Review Article

Exploring the interplay between paraspinal muscular status and bone health in osteoporosis and fracture risk: a comprehensive literature review on computed tomography (CT) and magnetic resonance imaging (MRI) studies

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Background and Objective: Computed tomography (CT) and magnetic resonance imaging (MRI) of the spine are fundamental non-invasive tools to investigate the status of the bone and soft tissue in vivo. A novel and promising approach is to investigate the quality and quantity of paraspinal muscles even beyond the clinical question. The aim of the present review is to summarize current evidence on CT and MRI about the relationship between paraspinal muscular status and bone health in osteoporosis (OP) and fracture risk.
Methods: Literature research was carried out on September 2023 using PubMed, Scopus, and Cochrane databases.
Key Content and Findings: Research investigating the intricate interplay between musculature and bone health reveals that degenerating paraspinal muscles, characterized by shrinking and fatty infiltration, are associated with lower bone mineral density (BMD) and the development of OP. Additionally, research indicates that weaker paraspinal muscles are linked to a higher risk of fractures, including those at the spine.
Conclusions: The findings suggest that paraspinal muscle health may be a significant factor in identifying individuals at risk for OP and fractures. Further investigation is needed to explore the potential of paraspinal muscles in preventing these conditions.

Keywords: Osteoporosis (OP); vertebral fractures; spine; paravertebral muscles; computed tomography (CT); magnetic resonance imaging (MRI)

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Introduction

Osteoporosis (OP) is a systemic skeletal disease which represents a major public health issue in aging societies. It is characterized by low bone mineral density (BMD) and degradation of bone microstructure, leading to a reduction of bone strength and, consequently, an increased susceptibility to fractures (1-4). BMD is influenced by genetic factors such as endocrine parameters, body fat content, lean body mass and muscle strength (5,6). It is also correlated with correctable factors like body fat content, lean body weight and muscle power (7,8).

Indeed, OP is a multifactorial disorder is driven by an imbalance in bone remodeling due to various factors: hormonal shifts (e.g., estrogen, testosterone), nutritional deficiencies (e.g., calcium, vitamin D), medical conditions (e.g., inflammatory, kidney disease), and lifestyle (e.g., inactivity, smoking, alcohol) (1-8). Understanding this complex pathogenesis is critical for developing therapies and preventative strategies to combat the significant healthcare burden associated with OP (1-8).

Recently, studies have shown that bone and skeletal muscle, considered as common functional units, have a role in the pathological process that leads to OP (9,10). More specifically, sarcopenia, defined by the European Working Group on Sarcopenia in Older People as a reduction of muscle strength accompanied by low muscle mass and quality (11), has been shown to be related with low BMD and OP (12-14). With aging, the musculoskeletal system degenerates leading to a reduction of function and strength (15). The decline of muscle strength is associated with structural changes such as atrophy and fat infiltration, the latter being the main factor involved; these modifications can be observed as a decrease in muscle volume (or cross-sectional area, CSA) and an increase in muscle fat fraction (FF) (16,17). At the same time, muscle weakness increases the risk of falls, playing an important role in the occurrence of fractures, especially in patients affected by OP who have an intrinsic increased risk of developing fractures (18,19). Osteoporotic vertebral fractures (OVF) have a significant impact on the health status of elderly people and can result in a decline in the patients' quality of life and survival rate (20,21).

Paraspinal muscle, or paravertebral muscles, especially the multifidus, erector spinae, and psoas, are a group of skeletal muscles located in both sides of the spine and have an important role on spinal stability and function (22,23). It has also been demonstrated their relationship with low back pain, sagittal balance, and quality of life (24-26). Density, atrophy, and fatty degeneration of the paraspinal muscles can be evaluated using imaging technics like computed tomography (CT) and magnetic resonance imaging (MRI) (27-29).

In the last two decades, several studies have put a focus on the morphology of paraspinal muscles with different disorders, especially low back pain and spinal disorders. A significant number of studies have also described the relationship between paraspinal muscles and BMD/OP and between paraspinal muscles and OVF. The conclusions of studies regarding these correlations needs to be summarized. Therefore, we have reviewed the scientific literature about the role of morphological characteristics of paraspinal muscles in (I) BMD and OP and (II) OVF. We present this article in accordance with the Narrative Review reporting checklist (available at https://qims.amegroups.com/article/view/10.21037/qims-23-1770/rc).

