Published in final edited form as:

Prev Med. 2020 October ; 139: 106234. doi:10.1016/j.ypmed.2020.106234.

Barriers to eating are associated with poor physical function in older women

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Author contributions: MLN, LVH, JS, MS and LFT conceived of the idea, developed the survey instrument and oversaw data collection. These authors plus KJ and RB assisted with and oversaw study subject recruitment. RPH conducted data analysis. MLN was the primary study author and all authors participated in manuscript revisions, final decisions about data analysis and presentation and all authors approved of the final manuscript.

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Conflict of interest: All authors have declared no financial or personal conflict of interest.

Abstract

Older adults have physical and social barriers to eating but whether this affects functional status is unknown. We examined associations between eating barriers and physical function in the Women's Health Initiative (WHI). In 2012-14, a subset of alive and participating women (n=5910) completed an in-home examination including the Short Physical Performance Battery (SPPB) (grip strength, balance, timed walking speed, chair stand). WHI participants complete annual mailed questionnaires; the 2013-14 questionnaire included items on eating alone, eating < two meals/day, dentition problems affecting eating, physical difficulties with cooking/shopping and monetary resources for food. Linear regression tested associations of these eating barriers with SPPB, adjusting for BMI, age, race/ethnicity, and medical multimorbidities. Over half (56.8%) of participants were ≥ 75 years, 98.8% had a BMI ≥ 25.0 kg/m² and 66% had multimorbidities. Eating barriers, excluding eating alone, were associated with significantly lower total (all p<0.001) and component-specific, multivariate-adjusted SPPB scores (all p<0.05). Compared to no barriers, eating < two meals/day (7.83 vs. 8.38, p<0.0002), dentition problems (7.69 vs. 8.38, p<0.0001), inability to shop/prepare meals (7.74 vs. 8.38, p<0.0001) and insufficient resources (7.84 vs. 8.37 p<0.001) were significantly associated with multivariate-adjusted mean SPPB score < 8. Models additionally adjusting for Healthy Eating Index-2010 had little influence on scores. As barriers increased, scores declined further for grip strength (16.10 kg for 4-5 barriers, p=0.001), timed walk (0.58 meters/second for 4-5 barriers, p=0.001) and total SPPB (7.27 for 4-5 barriers, p<0.0001). In conclusion, in this WHI subset, eating barriers were associated with poor SPPB scores.

Keywords

physical function; older adults; postmenopausal; eating; obesity

Introduction

The 2010 U.S. Census documented that over 40 million adults were ≥ 65 years and over 5 million were ≥ 85 years.¹ By 2050, approximately 83.7 million U.S. adults will be ≥ 65 years.¹ While increased longevity is laudable, aging is associated with multiple physiological changes leading to barriers to healthy eating and compromised nutritional status. Saliva production decreases, peristalsis slows, dentition deteriorates, and the hunger, thirst and satiety sensations become dysregulated in older individuals.² These physiologic changes may cause alterations in food and fluid choices leading to unintended weight changes and declines in nutritional status and health. Moreover, age related sensory changes, including deterioration of olfaction, hearing and vision, make shopping and food preparation more arduous while diminishing food enjoyment.³ Age-related changes in dentition limit the types of foods that can be safely masticated. Changes in living conditions (i.e., loss of spouse, isolation) may adversely impact interest in food and nutrient intake.⁴ Taken together, the aging process generates impediments or barriers to food intake, which is a concern for achieving and maintaining proper nutritional status.

The special nutritional needs of older adults were recognized in the 1990s when a collaborative effort of the American Dietetic Association, the National Council on Aging

and the American Academy of Family Physicians launched the Nutrition Screening Initiative.⁵ This Initiative was designed to help older adults, personal care providers and health care providers identify those at risk for nutrition-related diseases. The Nutrition Screening Initiative created a tool called the DETERMINE checklist,⁶ which is still recognized as an important means for screening older individuals' nutritional risk.⁷ For example, many studies documented associations between poor diet and surgical complications,^{8,9} as well as specific health outcomes including cardiovascular disease or diabetes,¹⁰ and functional measures such as frailty.¹¹ A 2016 narrative review examined cross-sectional, cohort and intervention studies of the relationship between nutrient intake and aging symptomology.¹² The authors reported inverse associations of energy, protein and diet quality with frailty, but study methods were too heterogeneous to offer firm synthesis. A 2017 systematic review reported associations between poor diet quality and poor intake of specific nutrients with increased frailty among elderly.¹³

Physical function is closely related to frailty. Physical function is assessed with well-established measures¹⁴ that are objective tests of the ability to complete specific tasks, such as rising from a chair and walking a short distance. Scores from these tests reliably predict mortality and nursing home admission.^{14,15} A gap in the literature is whether physical and psychosocial barriers to eating, identified by the DETERMINE checklist, is associated with functional outcomes in older adults. To address this gap, we used data from the Women's Health Initiative (WHI) to investigate whether selected barriers to eating, such as insufficient funds for foods, psychosocial challenges (e.g. eating alone) and physical barriers (e.g. physically unable to shop, cook) were associated with physical function measures in WHI. We hypothesized that barriers to eating would be associated with poor physical function in older, community dwelling women.

