

**Non-pharmacological Management of Osteoporotic Vertebral Fractures: A Qualitative
Analysis of Patient and Health-Care Professional Perspectives and Experiences**

by

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Author's Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners. I understand that my thesis may be made electronically available to the public.

Abstract

Introduction: Osteoporosis is a chronic disease that is characterized by a femoral neck or lumbar spine bone mineral density (BMD) less than 2.5 standard deviations below the mean of young adult females and encompasses changes to bone structure and bone quality, resulting in reduced strength and increased risk of fracture. Vertebral fractures are the most prevalent fracture in women with osteoporosis, affecting at least 20% of the older population. Vertebral fracture incidence and prevalence increase steadily with age and may appear without any symptoms. Once someone becomes symptomatic, they can experience a plethora of changes to their physical, social, and psychological functioning. Currently, information on non-pharmacological strategies to address consequences of vertebral fracture exist; however, lack of awareness of guidelines and inconsistencies among the literature on the effect of non-pharmacological strategies may reduce their use and effectiveness.

Objective: We have discovered that a gap in research exists in treatment/management of vertebral fractures, especially the use of non-pharmacological interventions. Considering that recommendations available are targeted towards individuals living with osteoporosis with or without vertebral fractures, our objective was to understand health care professionals' (HCPs) and individuals living with vertebral fractures' experiences and perceptions of post-vertebral fracture rehabilitation, use of non-pharmacological strategies, and virtual rehabilitation.

Methods: We performed a qualitative analysis using semi-structured interviews. Semi-structured interviews were conducted over web conference or telephone with both individuals living with vertebral fractures and HCPs within Canada. We used criterion sampling to recruit physicians (mainly geriatricians, family physicians and psychiatrists) and allied health professionals (physiotherapists and nurses who work in geriatrics). We also used purposeful sampling to recruit

individuals who are BoneFit™ trained, are specialists in osteoporosis care, are clinician researchers with experience with this population, or clinicians who self-declare an interest and see patients with osteoporosis. Individuals living with vertebral fractures were recruited from the Canadian Osteoporosis Patient Network (COPN), social media, and our Bone health and Exercise Science Lab email distribution list. Individuals living with vertebral fractures were included if they had been diagnosed with a vertebral fracture in the past, regardless of location of fracture. Questions for the interview guide were centred on non-pharmacological treatments such as exercise, spine sparing and movement modification, pain management, and nutrition. Considering that our intention is to inform the development of an online exercise/education intervention to provide information on exercises, nutrition, pain management and safe movement, we also asked about the attributes that both individuals living with vertebral fractures and HCPs would find important in the development of an online tool. To inform the semi-structured interview guide, we used the Diffusion of Innovations Theory, and the APEASE criteria. Interviews were audio recorded and transcribed verbatim. Once the interviews were completed and transcribed, two researchers conducted an inductive thematic and content analysis.

Results: 13 HCPs (7F, 6M, aged 46 ± 12 years) were interviewed. Two major themes emerged from our interviews: acuity of fracture matters when selecting rehabilitation strategies; and roadblocks to rehabilitation. Early rehabilitation interventions included pain and osteoporosis medicine, education on harmful and high-risk movements, and non-pharmacological strategies to help reduce patient pain and increase early mobilization. Rehabilitation in the chronic stage of vertebral fractures incorporated more exercise-based strategies to help increase strength, mobility and functionality and was informed by a comprehensive assessment. Regardless of the stage of recovery, barriers such as delayed identification of fracture, delayed or no referral to

physiotherapy, and lack of knowledge of osteoporosis or vertebral fracture among HCPs may reduce the access to or effectiveness of non-pharmacological interventions. HCPs believed that virtual rehabilitation that includes an online educational component, an online assessment, and online exercise classes in groups tailored to individuals could be a feasible alternative; however, concerns related to the online assessment such as the inability to perform manual strength testing, and patient confidence in using technology were voiced.

10 individuals living with vertebral fractures (9F, 1M, aged 71 ± 7.9 years) were interviewed. Five major themes emerged from our interviews: chronic pain from spine fractures contributes to activity limitations and other consequences; fracture identification may be delayed, influencing care trajectory; living with fear; being dissatisfied with fracture management; and non-pharmacological strategies can help patients “get back into the game of life”. We have identified that the experience of vertebral fracture recovery among patients involves a substantial amount of back pain, mobility related issues, and psychological and social impairments. Rehabilitation provided to patients was dependent on the identification of fracture and was delayed, either from patient reluctance to see a HCP initially, or due to issues related to radiological diagnosis and access to an X-ray. Pain medication was perceived as helpful in reducing pain but non-pharmacological alternatives to reduce pain and improve mobility was emphasized as important, and patients believed that they should be advised. Rehabilitation in the chronic stages of vertebral fracture recovery involved more non-pharmacological interventions, such as weight-bearing exercise and education on safe movement and activity modifications and was facilitated by physiotherapy. To improve access to non-pharmacological options, education and exercise delivered online via virtual rehabilitation was perceived positively and could be an acceptable and

feasible strategy; however, participants were concerned about access to technology and the individualization of programs in a group setting.

Conclusion: We have identified that rehabilitation provided by HCPs was dependent on the acuity or stability of fracture, and that non-pharmacological strategies were facilitated by physiotherapy. To select and individualize physical therapy interventions, physiotherapists emphasized using assessments to determine patient goals, physical functioning, and identify co-morbidities. To improve access and address barriers, virtual rehabilitation could be a feasible and effective alternative for patients but may require further evaluation.

We have identified that individuals who suffer a vertebral fracture report chronic back pain that influences their ability to perform activities of daily living, impacting psychological and social well-being. To address consequences of vertebral fractures pain medication was used and considered helpful, but that non-pharmacological strategies, facilitated by physiotherapy, was considered important and should be advised; however, barriers to fracture identification and access and referral to physiotherapy may limit the use of these options. To improve access to non-pharmacological strategies, patients believe that virtual rehabilitation could be a feasible and effective alternative but may require further evaluation.

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TABLE OF CONTENTS

LIST OF FIGURES	x
LIST OF TABLES	xi
INTRODUCTION	1
1. Osteoporosis	1
2. Vertebral Fractures	3
2.1. Structural changes to the spine.....	4
2.2. Physical consequences of vertebral fractures and hyperkyphosis.....	6
2.2.1. Mobility.....	7
2.2.2. Pulmonary function.....	7
2.2.3. Digestive system	8
2.3. Psychological changes	8
3. Treatment and rehabilitation for vertebral fractures.....	10
3.1. Pain and pain management	11
3.2. Spinal orthosis for VFs	12
3.3. Nutrition.....	12
3.4. Exercise and intervention types	13
3.4.1. Back extensor training	14
3.4.2. Exercise targeting hyperkyphosis	15
3.4.3. Balance training	16
3.4.4. General exercise and safe movement.....	16
3.4.5. Complications and safety	18
3.5. Exercise summary	18
4. Implementation of exercise interventions	19
4.1. Multi-component interventions.....	19
4.2. Delivery Method	20
5. Barriers to program implementation.....	21
5.1. Patient barriers limiting the ability to be physically active.....	22
5.2. Health care professional barriers limiting implementation	23
5.3. Behaviour Change Wheel	24
5.4. Telerehabilitation.....	25
6. Objective	26

METHODS	27
1. Study Design.....	27
2. Recruitment and screening.....	29
3. Interview guide	30
4. Thematic and content analysis	31
RESULTS	33
1. Thematic analysis: Health care professionals.....	39
1.1. Acuity of fracture matters when selecting rehabilitation strategies.....	40
1.1.1. Minimizing pain to facilitate early mobilization	40
1.1.2. Regaining function and getting back to ‘normal’	43
1.2. Roadblocks to rehabilitation.....	47
2. Content analysis and virtual rehabilitation: Health care professionals.....	52
2.1. Content and structure of a successful virtual rehabilitation program specific to vertebral fracture.....	54
2.2. Considerations related to virtual rehabilitation implementation	58
DISCUSSION	61
CONCLUSION	67
3. Thematic analysis: Individuals living with vertebral fractures.....	68
3.1. Chronic pain from spine fractures contributes to activity limitations and other consequences	69
3.2. Fracture identification may be delayed, influencing care trajectory.....	71
3.3. Living with fear.....	73
3.4. Being dissatisfied with fracture management.....	75
3.5. Non-pharmacological strategies can help patients “get back into the game of life”	77
4. Content analysis and virtual rehabilitation: Individuals living with vertebral fractures.....	83
4.1. Virtual rehabilitation perceptions and advice	85
DISCUSSION 2	88
CONCLUSION 2	95
REFERENCES	96
APPENDICIES	116

LIST OF FIGURES

FIGURE 1. Thematic map of HCP experience and perception of vertebral fracture rehabilitation and the perceived barriers.

FIGURE 2. Thematic map of patient experience and perception of vertebral fracture recovery

LIST OF TABLES

TABLE 1. Characteristics of health care professionals

TABLE 2. Characteristics of individuals living with vertebral fractures

TABLE 3. Suggestions and considerations provided by HCPs on the structure and educational content

TABLE 4. Content analysis of exercise, pain management, and educational interventions provided by HCPs

TABLE 5. Content analysis of patient symptoms and experienced interventions

INTRODUCTION

1. Osteoporosis

Osteoporosis is a chronic disease that is characterized by a femoral neck or lumbar spine bone mineral density (BMD) less than 2.5 standard deviations below the mean of young adult females and encompasses changes to bone structure and bone quality, resulting in reduced strength and increased risk of fracture.^{1,2} Approximately 30% of all postmenopausal women in the US and Europe,^{3,4} and 15.8% of women in Canada aged ≥ 50 have osteoporosis,⁵ which may be accompanied by fractures at the hip, wrist, and spine. Fractures do not require a large amount of trauma and may occur during activities of daily living (ADLs), even in the absence of a fall.⁶ When a fracture occurs with minimal trauma or force they are referred to as fragility fractures, and more than 40% of women with osteoporosis will develop a fragility fracture in their lifetime.⁷ Despite this, less than 20% of women with fragility fractures will receive treatment to reduce future fractures.^{8,9} Therefore, diagnosis often occurs after the incidence of fracture. Once a fracture occurs, depending on the location, either DXA or radiography is performed.¹ Radiography is performed on the spine to determine if there is the presence of an increased lucency of the vertebral body, a loss of horizontal trabeculae, increased prominence of the cortical end plate and vertical trabeculae, reduced cortical thickness, and/or anterior wedging.¹⁰ However, even though BMD is typically used to form a diagnosis, there are many other clinical risk factors contributing to fractures, such as age, sex, and low body mass index.¹ Using the computer based algorithm FRAX, clinical factors, in addition to BMD, can estimate the 10-year probability of a major fracture.¹¹

Regardless of diagnosis and severity, patients report that treatment was consistently delayed.¹² Because there is a small proportion of patients treated compared to many of the population that

could be treated based on their fracture risk, there is a high societal and personal burden put on both public health and physicians,¹ especially considering that the prevalence of osteoporosis is quite high. It is important to note that because women have a higher probability of developing osteoporosis, men tend to be forgotten in the implementation of research; however, approximately 5% of men in the US and 6.6% of men in Canada live with osteoporosis^{4, 5} and experience similar structural and lifestyle changes as women. Research also suggests that men associate being physically active with their construction of masculinity and sense of self.¹² Therefore, even though men do not develop osteoporosis as often as women, men do experience similar and unique challenges and should be included in osteoporosis research.

Treatments for osteoporosis range from pharmacological interventions using anti-resorptive and anabolic bone drugs, to approaches such as exercise and changes to nutrition.^{13, 14} Treatment goals are to maintain bone mass and to reduce fracture risk. Maintenance of bone mass is determined by a multitude of factors, such as physical activity, hormones, and nutrition,¹⁵ usually in combination with medication. In terms of exercise and physical activity (PA), animal models have revealed that magnitude¹⁶, rate¹⁷, and frequency¹⁸ of strain are the most impactful characteristics to promote osteogenesis, with an emphasis on dynamic rather than static movement patterns.¹⁹ Based on the current literature, the Too Fit to Fracture (TF2F) guidelines were created to provide information on medical history and medications, fracture risk results using a validated risk calculator, history of falls, physical performance, and standing posture in osteoporotic individuals with or without vertebral fracture.²⁰ Sub goals were also developed for the prevention of falls. These sub goals included information on fall prevention, performing safe movements, and how to prescribe exercises that maintain bone mass.²⁰ Even though these guidelines were not

directly targeted towards individuals living with vertebral fractures, separate recommendations were made to address this population.^{20, 21}

2. Vertebral Fractures

Vertebral fractures are the most prevalent fracture in individuals living with osteoporosis,²² affecting at least 20% of the older population.²³ Vertebral fracture incidence and prevalence increase steadily with age²³ and may appear without any symptoms. This is one of the major concerns and discrepancies with osteoporosis and vertebral fractures, as 50-75% of individuals may be asymptomatic.²⁴ Not a lot is known on what makes someone asymptomatic²⁵; however, regardless if someone is asymptomatic, the presence of a fracture greatly increases the risk of subsequent fractures.^{3, 20, 21} Therefore, individuals who are asymptomatic have a higher chance of becoming symptomatic over time. Once someone becomes symptomatic, they can experience a plethora of changes to their physical, social, and psychological functioning. Physical symptoms can involve back pain,²² trunk weakness, deformity,²⁶ and height loss.³ These physical complications, along with age, may contribute to physical limitations and postural changes, such as hyperkyphosis, sleep disturbance, impairments in ADLs, disability, and balance instability.^{3, 21, 22, 26} With the onset of physical symptoms and limitations comes major changes to psychological and social wellness that may be overlooked by physicians, such as: fear of falling, anxiety, depression, and loss of social roles/ role identification.^{3, 21, 27} Paired together, physical and psychological complications contribute to a very painful and debilitating condition, influencing the health-related quality of life in older adults, as QOL with a acute vertebral fracture is considerably lower compared to controls 7 years post fracture.²⁸

2.1. Structural changes to the spine

To discern the causes and consequences of vertebral fractures, we must first understand how the structure and biomechanics of the spine and muscles are integrated. Most vertebral fractures occur in mid thoracic (T7-T8) and the thoracolumbar (T11-L1) regions of the spine.^{29, 30} It is not fully known why most fractures occur in these regions; however, authors have theorized that variations in the spine curvature are what contribute to these findings.³¹ In the mid-thoracic spine, hyperkyphosis at T7-T8 seems to be one of the causes contributing to fracture, as the extreme curvature of the spine increases anterior bending moments, creating large compressive and shear forces on the vertebral bodies.³² For fractures occurring in the thoracolumbar part of the spine it is proposed that the transition from kyphotic to lordotic allows the thoracic cage to give way to the more mobile lumbar spine, increasing the load affecting vertebral bodies.³¹ Other than spine curvature, fracture risk can also be influenced by the compressive strength of the vertebrae, which is determined by the individual size and BMD.³³ Size and density may be the main factors contributing to the strength of the vertebrae; however, microarchitecture, collagen characteristics, microdamage accumulation, mineralization, and osteocyte number also play a relative role.³¹ It is typically thought that vertebral compressive load gradually increases from thoracic to the lumbar spine; however, differences in BMD and bone structure do not vary significantly among vertebrae, meaning that some areas of the spine may be more susceptible to fractures than others based on their position rather than their structure.^{31, 34, 35}