Methods

The literature research was carried out on September 2023 using PubMed, Scopus, and Cochrane databases. Only articles written in English and published after January 1 of 2000 were included. The keywords used for the articles search were: paraspinal muscle OR psoas OR multifidus AND (osteoporosis OR bone density OR fracture) (*Table 1*). The titles of all the articles of potential interest to our topic were screened and we identified 31 papers of interest. We proceeded the screening by reading all the articles abstracts. The exclusion criteria were the following: (I) review articles, case reports articles, animal studies; (II) studies comparing paraspinal muscles characteristics in other diseases such as low back pain, lumbar spinal stenosis, lumbar disc herniation or degeneration; (III) studies in which the muscles characteristics were analyzed thanks to other imaging modalities (ultrasound or dual energy X-ray absorptiometry). We included in this manuscript the articles investigating BMD, OP, and fractures together with paraspinal muscles morphology, studied thanks to CT or MRI.

Results

After screening titles and abstracts, 28 articles were selected for this study (*Figure 1*). The studies included in this review analyzed the paraspinal muscle degeneration in the lumbar spine using CT or MRI as imaging modalities. More specifically, the parameters considered were fatty

Table 1 The search strategy summary

Items	Specification
Date of search	September 2023
Databases and other sources searched	PubMed, Scopus, and Cochrane
Search terms used	Paraspinal muscle OR psoas OR multifidus AND (osteoporosis OR bone density OR fracture)
Timeframe	2000–2023
Selection process	C.A.M. and C.V. by consensus

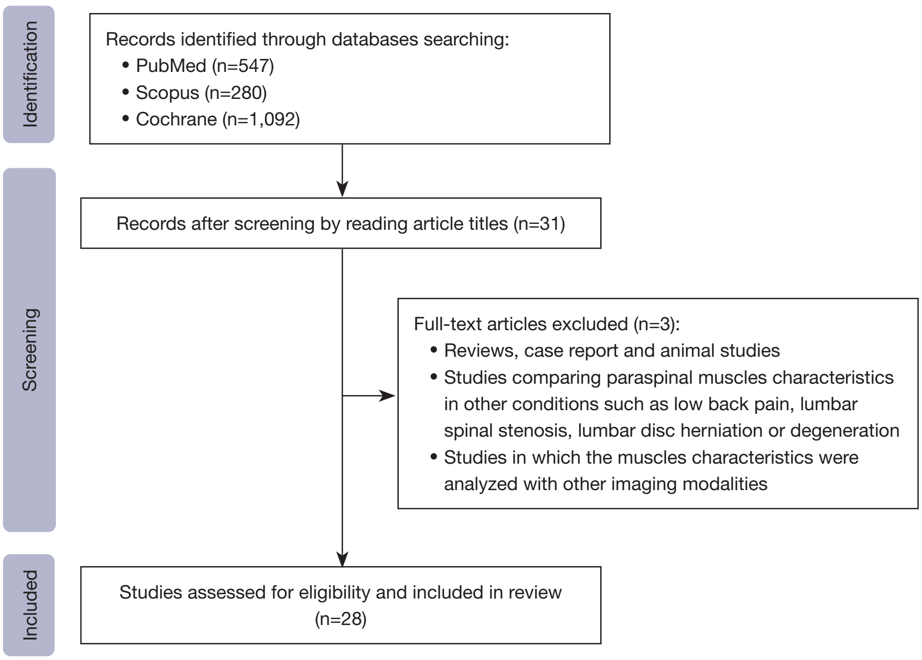

Figure 1 Flowchart diagram showing the articles selection process.

infiltration, cross sectional area, muscle area, muscle index, percentage of muscle fibre, the two formers being the most commonly observed. The studies investigated the possible correlation between paraspinal muscle degeneration and osteopenia/OP and fractures in patients that underwent or not surgical procedures. We divided the studies into two categories, identifying 13 studies about osteopenia/OP and 15 studies about fractures.