Methods

Participants

WHI began in 1993 at 40 U.S. clinical centers. WHI goals were to study the etiology and prevention of morbidity and mortality in postmenopausal women in three overlapping clinical trials and an observational study ([clinicaltrials.gov](https://clinicaltrials.gov/ct2/show/study/NCT00000611) identifier: [NCT00000611](https://clinicaltrials.gov/ct2/show/study/NCT00000611)). WHI design, implementation, and results have been extensively detailed elsewhere¹⁶ and at www.whi.org, which links to all WHI data collection instruments, consent forms and protocols. Briefly, eligible women were 50-79 years of age, postmenopausal, residing near a clinical center, able to give voluntary informed consent and had predicted survival of three years or more. Exclusion criteria differed between the clinical trials and the observational study, including exclusion of women with a cancer diagnosis within the past 10 years from the clinical trials, but not from the observational cohort. All procedures were approved by the Institutional Review Boards of the 40 clinical centers and the Clinical Coordinating Center (CCC) at Fred Hutchinson Cancer Research Center (Seattle, WA). All participants signed written, informed consent.

Upon completion of initial WHI study period, women were invited to be re-consented in 2005 and 2010 for additional follow-up, which continues today. As part of this follow-up, 7,875 women enrolled in a WHI sub-study, "The Long-Life Study" (LLS) and completed a

one-time home visit 2012-2013. Women were eligible for the LLS if they: (1) were part of the WHI “Medical Records Cohort” for which several medical outcomes were fully adjudicated (this included all African-American and Hispanic participants and all WHI Hormone Trial participants); (2) had or were scheduled to have genome-wide association studies; and (3) had baseline cardiovascular disease biomarker studies. Age eligibility for home visit participation was initially 72 years on 1/1/2012 and later expanded to include 65 years followed by no age restrictions for minorities. Age eligibility for European Americans remained 81 years on 1/1/2012. Exclusion criteria included inability to provide informed consent or not living independently. The projected sample size for LLS was 8,000 women; participants were drawn from an eligible recruitment pool of 14,081 participants. 7,875 women (98.4% of intended sample size) completed the LLS home visit (Figure 1). Supplementary Table 1 displays demographic characteristics of all LLS-eligible women and LLS-eligible and participating women. At LLS home visits participants signed informed consent, completed a clinical assessment (height, weight, vital signs) and tests of functional status. Trained and certified staff from Examination Management Services Inc, (EMSI) conducted all procedures.

Measurement of Barriers to Eating

All consented WHI participants are invited to complete annual questionnaires by mail. These updates query current health status, weight/weight change, health behaviors (smoking, physical activity and sleep), psychosocial factors, and various other domains. In 2013-2014, five questions were included in the annual questionnaire to obtain information on barriers to eating. This timing for the annual questionnaire overlapped with the 2012-2013 LLS home visit. The barriers to eating questions were adapted from a validated screening tool developed to help health care providers identify older adults at nutrition risk: the DETERMINE checklist ^{5, 6} Five of the original 10 screening question with yes/no response options were selected for use in this study. These items included: 1) I eat fewer than 2 meals per day; 2) I eat alone most of the time; 3) I have tooth or mouth problems that make it hard for me to eat; 4) I am not always physically able to shop, cook and/or feed myself; and 5) I don't always have enough money to buy the food I need.

Physical Function Tests

Physical function was assessed during LLS using grip strength and components of the Short Physical Performance Battery (SPPB): balance, timed walk and chair stand tests. Staff explained and demonstrated all components prior to participants attempting the tests. For the grip strength test, a calibrated Jamar hand-grip dynamometer measured grip strength. Participants completed a submaximal trial followed by two measurements in each arm. Coaching encouraged maximal performance. Results were recorded to the nearest kilogram with the mean of the two dominant hand measures used for analysis. For SPPB tests, the protocol was based on that used in the Health ABC Study. ¹⁷ The balance test comprised holding four standing positions (side-by-side, semi-tandem, tandem and one-leg) with eyes open for 10 seconds for the side-by side and 30 seconds for all other positions. Assistive devices such as walkers or canes were not permitted during the stand tests. Staff measured the stand times with a stopwatch. The timed walk assessed gait speed. Staff affixed a 4-meter measuring ribbon to the floor to mark the course and participants were encouraged to walk

the course at their normal walking speed while staff timed it using a stopwatch. Walkers and canes were discouraged but permitted if necessary, during the timed walk. The walk test was conducted twice, and the mean of the measures was used for analysis. A straight-back armless chair with a hard seat placed against a wall was used for the chair stand. Participants folded their arms across their chest and stood up without assistance. If successful, the procedure was repeated five times as quickly as possible. Timing by stopwatch began with the command to stand and ended after the fifth repetition. The Established Populations for the Epidemiologic Studies of the Elderly (EPESE) ¹⁴ approach was used to compute the SPPB summary score, which was the sum of three individual scores for total balance, the chair stand and gait speed. The total SPPB score range is 0 to 12 where a lower score is worse performance and score <10 indicates poor physical function.¹⁸

