

# Optimism, Cynical Hostility, Falls, and Fractures: The Women's Health Initiative Observational Study (WHI-OS)

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## ABSTRACT

Traits of optimism and cynical hostility are features of personality that could influence the risk of falls and fractures by influencing risk-taking behaviors, health behaviors, or inflammation. To test the hypothesis that personality influences falls and fracture risk, we studied 87,342 women enrolled in WHI-OS. Optimism was assessed by the Life Orientation Test-Revised and cynical hostility, the cynicism subscale of the Cook-Medley questionnaire. Higher scores indicate greater optimism and hostility. Optimism and hostility were correlated at  $r = -0.31$ ,  $p < 0.001$ . Annual self-report of falling  $\geq 2$  times in the past year was modeled using repeated measures logistic regression. Cox proportional hazards models were used for the fracture outcomes. We examined the risk of falls and fractures across the quartiles (Q) of optimism and hostility with tests for trends; Q1 formed the referent group. The average follow-up for fractures was 11.4 years and for falls was 7.6 years. In multivariable (MV)-adjusted models, women with the highest optimism scores (Q4) were 11% less likely to report  $\geq 2$  falls in the past year (odds ratio [OR] = 0.89; 95% confidence intervals [CI] 0.85–0.90). Women in Q4 for hostility had a 12% higher risk of  $\geq 2$  falls (OR = 1.12; 95% CI 1.07–1.17). Higher optimism scores were also associated with a 10% lower risk of fractures, but this association was attenuated in MV models. Women with the greatest hostility (Q4) had a modest increased risk of any fracture (MV-adjusted hazard ratio = 1.05; 95% CI 1.01–1.09), but there was no association with specific fracture sites. In conclusion, optimism was independently associated with a decreased risk of  $\geq 2$  falls, and hostility with an increased risk of  $\geq 2$  falls, independent of traditional risk factors. The magnitude of the association was similar to aging 5 years. Whether interventions aimed at attitudes could reduce fall risks remains to be determined. © 2016 American Society for Bone and Mineral Research.

**KEY WORDS:** PERSONALITY; OPTIMISM; HOSTILITY; FRACTURES; FALLS; PROSPECTIVE STUDY; WOMEN'S HEALTH INITIATIVE

## Introduction

Personality traits of optimism (expecting good things to happen), pessimism (expecting bad things to happen), and cynical hostility (mistrust of people) have been linked to an overall increased mortality, cardiovascular disease (CVD), and CVD risk factors.<sup>(1)</sup> To our knowledge, few have explored whether personality traits influence risk of falls or fractures.<sup>(2)</sup>

Personality factors were identified as potentially contributing to fall risk in a report derived from focus groups with nursing home staff members.<sup>(3)</sup> Specific personality factors described in

relation to fall risk were "a desire for independence, dignity, impatience, and impulsiveness." In approaching falls/fractures prevention, Klosock and colleagues<sup>(3)</sup> noted the challenge and importance of understanding the interactions between person and environment. This review points out that research has scarcely explored how personality might affect fracture and fall risk. Type A personality has also been examined in the relation to fracture risk among athletes.<sup>(4)</sup> Athletes who had fractures were found to be more motivated, ambitious, and competitive (Type A).<sup>(4)</sup> In a cohort of community-dwelling older Chinese men and women, Type A patterns were independently associated with

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fall risk among men but not women.<sup>(5)</sup> Nevertheless, the risk of fractures and falls differs markedly in athletes and nursing home residents compared with community-based populations.

There are several mechanisms whereby personality could influence fall and fracture risk. Personality could influence a tendency toward riskier or unsafe behavior, eg, standing on ladders without support and, thus, the risk of fractures and falls. Personality can also influence lifestyle. For example, optimists tend to be more physically active,<sup>(6)</sup> and greater physical activity has been linked to lower fracture rates.<sup>(7)</sup>

In addition, higher rates of smoking are documented among Women's Health Initiative (WHI) participants with lower optimism scores.<sup>(1)</sup> Smoking, in turn, is associated with lower bone density, higher rates of fractures,<sup>(8)</sup> and unfavorable body composition (ie, greater visceral adiposity).<sup>(9–11)</sup> Pessimistic and hostile women in WHI have poorer diets, both at baseline entry into the study and over the 1-year intervention.<sup>(12,13)</sup> The combination of inactivity, adiposity, and poor diet could put individuals at risk for fractures and falls.