Discussion

The degeneration of the paraspinal musculature has become an important topic of interest in recent years. Many authors have studied the changes regarding these muscles in the general population, trying to find a correlation with clinical data. Some authors found that paraspinal muscles undergo degenerative changes, such as atrophy and fat infiltration, with physiologic ageing (30). Other studies have reported a correlation between paraspinal muscle degeneration and parameters like sex and body mass index (BMI); for example, it has been demonstrated a larger paraspinal muscles FF signal in females compared to males (31), while other authors have found a positive correlation between weight and muscle area (32). A correlation, linking the level of physical activity, fatty infiltration, and asymmetry of the paraspinal musculature was also demonstrated in another study (32). In the last two decades many studies have put a focus on the possible link between the morphology of paraspinal musculature and various conditions. Many authors studied the morphology of these muscle in patients

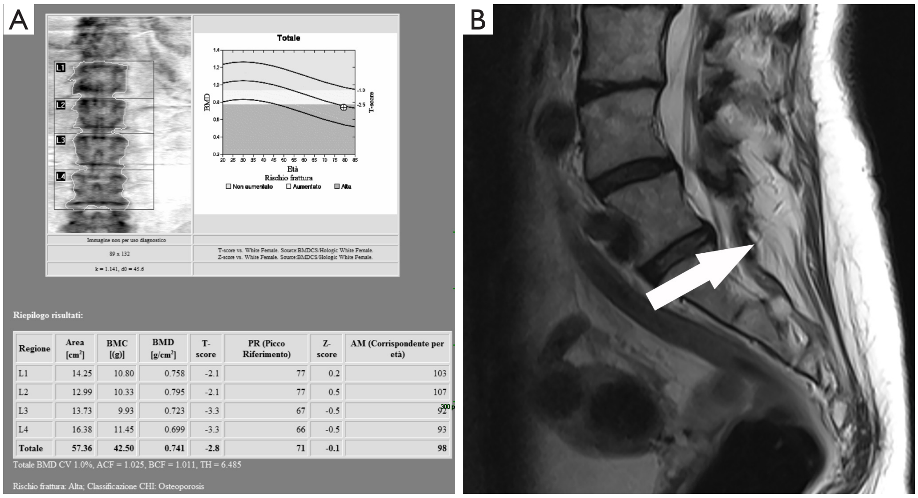

Figure 2 Association between osteoporosis and muscle atrophy. Dual-energy X-ray absorptiometry (A) and sagittal T2-weighed MRI (B) of a 79-year-old woman. The images show the association of osteoporosis (A) with fatty degeneration of paraspinal muscles [arrow in (B)]. BMD, bone mineral density; BMC, bone mineral content; AM, age-related; CV, coefficient of variation; ACF, autocorrelation function; BCF, bias correction factor; TH, total hip; CHI, classification.

presenting with low back pain and found atrophy and fatty infiltration to be very common, therefore recognizing the role of paraspinal musculature degeneration in low back pain (33,34). Other studies have oriented their research on the correlation between paraspinal muscles degeneration and spinal diseases, such as spinal stenosis and reported similar results (35,36). More recently it has been developed an interest on the possible role of these muscles in the pathology of OP and fractures, being two important and widespread conditions of the ageing society. Interesting results have emerged, and we have summarized them dividing the two topics of interest.

Paraspinal muscles and osteopenia/OP

In recent years, several research studies investigated the correlation between the morphology of paraspinal muscles and BMD or OP (*Figure 2*). The major characteristics of these studies are summarized in *Table 2*.

One of the first studies that found a correlation between the cited parameters was conducted by Lee *et al.* (37). They showed a statistically significant correlation between paraspinal muscle area and lumbar BMD, but no significant correlation was found with psoas muscle area.

Ekin *et al.* (38) demonstrated that psoas and paraspinal muscle atrophy was 5.7 times more frequent in patients that showed a reduction of BMD; these results were significantly observed more frequently in women.

Zhao *et al.* (39) were the first study group that used the combination of chemical shift encoding-based water-fat MRI to investigate paraspinal muscle fat infiltration and quantitative CT (QCT) to measure lumbar BMD. A moderate inverse correlation between paraspinal muscle proton density fat fraction (PDFF) and lumbar QCT-BMD was found after controlling for age, sex, and BMI. They evaluated the fatty infiltration of erector spinae, multifidus, and psoas independently, and demonstrated that all these paraspinal muscles fatty infiltration had an inverse correlation with lumbar BMD.

