Weight Cycling and Risk of Forearm Fractures: A 28-Year Follow-up of Men in the Oslo Study

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Weight cycling may lead to fractures in non-weight-bearing bone. The authors investigated the association between self-reported episodes of weight loss and forearm fracture in a cohort of elderly Norwegian men (n = 4,601; mean age = 71.6 years). Men initially examined in 1972–1973 as part of the population-based Oslo Study were reexamined in 2000. Weight and height were measured both times; histories of weight cycling (amount and frequency) and fracture and information on covariates were elicited by questionnaire. Irrespective of amount of weight loss, 35–43% of men reporting four or more weight loss episodes at ages 25–50 years had experienced a forearm fracture, as compared with 17–18% of men without weight loss episodes. For weight loss episodes that had occurred after age 50 years, associations were weaker. In an analysis limited to men whose last fracture had occurred after the weight loss episodes, the adjusted odds ratio for forearm fracture was 2.91 (95% confidence interval: 1.10, 7.64) for four or more weight loss episodes versus none. These findings suggest that weight cycling may predict forearm fracture in elderly men and indicate that the potentially harmful effects of weight cycling are related to the number of episodes occurring at ages 25–50 years.

Parallel to the increasing prevalence of obesity in the Western world and the promotion of pills and programs that purport to aid in weight loss, a large proportion of the population is attempting to lose weight at any given time. Unfortunately, these efforts are often followed by weight regain and may even lead to a higher weight than the initial one (1). Most observational studies report an association between weight cycling, defined as repeated loss and regain of weight, and increased morbidity—including increases in cardiovascular disease risk factors and diabetes mellitus (2–10)—as well as increased cardiovascular and total mortality (2, 8, 11–16). Because there are several methodological limitations connected to many of these studies, such as failure to distinguish between intentional and unintentional weight loss (17), no health authority has yet officially warned about weight cycling. Furthermore, there is an inherent difficulty in determining whether the association between weight cycling and health is causal (18).

One of the consequences of weight cycling may be an increase in the incidence of bone fractures. A prospective study conducted in Norway showed an increased risk of hip fracture in almost 20,000 middle-aged men and women followed for 11.6 years (19). Men in the highest quartile of weight variability had a nearly threefold increased risk of hip fracture compared with men in the lowest quartile. The corresponding figure for women was a twofold increase.
The Iowa Women’s Health Study found a clear trend towards an increased risk of hip fracture with increasing weight variability during adulthood (6).

Fractures of the distal forearm or wrist are among the most common of all fractures. The incidence rates of distal forearm fracture in Norway are the highest reported (20–22). The capital city of Oslo had a higher incidence than elsewhere when the analyses were restricted to the summer months without snow and ice (20). Wrist fracture is an important predictor of subsequent osteoporotic fracture (23, 24) and is an early and sensitive marker of male skeletal fragility (25). To our knowledge, no study has examined the relation between weight cycling and forearm or wrist fractures.

As part of the 2000 Oslo Study, we collected self-reported data on the frequency and amount of weight loss before and after age 50 years and on history of forearm fractures from a large cohort of elderly men (mean age = 71.6 years). Our aim in the present analysis was to examine the association between repeated weight loss episodes and forearm fractures in this cohort.

MATERIALS AND METHODS

Subjects and measurements

The cohort was originally examined in the Oslo Study of 1972–1973, as described previously (26). In brief, in 1972–1973, all men born during the years 1923–1932 and residing in the city of Oslo, Norway, were invited to undergo screening for cardiovascular diseases and risk factors. A total of 16,209 men aged 40–49 years attended, representing 63 percent of this age group. Among other examinations, height (in centimeters) and weight (in kilograms) were measured, and participants filled in a questionnaire regarding prevalent diseases, symptoms of cardiovascular origin, smoking habits, degree of physical activity during leisure time, occupational activity, and stress.

