Review

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Examining the Psychosocial Dimensions of Stress in Osteoporosis: A Systematic Review

Osteoporozda Stresin Psikososyal Boyutlarının İncelenmesi: Sistematik Bir Derleme

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ABSTRACT

Osteoporosis is a silently progressing disease that is often disregarded as an inevitable consequence of ageing. Stress is critical for osteoporosis as it inflicts damage on bones and related issues. Studies exploring the link between stress and osteoporosis mostly focus on the biological, but a few studies have touched on the psychosocial perspective. The study aimed to examine these studies in terms of methodology and outcomes. A systematic review was conducted following the PRISMA guidelines. Studies that addressed the stress of osteoporosis patients from a psychosocial perspective and with an original research design were included, while did not measure with subjective scales and focused on different samples rather than the clinical group were excluded; finally, seven studies were analysed. Most of these indicated high perceived stress, low social support, and prolonged psychological distress in women were related to a significant increase in bone mineral density loss and fracture risk. Also, studies showed that stress can influence osteoporosis directly, through causing dysfunctional biological systems, and indirectly, by prompting risky behaviours. Hence, these results underline the need to conceptualise osteoporosis not only as a biomedical but also as a psychosocial issue. Assessing the psychosocial stress for osteoporosis patients and integrating it into intervention strategies is considered crucial for preventive healthcare and patients' quality of life.

Keywords: Osteoporosis, psychosocial stress, biopsychosocial model

ÖZ

Osteoporoz, çoğu zaman yaşlanmanın kaçınılmaz bir sonucu olarak görülerek göz ardı edilen ve sessizce ilerleyen bir hastalıktır. Ancak hastalığın kemiklerde oluşturduğu hasar ve bununla ilişkili karşılaşılan sorunlar sebebiyle stres bu süreçteki kritik bileşenlerden birisidir. Stresin osteoporoz ile ilişkisini irdeleyen çalışmalarda genellikle stresin biyolojik perspektiften ele alındığı dikkat çeker. Ancak az da olsa stresin psikososyal yönüne değinenlerin de olduğu görülmektedir. Mevcut çalışma bu az sayıdaki araştırmayı yöntemsel ve bulgusal olarak ele almayı amaçlamaktadır. Bu çalışmada PRISMA ilkeleri izlenerek sistematik derleme yöntemi benimsenmiştir. Osteoporoz hastalarının stres yaşantılarını psikososyal açıdan ve orijinal bir araştırma deseniyle ele alan çalışmalar derlemeye dahil edilirken bunu subjektif ölçeklerle ölçmeyen, hastalık grubuna değil farklı örneklemlere odaklanan çalışmaların ise dışlanmasının ardından yedi çalışma derlemede yer almıştır. Bu çalışmaların büyük bir kısmı kadınlarda algılanan yüksek düzeyde stres, düşük sosyal destek ve uzun süreli psikolojik sıkıntının kemik mineral yoğunluğu kaybı ve kırık riskinde anlamlı artışla ilişkili olduğunu bulgulamıştır. Ayrıca araştırmalarda stres osteoporozu doğrudan biyolojik sistemlerde yarattığı disfonksiyonla ve dolaylı olarak riskli davranışlara sebep olmasıyla etkileyebildiği ortaya konmaktadır. Sonuç olarak, osteoporozun yalnızca biyomedikal değil, aynı zamanda psikososyal bir hastalık olarak ele alınması gerektiği gözden kaçmamalıdır. Psikososyal stresin osteoporoz hastalarında değerlendirilmesi ve müdahale stratejilerine entegre edilmesi hem önleyici sağlık hizmetleri hem de hasta yaşam kalitesi açısından büyük önem taşıdığı düşünülmektedir.

Anahtar sözcükler: Osteoporoz, psikososyal stres, biyopsikososyal kuram

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Introduction

Osteoporosis (OP) is a systemic skeletal disorder defined by reduced bone mass and the deterioration of bone tissue microarchitecture, resulting in increased fragility and a heightened risk of fractures (Sindel 2023). OP typically progresses asymptomatically until clinical manifestations emerge. Bone density and quality decline are significant concerns that are frequently linked to the natural aging process. Hence, OP is frequently regarded not as a disease but as a chronic, age-related condition (Lems and Raterman 2017). This perception is particularly prevalent among postmenopausal women and the elderly, reinforcing the notion that OP is an inevitable consequence of aging (McClung et al. 2021). However, it is imperative to recognize OP as a significant health concern that requires appropriate attention and intervention. Therefore, it is considered to require identifying OP as a disease to significantly increase its visibility (Kirazlı et al. 2020).

OP exhibits hazardous characteristics in terms of its clinical outcomes, with the most notable being the erosion and fractures of the protective surface of bones. The most critical consequence of OP is the reduction in bone mineral density (BMD), which displays as fractures, compressions, or bone crumbling (Cosman et al. 2014). In such cases, OP patients may experience fractures or compressions severe enough to damage bones, even during routine movements (Lems and Raterman 2017). Consequently, OP leads to not only biological challenges such as pain, discomfort, and fatigue but also significant psychosocial difficulties. These include prolonged periods of immobility due to the extended hospital or homestays, fear of movement due to fragile bones, and withdrawal from social or professional life (Hiligsmann et al. 2019).

The psychosocial perspective of stress concerning OP is crucial for understanding its role in the development and progression of chronic diseases. Crosswell and Lockwood (2020) defined stress as a mental tension that can stem from major life events, trauma, or daily hassles. Many concepts can be traced to consider the effects of stress on the body. The concept of allostatic load, which refers to the cumulative physiological wear resulting from prolonged exposure to stress, is particularly relevant in chronic diseases like OP. Higher levels of allostatic load have been linked to negative health outcomes, including compromised bone health. Sustained stress may interfere with hormonal regulation—such as through elevated glucocorticoid levels—stimulate inflammatory processes, and disrupt cellular communication pathways, ultimately contributing to accelerated bone deterioration and increased susceptibility to OP (O'Connor et al. 2021). The impact of allostatic load caused by stress on bone health also explains the link between OP and age.