Sollman *et al.* (40) have highlighted differences between males and females, the former showing significantly higher lumbar BMD, psoas and erector spinae muscle CSA and CSA ratio (CSAR) at L2 and L4/L5 levels. After adjusting for age, BMD and CSAR were significantly correlated al level L4/L5 as well as muscle attenuation and CSAR, however, there was no correlation between BMD and muscle attenuation with CSAR at level L2. No correlations with vertebral fractures were found other than with BMD. These results indicates that paraspinal muscle CSA and BMD are correlated at L4/L5 level.

Kajiki *et al.* (41) demonstrated a significant association between psoas muscle index (MI) and BMD at the lumbar spine and femoral neck level; they also observed that psoas MI was lower in patients suffering from OP and it was also

Table 2 Summary of articles about the correlation between paraspinal muscles and BMD/OP

Study	Design	Sample characteristics	Target muscles	Method and target disc levels	Parameter	Results
Lee *et al.* 2015 (37)	Rs	79 female patients, 60–75 y	P, PS	MRI, L3/4–L4/5–L5/S1	MA	PS MA showed positive correlation with BMD of lumbar spine
Ekin *et al.* 2019 (38)	Rs	312 patients, >65 y	P, PS	CT, L3	Muscle density	Reduced BMD and muscle atrophy were significantly associated
Zhao *et al.* 2019 (39)	Ps	88 patients, 46.6±14.2 y	ES, M, P	MRI, L2/3–L3/4–L4/5	FI	PS FI increased while lumbar bone mineral density decreased after adjusting for age, sex, and BMI. PS FI may be a marker of low lumbar BMD
Sollmann *et al.* 2020 (40)	Rs	116 patients, 69.7±8.1 y with or without vertebral fractures	ES, P	CT, L2 and L4/5	CSA, CSAR, muscle attenuation	Males showed significantly higher BMD, CSA, and CSAR at L2 and L4/5 levels, females had decreased ES muscle attenuation at L4/5. Significant correlations of BMD and the CSAR at level L4/5 were found, but not with muscle attenuation
Kajiki *et al.* 2022 (41)	Ps	87 patients with degenerative spinal diseases	P	CT, L3	MI	Lower P MI was significantly associated with lower BMD and higher fracture risk
Gassert *et al.* 2022 (42)	Rs	58 patients	PS	MRI, L1/5	CSA	PS CSA significantly longitudinally decreased in patients with osteopenia/osteoporosis
Gurusamy *et al.* 2022 (43)	Cross sectional	1,923 patients	ES, M, P	CT, L2/3–L3/4–L4/5	Muscle density, FI	Muscle density was positively associated with higher lumbar BMD
Han *et al.* 2022 (44)	Rs	114 patients with degenerative spinal diseases	ES, M, P	MRI, L4/5–L5/S1	CSA, FI	Osteoporotic patients showed higher M FI and ES FI when compared with normal BMD patients
Huang *et al.* 2022 (45)	Rs	180 patients	P	CT, L3	MI	BMD of L1–L4, femoral neck and FRAX (major osteoporotic fracture) were closely correlated with P MI
Yang *et al.* 2022 (46)	Ps	605 patients, 20–59 y	ES, M, P	MRI, L3/4	CSA, FI	Greater FI of ES-M unit was associated with lower BMD, but not with CSA
Zhang *et al.* 2022 (47)	Rs	184 women, >50 y	P	CT, L3	MA, MI	A decrease in height, weight, BMI, bilateral P MA and P MI is associated with osteoporosis. Combined thoracolumbar fractures are more common in osteoporosis women
Zhou *et al.* 2022 (48)	Rs	119 patients, M 50.88±17.79 y, F 49.41±17.69 y	ES, M, P	DECT; ES: L1/2–L4/5; M, P: L2/3–L5/S1	FI	PS fat content showed a significant inverse association with lumbar BMD after controlling for age, sex and BMI
Liu *et al.* 2023 (49)	Ps	130 patients with chronic low back pain, >18 y	ES, P	CT, L3	MA, FI	ES and P CSA and FI are significantly correlated with BMD and have a role in the progression of osteoporosis

BMD, bone mineral density; OP, osteoporosis; y, years; Rs, retrospective study; P, psoas muscle; PS, paraspinal muscles; MRI, magnetic resonance imaging; MA, muscle area; CT, computed tomography; Ps, prospective study; ES, erector spinae muscle; M, multifidus muscle; FI, fatty infiltration; CSA, cross sectional area; CSAR, cross sectional area ratio; MI, muscle index; FRAX, Fracture Risk Assessment Tool; DECT, dual-energy computed tomography; BMI, body mass index.

correlated with fracture risk measured by Fracture Risk Assessment Tool (FRAX). According to ROC analysis, psoas MI had moderate accuracy in the diagnosis of OP and FRAX.