Other Data

Demographic characteristics and medical history were obtained from the WHI database. Multimorbidities were defined as two or more of the following reported at baseline or follow-up: coronary heart disease, stroke, cancer, diabetes, hip fracture, osteoarthritis, depressive symptoms, chronic obstructive pulmonary disease, cognitive impairment, sensory impairment, frequent falls or urinary incontinence.¹⁵ Dietary assessment was optional for LLS participants through a separate ancillary study. Women were invited to complete a self-administered food frequency questionnaire (FFQ) approximately one month after the home visit. 6,095 (77%) participants returned a completed FFQ, of which 363 (5.9%) were excluded because energy intake was outside acceptable limits for reliability (<500 kcals/day and >5000 kcals/day). Healthy Eating Index-2010 (HEI-2010) scores, as described previously,¹⁸ were computed.

Statistical Analysis

WHI participants completing both the 2012-2013 LLS home visit and the 2013-2014 annual mailed questionnaire comprised the primary sample set for this cross-sectional analysis. Participants were excluded for known movement disorders (e.g., Parkinson's Disease, lupus), Alzheimer's Disease, Modified Mini Mental State Examination (3MSE) score ≤ 8 or if wheelchair bound. Following exclusions, $n=5,910$ participants were included. Those completing the optional FFQ ($n=5010$) were in subgroup analyses. Descriptive statistics characterized the study sample. Linear regression tested associations between the five barriers to eating (as yes/no exposures) and functional outcomes of grip strength, chair stand, timed walk and overall SPPB score, each as continuous measures. We also tested whether having more barriers (categorized as none, 1, 2-3, 4-5) were associated with worse functional status. Outcome variables with skewed distributions (e.g., chair stand) were log transformed and then back transformed for presentation. Least squared means (or geometric means for the chair stand) and standard errors are presented. All models were adjusted for age (continuous) at the start of WHI Extension Period 2, race/ethnicity (categorical), home visit-measured body mass index (BMI) (log transformed from continuous), and history of multimorbidity (categorical). Missing data on comorbidities were handled as follows: if a participant had no reported incidence of a given condition but had a missing value for the condition at any time point during WHI follow-up, then she was counted as missing for that variable. For example, if a woman had no incident coronary heart disease, but had missing

history at baseline, she was coded as missing for that condition. For the overall multi morbidity score, a participant was counted as missing if she had <2 conditions and had a missing value for any of the conditions. For the outcome variables, many women were not able to complete all the physical function tests (n=22, 11 and 116 were not able to complete the grip strength, timed walk and chair stand, respectively). Missing grip strength was set to zero while missing timed walk and chair stand were set to the equivalent of the 99th percentile of the distribution since setting to zero for these tests would have given an inaccurate ‘better’ test thus biasing the results. Additional analyses adjusted for HEI-2010 for the subset with available data. All tests were two-sided and statistical significance was set to $p<0.05$. Analyses were completed with SAS (version 9.4, SAS Institute, Cary, NC).

Results

Table 1 shows that over half of the participants were > 75 years and half were Black or Hispanic. Less than 2% of the participants had a BMI ($<25.0 \text{ kg/m}^2$) and two-thirds had two or more medical morbidities. Women reporting fewer than two meals per day were predominantly less than 75 years (58%), Black (48.1%), obese (BMI $>30.0 \text{ kg/m}^2$) (76.4%) or had at least two medical conditions (74.8%). Half of women reported eating most of their meals alone, and this eating pattern was a common behavior among older (62.6%) and white women (51.3%) or those with higher BMI (69.2%). Tooth and mouth problems were less commonly reported (5%) but those who did were older (52.1%), white (43.1%), obese (73.1%) or have multiple medical problems (79.1 %). Those not always physically able to shop, cook or feed themselves were older (65.6%), obese (73.3%) or with multiple medical co-morbidities (80%). Insufficient economic resources to purchase food was not frequently reported but was more common among younger (59.3%), Black (55.2%) obese (78.6%) or women with multiple comorbidities (79.4%).

