

# Association of stressful life events with incident falls and fractures in older men: the Osteoporotic Fractures in Men (MrOS) Study

HOWARD A. FINK<sup>1</sup>, MICHAEL A. KUSKOWSKI<sup>1</sup>, LYNN M. MARSHALL<sup>2</sup>

<sup>1</sup>VA Medical Center, Geriatric Research Education and Clinical Center, One Veterans Drive, 11-G, Minneapolis, MN 55417, USA

<sup>2</sup>Department of Orthopaedics and Rehabilitation, Oregon Health and Science University, Portland, OR, USA

Address correspondence to: H. A. Fink. Tel: 612-467-3304; Fax: 612-725-2084. Email: howard.fink@va.gov

## Abstract

**Background:** small, retrospective studies suggest that major life events and/or sudden emotional stress may increase fall and fracture risk. The current study examines these associations prospectively.

**Methods:** a total of 5,152 men aged  $\geq 65$  years in the Osteoporotic Fractures in Men study self-reported data on stressful life events for 1 year prior to study Visit 2. Incident falls and fractures were ascertained for 1 year after Visit 2. Fractures were centrally confirmed.

**Results:** a total of 2,932 (56.9%) men reported  $\geq 1$  type of stressful life event. In men with complete stressful life event, fall and covariate data ( $n = 3,949$ ), any stressful life event was associated with a 33% increased risk of incident fall [relative risk (RR) 1.33, 95% confidence interval (CI) 1.19–1.49] and 68% increased risk of multiple falls (RR = 1.68, 95% CI = 1.40–2.01) in the year following Visit 2 after adjustment for age, education, Parkinson's disease, diabetes, stroke, instrumental activities of daily living (IADL) impairment, chair stand time, walk speed, multiple past falls, depressive symptoms and antidepressant use. Risk increased with the number of types of stressful life events. Though any stressful life event was associated with a 58% increased age-adjusted risk for incident fracture, this association was attenuated and no longer statistically significant after additional adjustment for total hip bone mineral density, fracture after age 50, Parkinson's disease, stroke and IADL impairment.

**Conclusions:** in this cohort of older men, stressful life events significantly increased risk of incident falls independent of other explanatory variables, but did not independently increase incident fracture risk.

**Keywords:** accidental falls, fractures, life change events, psychological stress, prospective studies, aged, male, men, older people

## Introduction

One-third of community-dwelling adults aged  $\geq 65$  years fall at least once annually, half of whom have multiple falls [1–3]. Two to six percent of falls result in fractures [1–4]. While demographics, medical conditions, physical function, medications and sensory impairments are established predictors of falls [5–7] and fractures [8, 9], limited data suggest that stressful life events also may predict these outcomes [10, 11].

Many studies have examined the association between psychological stress and adverse health outcomes. According to the allostatic load model, environmental stress may trigger a neurohormonal response, leading to physiological dysregulation and adverse health outcomes [12]. However, perceived stress and physiological stress response may vary according to individual and social/environmental factors. Some but not

all prospective studies report a positive association between stressful life events, such as death of a spouse, job loss or change in residence, and incident cardiovascular disease or mortality [13–17]. Numerous indices of allostatic load, combining inflammatory and metabolic biomarkers, have predicted increased risk of impaired physical function [12]. Two retrospective studies, including one conducted in long-term care residents, reported that major life events and sudden emotional stress increased risk of falls and fractures [10, 11].

We are unaware, however, of any studies that prospectively examined the effect of stressful life events on falls and fractures in community-dwelling adults, while effectively accounting for important confounding variables, including comorbid conditions, and measures of physical function and social integration. This, therefore, is the aim of the current study.