Another proposed mechanism linking personality to health suggests that lower optimism<sup>(14,15)</sup> and higher hostility<sup>(16)</sup> scores are associated with higher levels of inflammatory cytokines. Higher levels of inflammatory cytokines, in turn, have been associated with an increased risk of fracture.<sup>(17–20)</sup> Personality may also influence chronic disease by activating stress response systems.<sup>(2,21)</sup> For example, hostility impairs the stress-buffering effects of social support. Different patterns of neural activation in optimists and pessimists have been identified and may influence calibration of neural, cardiac, and endocrine physiology.<sup>(2,22)</sup> Personality tendencies may also influence medical adherence and, in turn, fracture, e.g., adherence to recommendations of calcium, vitamin D, hormone therapy, osteoporosis treatment, and through engaging in routine screening and clinical assessments. WHI participants with higher optimism scores were more likely to adhere to calcium supplements, whereas those with higher hostility were less likely to adhere.<sup>(23)</sup> Finally, personality traits can be protective against or conducive toward depression,<sup>(2,24)</sup> which has been linked to fractures<sup>(25)</sup> and falls,<sup>(26)</sup> perhaps through a host of factors that could predispose older women to falls and fractures. For example, optimism may influence how people cope with adversity or seek social support and, in turn, could influence the risk of depression.<sup>(21)</sup> Several of these mechanisms also underlie the association of optimism and cynical hostility with cardiovascular disease, e.g., lifestyle, inflammation, stress responses, and medical adherence.<sup>(2)</sup>

To test the hypothesis that personality traits of optimism and cynical hostility are associated with the risk of falls and fractures, we studied 87,342 women in the Women's Health Initiative Observational Study (WHI-OS). We hypothesized that higher optimism and lower cynical hostility will be associated with a lower risk of falls and fractures.

## Materials and Methods

The WHI-OS consisted of 93,676 women aged 50 to 79 at baseline; women were recruited at 40 US clinical centers (1993–1998) primarily using population-based mass mailings to age-eligible women.<sup>(27,28)</sup> Response rates varied from 2% to 20%, depending on the type of mailing list. Mass mailings were supplemented by community presentations, print ads, public service announcements, health fairs, and physician referrals.

Women were eligible to participate in the OS if they were not planning to move for at least 3 years, had a life expectancy of >3 years, did not have a substance abuse problem, mental illness, or dementia, and declined participation in the WHI-hormone or diet modification clinical trials. Our analytic sample consisted of 87,342 women after excluding women with no information on falls, optimism, hostility, or follow-up (Fig. 1).

When the OS ended on March 30, 2005, women were recontacted to participate in two extension studies: 77% of surviving women agreed to participate in the first extension (2005–2010) and 86% for the second extension (2010–2014).

### Measurement of optimism and hostility

Questionnaires that measured optimism and cynical hostility were administered to all participants at baseline. The Life Orientation Test-Revised measures optimism and contains six items.<sup>(29)</sup> Item ratings are summed to yield a total score that ranges from 6 to 30 (higher scores indicate greater optimism, and lower scores indicate greater pessimism). Sample questionnaire items were as follows: "In unclear times, I usually expect the best"; "If something can go wrong for me, it will" (reverse scoring), to which individuals indicate their level of agreement or disagreement on a multipoint scale. There were five options for answers to each question ranging from strongly disagree (score 1); disagree, neutral, agree, or strongly agree (score 5). Personality measures were considered as continuous variables in the analysis. Optimism scores were also categorized into quartiles based on the sample distribution, using the following cut-offs: highest (26; "optimists"); mid-high (24–25); mid-low (22–23); and lowest (<22; "pessimists").

Cynical hostility was assessed by the cynicism subscale of the Cook-Medley Questionnaire, which contains 13 true/false items, with higher scores indicating greater cynical hostility.<sup>(30)</sup> Example items are "I have often had to take orders from someone who did not know as much as I did," and "It is safer to trust nobody." Cynical hostility scores were added and categorized into quartiles, with the following cut-offs: most ( $\geq 6$ ); mid-high (4–5); mid-low (2–3); and least (0–1). In this

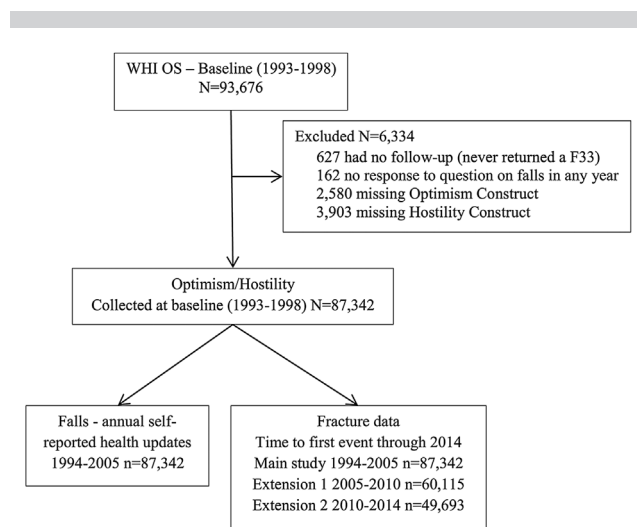


Fig. 1. Diagram of the analytic sample.

sample, the correlation between optimism and hostility was  $r = -0.31$ ,  $p < 0.001$ .

## Study outcomes

### Falls

Women were asked on annual self-reported health updates, "How many times did you fall and land on the floor or ground (do not include falls due to sports activities such as snow or water skiing or horseback riding)." The falls outcome was defined as annually repeated assessment of self-report of falling  $\geq 2$  times in the past year, similar to a previous WHI report.<sup>(31)</sup> Self-report of falls was discontinued during the extension phase, limiting the average follow-up for falls to 7.6 years.