Even though the spinal motion segment consists of two vertebrae, the intervertebral disc, and two posterior articulations, there are also a multitude of ligaments and muscles that keep the structure stable.²⁵ The multifidus, transverse abdominis, internal obliques and pelvic floor are deep muscles with segmental attachment sites that work together with the diaphragm to create stability

in the lumbar region of the spine.²⁵ Larger erector muscles are considered global multi-segmental muscles that are used to stabilize direction dependent movement.²⁵ Both muscle groups work together to control spinal movement in the sagittal plane but work independently in the transverse plane.²⁵ Extensors of the spine are recruited to maintain upright posture and resist gravity, while the spinal flexors and flexion of the spine produce compressive forces on the intervertebral disks, which transfers to the vertebral body.³⁶ Therefore, during extension or flexion of the spine, both muscle groups work together to maintain stability.³⁷ Spinal stability is a term used to describe the balance of the loading forces acting across the bones, joints, intervertebral disks, ligaments, and muscles.¹⁵ Typically, 20% of vertical load is absorbed by the pedicle facet complex (posterior column), while 80% is absorbed by the disk and the vertebral body (anterior column).³⁸ Regardless if a fracture is from trauma or movement, there is typically a 15-25% loss of anterior height of a vertebra, which may be accompanied by changes in biconcavity of the vertebrae.¹⁰

Another major factor that will lead to alterations in the integrity of the spine and must be considered is age. Aging is associated with reductions in muscle mass, bone mass, balance, strength, and intervertebral disc thickness, contributing to increased mechanical load and probability of fracture.³¹ Typically, healthy intervertebral discs disperse the magnitude and distribution of force among the spinal segments; however, because there is a progressive deterioration over time, the ability for these discs to absorb impact is reduced. Degradation of intervertebral discs contributes to the development of a more fibrous intervertebral disc, reducing its compressive and distributive qualities. Therefore, as the intervertebral disc becomes more fibrous, the mechanical load on the vertebrae is increased, contributing to bone loss in the anterior body of the vertebrae³⁹ and causing extreme stress during flexion of the spine.⁴⁰

Hyperkyphosis refers to an excessive anterior curvature of the spine that increases morbidity among older adults.⁴¹ Development of this excessive curvature increases the load on the anterior part of the spine, which may increase the presence and severity of vertebral fractures among men and post-menopausal women.⁴¹ Considering that most fractures occur in the mid thoracic and thoracolumbar junction areas, and may be accompanied by microfractures, there is a high probability of developing a hyperkyphotic posture.¹⁵ Hyperkyphosis has been reported to be present in 20–40% of older adults⁴²; however, some studies have found that vertebral fractures are not completely associated with the formation of hyperkyphosis and chronic back pain.^{41, 43} Even if the presence of vertebral fractures does not directly cause the development of hyperkyphosis, Katzman et al., suggested that hyperkyphosis and fracture risk can be used together as a clinical marker of vertebral fractures.⁴¹ One of the reasons that there are discrepancies in the association of hyperkyphosis and vertebral fractures is that excessive formation of kyphosis is largely affected by age, as aging is associated with a decrease in bone mass, muscle strength, and axial bone strength, with or without the presence of vertebral fractures.^{15, 44} Therefore, the presence of hyperkyphosis should be viewed as a structural complication that is associated with aging and bone loss rather than vertebral fractures alone.⁴¹ Regardless, vertebral fractures and hyperkyphosis are both accompanied by chronic back pain, which can be caused by acute trauma from a break, or changes in the segmental joints, muscles, and ligaments.⁶

2.2. Physical consequences of vertebral fractures and hyperkyphosis

Changes to spinal structure and biomechanics are main physical contributors to excess mortality seen in patients with vertebral fractures.¹² The combination of these factors contribute to reductions in physical activity which creates an environment of physical inactivity. Inactivity accelerates bone loss and progresses to further bone fragility, pain induced inactivity, muscle hypotrophy, and

muscle weakness, multiplying the risk of falls and subsequent fractures.²⁷ These physical symptoms can also contribute to changes in lifestyle and movement, affecting mobility and pulmonary and digestive function.

2.2.1. Mobility

Mobility and movement with vertebral fractures can become challenging due to pain, structural changes, and hyperkyphosis. To compensate for forward posture, individuals may shorten stride lengths and rate, and increase gait variability and balance instability.⁴⁵ To maintain an upright torso, individuals may use strategies such as flexing their knees, or posteriorly rotating their pelvis.⁴⁶ These compensation strategies may lead to hyperkyphosis and forward head posture and are considered independent factors in decreasing mobility performance on tests such as the timed-up-and-go (TUG) and the four meter walk.^{45, 47, 48} Even though fractures may make it challenging to perform certain movements, location, severity, and number of fractures cannot explain all of the variability in these tests; instead, some of this variance may be related to osteoarthritis, neurological disorders, and pain severity.⁴⁹ Therefore, balance instability, and changes in gait will affect mobility and are influenced by the degree of hyperkyphosis but do not seem to be affected strongly by vertebral fractures alone.

2.2.2. Pulmonary function

Chronic Obstructive Pulmonary Disease (COPD) is an inflammatory disease of the lungs that usually encompasses airway limitations and restrictions.⁵⁰ COPD is often associated with other diseases and comorbidities and is therefore referred to as a systemic inflammatory disease.⁵¹ There is a high prevalence of COPD patients developing low BMD and vertebral fractures,⁵²⁻⁵⁴ and older adults who have severe fractures show signs of pulmonary dysfunction, such as reduced lung volume.⁵¹ Reduced lung volume and restrictive lung disease in individuals living with vertebral

fractures may be related to multiple vertebral fractures and ensuing hyperkyphosis. Therefore, because COPD and osteoporosis are often found together and have some similarities, it may be important to consider the environment and treatment plan for both COPD and osteoporosis, as both osteoporosis and COPD have separate treatments. It may be possible to combine some aspects of treatments considering that using bisphosphonates, vitamin D, and calcium has been shown to be effective in improving BMD in COPD patients with osteoporosis.⁵⁴

2.2.3. Digestive system

Finally, even though a lot of the physical consequences of vertebral fractures are movement and mobility related, there are also changes that occur to the digestive system. Research has been done on the prevalence of hiatus hernia and reflux esophagitis in Asia and the influence of vertebral fractures.⁵⁵ Vertebral fractures have been associated with their development; however, research has reported that osteoporosis and hyperkyphosis may be the contributing factors predisposing post-menopausal women to hiatus hernia and reflux esophagitis rather than vertebral fractures.⁵⁶
⁵⁷ Development of these diseases is not clear, but researchers believe it may be related to intraabdominal pressure and lumbar compressive forces. When intrabdominal pressure is increased, lumbar compressive forces are reduced, and thus push upon the esophagus, predisposing individuals to hiatus hernia.⁵⁸ Therefore, even though the presence of the vertebral fractures and hyperkyphosis are related to their development, it may be considered a consequence of aging rather than a consequence of vertebral fractures.⁵⁹

2.3. Psychological changes

Other than physical and structural issues there are major psychological changes that are associated with vertebral fractures. Some psychosocial symptoms associated with vertebral fractures are increased risk of falls, fear of falling, anxiety, depression, loss of social roles/ role identification,³

^{21, 27} loss of independence, increased isolation, reduced confidence and self esteem,²⁷ and feelings of isolation and humiliation.⁶⁰ Changes in psycho-social functioning also contribute to reductions in social interaction and physical activity, furthering the progression of both physical and psycho-social changes. When evaluating changes in lifestyle and psychological outlook, it is important to get the perspective of the individuals themselves to understand the challenges that they experience. To understand these perceptions Svensson et al., performed a qualitative analysis to understand the challenges and feelings that women living with vertebral fractures face. They reported that the participants felt like they were living in turmoil/chaos and had trouble finding stability in their lives. If they were not in pain, they were afraid of the pain that would come from falling or moving. They described the initial pain as intense and persistent; however, over time this perception changed. Some described the pain as less intense and more intermittent, while others described their pain as constant and unchanging. Regardless of their pain perception, all the women considered pain a normal part of their lives. They found that even small movements could initiate severe pain, which left them in a state of constant fear. This constant fear led them to perceive new environments as challenging and unpredictable. Even at home there were challenges with fear of pain. Nights were described as extremely troublesome and painful, making it very difficult to get a good night's sleep.⁶⁰ Similarly Kim et al., found that these confounding factors left women feeling trapped and confined to their homes, allowing feelings of negativity to affect their disability in the acute stages of an osteoporotic vertebral fracture; however, as the fracture healed, their disability tended to reflect changes in age rather than catastrophizing.⁶¹ Svensson et al., described this transition in 3 stages: an initial change, a stage of instability and distress, and a stage of balance and acceptance. Regardless of this transition, fear and concern of pain around everyday activities persisted, but physical activities and the ability to perform them was still related to the

individual's identity. They also described that better mobility, independence and being less reliant on supportive devices and family members improved confidence.⁶⁰ Therefore, because identity, confidence, and the ability to socialize was related to the ability to be physically active, non-pharmacological treatments that address these physical, psychological, and social issues, may help improve pain perception and QOL.

3. Treatment and rehabilitation for vertebral fractures

Individuals living with vertebral fractures report high levels of pain, impaired physical function, and a reduction in QOL; however, despite these characteristics, 75% seeking urgent care do not receive a treatment plan, and are sent home without proper pain medication, or support.⁶²⁻⁶⁴ Svensson et al., reported that patients felt that health care professionals (HCPs) did not take their condition seriously and were put on low priority. They knew something was wrong but had to push for radiography to be diagnosed. Once they were diagnosed with an acute vertebral fracture, they were told that there was nothing more they could do.⁶⁰ This is unfortunate as individuals living with vertebral fractures have many options for treatment. Pharmacological treatment has increased in the past years as studies have shown success with antiresorptive agents, such as bisphosphonates or denosumab¹; however, there is no established treatment plan.²⁷ When treated properly and given the correct attention, early pharmacological treatments can reduce the risk of subsequent fracture risk by 30-70%.⁶⁵ Some treatment plans also include mobilization therapy combined with the pharmacological treatment to reduce pain and slow bone resorption.²⁷ Other treatments include surgical manipulations such as percutaneous vertebroplasty and percutaneous balloon kyphoplasty, which have been shown to reduce pain and increase QOL; however, it is not fully agreed upon,²⁷ and is currently not recommended, according to the American Society for Bone and

Mineral Research (ASBMR) Task Force Report.⁶⁶ Therefore, to provide the most comprehensive treatment plan, non-pharmacological options should be considered.

3.1. Pain and pain management

Vertebral fractures can be very painful and may persist for a long time. Onset of pain can be initiated from movement, sneezing, coughing, and lifting.^{67,68} Because pain occurs with movement, typical treatment will include a form of pain relief. Addressing pain is an important part of vertebral fracture care since using non-pharmacological treatments will require movement that may induce some form of pain. Non-pharmacological and non-surgical treatments that are used in managing pain can include early mobility, bed rest (if pain is intolerable), non-steroidal anti-inflammatory drugs (NSAIDs), narcotics, lidocaine patches, and muscle relaxants.^{67,69,70} Other medications such as calcitonin have been shown to improve early mobility and pain symptoms for up to 4 weeks in individuals with vertebral compression fractures with no neurological symptoms.⁷¹⁻⁷³ However, regardless of their effectiveness, medication is not a long-term treatment of pain and instead should be used to allow individuals living with vertebral fractures to be more physically active and participant in non-pharmacological interventions.⁶⁷ By using non-pharmacological treatments or rehabilitation in the initial stage of treatment pain can be improved, as an individual that shows success using non-pharmacological treatments by 3 weeks has a 95% chance of maintaining pain relief for 12 months.⁷⁰ However, risk factors for failure of non-pharmacological treatments were identified as severe osteoporosis, older age, obesity, and higher rates of initial vertebral collapse.⁷⁰ Therefore, when individuals with vertebral fractures do not have any risk factors the use of non-pharmacological treatment may be helpful in the initial treatment of pain in individuals living with vertebral fractures.

3.2. Spinal orthosis for VFs

Spinal orthosis are devices that are typically used in the sub-acute treatment of vertebral fractures and in some cases long-term.⁷⁴ These devices are used mainly as a strategy to limit movement, improve posture, reduce pain and fatigue, and to allow for safe participation in physical activity.⁷⁵ They are typically prescribed for 2-3 months after a vertebral fracture to help reduce the acute complications that will prevent from being immobile during the acute phase.⁷⁶ Other than limiting movement, a spinal orthosis also aims to reduce hyperkyphosis to improve balance, trunk stability and muscle strength.^{74, 77} However, the effectiveness of bracing on pain outcomes are mixed^{77, 78} and the quality of evidence is weak⁶⁶ as there is a lack of information on the type, how long they should be worn, and when to use them.⁶⁷ Therefore, the use of bracing should be specific to the individuals as complications such as muscle atrophy and skin irritation may become troublesome.⁶⁷ According to the ASBMR Task Force Report and a systematic analysis by Newman et al., because there is limited evidence on the effectiveness of spinal orthosis, larger and higher quality studies are needed before spinal orthosis are recommended to patients.^{66, 75}

3.3. Nutrition

Nutrition is an important non-pharmacological treatment for individuals living with osteoporosis that aims to slow bone loss, and thus should be a major consideration for individuals living with vertebral fractures. Individuals living with vertebral fractures struggle to maintain appetite and a healthy diet due to progressive hyperkyphosis affecting the thoracic cavity.^{79, 80} By limiting the amount of food that is consumed deficiencies begin to appear in calcium intake, vitamin D, and protein and energy consumption, which contribute to more fragile bones.^{81, 82} Prevalence of nutritional deficiencies increase with age and affect many osteoporotic patients,⁸³ contributing to the probability of developing a fragility fracture or a subsequent fracture. However, by increasing

calcium consumption, spine fracture incidence can be reduced,⁸⁴ especially when paired with the consumption of vitamin D.⁸⁵ Protein-energy malnutrition also contributes to sarcopenia, and frailty, as an inadequate amount of protein negatively affects the balance of calcium and the production of growth factors.⁸⁶ One of the contributing factors that may be influencing the consumption of food is constipation. Constipation is a very prominent symptom that is highly associated with vertebral fractures, even 1 year post surgery.⁸⁷ However, there is currently no research linking the two together and therefore has not been addressed in recommendations. Therefore, even though nutrition is considered a weak risk factor in the development of vertebral fractures,⁸⁰ it is still important to make sure that individuals living with vertebral fractures consume both calcium and vitamin D and eat an adequate amount of calories to facilitate both maintenance of bone mass, performance of physical activity, and prevention of sarcopenia. To facilitate this, it is recommended that individuals over the age of 50 and individuals with low BMD consume at least 1200 mg of calcium, 800-1200 IU of vitamin D,⁸⁸ and 1.0-1.2g of protein/kg of body weight per day,⁸⁹ according to Osteoporosis Canada and the PROT-AGE Group respectively.

