

# Widening the perspectives of fracture prevention in osteoporosis by identifying subgroups based upon psychological aspects and health behaviour

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## ABSTRACT

The potential importance of psychological aspects in relation to risk factors for fractures and preventing unhealth behaviour has rarely been investigated in the field of osteoporosis. This study explores some psychological aspects and health behaviour of people detected to have osteoporosis at the time of a forearm fracture. Moreover, it aims at revealing subgroups within this population with clinical relevance for managing secondary prevention actions. Data collection was based on questionnaires and physical tests. Eighty-five individuals were analysed. The results confirm earlier research on a similar population having relatively good self-reported health behaviour. The individuals reported high quality of life, high amount of physical activity and low alcohol intake. A majority reported good osteoporosis knowledge, a high sense of coherence (mean = 74) and high activity-specific balance confidence (mean = 81). Furthermore, hierarchical cluster analysis indicated a typology of two subgroups where 75% matched a health-resilient group while 25% matched a health-vulnerable group. The vulnerable group had a significantly lower sense of coherence SOC ( $p = 0.02$ ) and activity-specific balance confidence, ABC ( $p = 0.001$ ). This pattern was confirmed from behavioural aspects but only regarding one traditional risk factor namely the history of fractures. The health-vulnerable group achieved a significantly weaker physical profile, less reported time spent outdoors and lower quality of life. The dif-

ferences found between the subgroups indicate that this typology, as a complement to models based upon relative risk like FRAX, can be relevant for widening perspectives in future research and clinical practice of fracture prevention in osteoporosis.

**Keywords:** Fracture Prevention; Health Behaviour; Sense of Coherence; Activity-Specific Balance Confidence; Cluster Analysis

## 1. INTRODUCTION

The phenomenon of low-energy fractures in elderly people is today recognized as a public health problem with severe consequences, characterized by both physical and psychosocial problems, sometimes even leading to increased mortality [1,2]. The vast majority of previous studies of prevention of low-energy fractures in the elderly are based upon the assumption that osteoporosis is one essential primary risk factor. Other reported risk factors for such fractures are age, heredity, gender and history of fractures, low Body Mass Index ( $BMI < 20 \text{ kg/m}^2$ ), current smoking, and alcohol intake ( $>3$  units a day) [1,2]. There are reasons to believe that it would be more fruitful to prevent fractures by attending stronger to the risk of falling than to the bone density value [3-6]. It has been estimated that 85% - 97% of all fractures, among the elderly, identified as low-energy fractures are associated to fall-accidents [3,5,6]. Although low-energy forearm fractures, are closely associated with osteoporosis, empirical studies point out fall-accidents as one of the main reasons for such fractures [4,7,8]. Distal forearm fractures tend to strike people who are in relatively good health,

especially women, but prone to fall on their outstretched hand. For an individual to prevent such falls requires good neuromuscular function including intact reaction time. In other words, a distal forearm fracture may be a sign of sufficient physiological capacity and thereby avoids more severe fractures [4,5,9].

It is widely recognized that health behaviour, such as physical activity, adequate nutrition (particularly of calcium and D-vitamin), exposure for day light for D-vitamin, and avoidance of tobacco and alcohol abuse, is essential in preventing fractures, particularly if combined with factors that decrease the risk of falling [1,3,10]. However, the potential importance of psychological factors that may explain older people's exposure to falls and low trauma fracture [11-13] has rarely been investigated in the field of osteoporosis. Accordingly, in this study the theories of sense of coherence [14] and self-efficacy [15] have been incorporated into the traditional medical approach to risk factors for fractures.

The concept of Sense of Coherence (SOC) is grounded in the salutogenic theory which originates from the general intention to better understand resilience factors that support people towards health and cope with stressful events in life. SOC captures a particular global orientation to life by conceptualizing three dimensions: manageability, meaningfulness and comprehensibility [14]. SOC is related to perceived health, especially mental health, and has been shown to predict both health and quality of life [16]. Furthermore, the stronger the SOC, the more favourable health behaviour [17,18] as well as coping behaviours and skills for managing stressful situations [16,19,20].