## Methods

### Participants

A total of 5,994 community-dwelling men aged  $\geq 65$  years enrolled in the Osteoporotic Fractures in Men (MrOS) study at six US sites (March 2000 to April 2002): Birmingham, AL; Minneapolis, MN; Palo Alto, CA; Monongahela Valley near Pittsburgh, PA; Portland, OR and San Diego, CA. Exclusion criteria included inability to walk without assistance from another person or bilateral hip replacement. Written informed consent was obtained from all participants. Institutional review boards at all centres approved the study protocol, and procedures were conducted in accordance with the ethical standards for human subjects research described in the Helsinki Declaration. MrOS study design and recruitment are detailed elsewhere [18, 19].

A total of 5,152 MrOS participants participated in a second study visit (March 2005 to May 2006) and reported complete data on a history of stressful life events in the prior year (fracture cohort). A further subset of 4,981 reported complete data on incident falls for 1 year after the second study visit (fall cohort) (see Supplementary data available in *Age and Ageing* online, Appendix Figure S1).

### Stressful life events

At MrOS study Visit 2, participants were asked their marital status, and, if widowed, their spouse's date of death. In addition, they were asked to report occurrence of any of several stressful life events in the past year: serious illness or accident of wife or partner; death of other close relative or close friend; separation from child, close friend or other relative on whom participant depends for help; loss of pet; given up important hobby or activity; serious financial trouble and/or move or change in residence. Because of questionnaire wording, each type of stressful life event could be counted only once per participant.

### Falls and fractures

Following study Visit 2, all MrOS participants (or, if deceased, participant's contacts) were queried by mail every 4 months for 1 year regarding incident falls or fractures. Overall response rates exceeded 99%, including 97% complete ascertainment for falls. Fractures were confirmed by central review of radiographic reports.

### Covariables

Race and education were reported at MrOS baseline. Other covariables were first assessed, or were updated, at study Visit 2. Physical activity was measured using the Physical Activity Scale for the Elderly (PASE) [20]. Medical history included self-reported comorbid conditions, fractures since age 50, and number of falls in the previous year. Depressive symptoms were assessed using the 15-item Geriatric Depression Scale [21]. A medication inventory was used to classify medications

used within the preceding 30 days into categories by their ingredients, including antidepressant and other psychotropic medications [22]. Health status was assessed as impairment in instrumental activities of daily living (IADLs). Weight was measured using a balance beam or digital scale. Participants were timed walking 6 m taking  $\leq 2$  deviations outside a 20-cm narrow path. Time to complete five chair stands also was measured. Total hip bone mineral density (BMD) ( $\text{g}/\text{cm}^2$ ) was measured with dual energy X-ray absorptiometry (QDR 4500 W; Hologic, Inc., Waltham, MA, USA).

We calculated change between MrOS baseline and Visit 2 for weight, self-reported co-morbid conditions, PASE score, IADL impairment, walk speed and chair stands. We also estimated scores at Visit 2 for several measures of social integration [23] ([living arrangement (alone, with spouse/partner, with other), social network score (1 point each for having  $\geq 3$  living children versus  $\leq 2$ , and for having  $\geq 1$  confidants versus none), and social engagement score (1 point each for working, caregiving, and participating in non-religious and religious social groups)] and change in these scores compared with MrOS baseline.

### Statistical analyses

For each participant, the number of types of stressful life events was categorized as any, none, one, two, three or more, or as the sum of types of stressful events. Differences in characteristics between participants with and without any stressful life event were assessed using Chi-square tests for dichotomous variables and *t* tests for continuous variables.

For 1 year following study Visit 2, incident falls were categorized as  $\geq 1$  versus none, and  $\geq 2$  versus zero or one. Risks of  $\geq 1$  incident falls, multiple incident falls and incident fracture were assessed using log binomial regression or Poisson regression with robust variance estimators, with results expressed as relative risks (RRs) with 95% confidence intervals (CIs) [24]. All models were adjusted for age. Additional covariables were included if, after age-adjustment, they were significantly ( $P < 0.05$ ) associated with any stressful life event, and with incident falls (fall models) or incident fracture (fracture models). To investigate the impact of recent changes in health status on the association between stressful life events and falls, measures of change between MrOS baseline and Visit 2 in weight, physical activity, IADL impairment, walk speed, chair stands and newly reported comorbid conditions were separately added to multivariable models and included if statistically significant ( $P < 0.05$ ).