Stress influences both psychological well-being and biological processes, contributing to OP through two primary mechanisms. First, chronic stress increases inflammation, promoting osteoclast differentiation (bone resorption) and osteoblast apoptosis (bone formation inhibition), accelerating OP progression (Kelly et al. 2019). Second, psychosocial stress influences bone health via the hypothalamic-pituitary-adrenal (HPA) axis, sympathetic nervous system, and endocrine pathways (He et al. 2021, Hao-Kun et al. 2024). Extracellular vesicles (EVs) play a crucial role in bone remodeling, carrying microRNAs (miRNAs) that regulate osteoblast and osteoclast activity (He et al. 2021). EVs also show potential as biomarkers for early OP diagnosis (Steppe et al. 2023) and as therapeutic targets for bone regeneration and inflammation reduction (Hao-Kun et al. 2024). These findings highlight the importance of stress-related pathways and EV-mediated mechanisms in OP diagnosis and treatment, offering novel strategies for disease management. Besides, the use of benzodiazepines, neuroleptic agents, and antidepressants raises the risk of falls in OP patients due to their impact on balance. Therefore, drugs used for stress-related symptoms such as depression and anxiety can also cause negative problems for bone health (McClung et al. 2021).

Stress should not be considered solely as a predisposing factor for OP; rather, it plays a critical role in the disease's progression and symptom burden. The experiential dimension of stress becomes particularly salient during the post-fracture period, where prolonged hospitalization, chronic pain, immobility, or home confinement often result in increased psychological distress among patients (Huang et al. 2015). In such cases, stress emerges not only as a response to physical impairment but also because of disrupted daily routines, perceived loss of autonomy, and increased dependency. Studies have shown that OP patients undergoing fracture-related treatment report higher levels of perceived helplessness and emotional

fatigue, which may contribute to heightened vulnerability to anxiety and depressive symptoms (Silverman et al. 2007). Moreover, chronic stress may manifest through behavioral maladaptation such as poor sleep hygiene, smoking, alcohol use, and reduced adherence to treatment, all of which have been independently associated with lower BMD and higher fracture risk (Kelly et al. 2019). In addition, the social consequences of OP-related stress—such as fear of falling, social withdrawal, and isolation—can reduce patients' participation in physical and social activities, ultimately exacerbating both psychological and physiological deterioration (El-Gabalawy et al. 2018). Therefore, stress in OP must be conceptualized as both a contributing factor and an outcome of the disease, acting through interconnected psychological, behavioral, and social pathways.

Psychosocial stress exists on a broad spectrum, with traumatic experiences representing some of the most intense forms of it. Trauma can be defined as an extreme, sudden, and life-threatening stressor, such as those experienced in war, sexual assault, or natural disasters. While trauma is related to stress, not all stress can be classified as trauma. While post-traumatic stress disorder (PTSD) is formally categorized as a trauma-related disorder, it can be understood as a prolonged and intensified form of psychosocial stress (Yehuda and LeDoux 2007). Research consistently highlights that trauma plays a crucial role as a significant stressor in the lives of OP patients. Understanding this connection is useful for addressing their unique stress experiences effectively. A study involving 6,041 patients diagnosed with PTSD over seven years found that this group was significantly more likely to develop OP compared to a control group of healthy individuals. This trend persisted during a three-year follow-up period (Huang et al. 2018). Similarly, a large-scale study conducted in a Danish sample found that among 4,114 individuals diagnosed with PTSD, the risk of fractures was 24% higher compared to the general population (Jiang et al. 2018). The prevalence of OP has also been noted in other populations, such as American soldiers returning from war (El-Gabalawy et al. 2018) and survivors of genocide (Paratz and Katz 2011). Also, a comprehensive study examining multiple chronic diseases demonstrates the direct impact of PTSD on these conditions, as well as its significant mediating effects (Ryder et al. 2018). Individuals with PTSD frequently engage in maladaptive health behaviors—such as smoking, alcohol or substance use, physical inactivity, poor dietary habits, and disrupted sleep—which are established risk factors for reduced bone mineral density (Catalano et al. 2018, El-Gabalawy et al. 2018). From a biological perspective, chronic stress leads to prolonged elevation of glucocorticoids, suppression of osteoblast activity, increased osteoclastogenesis, and neuroimmune dysregulation, all of which contribute to an osteoporotic phenotype (He et al. 2021, Hao-Kun et al. 2024). These findings demonstrate that PTSD elevates the risk of OP through a complex interaction of behavioral, hormonal, and immune mechanisms, rather than a single, direct cause. Hence, PTSD is an influential chronic stressor that undermines bone integrity (Catalano et al. 2018, El-Gabalawy et al. 2018). Even though the stress-driven relationship between PTSD and OP has been emphasized in detail, it has not been demonstrated enough for the mediating factors to be seen (Yehuda and LeDoux 2007). As stress-related studies remain prominent in the literature, our study will focus on the relationship between stress and OP.

OP patients reported experiencing high levels of stress, along with frequent psychological challenges such as depression and anxiety (Jiang et al. 2018). Notably, repeated fractures, along with the associated pain, social withdrawal, and physical limitations, increase stress and contribute to a higher prevalence of depression and anxiety. Additionally, studies comparing OP patients with or without a fracture history indicate that those who have experienced fractures report higher levels of depression than those who have not (Silverman et al. 2007). Therefore, it is seen that illness stressors such as fractures and osteoporotic issues are related to depression levels. Besides, the depression and OP relation is bi-directional, and depression may be a significant risk factor for osteoporotic fractures. Silverman et al. (2007) also indicated that depressive symptoms were particularly pronounced among postmenopausal women suffering from vertebral fractures or low BMD, highlighting a strong psychological burden associated with skeletal deterioration. Even if depression emerges as both a cause and a consequence, the mediator effects in this relationship need to be underlined. Depression influences fracture risk through promoting sedentary behaviors, such as poor nutrition and physical inactivity, and certain antidepressant medications have adverse effects on bone health (Aloumanis and Mavroudis 2013, McClung et al. 2021). Hence, high levels of stress may lead to an increase in these behaviors, while simultaneously reducing motivation for engaging in protective healthy behaviors (Mezuk et al. 2008, Jiang et al. 2018).

OP often progresses silently, and numerous patients experience heightened anxiety following their first fracture due to increasing concern about preventing future injuries (Cosman et al. 2014). Among the most prominent sources of anxiety is the fear of falling, which frequently leads to avoidance behaviors such as social withdrawal and reduced mobility within perceived "safe zones." This behavioral pattern reinforces anxiety and contributes to a self-perpetuating cycle of physical inactivity and diminished social engagement (Kelly et al. 2019). Falling anxiety may also limit patients' willingness to follow health-related advice from physicians, further compromising disease management. Research suggests that high anxiety levels are associated with lower fracture risk assessment tool (FRAX) scores and reduced BMD (Catalano et al. 2018). Importantly, anxiety is a distinct emotional state characterized by excessive worry and vigilance, while depression is often marked by persistent low mood, helplessness, and withdrawal. Both conditions can influence OP outcomes through different pathways: anxiety may heighten fall risk and reduce treatment adherence, whereas depression is more commonly associated with inactivity, poor self-care, and altered neuroendocrine functioning (Catalano et al. 2018, Kelly et al. 2019). On the other hand, perceived stress refers to the subjective appraisal of one's inability to cope with demands and may encompass but is not identical to clinical anxiety or depression. In another word, perceived stress should not be conflated with clinical anxiety or depression (Crosswell and Lockwood 2020, Tan et al. 2021). It is essential to acknowledge that a robust body of research demonstrates a clear positive relationship between perceived stress and both anxiety and depression (O'Connor et al. 2021). High levels of perceived stress significantly elevate the likelihood of experiencing symptoms of anxiety and depression, with studies indicating a bidirectional relationship—depression can also forecast future perceived stress (Hansell et al. 2022). Consequently, stress must be treated as a multidimensional concept, and its specific components, including anxiety and depression, should be independently examined when assessing fracture risk in patients with OP.