3.4. Exercise and intervention types

Exercise is another form of non-pharmacological treatment that aims to improve physical and psychological consequences of vertebral fractures by increasing muscle strength, muscle size, dynamic and static balance, QOL outcomes, and decreasing pain.²⁷ It requires little cost in terms of materials or equipment and can be done in a safe environment or at home.⁶ Therefore, it may be beneficial to understand the different modes of exercise and their effects on the consequences of vertebral fractures and bone health.

3.4.1. Back extensor training

According to Behm et al., resistance training is defined as “a specialized method of conditioning that involves the progressive use of a wide range of resistive loads, including body mass, and a variety of training modalities designed to enhance health, fitness, and sporting performance.”⁹⁰ In a clinical setting, resistance training targets all the major muscle groups to improve strength, muscle size, pain, psychological well being, QOL, and functional outcomes associated with sarcopenia and frailty.⁹¹ In the context of vertebral fractures, most studies that utilize resistance training include some form of spinal extension exercises. These exercises are chosen because back extensor strength is considered an important factor in increasing QOL in individuals living with vertebral fractures.^{15, 92} Spinal extension exercises have been used to increase back extensor strength, improve posture, mobility, and reduce chronic back pain.⁹³ When performing these types of exercises, pain management is an important feature because vertebral fractures may cause muscle spasm, protective movement, and fear of pain/falls.⁹³ This can be frightening for both individuals living with vertebral fractures and HCPs considering that these exercises target the area of pain; however, muscular endurance should be the focus when training the spinal erectors since postural muscles are more endurance-based muscle fibers.²⁰ By working on endurance participants can focus on recruitment patterns and postural stability during extension, which is important because this population exhibits a delayed response in paraspinal muscle activity and tend to activate the multifidus earlier than the larger erector muscles when standing on a short base surface during ballistic arm movement.⁹⁴ Therefore, an emphasis on recruitment patterns and muscle coordination, rather than muscle strength may be beneficial²⁵ by enhancing proprioception between joints, ligaments, and muscles, allowing them to become more aware of proper posture and how the structures are integrated.⁹⁵

3.4.2. Exercise targeting hyperkyphosis

Hyperkyphosis is a complication related to vertebral fractures and can exacerbate pain. The constant stretching of the ligaments and muscles of the spine reduce spinal extensor strength which contributes to poor posture and back pain.¹⁵ However, by incorporating resistance training and spinal extension exercises, hyperkyphotic posture and consequences of hyperkyphosis can be improved. Some studies show that higher intensity training is more effective than lower intensity programs at improving posture, bone mass, and QOL and can have a high adherence rate (89%); however, there is a limited number of studies evaluating the difference in intensity and studies that do report an effect with high intensity tend to have healthier and more mobile participants.^{6, 96} Regardless of high intensity, research suggests that resistance training can improve consequences of hyperkyphosis, such as balance and physical functioning,⁶ but seems to be limited in its effects on improving hyperkyphosis.⁹³ However, there is some research to suggest that the addition of postural exercises and longer interventions can reduce hyperkyphosis even without changes in muscle strength.⁹⁷ Studies that detect changes in hyperkyphosis typically incorporate posture exercises that emphasize diaphragmatic breathing, relaxation of the lumbar multifidus, and coactivation the transverse abdominus, pelvic floor, and back-extensor muscles.²⁵ To achieve similar results some authors suggest that interventions last at least 10 weeks to observe changes in the diaphragmatic breathing pattern due to the dominant activation of the rectus abdominis, external oblique, and multifidus.²⁵ Therefore, the effectiveness of exercise to improve hyperkyphosis in older adults may be time dependent, as longer studies tend to show improvements in hyperkyphosis, whereas shorter studies do not. Types of exercises that target the deep muscles of the spine and the pelvic stabilizing muscles may also influence the effectiveness of the program in reducing hyperkyphosis and lordosis that is associated with hyperkyphosis.⁹⁸

3.4.3. Balance training

Exercise and fear of falling have been studied extensively and show positive results; however, there are mixed results on the effectiveness of these programs alone to address QOL and pain outcomes.²¹ To address fear of falling and risk of fractures, balance training has been used to improve coordination and balance in static and dynamic postural positions. As an example, Stanghelle et al., followed the TF2F guidelines and developed a program for women living with vertebral fractures and found that incorporating balance in combination with resistance training was effective and consistent with current guidelines in terms of improving muscle strength, balance, and fear of falling.²¹ Not only did this program reduce fear of falling, it also helped improve muscle strength. This is important because upper limb strength begins to decline at the age of 40, and lower body strength is correlated to physical dysfunction, falls, and hospitalization. Therefore, utilizing similar programs that incorporate balance and resistance training may be helpful in reducing fear of falling and maintaining/improving upper and lower body strength throughout the aging process.²¹ However, it is important to note that not all programs will have the same effectiveness at improving balance and coordination considering that the presence of vertebral fractures, hyperkyphosis, back pain, and movement restrictions may influence the ability to perform these exercises correctly.⁶ Therefore, effectiveness of a balance program on fear of falling may be dependent on the severity and unique complications of the individual, but should be considered in program design.

3.4.4. General exercise and safe movement

Even though exercise programs may improve consequences of vertebral fractures, it is also important to understand the effects that physical activity has on pain and QOL outcomes in the treatment of vertebral fractures. Early pain management is used specifically to allow individuals

to be more mobile and active during the acute stages of a vertebral compression fracture, helping improve symptoms related to physical inactivity.⁶⁷ In support of this, Kataoka et al., found that performing early physical activity, with the help of pain management, improved patients with acute vertebral fractures ability to perform activities of daily living (ADLs); however, there were no changes in any pain outcomes.⁹⁹ Therefore, in the acute treatment of vertebral fractures, before individuals living with vertebral fractures perform physical activity or exercise, they must know how to avoid pain and feel confident and comfortable performing ADLs. Information on how to perform activities safely and what movements should be avoided to reduce pain are provided through the Too Fit 2 Fracture guidelines for individuals living with osteoporosis. According to these guidelines safe movement emphasizes postural alignment, proper body mechanics that reduce the load on the spine, and incorporates strategies to increase back extensor endurance while increasing the flexibility in muscles that restrict movement.²⁰ There are no clinical trials specifically examining the efficacy of providing guidance on safe movement. A consensus that was informed by expert opinion recommends that individuals living with osteoporosis with or without the presence of vertebral fractures practice spine sparing strategies, and be informed that they may need to modify or avoid performing lifts/activities that incorporate weighted, repetitive, rapid or end-range twisting or flexion of the spine, as well as lifting heavy loads from the floor or overhead.²⁰ In the presence of more severe cases with multiple fractures it is recommended that individuals living with vertebral fractures consult an occupational therapist to get recommendations on how to perform/alter ADLs safely.²⁰ It is also advised that individuals with vertebral fractures that exhibit pain perform 5-10 mins of supine rest when performing activities that involve sitting or standing for lengthened periods of time. ²⁰ Lastly, individuals living with multiple vertebral fractures should consider altering activities that require their head to move

outside their base of support, as forward posture while lifting will increase the load through the spine.²⁰

3.4.5. Complications and safety

Adverse events associated with exercise, such as muscle pain and fractures, may occur in 8.1% of individuals living with vertebral fractures.⁶ Because of the increased risk with this population, adverse events may occur and therefore, it is important to make safety a consideration in program design.³ Overload of physical activity with improper form can contribute to the formation of back pain and vertebral microfractures, which may progress over time,¹⁵ contributing to hyperkyphotic posture. Therefore, instruction on proper form rather than intensity and challenge in this population should be emphasized. If pain and mobility issues are present that restrict the individual's ability to perform exercises supine or prone, water-based activities, orthotics, and seated isometric trunk extension can be used instead.²⁶ Therefore, to limit the number of adverse events, individuals living with vertebral fractures should be able to access information on non-pharmacological interventions and what is safest for them.

3.5. Exercise summary

Use of exercise as a therapeutic approach to improving physical and psychological symptoms of vertebral fractures has been shown to be moderately effective at addressing outcomes of pain, mobility, and back extensor strength and endurance⁶⁶; however, there are a lot of different interventions to choose from. Exercise types may include resistance training, balance training, and physiotherapy exercises. It is suggested that resistance training include all the major muscle groups to increase muscle mass, prevent bone loss, increase mobility, and decrease pain. In terms of specificity, research has determined that resistance training programs for individuals living with vertebral fractures should incorporate spinal extension exercises to increase back extensor strength

and endurance, mobility, and reduce chronic back pain.⁹³ However, when administering spinal extension exercises the emphasis should be on endurance, proper movement, and form to allow individuals to be more aware of proper posture and muscle coordination, while minimizing fear and adverse events. Balance training is another widely used exercise type and aims to improve balance and fear of falling. Balance training shows positive results in improving fear of falling; however, research on its utilization to improve and manage pain and QOL outcomes are limited. Regardless, it is difficult to compare these programs because differences in fracture number, severity, and angle of kyphosis can limit the effectiveness of balance programs. Therefore, based on the current recommendations from the TF2F guidelines, exercise programs should incorporate a combination of resistance and balance training with an emphasis on form and endurance of the spinal extensors²⁰ to address the physical and psychological consequences of vertebral fractures.

4. Implementation of exercise interventions

4.1. Multi-component interventions

Because vertebral fractures are associated with changes to physical, psychological, and social health, some studies have used multi-component interventions. Multi-component interventions refer to programs that involve different modes of treatment to target multiple areas of health. Studies may incorporate and combine a variety of different modes of treatment such as exercise, nutrition, pharmacological, psychological, and physiotherapy interventions. Gold et al., stated that that multimodal exercise training, consisting of an exercise class and a coping class run by an exercise specialist and a psychiatrist social worker, can increase trunk extension strength and decrease negative psychological symptoms of vertebral fractures.²⁶ They also found that the control group back extensor strength worsened over the course of the study; however, once they received the physical intervention their symptoms began to improve.²⁶ Interestingly, even though

there were reductions in physical outcomes after cessation of the program, psychological symptoms did not worsen after the study, which may have been because the patients learned valuable coping skills to help them become more confident, self-aware, and better at understanding time management of exercise.²⁶ It is important to note that studies using multi-faceted approaches to exercise interventions make it difficult to determine true effects of the exercise intervention itself²⁷ due to confounding factors and lower adherence. However, this may be due to the delivery style of these interventions, as individuals living with vertebral fractures may have difficulty traveling to locations where programs are located.

4.2. Delivery Method

Even though comprehensive multi-component interventions can target multiple areas of health, implementing such interventions in individuals living with vertebral fractures can be challenging. Group exercise classes can be effective in improving QOL, but fear of falling during wintertime and other barriers reduce the effectiveness of the intervention. Therefore, to improve adherence of exercise interventions this population may benefit from at home self-directed exercise.²² Adherence to a home-based exercise program in individuals living with vertebral fractures can be as high as 62%, falling within the typical exercise adherence rates in older women (40-75%).²² These home-based programs show promise with more severe cases, enabling them to work at their own pace in the safety of their home, considering that safety and uncertainty is a concern. As an example, Papaioannou et al., found improvements in QOL symptoms, emotion, leisure, and social activity with a home-based exercise program developed for frail older women with vertebral fractures. During this program participants reported improvements in energy, fatigue, and pain from movement. Psychological and physical improvements were maintained for 12 months, allowing the participants to feel more in control of their life and travel. It was also noted that

participants with multiple vertebral fractures had greater improvements in QOL than participants with a single fracture.²² However, even though home-based programs may increase participation in exercise programs some researchers suggest that the benefits to physical function after a home-based program are limited. Cergel et al., found that a home-based training was not as effective as 6 weeks of supervised back extensor training at improving back extensor muscle strength, pain at rest and activity, arm muscle endurance, endurance, functional mobility and QOL in women with osteoporotic vertebral fractures. Although, they did state that home-based interventions may need longer training periods to elicit similar results.⁹³ Regardless, even though some authors suggest that there are additional benefits to exercising in groups,¹⁰⁰ a longer exercise intervention that allows participants the ability to perform exercises in a safe environment may be more feasible, acceptable and equitable for both individuals living with vertebral fractures and HCPs. Therefore, understanding the barriers to implementing a comprehensive non-pharmacological program that can be performed at home may be warranted given the effectiveness of nutrition, exercise, safe movement, and pain management at improving the consequences of vertebral fractures.

5. Barriers to program implementation

Research on the benefits of exercise to improve physical, psychological, and emotional functioning is becoming a widely accepted, and may be used to support and treat individuals living with osteoporosis with or without the presence of vertebral fractures. Adding PA routines to treatment plans can increase confidence in individuals with high risk of fractures, improving self-esteem, self-confidence, and PA self-efficacy.¹⁰⁰ However, there is still a disconnect between the research that is available and the implementation of exercise interventions. Knowledge translation (KT) is a complex process to raise awareness of current research available to facilitate access usage of that information. Once this information becomes available it must be adapted to the specific context of

the intervention to facilitate the uptake of guidelines. To be even more effective, KT strategies should address barriers and facilitators to behaviour change and consider the mechanisms that affect the behaviour.^{101, 102} By addressing barriers to exercise, while leveraging the facilitators, adherence to an intervention will be improved.¹⁰³ Therefore, before the development of a home-based intervention we must first understand the specific barriers individuals living with vertebral fractures and HCPs both face.