### Fractures

Fractures were self-reported annually. All fractures reported up to August 2014 were included for an average follow-up of 11.4 years. Hip fractures were centrally adjudicated during the main study and extension 1. Hip fractures were self-reported for extension 2 (2010–2014). All other types of fractures were self-reported during the entire follow-up.

Total fractures included all reported clinical fractures except for those of the ribs, sternum, skull, face, fingers, toes, and cervical vertebrae. Fracture outcomes included hip, clinical vertebral, lower arm, and total fractures.<sup>(32)</sup>

### Other measurements

Demographic characteristics, medical history, lifestyle factors, and health status were collected using standardized questionnaires at the baseline examination. Calcium intake was defined as the dietary calcium intake assessed by food-frequency questionnaires developed and validated by the Fred Hutchinson Cancer Research Center (Seattle, WA, USA).<sup>(33)</sup> Information was also obtained about intake of calcium from supplements in the previous 2 weeks. Total vitamin D intake was similarly determined. Physical activity was assessed by a detailed questionnaire on the frequency and duration of walking and mild, moderate, and strenuous activities in the prior week. Kilocalories of energy expended was calculated (metabolic equivalent [MET]),  $\text{score} = \text{Kcal/hr/wk/kg}$ .<sup>(34)</sup> Assessment of depression was done with baseline questions drawn from the Center for Epidemiologic Studies–Depression Scale and the Diagnostic Interview Schedule. Response to the eight items were analyzed using an algorithm developed by Burnam et al.<sup>(35)</sup>

Information regarding current use of menopausal hormone therapy, daily oral corticosteroid use, baseline use of drugs for osteoporosis (bisphosphonates, selective estrogen receptor modulators [SERMs], calcitonin, parathyroid hormone), use of oral or injectable drugs for the treatment of diabetes (thiazolidinediones, dipeptidyl peptidase-4 inhibitors, meglitinides, glucagon-like peptide-1 agonists, insulin injection, amylin analog, sulfonylureas, biguanides, and alpha-glucosidase inhibitors) and hypnotics (barbiturates; benzodiazepines) was obtained.

### Statistical analyses

We used chi-square tests and ANOVA to compare characteristics of women across quartiles of optimism and cynical hostility.

For the analysis of falls, we used the generalized estimating equation (GEE) approach for repeated logistic regression models

to study the association between personality and  $\geq 2$  falls in the past year. We used Cox proportional hazard regression to determine the association between personality, and time to first fracture using separate regression models for total fractures and for each anatomical fracture location: hip, spine, and lower arm. Among women who experienced a fracture, duration of follow-up was defined as time to first fracture. Among women who did not experience a fracture during follow-up, duration of follow-up was defined as time until last follow-up visit, or death, whichever came first.

We examined the risk of falls and fractures per 1 standard deviation (SD) increase in optimism or cynical hostility and across quartiles of personality with quartile 1 (lowest) as referent. Tests for trends across quartiles were also conducted. All covariates were measured at baseline. We adjusted fall models for age, region, ethnicity/race, weight, height, treated diabetes, smoking status, general health status, hormone therapy, total calcium and vitamin D intake, and physical activity (model 1). Fracture models were additionally adjusted for baseline information on history of falls in the past 12 months, oral glucocorticoid use, and previous fracture. Subsequent models additionally adjusted for depression symptoms and use of antidepressant medication and hypnotics to test whether the association was influenced by depression and hypnotics (model 2). Finally, we adjusted the optimism models for hostility score and vice versa to test whether the associations with personality were independent of each other (model 3). Missing data on categorical covariates were recoded as unknown and included in our modeling. All analyses were completed in SAS version 9.4 (SAS Institute, Cary, NC, USA).

## Results

Optimists (quartile 4) in comparison to pessimists (quartile 1) were slightly younger, more likely to be white, better educated, less likely to have a personal or parental history of fracture, more physically active, more likely to drink alcohol, less likely to be a current smoker, and less likely to have a history of a fall (Table 1). Average body mass index and depression scores were lower among optimists than pessimists. The prevalence of diabetes was lower among optimists, and they were much less likely to report fair or poor health status. Optimists were also more likely to report current menopausal hormone use. Total calcium and vitamin D intake was also higher in optimists compared with pessimists. The prevalence of use of glucocorticoids, bisphosphonates, SERMs, anxiolytics, antidepressants, and hypnotics was low overall but lowest among the most optimistic. Characteristics of women across the hostility construct were generally opposite of those for the optimism construct (Supplemental Table S1).

### Falls

A total of 26,715 (30.6%) of women experienced  $\geq 2$  falls in the past year over the follow-up period. In age-adjusted models, each SD higher optimism score was associated with a 16% lower risk of  $\geq 2$  falls in the past year (Table 2). In the full MV model, including adjustment for traditional risk factors, depression, and use of antidepressants and hypnotics (model 2), each SD higher optimism score was associated with a significant 5% lower risk of  $\geq 2$  falls in the past year.