Gassert *et al.* (42) conducted a study with the aim of assessing longitudinal changes in PDFF, T2* and CSA of the paraspinal musculature over 6 months of time in patients with or without osteopenia/OP. They showed that paraspinal muscles CSA decreased more significantly over 6 months in patients with osteopenia/OP compared to those without. Additionally, greater vertebral PDFF and paraspinal muscles PDFF at baseline were associated with greater bone fragility. Because of these results, the study group suggests that longitudinal PDFF and T2* mapping may be useful tools for the assessment and prediction of muscle and bone health, especially in patients suffering from osteopenia/OP.

Gurusamy *et al.* (43), observed that greater psoas, paraspinal and oblique muscle density was significantly associated with higher lumbar BMD at L3 level in both men and women; at the same time, higher muscle FF was associated with lower L3-BMD.

Han *et al.* (44) reported that patients with OP showed lower BMI and higher multifidus and erector spinae muscle fatty infiltration at L4/L5 level compared to patients with normal BMD; both multifidus and erector spinae muscle fatty infiltration were significantly correlated with lumbar T-score and minimum T-score.

Huang *et al.* (45) found a close correlation between psoas muscle index and BMD in the femoral neck and lumbar spine; a strong association was also found with the FRAX. This study group demonstrated that L3-based muscle index could be a useful tool in the diagnosis of OP, and that psoas muscle index is a better indicator of OP compared to skeletal muscle index. They also demonstrated that both visceral and subcutaneous fatty infiltration and visceral-to-subcutaneous ratio of the fat area do not help in OP diagnosis.

Yang *et al.* (46) reported that fatty infiltration of paraspinal muscles, especially multifidus and erector spinae muscle, increases with both age and declining lumbar spine MBD in both sexes. They also demonstrated that paraspinal muscles CSA is not correlated with either age or BMD at any region; this result contradicts with other studies, such as the previously mentioned by Sollman *et al.* (40), where CSA was found to be associated with lumbar BMD.

Zhang *et al.* (47), in their postmenopausal women-based study, showed that a decrease in height, weight, BMI, bilateral psoas area and muscle index were associated with OP. They also observed that psoas muscle index of non-osteoporotic patients with vertebral fractures was lower compared to non-osteoporotic patients with non-vertebral fractures; they did not find a significant difference regarding psoas muscle index in osteoporotic patients with or without vertebral fractures. The study group suggests that sarcopenia may be a risk factor for non-OVF.

Zhou *et al.* (48) demonstrated that fatty infiltration of paraspinal muscles, specifically erector spinae, multifidus, and psoas muscle, measured using dual energy CT (DECT) had a negative correlation with lumbar BMD after controlling for age, sex, and BMI. Erector spinae and multifidus muscle fat content was found to have a stronger correlation with lumbar BMD compared to psoas fatty infiltration.

Liu *et al.* (49) also conducted a study using DECT to evaluate the fatty infiltration of erector spinae and psoas muscles. They showed that lumbar BMD is significantly correlated with CSA and fatty infiltration of paraspinal muscles, therefore these parameters have a role in the progression of OP.

Research studies have explored the relationship between paraspinal muscle morphology and bone BMD or OP. Findings include significant correlations between lumbar BMD and paraspinal muscle area, with variations between muscle types, gender differences in muscle characteristics, and associations between muscle indices and BMD or fracture risk. Additionally, studies using imaging techniques like MRI and CT reveal correlations between fatty infiltration of paraspinal muscles and lumbar BMD, suggesting potential implications for OP assessment and prediction.

Paraspinal muscles and fractures

Over the last few years, several studies focused on the correlation linking paraspinal muscles degeneration and fractures in patients with or without OP (*Figure 3*). The major characteristics of these studies are summarized in *Table 3*.