Table 2 presents associations between eating barriers and measures of physical function. Eating fewer than two meals/day was associated with significantly lower adjusted mean values for grip strength (17.65 vs. 18.54, $p=0.03$), timed walked (0.624 vs. 0.681 meter/second, $p=0.001$) and overall SPPB score (7.69 vs. 8.38, $p=0.0002$), and was marginally associated with adjusted mean lower chair stand time (0.326 vs. 0.341 seconds, $p=0.05$). Results for grip strength and chair stand were no longer statistically significant after HEI-2010 adjustment in the subgroup analysis. Eating difficulties due to tooth and mouth problems were associated with adjusted mean lower grip strength (17.52 vs. 18.54 kg, $p=0.01$), timed walk (0.616 vs. 0.681 meters/second, $p=0.0003$) and overall SPPB score (7.69 vs. 8.38, $p<0.0001$). Results were slightly attenuated, but all remained statistically significant after adjusting for HEI-2010 scores in the subgroup analysis. Women with an inability to physically shop, cook or feed themselves had significantly lower adjusted mean timed walk (0.646 vs. 0.680, $p=0.04$) and overall SPPB score (7.74 vs. 8.38, $p<0.0001$). The timed walk score was slightly attenuated (0.648 vs. 0.680 meters/second) when adjusting for HEI-2010 but the overall SPPB score remained strong and significant. Reporting insufficient economic resources to purchase food was associated with lower adjusted mean grip strength (17.31 vs. 18.55 kg, $p=0.003$), timed walk (0.642 vs. 0.680 meters/second, $p=0.04$) and total SPPB score (7.84 vs. 8.37, $p=0.001$). Only the timed walk score lost statistical significance

(0.653 vs. 0.679, $p<0.21$) when adjusted for HEI-2010 in the subgroup analysis. Eating alone was not associated with any objective measures of physical function.

Table 3 categorized women as having no 0, 1, 2-3 or 4-5 eating barriers in relation to physical function measures. In the adjusted models, as the number of barriers increased, declines in physical function increased with significantly decreased grip strength (16.0 kg for 4-5 barriers vs. 18.49 for none, $p=0.001$), time walk (0.58 meters/second for 4-5 barriers vs. 0.68 meters/second for none, $p=0.001$) and total SPPB score (7.27 for 4-5 barriers vs. 8.41 for none, $p<0.0001$). In the subgroup analysis with adjustment for HEI-2010 scores, results were slightly attenuated, but all remained statistically significant.

Discussion

In this study of over 5,900 independently living older women, barriers to eating were infrequently reported. However, among those reporting barriers, these barriers were associated with significantly decreased performance of objective measures of physical function. Those who reported eating less than two meals per day, tooth and mouth problems, inability to physically shop, cook and feed self and insufficient economic resources had significantly lower SPPB scores. These lower mean scores remained robust when adjusted for variables that could independently influence scores including age, race/ethnicity, BMI and history of medical multimorbidity. Some findings were attenuated after adjustment for HEI-2010 score in the subset of participants who had available FFQ data, but the magnitude of change with HEI-2010 adjustments was small and most results remained statistically significant. Notably, as the number of barriers increased, physical function was significantly lower; these women may be at risk of nutrition-related morbidity and mortality.

The range of SPPB scores in this sample of women would be considered 'fair'.¹⁹ A recent systematic review and meta-analysis²⁰ confirmed that SPPB scores of 7-9 and 4-6 were associated with an increased risk of all-cause mortality (OR=1.5 and 2.41, respectively) compared to scores of 10-12. Grip strength < 20 kg in women was recently shown to be highly predictive of mobility limitations in older women²¹ as well as overall muscle weakness and predictor of sarcopenia.²² Both SPPB and grip strength have been used for in-patient assessment;²³ but are not commonly used for geriatric assessment in the community setting despite their predictive value.²⁴⁻²⁷

Measures of physical function reliably predict declines in activities of daily living, quality of life, falls and death.²⁸⁻³⁰ Minneci reported that mean SPPB scores of 8.7 and 8.5 were significantly associated with falls in the previous year and death within four years, respectively.²⁸ Deshpande reported that activity restriction, partly due to fear of falling was linked to low SPPB scores.³¹ Since the multivariate adjusted mean SPPB scores for each of the eating behaviors in this WHI report were lower than those reported by Minneci and Deshpande (except for those who severely restricted activity due to fear of falling),³¹ the findings presented here are cause for concern. The WHI participants in the 2012-2013 LLS home visit were living independently and preparing their own meals, but barriers to eating were independently associated with low scores on the physical function tests. We are unaware of any other studies that have reported associations between age-related physical

and psychosocial barriers to eating and low scores on objective measures of physical function such as the SPPB. While a body of literature exists on associations of diet quality with physical function,^{11, 13, 32, 33} this report provides a novel finding that barriers to food access and eating were associated with physical function, most of which remained statistically significant with little change in the effect sizes after controlling for HEI-2010. A concern emerging from these data was the sharper declines in physical function as the number of eating barriers increased.