5.1. Patient barriers limiting the ability to be physically active

Considering that individuals living with vertebral fractures have osteoporosis it is important to understand the barriers that individuals living with osteoporosis face. According to a systematic review done by Rodrigues et al., and a qualitative analysis by Dohrn et al., the main barriers for being inactive and not participating in physical activities outside of their homes in women with osteopenia or osteoporosis are transportation, lack of time, weather, taking care of grand children, and lack of motivation.^{100, 103} In regard to lack of time, there is not enough evidence to determine whether or not this lack of time is perceived or not,¹⁰³ therefore, it may be important to ask questions to determine what can be done to address this when developing an intervention. Travel and the ability to get to exercise classes is also a major challenge for women living with osteoporosis. By finding a facility that has flexible schedules and is close to the participants, adherence to the program can be improved; however, this may not be feasible or available. Another option is providing round-trip transportation for participants, which can be expensive and difficult given that individuals living with osteoporosis may have reduced flexibility, functional mobility, or severe disability.^{100, 104} As these problems become worse individuals may begin to fear that their movement will become more restricted. Even though these challenges could be addressed by being

physically active, fear of pain and conflicting advice from HCPs create feelings of uncertainty on the safety and effectiveness of exercise.¹⁰⁰

5.2. Health care professional barriers limiting implementation

Regardless if guidelines were available, they may not address every barrier to knowledge use,¹⁰¹ and therefore cannot effectively translate to action. This creates issues and barriers to implementing guidelines into practice.¹⁰² These barriers include lack of awareness, familiarity and agreement of guidelines, poor outcome expectancy, low confidence in utilization, and disagreements between HCPs on the roles and responsibilities for management.¹⁰² To be able to effectively use guidelines, primary care providers must be aware of the guidelines, have the skills and knowledge to alter them based individual cases, be able to ask and address questions related to PA,¹⁰¹ and have an understanding of behaviour change techniques.¹⁰² However, HCPs may not know where to access these guidelines and therefore do not have information on how to advise, refer, access, alter, or make prescriptions concerning non-pharmacological treatment options.¹⁰¹ Although having primary care providers understand how to treat vertebral fractures using non-pharmacological treatments may be beneficial, it is not feasible to have physicians teach exercises or explain more than brief exercise advice. Once physicians know where and how to refer patients living with vertebral fractures, further information on physical activity and exercise can be provided from an exercise specialist.¹⁰¹

Unfortunately, referral to an exercise professional does not fix the problem, as they may not feel comfortable prescribing exercise and working with individuals living with vertebral fractures. Rehabilitation specialists report that time, perceived lack of skills, and patient expectations are barriers to working with individuals living with vertebral fractures.¹⁰² Interestingly, rehabilitation specialists lack of knowledge or self-efficacy was not totally related to

implementing exercise for individuals living with osteoporosis, but rather on how to adapt to the specific client and situation, especially when the client had low motivation.¹⁰² To improve confidence and prescription, McArthur et al., and Clark et al., both suggested that rehabilitation specialists need more training on behaviour change techniques to make it easier for them to assist their clients in performing and completing recommended exercise, PA, and safe movement.^{101, 102} Therefore, to effectively facilitate the translation of knowledge on non-pharmacological treatments and behaviour change techniques, a comprehensive approach to implementation should be utilized.

5.3. Behaviour Change Wheel

Behaviour change interventions refer to coordinated activities designed to change behaviour patterns.¹⁰⁵ The first step to behaviour change is determining the broad approach before working on the specifics of the intervention. Most interventions in studies do not use a formal design method in the development of the intervention.¹⁰⁵ These interventions lack analysis of the target behaviour or the predicted mechanisms of action and are therefore designed without evidence or process.¹⁰⁵ To improve the choice of intervention and intervention design it is important to use a systematic method that incorporates behaviour change, allowing for characterization of interventions and their components. This framework should be comprehensive, flexible, and group all its information into one coherent entity with a similar level of specificity.¹⁰⁵

The behaviour change wheel (BCW) is a framework that was developed into a theory and evidence-based tool that allows a wide range of users to design and create interventions according to behaviour change, the mechanisms that create behaviour change, and interventions that target the behaviour change mechanisms.^{101, 105} This theory aims to target the understanding, selection, and specification of the behaviour before creating the intervention. The BCW uses the COM-B system, which states that individuals must possess the skills, abilities, opportunities, as well as the

motivation to perform the behaviour.^{101, 102} Based on the BCW, ideas to create behaviour change should be centered around the probability that the behaviour can be changed, the impact the behaviour could make, and the potential that the behaviour could influence other behaviours. It is also important to consider the possible contexts of the behaviour, what behaviours are needed to be performed, who are needed to perform them, when they are needed to be performed, and where and for whom should they be performed.¹⁰²

Using the BCW, McArthur et al., suggested that to facilitate knowledge translation, delivery of education and training should be focused on service provision, communication, and marketing. They also suggested that service provision focus on integrating education and training of behaviour change techniques and how to adapt PA to different populations with varying conditions in health care educational courses. By participating in service provision in small teams to learn together, trust can be built within the team, eventually improving the delivery of PA programs.¹⁰² However, this is a long process and may not be feasible for all HCPs. Therefore, considering other options to target service provision may be beneficial, such as utilizing personal work supports at home that enable exercise to be delivered in a safe, feasible, and effective manner, while eliminating patient barriers.¹⁰²

5.4. Telerehabilitation

Research suggests that longer home-based exercise interventions can be an effective strategy to manage pain, reduce fatigue, and increase QOL in individuals living with vertebral fractures.²² The only question that remains to be answered is how these at home-programs should be delivered. Telerehabilitation programs are home-based interventions that use phone or web-based technology to provide online exercise/non-pharmacological treatment information to participants. Telerehabilitation has currently been reported to be safe, feasible, and effective in preventing falls

in frail older adults with chronic disease,¹⁰⁶ reducing dyspnea, increasing physical functioning, and improving QOL in patients with COPD and chronic heart failure,¹⁰⁷ and improving fall efficacy and instrumental ADL performance in patients following a hip fracture.¹⁰⁸ However, even though there is evidence to suggest that telerehabilitation can be successful, there is currently no evidence that it is feasible, acceptable, and equitable to address consequences of vertebral fractures. Therefore, considering that the major barriers and recommendations are targeted towards individuals living with osteoporosis with or without vertebral fractures, we must first understand the specific experiences that individuals living with vertebral fractures face before we can design an online-based rehabilitation program for this population that incorporates behaviour change strategies and addresses barriers to being physically active.

6. Objective

Based on the information provided we have discovered that a gap in research exists in treatment/management of vertebral fractures, especially in the use of non-pharmacological treatments. Considering that recommendations available are targeted towards individuals living with osteoporosis with or without vertebral fractures, the objectives of this study are to a.) understand health care professionals' (HCPs) and individuals living with vertebral fractures' experiences and perceptions of post-vertebral fracture rehabilitation, b.) identify what non-pharmacological strategies are used and preferred, and c.) identify preferences with respect to a virtual rehabilitation program at program and how this can be designed to be effective and adopted.

Our intention is to use the information that we gather to help inform the development of an online exercise/education intervention to provide information on exercises, nutrition, pain management and safe movement that is specific to vertebral fracture rehabilitation.

METHODS

1. Study Design

Using the Knowledge-to-Action (KTA) cycle,¹⁰⁹ we have determined that a research-to-practice gap and barriers to knowledge use exist in the treatment of vertebral fractures, especially the use of non-pharmacological interventions. To address this gap, we have designed a qualitative study from a post-positivism perspective using semi-structured interviews to inform the selection and tailoring of an intervention. Semi-structured interviews were conducted over web conference or telephone with both individuals living with vertebral fractures and HCPs. Our questions reflected our epistemology by attempting to understand the different experiences of rehabilitation treatment from both the patient and HCP perspectives, helping inform an intervention that addresses barriers to implementation while also taking into consideration the real experiences of vertebral fracture recovery.

Even though our goal was to understand the experiences and perspectives of HCPs and individuals living with vertebral fractures and act as a conduit for the participants, we recognize that as researchers on this project we must be aware of our own perceptions when we interpret the data; therefore, we have used the intersectionality tools provided by the Knowledge Translation Program to evaluate our role as researchers. By using these tools, we have identified that the main researcher is a white, middle-class, English speaking, Canadian student, with a background in kinesiology and exercise physiology. These factors may influence the perceived effectiveness of exercise and may not align with the participant groups in terms of gender, age, economic status, ethnicity, and occupation. To address this, we have decided to take a patient-oriented approach to enhance relevance, accountability, and transparency. We have done this by including HCPs, researchers and individuals living with vertebral fractures with patient experience on a research

team that will help inform the decisions that are made on the project. We attempted to be as inclusive as possible by creating a diverse research team that encompasses differences in age, gender, stage of research career, professional and personal perspective, lived experience and geographical location. To reduce the possible power structures within the team, we have made it clear that anyone at any time can speak from their perspective, and that everyone's opinion is important in the development of the project. To ensure all team members had time to review and reflect on what they believe needed to be changed or altered, an email was sent beforehand with all the materials that were discussed in the meetings.

To further improve the rigor and trustworthiness of our study we decided to incorporate the four-dimensional criteria (FDC). According to Forero et al., the FDC incorporates credibility, dependability, transferability, and confirmability criteria to provide an important and systematic approach to achieve trustworthiness in qualitative findings.^{110, 111} Credibility was used to establish confidence that the perceptions and experiences we report in our study are true, credible, and believable by holding several peer debriefing meetings with our research team. Dependability was used to ensure that our study results could be reproduced (given a similar population) by establishing an audit trail during the data collection and analysis, thus developing a detailed track record. Transferability was used to improve the generalizability of our findings by incorporating different forms of purposeful sampling techniques to recruit participants. Confirmability was used to improve confidence that our interpretations we develop are objective and do not represent bias attributed to the individual researchers' opinions by using reflective journals before and after each interview. This study was reviewed by and received ethics clearance through the University of Waterloo Research Ethics Board (ORE 42301).

2. Recruitment and screening

We decided to interview several HCPs as well as individuals living with vertebral fractures within Canada. To select HCPs, we used criterion sampling, purposeful sampling and snowball sampling and recruited via email through our networks. Criterion sampling was used to create a sample that incorporated HCPs that have been deemed as relevant in the treatment of vertebral fractures. We have identified through meetings with the research team that the occupations that are considered relevant were physicians, geriatricians, family physicians, physiatrists, primary care dietitians, occupation therapists, physiotherapists, physical therapists, and nurses who work in geriatrics. To provide more breadth and relevance to our analysis, we also used purposeful sampling to recruit individuals who are BoneFit™ trained, are specialists in osteoporosis care, are clinician researchers with experience with this population, or clinicians who self-declare an interest and see patients with osteoporosis. Once connection was made with a potential participant, snowball sampling using word of mouth was used to identify HCPs with similar characteristics and interests. We chose to perform criterion sampling because it allows us to confirm that the HCPs we chose had expert knowledge in one of the target areas of non-pharmacological management of vertebral fractures, and thus able to provide information that is both detailed (depth) and generalizable (breadth).¹¹² We expected to recruit at least 10 HCP participants to fulfill all relevant HCPs that may frequently provide rehabilitation and provide care to patients with vertebral fractures.

Individuals living with vertebral fractures were recruited from the Canadian Osteoporosis Patient Network (COPN), social media, and our Bone health and Exercise Science Lab email distribution list. Individuals living with vertebral fractures were included if they have been diagnosed with a vertebral fracture in the past, regardless of location of fracture. If a potential participant reported a self-diagnosis, we asked follow-up questions on how and when they obtained the fracture, who

performed the diagnosis, and how they were diagnosed, to help confirm that participants had experienced an osteoporotic vertebral fracture. Participants were excluded if they did not speak English (unless they have a translator), if they had impairments that limited the ability to perform over the phone interviews, such as a severe hearing impairment, if they had cognitive impairments that affected their ability to provide insight, or if they had cancer development in bone or metastasized to bone. We were aiming to recruit 10 participants living with vertebral fractures to obtain a similar depth of analysis in comparison to the HCP group. To be considerate of intersectionality during recruitment, we attempted to recruit participants from a variety of genders, ethnicities, and locations within Canada.

By recruiting 20 participants we hoped to gain a sufficient understanding of user needs and perspectives while also obtaining depth in analysis. We continued sampling until we reached thematic saturation or informational redundancy. After participants were determined eligible to participate, a consent form and proposed interview times were sent over email. During the beginning of the interview verbal consent was obtained and the researcher reiterated the purpose of the study and addressed any concerns that participants may have had. Once this had been completed, we asked pre-interview questions related to age, gender, occupation, education level, and exercise habits. Following this we performed the rest of the 1-on-1 interview according to the semi-structured interview guide.

3. Interview guide

Questions for the interview guide included 3 sections and were informed by the Diffusion of Innovations Theory (DIT),¹¹³ and the APEASE criteria.¹¹⁴ Section 1 was informed by the DIT to address compatibility with existing practice by asking about experiences, perceptions, and insights on current practice. Section 2 was informed by the DIT to address relative advantage by asking

about experiences, goals, and potential harms or fears related to non-pharmacological treatments, such as exercise, spine sparing and movement modification, pain management, and nutrition. Lastly, section 3 incorporated questions on the delivery of a virtual-care rehabilitation intervention and was informed by the APEASE criteria and the DIT. The APEASE criteria was used to provide context of our proposed intervention by addressing the perceived affordability, practicality, effectiveness and cost-effectiveness, acceptability, safety, and equity of virtual care components we are considering (i.e., nutrition, exercise, safe movement, pain management).¹¹⁴ Complexity from the DIT was used to inform questions about materials, videos, and delivery modes that would be most accessible and feasible for both HCPs and individuals living with vertebral fractures. Both HCPs and individuals living with vertebral fractures received a similar format and structure of interview questions. To reduce bias and gain insight on the questions we were proposing, we provided the interview guide to our research team to finalize the content, structure, and tone of the proposed guide.

4. Thematic and content analysis

Interviews were audio recorded and transcribed verbatim. Note taking was used to determine the tone and context of the conversations where needed, and an entry into a reflective journal was completed by the interviewer before and after each interview. Once the interviews were completed, two researchers conducted an inductive thematic and content analysis by identifying codes for the data on each transcript,¹¹⁵ and iteratively consolidated the themes via discussion. It is important to note that analysis was not iterative with data collection. Content analysis was performed by identifying the codes that were used most frequently to understand the most common issues or items that both groups experienced or perceived to be important in rehabilitation, whereas the thematic analysis was performed semantically and utilized to help understand the context behind

the recovery and rehabilitation by conceptualizing themes in a thematic map and comparing them to the data corpus.

To create an in-depth analysis of key themes that take place across the whole data set, while maintaining the views and perceptions of each research participant, we used Braun and Clark, and the Framework method as a guide to our thematic analysis.^{116, 117} By using these resources as a guide, we followed several steps in conducting our thematic analysis. Step 1 included the transcription of the interview, where the researchers transcribed the audio from the interview verbatim. Step 2 included familiarization of the interviews where the two researchers listened to the audio and read over the transcript several times to understand the interview in whole. Step 3 involved the coding of the first 2 transcripts (2 from each cohort), where the two researchers identified paraphrases and labels (codes) that were interpreted as important. Step 4 required the researchers to develop an initial analytical framework by meeting to compare codes and labels, coming to a consensus on the codes and their definitions. We used the initial analytical framework to code another 2 transcripts (2 from each cohort) and met to discuss new codes that may have emerged from the data. Once this was complete, a consensus was made on the broader categories that codes were allocated to, forming the final analytical framework. In step 5, the remaining transcripts were split between the two researchers and coded using the final analytical framework, and new codes that emerged were discussed and incorporated in the framework. Finally, step 6 involved the interpretation of the data collected.¹¹⁷ To improve the interpretation of our data into different themes, we used the categories that have been identified previously as our initial working themes and conceptualized them in an initial thematic map. All themes were compared to the extracted data from within the codes to identify a coherent pattern. Once all the themes have been identified as having a coherent pattern, we then considered the validity of each theme in relation

to the data set to see if the candidate thematic map accurately represented the meaning of the data set. Once we decided that the final thematic map represented the data set, we worked on defining and refining the themes within the thematic map. It is important to note that both researchers met to discuss the initial and final thematic maps to determine that they represented the themes identified. To help improve credibility and minimize biases with our interpretation we also provided the final themes, thematic maps, and content analyses to our research team in a peer debriefing session.