We next examined whether several individual measures of social integration (i.e. living arrangement, social network, social engagement) or changes in these individual measures moderated the association between stressful life events and falls. We considered a variable a moderator if its interaction term was statistically significant in multivariable models ( $P < 0.05$ ) [23].

Finally, to explore the association between different types of stressful life events and fall risk, separate age-adjusted models were created for each type of stressful life event.

All analyses were performed with SPSS, version 17 (Chicago, IL, USA).

## Results

Of 5,152 MrOS participants with complete stressful life events data in the year before study Visit 2 (fracture cohort), 2,932 (56.9%) reported  $\geq 1$  type of stressful life event, including 37.1% with one, 14.1% with two and 5.7% with  $\geq 3$  types of events (Table 1). Frequency of stressful life events was similar in the fall cohort (data not shown).

Compared with other MrOS enrollees not included in the fracture and fall cohorts, respectively, those in these cohorts were younger, more educated, had less IADL impairment, more physical activity, better physical function and fewer had comorbid conditions or past fractures (data not shown). Within the fracture and fall cohorts, compared with men with zero stressful events, those with  $\geq 1$  stressful life event were older, more often reported comorbid conditions and past fractures, had more IADL impairment and had worse physical function (see Supplementary data available in *Age and Ageing* online, Appendix Table S1). Compared with men included in multivariable-adjusted fall models, those excluded because of missing covariable data had poorer self-reported health (data not shown).

### Stressful life events and falls

Among 4,981 men with complete stressful life event and falls data, 27.7% fell and 14.7% fell multiple times during the year after Visit 2. Among men with 0, 1, 2 and  $\geq 3$  types of stressful life events, incident falls occurred in 21.9, 29.9, 35.5 and 39.9%, respectively.

In age-adjusted analyses, any stressful life event was associated with a 41% increase in risk for incident fall (RR = 1.41, 95% CI = 1.28–1.55) and a nearly 2-fold increase in risk for multiple incident falls (RR = 1.87, 95% CI = 1.61–2.18) (Table 2). Further adjustment for education,

Parkinson's disease, diabetes, stroke, IADL impairment, chair stand time, walk speed, multiple past falls, depressive symptoms and antidepressant use modestly attenuated these results. Results also suggested dose–response relationships between the number of types of stressful life events and fall risk. Effect estimates were not altered by further adjustment for measures of change between MrOS baseline and Visit 2 in weight, physical activity, IADL impairment, walk speed, chair stands, or newly diagnosed comorbid conditions, nor by adjustment for any social integration variables (data not shown).

However, the interaction between social network score and stressful life events was significant ( $P = 0.019$ ) when added to the final multivariable model predicting incident falls. Stratified analyses suggested that fall risk associated with stressful life events may be inversely related to social network score, from RR = 2.18 (95% CI = 1.24–3.82) in those with a score of 0, to RR = 1.42 (95% CI = 1.20–1.68) and RR = 1.18 (95% CI = 1.01–1.38) in those with scores of 1 and 2, respectively.

Age-adjusted risk for incident falls appeared increased for most individual types of stressful life events. (see Supplementary data available in *Age and Ageing* online, Appendix Table S2) Few men experienced the death of their wife or partner.

### Stressful life events and fractures

During up to 1 year after Visit 2, 109 (2.1%) men experienced  $\geq 1$  incident fractures, including 75 (2.6%) men with  $\geq 1$  types of stressful life events and 34 (1.5%) men with no stressful life events. Any stressful life event was associated with a 58% increase in age-adjusted risk for incident clinical fracture (Table 3). Results were attenuated and no longer statistically significant after additional adjustment for BMD, fracture after age 50, Parkinson's disease, stroke and IADL impairment.

## Discussion

In this cohort of community-dwelling older men, stressful life events were independently associated with increased risk of future falls. Fall risk increased further for men with more types of stressful events. Exploratory analyses suggested that fall risk subsequent to stressful events may be moderated by social network. By comparison, the age-adjusted association of stressful life events with increased risk of incident fractures did not appear independent of other explanatory factors.