A notable finding from this report was that 98% of the participants were overweight or obese (BMI ≥ 25.0 kg/m²). Much of the nutrition and aging research has focused on undernutrition and unintended weight loss.^{8, 12, 34, 35} Although potentially counter-intuitive, these older WHI participants with overweight/obesity who often reported two or fewer meals per day, also had poor physical performance scores. Possible associations with sarcopenic obesity, recently described as a major risk factor for deterioration in muscle function in the elderly, cannot be ruled out.³⁶ Similar to the high prevalence of overweight/obesity in WHI, the mean BMI in the both Minneci²⁸ and Deshpande³¹ studies was 27.0 kg/m² suggesting that overweight in the elderly may be more common than previously recognized. While none of the aforementioned studies directly assessed sarcopenic obesity, our finding here suggests that sarcopenic obesity may be important to assess as part of future protocols in this age group. In addition, the results in this report underscore the need for nutrition strategies that help with weight management in older women without placing them at risk for loss of lean mass and development of sarcopenia. Important research and clinical gaps are the need to develop and test age-specific nutrition content for older women along with modest achievable physical activity that will improve physical function. Previous interventions mostly focused on provision of extra calories, protein supplements or various micronutrients.^{12, 13} Many studies also focused on prevention of frailty as an endpoint.^{30, 34, 35} Frailty was also noted as a risk factor for malnutrition in older adults in a recent report.⁷ These WHI data lend additional evidence that heavier, frail women may have different needs than underweight, frail women. Consequently, guidelines to address the nutritional and physical activity needs of the current population of older individuals should recognize such distinctions. Research is needed to identify the optimal calorie, macronutrient, micronutrient and diet quality intake for this ever-increasing age group. Effective strategies are needed to encourage physical activity and overcome the barriers to eating linked to poor physical performance identified in this study.

Strengths of this study include the well-characterized WHI cohort women followed for more than two decades and the LLS administered standardized, objective measures of physical function. Limitations include a cross-sectional design with physical function tested on a single day that may not reflect usual performance; and the eating barrier questions were not asked not on the same day. Another limitation is that the LLS subset is not intended to be representative of the WHI overall. Additionally, HEI-2010 score are not available on all LLS participants. Finally, as in any study, the possibility for Type I errors (false positives) may exist. For example, in this study, two tests could have been statistically significant on chance alone. We urge readers to be judicious in assessment of results.

Conclusions

This study identified physical and psychosocial barriers underlying poor eating behaviors. These barriers to eating were significantly associated with poor functional status, which is highly predictive of subsequent health events and mortality. Whether intervening on older women to improve physical function can effectively reverse long-standing poor nutrition habits is currently unknown but constitutes a high research priority given the rapidly aging U.S. population.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgements

Sponsor's role: The WHI program is funded by the National Heart, Lung, and Blood Institute, National Institutes of Health, U.S. Department of Health and Human Services through contracts HHSN268201600018C, HHSN268201600001C, HHSN268201600002C, HHSN268201600003C, and HHSN268201600004C. The authors acknowledge the following investigators in the WHI Program: Program Office: (National Heart, Lung, and Blood Institute, Bethesda, Maryland) Jacques E. Rossouw, Shari Ludlam, Dale Burwen, Joan McGowan, Leslie Ford, and Nancy Geller. Clinical Coordinating Center: Women's Health Initiative Clinical Coordinating Center: (Public Health Sciences, Fred Hutchinson Cancer Research Center, Seattle, WA) Garnet L. Anderson, Ross L. Prentice, Andrea Z. LaCroix, and Charles L. Kooperberg. Investigators and Academic Centers: (Brigham and Women's Hospital, Harvard Medical School, Boston, MA) JoAnn E. Manson; (MedStar Health Research Institute/Howard University, Washington, DC) Barbara V. Howard; (Stanford Prevention Research Center, Stanford, CA) Marcia L. Stefanick; (The Ohio State University, Columbus, OH) Rebecca Jackson; (University of Arizona, Tucson/Phoenix, AZ) Cynthia A. Thomson; (University at Buffalo, Buffalo, NY) Jean Wactawski-Wende; (University of Florida, Gainesville/Jacksonville, FL) Marian C. Limacher; (University of Iowa, Iowa City/Davenport, IA) Robert M. Wallace; (University of Pittsburgh, Pittsburgh, PA) Lewis H. Kuller; (Wake Forest University School of Medicine, Winston-Salem, NC) Sally A. Shumaker Women's Health Initiative Memory Study: (Wake Forest University School of Medicine, Winston-Salem, NC) Sally A. Shumaker. Permission has been granted from those named on this acknowledgement statement. Naming of these individuals is a requirement of the WHI Publications and Presentations Committee.