Research shows that after having experienced a fall older people respond with fear of falling, activity avoidance and loss of falls efficacy (low perceived self-efficacy about balance) and self-confidence [21,22]. Moreover, fear of falling has been recognized not only as a psychosocial consequence of falls but also as a risk factor for future falls [11-13]. In addition, activity-specific balance confidence is considered as a resilience factor to fear and activity-specific balance confidence has a similar capacity to predict falls [21,23,24]. The concept of activity-specific balance confidence is based on the self-efficacy theory which is situation-specific [15]. Hence, the confidence score varies upon the activity and environment where falls efficacy is a continuum, not a dichotomous factor [23,25]. The activity-specific balance confidence scale covariates with a range of balance impairments as well as reaction time, mobility and falls after rehabilitation from hip fractures [21,23,24,26].

Some studies show that a person's knowledge about unfavorable results from a bone scan may trigger different dimensions of fear and a psychological reconstruction of the body as weak with reduced capacity [27-29].

However, fear related to osteoporosis also can be channeled into productive behaviour [30] where the tension between fear, confidence and aspects of social contexts drive women to achieve control by developing healthy risk awareness [31]. By an eco-epidemiological approach, such psychological and social perspectives have the potential to widen the understanding of health behaviour and aspects of adherence in relation to injury prevention [32]. Thus the aim of this study is to explore health behavior in relation to some psychological characteristics of people detected for osteoporosis at the time of a distal forearm fracture. A person-centered approach was used to reveal potential subgroups with clinical relevance managing secondary prevention actions.

## 2. METHODS

### 2.1. Participants and Procedures

The inclusion criteria for participation were: women and men suffering a forearm fracture at the age of 50 - 80 year, a T-score value of bone mass density (BMD) equal to or more than  $-2.0$  standard deviations below the population mean, obtained by DXL Calscan [33]. The local hospital in this study had access to the European Injury Data Base (IDB) which was used to control the population of forearms fractures during 2009-2010. Those individuals who had impaired cognitive capacity with difficulties to understand the questionnaire or were unable to follow instructions were excluded from the study. The hospital is located in south west Sweden and has a county-wide mission, besides functioning as local hospital for residents in four municipalities. The study design is comparable to a total population design were the population consisted of women and men diagnosed as having risk factors for osteoporosis at the time they had a distal forearm fracture and belonging to this local hospital.

The participants were informed about the study procedure including the physical-performance tests. In addition to the physiological tests, each participant also answered questions concerning demographics (*i.e.*, age), health behavior (*i.e.*, drinking and smoking habits), history of fractures and fall-accidents. They also took a quiz for their knowledge of 25 facts concerning osteoporosis [34], and for quality of life the VAS-scale in EQ-5D was conducted. The questionnaires were completed individually and took approximately 45 minutes to fill out. The physical-performance tests were carried out by trained physiotherapists at the rehabilitation clinic approximately 6 weeks post fracture, at the same time as the follow up for checking the condition of their forearm fracture.

### 2.2. Ethical Considerations

The study was carried out in accordance with the Hel-

sinki Declaration and approved by the regional ethical review board in Uppsala, Sweden (Dnr: 2008/091). All participants received oral and written information about the study before a written consent was obtained. Those who showed a T-score  $\leq -2.0$  SD measured with DXL-Calscan were referred to their general practitioner for follow-up and invited to an osteoporosis school in the primary health care.

### 2.3. Psychometric Measurements

*Sense of Coherence (SOC-13)*. The SOC-13 [16] is a 7-point scale consisting of 13 items that cover the following three dimensions: manageability, comprehensibility and meaningfulness. High scores represent a high degree of sense of coherence. All three aspects need to be present for a person to reach a basic sense of coherence. Therefore, the questionnaire was analysed as a measurement of the whole scale, rather than being examined for the three dimensions separately [14]. The SOC-scale has been found to be reliable and valid across multiple socio-cultural contexts [16]. Cronbach's alpha for the current sample was 0.88.