Social support is another critical factor associated with stress in the context of chronic illness. Social support is broadly defined as the assistance or comfort provided by others to help individuals cope with biological, psychological, and social stressors. It can be derived from various sources within an individual's social network, including family members, friends, or broader community ties (American Psychological Association [APA] 2015). Social support constitutes a critical protective resource for OP patients who require prolonged treatment and care. Patients often experience heightened stress levels during extended hospitalization or home confinement periods (Huang et al. 2015). Notably, perceived social support has been empirically shown to moderate the impact of illness-related stress—particularly the perception of threat—on psychological outcomes such as depression and anxiety (Cohen et al. 2015). This phenomenon is conceptualized as the buffering effect hypothesis, which posits that social support provides psychological and emotional resilience to mitigate the deleterious effects of stress on health (Ditzen and Heinrichs 2014, Cohen et al. 2015). According to this framework, the protective role of social support becomes especially salient when individuals are exposed to elevated levels of stress. Given the chronic and progressive nature of OP, which often entails long-term pharmacological management, reduced mobility, and the need for assistance in daily activities, the buffering effect hypothesis offers a meaningful lens through which patients' psychosocial experiences can be understood. Perceived social support may play a pivotal role in regulating the psychological burden associated with the disease, thereby preventing further bone health deterioration. Empirical studies have demonstrated that emotional and informational forms of social support are associated with reductions in depressive symptoms and perceived stress—both of which are independently linked to lower BMD and increased OP risk (Huang et al. 2015).

Stress is a multidimensional construct that encompasses various biological, psychological, and social components. As such, its measurement presents several challenges in the literature. Although the OP literature tends to focus more heavily on the biological indicators of stress (Kelly et al. 2019), as previously discussed, stress can also be conceptualized within a psychosocial framework, encompassing experiences such as depression, anxiety, and PTSD. Therefore, divergent definitions of perceived stress within the OP literature may lead to inconsistencies in measurement approaches and interpretation. While objective measures, such as stress-related biomarkers like cortisol, provide a biologically grounded assessment approach (Steppe et al. 2023), they have limitations, including the need for extended monitoring and unreliable duration data. Conversely, subjective measures, such as self-report

questionnaires, are frequently employed for their efficiency but rely on the validity of stress-specific instruments. Therefore, integrating both objective and subjective methods is essential for a comprehensive assessment of stress (Crosswell and Lockwood 2020). To successfully integrate the two methods, it is needed to compile findings from studies in the literature that measure stress through self-reports. This is an important step in enhancing our understanding and implementation of these approaches.

This systematic review aimed to comprehensively evaluate the current literature on the role of psychosocial stress in the onset and progression of OP. Although a substantial body of research has investigated the biological mechanisms underlying the stress–OP relationship (Kelly et al. 2019), to the best of our knowledge, no study has systematically assessed and synthesized evidence concerning the psychosocial dimensions of stress. This review explores how stress-related constructs influence OP-related outcomes via behavioral, psychological, and social factors. Also, the direct and indirect effects of stress, as well as stress-related psychological conditions—both on their own and through health behaviors—explored the role in the onset, progression, and overall course of OP. This highlights the need for research that focuses on the clinical and health psychology aspects of the OP experience (Besser 2014). This study integrates findings from studies employing subjective self-report instruments to assess the methodological rigor of existing research, identify conceptual and operational inconsistencies, and delineate the limitations of current approaches. Nevertheless, it does not specifically exclude objective biomarker studies; rather, it focuses on the subjective viewpoint. Consequently, this review intends to contribute to a more comprehensive biopsychosocial framework for understanding the role of stress in OP, thereby informing future interdisciplinary research and guiding the development of holistic clinical interventions. Consequently, the systematic review focused on the following two research questions:

1. How do psychological stress and related constructs (stress factors associated with social support, anxiety, depression, PTSD) influence the development, progression, and outcomes of OP through behavioral, psychological, and social pathways?
2. What methodological approaches have been employed to assess psychological stress in OP-related studies, and what are the conceptual and operational limitations of these approaches in capturing the psychological dimension of stress?

Method

Relevant articles were found through literature searching using PubMed, Science Direct, Scopus, and Web of Science (WOS) platforms. The search terms were used "osteoporosis* OR osteoporoses* OR age-related bone loss* OR osteoporotic fracture*" AND "psychological stress* OR stress* OR psychological wellbeing*". Comprehensive hand searches were conducted on the references cited in related articles. Based on the reasoning of Hillen et al. (2017), it was decided not to include the term "ambiguity" in our search criteria. The review article scanning was conducted between September 2024 and February 2025, with the literature review current as of the latter date, with no restrictions on the start date for the included articles. The review search was implemented by the author and managed using EndNote (21) in terms of inclusion and exclusion criteria. The selection of studies was guided by well-defined inclusion and exclusion criteria. To be included, studies were required to (1) involve individuals diagnosed with OP, (2) focus specifically on the psychological stress experienced by these patients, and (3) be original research articles presenting empirical findings. Studies were excluded if they (1) included participants who were not diagnosed with OP, (2) addressed stress only indirectly or through associated factors rather than as a central variable, (3) explored topics unrelated to the research aim, or (4) focused on non-clinical populations such as caregivers. Additionally, articles were excluded if they were duplicates, inaccessible in full-text form, or categorized as reviews, meta-analyses, intervention trials, or case studies.

Each article was reviewed by the author, considering the following the PRISMA 2020 statement (Page et al. 2021), and 110 full-text documents were acquired during the initial search: EBSCO (11), PubMed (20), Science Direct (69), and Scopus (10). After a comprehensive evaluation, seven articles were selected for inclusion in the current review (Fig. 1).