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Figure 1.
Women's Health Initiative and Long Life Study

Table 1.

Eating and food procurement and preparation behaviors among postmenopausal women in the WHI Long Life Study*

Characteristic	Total (N= 5,910)		Eat <2 meals/day (N = 314)		Eat alone most of the time (N = 2,950)		Presence of eating difficulties due to tooth/mouth problems (N = 290)		Not always able to physically shop, cook and feed self (N = 381)		Insufficient economic resources to purchase food (N = 297)	
	N	%	N	%	N	%	N	%	N	%	N	%
Age at start of WHI Ext 2, y												
<75	2553	43.2	182	58.0	1102	37.4	139	47.9	131	34.4	176	59.3
75	3357	56.8	132	42.0	1848	62.6	151	52.1	250	65.6	121	40.7
Race/ethnicity												
White	2993	50.6	90	28.7	1513	51.3	125	43.1	172	45.1	69	23.2
Black	1912	32.4	151	48.1	1068	36.2	109	37.6	161	42.3	164	55.2
Hispanic	1005	17.0	73	23.2	369	12.5	56	19.3	48	12.6	64	21.5
Body mass index (BMI), kg/m ²												
18.5 – 24.9	69	1.2	5	1.6	43	1.5	5	1.7	8	2.1	4	1.4
25.0 – 29.9	1784	30.5	68	22.0	854	29.3	72	25.2	92	24.6	59	20.1
30.0	3995	68.3	236	76.4	2019	69.2	209	73.1	274	73.3	231	78.6
History of multimorbidity*	3700	66.1	223	74.8	1923	68.7	223	79.1	288	80.0	228	79.4

* Defined as 2 or more of the following conditions at baseline or during follow-up: coronary disease, stroke, cancer, diabetes, hip fracture, osteoarthritis, depression, chronic obstructive pulmonary disease, cognitive impairment, sensory impairment, frequent faller, or urinary incontinence.

* cell sizes, including for BMI, may vary due to missing values

Associations of eating behaviors with objective measures of physical function in older, community dwelling women *

Table 2.

	Grip Strength, kg			Repeated Chair Stand, sec [‡]			Timed Walk, m/sec			EPESE SPPB Score		
	N	LS Mean	(95% CI)	N	LS Mean	(95% CI)	N	LS Mean	(95% CI)	N	LS Mean	(95% CI)
Eat <2 meals/day												
Unadjusted												
No	5183	18.38	(18.18, 18.57)	5082	0.338	(0.335, 0.342)	4977	0.674	(0.666, 0.682)	5094	8.30	(8.24, 8.37)
Yes	297	18.27	(17.47, 19.06)	267	0.324	(0.310, 0.339)	277	0.605	(0.571, 0.639)	282	7.76	(7.46, 8.04)
p-value [‡]		0.79			0.07			0.0001			0.0004	
Adjusted [§]												
No	4863	18.54	(18.33, 18.75)	4775	0.341	(0.337, 0.345)	4679	0.681	(0.672, 0.691)	4783	8.38	(8.30, 8.45)
Yes	277	17.65	(16.88, 18.42)	252	0.326	(0.312, 0.341)	260	0.624	(0.590, 0.658)	265	7.83	(7.55, 8.12)
p-value [‡]		0.03			0.05			0.001			0.0002	
Adjusted (subgroup) [#]												
No	4124	18.51	(18.28, 18.74)	4078	0.341	(0.337, 0.345)	3974	0.681	(0.671, 0.691)	4071	8.38	(8.30, 8.46)
Yes	226	18.02	(17.17, 18.87)	205	0.332	(0.316, 0.349)	206	0.629	(0.591, 0.668)	212	7.86	(7.55, 8.18)
p-value		0.27			0.29			0.01			0.002	
Eat alone most of the time												
Unadjusted												
No	2732	18.53	(18.27, 18.79)	2703	0.341	(0.336, 0.345)	2654	0.685	(0.674, 0.696)	2712	8.42	(8.33, 8.52)
Yes	2748	18.21	(17.95, 18.47)	2646	0.334	(0.330, 0.339)	2600	0.655	(0.644, 0.666)	2664	8.12	(8.03, 8.22)
p-value [‡]		0.09			0.07			0.0001			<0.0001	
Adjusted [§]												
No	2561	18.47	(18.20, 18.74)	2542	0.338	(0.333, 0.343)	2491	0.679	(0.667, 0.690)	2549	8.35	(8.25, 8.45)
Yes	2579	18.51	(18.23, 18.79)	2485	0.343	(0.337, 0.348)	2448	0.677	(0.665, 0.690)	2499	8.34	(8.24, 8.44)
p-value [‡]		0.83			0.17			0.88			0.86	
Adjusted (subgroup) [#]												
No	2169	18.49	(18.19, 18.78)	2176	0.338	(0.332, 0.343)	2111	0.679	(0.666, 0.692)	2173	8.36	(8.25, 8.46)

