed (m/s)	0.026 (0.012, 0.039); <.001	0.012 (0.001, 0.024); .033
Rapid gait speed (m/s)	0.037 (0.018, 0.056); <.001	0.020 (0.004, 0.037); .015
400-m time, s (*n* = 150)	−6.533 (−11.234, −1.833); .007	−4.102 (−8.184, −0.019); .049
Health ABC Physical Performance Battery score	0.093 (0.053, 0.133); <.001	0.052 (0.017, 0.086); .004
Balance		
Total standing balance time (s)	2.451 (1.212, 3.689); <.001 (*n* = 147)	1.277 (0.195, 2.360); .021
Fine motor		
Complex tapping time (s/tap)	−0.004 (−0.007, −0.001); .007	−0.003 (−0.006, 0.000); .057
Simple tapping dominant hand (s/tap)	−0.002 (−0.004, −0.001); .010	−0.002 (−0.004, 0.000); .043
Simple tapping nondominant hand (s/tap)	−0.002 (−0.004, −0.000); .022 (*n* = 114)	−0.002 (−0.004, 0.000); .056
Manual dexterity		
Pegboard dominant hand	0.253 (0.114, 0.393); <.001	0.154 (0.024, 0.283); .021
Pegboard nondominant hand	0.324 (0.189, 0.459); <.001	0.245 (0.116, 0.374); <.001
Memory		
CVLT immediate	1.146 (0.419, 1.873); .002	0.690 (−0.077, 1.458); .077
CVLT short-delay	0.339 (0.119, 0.559); .003	0.258 (0.023, 0.494); .032
CVLT long-delay	0.375 (0.160, 0.590); <.001	0.296 (0.067, 0.526); .012
Visuoperceptual speed		
Digit symbol substitution test	1.213 (0.550, 1.876); <.001	0.718 (0.054, 1.381); .034
Executive function		
Trail Making Test part B (s)	−0.025 (−0.056, 0.006); .110	−0.007 (−0.041, 0.025); .649
Attention		
Trail Making Test part A (s)	−0.034 (−0.056, −0.012); .002	−0.018 (−0.040, 0.003); .095

Note: CI = confidence interval; CVLT = California Verbal Learning Test.

[a]Log transformed. Model 1, for fine motor and manual dexterity, adjusted for age, sex, race, and smoking history, with height and weight for mobility and balance, with education for cognition.

with olfaction after basic adjustment and with additional adjustment for CES-D or CVLT, but attenuated after adjustment for DSST (Table 3). The associations with complex tapping time were significant with adjustment for CVLT delayed recall, but not with other adjustments (Table 3). The associations with manual dexterity in the nondominant hand remained significant in all adjustments, while in the dominant hand, associations were significant with basic adjustment, but varied with other adjustments (Table 3). Overall, the most robust and consistent associations between olfaction and movement after adjusting for depressive symptoms or cognition were in 400-m time and nondominant hand manual dexterity.

Discussion

In a sample of older adults without common neurological diseases, this study demonstrates for the first time that olfactory function is associated with performance in a wide variety of motor functions, including mobility, balance, fine motor function, and manual dexterity. Independent of depressive symptoms and a range of cognitive tests, olfaction remained independently associated with 400-m time, HABCPPB score, fine motor function, and manual dexterity, with the strongest effects for challenging motor tasks such as 400-m walk and nondominant hand manual dexterity.

Olfactory and motor dysfunctions in aging may share some structural brain abnormalities, neurodegenerative pathologies, and neurotransmitter deficits. Although, to our knowledge, there are no prior studies of the association between olfaction and motor function in usual aging, the potential relationship is based on a strong rationale, including olfactory relationships in age-related motor disorders such as PD (7,14) and known regional brain changes in usual aging (8,15–18). The same neurodegenerative processes that affect cognition and movement in AD and PD also affect olfactory function and can occur in usual aging (2). Olfactory dysfunction in neurodegenerative diseases is associated with deposits of abnormal tau and α-synuclein in olfactory-related structures (6). Neurotransmitter deficits, especially cholinergic deficits, contribute to olfactory loss, and are also related to gait disturbances in aging and PD (19,20). Age-related neurochemical early changes are region specific, with those in the limbic system, including olfactory structures, occurring during aging (2).