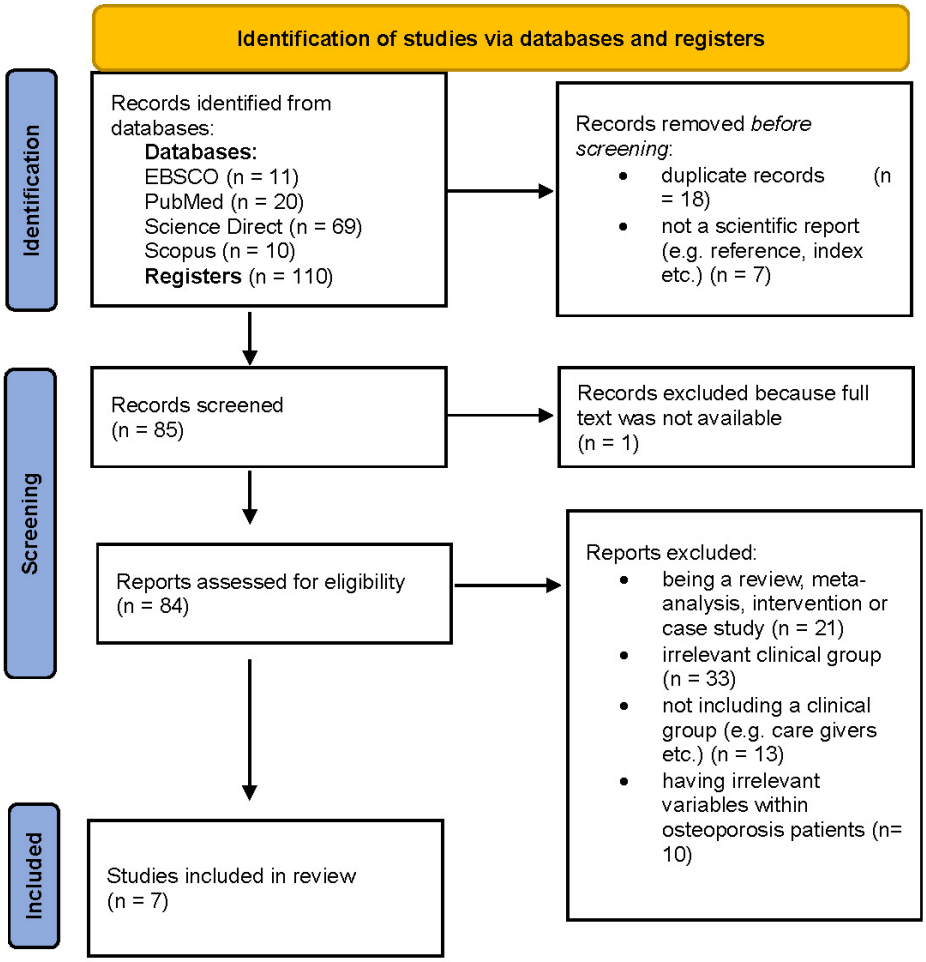

Figure 1. PRISMA flow diagram for study selection process

Results

Study Characteristics

The studies included in the review were conducted between 2009 and 2019. Among them, three were carried out in the USA, two in Norway, and one each in Sweden and Denmark. Full-text access was obtained for all the included studies, confirming that the targeted variables were thoroughly examined in each case.

Demographic Features of the Sample

The studies exhibited variability in participant characteristics, although nearly all utilized community-based samples. In terms of gender differences, two studies included only women, two focused exclusively on men, and the remaining three included both male and female participants. For male participants, sampling was based on risk factors, such as a history of fractures, while female samples were defined by criteria like postmenopausal status and age above a certain threshold. The reviewed studies encompassed a wide range of populations, with sample sizes varying considerably across investigations. Notably, participant numbers ranged from 337 to over 11,000, including diverse groups such as postmenopausal women (n = 11,020), older men aged 65 and above (n = 4,388), caregivers and non-caregivers (n = 954), and mixed-gender community-dwelling adults (e.g., n = 4,690; n = 7,495; n = 1,396). The studies varied in the age ranges of participants, which spanned from 25 to 84 years. Specifically, two studies exclusively included participants aged 65 and older, the other one focused on individuals over 55, and another examined participant aged 46 to 56. The other studies had broader age ranges for their participants.

Table 1. Summary of characteristics and outcome variables from the included studies

Source	Location	Population	Participant	Design	Aim	Variables	Measures	Results
Fink et al. (2014)	USA	Men experienced Osteoporotic Fractures	4388 men aged ≥65 years	Quantitative	The association between stressful life events and concurrent bone loss was investigated.	Rate of bone loss, risk of accelerated bone loss, bone loss and fractures, stressful life events, sociodemographic variables	Self-report: PASE, SLEQ Biological measurement: BMD was measured at the lumbar spine and right hip using DXA	In a study of older men living in the community, those who encountered stressful life events during follow-up were generally older, less educated, and reported poorer health. They were also more likely to experience low mood, diabetes, stroke, myocardial infarction, and fractures after the age of 50. The research indicated that these stressful events were linked to a statistically significant risk of accelerated hip BMD loss. Notably, losing an important hobby or activity was more strongly associated with increased bone loss than other types of stressful life events.
Follis et al. (2019)	USA	Postmenopausal women	11,020 postmenopausal women	Quantitative, Longitudinal, 6 years follow	The relationship between measures of psychosocial stress (social strain, social functioning, and social support) and bone mineral density was assessed within the longitudinal data. Also, interaction terms between stressors and age, race/ethnicity, income, and hormone therapy use were evaluated.	Social strain, social functioning, social support, BMD, and sociodemographic information	Biological measurement: BMD percentage=(BMD at follow-up time−BMD at baseline)/(BMD at baseline ×100) Self-report: MOS for evaluating social support, RAND subscales measured social functioning, and rating their perceived social strain was examined. Also, the sample's properties, such as age, race/ethnicity, education, BMI, smoking, CT arm, hormone therapy use, age at menopause, physical activity, history of fracture after age 55 years, and medications were obtained.	Increased social strain and reduced social functioning significantly contribute to BMD loss in the femoral neck and total hip. A lack of social support further worsens BMD loss in the femoral neck, while only social strain is linked to greater BMD loss at the lumbar spine. Addressing these social factors is vital for improving bone health.
Park-Lee et al. (2009)	USA	Women who were at risk of frailty and aged 65 or older	Three hundred thirty-seven caregiver and 617	Quantitative, Longitudinal	This study highlights that positive affect was associated	Positive affect, fragility, body mass, perceived stress,	Self-report: CES-D, PSS Clinical Assessment: Interview included	The study showed that older women with high positive affect are 50% less likely to become frail over two years than those with low positive