To our knowledge, this is the first prospective study to examine the association between stressful life events and risk of incident falls in community-dwelling older adults and to account for multiple confounders of this association. However, our finding of no independent association between stressful life events and risk of fracture contradicts an earlier case–control study [11]. In the prior study, fracture cases had significantly more stressful events in the past year than did control subjects, but the control group was younger, and

**Table 1.** Proportion of men with stressful life events in the year prior to study Visit 2<sup>a</sup>

| Stressful event type                                   | n (%)        |
|--------------------------------------------------------|--------------|
| Any stressful event                                    | 2,932 (56.9) |
| 1 type of stressful event                              | 1,913 (37.1) |
| 2 types of stressful events                            | 727 (14.1)   |
| 3+ types of stressful events                           | 292 (5.7)    |
| Wife/partner death                                     | 75 (1.5)     |
| Wife/partner illness/accident                          | 915 (17.8)   |
| Death other close relative/friend                      | 1,809 (35.1) |
| Separated from child, friend or relative you depend on | 134 (2.6)    |
| Loss of important activity/hobby                       | 670 (13.0)   |
| Moved/changed residence                                | 281 (5.5)    |
| Serious financial trouble                              | 166 (3.2)    |
| Loss of pet                                            | 281 (5.5)    |

<sup>a</sup>Results for 5,152 men who completed the stressful life events questionnaire at study Visit 2.

**Table 2.** Association of stressful life events with risk of incident falls in 1 year after study Visit 2, RR (95% CI)

| Model                       | No stressful events | Any stressful event | 1 Stressful event type | 2 Stressful event types | 3+ Stressful event types | Sum of types of stressful events |
|-----------------------------|---------------------|---------------------|------------------------|-------------------------|--------------------------|----------------------------------|
| Incident falls <sup>a</sup> |                     |                     |                        |                         |                          |                                  |
| Age                         | 1.0 (ref.)          | 1.41 (1.28–1.55)    | 1.11 (0.97–1.28)       | 1.39 (1.21–1.60)        | 1.71 (1.49–1.95)         | 1.13 (1.10–1.15)                 |
| MV1 <sup>b</sup>            | 1.0 (ref.)          | 1.38 (1.23–1.55)    | 1.14 (0.97–1.34)       | 1.39 (1.18–1.63)        | 1.66 (1.41–1.95)         | 1.12 (1.08–1.16)                 |
| MV2 <sup>c</sup>            | 1.0 (ref.)          | 1.33 (1.19–1.49)    | 1.13 (0.96–1.32)       | 1.35 (1.15–1.59)        | 1.46 (1.24–1.72)         | 1.08 (1.04–1.12)                 |
| Incident multiple falls*    |                     |                     |                        |                         |                          |                                  |
| Age                         | 1.0 (ref.)          | 1.87 (1.61–2.18)    | 1.29 (1.02–1.62)       | 1.87 (1.50–2.33)        | 2.57 (2.07–3.18)         | 1.20 (1.16–1.24)                 |
| MV1 <sup>b</sup>            | 1.0 (ref.)          | 1.80 (1.50–2.16)    | 1.26 (0.97–1.64)       | 1.72 (1.32–2.24)        | 2.28 (1.76–2.96)         | 1.18 (1.12–1.24)                 |
| MV2 <sup>c</sup>            | 1.0 (ref.)          | 1.68 (1.40–2.01)    | 1.21 (0.94–1.57)       | 1.62 (1.25–2.10)        | 1.85 (1.43–2.40)         | 1.13 (1.07–1.19)                 |

RR, relative risk; CI, confidence intervals; IADL, instrumental activities of daily living; MV1, multivariable model 1; MV2, multivariable model 2.