Examination of a gradient effect revealed that increasing optimism scores were associated with a decreased risk of

**Table 1.** Baseline Demographic and Health Factors by Quartile of Optimism Construct

Demographic/health Factors	Optimism construct					p Value
	Total 87,342	6–21 23,661	22–23 21,153	24–25 19,506	26–30 23,022	
	n (%)	n (%)	n (%)	n (%)	n (%)	
Age, mean (SD)	63.5 (7.3)	63.6 (7.5)	63.8 (7.3)	63.6 (7.3)	63.0 (7.3)	<0.001
Ethnicity						
White	73,645 (84.5)	18,637 (79.1)	18,045 (85.4)	16,872 (86.7)	20,091 (87.5)	<0.001
Black or African-American	6603 (7.6)	2074 (8.8)	1438 (6.8)	1377 (7.1)	1714 (7.5)	
Hispanic/Latino	3076 (3.5)	1306 (5.5)	679 (3.2)	544 (2.8)	547 (2.4)	
American Indian or Alaskan Native	366 (0.4)	144 (0.6)	86 (0.4)	61 (0.3)	75 (0.3)	
Asian or Pacific Islander	2486 (2.9)	1050 (4.5)	656 (3.1)	433 (2.2)	347 (1.5)	
Other	931 (1.1)	357 (1.5)	214 (1.0)	167 (0.9)	193 (0.8)	
Education						
High school or less	18,179 (21.0)	7163 (30.5)	4655 (22.2)	3432 (17.7)	2929 (12.8)	<0.001
Some college or vocational training	31,745 (36.6)	8771 (37.4)	7969 (37.9)	7161 (37.0)	7844 (34.3)	
College grad or more	36,731 (42.4)	7518 (32.1)	8386 (39.9)	8756 (45.3)	12,071 (52.8)	
Parental history of broken bone (age >40) (Yes)	32,334 (39.9)	8441 (39.3)	7748 (39.5)	7371 (40.4)	8774 (40.6)	0.010
Fracture history (age ≥55)						
Yes	11,616 (14.4)	3138 (14.4)	2890 (14.8)	2598 (14.4)	2990 (14.0)	<0.001
Age <55	11,746 (14.6)	3241 (14.9)	2634 (13.5)	2497 (13.8)	3374 (15.8)	
Physical activity (MET hrs/wk)						
<2.5	19,072 (22.0)	6562 (28.0)	4595 (21.9)	3809 (19.7)	4106 (18.0)	<0.001
2.5–<5	9102 (10.5)	2786 (11.9)	2328 (11.1)	1899 (9.8)	2089 (9.2)	
5–<12	20,407 (23.6)	5537 (23.7)	5008 (23.9)	4639 (24.0)	5223 (22.9)	
≥12	37,925 (43.8)	8520 (36.4)	9024 (43.1)	8969 (46.4)	11,412 (50.0)	
Alcohol intake						
Non-drinker	9527 (11.0)	3077 (13.1)	2281 (10.8)	2024 (10.4)	2145 (9.4)	<0.001
Past drinker	16,177 (18.6)	5230 (22.3)	3838 (18.2)	3275 (16.9)	3834 (16.7)	
<1 drink per month	10,134 (11.7)	2913 (12.4)	2537 (12.1)	2203 (11.4)	2481 (10.8)	
<1 drink per week	17,480 (20.1)	4753 (20.2)	4331 (20.6)	3983 (20.5)	4413 (19.3)	
1 to <7 drinks per week	22,409 (25.8)	5129 (21.8)	5443 (25.9)	5299 (27.3)	6538 (28.5)	
≥7 drinks per week	11,119 (12.8)	2389 (10.2)	2606 (12.4)	2619 (13.5)	3505 (15.3)	
Smoking status						
Never smoked	43,923 (50.9)	11,799 (50.6)	10,577 (50.6)	9773 (50.7)	11,774 (51.6)	<0.001
Past smoker	37,022 (42.9)	9656 (41.4)	9133 (43.7)	8403 (43.6)	9830 (43.1)	
Current smoker	5359 (6.2)	1878 (8.0)	1199 (5.7)	1089 (5.7)	1193 (5.2)	
Pack-years of smoking						
Never smoker	43,923 (52.1)	11,799 (51.7)	10,577 (51.7)	9773 (51.9)	11,774 (52.9)	<0.001
<5	12,458 (14.8)	3288 (14.4)	2988 (14.6)	2862 (15.2)	3320 (14.9)	
5–<20	12,098 (14.3)	3102 (13.6)	2971 (14.5)	2737 (14.5)	3288 (14.8)	
≥20	15,895 (18.8)	4622 (20.3)	3926 (19.2)	3466 (18.4)	3881 (17.4)	
Fell in last 12 months						
None	58,518 (67.8)	15,208 (65.1)	14,078 (67.3)	13,277 (68.9)	15,955 (70.0)	<0.001
1 time	17,212 (19.9)	4620 (19.8)	4,287 (20.5)	3862 (20.0)	4443 (19.5)	
2 times	7008 (8.1)	2242 (9.6)	1749 (8.4)	1445 (7.5)	1572 (6.9)	
3 or more times	3604 (4.2)	1282 (5.5)	800 (3.8)	689 (3.6)	833 (3.7)	
Body mass index (kg/m <sup>2</sup> ), mean (SD)	27.2 (5.9)	27.9 (6.3)	27.2 (5.8)	27.0 (5.7)	26.8 (5.5)	<0.001
Depression						
Yes (≥0.06)	9556 (11.2)	5362 (23.3)	1991 (9.6)	1294 (6.8)	909 (4.0)	<0.001
Diabetes treated (pills or shots) (yes)	3510 (4.0)	1397 (5.9)	834 (3.9)	641 (3.3)	638 (2.8)	<0.001
General health						
Excellent/very good	51,408 (59.1)	9886 (41.9)	11,603 (55.0)	12,492 (64.2)	17,427 (75.9)	<0.001
Good	27,490 (31.6)	9543 (40.5)	7595 (36.0)	5701 (29.3)	4651 (20.3)	
Fair/poor	8127 (9.3)	4134 (17.5)	1870 (8.9)	1243 (6.4)	880 (3.8)	
Hormone therapy						
Never used	34,920 (40.0)	10,232 (43.3)	8353 (39.5)	7584 (38.9)	8751 (38.0)	<0.001
Past user	13,010 (14.9)	3640 (15.4)	3237 (15.3)	2816 (14.4)	3317 (14.4)	
Current user	39,338 (45.1)	9766 (41.3)	9547 (45.2)	9091 (46.6)	10,934 (47.5)	
Total calcium (mg/d), mean (SD)	1220 (784)	1148 (848)	1214 (729)	1241 (727)	1280 (804)	<0.001