In 2000, men who were initially invited to the screening in 1972–1973 and were still resident in Oslo or in the neighboring county of Akershus were invited to participate in a repeat health survey (27). The measurements followed the same protocol as in 1972–1973. The participants filled in two questionnaires covering the same topics as in 1972–1973, as well as questions about education, alcohol consumption, use of medication, falls incurred during the last year, and other health-related items, including whether they had ever experienced a forearm/wrist fracture (“Have you ever fractured your wrist/forearm? If yes, indicate your age at the last occasion.”). In addition, they were asked to report the number of occasions on which they had lost weight (been on a diet/slimmed down) and the amount of weight lost on each occasion (<5 kg, 5–9 kg, or ≥10 kg). Participants were queried about these categories separately for weight loss at ages 25–50 years and weight loss after age 50 years. The numbers of occasions recorded were 0, 1, 2–3, and ≥4 for each of the three weight loss categories. Additional information on materials, methods, and questionnaires can be found at the Oslo Study website (www.fhi.no/oslo2).

Of the 10,328 men who were candidates for reexamination in 2000, 6,581 either provided a blood sample or answered the questionnaires or both, producing an overall attendance rate of 63.7 percent. A smaller number (n = 4,601) of participants answered the question about forearm fracture and responded to at least one of the six questions on weight loss, and thus were included in the current analysis.

Covariates

Variables on which data were collected in 1972–1973 included age, marital status (defined as married or not married), smoking (defined as current daily smoking or previous/never smoking), and leisure-time physical activity (26, 27), which was dichotomized into moderate/high activity (exercise, sports totaling at least 4 hours per week, or regular heavy training/competition several times per week) versus more sedentary activity. Responses to the question about occupational activity were dichotomized into sedentary activity (e.g., desk work) versus types of occupational activity demanding more walking, lifting, or heavy manual labor. Chronic disease was categorized as one or more of the following—myocardial infarction, angina pectoris, other heart disease, arteriosclerosis in the legs, cerebral stroke, and diabetes—versus none or was used as a continuous variable with values between 0 and 6. Because psychological distress might be a predictor of later fracture (28), we included a question regarding whether the respondent had felt noticeably more tense or irritable in the last year than before (yes or no).

In 2000, data on more factors known to be associated with fracture were collected. The question about total number of years spent in school/university was used as a continuous variable, whereas consumption of alcohol was dichotomized into consumption a few times per year/not during the last year/never versus more often. Number of falls during the last year was dichotomized into none versus at least one. Type(s) of prescription drug(s) used during the last 4 weeks was registered. In this paper, we have included bisphosphonates as the most important osteoporosis drug and peroral use of corticosteroids, which adversely affects bone (29). Furthermore, we combined data collected in 1972–1973 and 2000 to construct the smoking variables “stopped smoking,” “started to smoke,” “smoked both times,” and “smoked neither time,” as well as the variable “change in body mass index” (weight (kg)/height (m)^2), defined as the difference in body mass index between baseline and follow-up.

Statistical analysis

In the descriptive part of our study (table 1), we compared baseline variables obtained in 1972–1973 for men with no weight loss episodes/one weight loss episode with those for men with two or more episodes. The associations between baseline variables and the dichotomized weight cycling variable were tested by means of Pearson’s chi-squared test and the F test. Descriptive analyses at baseline were also conducted for men who were lost to follow-up, including those who died before 2000.

The prevalence of fracture according to number and amount of weight loss episodes was tested by linear association (trend) for weight loss at ages 25–50 years and weight loss after age 50 years separately. Logistic regression analyses were used to estimate the relations between weight loss categories and forearm fractures.

In our primary analysis, we included variables on which data were collected in 1972–1973 as possible confounding or explanatory factors. In the first model, we adjusted for age; in the second model, we included age, marital status, smoking, physical activity during leisure time, occupational activity, height, body mass index, psychological distress, and chronic diseases. In addition to calculating odds ratios and 95 percent confidence intervals, we conducted tests for trend with logistic regression.

In the secondary analyses, we added variables on which data were collected only in 2000, including duration of education, falls incurred during the past year, use of medication (two different types), and consumption of alcohol. In addition, we included variables describing changes in smoking and body mass index between baseline and follow-up. Interactions between body mass index, smoking, physical activity during leisure time, and occupational activity in 1972–1973 and the various weight loss variables versus forearm fractures were explored by testing for the significance of a cross-product term for each of these four variables in 1972–1973 and the weight cycling variables. None of the tests revealed significant interaction effects.