	Grip Strength, kg			Repeated Chair Stand, sec [†]			Timed Walk, m/sec			EPESE SPPB Score		
	N	LS Mean	(95% CI)	N	LS Mean	(95% CI)	N	LS Mean	(95% CI)	N	LS Mean	(95% CI)
Yes	2181	18.48	(18.18, 18.78)	2107	.0343	(0.338, 0.349)	2069	0.677	(0.664, 0.690)	2110	8.35	(8.24, 8.46)
<i>p</i> -value		0.98			0.15			0.83			0.89	
Presence of eating difficulties due to tooth/mouth problems												
<i>Unadjusted</i>												
No	5209	18.41	(18.22, 18.60)	5096	0.338	(0.335, 0.342)	5000	0.674	(0.666, 0.682)	5113	8.31	(8.25, 8.38)
Yes	271	17.57	(16.74, 18.40)	253	0.322	(0.307, 0.337)	254	0.597	(0.561, 0.632)	263	7.51	(7.21, 7.82)
<i>p</i> -value [‡]		0.05			0.03			<0.0001			<0.0001	
<i>Adjusted</i> [§]												
No	4880	18.54	(18.33, 18.75)	4783	0.341	(0.337, 0.345)	4694	0.681	(0.672, 0.690)	4796	8.38	(8.30, 8.46)
Yes	260	17.52	(16.73, 18.32)	244	0.330	(0.315, 0.345)	245	0.616	(0.580, 0.651)	252	7.69	(7.40, 7.99)
<i>p</i> -value [‡]		0.01			0.16			0.0003			<0.0001	
<i>Adjusted (subgroup)</i> [#]												
No	4133	18.53	(18.30, 18.76)	4076	0.341	(0.337, 0.345)	3977	0.680	(0.670, 0.690)	4072	8.38	(8.30, 8.47)
Yes	217	17.59	(16.72, 18.46)	207	0.331	(0.315, 0.347)	203	0.633	(0.594, 0.672)	211	7.73	(7.41, 8.05)
<i>p</i> -value		0.04			0.22			0.02			<0.0001	
Not always able to physically shop, cook and feed self												
<i>Unadjusted</i>												
No	5131	18.45	(18.26, 18.64)	5042	0.339	(0.336, 0.343)	4933	0.675	(0.667, 0.683)	5041	8.34	(8.27, 8.41)
Yes	349	17.18	(16.45, 17.92)	307	0.312	(0.300, 0.325)	321	0.596	(0.564, 0.627)	335	7.25	(6.98, 7.52)
<i>p</i> -value [‡]		0.001			0.0001			<0.0001			<0.0001	
<i>Adjusted</i> [§]												
No	4816	18.52	(18.31, 18.73)	4739	0.341	(0.337, 0.345)	4640	0.680	(0.671, 0.689)	4736	8.38	(8.31, 8.46)
Yes	324	18.00	(17.28, 18.71)	288	0.328	(0.314, 0.342)	299	0.646	(0.614, 0.678)	312	7.74	(7.48, 8.01)
<i>p</i> -value [‡]		0.16			0.07			0.04			<0.0001	
<i>Adjusted (subgroup)</i> [#]												

	Grip Strength, kg			Repeated Chair Stand, sec [‡]			Timed Walk, m/sec			EPESE SPPB Score		
	N	LS Mean	(95% CI)	N	LS Mean	(95% CI)	N	LS Mean	(95% CI)	N	LS Mean	(95% CI)
No	4088	18.51	(18.28, 18.74)	4046	0.341	(0.337, 0.346)	3937	0.680	(0.670, 0.690)	4029	8.39	(8.31, 8.47)
Yes	262	18.02	(17.23, 18.81)	237	0.327	(0.313, 0.343)	243	0.648	(0.613, 0.684)	254	7.75	(8.47, 8.04)
<i>p-value</i>		0.23			0.08			0.09			<0.0001	
Insufficient economic resources to purchase food												
<i>Unadjusted</i>												
No	5214	18.38	(18.19, 18.57)	5097	0.338	(0.335, 0.342)	5016	0.673	(0.665, 0.681)	5122	8.30	(8.24, 8.37)
Yes	266	18.11	(17.27, 18.95)	252	0.324	(0.310, 0.339)	238	0.619	(0.583, 0.656)	254	7.69	(7.38, 8.00)
<i>p-value</i> [‡]		0.53			0.07			0.01			0.0001	
<i>Adjusted[§]</i>												
No	4885	18.55	(18.34, 18.76)	4783	0.341	(0.337, 0.345)	4712	0.680	(0.671, 0.689)	4805	8.37	(8.29, 8.45)
Yes	255	17.31	(16.50, 18.12)	244	0.332	(0.317, 0.347)	227	0.642	(0.605, 0.678)	243	7.84	(7.54, 8.14)
<i>p-value</i> [‡]		0.003			0.28			0.04			0.001	
<i>Adjusted (subgroup)[#]</i>												
No	4130	18.54	(18.31, 18.77)	4069	0.340	(0.336, 0.345)	3986	0.679	(0.669, 0.689)	4074	8.37	(8.29, 8.46)
Yes	220	17.46	(16.59, 18.32)	214	0.341	(0.325, 0.358)	194	0.653	(0.614, 0.693)	209	7.94	(7.62, 8.26)
<i>p-value</i>		0.02			0.93			0.21			0.001	