*The Activity-specific Balance Confidence scale (ABC-scale)*. The ABC-scale is a questionnaire developed to measure an aspect of the psychological impact of balance impairments and falls without losing balance or become unsteady. The participant was asked to rate his/her confidence in relation to performing 16 different activities on a scale from 0 to 10, where higher score indicates stronger confidence [25,35]. Test-retest reliability for samples of community dwelling older people is high ( $r = 0.92$ ) and in terms of criterion validity this measure has been found to correlate significantly with a range of balance and mobility scores, as well as scores for fear of falling [23,35,36]. Cronbach's alpha for the current sample was 0.96.

### 2.4. Physical Performance Tests

The following four physical tests were selected for this study: One leg stance, tandem stance, time stand test and walking speed 30 m. All are functional tests assessing global functional level and have been proven to predict risk of falling or general health important for future fracture risk [37-42].

*The one leg stance (OLS) and the tandem stance (TS) test*. These tests were developed to measure balance activity while shifting the gravity from one leg to the other while remaining in postural position. One study showed that a test result from the OLS, less than 15 seconds, is significantly associated with forearm fractures, odds ratio 5.1 (95% CI = 2.0 - 13.4) [43]. We used an upper time-limit of 30 seconds for recording participants' performances as this time-range has been suggested as a cut

off for risk of falling [40,41,44] and even to predict injurious falls inclusive fractures [45]. These two balance tests were performed for both right and left side. The same procedure was repeated with eyes closed. The best performance out of three was recorded. The exact procedure has been reported elsewhere [40,44].

*Time Stands Test (TST)*. This test requires the participants to rise ten times from a chair as fast as possible with their arms folded across their chest. The chair was a standard site 0.44 m without armrests and 0.38 m deep, placed to a wall [39]. High scores in TST correlate with lower risk for falls [38]. A previous study with a community sample of older people found that reliability for the TST is excellent ( $r = 0.84$ ) [39].

*Maximal walking speed* was measured in seconds by timing subjects as they walked in a corridor 15 m turn around and return [44]. Walking speed has been recognized to predict independency after the age of 70 [37].

### 2.5. Analyses and Statistical Methods

Statistical analyses were conducted using SPSS version 18. As an initial step, we explored whether psychological aspects could identify subgroups within the current sample and in subsequent analysis generate a particular typology. To identify potential subgroups, clinical data on activity-specific balance confidence and sense of coherence were entered into a hierarchical cluster analysis. This is a multivariate data-reduction technique that assigns individuals to subgroups based on their similarity in characteristics entered into the analysis. Ward's method was used in this analysis for distance measure [46].

Validation and profiling of the clusters were conducted in three steps. First, each cluster was analysed separately to ensure a stable cluster solution with at least 10 - 20 percent of the total population and not less than 10 objects in each cluster [47]. The aim of the second step was to establish the criterion validity, analysing variables not used to form the clusters, comparing mean values for these variables across clusters. In the third step, the emerging subgroups were compared in terms of various risk factors. For this procedure independent sample *t*-tests and non-parametric Mann-Whitney tests were conducted. Fisher's exact test was used to investigate certain associations between the subgroups in relation to some of the risk factors. This test is more appropriate than the  $\chi^2$  test of association between small proportions, since it can be used even if the expected value is lower than 5. The value of acceptance for statistical significance was set at  $p < 0.05$ .

## 3. RESULTS

During 2009-2010 there were 356 cases of people with distal forearm fractures in the age of 50 - 80 (IDB Regis-