Finally, we constructed a model in which we limited the analyses to men who reported weight loss at ages 25–50 years and forearm fracture after the age of 50 years. Although this was still a cross-sectional study design, the fractures in this model occurred after the weight loss episodes. Because of the small number of fractures in this subpopulation, all amounts of weight loss were merged. For men reporting episodes in more than one weight loss category, we selected the category with the highest frequency of episodes. Men whose last fracture had occurred before age 50 years were excluded. Results of this analysis were adjusted for baseline variables. All of the analyses were performed using SPSS 14.0 (SPSS, Inc., Chicago, Illinois), and the level of statistical significance was set to \( p \leq 0.05 \) (two-sided tests).

## Ethics and approvals

All of the participants gave their written signed consent. The Norwegian Data Inspectorate approved the study, and it was evaluated by the Regional Committee for Medical Research Ethics. The study was conducted in full accordance with the World Medical Association Declaration of Helsinki.

## RESULTS

Table 1 shows baseline characteristics according to weight cycling status for men who participated in both surveys. Men with two or more weight loss episodes had a higher body mass index in 1972–1973. They were less likely to smoke and tended to report less physical activity, and a higher percentage of them reported psychological distress than men with fewer weight loss episodes.

Episodes of weight loss occurring after age 50 years were more common than episodes occurring between ages 25

<table>
<thead>
<tr>
<th>Baseline characteristics (1972–1973)</th>
<th>Weight loss episodes occurring at ages 25–50 years (\text{I} (N = 4,571–4,601))</th>
<th>Weight loss episodes occurring after age 50 years (\text{I} (N = 4,553–4,582))</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0 or 1 episode (n = 4,314)</td>
<td>(\geq 2) episodes (n = 287)</td>
</tr>
<tr>
<td>Age (years)</td>
<td>43.6</td>
<td>43.1</td>
</tr>
<tr>
<td>Married (%)</td>
<td>91.3</td>
<td>89.2</td>
</tr>
<tr>
<td>Body mass index§</td>
<td>24.2</td>
<td>26.8</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>178.2</td>
<td>178.4</td>
</tr>
<tr>
<td>Moderate/high physical activity during leisure time (%)</td>
<td>24.0</td>
<td>17.4</td>
</tr>
<tr>
<td>Sedentary occupational activity (%)</td>
<td>57.8</td>
<td>63.3</td>
</tr>
<tr>
<td>Current smoking (%)</td>
<td>42.4</td>
<td>34.8</td>
</tr>
<tr>
<td>One or more chronic diseases (%)¶</td>
<td>1.9</td>
<td>2.1</td>
</tr>
<tr>
<td>Psychological distress (%)</td>
<td>25.2</td>
<td>36.8</td>
</tr>
</tbody>
</table>

*Participants in 1972–1973 who also participated in 2000 and answered one or more of the questions on weight loss.
†Information about previous episodes of weight loss was collected in 2000.
‡Pearson’s two-sided chi-squared test for categorical variables and \(t\) test for continuous variables.
§Weight (kg)/height (m)².
¶Myocardial infarction, angina pectoris, other heart disease, arteriosclerosis obliterans, cerebral stroke, or diabetes.
50 years, and weight loss of <5 kg was more frequently reported than larger amounts of 5–9 kg or ≥10 kg (tables 2 and 3).

The proportion of men who reported a history of forearm/wrist fracture was 17.7 percent, and the proportion increased with an increasing number of weight loss episodes between the ages of 25 and 50 years (p < 0.05) (table 2). Irrespective of the amount of weight lost, 35–43 percent of the men reporting four or more weight loss episodes at ages 25–50 years had experienced a forearm fracture, as compared with 17–18 percent among men without reported weight loss episodes. There was a clear increase in the odds ratio for a forearm fracture with increasing episodes of weight loss, regardless of the amount of weight lost. Adjustment for covariates recorded in 1972–1973 did not change the results (table 2).