RESULTS

Considering that the goal of this study was to understand the experiences of vertebral fracture rehabilitation from both the HCP and patient perspectives we have conducted the analysis of both groups independently as the experience of vertebral fracture rehabilitation was different for patients compared to HCPs. Demographics of the 13 HCPs that were interviewed are included in TABLE 1, whereas the demographics of the 10 participants who have experienced a vertebral fracture are included in TABLE 2.

TABLE 1. Characteristics of health care professionals

Participants (n=13)	
Age (mean, SD)	46 (12)
Gender (n)	
Female	7
Male	6
Self-reported ethnicity (n)	
White	7
Chinese	2
Canadian	1
European	1
East Indian	1
Palestinian	1
Occupation (n)	
Physiotherapist	4
Physician	2
Geriatrician	2
Clinical nurse specialist	1
Physical therapist	1
Physiatrist	1
Kinesiologist	1
Family doctor	1
Education (n)	

Masters	6
Md	3
PhD	2
BSc physical therapy	1
Specified as post-graduate	1
Bachelor of physiotherapy	1
Self-reported current exercise participation (n)	
Aerobic	9
Resistance training	5
Leisure sport	2
Unspecified exercise	2
None	2
Pilates	1
Yoga	1

TABLE 2. Characteristics of individuals living with vertebral fractures

Participants (n=10)	
Age (mean, SD)	71 (7.9)
Gender (n)	
Female	9
Male	1
Self-reported ethnicity (n)	
White	7
Canadian	1
Anglo-Saxon	1
Austrian	1
Occupation (n)	
Retired	9
Unemployed	1
Education (n)	
Grade 12	2
College	3
University	3
Post-graduate	1
MBA	1
Self-reported current exercise participation (n)	
Aerobic	7
Physiotherapy	2

Osteoporosis videos	1
Weight bearing	5
Qi-gong	1
Yoga	2
None	2

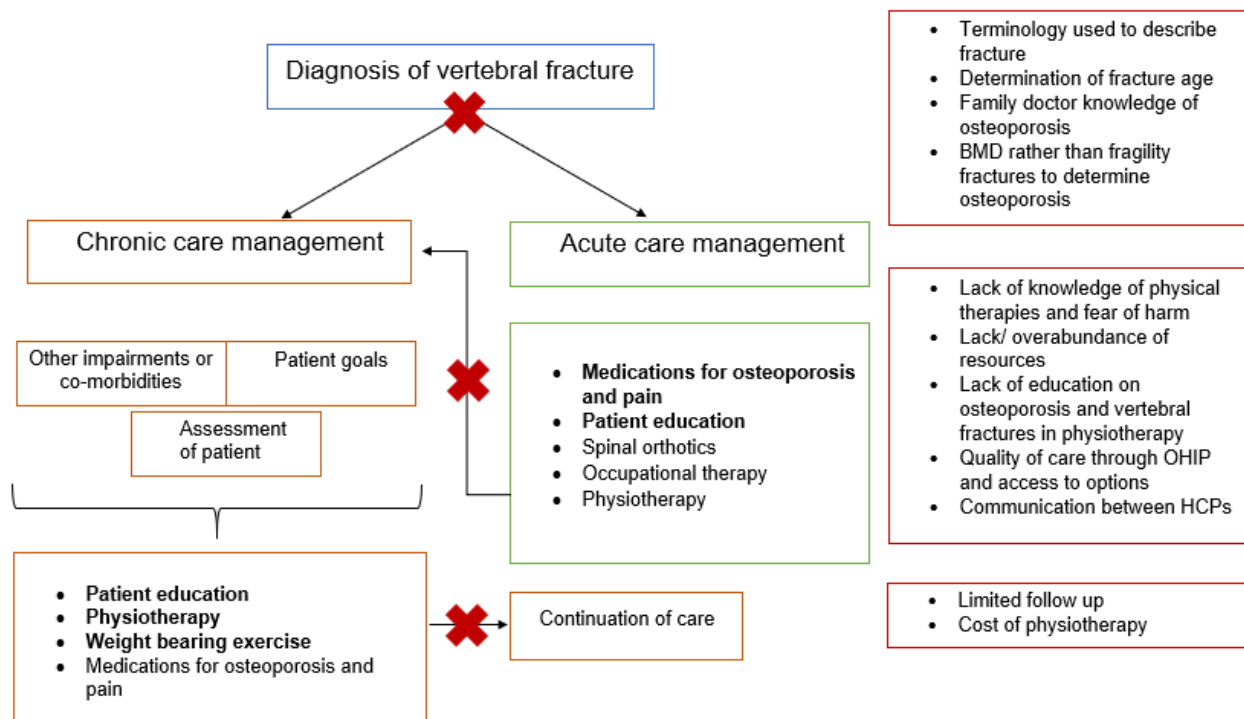
TABLE 3. Suggestions and considerations provided by HCPs on the structure and educational content

Health care professionals (13)	Individuals living with vertebral fractures (10)
Structure	
<ul style="list-style-type: none"> • Easy to read educational component for patients • Physiotherapy assessment • Exercise component delivered by qualified HCP 	<ul style="list-style-type: none"> • Easy to read educational component • Exercise based on physical functioning and acuity of fracture • Small cost • Long term rehabilitation or follow up
Education content	
<ul style="list-style-type: none"> • Basic physiology of vertebral fractures and osteoporosis • Goals and reasonable expectations • Proper body mechanics • Importance of exercise and the effect of mechanical loading on bone • Vitamin D and calcium • Osteoporosis medication • How to arrange living space to reduce fracture risk • Importance of preventative measures 	<ul style="list-style-type: none"> • Movements to avoid • Non-pharmacological strategies to help reduce Pain • Movement strategies to reduce pain • How to perform ADLs safely • Education on safe exercises • Importance of exercise

1. Thematic analysis: Health care professionals

Two themes emerged from the HCP perspective of vertebral fracture rehabilitation: acuity of fracture matters when selecting rehabilitation strategies; and roadblocks to rehabilitation. Themes 1 and 2 are presented in the final thematic map that represent the experience of vertebral fracture rehabilitation from the perspective of HCPs and the barriers that limit the use of non-pharmacological strategies (FIGURE 1). Both themes and sub-themes are discussed in detail within the sections 1.1 and 1.2 and include quotations to help the reader understand the context and connection with the interview data.

FIGURE 1. Thematic map of HCP experience and perception of vertebral fracture rehabilitation and the perceived barriers.



X's represent the barriers listed on the right and where they limit vertebral fracture recovery

1.1. Acuity of fracture matters when selecting rehabilitation strategies

HCPs reported that the main goals of rehabilitation were to reduce pain, improve patient mobility and functioning, and prevent further fractures, and that the non-pharmacological interventions provided to address these goals were based on the acuity of fracture.

“I think you have to think about it in two terms, I think there's acute which is more about recovery, pain management, questions, concerns, education, fears, counselling, all that stuff. And then there is more chronic, which is making sure that there's reinforcement of the lifestyle measures, making sure there's no falls risks, making sure that whatever is prophylactic or as prophylactic as possible can be done.” (P19)

Considering that rehabilitation provided to patients was influenced by the acuity of the fracture, it was important to know how HCPs define an acute and chronic fracture. We found that most HCPs differentiated the acuity of the fracture by the time since fracture and the pain associated with it.

“Anything less than three months would be acute, anything greater would be chronic. Acute... the pain tends to be a lot more intense, and it tends to be a lot more disabling.” (P9)

Based on this description, we observed two pathways in the rehabilitation of vertebral fracture, the acute management, and the chronic management of vertebral fractures.

1.1.1. Minimizing pain to facilitate early mobilization

Rehabilitation of acute vertebral fractures was focused on pain management and patient education. Pain management was perceived as very important and was focused primarily on medication, but could also include other strategies, such as: orthotics, transcutaneous electrical nerve stimulation (TENS), light stretching and mobility, heat, and gentle manual therapy.

“So definitely, in the acute stage, when the pain could be like eight or nine out of 10, they need the medication, and the proper instruction on moving and positioning. But some other things like just even a little bit of gentle massage, in different areas to decrease [muscle tension], because if they've got one centre location of pain, it's painful everywhere. So to try to do some massage on some alternate areas, or the TENS machine on the patient, you know, are usually helpful, but again, it's not long lasting pain relief for them.” (P11)

One HCP believed spinal orthotics could be helpful in the acute management to reduce pain and increase patient mobility; however, many HCPs perceived did not perceive this as an effective long-term treatment option, due to concerns related to the weakening of core muscles.

“[Spinal orthotics can] give patients some comfort to make them painless...so [the] brace is actually something like a between the pain control and the mechanical stability...[However] it is not going to be helpful to their ability to activate the core muscles, the back muscles, then that can cause some muscle atrophy. In the long term, that's not going to be good...” (P17)

Patient education was emphasized by all HCPs, and included information on safe movement, the importance of calcium and vitamin D, osteoporosis medication, the influence of smoking, alcohol, and caffeine intake, as well as educating patients on pain and how to have realistic expectations of pain. In most cases patients were provided advice on avoiding movements such as spinal flexion, forward bending, twisting or rotation and sometimes included specific advice on what activities or recreational activities may be unsafe or should be avoided.

“I encourage them not to partake in activities which might provoke further vertebral fractures, for instance, flexion activities or rotation and flexion activities [like] vacuuming

or [the] golf swing activities that can be particularly troublesome. So I give them a little bit of specific guidance, and hopefully that holds them back from doing too much stuff.” (P15)

If a patient seemed particularly troubled and in a lot of pain, HCPs provided referral to the Osteoporosis Canada website, or provided specific advice on how to dress and move around their home. Some reported referring a patient to an occupational therapist to alter their living space to improve functionality and reduce the risk of fracture at home.

“I can talk about transfers out of bed... I can talk about dressing while maintaining good spinal mechanics, all of those kinds of things. So, generally, that's what it is... And if someone has a vertebral fracture, especially if it's painful, [the nurse] can give the Too Fit to Fracture booklet or the website. So, sometimes it's the nurse that refers to the physio and OT.” (P8)

It is important to note here, that even though HCPs wanted patients to avoid or limit certain activities, they also reported that it was important for the client to move and stand as much as they can tolerate.

“So first of all, it's education, understanding the pain, what it's coming from, and, and how to manage it, then the second part of it is making people understand that if they don't keep active, that not only will kind of lead to disability, but it can actually make the pain worse.” (P21).

HCPs perceived that education on pain, how to have realistic expectations of pain, and coping strategies was as important in helping the client deal with pain and increase early activity.

“Well, a lot of people who haven't dealt with pain before they don't really understand what pain is and they don't know how to manage it appropriately. They have unreasonable

expectations. So educating them on what's expected and how with vertebral fractures, you're likely going to have pain for many, many months is the starting point. Then giving them tools like pacing, giving them goals in terms of making little gains at a time...So using mindfulness, using Cognitive Behavioural Therapy, giving coping strategies to help manage pain.” (P9)

In cases where the pain was substantial and limited the patient’s abilities to move, even with pain medication, graded activity or walking aids were suggested to help patients move while minimizing pain.

“...trying to avoid inactivity but trying to resume activity, but maybe with energy conservation techniques or... potentially using a walker initially or gate aids or Nordic poles or whatever else to try to increase activity in a pain free way.” (P8)

1.1.2. Regaining function and getting back to ‘normal’

Once the fracture has healed and the pain has subsided, HCPs may start to introduce other forms of treatment to address pain, mobility, and functional challenges, as well as to prevent further falls and fractures. While medications were still used to reduce pain, a greater range of non-pharmacological interventions were delivered by physiotherapists and primarily incorporated a combination of exercise and patient education strategies.

“Once one gets into chronic the physiotherapy interventions, I would say are more exercise based and less physical based to relieve muscle spasm. Although they may involve a combination.” (P15)

When a patient was referred to a physiotherapist, the first step to rehabilitation was an assessment of the patient to develop an individualized program. Physiotherapists reported that patients with

vertebral fractures present with different levels of mobility and function, pain, and may have other conditions that should be considered.

“I believe that anybody with osteoporosis, especially if they've had a vertebral fracture, it's not a cookie cutter approach to them, it can never be for any of them, because they're all individuals. So that it has to be based on the assessment, what you're finding on your assessment. And what you have to remember, maybe they had a history of cancer, so they've got more of a fatigue element than somebody else might have.” (P11)

This individualization of rehabilitation typically included 3 different components: determination of patient goals, physical assessments, and the evaluation of other conditions. Determining the patients' goals was important to HCPs as they wanted to tailor the program to improve the QOL of the patient, give them a program that was relevant to their specific lifestyle, and help educate them on goal setting.

“Well, goal setting, so I'll administer sometimes what's called the patient specific functional scale, which really is me asking them, what activities do you feel are really important to you, that you want to get back to doing [in] the next 6-12 weeks we are together? ... and they'll rank those activities in terms of their ability to do the activity. And then sometimes from that, I might pull some goals or activities they want to work toward, because... a lot of times patients do have a hard time setting goals, right?” (P14)

When administering physical assessments most HCPs were not concerned about causing harm and performed assessments to determine patient mobility, strength, balance, and hyperkyphosis.

“I'll do like, occipital to wall distance, I'll look at you know, ribcage to pelvis distance, I will do a good neurological exam. I will do a hip range of motion exam, if they've got other

impairments too... I look to their knees, their ankles, whatever... I'll deal with that stuff as well. I'll do some type of proprioceptive assessment...in the past, I've been trying to measure their spine [using] the flexicurve, [which is] way too time intensive, like don't do that. [Instead], I will look at their spine and see what they look like from a thoracic kyphosis type of point of view, but I won't measure it.” (P14)

If patients were more mobile and had less functional restrictions, the emphasis of the program was on building strength using light weight bearing exercise, such as body weight squats, core exercises such as a bird dog, upper body strengthening exercises, such as a push and pull with a Theraband, and some form of spinal extension exercise, such as hip and spine extenders that are taught in BoneFit™ to improve posture.

“I would want to give them some type of leg exercise. So I'm going to go with chair squat, right? Cool, functional, right? And you can do so much with just the chair squat from a progression point of view. So that one exercise, you can do so many things with it. I feel for an upper body exercise...Like a push-pull. And then number three would be some type of spinal extensor exercise. So whether it's your bird-dog, whether it's the prone work... so I try to pick something from each of those categories.”

On the other hand, if the patient presented with more limited mobility or functionality, and pain, exercises were prescribed with the goal of improving everyday functioning by working on breathing exercises, such as pursed lip breathing, manual therapy, sit to stand from an elevated surface, strategies to improve gait, and sometimes may incorporate work on the intrinsic muscles of the foot, the knee, and the hip.