**Table 1.** (Continued)

	Optimism construct					p Value
	Total 87,342	6–21 23,661	22–23 21,153	24–25 19,506	26–30 23,022	
Demographic/health Factors	<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)	
Vitamin D from single supplement (yes)	3725 (4.3)	952 (4.0)	912 (4.3)	856 (4.4)	1005 (4.4)	0.188
Vitamin D supplement (including multivitamin) (yes)	45,127 (51.7)	11,285 (47.7)	10,941 (51.7)	10,377 (53.2)	12,524 (54.4)	<0.001
Total vitamin D (mcg/d), mean (SD)	9.7 (7.2)	9.1 (7.2)	9.6 (7.1)	9.9 (7.2)	10.1 (7.3)	<0.001
Oral glucocorticosteroid (daily) (yes)	1015 (1.2)	326 (1.4)	258 (1.2)	216 (1.1)	215 (0.9)	<0.001
Bisphosphonate (yes)	2155 (2.5)	555 (2.3)	554 (2.6)	511 (2.6)	535 (2.3)	0.062
Tamoxifen (yes)	948 (1.1)	254 (1.1)	196 (0.9)	240 (1.2)	258 (1.1)	0.028
Raloxifene (yes)	37 (0.04)	15 (0.06)	6 (0.03)	6 (0.03)	10 (0.04)	0.253
Antidepressants (yes)	6567 (7.5)	2588 (10.9)	1524 (7.2)	1228 (6.3)	1227 (5.3)	<0.001
Anxiolytics (yes)	3054 (3.5)	1238 (5.2)	706 (3.3)	561 (2.9)	549 (2.4)	<0.001
Hypnotics (yes)	599 (0.7)	213 (0.9)	150 (0.7)	106 (0.5)	130 (0.6)	<0.001

Data are expressed as *n* (%) except where indicated; *p* values are from chi-square test for categorical data and ANOVA for continuous data.

experiencing  $\geq 2$  falls. Women who were the most optimistic had an 11% lower risk of  $\geq 2$  falls in the past year, an association independent of depression and other covariates (model 2). Further adjusting these models for hostility showed that the most optimistic women had a 9% lower risk of  $\geq 2$  falls in the past year (model 3).

In age-adjusted models, each SD higher cynical hostility score was associated with a 12% increase in the risk of  $\geq 2$  falls in the past year (Table 2). There was also a gradient effect with an increased risk of  $\geq 2$  falls with increasing hostility. In the full MV-adjusted model (model 2), women who were the most hostile had a 12% higher risk of  $\geq 2$  falls even after controlling for traditional fall risk factors. This association remained significant even after adjusting for optimism (model 3).

### Fractures

Over 11.4 years of follow-up, 26,715 (30.6%) reported any fracture including 2904 (3.3%) with an incident hip fracture, 1166

(5.2%) with an incident self-report clinical spine fracture, and 5980 (6.8%) with an incident self-report lower arm fracture.

In age-adjusted models, the most optimistic women (i.e., those in the highest quartile) had about a 10% lower risk of hip and total fractures, 14% lower risk of vertebral fractures, and a 7% lower risk of lower arm fractures compared with pessimists (Table 3). However, these associations were attenuated in the MV models. Women with the greatest hostility had a 5% increased risk of any fracture in the MV-adjusted models (models 1 and 2), but there was no association between hostility and specific anatomic location fractures (hip, clinical vertebral, lower arm).