For weight loss occurring after age 50 years, forearm fracture was only associated with weight loss episodes of <5 kg (p < 0.05). Adjustment for covariates recorded at baseline did not change the results (table 3).

The effect estimates for the relation between forearm fractures and weight loss episodes were similar with and without additional adjustment for variables on which data were collected in 2000—that is, the secondary analyses (level of education, consumption of alcohol, use of two types of medicine, falls during the last year, changes in smoking status, and change in body mass index; data not shown). If anything, the odds ratios increased with additional adjustments. This was true for weight loss episodes occurring between the ages of 25 and 50 years and those occurring above age 50 years.

Finally, we performed an analysis among the 333 men who reported experiencing their last forearm fracture after the age of 50 years and weight loss episodes between ages 25 and 50 years. Men reporting four or more weight loss episodes had more fractures than men with fewer episodes, irrespective of the amount of weight lost (data not shown). When the amounts were analyzed together, men with four or more weight loss episodes at ages 25–50 years and a last forearm fracture after age 50 years had an adjusted odds ratio for forearm fracture of 2.91 (95 percent confidence interval: 1.10, 7.64) in comparison with no episodes (table 4).

### TABLE 2. Numbers and percentages of participants sustaining a forearm fracture and odds ratio* for sustaining a forearm fracture according to number of episodes of weight loss and amount of weight lost at ages 25–50 years, Oslo, Norway, 1972–2000

<table>
<thead>
<tr>
<th>Amount of weight lost and no. of episodes</th>
<th>No. of participants</th>
<th>% of participants</th>
<th>% with forearm fracture</th>
<th>Age-adjusted OR†</th>
<th>95% CI†</th>
<th>Multivariate OR‡</th>
<th>95% CI‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;5 kg</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>4,035</td>
<td>91.2</td>
<td>17.0</td>
<td>Referent</td>
<td>Referent</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>174</td>
<td>3.9</td>
<td>18.4</td>
<td>1.07</td>
<td>0.72</td>
<td>1.60</td>
<td>1.10</td>
</tr>
<tr>
<td>2–3</td>
<td>176</td>
<td>4.0</td>
<td>21.6</td>
<td>1.36</td>
<td>0.94</td>
<td>1.97</td>
<td>1.47</td>
</tr>
<tr>
<td>≥4</td>
<td>40</td>
<td>0.9</td>
<td>35.0</td>
<td>2.84</td>
<td>1.46</td>
<td>5.52</td>
<td>3.02</td>
</tr>
<tr>
<td>Total</td>
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<td>100.0</td>
<td>17.4</td>
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</tr>
<tr>
<td>p-trend</td>
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<td></td>
<td>0.003</td>
<td>0.003</td>
<td>0.001</td>
<td></td>
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<td>5–9 kg</td>
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<td></td>
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<tr>
<td>0</td>
<td>3,103</td>
<td>94.4</td>
<td>17.7</td>
<td>Referent</td>
<td>Referent</td>
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<td></td>
</tr>
<tr>
<td>1</td>
<td>112</td>
<td>3.4</td>
<td>17.9</td>
<td>1.01</td>
<td>0.62</td>
<td>1.66</td>
<td>1.10</td>
</tr>
<tr>
<td>2–3</td>
<td>59</td>
<td>1.8</td>
<td>27.1</td>
<td>1.64</td>
<td>0.90</td>
<td>2.98</td>
<td>1.76</td>
</tr>
<tr>
<td>≥4</td>
<td>14</td>
<td>0.4</td>
<td>42.9</td>
<td>3.91</td>
<td>1.31</td>
<td>11.69</td>
<td>3.86</td>
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<tr>
<td>Total</td>
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<td>100.0</td>
<td>18.0</td>
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<tr>
<td>p-trend</td>
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<td></td>
<td>0.010</td>
<td>0.014</td>
<td>0.007</td>
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<tr>
<td>≥10 kg</td>
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</tr>
<tr>
<td>0</td>
<td>3,136</td>
<td>96.4</td>
<td>17.5</td>
<td>Referent</td>
<td>Referent</td>
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<tr>
<td>1</td>
<td>80</td>
<td>2.5</td>
<td>31.3</td>
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<td>1.27</td>
<td>3.38</td>
<td>2.21</td>
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<tr>
<td>2–3</td>
<td>30</td>
<td>0.9</td>
<td>16.7</td>
<td>0.94</td>
<td>0.36</td>
<td>2.45</td>
<td>1.03</td>
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<tr>
<td>≥4</td>
<td>7</td>
<td>0.2</td>
<td>42.9</td>
<td>3.42</td>
<td>0.76</td>
<td>15.33</td>
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<tr>
<td>Total</td>
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<td>100.0</td>
<td>17.9</td>
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<td>p-trend</td>
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<td></td>
<td>0.013</td>
<td>0.022</td>
<td>0.012</td>
<td></td>
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</table>