“So I work a lot on gait, on walking. So I isolate each part of the body that's required for walking. That's why I'm telling you that I work on breathing, I work on the transverse abdominus, I work on the foundation. If they have a good foundation, everything else follows right. But if you don't have a good foundation, it's going to be difficult to just work on walking.” (P20)

Other than the referral to a physiotherapist in clinic, some patients were referred to group-based programs, which in most cases included individuals with and without fracture. In the group setting, the assessments and medical history of the patients were used to help determine the functionality of the patient and limit exercises that may put patients at risk; however, this did not seem to alter the program's structure or focus. Instead, patients with vertebral fracture performed exercises alongside osteoporotic individuals without fracture, with some special considerations. One consideration was the modification of exercises based on hyperkyphotic posture, as this limited their ability to perform prone exercises.

“And in the group, we learn all about kind of bone density and the importance of strengthening and diet and that type of thing. And then we go through a series of exercise sessions. And then the expectation is they'll continue on with these generalised exercises, right? For stair climbing and squatting and upper body motions and core and spine and balance. But usually, if someone has had a fracture, they might start within the group structure, but then they kind of need like a little bit more individualised exercise programming. And so I'll get them on more specific exercises, but in the end, they kind of also end up doing more total volume of exercise” (P13)

It is important to note that some patients with vertebral fracture may not be able to perform the level of exercise that is provided in a group session and may need a more individualized approach,

considering that one HCP mentioned a small subgroup of individuals that had to drop out due to immobility and challenge.

1.2. Roadblocks to rehabilitation

HCPs reported barriers that limited access and referral of non-pharmacological interventions in the acute, chronic, and the long-term rehabilitation and prevention of fractures, which included the identification and diagnosis of vertebral fracture; referral and access to physiotherapy; lack of education on bone health and vertebral fractures among HCPs; communication between HCPs; and limited follow up.

Before a patient has the option to be referred for acute rehabilitation, they must be identified with a vertebral fracture and have a family doctor or physician identify the appropriate interventions. However, one physician mentioned that there are barriers related to diagnosis, and specifically mentioned that the terminology used by radiologists in X-ray reports can be quite variable and depending on what is written, may prevent patients from receiving care specific to vertebral fractures.

“...we see that time and time and again, the fracture is reported, but it's not called a fracture on the X ray report [by the radiologists]. And so the family doctor doesn't do anything and it stops right there. So how are you going to find those patients?... Back pain is a really common occurrence in family medicine. And they're discouraged from doing a lot of X-rays.” (P15)

Another issue in the diagnosis and identification of vertebral fractures is the challenge of determining the age of the fracture. By not being able to determine the age of fracture, the

identification of vertebral fracture acuity is solely based on pain, presenting another challenge to determining the rehabilitation strategy.

“I think the difficulty comes when there's a vertebral fracture there and nobody's quite sure whether it's new or old, or it may have been pre-existing, but the last film was like two or three years ago, and we're not sure whether this, you know, worsening L1 fracture is actually the cause of their admission versus something else.” (P12)

Regardless of an X-ray, a family doctor can begin acute vertebral fracture treatment based on their BMD, symptoms, and risk factors, but must have specific knowledge related to osteoporosis and vertebral fractures, which some HCPs report is lacking. HCPs also discussed the challenges with the use of BMD in determining the presence of osteoporosis, which may present as a barrier to identifying vertebral fractures. One geriatrician reported that patients who have suffered a fragility fracture may present with a high BMD and are not diagnosed with osteoporosis and therefore do not receive treatment for osteoporosis and fracture prevention.

“There's a lot of misconception about how to diagnose osteoporosis, people think that it is something diagnosed based on a bone mineral density. But, in fact, a lot of people don't end up getting treated who have had fragility fractures, which are the higher risk people. [And] as a geriatrician, there's very poor correlation between risk of fracture and bone mineral density score as people get older. And it actually ends up being an almost unreliable and even harmful path, because a lot of people will score what's been interpreted as kind of moderate or low risk on the test, but then end up actually being very high risk due to other factors, especially if they have fractured before. The DXA score on the spine is completely unreliable if you have bad degenerative disease or compression fractures. It is a real problem, especially for older patients who I tend to deal with.” (P21)

Physiotherapists report that physicians and family doctors may be afraid that rehabilitation may do harm during the acute stages after fracture.

“One barrier I've seen is actually the doctor being afraid to refer their patient to someone because they're afraid they're going to be made worse. So I think that's why it's important that doctors are aware of the experience of any practitioner that they might be wanting their patient to see.” (P11)

Once a participant's fracture has healed and presents with less pain, patients were provided chronic rehabilitation that included a larger variety of non-pharmacological interventions to improve mobility, reduce fracture risk, and increase QOL. A referral to physiotherapy was most common; however, HCPs reported being uncertain where to refer patients, either due to an overabundance of options, lack of resources, or lack of confidence in the resources that are provided in their area.

“I don't have a list of favourite physiotherapists to send people to, I tell them to find somebody in their local environment. And I do that because our catchment is province wide and I can't tell people to come to my favourite local physio, because it's not going to do that for repeated appointments. So, it requires that the general physio expertise in dealing with this sort of patient is good. And I have absolutely no idea of what the variability is amongst physio approaches...” (P15)

Accessing a physiotherapist who is knowledgeable about osteoporosis and vertebral fractures is another barrier, and two of the physiotherapists identified that they did not have any specific training in vertebral fractures and osteoporosis and had to take independent courses to learn the considerations needed to treat this population effectively and safely.

“Like I'm a physiotherapist 24 years now. And I took that BoneFit™ course, almost five years ago now and the Osteo-Circuit [physiotherapy] course... And I had no training in terms of this type of programming 24 years ago in my programme... and I can't say, up until I took the course, I really knew what to do with a vertebral fracture per se. So, I think knowledge is one of the biggest barriers to treatment.”

Unfortunately, even if patient is referred to or has access to a knowledgeable physiotherapist or other HCP to provide rehabilitation specific to vertebral fractures, there are barriers that may limit the number of sessions they can attend. One of these barriers is cost, as physiotherapy is perceived as expensive and thus may limit the amount of patients that can attend physiotherapy.

“Cost in BC is always a barrier, so it costs money to go and see a physio and then you don't have a private insurance and so don't have a lot of coverage for physio visits, so I can advise it. But if they either can't afford it, or feel that they can't afford it, [and] don't want to spend the money, then it doesn't happen” (P15)

To address this issue, many HCPs suggested that OHIP can be a good alternative for patients to gain access to a physiotherapist; however, two physiotherapists and one family doctor identified that physiotherapists who are knowledgeable may not be accessible through OHIP, which reduces the effectiveness of chronic rehabilitation, and may lead to patient frustration or incorrect programming that is not specific to vertebral fractures.

“If you're over 65, you can go to our OHIP clinics, but I'm not trying to diss my brothers and sisters who work in the OHIP. But a lot of times it is very generic... It is not specialised programming... And even in my environment here... I'm supposed to see people who are

between 19 and 65. Under 19 [and] over 65, you can go to an OHIP clinic, so you can't see me because they've got somewhere else to go.” (P14)

On the other hand, if a knowledgeable physiotherapist is accessible through their family doctor, time is very limited and may reduce the effectiveness of helping patients manage their symptoms over time.

“I do have a physio as part of our CHC. So I will send them there, but it's very time limited, right? Like, I think they were only allowed for 8 sessions that are covered by OHIP.” (P17)

Patients may have questions, need encouragement, or require an increase in treatment volume or intensity. Unfortunately, due to time and cost, physiotherapists have reported that follow-up is very limited and are concerned that patients are not continuing their programs. Physiotherapists perceived the physical therapy and exercise programs provided in the chronic rehabilitation as lifelong management to improve QOL and reduce future fractures and suggest that patients continue exercising even once their symptoms improve.

“[For] long term follow-through, are they maintaining this stuff long term?... Because I tell people, this is something you're going to have to work on for the rest of your life.” (P10)

Lastly, one physiotherapist mentioned disagreements related to care philosophy among HCPs and believed this to be a major challenge in managing patients.

“It's difficult sometimes working in a team. And it's to get your point across, right?... And for rehab professionals it's the patient first, you want to make sure that they're functional, and that they're able to move, and what do they want to do as well? So, what is their role? Not by just fixing and that's it, because you can fix something as a physician, but sometimes they may have mobility deficits still. So, you need to work on proper musculature, the

activation of proper musculature. So, it's just the communication part between the team. This is the most common issue.”

2. Content analysis and virtual rehabilitation: Health care professionals

Perceptions, suggestions, and considerations on virtual rehabilitation, and how it can be considered feasible, acceptable, and equitable are provided in TABLE 3 and are discussed in detail in the section 2.1 and 2.2. Content analysis of the exercise and pain management interventions and educational content provided in the interviews with HCPs are provided in TABLE 4 and was used to determine the interventions that were used and preferred.

TABLE 4. Content analysis of exercise, pain management, and educational interventions provided by HCPs

Health care professionals (n=13)	
Assessment (n)	9
Exercise (n)	
Weight-bearing	6
Posture specific	3
Gentle stretches	2
Manual therapy	1
Gait and breathing specific	1
Education (n)	
Exercise	10
Nutrition	10
Proper body mechanics and safe movement	9
Specific activity limitations and modifications	5
Osteoporosis and vertebral fractures	4
Pain and coping strategies	3
Medication	2
Lifestyle changes	1
Pain management (n)	
Pain medication	9
Exercise	7
Proper body mechanics and safe movement	5

Ice and heat	3
Gentle stretches	2
Manual therapy or massage	2
Pain expectations	2
Spinal orthotics	1

2.1. Content and structure of a successful virtual rehabilitation program specific to vertebral fracture

We found that many of the HCPs had positive experiences with virtual rehabilitation and did not have many concerns related to the safety of virtual care, when delivered by a qualified HCP. “Online is amazing. Online. I used it during the pandemic. We had a good back and forth.” (P20). All four of the physiotherapists and the one kinesiologist we interviewed reported having had experience with virtual rehabilitation and found that it was effective, easy to access, and led to positive experiences for the patients, regardless of if it was performed in a group or individual setting.

“[I thought it was] pretty good. I don't think I'm popular for saying that. But I find attendance rates have gone up like when I host-so with that osteoporosis group, I'll host it once a month and there's usually between 20 and 40 people that will come on and for the education or the exercise portion.” (P13)

HCPs were skeptical about the ability to provide quality care online; however, once they had experienced virtual rehabilitation, they were surprised by the effectiveness of online rehabilitation to provide individualized care.

“I did 12 weeks of virtual straight there in the in the spring, and I felt I was able to adapt pretty easily... I didn't find the exercise prescription pieces [as] hard [as] I thought it was going to be” (P14)

Even though only 5 of the HCPs we interviewed had experience with virtual rehabilitation, all HCPs provided advice on the structure, organization, and components that they believed should be included in a virtual rehabilitation program for people with vertebral fractures. HCPs believed the virtual rehabilitation should be structured into an educational piece for patients, an individualized assessment to determine the prescription of the exercises provided, and an online group component or follow-up sessions for patients to ask questions. For the delivery of the program, most HCPs agreed that the assessment should be performed by a physiotherapist, considering that other HCPs may not have extensive training in pain, mobility, and knowledge of how to adapt programs based on client needs. However, the delivery of the group-based exercise component could be provided by any other HCP that had knowledge on osteoporosis and vertebral fractures.

“It doesn't necessarily need a physio, but I think once you bring in the vertebral fracture, I think a physio assessment is pretty important. Just because with the fracture, you're getting a change in their spinal position, you're getting changes in the breathing, depending on how much of a kyphosis is there, you're getting into pain.... So having that physio assessment, like I was saying, [but I do not think] they necessarily need to deliver the programme, as long as it's somebody knowledgeable. (P11)

In the case where the group-based program was not the ideal for the patient, HCPs suggested that a booster call be provided to patients to allow them to ask questions and monitor their progress, helping keep patients motivated and confident.

“I think reinforcement, because they find often that that's the piece that's missing, people will start they'll initiate it, but then they won't necessarily go back because there's not follow up or accountability or anything like that.” (P19)

HCPs suggested that specific types of exercises that were perceived to be important included: core exercises, some form of spinal extension, lower-body exercises such as a sit to stand, balance exercises, breathing exercises, and postural exercises to improve consequences of hyperkyphosis.

“Yeah, so spinal extension, strengthening, I think would be the one thing, quad strengthening, balance exercises, glutes, bicep curls... so large muscles. So, really, it's functional fitness. So, sit to stand... [But] I mean it depends.” (P8)

To reduce the burden on patients, HCPs suggested that minimal equipment be used to perform exercise. One HCP suggested that patients could be sent a Theraband in the mail as a part of the program registration, which was perceived as a very useful and cost-effective option.

“I mean, I do a lot of Theraband work. It's so easy to use Theraband... I just started mailing them out their Theraband... And they knew at the next session, they'd have it... But if you look around my clinic space. I've got lots of other pieces of equipment. But at the end of the day, even when patients come in, what do I do? I use bodyweight, chairs, [and] Theraband, I'm really not using a lot of fancy equipment. And you don't need to” (P14)

In terms of duration and frequency, most HCPs agreed that a virtual program that ran for 8 weeks 2 times per week for 45 mins to 1 hour that taught individuals how to perform exercises and the

importance of improving physical fitness for improvement in QOL and prevention of fractures would be acceptable. However, one physician believed that there should be an emphasis on self-directed exercise to help facilitate learning and improve exercise adherence.

“Yeah, I think maybe two or three sessions at the start to get people engaged in it. And if you can engage them, then you can give them resources that they can start doing things on their own [at] home... maybe have some sort of website that they can work through step by step, or there's sort of a workbook, [or] if there's videos that they can watch, [so that] they can do a lot of the education themselves... [I believe] it needs to be as self directed as it can be because people are lazy. And when it comes to pain, people need to have things that are active and self directed. If they are forever going back to the whomever the chiropractor or the physio or whoever and just having things done for them, they're never going to engage in things themselves.” (P9)

For the educational piece, HCPs believed patients should have materials to help them understand basic physiology on vertebral fractures and osteoporosis, how to set goals and reasonable expectations, proper body mechanics to reduce fracture risk, the importance of exercise and the effect of mechanical loading on bone, strategies to help reduce pain, vitamin D and calcium, osteoporosis medication, how to arrange their living space to reduce fracture risk, and the importance of preventing future fractures.

“First and foremost, I think you have to give them reassurance that it's okay to move, to give them tools in order to [mobilize], [some] coping strategies [to] try to avoid some of these pain behaviours, [and] you have to give them some sort of an exercise plan, that's a bit of a progressive plan, it should be more active, careful, strengthening exercises, weight

bearing exercises, [and] nutritional support would be helpful. If there's a bit of a psychology component to it, that would be great.” (P9)

“Yeah, well, first, I would say that some basic education about what the fracture means, what osteoporosis is, how these things happen, you know, it's a combination of, of a fall and bone health, in a way that is understandable for people.” (P21)

It is important to note that even though virtual rehabilitation was perceived as a great way to increase the access to resources to increase patient participation in non-pharmacological interventions, that it was not perceived as ideal care.