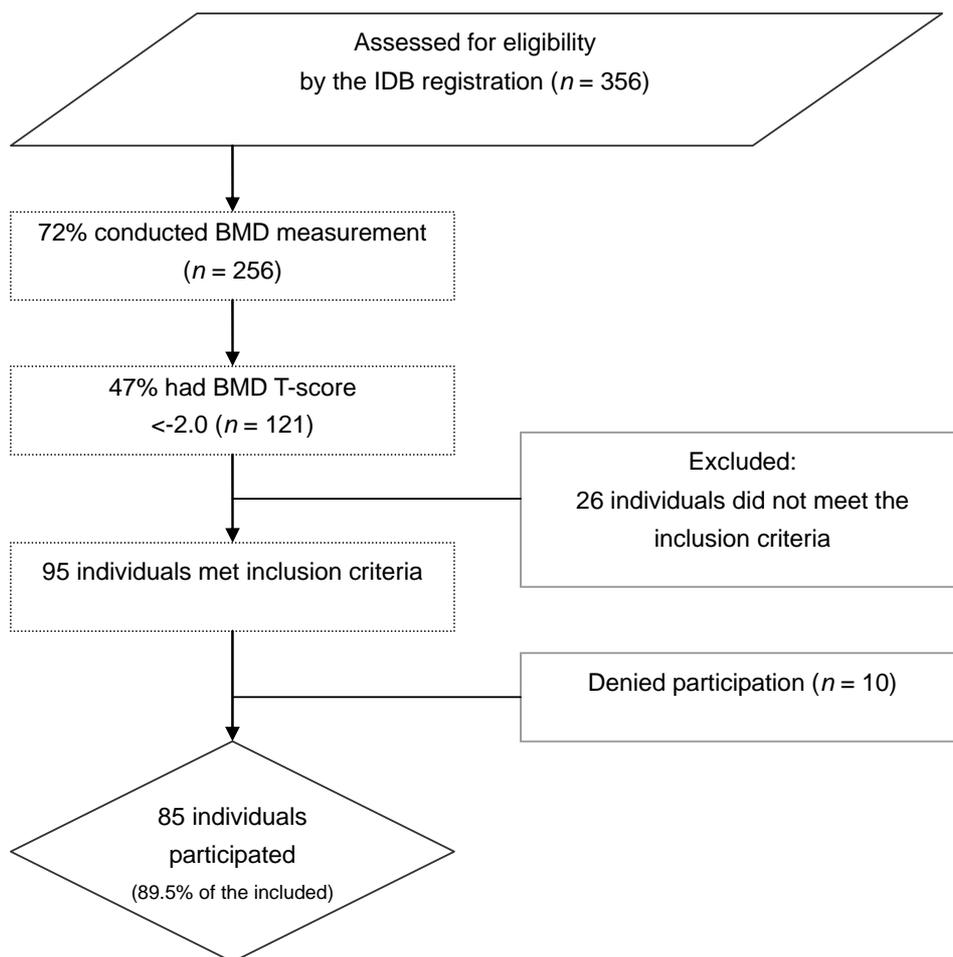
tration) at this hospital. Seventy two percent ( $n = 256$ ) of those individuals underwent osteoporosis examination and 47% of those had a T-score equal to or lower than  $-2.0$  SD below the population mean and were included. Twenty-six individuals were excluded; 22 because they did not geographically belong to the hospital area and 4 because of cognitive impairments. As a result, ninety-five individuals matched the inclusion criteria while 10% ( $n = 10$ ) of them declined to participate or never completed the survey. The recruiting process resulted in 85 final participants (see **Figure 1**), 94% ( $n = 80$ ) women and 6% ( $n = 5$ ) men. The mean age was 65 years ( $SD = 7.58$ ). Ninety percent were born in Sweden, 4% in another Scandinavian country and 2% were born in either a European country outside Scandinavia or in North America, whereas 4% did not report their place of birth.

Forty five percent of the sample had never had an earlier fracture while 51% had had at least one fracture (see **Figure 2**). The mean T-score value for the total sample was  $-2.61$ , median T-score  $-2.60$  ( $SD = 0.42$ ). The mean Body Mass Index (BMI) was 26 ( $SD = 7.36$ ). Of the total sample, 31% of participants reported to have a heredity

for fractures among close relatives (mother, father, sister, brother, grandmother, grandfather, aunt or uncle), 49% reported that they had not, whereas 20% did not know.