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			non-caregiver participants		with a significant decrease in frailty among elderly women over two years. It also examines the stress-buffering hypothesis by comparing the effects on caregivers and non-caregivers.	sociodemographic variables	sociodemographic variables, fragility rates, and comorbidity illness was investigated.	affect. Although women with high depressive symptoms had higher frailty rates, this difference disappears when considering race and health status. Similar trends were observed in both caregivers and non-caregivers.
Pedersen et al. (2016)	Denmark	People 55 years or older	7943 people	Cohort study	A population-based cohort study in Denmark was implemented to demonstrate the association between perceived stress and the increased risk of future osteoporotic fractures.	Perceived stress, osteoporotic fractures, demographical variables such as gender, marital status, school education, income, etc., body mass, physical activity, smoking, alcohol consumption, diet, sleeping problems, visual problems, perceived general health categories	Self-report: PSS, Osteoporotic fractures according to ICD-10 diagnosis codes, demographic and clinical information form was applied.	It was seen that 5.8% experienced an osteoporotic fracture within five years of stress assessment, while 8.2% did so within a median follow-up of 6.8 years. Those with high perceived stress faced a 37% increased risk of any osteoporotic fracture and a 68% increased risk of hip fracture compared to those with low stress. This risk remained significant after adjusting for personal features and was similar for men and women, but it decreased with longer follow-ups.
Søgaard et al. (2005)	Norway	All men and women living in Tromsø were between 25 and 84 years old.	4690 men and women	Cohort study	This study aimed to prospectively investigate how subjective mental distress relates to the risk of non-vertebral fractures and low BMD in a population-based cohort.	Fracture analysis, BMD, height, weight, blood pressure, and non-fasting analyses of serum total cholesterol, HDL, triglycerides, and glucose, sociodemographic factors, social security pensions, health status, symptoms, diseases, and health behavior including use of medication, diet,	Self-report: CONOR HSCL-10, and HADS Clinical Assessment: An interview about fracture history, comorbidity, health behavior, and habits was conducted.	It was seen that more women than men reported mental distress. The study, which observed the same participants from 1979-1980 to 1994-1995, established a link between cumulative mental distress and both non-vertebral and osteoporotic fractures in women, but not in men. Women who reported mental distress twice and used medication had more than four times the odds of sustaining a non-vertebral fracture.

Table 1. Summary of characteristics and outcome variables from the included studies

Source	Location	Population	Participant	Design	Aim	Variables	Measures	Results
						physical activity during leisure time, smoking and alcohol consumption, and mental distress		
Trimpou et al. (2010)	Sweden	Men aged 46–56 years	7,495 randomly selected men	Cohort study, Prospective	The study evaluated psychologic al stress, lifestyle factors, physical activity at work and leisure, and other potential risk factors for hip fractures in men.	Regarding lifestyle factors, mellitus, alcohol problems, smoking, physical activity, etc, psychological stress, occupational class, and previous myocardial infarction, stroke, and diabetes	Self-report: Questionnaires were used to collect information about illness history, physical activity, habits and consumption, psychological stress, BMI, blood pressure, occupational class, and hip fracture rate.	A high level of leisure-time physical activity, a higher occupational class, and a higher BMI were found to be protective against hip fractures, but work-related physical activity was not protective. Smoking, tall stature, and interim stroke or dementia increased the risk. After 10 years, personal properties became less significant. Men with a history of stroke or dementia faced a higher risk of fractures due to an increased likelihood of falling.
Trimpou et al. (2011)	Norway	A random sample of men and women aged 25 to 64 years, representing a diverse demographic	1,396 men and women	Cohort study, Prospective	It was aimed to assess with a 20-year prospective study examining a sample aged 25 to 64 years to determine how blood lipids, blood pressure, fibrinogen, and lifestyle factors predict osteoporotic fractures.	Physical activity at work and during leisure time, psychological stress, smoking habits, coffee consumption, BMI, waist/hip ratio, blood pressure, total HDL and LDL cholesterol, triglycerides, fibrinogen, and osteoporotic fractures	Self-report: Fracture record, past and present health status, smoking habit, coffee consumption, medication, psychological stress, and physical activity during work and leisure time were assessed with questionnaires, and blood comorbidity illness information was gained.	Stress and health behaviors were not significantly associated with fracture occurrences, but blood biomarkers were predictive. Therefore, comorbid illnesses were identified as factors influencing fracture frequency.

BMI: Body Mass Index, CES-D: Center for Epidemiologic Study Depression Scale, CONOR: CONOR Mental Health Index, CT: Computed Tomography, DXA: Dual-energy X-ray Absorptiometry, HADS: Hospital Anxiety and Depression Scale, HDL: High Density Lipoprotein, HSCL-10: Hopkins Symptom Check List, ICD: International Classification of Diseases, LDL: Low-Density Lipoprotein, MOS: Medical Outcomes Study, PASE: Physical Activity Scale for the Elderly, PSS: Perceived Stress Scale, RAND: RAND 36-Item Health Survey Quality of Life, SLEQ: Stressful Life Event Questionnaire

Methodological Overview

After reviewing the articles, it was found that only one study used a quantitative-crossectional design. This study collected data from 4,388 male participants, utilizing measures such as the Physical Activity Scale for the Elderly (PASE), Stressful Life Event Questionnaire (SLEQ), and BMD measurements at the lumbar spine and right hip, which were obtained using dual-energy X-ray absorptiometry (DXA) (Fink et al. 2014). Two additional studies adopted quantitative and longitudinal designs. The first study tracked participants over six years, employing measures like the RAND 36-Item Health Survey for Quality of Life, the Medical Outcomes Study (MOS) Social Support Subscales, and DXA scores for assessments (Follis et al. 2019). The

second study followed participants for three years and gathered data on caregiving status, the Perceived Stress Scale (PSS), the Center for Epidemiologic Studies Depression Scale (CES-D), and a frailty index that included indicators such as weight loss, exhaustion, slow walking speed, and weak grip strength (Park-Lee et al. 2009).