* The logistic regression analyses were restricted to the number of participants with data on all covariates.
† OR, odds ratio; CI, confidence interval.
‡ Adjusted for age, marital status, smoking, physical activity during leisure time, occupational activity, height, body mass index (weight (kg)/height (m)²), psychological distress, and number of chronic diseases (myocardial infarction, angina pectoris, other heart disease, arteriosclerosis obliterans, cerebral stroke, or diabetes mellitus). Data on the covariates were collected in 1972–1973.
DISCUSSION

Among these elderly men, number of weight loss episodes, particularly episodes occurring between the ages of 25 and 50 years, was associated with an increased risk of forearm fracture. The findings were similar after adjustment for covariates measured at baseline and after additional adjustment for variables on which data were collected at follow-up. The amount of weight lost each time was of lesser importance. In the analysis limited to men whose last fracture had occurred after the weight loss episodes, the odds ratio for a forearm fracture was almost tripled among men reporting four or more weight loss episodes as compared with none.

Possible causes of the association

The association between forearm fracture and weight cycling could be due to an increased risk of falling or increased fragility. One study conducted in the United States reported that elderly women who lost weight had a slightly increased risk of subsequent falls—and the risks were similar regardless of whether or not the weight loss was intentional (30). However, in that study as well as in the present study, adjustment for falls did not alter the association between weight loss and fracture.

A Finnish study of 169 premenopausal women aged 29–46 years suggested that weight cycling might be associated with lower bone mineral density in the spine and distal radius but not with bone mineral density in the femoral neck and trochanter (31). No significant association between weight cycling and indices of bone density was found in a study of obese women aged 21–45 years (32), but those who had incurred weight loss of >5 kg in the last year were excluded from the study population. Bone mineral density (lumbar, femoral, and total body) was also unaltered by weight cycling among 48 elite judoists whose bone mineral densities were measured before and after the first weight cycle of the season (33). In nonathletes, weight loss interventions combining dieting and exercise training/aerobic exercise do not necessarily prevent bone loss but may reduce it (34–37). Attenuated loss of bone has also been

<table>
<thead>
<tr>
<th>Amount of weight lost and no. of episodes</th>
<th>No. of participants</th>
<th>% of participants</th>
<th>% with forearm fracture</th>
<th>Age-adjusted OR</th>
<th>95% CI</th>
<th>Multivariate OR</th>
<th>95% CI</th>
<th>p-trend</th>
</tr>
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<tbody>
<tr>
<td>&lt;5 kg</td>
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<td>3,602</td>
<td>85.1</td>
<td>17.4</td>
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<td>Referent</td>
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<td>1</td>
<td>302</td>
<td>7.1</td>
<td>19.2</td>
<td>1.15</td>
<td>0.85, 1.55</td>
<td>1.17</td>
<td>0.86, 1.58</td>
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<td>2–3</td>
<td>256</td>
<td>6.1</td>
<td>19.1</td>
<td>1.13</td>
<td>0.82, 1.57</td>
<td>1.14</td>
<td>0.82, 1.60</td>
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<tr>
<td>≥4</td>
<td>74</td>
<td>1.7</td>
<td>29.7</td>
<td>2.01</td>
<td>1.21, 3.34</td>
<td>2.04</td>
<td>1.22, 3.40</td>
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<td>5–9 kg</td>
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<td>Referent</td>
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<td>0.81, 1.70</td>
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<td>1.37</td>
<td>0.84, 2.23</td>
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<tr>
<td>≥4</td>
<td>21</td>
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<td>23.8</td>
<td>1.45</td>
<td>0.53, 3.97</td>
<td>1.42</td>
<td>0.51, 3.93</td>
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<tr>
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<td>18.1</td>
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<td>p-trend</td>
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<td></td>
<td>0.114</td>
</tr>
<tr>
<td>≥10 kg</td>
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<td>0</td>
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<td>93.3</td>
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<td>1.14</td>
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<td>1.21</td>
<td>0.61, 2.40</td>
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<td>≥4</td>
<td>17</td>
<td>0.5</td>
<td>11.8</td>
<td>0.66</td>
<td>0.15, 2.91</td>
<td>0.62</td>
<td>0.14, 2.76</td>
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<td>17.8</td>
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<td></td>
<td></td>
<td></td>
<td>0.498</td>
</tr>
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</table>