The first study regarding this matter is the one conducted by Kim *et al.* (50) in postmenopausal women. They demonstrated that the mean CSA of erector spinae, psoas and paraspinal muscles were smaller in patients with osteoporotic vertebral compression fractures (OVCF) compared to patients without fractures, however multifidus muscle CSA was not significantly smaller in the former

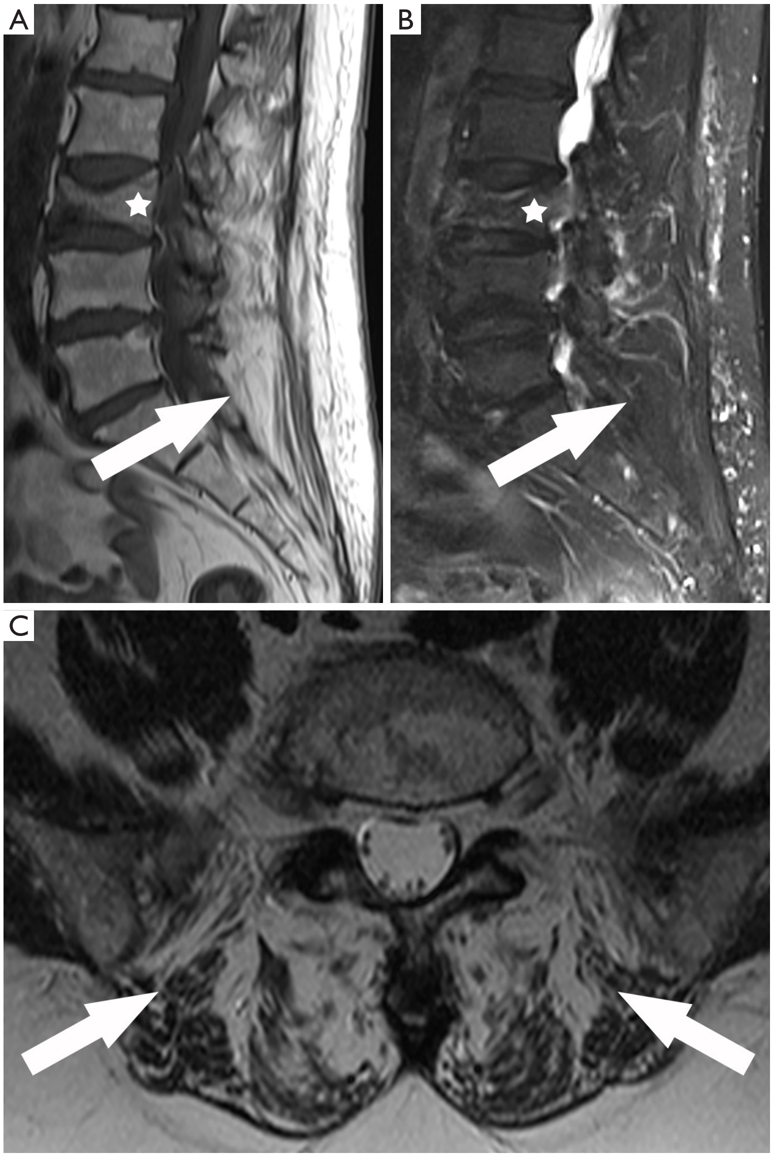

Figure 3 Association between osteoporosis and vertebral fracture. Sagittal T1-weighted (A), sagittal T2-weighted (B) with fat suppression, and axial T2-weighted MRI (C) of a 75-year-old woman. Non-recent vertebral osteoporotic fracture at L3 [star in (A) and (B)] is detected together with fatty degeneration of paraspinal muscles [arrows in (A), (B) and (C)].

group. In addition, more severe grades of muscle fatty infiltration were more common in patients with OVCF.

Byun *et al.* (51) based their study on a population of patients with hip fracture and showed that lower psoas CSA was correlated with a higher 1-year mortality risk. They also showed that psoas CSA had a moderate association with appendicular lean mass in both genders.

Huang *et al.* (52) reported that a decrease in psoas muscle mass was more common in patients with OVCF when compared to age-matched osteoporotic controls, but no significant correlation was found with increased psoas fatty infiltration.

Similar to Byun *et al.* (51), Touban *et al.* (53) studied the possible correlation between psoas muscle morphology and the survival rate in orthopedic trauma patients; they showed that male patients presenting with higher psoas CSA had a decreased 1-year all-cause mortality risk, but they were not able to find a significant correlation in female patients.