<sup>a</sup>Results for any stressful event and falls available for 4,981 participants in age-adjusted models, 3,977 in MV1 models and 3,949 in MV2 models. Results for sum of types of stressful events and number of stressful events available for 4,959 participants in age-adjusted models, 3,966 in MV1 models and 3,933 in MV2 models.

<sup>b</sup>MV1 models adjusted for age, education, Parkinson's disease, diabetes, stroke, IADL impairment, chair stand time and gait speed.

<sup>c</sup>MV2 models adjusted for MV1 variables as well as for multiple falls in the year before V2, depressive symptoms, and antidepressant medication use.

**Table 3.** Association of stressful life events with risk of incident clinical fracture in 1 year after study Visit 2, RR (95% CI)

| Model            | Any stressful event | Sum stressful event types |
|------------------|---------------------|---------------------------|
| Age              | 1.58 (1.05–2.36)    | 1.04 (0.91–1.18)          |
| MV1 <sup>a</sup> | 1.32 (0.82–2.13)    | 1.06 (0.90–1.25)          |
| MV2 <sup>b</sup> | 1.12 (0.72–1.74)    | 0.95 (0.81–1.11)          |

RR, relative risk; CI, confidence interval; BMD, bone mineral density; IADL, instrumental activities of daily living; MV1, multivariable model 1; MV2, multivariable model 2.

<sup>a</sup>MV1 models adjusted for age, V2 total hip BMD, fracture after age 50, Parkinson's disease, stroke and IADL impairment.

<sup>b</sup>MV2 models additionally adjusted for multiple falls in the year before V2, depressive symptoms and antidepressant medication use.

results were not adjusted for comorbidities, health status or BMD. Further, because stressful events data were collected after fracture, these earlier results were more prone to recall bias. In another study, elderly long-term care residents who recently had undergone the major life event of changing residence were at increased falls risk [25]. Although our results could be interpreted as validating this earlier study, since the prior study did not account for possible confounders, it is uncertain whether its findings can be attributed to the life event itself.

The association between stressful life events and falls observed in the current study appears moderate in strength, similar in magnitude to that associated with sedative use or urinary incontinence, but smaller than the risk associated with gait or cognitive impairment [5]. However, the mechanism connecting stressful life events to falls is uncertain. One possible explanation, suggested by the allostatic load model, is that stressful life events trigger a neurohormonal response, causing stress hormone release and multi-system physiological dysregulation, leading to adverse health outcomes such as falls [12]. Some data suggest that inflammation, a potential indicator of physiological stress, could lead to loss of muscle mass [26] and impaired physical function. Alternatively, sudden emotions, possibly triggered by a stressful life event,

could transiently impact balance or visual attention, leading to a fall [10]. Some studies also suggest that stressful life events might lead to worsened clinical outcomes by adversely impacting self-care behaviour [27, 28]. Our exploratory finding that fall risk associated with stressful life events appeared greater in men with a lower social network score suggests that stressful life events could lead to increased social isolation, which plausibly could lead to decreased physical activity, strength and balance, thereby increasing fall risk. Though we found no evidence that results were impacted by changes in physical activity or function between MrOS baseline and Visit 2, we had no data on changes in these measures between the stressful life event and MrOS Visit 2 to more directly investigate this pathway.

This study has numerous strengths. It provides the strongest evidence to date supporting stressful life events as a risk factor for falls. As a prospective cohort study in which participants were recruited from population-based sources, were not selected on the basis of stressful life event history, and in which stressful life events were ascertained prior to follow-up for falls and fractures, results regarding the association between stressful life events and incident falls and fractures were less subject to selection bias than those from prior studies. Additional strengths included the nearly complete follow-up for incident falls and fractures, and the accounting for a comprehensive set of possibly confounding variables.