### Discussion

To our knowledge, this is the first study to prospectively examine the association between personality traits of optimism and cynical hostility with falls and fracture. We found that optimism

**Table 2.** Association of Self-Report  $\geq 2$  Falls in Past Year by Optimism and Hostility Constructs (Odds Ratios [OR]; 95% Confidence Intervals [CI]) (*n* = 87,342)

Event	Age adjusted OR (95% CI)	Model 1 <sup>a</sup> OR (95% CI)	Model 2 <sup>b</sup> OR (95% CI)	Model 3 <sup>c</sup> OR (95% CI)
<b>Optimism</b>				
Continuous <sup>d</sup>	0.84 (0.83–0.85)	0.91 (0.90–0.92)	0.95 (0.94–0.97)	0.96 (0.94–0.97)
6.0–21.0	1 (ref)	1 (ref)	1 (ref)	1 (ref)
22.0–23.0	0.79 (0.76–0.82)	0.85 (0.82–0.88)	0.91 (0.87–0.95)	0.92 (0.88–0.96)
24.0–25.0	0.71 (0.68–0.73)	0.81 (0.77–0.84)	0.87 (0.83–0.91)	0.88 (0.84–0.92)
26.0–30.0	0.67 (0.64–0.70)	0.82 (0.78–0.85)	0.89 (0.85–0.93)	0.91 (0.87–0.95)
<i>p</i> trend	<0.001	<0.001	<0.001	<0.001
<b>Hostility</b>				
Continuous <sup>d</sup>	1.12 (1.11–1.14)	1.07 (1.05–1.08)	1.04 (1.03–1.06)	1.03 (1.02–1.05)
0.0–1.0	1 (ref)	1 (ref)	1 (ref)	1 (ref)
2.0–3.0	1.10 (1.06–1.15)	1.05 (1.01–1.09)	1.05 (1.00–1.09)	1.04 (1.00–1.08)
4.0–5.0	1.18 (1.13–1.23)	1.09 (1.05–1.14)	1.08 (1.04–1.13)	1.07 (1.03–1.12)
6.0–13.0	1.35 (1.29–1.40)	1.17 (1.13–1.22)	1.12 (1.07–1.17)	1.09 (1.05–1.14)
<i>p</i> trend	<0.001	<0.001	<0.001	<0.001

<sup>a</sup>Model 1 adjusted for age, weight, height, treated diabetes, ethnicity/race, region, smoking status, general health status, current hormone therapy use, total calcium, total vitamin D intake, and physical activity (*n* = 85,596).

<sup>b</sup>Model 2 adjusted for model 1 plus antidepressant medication use, depressive symptoms score, and hypnotics medication use (*n* = 83,940).

<sup>c</sup>Model 3 adjusted for model 2 plus optimism or hostility constructs.

<sup>d</sup>OR expressed as 1 SD higher score.

**Table 3.** Hazard Ratios (HR) (95% Confidence Intervals [CI]) of Fracture by Optimism and Hostility Construct (*n* = 87,342)