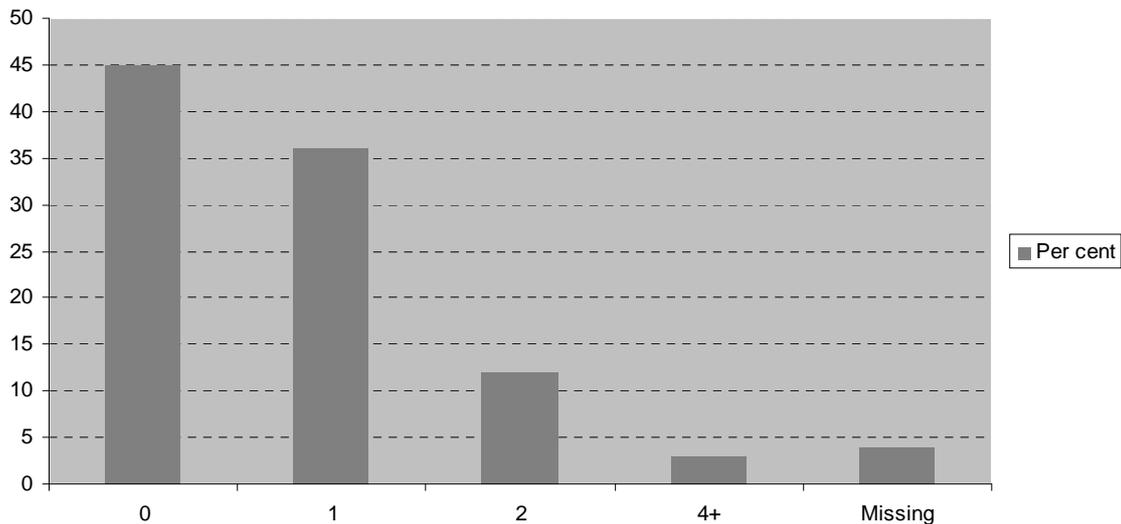
Concerning health behaviour, this sample consumes less than 2 units alcohol a day while 21% of the sample regularly uses tobacco. Outdoor activities were estimated to a meantime of 2 - 3 hours a week, irrespective of season. This sample was physically active reporting a meantime physical activity of 6.28 hours a week ( $SD = 7.17$ ). The most common physical activity was walking where 81% reported that they use to walk. More unusual was exercising balance activities including Tai Chi or dancing and about one tenth regularly did fitness training (see **Table 1**). Forty percent of the sample performed the one leg stance for 30 seconds or more and 72% performed the tandem stance for 30 seconds or longer.

Participants' knowledge about fracture prevention and osteoporosis was according to the questionnaire high with a mean of 18 correct answers of 25 possible. When studying this whole sample in relation to sense of coherence (SOC) and specific activity balance confidence (ABC) these values were also high. The mean for SOC



**Figure 1.** Flow diagram over case selection.

## Experienced fractures before suffering a wrist fracture



**Figure 2.** Distribution among participants in terms of history of fractures before they suffered a forearm fracture.

**Table 1.** Proportions (%) of participants actively involved in physical activity (N = 85).

Type of physical activity	(n = 85)	Exercisers (%)	Non-exercisers (%)
Walking		81	19
Cycling		28	72
Balance program		13	87
Muscle strengt training		11	89
Fitness training		9	91
Jogging/Running		5	95
Dancing		4	96
Tai chi		2	98
Other physical activities		14	86

including 84 individuals was 74 ( $SD = 12.73$ ) and the mean for ABC including 82 individuals was 84.54 ( $SD = 17.85$ ).

### 3.1. Hierarchical Cluster Analysis

The hierarchal cluster analysis generated two clusters. This conclusion was based upon an examination of the agglomeration coefficients for each cluster solution (*i.e.*, the scree-plot method; Hair *et al.* 2010), which revealed that the largest distance appeared between two and three clusters. Four subjects (1 man and 3 women) of the 85 included were drop outs, due to missing data of SOC or ABC. The first cluster was identified as the health-resilient group with high levels of sense of coherence ( $M = 77.09$ ,  $SD = 10.67$ ) and strong activity-specific balance confidence ( $M = 93.39$ ,  $SD = 4.61$ ), whereas the second cluster was identified as the health-vulnerable group with low level of sense of coherence ( $M = 66.27$ ,  $SD = 14.49$ ) and reduced activity-specific balance confidence ( $M =$

$57.03$ ,  $SD = 15.39$ ). Seventy five percent of the sample ( $n = 61$ ) was grouped into cluster 1 (the health-resilient group), whereas 25% ( $n = 20$ ) was grouped into cluster 2 (the health-vulnerable group). The difference between the two clusters was statistically significant, both in terms of sense of coherence,  $t(79) = 3.59$ ,  $p = 0.001$ , and activity-specific balance confidence,  $t(79) = 16.50$ ,  $p = 0.0001$ .