Table 3 Summary of articles about the correlation between paraspinal muscles and fractures

Study	Design	Sample characteristics	Target muscles	Method and target disc levels	Parameter	Results
Kim *et al.* 2013 (50)	Rs	81 postmenopausal patients with/without osteoporotic fractures	ES, M, P, PS	MRI, L3/4–L4/5	CSA, FI	Postmenopausal OVCF is associated with reduction of CSA and increased FI of the lumbar paraspinal muscles
Byun *et al.* 2019 (51)	Rs	494 patients with hip fracture, >50 y	P	CT, L4/5	CSA	Lower P CSA was associated with higher risk of mortality after hip fracture; P CSA was also associated with appendicular lean mass
Huang *et al.* 2019 (52)	Rs	32 post-menopausal women with osteoporosis/low bone mass	P, PS	MRI, L5/S1	CSA, FI	Decreased P and PS muscle volume is associated with compression fractures in post-menopausal women with underlying osteoporosis/low bone density
Touban *et al.* 2019 (53)	Rs	558 elderly orthopedic trauma patients	P	CT, L3/4	CSA	Decreased P CSA was significantly associated with 1-year mortality
Takahashi *et al.* 2020 (54)	Cohort study	153 patients with OVF	ES, M	MRI, L3	CSA, FI	Increase in the FI was significantly related to OVF, low back pain and delayed union after OVF
Sim *et al.* 2021 (55)	Rs	615 patients who underwent hip fracture surgery	P	CT, L4	CSA, PLVI	Low PLVI was significantly associated with higher mortality
Habibi *et al.* 2021 (56)	Ps	117 patients OVF, ≥65 y	PS	MRI, L1–L5	CSA, FI	Higher FI of PS is correlated with the occurrence of new OVF
Kawakami *et al.* 2021 (57)	Rs	104 female patients treated for intertrochanteric fractures.	P	CT, L4/5	MA	Lower P MA is associated with a major risk for contralateral hip fracture after intertrochanteric fractures
Zhao *et al.* 2021 (58)	Rs	92 patients with OVCF who underwent percutaneous kyphoplasty	PS	MRI, T5/L5	CSA	The quality of the PS significantly decreased in patients with new OVCFs after percutaneous kyphoplasty
Si *et al.* 2022 (59)	Rs	202 patients with single-level OVCF who underwent percutaneous kyphoplasty	ES, M, P	MRI, L4/5	CSA, FI	ES FI, P FI and the difference index of the muscle CSA between M and P were independent risk factors for the occurrence of new OVCF fractures after percutaneous kyphoplasty
Okuwaki *et al.* 2022 (60)	Rs	95 post-postmenopausal women with acute osteoporotic vertebral fractures	ES, M, P	MRI, L3/4	CSA	Decreased CSA of ES was associated with the severity of osteoporotic vertebral fractures, no significant association in M and P CSA was observed
Shah *et al.* 2022 (61)	Rs	77 patients, >60 y with LBP and vertebral body fractures	M, P, PS	MRI, L4/5	CSA, CSAR	Vertebral insufficiency fractures in the elderly are associated not only with atrophy of P and the M group of muscles as evident by the CSA values, but they also affect the CSAR depending on the number of fractures
Backhauß *et al.* 2023 (62)	Rs	105 patients, 50–90 y	ES	CT, T7/12–L1/5	FI, asymmetry	FI of ES is associated with non-traumatic vertebral body fractures of the lower thoracic spine; a moderate correlation between FI of the ES and fractures severity was also found
Huang *et al.* 2023 (63)	Rs	47 postmenopausal patients with OVCF, >50 y	PS	MRI, L3/4–L4/5–L5/S1	CSA, FI	Greater PS FI is associated with increased severity of OVCF
Lee *et al.* 2023 (64)	Rs	120 patients, >60 y	M	MRI, L4/5–L5/S1	CSA, PNF	PNF value, not the CSA, of M increases the spinal fracture risk

Rs, retrospective study; ES, erector spinae muscle; M, multifidus muscle; P, psoas muscle; PS, paraspinal muscles; MRI, magnetic resonance imaging; CSA, cross sectional area; FI, fatty infiltration; y, years; CT, computed tomography; OVF, osteoporotic vertebral fracture; PLVI, psoas-to-lumbar index; Ps, prospective study; MA, muscle area; OVCF, osteoporotic vertebral compression fracture; CSAR, cross sectional area ratio; PNF, percentage of muscle fibre.