The remaining four studies employed a cohort design. The first study investigated the relationship between perceived stress and osteoporotic fractures. This was assessed using the Perceived Stress Scale, along with osteoporotic fracture data derived from ICD-10 diagnosis codes and a demographic and clinical information form (Pedersen et al. 2016). In the cohort study conducted by Søgaard et al. (2005), the association between mental distress, low BMD, and fractures was evaluated. This study utilized the CONOR Mental Health Index, the Hopkins Symptom Checklist (HSCL-10), the Hospital Anxiety and Depression Scale (HADS), and clinical assessments that included fracture history, comorbidities, health behaviors, and lifestyle habits. Two of the cohort studies utilized a prospective design. The first study tracked participants for 30 years to examine the impact of behavioral risk factors on predicting hip fractures in men. Data collected included illness history, physical activity, lifestyle habits, psychological stress, body mass index (BMI), blood pressure, occupational class, and hip fracture rates (Trimpou et al. 2010). In the second prospective cohort study, participants were followed for 20 years to investigate how blood lipids and lifestyle factors predict osteoporotic fractures. Data were gathered through questionnaires that assessed fracture history, current and past health status, smoking habits, coffee consumption, medication use, psychological distress, and physical activity during both work and leisure time. Additionally, important information regarding blood-related comorbidities was collected (Trimpou et al. 2011).

Study Objectives and Key Findings

The studies included in this review vary in their conceptualization of stress, the OP-related symptoms, and the behavioral and biomarker variables. One study focused on the effects of psychological stress on BMD loss. It emphasized the social aspects of stress, finding that high social tension, low social support, and poor social functioning were significantly associated with BMD loss in the femoral neck and hip regions over a six-year follow-up period. This study highlights the negative effects of impaired social relationships on bone health (Follis et al. 2019). Another study evaluated the impact of perceived stress on the risk of osteoporotic fractures. It found that high levels of perceived stress increased the risk of osteoporotic fractures by 37% over a five-year follow-up, with the risk of hip fractures specifically rising by 68%. These findings suggest that stress management could be crucial to fracture prevention strategies (Pedersen et al. 2016). A study investigating the impact of long-term mental distress on BMD and osteoporotic fracture risk reported that women who experienced persistent mental distress—such as depression, anxiety, and sleep problems—across multiple time points had a two to three times higher risk of osteoporotic fractures. However, a similar relationship was not observed in men. These findings underscore the significant impact of mental health on bone health, particularly among women (Søgaard et al. 2005). Another study explored the protective effects of positive emotions on frailty, aiming to mitigate the negative impact of stress. It found that older women with high positive emotions had a 50% lower risk of frailty. This effect was consistent across both caregiver and non-caregiver groups. However, the buffering effect of positive emotions on stress was not confirmed (Park-Lee et al. 2009). One of the reviewed articles focused on evaluating the relationship between stressful life events and BMD loss in older men, aiming to determine whether this relationship was independent of other factors. This study specifically examined the effects of traumatic life events on bone loss in elderly men. The findings indicated that individuals who experienced traumatic life events exhibited accelerated bone loss, which was thought to be linked to increased stress hormone levels and changes in osteoclast activity (Fink et al. 2014).

Some studies found that the effect of stress on OP was not significant. Trimpou et al. (2011) examined the long-term effects of stress, behavioral habits, and serum cholesterol levels on the risk of osteoporotic fractures in a study. This research focused on blood-related issues, OP, and their stress-related antecedents. It was observed that individuals with a history of fractures did not significantly differ from those without fractures in terms of stress levels. However, smoking and elevated serum total cholesterol levels were associated with an increased risk of osteoporotic fractures, and this risk became more

pronounced over time (Trimpou et al. 2011). Another study, which did not find that stress is a significant factor, aimed to identify factors contributing to hip fracture risk in men. This research evaluated the impact of participants' lifestyle factors (such as physical activity, smoking, and alcohol consumption), stress levels, biological characteristics (like BMI and height), and socioeconomic status over a 30-year follow-up period. The study provided a comprehensive perspective on hip fracture risk factors in men. Strategies for reducing the incidence of hip fractures included decreasing smoking and alcohol consumption, increasing physical activity, and addressing socioeconomic inequalities. The importance of long-term monitoring of factors influencing fracture risk was also emphasized. Yet, this study also did not identify stress as a significant factor (Trimpou et al. 2010).

Discussion

This systematic review aimed to synthesize evidence from studies that directly evaluated stress-related components and their relationship to OP-related outcomes to investigate the role of the psychological aspect of stress in OP clinical progression. This review focuses on empirical studies that measure stress through self-report tools, allowing for a focused exploration of the psychological aspect of stress in this population. In addition to examining the effect of stress on disease symptoms and progression, the methodological features of the included studies were critically evaluated. After applying predefined inclusion and exclusion criteria, seven eligible studies were identified. Study objectives, sample characteristics, methodological designs, and key findings were systematically examined to advance existing knowledge and guide future research within a biopsychosocial framework.

OP affects more than 200 million people worldwide and has a significant prevalence in both women and men (Kanis et al. 2007). A review of the gender distribution in studies revealed that two involved women, two to men, and three to both sexes, challenging the misconception that OP is a disease unique to older women (McClung et al. 2021). These findings highlight the need to shift the narrative around the OP, acknowledging its broader impact beyond assumptions based on biological sex alone. Furthermore, beyond reducing quality of life and well-being, OP can lead to risks of death from hip fractures, which have been identified as a leading cause of death, especially in long-term cohort studies (Trimpou et al. 2010, Hiligsmann et al. 2019). Although it poses risks comparable to other chronic diseases, OP is often perceived as an inevitable consequence of aging, potentially increasing its risks (Kirazlı et al. 2020).

The diversity of the study samples examined highlights the generalizability and relevance of the findings across various demographic groups. Sample sizes varied significantly from smaller, targeted populations, such as caregivers (n = 337), to large-scale cohorts of postmenopausal women (n = 11,020) and older men aged 65 years (n = 4,388) – reflecting both focused and population-based research designs. This variation increases the ecological validity of the observed associations between psychological stress and OP-related outcomes. However, heterogeneity in sample composition may also result in variability in outcome measures, especially since psychological stress is likely to manifest differently depending on gender, age, care roles, or socio-cultural context. Subgroup analyses to identify differential stress responses and their effects on OP progression will benefit future research. In addition, in some of the reviewed studies, the lack of a longitudinal design may indicate a feature that may limit causal inference, despite robust sample sizes.