### 3.2. Validation and Profiling of Clusters

The clusters were compared in terms of physiological and behavioural risk factors. The clusters did not differ in terms of gender distribution (Fisher's exact test two-sided  $p = 0.57$ ). The reported use of tobacco did not distinguish between the subgroups (Fisher's exact test two-sided  $p = 0.24$ ). The amount of self-reported alcohol drinking did not differ between the groups (Mann-Whitney). However the amount of alcohol consumption was lower than 2 units a day in both groups and thus not

related to risk behavior. It was more common in the health vulnerable group to use antidepressants (Fisher's exact test two-sided  $p < 0.05$ ).

The following differences are more clearly described in **Tables 2** and **3**. There was no significant difference in age. Neither was there significant difference in bone density. The health-vulnerable group reported that they had experienced significantly more fractures and more types of fractures than the health-resilient group. Moreover, the vulnerable group scored significantly weaker on the quality of life scales (see **Table 2**). Sixty-five subjects out of 85 (76%) reported that they had fallen outdoors, no one reported falling only indoors while 28 subjects of 85 (33%) reported falling indoors and outdoors. The health-resilient group spent significantly more time outdoors during all seasons compared to the health-vulnerable group. There were no significant differences between the subgroups in terms of where the fall had occurred. The

knowledge of osteoporosis was almost the same between the groups with no significant differences (see **Table 2**).

There are big differences between the clusters in the reported time for physical activity in which the health-resilient group is significantly more physically active per week than the health-vulnerable group, 7 hours and 3 hours respectively (**Table 2**). The same pattern is shown in physical performance where the health-vulnerable group achieves a significantly lower physical profile. Functional muscle strength (TST) and walking speed exhibit the greatest differences where the health-vulnerable group needs almost 8 seconds more to raise a chair ten times and 5 seconds more to walk 30 m, compared to the health-resilient group. The balance tests indicate more nuanced results, in which three tests (OLS max, OLS max eyes closed, TS max) distinguish the groups, while performing tandem stance max with eyes closed does not vary significantly between the groups (**Table 3**).

**Table 2.** Comparisons in health and risk profiles between the two clusters.

Health-risk factor	Cluster 1 ( $n = 61$ ) resilient group		Cluster 2 ( $n = 20$ ) vulnerable group		$t$	$df$
	$M$	$SD$	$M$	$SD$		
Age	64.57	7.12	68.4	8.59	1.98	79
T-score (BMD)	-2.60	0.44	-2.63	0.41	0.26	79
Quality of life (EQ5-D)	82.05	14.17	57.22	19.65	5.87***	72
Experienced fractures before wrist fracture	0.55	1.03	1.33	0.73	3.54***	76
Falls outdoors in the past year	1.26	1.61	1.25	0.97	0.03	79
Falls inside and outdoors in the past year	0.61	2.61	0.45	0.60	0.26	79
Physical activity (sum. hours/week)	7.52	7.93	3.00	3.18	2.45*	79
Time outdoors summer (hours/week)	3.98	0.13	3.50	0.89	4.17***	79
Time outdoors winter (hours/week)	3.67	0.75	2.90	1.11	3.44***	79
Osteoporosis knowledge	18.82	2.36	18.10	2.29	1.19	79

Note: The clusters were compared using  $t$ -tests (two-tailed) for independent groups. \* $p < 0.05$ ; \*\* $p < 0.01$ ; \*\*\* $p < 0.001$ .