[‡] Computations for the repeated chair stand were done on the natural log scale and values were back-transformed. Geometric means are presented.

[‡] P-values are for the main effect of the corresponding eating behavior in a linear regression model and come from type III sum of squares F-tests. All testing for the repeated chair stand was done on the log scale.

[§] Adjusted for age at the start of WHI Extension 2, race/ethnicity, body mass index and history of multimorbidity.

[#] Adjusted for age at the start of WHI Extension 2, race/ethnicity, body mass index, HEI-2010 score and history of multimorbidity

* cell sizes may vary due to missing values

Table 3.

Associations of number of eating behaviors with objective measures of physical function in older, community dwelling women*

	Grip Strength, kg			Repeated Chair Stand, sec**			Timed Walk, m/sec			EPESE SPPB Score		
	N	LS Mean	(95% CI)	N	LS Mean	(95% CI)	N	LS Mean	(95% CI)	N	LS Mean	(95% CI)
Number of eating behaviors												
<i>Unadjusted</i>												
None	2396	18.59	(18.31,18.87)	2407	0.344	(0.339,0.349)	2346	0.69	(0.68,0.70)	2396	8.53	(8.43,8.63)
1	2371	18.30	(18.02,18.58)	2435	0.336	(0.331,0.341)	2323	0.66	(0.65,0.68)	2371	8.20	(8.10,8.30)
2 – 3	569	17.88	(17.32,18.44)	597	0.319	(0.309,0.329)	547	0.61	(0.58,0.63)	569	7.50	(7.40,7.81)
4 – 5	40	16.77	(14.63,18.90)	41	0.328	(0.292,0.368)	38	0.54	(0.45,0.63)	40	7.10	(6.33,7.87)
<i>p-value^{††}</i>		0.05			0.0002			<0.0001			<0.0001	
<i>Adjusted^{‡‡}</i>												
None	2249	18.49	(18.20,18.77)	2253	0.340	(0.335,0.346)	2194	0.68	(0.67,0.70)	2243	8.41	(8.31,8.52)
1	2291	18.69	(18.40,18.98)	2225	0.343	(0.337,0.348)	2193	0.68	(0.67,0.70)	2233	8.38	(8.27,8.49)
2 – 3	561	17.72	(17.17,18.27)	512	0.328	(0.318,0.338)	516	0.64	(0.61,0.66)	534	7.79	(7.59,8.00)
4 – 5	39	16.10	(14.12,18.08)	37	0.332	(0.297,0.372)	36	0.58	(0.49,0.67)	38	7.27	(6.54,8.00)
<i>p-value^{††}</i>		0.001			0.08			0.001			<0.0001	
<i>Adjusted (subgroup)[#]</i>												
None	1909	18.49	(18.18,18.80)	1928	0.340	(0.335,0.346)	1863	0.68	(0.67,0.70)	1914	8.44	(8.32,8.55)
1	1940	18.67	(18.36,18.99)	1894	0.342	(0.337,0.348)	1861	0.68	(0.67,0.70)	1895	8.39	(8.28,8.51)
2-5	471	17.84	(17.23,18.44)	432	0.331	(0.318,0.339)	403	0.64	(0.61,0.67)	446	7.85	(7.63,8.01)
4-5	30	16.47	(14.17,18.76)	29	0.365	(0.309,0.389)	26	0.64	(0.53,0.74)	28	7.76	(6.90,8.93)
<i>p-value</i>		0.03			0.25			0.02			<0.0001	

** Computations for the repeated chair stand were done on the natural log scale and values were back-transformed. Geometric means are presented.

^{††} P-values are for the main effect of number of eating behaviors in a linear regression model and come from type III sum of squares F-tests. All testing for the repeated chair stand was done on the log scale.

^{‡‡} Adjusted for age at the start of WHI Extension 2, race/ethnicity, body mass index and history of multimorbidity.

[#] Adjusted for age at the start of WHI Extension 2, race/ethnicity, body mass index, HEI-2010 score and history of multimorbidity

* Cell sizes may vary due to missing values