* The logistic regression analyses were restricted to the number of participants with data on all covariates.
† OR, odds ratio; CI, confidence interval.
‡ Adjusted for age, marital status, smoking, physical activity during leisure time, occupational activity, height, body mass index (weight (kg)/height (m)^2), psychological distress, and number of chronic diseases (myocardial infarction, angina pectoris, other heart disease, arteriosclerosis obliterans, cerebral stroke, or diabetes mellitus). Data on the covariates were collected in 1972–1973.

reported when dieting has been combined with additional calcium intake (38). Although there seems to be agreement that bone loss occurs with weight loss in older persons, it remains unclear whether there is any detriment to bone health in younger persons with weight reduction or weight cycling (39). Our findings suggest that repeated dieting and weight gain in young and middle-aged men could be harmful to bone health, even in the forearm.

Weight cycling may cause bone loss through a variety of mechanisms (39). It has been suggested that since weight loss often is “unphysiologically” fast, bone loss occurring during weight loss is not fully reversed during weight gain, which often occurs more slowly (31). It could also be that repeated weight loss episodes followed by bone loss produce permanent microarchitectural damage in the bones, leading to a lower fracture threshold, but we have no further information with which to investigate this.

Another possible explanation for our findings could be that weight cycling defines a group of men with an otherwise increased risk of fracture. This question needs further study.

**Number of episodes versus amount of weight loss**

We found that the risk of forearm fracture was due to the number of episodes of weight cycling, not so much to the amount of weight lost in kilograms. Number of episodes was also more important than amount with regard to diabetes and the metabolic syndrome in the same cohort of men (40). One potential explanation is that repeated episodes are associated with repeated decreases in levels of hormones crucial for bone formation (estrogen, leptin, glucagon-like peptide 2, growth hormone, and insulin-like growth factor 1), repeated increases in cortisol levels, or reduced dietary calcium intake and/or reduced efficiency of calcium absorption (39). Bone structure may not be fully restored between weight loss episodes, or a large number of weight loss episodes could cause permanent damage to the bone microarchitecture. Future controlled trials of weight loss/weight cycling should be designed to better understand the mechanisms influencing the density and quality of bone.

**Fracture and weight loss—the sequence of events**

The fractures reported in this study may have occurred recently or many years previously, and weight loss may have been attempted before or after the fracture. Thus, no conclusions regarding causality can be made in this study. We attempted to approach a “prospective” analysis by including only men with fractures after the age of 50 years who reported weight loss before that time. Although the statistical power of that analysis was reduced, the results were similar to those obtained from the entire data set, indicating a possible causal link between weight loss and fracture.

**Strength and weaknesses**

The strengths of this population-based study were the 28 years of follow-up, the use of standardized procedures and questions both times, and the possibility of analyzing a subsample of participants in whom the fractures occurred after the weight loss episodes. We were also able to distinguish between the number of weight loss episodes and the amount of weight lost and between weight cycling before age 50 years and weight cycling after age 50 years.