Our findings confirm known relationships in older adults between olfactory function and memory (21,22), depressive symptoms (23,24), and global mental state (25). To our knowledge, this is the first study to report that olfactory function is associated with DSST, a test of psychomotor speed.

This study has several strengths. The sample is diverse in age, sex, and race. The olfactory test is well validated. We examined a range of lower and upper extremity motor tasks and tested for relationships independent of depressive symptoms and cognition. Limitations include (i) a cross-sectional design cannot infer causation, (ii) there may be other unmeasured confounders, such as other neurological conditions or nutritional deficiencies, and (iii) self-reported diagnoses may be unreliable. Although our sample size is modest, our main findings are quite robust.

Table 3. Associations Between Olfaction and Motor Function Adjusted for Depressive Symptoms and Cognition in Adults Aged 60 and Older ($n = 114$)

	Model 1: Basic Adjustment	Model 1 + CES-D	Model 1 + CVLT Immediate	Model 1 + DSST
	β (95% CI); *p* Value			
Usual gait speed (m/s)	0.009 (−0.005, 0.022); .218	0.008 (−0.006, 0.022); .247	0.007 (−0.006, 0.021); .274	0.008 (−0.007, 0.022); .289
Rapid gait speed (m/s)	0.017 (−0.002, 0.036); .087	0.014 (−0.005, 0.033); .151	0.013 (−0.006, 0.032); .177	0.013 (−0.007, 0.032); .201
400-m time, s ($n = 103$)	**−6.350 (−10.086, −2.613); .001**	**−4.931 (−8.613, −1.248); .009**	**−6.258 (−10.147, −2.369); .002**	**−6.374 (−10.205, −2.543); .001**
Health ABC Physical Performance Battery score	**0.052 (0.013, 0.090); .009**	**0.050 (0.012, 0.088); .011**	**0.057 (0.017, 0.097); .006**	**0.044 (0.005, 0.084); .029**
Total standing balance time (s)	1.291 (0.002, 2.579); .050	1.006 (−0.236, 2.248); .111	1.111 (−0.175, 2.396); .090	1.079 (−0.245, 2.404); .109
Complex tapping time (s/tap)	−0.003 (−0.006, 0.001); .133	−0.002 (−0.006, 0.001); .159	−0.003 (−0.006, 0.000); .054	−0.001 (−0.005, 0.002); .462
Simple tapping dominant hand (s/tap)	**−0.003 (−0.005, −0.000); .027**	**−0.003 (−0.005, −0.000); .024**	**−0.003 (−0.005, −0.000); .028**	−0.002 (−0.004, 0.001); .140
Simple tapping nondominant hand (s/tap)	**−0.003 (−0.005, −0.001); .017**	**−0.003 (−0.005, −0.000); .033**	**−0.003 (−0.005, −0.000); .021**	−0.002 (−0.005, 0.000); .103
Pegboard dominant hand	**0.154 (0.024, 0.283); .021**	0.133 (−0.000, 0.266); .050	**0.135 (0.001, 0.269); .049**	0.093 (−0.029, 0.216); .132
Pegboard nondominant hand	**0.245 (0.116, 0.374); <.001**	**0.221 (0.089, 0.352); .001**	**0.236 (0.101, 0.371); <.001**	**0.195 (0.069, 0.321); .003**

Note: CES-D = Center for Epidemiologic Studies Depression Scale; CI = confidence interval; CVLT = California Verbal Learning Test; DSST = Digit Symbol Substitution Test. Bold numbers reflect significance.

Olfactory function is known to change with aging and to predict dementia and PD. This study suggests that olfactory function may provide a window into the earliest age-related brain changes that affect neural aspects of age-related movement decline. Although the neuroanatomy linking olfactory function to motor function is well understood, and neuroimaging studies suggest consistent regional age effects, future longitudinal studies combining olfaction, mobility, and neuroimaging might provide further insights into the sequence of events and causal pathways. We hope these early findings may lead to further research, and ultimately, to new strategies for preventing the dysmobility of aging (26).

Supplementary Material

Supplementary data are available at *The Journals of Gerontology, Series A: Biological Sciences and Medical Sciences* online.

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Conflict of Interest

None.

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