Takahashi *et al.* (54) analyzed the changes in paraspinal muscles after OVF; they observed a progressive increase in the fatty infiltration, but not in the muscle CSA. The study group also observed a delayed union after OVF in patients with an increased paraspinal FF.

Sim *et al.* (55) evaluated the association between preoperative psoas-to-lumbar index (PLVI), used to estimate sarcopenia, and mortality in elderly patients who underwent hip fracture surgery; they reported an increased 1-year and overall mortality in patients with low PLVI, therefore in patients with a reduced psoas muscle mass and sarcopenia.

Habibi *et al.* (56) observed that patients with an increased fatty infiltration of the paraspinal musculature had a much higher persistence of low back pain after OVF and a higher risk of new OVF in the thoracolumbar region. They did not find a significant correlation between paraspinal musculature and severe compression fracture or delayed union. No significant correlation was found regarding psoas CSA because CSA is not likely to reflect early muscle changes compared with the fatty infiltration; this result is consistent with other studies like the one by Takahashi *et al.* (54).

Kawakami *et al.* (57) studied patients with intertrochanteric fracture and demonstrated that patients with a decreased psoas muscle area had a significantly higher risk of developing a contralateral femoral fracture in the two years following the initial fracture.

Zhao *et al.* (58) analyzed patients who underwent percutaneous kyphoplasty after OVF and observed that patients who sustained new vertebral fractures after the surgery had a decreased paraspinal muscle CSA.

Si *et al.* (59) conduced a similar study on patients after percutaneous kyphoplasty and observed that multifidus, psoas, and erector spinae muscles fatty infiltration was correlated with the occurrence of new OVCF after undergoing the procedure. They also observed that the CSA difference index between multifidus muscle and psoas muscle represented a risk factor for the recurrence of OVCF.

Okuwaki *et al.* (60) reported that erector spinae CSA was correlated with vertebral instability in patients with OVCF, therefore with the severity of the OVCF; this was not valid for the CSA of multifidus and psoas muscles, which were reported to be correlated to BMD only.

Shah *et al.* (61) revealed a statistically significant correlation between vertebral insufficiency fractures in the elderly and the reduction of CSA in the psoas and multifidus muscles. They also observed a reduction in the multifidus to psoas muscle CSA ratio depending on the number of fractures.

Backhauß *et al.* (62) reported that fatty infiltration of the autochthonous muscle, especially the erector spinae muscle, is associated with non-traumatic vertebral body fractures in the lower thoracic spine and their severity; no significant association was found in the lumbar spine.

Huang *et al.* (63) demonstrated that a higher degree of fatty in filtration in the paraspinal muscles was related to the severity of OVCF in postmenopausal women.

Lee *et al.* (64) showed a significant association between multifidus muscle percentage of muscle fibre and OVF al L4/L5–L5/S1, but not with multifidus muscle CSA which appeared to be higher in the fracture group when compared to the control group. According to this study group the fatty infiltration of the paraspinal muscle, rather than the muscle CSA, significantly affect the risk of OVF.

Studies on postmenopausal women indicate a correlation between smaller erector spinae, psoas, and paraspinal muscle CSA and OVCF. Additionally, associations are found between lower psoas CSA and higher 1-year mortality risk in hip fracture patients. Other investigations highlight the impact of psoas muscle morphology on survival rates, increased fatty infiltration after OVF, and the role of paraspinal muscle CSA in predicting new vertebral fractures. Findings underscore the significance of muscle characteristics in assessing fracture risk and outcomes in OP-related conditions.

Conclusions

This paper provides an overview of the changes observed in the paraspinal musculature in patients with osteopenia/OP and fractures. The current evidence suggests that paraspinal muscle degeneration, intended as atrophy and fatty infiltration of the muscles, plays an important role in the occurrence of osteopenia/OP and fractures. Assessing the paraspinal musculature may be a useful tool in the identification of patients that may be at high-risk for these conditions, therefore it can be useful to prevent a worsening of the quality of life of these patients. Further studies are needed to understand the possible role of paraspinal musculature in the prevention of OP and fractures.

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Footnote

Reporting Checklist: The authors have completed the

Narrative Review reporting checklist. Available at https://qims.amegroups.com/article/view/10.21037/qims-23-1770/rc

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://qims.amegroups.com/article/view/10.21037/qims-23-1770/coif). C.A.M. serves as an unpaid editorial board member of *Quantitative Imaging in Medicine and Surgery*. The other authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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