The finding of a “dose-response” relation between weight cycling episodes and fractures and the almost-consistent results across amounts of weight loss strengthen the notion of a real association between forearm fractures and weight cycling.

Some of the limitations of this study are discussed below.
Self-reports of fracture

Our data about the history of forearm fracture were collected by self-report. Several studies have compared self-reports with official hospital registries/medical records and found fairly high validity (41–46). In the Tromsø Study, using the same question about fractures as we did, 85 percent of all forearm fractures registered in the x-ray registry at Tromsø University Hospital were also self-reported (45). Very few cases of overreporting were found.

In our study, the respondents were asked to recall forearm fractures that had occurred at any time previously—a long time span for these elderly men, and a possible source of measurement errors. However, we believe that these errors would have been random and as such probably would have attenuated the observed results.

The question of whether men who lost weight reported past forearm fractures differently than men who did not lose weight is crucial. We have no reason to believe that men who experienced a forearm fracture recalled or deliberately reported weight loss episodes differently than men without such fractures. These events are unlikely to have been linked.

The question about weight loss

Our question about weight loss was formulated as how much and how many times the individual had followed a diet or attempted slimming. The heading of the question was “slimming,” and Norwegians will normally interpret this as intentional weight loss. However, because we did not specify whether or not the weight reduction was intentional, we cannot exclude the possibility that some respondents referred to episodes of unintentional weight loss.

Our main exposure variable, weight loss episodes, was reported retrospectively when the subjects were 68–77 years of age. This reporting may have been subject to recall bias and may have introduced misclassification. Although studies have revealed that men underestimate their weight by 0–3 kg in comparison with their measured weight (47), our question was about past episodes of weight loss. We are unaware of studies which have validated such questions, but when comparing different ways of measuring weight variability, French et al. (48) found that a self-reported categorical measure, in contrast to the root mean square error and coefficient of variance, approximated the cyclical fluctuations of weight gain and loss most closely.

Hypothetically, obese men could have reported more weight loss episodes than they had actually accomplished, as compared with nonobese men. However, this would have been nondifferential misclassification, because the proportion of subjects misclassified on exposure (weight loss) did not depend on disease status (self-reported forearm fracture) (49). The respondents would not have been aware of any possible association between weight loss and forearm fracture. Although it would have been nondifferential, we do not know the potential impact of such misclassification; however, it is likely that the observed associations were weaker than they would have been if weight loss history had been recorded more accurately.

Loss to follow-up

As expected, higher proportions of respondents than of persons lost to follow-up were nonsmokers and were physically active during leisure time, and respondents had fewer chronic diseases in 1972–1973 than did persons lost to follow-up. We have previously reported that nonattendees had a higher mortality rate than attendees (50).

This obvious selection of more healthy men to participate in the follow-up study in 2000 may have influenced the prevalence estimates presented, but it is likely to have had less of an impact on the associations between weight loss and forearm fracture. Studies with follow-up data for all or almost all subjects show a rather small impact of nonresponse on risk estimates pertaining to health or disease with regard to various background characteristics (51, 52). In the Oslo Health Study, which was carried out just after the follow-up of the Oslo Study, most of the associations between outcome and exposure variables (available for both attendees and nonattendees) were unbiased (52). A highly representative sample of participants is not considered essential for generalizability in etiologic studies that report risk estimates rather than prevalence estimates (49).

Fractures of the distal forearm are among the most common of all fractures and are important predictors of subsequent osteoporotic fracture. Understanding the potential risk of repeated attempts at weight loss is important from a health promotion perspective. Our findings indicate that the potentially harmful effects of weight cycling relate to a greater extent to the number of episodes occurring between ages 25 and 50 years than to later weight loss or amount of weight loss.

ACKNOWLEDGMENTS

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In 1972–1973, the data were collected by Ullevål University Hospital (Oslo, Norway), whereas in 2000 data collection was conducted in collaboration with the National Health Screening Service of Norway (now part of the Norwegian Institute of Public Health), the City of Oslo, and Ullevål University Hospital.

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Conflict of interest: none declared.

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