It appears that most of the studies included in the current systematic review are based on general population samples rather than clinically diagnosed OP patients. This limits the generalization of the findings to clinical samples directly in the context of disease-specific stressors; it offers limited insight into the nature, severity, and consequences of psychological stress experienced by individuals diagnosed with OP (Hiligsmann et al. 2019, Wang and Kattan 2020). However, in clinically diagnosed OP patients, the sources of stress are multi-layered: disease-specific factors such as fracture history, pain-related limitation of movement, transition to dependent life, fear of falling, and social isolation increase the psychological burden and shape both the emotional and behavioral components of stress (Silverman et al. 2007, El-Gabalawy et al. 2018). Thus, the stress responses observed under OP-specific clinical conditions differ from the overall stress levels measured in samples belonging to the general population. For this

reason, it is recommended that clinical evaluations that focus on the psychological context as well as the biomedical effects of the disease should be included in the studies to be carried out in individuals diagnosed with OP (McClung et al. 2021). In addition, cohort designs have often been preferred in studies examining the effect of stress on OP at the causal level. In particular, this approach makes it possible to track changes in stress levels over time and to establish longitudinal links with clinical outcomes such as fractures and BMD decreases associated with OP. For example, Pedersen et al. (2016) stated that high stress levels significantly increased the risk of hip fracture; Søgaard et al. (2005) prospectively demonstrated the association of stress with vertebral fractures and BMD reduction. However, most of these studies include individuals who have not been diagnosed with OP; therefore, the specific course of stress during the disease process is not sufficiently elucidated. Moreover, the psychological consequences of stressors (e.g., history of multiple fractures, resistance to treatment, significant decline in quality of life), depending on the clinical progression of OP, are often excluded from the measurement, or their dynamic effects over time cannot be captured due to cross-sectional designs (Huang et al. 2015, Catalano et al. 2018). Therefore, longitudinal studies based on disease process-sensitive stress monitoring protocols are needed in individuals diagnosed with OP.

The term 'ageing' is frequently overshadowed by its association with the process of getting older, thereby reinforcing the misconception that OP is an inevitable consequence of aging. However, as the aging population continues to increase and the onset of OP-related problems appears at younger ages (Herath et al. 2022). OP is a major health crisis for older adults, causing widespread disability, increased mortality, and substantial healthcare costs. Prevention, early detection, and effective management are critical to reducing its impact (Hiligsmann et al. 2019, McClung et al. 2021). However, although the literature review of our study was completed in February 2025, all included studies are between 2009 and 2019. This situation has been interpreted as quite interesting. For this reason, during the writing phase of the article, relevant studies were tried to be found by continuing to scan the bibliography simultaneously, but unfortunately, no other published research was found between these years. It is thought that there may be two main reasons for this. The first of these may be that the majority of studies published in recent years have focused on confirming medical and biologically based hypotheses that explain the effect of stress on bone health. It should not be overlooked that another reason related to this may be that public health-oriented research, especially with the effect of the pandemic period, critically focuses on pandemic protection behavior. On the other hand, osteoporosis is already known to be a chronic disease that has received relatively little attention from social science researchers. For example, in 2024, 959 diabetes-related articles were published in psychology and related social science journals in the Web of Science index, while the number of osteoporosis-related publications decreased to 41. When the abstracts of these articles were scanned, only 26 of them were found to have osteoporosis patients in the sample list; In the content of the other articles, no direct information about this group could be reached. The majority of these articles cover the effects of antidepressants and antipsychotics on bone health. Therefore, it would not be wrong to say that in recent years, psychology-focused studies evaluating the effect of stress on the disease have almost stopped. However, it is also known that it is not reasonable to reach assumptions such as "individuals with osteoporosis do not experience stress" and "osteoporosis disease and the treatment process are not a stressful experience". However, it is necessary to prioritize research on the psychological effects of stress in OP in order to understand the disease in a biopsychosocial context, to develop prevention and intervention strategies.

The studies examined the progression of OP through a variety of factors, including loss of BMD, fractures, frailty, and bone deterioration, which were identified as key determinants. Furthermore, studies have revealed differences in how stress is conceptualized by examining different forms, including social stress, perceived stress, and traumatic stress. In the studies reviewed, various measurement tools were used to assess psychological stress, psychological functioning, behavioral risk factors, and bone health outcomes, reflecting a multidimensional understanding of the OP disease process. Psychological stress and related emotional states were most frequently assessed with standardized self-report tools such as PSS, CES-D, HADS, etc. These scales, which have been widely validated, differ in their conceptual definitions, reference time frames, and the importance they place on emotional and somatic symptoms. This variation limits comparability between studies and may contribute to inconsistencies in identifying the specific

dimensions of stress most relevant to OP progression. Although the PSS provides a general measure of perceived stress, it lacks specificity regarding the sources or chronicity of stress and thus restricts interpretability regarding disease-related stressors. Similarly, while measures of depression and anxiety, such as CES-D and HADS, are useful, they can conceptually overlap with measures of stress, leading to potential confounding effects in analyses. BMD, the primary biological marker of OP, was consistently assessed using DXA in the lumbar spine and hip regions, and in some cases, the percentage change in BMD over time was calculated to capture disease progression. This objective approach ensures the reliability of skeletal outcome measurements; However, only a few studies have directly integrated these biological metrics with stress assessments across longitudinal timelines. Physical activity, an important mediator and protective factor, was measured primarily through PASE and self-report questionnaires. Although practical in large samples, such tools are prone to recall and self-report bias, especially among elderly or functionally limited populations. What's more, known behavioral pathways linking stress to bone health, such as smoking, alcohol use, caffeine consumption, and sleep quality, were inconsistently measured and often operationalized through single-item indicators, reducing their explanatory power. Social factors, which are critical in buffering stress and promoting well-being in OP patients, have been studied less frequently. When tools like MOS and RAND-36 were included, they provided valuable but underutilized insights.

Finally, demographic and clinical auxiliary variables (e.g., age, body mass index, comorbidities, drug use, and menopausal history) were frequently included in regression models, but there were differences in how they were measured and adjusted. Although Søgaard et al. (2005) and Trimpou et al. (2011) measured stress through blood pressure, these findings were presented as an adjunct consideration to primary hypothesis testing. Overall, the use of heterogeneous assessment tools in studies highlights the need for more integrated and biopsychosocially informed measurement frameworks. It is emphasized that the most effective approach to assess stress is to combine both objective and subjective methods (Crosswell and Lockwood 2020). Future research should prioritize integrated assessment strategies that combine subjective and objective methods, enabling more robust and comprehensive analyses of the stress-OP relationship.

Among the reviewed studies, stress was not found to have a significant effect on OP progression, possibly due to measurement limitations, as stress was assessed using single-question or binary response formats (Trimpou et al. 2010, 2011). This highlights the importance of measurement quality in detecting stress-OP relationships. The findings suggest that stress affects fracture risk not only through physiological pathways, but also indirectly through maladaptive health behaviors (Trimpou et al. 2010). Studies that have identified meaningful relationships have highlighted the role of social relationships and environmental influences in the development of OP (Fink et al. 2014, Follis et al. 2019). In addition, distress and positive affectivity were found to be critical emotional factors contributing to fracture risk (Søgaard et al. 2005, Park-Lee et al. 2009). Another study highlighted that perceived stress affects fracture frequency (Pedersen et al. 2016). These findings suggest that psychological stress serves as an important psychological risk factor for OP and related conditions through environmental, emotional, experiential, and behavioral pathways.