“I mean, I think it's better than nothing, but is it ideal? Is it [the] best care? No, I wouldn't say that. So, I think, it gets to a certain degree, but it's lacking a finesse or lacking a certain sophistication, at least from a physiotherapy point of view.” (P8)

2.2. Considerations related to virtual rehabilitation implementation

HCPs reported that patient access to virtual rehabilitation and technology, how to perform the online assessment, and the individualization of an exercise program in a group setting were items that needed consideration. First and foremost, to be able to access a virtual rehabilitation resource, patients must have access to internet that can support online video, a space in their home that they can safely perform the assessment and exercises, and knowledge of online streaming platforms. Even though HCPs reported that most of their patients have become more proficient with zoom and other video streaming platforms due to the recent pandemic, not all participants would be able to access an online resource.

“I think for some people, they were not sure if they were going to be able, from a technical perspective, do it. And if they were nervous about it, we would just do a trial run with them

beforehand. But now, so many people are using zoom, they're pretty comfortable with it.”
(P14)

In the case where a patient does have access, they may not be completely comfortable opening zoom and using the service, and therefore a set-up consultation to help patients set up their online/physical environment may need to be considered; however, this may present as a barrier to implementation for some HCPs.

“I do have to take a lot of time where I'm kind of helping them get on the-get the video system downloaded and how are you going to set up your camera in your house so I can see you from head to toe like, that takes some time. And I have to be extremely patient and find creative ways to explain things to people because I can't just kind of, you know, help guide their body in a certain way, like so, it takes a lot of patience.” (P13)

Another concern that HCPs had regarding virtual rehabilitation was the online assessment. Although physiotherapists believed that an online assessment was possible, there were concerns regarding its perceived effectiveness. The first concern related to the assessment was the patient confidence in being assessed online, which could influence their experience.

“Maybe you can evaluate paravertebral muscle spasm and, and the capabilities of the patients on zoom. But I think that would be a challenge. And I think patients may be more confident with the face-to-face interaction where they feel that their physio has actually evaluated them and given them an evaluation that can help to tailor what their needs are, it may be that a TV approach, patients wouldn't have quite the confidence.” (P15)

Secondly, one physiotherapist and kinesiologist believed that putting their hands on the patient to evaluate muscle strength and show them muscle activation was an important and useful tool to

help patients understand the exercises and gauge strength, which would not be available online, and perceived this as a limitation.

“So for example, how I might maybe look at, like, feel for strength, when I'm assessing person, obviously, I can't do that. So it's a lot more subjective, like, I'll have to, you know, be asking a lot of questions to get a better understanding of like, strength, basically. So that's a challenge.” (P13)

Lastly, HCPs were concerned about the safety of performing balance assessments and exercises, considering that they would not be able to monitor the client.

“I mean, I may be able to see that their, that their balance isn't great, but I wouldn't feel safe necessarily challenging them that much...” (P8)

HCPs were also concerned about how the exercise sessions should be delivered, either in a 1-on-1 individualized session, or in a group setting. Regardless of the mode of delivery there were concerns regarding the feasibility or effectiveness of the interventions. HCPs reported that even though an individual online 1-on-1 session may be the most beneficial for the patient in terms of program specificity, it was not considered feasible and therefore presents a substantial challenge in terms of cost and time, which already appear to be in short supply.

“[The major challenge is] to make it broad enough to cover the bases but also efficient enough to [make] it time and cost efficient for staff. Cause a lot of people I've worked with for osteoporosis, I think, has been one on one. So, I have the ability to fine tune things to an individual level; [however], in a group setting, it doesn't make sense” (P10)

Group classes were perceived as a more feasible alternative for both HCPs and patients by providing a service that addresses consequences, while also reducing the cost of implementation for both HCPs and patients. On the other hand, HCPs believed it would be very difficult to provide

individualized training in a group due to the variability in patient symptoms and limitations; however, by monitoring the patient during their sessions, HCPs believed it may be possible to provide some form of individualization.

“I suppose you could have that tailored to how the patient's doing if they don't do well in the first week, then extend the milder interventions for another week. So that might be a rule for an online physio, to gauge what they're doing and to give them a pattern for what usually happens in terms of recovery from vertebral fractures.” (P15)

Regardless, HCPs believed that group-based training was much more feasible and would allow patients to connect with other patients to share their stories and experiences and reduce feelings of loneliness and isolation.

“I think doing group-based stuff would be helpful because it allows people to see that there's other people suffering the same problem. So that would be helpful with having funding for things like that. So, something like my clinic, having some funding for a kinesiologist to run a programme like that would be great. You know, maybe having an avenue to do it virtually, where you can, again, do it in a group but you can capture a bigger audience. You can be more efficient. I think those would be the big ones.” (P9)

DISCUSSION

Our key findings from this study illustrate that non-pharmacological interventions specific to the acuity of fracture can support post-vertebral fracture rehabilitation, but care gaps and barriers to fracture identification and access and referral to a qualified HCP to deliver interventions limit their use. We also found that virtual rehabilitation that included an initial online assessment delivered by a physiotherapist to provide individualized training was perceived positively and considered feasible among HCPs; however, there are concerns regarding the implementation of virtual

rehabilitation that should be considered before designing a program.

Rehabilitation to reduce pain, improve mobility and functioning, and prevent further fractures included pharmacological and non-pharmacological interventions. Pharmacological management did not change significantly over the course of the fracture; however, it appears that the non-pharmacological interventions are dependent on fracture acuity. Another way that HCPs may refer to these time frames is fracture stability, and thus providing treatment based on the stability of the fracture.¹¹⁸ In early rehabilitation, when a fracture is considered acute, pain medication was used to reduce pain and increase early mobilization, and appears to be consistent to what others have reported.^{119, 120} Although this was perceived as an important part of care, education on movements that increase fracture risk, strategies to improve everyday functionality, realistic pain expectations, coping strategies for pain, and the importance of early mobility was also provided. Non-pharmacological strategies that increase early mobility in patients who have debilitating back pain was perceived as important, considering that early mobilization is recommended to begin as early as possible, especially for elderly patients.^{118, 120} It is important to note that bed rest may be advised at the beginning of treatment but should not last longer than a few days^{118, 120} and that non-pharmacological strategies such as physiotherapy, TENS, heat, gait aids, and spinal orthotics can be effective at increasing patient mobility. Physiotherapists appear to be the most common HCP to deliver safe-movement education and physical therapy, which may include postural retraining and exercises to improve the strength of back extensor musculature and early mobility in patients with vertebral fractures.¹¹⁹ Therefore, it appears that the main goals of rehabilitation during the initial stages after fracture are to increase patient mobility, and reduce pain by providing pain medication and a variety of non-pharmacological strategies; however, research on the effectiveness of physical therapy interventions is limited.

After 12 weeks when the fracture is considered chronic, more non-pharmacological interventions can be used to increase patient mobility and functionality, as well as prevent further fractures. Information on lifestyle changes, such as smoking cessation, reduction in alcohol consumption, information on vitamin D and calcium, osteoporosis medication, and sometimes general exercise advice may be provided by a primary care provider and is consistent with current practice according to Old and Calvert.¹¹⁸ Although primary care providers may begin rehabilitation, the specifics of exercise and safe-movement education was provided by a physiotherapist. Physiotherapists facilitate chronic rehabilitation by providing an assessment of the patients' physical measures, goals, and other co-morbidities or conditions to develop an individualized program. Exercise programs provided may include weight-bearing exercises such as upper body-push and pull, chair sit to stands, core strengthening, and some form of spinal extension, and are consistent with current research that suggest exercises provided to patients with vertebral fractures include resistance training for major muscle groups to increase muscle mass, prevent bone loss, increase mobility, and decrease pain, and spinal extension exercises to increase back extensor muscle strength and endurance, mobility, and reduce chronic back pain.⁹³ Physiotherapists also advise and educate patients on osteoporosis, proper body mechanics, and strategies to reduce fall risk at home. Therefore, it appears that the chronic management of vertebral fractures includes more exercise-based non-pharmacological strategies to improve consequences of vertebral fractures, and prevent subsequent fractures, and that the delivery and selection of these strategies can be facilitated by referral to a physiotherapist, and thus is considered an important component in the rehabilitation of vertebral fracture according to the National Osteoporosis Guideline Group.¹²¹

Even though we have described a care pathway that seems to exist for individuals living with vertebral fractures, there are many barriers that limit the use of non-pharmacological interventions. Barriers include absent or delayed identification of vertebral fractures, referral to physiotherapy in both the acute and chronic settings, and continuation of rehabilitation. Identification of vertebral fractures and radiological diagnosis, knowledge of osteoporosis and fragility fractures among family doctors, and the usage of BMD rather than fragility fractures to determine fracture risk influence the time in which patients may receive care. Radiological identification of vertebral fractures is considered extremely important, as it is usually the first presentation of osteoporosis.¹²² Several methods of radiological assessment of vertebral fractures exist; however, there is no clear standard of evaluation¹²³ and vertebral fracture prevalence differs significantly between methods, with false negative rates as high as 23.9%, according to a study conducted in China.¹²⁴ Other than radiologist identification of vertebral fracture, general internists also appear to lack knowledge and awareness of osteoporosis and may lead to an underdiagnosis and identification of vertebral fractures.¹²⁵ Using BMD to determine fracture risk also influences the care provided to patients, as the UK National Osteoporosis Guideline Group has recognized that the presence of a vertebral fracture increases the risk of fracture substantially and that the FRAX algorithm may not take this into account and therefore requires clinical judgement.¹²¹ Considering that identification of vertebral fractures and osteoporosis is an important component that facilitates or limits the referral to non-pharmacological interventions, it may be important to provide a tool that can increase knowledge of osteoporosis, its relation to vertebral fractures, and the impact that a fracture has on the risk of subsequent fractures. By increasing knowledge of vertebral fractures and its association with osteoporosis among physicians, especially general internists, and identifying consistent assessment methods and improving communication of

vertebral fractures among radiological specialists, patients may be identified earlier and receive proper pharmacological and non-pharmacological strategies to support recovery.

Unfortunately, when an osteoporotic vertebral fracture is properly identified, there are barriers that limit the referral and effectiveness of physiotherapy. Family doctors may not have experience or education in physical therapy techniques, may be unsure where to refer due to a lack or overabundance of options, and when referred, physiotherapists may lack education on osteoporosis and vertebral fractures, reducing the effectiveness of rehabilitation. Lack of confidence in physiotherapy to improve consequences of vertebral fractures can be partially explained by the limited quality and quantity of evidence regarding non-pharmacological interventions to address consequences of vertebral fractures.¹²⁶ However, according to Perracini et al., assessments provided by physiotherapists rely on a biopsychosocial approach that can include spinal assessment, pain management, biomechanics, posture and movement education, exercise prescription, while also taking into consideration the lifestyle, social support, and preferences of the patient¹²⁷ and therefore may be able to provide treatment regardless of limited evidence. However, physiotherapists may not receive proper education on osteoporosis and vertebral fractures and therefore may be hesitant in providing care. Physiotherapists who are knowledgeable in vertebral fracture also report that the cost of physiotherapy and available time limit the frequency of follow up, reducing the effectiveness of the interventions. Similarly, McArthur et al., found that rehabilitation specialists reported that a lack of time and skills were major barriers to working with individuals living with vertebral fractures.¹⁰² Therefore, by providing a service provision tool in the form of virtual rehabilitation that provides HCPs information on non-pharmacological management specific to vertebral fracture may increase confidence, while also reducing the time and resources spent.

HCPs had positive experiences with virtual rehabilitation, which included online assessments, exercise prescription, group-based exercise classes, and provided educational lectures. HCPs' structure and content suggestions seem to be consistent with what we have identified in the general rehabilitation of vertebral fracture, although there is currently no research on the effectiveness and feasibility of virtual rehabilitation for vertebral fracture. Virtual rehabilitation has been reported to be safe, feasible, and effective for: preventing falls in frail older adults with chronic disease¹⁰⁶; reducing dyspnea, increasing physical functioning, and improving QOL in patients with COPD and chronic heart failure¹⁰⁷; and improving fall efficacy and instrumental ADL performance in patients following a hip fracture.¹⁰⁸ Although virtual rehabilitation seems promising, there are concerns regarding its implementation. Some patients may not have access to internet, physiotherapists cannot perform manual tests to determine patient strength, and patient confidence may be reduced. Similarly, Annaswamy et al., reported that access to technology and internet speed, developing electronic medical records, cost, determining training personnel, coordinating diagnostic tests, and facilitating communication for individuals with hearing or cognitive impairments to participate are barriers to telehealth in persons with disabilities.¹²⁸ Regardless of the challenges that may need to be considered in the design and implementation of a virtual rehabilitation program, HCPs believed that virtual rehabilitation can be an effective and feasible alternative to reduce barriers and increase access to non-pharmacological interventions.

We went to great lengths to ensure rigour and credibility of our data collection and analysis by including the four-dimensional criteria, reflectivity, participant quotations, content analysis of the interventions, and meeting with our research team of multiple experts in different areas of osteoporosis management to discuss themes. Regardless, there are limitations to our study. We did

purposeful sampling of HCPs who had experience with vertebral fracture rehabilitation, and their experience with osteoporosis and post-vertebral fracture rehabilitation may not represent all HCPs' experiences. Only one family doctor was interviewed and considering that a few barriers were related to family doctor/general internist knowledge and referral, it may have been beneficial to incorporate more of their experiences and perceptions. However, we have captured family physicians' barriers to osteoporosis management previously.¹⁰¹ Lastly, we acknowledge that we did not find any negative cases in the interview data, which suggests that a selection bias may have occurred and therefore may not represent all HCP experiences. Even though we recognize that our findings may not represent all HCP experiences, thematic saturation was observed, as no new codes or themes emerged from our data during the final stages of data analysis.