Event	Fractures			
	Hip 2904 HR (95% CI)	Vertebral 4457 HR (95% CI)	Lower arm 5980 HR (95% CI)	Total 26,715 HR (95% CI)
<b>Optimism (age-adjusted)</b>				
Continuous <sup>a</sup>	0.94 (0.90–0.97)	0.93 (0.90–0.95)	0.96 (0.94–0.99)	0.96 (0.95–0.97)
6.0–21.0	1 (ref)	1 (ref)	1 (ref)	1 (ref)
22.0–23.0	0.97 (0.87–1.07)	0.88 (0.82–0.96)	0.98 (0.91–1.05)	0.95 (0.91–0.98)
24.0–25.0	0.90 (0.81–1.00)	0.81 (0.75–0.88)	0.99 (0.92–1.07)	0.92 (0.89–0.95)
26.0–30.0	0.90 (0.81–0.99)	0.86 (0.79–0.93)	0.93 (0.87–1.00)	0.90 (0.87–0.93)
<b>Optimism (model 1<sup>b</sup>)</b>				
Continuous <sup>a</sup>	0.99 (0.95–1.03)	0.98 (0.95–1.01)	0.97 (0.95–1.00)	0.99 (0.98–1.01)
6.0–21.0	1 (ref)	1 (ref)	1 (ref)	1 (ref)
22.0–23.0	0.99 (0.89–1.09)	0.92 (0.84–1.00)	0.99 (0.92–1.06)	0.98 (0.94–1.01)
24.0–25.0	0.95 (0.85–1.06)	0.87 (0.80–0.95)	1.01 (0.94–1.09)	0.98 (0.95–1.02)
26.0–30.0	1.00 (0.90–1.11)	0.98 (0.90–1.07)	0.96 (0.89–1.03)	0.98 (0.94–1.01)
<b>Optimism (model 2<sup>c</sup>)</b>				
Continuous <sup>a</sup>	1.00 (0.96–1.04)	1.00 (0.97–1.04)	0.98 (0.95–1.00)	1.00 (0.99–1.02)
6.0–21.0	1 (ref)	1 (ref)	1 (ref)	1 (ref)
22.0–23.0	1.00 (0.90–1.12)	0.95 (0.87–1.03)	1.00 (0.92–1.07)	0.99 (0.96–1.03)
24.0–25.0	0.97 (0.86–1.08)	0.89 (0.82–0.98)	1.03 (0.95–1.11)	1.00 (0.96–1.04)
26.0–30.0	1.03 (0.92–1.15)	1.02 (0.94–1.12)	0.97 (0.90–1.05)	1.00 (0.97–1.04)
<b>Optimism (model 3)</b>				
Continuous <sup>d</sup>	1.00 (0.96–1.05)	1.00 (0.97–1.03)	0.98 (0.95–1.01)	1.01 (0.99–1.02)
6.0–21.0	1 (ref)	1 (ref)	1 (ref)	1 (ref)
22.0–23.0	1.01 (0.91–1.12)	0.94 (0.86–1.03)	1.00 (0.93–1.08)	1.00 (0.96–1.03)
24.0–25.0	0.97 (0.87–1.09)	0.89 (0.81–0.98)	1.03 (0.96–1.12)	1.01 (0.97–1.04)
26.0–30.0	1.03 (0.92–1.16)	1.02 (0.93–1.11)	0.98 (0.91–1.06)	1.01 (0.98–1.05)
<b>Hostility (age-adjusted)</b>				
Continuous <sup>a</sup>	1.02 (0.98–1.06)	1.00 (0.97–1.03)	1.01 (0.98–1.04)	1.03 (1.02–1.04)
0.0–1.0	1 (ref)	1 (ref)	1 (ref)	1 (ref)
2.0–3.0	0.99 (0.90–1.09)	1.05 (0.97–1.13)	1.00 (0.93–1.07)	1.04 (1.01–1.08)
4.0–5.0	0.98 (0.88–1.09)	1.02 (0.94–1.11)	1.02 (0.95–1.10)	1.07 (1.03–1.10)
6.0–13.0	1.03 (0.93–1.15)	1.02 (0.94–1.11)	1.01 (0.94–1.09)	1.08 (1.04–1.12)
<b>Hostility (model 1<sup>b</sup>)</b>				
Continuous <sup>a</sup>	1.02 (0.98–1.06)	0.99 (0.96–1.03)	1.02 (0.99–1.05)	1.02 (1.01–1.04)
0.0–1.0	1 (ref)	1 (ref)	1 (ref)	1 (ref)
2.0–3.0	0.96 (0.87–1.07)	1.01 (0.93–1.09)	0.99 (0.92–1.06)	1.02 (0.99–1.05)
4.0–5.0	0.97 (0.87–1.08)	1.00 (0.91–1.09)	1.03 (0.96–1.11)	1.04 (1.01–1.08)
6.0–13.0	1.03 (0.92–1.14)	0.99 (0.91–1.08)	1.04 (0.96–1.12)	1.05 (1.02–1.09)
<b>Hostility (model 2<sup>c</sup>)</b>				
Continuous <sup>a</sup>	1.02 (0.98–1.06)	0.99 (0.96–1.02)	1.02 (0.99–1.05)	1.02 (1.01–1.03)
0.0–1.0	1 (ref)	1 (ref)	1 (ref)	1 (ref)
2.0–3.0	0.97 (0.87–1.07)	0.99 (0.92–1.08)	0.98 (0.92–1.06)	1.02 (0.98–1.05)
4.0–5.0	0.97 (0.87–1.08)	0.99 (0.91–1.08)	1.04 (0.96–1.12)	1.04 (1.01–1.08)
6.0–13.0	1.01 (0.91–1.13)	0.98 (0.90–1.07)	1.04 (0.96–1.12)	1.05 (1.01–1.09)
<b>Hostility (model 3<sup>d</sup>)</b>				
Continuous <sup>a</sup>	1.02 (0.98–1.06)	0.99 (0.95–1.02)	1.01 (0.98–1.04)	1.02 (1.01–1.04)
Quartile: 0–1.0	1 (ref)	1 (ref)	1 (ref)	1 (ref)
Quartile: 2.0–3.0	0.97 (0.88–1.07)	1.00 (0.92–1.08)	0.98 (0.92–1.06)	1.02 (0.98–1.05)
Quartile: 4.0–5.0	0.98 (0.88–1.09)	0.99 (0.91–1.08)	1.03 (0.96–1.11)	1.04 (1.01–1.08)
Quartile: 6.0–13.0	1.02 (0.91–1.14)	0.97 (0.89–1.07)	1.03 (0.96–1.12)	1.05 (1.01–1.09)

<sup>a</sup>HR expressed as 1 SD.<sup>b</sup>Model 1, adjusted for age, weight, height, treated diabetes, ethnicity/race, region, smoking status, fall in past 12 months, general health status, current hormone therapy use, oral glucocorticoid use, total calcium, total vitamin D intake, physical activity, history of fracture after age 55 years, and parental history of broken bone after age 40 years (*n* = 84,682).<sup>c</sup>Model 2, adjusted for model 1 plus antidepressant medication use, depressive symptoms score, and hypnotics medication use (*n* = 83,137).<sup>d</sup>Model 3, adjusted for model 2 plus optimism or hostility score.

was associated with a reduced risk of  $\geq 2$  falls in the past year, independent of important fall risk factors including depression. Conversely, cynical hostility was associated with an increased risk of  $\geq 2$  falls in the past year. Women with the greatest optimism had an 11% lower risk of  $\geq 2$  falls in the past year compared with the most pessimistic women. Similarly, the most hostile women had a 12% increased risk of  $\geq 2$  falls in the past year. The magnitude of these associations is similar to an effect of aging 5 more years.