However, this study had several limitations. First, because recall of stressful life events is retrospective and stressful life events and falls are self-reported, both are susceptible to error. Secondly, because the timing of discrete stressful life events was not precisely known, analyses were limited in their ability to estimate the duration of their effect on falls. Thirdly, self-reported life events may not be equally stressful to all individuals, and no data were available to estimate participants' resiliency or coping style and no measures of perceived stress or physiological stress were available to correlate with these life events. Fourthly, this study had limited power to examine the association between stressful life events and hip fractures, to examine dose relationships between stressful life events and fractures and to examine associations of specific

types of stressful life events with falls and fractures. Fifthly, despite accounting for a comprehensive set of possibly confounders, we cannot exclude the possibility of residual confounding. For example, because of the timing of data collection, we could not account for whether changes in psychotropic medication use in the year after MrOS Visit 2 impacted risk of falls during that period. Finally, because men included in these analyses were community-dwelling, largely healthy men, even compared with other MrOS participants, study findings are prone to selection bias and may not apply to other populations.

In conclusion, we found that within this prospective cohort of community-dwelling older men, those with stressful life events in the past year had a significantly increased risk of falls and multiple falls during the subsequent year. Future studies are needed to confirm these findings and to investigate the mechanism that may underlie this association. Additional studies may explore whether clinical screening of older men with recent stressful life events for fall reduction interventions and/or a social network intervention will reduce falls.

## Key points

- A recent history of one or more stressful life events increased risk of future falls in older, community-dwelling men, independent of multiple confounding factors.
- Though the association between stressful life events and falls observed in the current study appears moderate in strength, the mechanism is uncertain.
- Stressful life events did not independently increase incident fracture risk.

## Conflicts of interest

None declared.

## Funding

This work was supported by the National Institute of Arthritis and Musculoskeletal and Skin Diseases, the National Institute on Aging, the National Center for Research Resources, and the National Institutes of Health Roadmap for Medical Research under the following grant numbers: U01 AR45580, U01 AR45614, U01 AR45632, U01 AR45647, U01 AR45654, U01 AR45583, U01 AG18197, U01-AG027810, and UL1 RR024140. The funding agencies had no direct role in the conduct of the study; the collection, management, analyses and interpretation of the data; or preparation or approval of the manuscript.

## Supplementary data

Supplementary data mentioned in the text is available to subscribers in *Age and Ageing* online.

## References

1. Nevitt MC, Cummings SR, Kidd S, Black D. Risk factors for recurrent nonsyncopal falls. A prospective study. *JAMA* 1989; 261: 2663–8.
2. Tinetti ME, Speechley M, Ginter SF. Risk factors for falls among elderly persons living in the community. *N Engl J Med* 1988; 319: 1701–7.
3. O'Loughlin JL, Robitaille Y, Boivin JF, Suissa S. Incidence of and risk factors for falls and injurious falls among the community-dwelling elderly. *Am J Epidemiol* 1993; 137: 342–54.
4. Nevitt MC, Cummings SR, Hudes ES. Risk factors for injurious falls: a prospective study. *J Gerontol* 1991; 46: M164–70.
5. Deandrea S, Lucenteforte E, Bravi F, Foschi R, La Vecchia C, Negri E. Risk factors for falls in community-dwelling older people: a systematic review and meta-analysis. *Epidemiology* 2010; 21: 658–68.
6. Verghese J, Holtzer R, Lipton RB, Wang C. Quantitative gait markers and incident fall risk in older adults. *J Gerontol A Biol Sci Med Sci* 2009; 64: 896–901.
7. Hartikainen S, Lonnroos E, Louhivuori K. Medication as a risk factor for falls: critical systematic review. *J Gerontol A Biol Sci Med Sci* 2007; 62: 1172–81.
8. Lewis CE, Ewing SK, Taylor BC *et al.* Predictors of non-spine fracture in elderly men: the MrOS study. *J Bone Miner Res* 2007; 22: 211–9.
9. Taylor BC, Schreiner PJ, Stone KL *et al.* Long-term prediction of incident hip fracture risk in elderly white women: study of osteoporotic fractures. *J Am Geriatr Soc* 2004; 52: 1479–86.
10. Moller J, Hallqvist J, Laflamme L *et al.* Emotional stress as a trigger of falls leading to hip or pelvic fracture. Results from the ToFa study—a case-crossover study among elderly people in Stockholm, Sweden. *BMC Geriatr* 2009; 9: 7.
11. Peterson MG, Allegrante JP, Augurt A, Robbins L, MacKenzie CRCornell CN. Major life events as antecedents to hip fracture. *J Trauma* 2000; 48: 1096–100.
12. Juster RP, McEwen BS, Lupien SJ. Allostatic load biomarkers of chronic stress and impact on health and cognition. *Neurosci Biobehav Rev* 2010; 35: 2–16.
13. Kriebbaum M, Christensen U, Lund R, Prescott E, Osler M. Job loss and broken partnerships: do the number of stressful life events influence the risk of ischemic heart disease in men? *Ann Epidemiol* 2008; 18: 743–5.
14. Phillips AC, Der G, Carroll D. Stressful life-events exposure is associated with 17-year mortality, but it is health-related events that prove predictive. *Br J Health Psychol* 2008; 13(Pt 4): 647–57.
15. Gallo WT, Teng HM, Falba TA, Kasl SV, Krumholz HM, Bradley EH. The impact of late career job loss on myocardial infarction and stroke: a 10 year follow up using the health and retirement survey. *Occup Environ Med* 2006; 63: 683–7.
16. Martikainen P, Valkonen T. Mortality after death of spouse in relation to duration of bereavement in Finland. *J Epidemiol Community Health* 1996; 50: 264–8.
17. Kornerup H, Osler M, Boysen G, Barefoot J, Schnohr P, Prescott E. Major life events increase the risk of stroke but not of myocardial infarction: results from the Copenhagen City Heart Study. *Eur J Cardiovasc Prev Rehabil* 2010; 17: 113–8.