**Table 3.** Differences in physical performance between the two clusters.

Physical performance	Cluster 1 ( $n = 61$ ) resilient group		Cluster 2 ( $n = 20$ ) vulnerable group		$t$	$df$
	$M$	$SD$	$M$	$SD$		
OLS max	24.96	8.56	16.91	10.96	3.20**	74
OLS max eyes closed	8.77	3.38	8.99	5.42	2.34*	57
TS max	28.80	5.04	24.76	8.95	2.40*	72
TS max eyes closed	17.59	12.10	12.50	12.03	1.50	64
TST	22.83	7.49	30.38	7.50	3.56***	72
Walking speed	18.24	4.50	24.65	7.60	4.36***	73

Note: OLS = One Leg Stance; TS = Tandem Stance; TST = Time Stands Test. As the performances for left and right leg within tests of OLS and TS were highly correlated (with  $r$ s ranging from 0.76 to 0.83), the results from each pair of these tests were combined into a single time score. The clusters were compared using  $t$ -tests (two-tailed) for independent groups. \* $p < 0.05$ ; \*\* $p < 0.01$ ; \*\*\* $p < 0.001$ .

## 4. DISCUSSION

This study confirms other research [4,8,9], reporting that this group of individuals breaking their distal forearm, in the age of 50 - 80 years, can be considered as being a physically healthy and active population. By using a person-centered analytical approach, as applied with cluster analysis, we opened for the possibility to reveal typologies among the observations that would add some new perspectives in relation to managing and developing secondary prevention in osteoporosis [46]. As a result of this approach, we could, based on solely psychometric measurements, identify a health-vulnerable group that reported a history of more frequent fractures, which in turn is a powerful predictor for future fractures [1]. Although no differences across clusters were found in terms of age, gender, or T-score values, significant group differences for risk factors such as physical capacity, time spent outdoors, the amount of physical activity and quality of life further emphasize the importance of separating between resilient and vulnerable individuals among older persons with forearm fractures. Compstone argues that the causes of poor adherence of secondary prevention are poorly understood, and that traditional factors as age, history of fractures, multiple medications etc. constitute less than 10% of factors relating to adherence [48]. Revealing this typology elucidates the relevance for a wider discourse of fracture preventive initiative and the need to distinguish subgroups with different psychological prerequisites for enhancing behaviours that decrease the risk of fall accidents.

In previous studies of falls in the elderly, the ABC-scale has been used where a score below 67 - 69 is suggested to indicate higher risk of recurrent falls [23,24,26]. Our results show a mean of 84 for the whole sample, the health-resilient group had a mean of 93 while the health-vulnerable group only reported a mean of 57. Furthermore, the usefulness of the ABC-scale as a clinical screening instrument has been advocated for similar populations because, compared with other instruments, it is the most likely instrument to correlate with balance dysfunction [21,23,36,49]. Accordingly, there is clinical relevance in identifying individuals who sort into the health-vulnerable group which concerns both history of fractures and frail physical profile indicating that this subgroup can be at extreme risk for new fractures. FRAX is an algorithm calculating a 10-year risk for hip fracture based on age, gender, BMI, history of fractures, use of tobacco or alcohol and bone density but excludes fall risk [3,50]. We suggest that the results of our study can constitute a complement to FRAX, [2,50] in distinguishing a vulnerable subgroup, identifying risk of recurrent falls and thereby monitoring fracture preventive actions.

Our results show that the health-resilient group and the

vulnerable group differ with respect to the level of physical-activity level and performed walking speed. In a 10 year longitudinal study (aged 66 - 76), daily activity level strongly correlated to physical activity and physical performance where walking speed and muscle strength predicted future independency [37]. In line with Frändin's findings, our results can contribute to economic gain in case of screening those groups who would benefit the most from exercise interventions and from encouragement of independency. The importance of exercise in interventions for the prevention of bone loss has been controversial. However, a recent literature review shows that weight bearing and resistance exercise are effective on the BMD of spine, hip and wrists [51]. Moreover, exercise can reduce fall rates if it contributes to balance and muscle strength and is maintained over time [52-55]. Furthermore, studies on exercise interventions report that improved physical capacity increases patients' specific-activity balance confidence and decreases their risk of falling [56,57]. In light of these findings, we believe that individuals in the health-vulnerable group identified in this study are likely to benefit from interventions aimed to improve their physical capacity as well as their activity-specific balance confidence. For individuals in the vulnerable group, low self-efficacy with low sense of coherence might be compared to reduced coping ability (Eriksson, 2007; Bandura 1997) for adherence of secondary prevention recommendations. Such decreased resilience resources are challenging a patient-centred approach in achieving empowered behaviour change. In contrast, the health-resilient group that was identified in this study is likely to benefit fully from health education programmes that encourage them to sustain their healthy lifestyle with high quality of life. Moreover, this health-resilient group would promote fall prevention further by exchanging part of weekly walking for activities designed to improve muscle strength and specific balance training [38,52,54]. A review of post fracture exercise reported that only 4% of the exercise prescriptions to people 45 years or older, contributed to fracture prevention, and in relation to forearm fractures no preventive prescription was found [58]. One underlying dimension of successful multifactorial fall prevention programmes [54] might according to these results be programmes that support psychological aspects of empowerment [59]. Our results can be applied in post fracture interventions by combining physical exercise with psychological support in relation to fall related injuries.