In age-adjusted models, women with the greatest optimism had a 10% lower risk of fractures. However, this association was attenuated in the MV models, suggesting that optimism may contribute to fracture risk by reflecting or contributing to established determinants of fractures (i.e., falls). Greater hostility was associated with a modest increase in fractures at any site but was not related to specific anatomic location fractures.

Optimism has been associated with healthy aging.<sup>(36)</sup> Indeed, in an analysis of successful aging, psychological factors (perceived self-efficacy and optimism) predicted quality of life.<sup>(37)</sup> Aging successfully requires attention to both physical and psychological health. We have shown in the Osteoporotic Fractures in Older Men Study (MrOS) that optimism was related to both greater physical and mental health.<sup>(38)</sup> The characteristics of optimistic women in our study also paralleled characteristics of healthy aging. Optimists were less likely to smoke, more likely to drink alcohol moderately, better educated, more physically active, had a lower body mass index (BMI), a lower prevalence of diabetes, and were less likely to report poor or fair health status. Adjustment for these factors tended to weaken the association with falls and fractures, suggesting that these factors are in the pathway whereby optimism influences falls and fracture risks. Nevertheless, the association between optimism and falls but not optimism and fracture remained statistically significant.

Optimism and hostility were weakly correlated and reflect distinct personality constructs. We simultaneously adjusted for optimism and hostility, and our results showed that the effects were independent of each other. Optimists are individuals who tend to hold positive expectations for their future. Optimists adjust more favorably to important life transitions than pessimists. They also differ from pessimists in how they cope with specific life challenges.<sup>(29)</sup> These positive attitudes could influence decisions about health, lifestyle, screenings, and adherence. For example, in the WHI Diet Modification Trial, in which women were randomized to a usual diet comparison group or a low-fat dietary pattern group, optimists were more likely to adhere to the low-fat diet and maintain the low-fat dietary eating pattern.<sup>(12)</sup>

Hostility is a multidimensional construct that has cognitive, affective, and behavioral components.<sup>(39)</sup> The Cook-Medley scale that we used focuses primarily on the cognitive aspects of hostility, specifically, negative beliefs about others and attitudes toward others, including cynicism and mistrust. Hostility was associated with a variety of behaviors that could negatively impact health, including lower education, lower physical activity and higher BMI, more diabetes, and lower self-rated health. Thus, these characteristic patterns could contribute to the observation that the most hostile women were 12% more likely to experience  $\geq 2$  falls in the past year.

Depression has been linked to an increased risk of falls and fractures.<sup>(40)</sup> In a previous study, optimism had a protective effect on the development of depression over 15 years of follow-up,<sup>(24)</sup> as well as for recovery from depression and

rehospitalization after coronary bypass surgery.<sup>(41)</sup> We showed that optimists reported fewer depressive symptoms and were less likely to report antidepressant medications. However, we adjusted for these variables in our analysis, and our results were independent of these factors.

Adjustment for other risk factors attenuated to non-significance the association between personality and fractures but not falls. It is possible that we were better able to capture risk factors for fractures than falls. We had information on all the risk factors that are currently used in fracture risk assessment tools (eg, FRAX).<sup>(42)</sup> But, we had no information on risk-taking behavior or fear of falling, and thus, we could not adjust for these important risk factors for falls.

Personality is thought to develop early in life<sup>(43)</sup> and may influence health over the life course. The risk of osteoporosis also spans the entire life course with evidence that early growth patterns are associated with peak bone mass and hip fracture.<sup>(44)</sup> Early dietary exposures can have lifelong impact on food choices.<sup>(45)</sup> Therefore, the impact of personality on the risk of falls may reflect differential exposures throughout the life course.

There are a number of strengths to our study. We used well-studied and validated measures of optimism and cynical hostility. We adjusted simultaneously for optimism and hostility to test whether the associations were independent of each other. We prospectively evaluated associations with a number of fracture outcomes in a large cohort of women over an average of 11 years. There were, however, several limitations. Except for hip fractures, we relied on self-report of all other fractures, but we previously showed that 76% of all self-reported fractures were confirmed by radiographic report.<sup>(32)</sup> However, inaccurate recall of falls and fractures would bias our results to the null. We had no information on degree of trauma associated with the fracture, but skeletal fragility has been linked to both low- and high-trauma fractures.<sup>(46)</sup>

For falls, as previously noted, information on several risk factors that could underlie association between personality and falls was missing. Fractures, especially hip fractures, are associated with an increased mortality,<sup>(47)</sup> and thus, there may be potential follow-up bias. Bone mineral density (BMD) was measured at only three WHI clinics, and thus, we could not adjust for BMD. Our study was observational, and residual confounding by unmeasured factors could have occurred.

In conclusion, optimism and cynical hostility were associated with  $\geq 2$  falls in the past year, independent of traditional risk factors. Associations with fractures were largely explained by other risk factors supporting conceptual models of how personality traits may prospectively influence biological outcomes. Finally, whether interventions aimed at attitudes could reduce fall risks remains to be determined.

## Disclosures

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All authors state that they have no conflicts of interest.

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