18. Blank JB, Cawthon PM, Carrion-Petersen ML *et al.*. Overview of recruitment for the osteoporotic fractures in men study (MrOS). *Contemp Clin Trials* 2005; 26: 557–68.
19. Orwoll E, Blank JB, Barrett-Connor E *et al.*. Design and baseline characteristics of the osteoporotic fractures in men (MrOS) study—a large observational study of the determinants of fracture in older men. *Contemp Clin Trials* 2005; 26: 569–85.
20. Washburn RA, Smith KW, Jette AM, Janney CA. The Physical Activity Scale for the Elderly (PASE): development and evaluation. *J Clin Epidemiol* 1993; 46: 153–62.
21. Yesavage JA, Brink TL, Rose TL *et al.*. Development and validation of a geriatric depression screening scale: a preliminary report. *J Psychiatr Res* 1982; 17: 37–49.
22. Pahor M, Chrischilles EA, Guralnik JM, Brown SL, Wallace RBCarbonin P. Drug data coding and analysis in epidemiologic studies. *Eur J Epidemiol* 1994; 10: 405–11.
23. Michael YL, Berkman LF, Colditz GA, Kawachi I. Living arrangements, social integration, and change in functional health status. *Am J Epidemiol* 2001; 153: 123–31.
24. Spiegelman D, Hertzmark E. Easy SAS calculations for risk or prevalence ratios and differences. *Am J Epidemiol* 2005; 162: 199–200.
25. Luukinen H, Koski K, Laippala P, Kivela SL. Risk factors for recurrent falls in the elderly in long-term institutional care. *Public Health* 1995; 109: 57–65.
26. Beyer I, Mets T, Bautmans I. Chronic low-grade inflammation and age-related sarcopenia. *Curr Opin Clin Nutr Metab Care* 2012; 15: 12–22.
27. Helgeson VS, Escobar O, Siminerio I, Becker D. Relation of stressful life events to metabolic control among adolescents with diabetes: 5-year longitudinal study. *Health Psychol* 2010; 29: 153–9.
28. Goldston DB, Kovacs M, Obrosky DS, Iyengar S. A longitudinal study of life events and metabolic control among youths with insulin-dependent diabetes mellitus. *Health Psychol* 1995; 14: 409–14.

**Received 15 February 2013; accepted in revised form 15 May 2013**