The subgroups did not differ in relation to the high use of tobacco. Compared to 13% of Swedish population, in the age of 18 - 80 [60], or to 9% of a similar population in the GLOW study [61] about 21% used tobacco in this sample. Post fracture actions should therefore highlight the encouragement of quit smoking programs.

Like previous research the vulnerable group identified in this study matches people with increased risk for fall related injuries, which appear to trigger a downward spiral: they are characterized by loss of activity confidence, restriction of physical activities and social participation, loss of independence, physical frailty and repeated falls [12,56]. In addition, there is a risk that individuals who are diagnosed with osteoporosis, as a consequence, develop an exaggerated feeling of fear [27,28,31] with negative risk perception on the body image as well as their identity [29]. Our results indicate that adding knowledge about the patients' psychological resilience resources to a clinical context, rather than solely focusing on relative risk and osteoporosis, might prevent the risk of triggering a downward spiral of fear with increased risk of falling.

In interpreting the results of this study, there are strengths as well as limitations. The fact that 72% of the patients suffering from a distal forearm fracture got their bone density measured compared to the average follow up reported as 23% in Sweden [62] and in other countries, 5% - 30% [63-65] is a strength in this study. However it is important to recognise that there was still 28% that did not return to the BMD measurement and that there were 10% of the included individuals that did not attend the follow-up. The subgroups in the present analysis did constitute 24 - 72 percent each of the total sample. However, although the statistical assumptions for the cluster analysis were met, [47] the total sample was small in relation to the population. Therefore to ensure external validity, more research is needed with a larger and more thoroughly randomized sample.

For future research, the typology revealed in this study could be used in diverse ways to distinguish vulnerable groups from the most healthy and resilient groups. One reason that those differences have not been recognized previously might be that the analyses in randomized intervention studies, which is a widespread design in this area of research, focus on mean differences between variables and cannot therefore reveal subgroups within samples. When planning and conducting secondary prevention interventions, in this population studied, it would be of interest to consider this typology since different prerequisites according to coping behaviour and meaningfulness with self-efficacy might have an impact on the overall outcomes.

In conclusion and in line with an ecoepidemiological approach for injury prevention, we suggest that contextual factors are relevant for the successful implementation of injury-prevention programs. For example, in order to effectively manage the implementation of fracture-prevention strategies, it is not sufficient to identify deficits in physical strength or balance as a proximal risk factor for falls. Rather, knowledge of and focus on physiological risk factors must be combined with an un-

derstanding of the psychological and social motivational forces behind physical activity [32]. Accordingly, our findings propose a hypothesis that a wider perspective on behavioral and psychological resilience factors in individuals with osteoporosis can increase opportunities to develop effective fracture prevention programs. Previous research suggests that future implementation of secondary prevention in osteoporosis should focus on both system and patient barriers [65,66]. It can, in line with these results, be a system barrier not to know about diverse prerequisites in subgroups of osteoporosis. This study presents a typology vital for future discourse on implementation of secondary prevention in osteoporosis. More specifically, specific-activity balance confidence and sense of coherence can, according to the results of this study, be used to identify potential subgroups with clinical relevance for managing secondary prevention actions in osteoporosis.

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