This study represents the first known systematic review examining the role of psychological stress in OP. The findings underscore the complex interplay between stress and OP-related outcomes, highlighting the critical role of psychological and emotional factors in both preventive and therapeutic strategies. In this direction, this study aims to contribute to the literature by supporting clinical-health psychology perspectives in OP research. Despite these insights, several key questions remain unanswered: "Is osteoporosis just a medical condition, or does it pose a broader public health problem? How does psychological stress contribute to and exacerbate these challenges?" Addressing these questions is crucial to developing effective interventions and support mechanisms tailored to OP patients. However, a notable gap in the available literature is the lack of research on the role of stress in the treatment process, such as treatment adherence, recovery, or overall disease management in OP patients.

This highlights the need for a paradigm shift in how OP is understood and managed, and there is a need for increased studies to point to its preventable and treatable nature, rather than accepting it as an inevitable

part of aging. Therefore, it has become increasingly apparent that there is a need for a paradigm shift in how stress is conceptualized in the context of OP. Stress is more than just a burden on our biological systems; It is an important catalyst for a range of emotional, cognitive, social, and relational challenges. The existing literature is primarily focused on stress as measured by biomarkers (Steppe et al. 2023, Hao-Kun et al. 2024), while studies on its behavioral and emotional dimensions have received less attention. However, in order to explain the biological effects of stress, it is necessary to evaluate behavioral components such as smoking, alcohol consumption, and sleep problems that occur due to stress and increase the risk of OP in terms of disease progression. Focusing on such behavioral factors will also guide physicians in developing patient-centered treatment strategies (Cosman et al. 2014).

Future research must adopt a biopsychosocial approach to provide a better understanding of the relationship between stress and OP. This review provides a framework for assessing stress levels and analyzing the effects of interventions to be developed in this direction on the disease process by examining the stress experiences of OP patients, especially in clinical settings. In particular, it is thought that interventions aimed at reducing psychological stress can both improve the course of the disease and increase the quality of life. In this context, the Enhanced Recovery After Surgery (ERAS) protocol offers a multidisciplinary approach to reducing stress and accelerating the healing process, indicating that psychology-based interventions compatible with the principles of this protocol can also be used in OP management (Ji et al. 2023). In particular, determining the effect of assessing the stress associated with the disease on patient compliance may have the potential to open the door to interventions. However, a number of potential limitations need to be considered in the integration of such intervention strategies into clinical practice. Factors such as the inadequacy of resources in the health system, the lack of adequate personnel and expertise support for psychological components, and the difficulties experienced in the sustainability of multidisciplinary cooperation are among the main obstacles that may be encountered in the implementation process. Policymakers have a much more critical role to play here, and the need for them to take more responsibility in removing obstacles to this should not be overlooked.

On the other hand, this study has some limitations. First, it focused solely on psychological stress, ignoring biological perspectives that might limit the comprehensiveness of the findings. Second, all of the included studies were based on self-reported assessments, which increased the risk of response bias and inaccuracy. Future research should integrate objective biomarkers to improve the reliability of stress assessment. Third, the literature review was conducted by a single researcher, potentially revealing selection bias and limiting different perspectives. Indeed, in systematic reviews, it is recommended that the selection process be carried out by two independent evaluators in order to reduce the risk of selection bias and to increase methodological reliability. In our study, due to limited researcher resources, all screening and inclusion processes were carried out by a single researcher. Being aware of the potential bias of this situation, the PRISMA guideline was taken as a basis throughout the process, and strict adherence to the determined inclusion-exclusion criteria. It is believed that the simultaneous evaluations carried out by two independent researchers in future systematic reviews will contribute to making the literature selection process more objective and reproducible. Finally, the exclusion of non-English studies can restrict access to relevant research, potentially impacting the scope and generalizability of the findings. Addressing these limitations can improve future research in this area.

The findings of this review emphasise the importance of systematically incorporating psychosocial considerations into OP management. Regular monitoring of perceived stress levels in individuals diagnosed with OP is crucial, and stress-coping strategies should be prioritised during clinical assessments. Additionally, educational modules aimed at increasing awareness of the relationship between ageing, stress, and bone health may challenge the common misconception that ageing is an inevitable consequence of OP. Psychotherapeutic interventions—particularly cognitive behavioural therapy (CBT) and third-wave approaches such as acceptance and commitment therapy (ACT) and mindfulness-based cognitive therapy (MBCT)—offer promising avenues to enhance psychological resilience and improve quality of life in patients with OP. However, it is also recognised that few intervention studies adequately address this issue. Moreover, routine evaluation of psychological

variables, such as stress, anxiety, and depression, could be facilitated by integrating clinical psychologists within endocrinology, physical therapy, and rheumatology teams.

Socially isolated individuals or those with impaired social functioning are at higher risk of OP progression; therefore, psychosocial interventions aimed at strengthening social support networks should be actively encouraged. Postmenopausal women constitute a particularly vulnerable group, both biologically and psychologically; thus, early screening for stress and affective symptoms in this population is of great importance. Finally, clinical assessments should rely on subjective self-report instruments, complemented by biological stress markers such as cortisol, to enable a more comprehensive understanding of patients' psychological states and their implications for disease progression.

Conclusion

This review emphasises the significance of psychosocial stress as a critical yet frequently overlooked factor affecting patients with OP. Although the included studies differ in their methodology and the psychological concepts they measure, a consistent pattern emerges, showing that perceived stress, anxiety, depression and PTSD harm bone health and related outcomes. These findings contribute to the growing body of literature that supports a biopsychosocial approach to managing OP, highlighting the importance of incorporating psychological screening and support alongside conventional medical treatment. However, the small number of longitudinal and interventional studies investigating psychological factors reveals a significant research gap.

Therefore, future research should utilise standardised stress measures, longitudinal designs, and biopsychosocial models to better understand causal mechanisms and assess the impact of stress-reduction interventions on bone health. Examining diverse populations, various types of stress, and the role of protective psychosocial resources such as resilience and social support will further enhance our understanding and improve strategies for OP prevention and management. Additionally, developing and evaluating stress-targeted interventions, such as CBT, mindfulness-based programmes, and social support enhancement, in OP populations could boost psychological well-being and improve physical health outcomes. Taking a comprehensive approach to these issues could lead to more effective, person-centred care strategies in the prevention and treatment of OP.

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