CONCLUSION

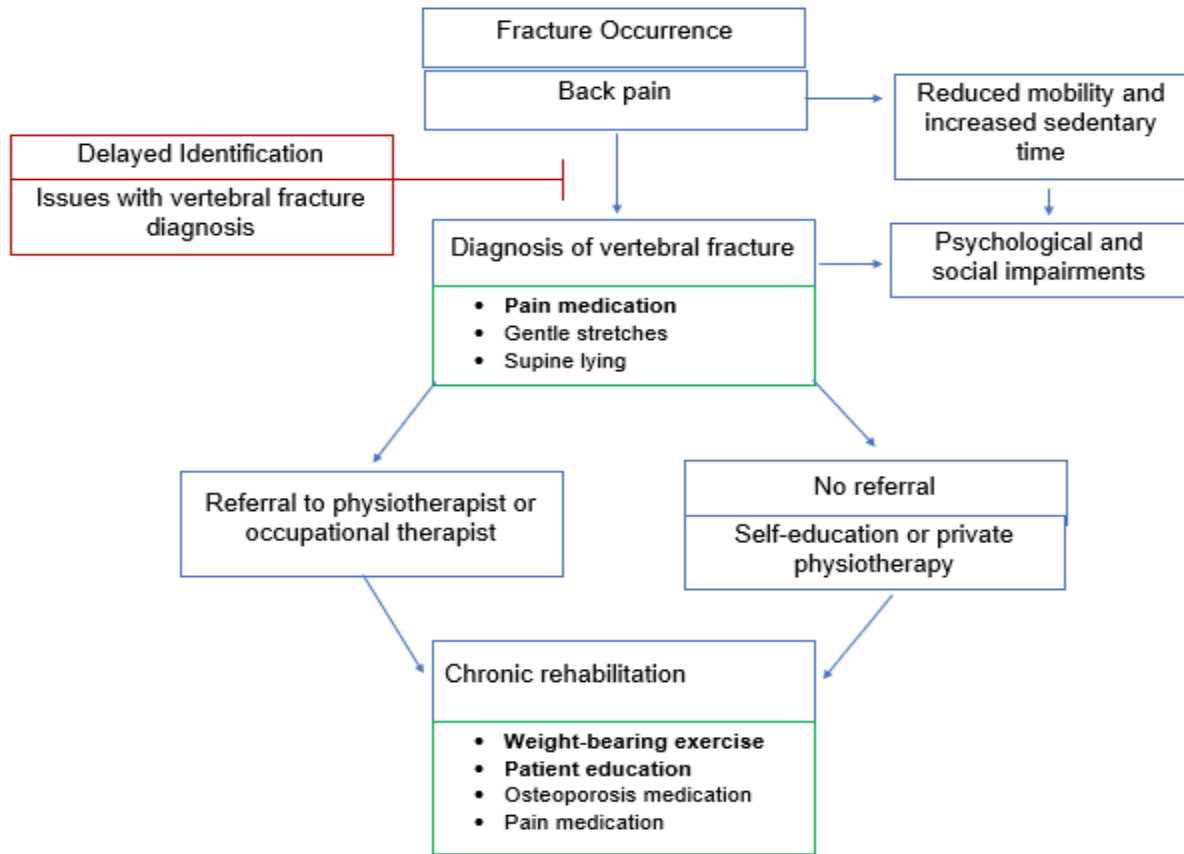
In conclusion, we have identified that HCPs provided pharmacological and non-pharmacological interventions to address consequences of vertebral fractures. Non-pharmacological strategies provided by physiotherapists were dependent on the acuity or stability of the fracture. Early physiotherapy interventions included education on harmful and high-risk movements and non-pharmacological strategies to help reduce patient pain and increase early mobilization. When a fracture was stable, physiotherapy incorporated more exercise-based strategies to help increase strength and mobility and functionality and was informed by a comprehensive assessment. Unfortunately, HCPs believed that barriers related to the identification of fracture, referral to physiotherapy, and knowledge of osteoporosis and vertebral fracture among HCPs reduces the access and effectiveness of these interventions. To increase access, HCPs believed that virtual rehabilitation could be feasible and effective, and suggested that the program consist of an educational component, an assessment by a physiotherapist, and an exercise group that is delivered

by a HCP knowledgeable in exercise and osteoporosis. Even though perceptions were generally positive there were many concerns related to its implementation, such as patient confidence, how to perform an online assessment, and the safety balance related activities, and therefore should be considered in the development of a virtual rehabilitation program and future research.

3. Thematic analysis: Individuals living with vertebral fractures

We identified 5 themes that represent the patient's experiences and perceptions of vertebral fracture rehabilitation: chronic pain from spine fractures contributes to activity limitations and other consequences; fracture identification may be delayed, influencing care trajectory; living with fear; being dissatisfied with fracture management; and non-pharmacological strategies can help patients "get back into the game of life". Themes 1-5 are incorporated in the final thematic map that represent the experience of vertebral fracture rehabilitation from the perspective of individuals living with vertebral fractures (FIGURE 2) and are discussed within the sections 3.1-3.5 and include quotations to help the reader understand the context and connection with the interview data.

FIGURE 2. Thematic map of patient experience and perception of vertebral fracture recovery



3.1. Chronic pain from spine fractures contributes to activity limitations and other consequences

To understand the experience of a vertebral fracture and the impact that it has on the patients lives, we asked questions related to the symptoms that were associated with vertebral fracture. All except two participants reported having back pain associated with the fracture. Participants described this pain as an excruciating and disabling pain that radiated along the back, and sometimes down one side. Participants reported that the pain they experienced was so severe that it limited their movement, and sometimes could not be managed by anything at the time.

“First and foremost, excruciating, debilitating pain. And, you know, all the time, during the day, during the night. So it affected mobility, flexibility, daily activities, back spasms, and inability to function really, because it was multiple compression fractures, not just one.” (P4)

Even though patient pain seemed to lessen over time, pain was always a part of their lives, and was considered chronic. Chronic pain for participants was variable and involved less pain overall but included instances of back spasms or flare-ups that initiated severe pain. The amount of pain initiated during these flare-ups was variable between participants and incidences. Some participants believed that certain movements caused them more pain and initiated flare-ups, whereas others reported having pain occur very suddenly without any reason.

“Well, they vary in how extreme they are. The last one was very extreme. They're not always as severe. It's just terrific amounts of pain and very little that can be done, my only release is if I'm able to sleep and I'm not the best sleeper.” (P1)

When pain was very extreme, either in the beginning, or during flare-ups, participants reported changes in their ability to move and perform activities of daily living. Pain was so excruciatingly debilitating for many participants that they reported an inability to move and spent a lot of time supine and immobile.

“Well, at the beginning, it's almost impossible to get out of a chair or get out of bed or to walk. And then, you know, after a few days, you're able to do a little bit more and a little bit more. But it's just it's pain-it's fairly constant for the first few weeks.” (P18)

In combination with an inability to move, and constant pain, some participants experienced changes in sleep. Participants reported having trouble getting in and out of bed, finding a

comfortable position to sleep in, and felt that their quality of sleep had been altered.

“Going to bed is challenging, you hate if you have to get up in the middle of the night. [If] there's any issue [and] you have to go to the bathroom, that is the worst thing. Oh my god. Now you've got to do it carefully and get your wits about you, just don't rush out and go to the bathroom.” (P6)

One final consequence we noticed that was related to immobility was caloric intake and satiety. When we asked further questions regarding their diet following fracture, we noticed that a few participants reported a large reduction in caloric intake.

“Yes, at the time, I lost weight. Because I was not, you know, I wasn't very active. I wasn't moving around very much. I was on pain medication, and I was just depressed. So yes, I ate very little” (P4)

3.2. Fracture identification may be delayed, influencing care trajectory

Half of the participants we interviewed talked about how their vertebral fracture occurred and believed that it influenced how and when their vertebral fracture was identified. In many cases the fracture was attributed to a fall, an event that involved heavy lifting, such as shoveling snow, or by a low-impact movement, such as picking up a newborn daughter. Fractures due to a fall seemed to trigger a fast identification of fracture. However, this was not evident in all instances, and therefore may be dependent on the severity of the fall and whether it required hospitalization.

“I was coming downstairs one morning in my bare feet, and I missed the top step and landed on my tailbone and bounced down the six steps and ended up in hospital. And I had three fractured vertebrae and a fractured tailbone. So I was in the hospital for a few days.” (P22).

Even though pain after the fracture was extreme and debilitating, some participants did not seek medical attention immediately, as they believed the pain was attributed to the muscles of the back or broken ribs rather than the spine, even if they were already knowledgeable about osteoporosis, thus delaying fracture identification.

“Yeah, it was really sore. Especially all down one side. And I guess, sort of radiating into that one side of my back. I mean, initially, I thought, oh, maybe I've broken a rib. So I didn't, I didn't really know. And I guess I was kind of a little bit overconfident. Even though knowing I've got fairly significant osteoporosis that because I just recently had an X-ray that didn't show up any spinal fractures, that wasn't gonna happen. So I kind of soldiered on with it.” (P3)

Considering that a diagnosis of a vertebral fracture is important in the identification of the issue and the rehabilitation that is provided, we asked patients on their experience with vertebral fracture diagnosis. We found that eight of the participants did not receive a diagnosis of vertebral fracture until weeks after it occurred. In most cases, participants reported seeing their GP about their persistent back pain, and insisted on having an X-ray, which led to the identification of the fracture: “When the pain didn't go away, then I phoned my doctor. And she ordered some X-rays. And the X rays showed that there was a fracture.” (P16). However, a few other participants had issues accessing an X-ray, and thus a diagnosis. These patients reported going to the emergency department for a fall and associated back pain, but did not receive an X-ray, even after insisting.

“Went to emergency, they did all sorts of tests, because I had fainted. So they did blood work. And they did an MRI and did they did everything except an X ray on my back, which is what my big problem was. So I went for about, I guess it was about five or six weeks before I finally talked my doctor into having me x rayed.” (P23)

Regardless, it appeared that all the participants either waited several weeks before seeing a HCP, or had issues with accessing an X-ray, and therefore did not become diagnosed until later. It is important to note, that in these cases, participants were provided with pain medication, but nothing specific to vertebral fractures. One participant had waited an entire year before having a compression fracture identified. The delay in diagnosis is important, considering that patients may continue activities that contribute to increased fracture risk, even if pain is debilitating, if a fracture is not identified.

“I had a lot of pain from that, which took a long time to heal. So my assumption is that it occurred then. And you know, that was probably several weeks of a significant discomfort, albeit, it didn't stop me from doing things. I continued to ride [horses]...I wasn't doing any other kind of exercising, [but] I have dogs I continued to walk. And then almost a year later, I had an MRI. And that's when they discovered that I had compression fractures. (P3)”

3.3. Living with fear

Before identification, most participants were not aware of their risk of subsequent fracture and may have been fearful of the pain they were experiencing and that it would persist; however, once patients were identified as having vertebral fracture and provided information on the fracture and risk of subsequent fracture, their fear seemed to grow substantially.

“...it's lonely living with fear, lonely thinking you're flipping fragile. And yet, you don't know how fragile you are. And you've got [these] statistics thrown at you, this is your risk factor, and this is what will happen. I mean, that's what I got told, that's what I got from my doctor, you are at risk. And this is what will happen if you break your spine, how they

will cement it and all the horrible pain that will come with it. And all the mobility that you'll lose when he told me about my spine, or conversely with my hip, you'd be dead within-potentially dead within two years. Great.” (P3)

Participants were particularly fearful of having a fall, movement that increased back pain, having another fracture, and not being able to get back to their normal routines.

“initially when I first found out what I had, I just kind of wanted to die. I was incredibly fearful, I thought my life is over I can no longer live in this house, I couldn't take care of anything, I can't take care of the yard, I can't walk, I might as well just go to some care home and do nothing so...that's how I felt initially when I found out the diagnosis... I didn't think it was a very good way that I was told the diagnosis. Of course it's COVID times, so everything's over the phone and it was devastating” (P23)

These feelings were especially strong, and many participants believed that these thoughts dictated everything that they did.

“Oh, you're terrified to move, you're afraid to do anything, you're afraid to open the dishwasher, you're afraid to open the oven door. You are literally terrified of any[thing], as I say, I live my life now with two things in mind "don't fall, and don't mess up your back". And they govern every single action that I take, 99% of the time.” (P18).

Fear of fracturing, feelings of depression and isolation, and increased time being immobile also affected social interactions with family and friends. Two participants talked about their spouses and the burden they had to carry at the time, reporting that they would have to take care of them and perform more of the daily chores, while also having to witness the pain that they were in, and described this as very challenging.

“...my husband was extremely good. But he can only do so much he had to go to work during the day. So you know, he'd come home, and I would still be in pain. And it was really tough for him, it was very tough for him.” (P4)

Another participant described the challenge of connecting with friends and family because of issues with travel and the fear of fracturing: “I didn't do as many things with friends and family. Because I was afraid to do so many of them. So yeah, it isolates you.” (P18).

3.4. Being dissatisfied with fracture management

Even when treatment was delayed, participants eventually received pharmacological and non-pharmacological interventions to address consequences of vertebral fractures. Pharmacological management included pain medication and osteoporosis medication, whereas the most common forms of non-pharmacological management were exercise, nutrition education, and education on vertebral fractures and safe movement.

At the beginning of treatment, the most common form of interventions provided to patients were pain medication and information on osteoporosis medications, such as denosumab or a bisphosphonate. Pain medication was reported by all participants, and the majority found the medication helpful in managing their pain and increasing physical activity, allowing them to perform activities of daily living more comfortably. However, participants expressed that pain medication was not sufficient to reduce the pain to tolerable levels or eliminate the pain.

“Well, I would say it was okay. I probably could have even used something stronger. But I didn't even know back then. I would say you know it maybe took the pain down from a nine to six.” (P4)

Other times when the pain was very excruciating, such as a flare-up, pain could not be managed

with medication, and led to feelings of frustration from some participants, as nothing seemed to help reduce pain at these times.

“I recognise that I have pain and sometimes a pain killer an anti inflammatory will help and other times it does absolutely nothing for me. And they're pretty strong. I mean I have things like Celebrex, naproxen. Now I have Tramadol. Sometimes it just really does nothing, like the last time I had a backache nothing did anything and it lasted, you know, maybe 5-6-7 days.” (P1)

Regardless, all the participants believed that the pain medication was helpful and developed strategies to improve the effectiveness of the medication by taking it before the pain began and lying down until it took effect. On the other hand, the perceptions related to osteoporosis medications were much different, as many participants reported concerns regarding the effectiveness of the medications, the side effects that they have read about online, the cost of some medications, and the pressure from HCPs to take these medications.

“If there would be a guarantee that it would help. The side effects and what it can do to you, then why would I spend all this money and then I could have a fracture of the thigh bone. And it can cost all kinds of-can cause all kinds of side effects. Why would I do it myself? It has to be refrigerated. So when you travel, it's a problem, you have to give yourself an injection every day. To me, it did not seem ideal.” (P16)

Even though HCPs stressed the importance of these medications to participants, most of them interpreted this negatively, and did not associate it with help. Communications with HCPs seemed especially troublesome for some participants, as they did not believe that their concerns were being heard and felt like they were only being offered pharmacological options to prevent fractures,

rather than other options that may be available.

“They don't get alternatives. They get all these statistics of, you know, if you've got this, this and this, this is your fracture risk, right. And that's what he threw at me.” (P3)

Participants reported having issues accessing non-pharmacological treatment options and described their initial meetings with their primary care provider as very demoralizing. Participants felt like they were not made a part of the decision-making process and were given very little advice or resources regarding these options.

“I was a lost soul...I was really a mess, so I couldn't really advocate for myself, I just wanted it... to be fixed. I would go from one appointment to another and we would raise the issue and somebody would just say, ‘Oh, yeah, you know, it's this or whatever.’ And I remember even being with an orthopaedic surgeon, and he was talking to his assistant, and it was like I wasn't even in the room. And I thought, I can't believe this... even after I was diagnosed with the fractures, I said, what happens if I fracture again, this was when I was hospitalised and he said, ‘Oh, you just, you know, put on your back brace and carry on.’ No recommendation of medication, no recommendation for Occupational Therapy, no recommendation for physio, nothing. It wasn't until I saw a rheumatologist who saw that I had the symptoms of depression and saw what I was going through that she linked me up with a physiotherapist.” (P4)

3.5. Non-pharmacological strategies can help patients “get back into the game of life”

Some participants were initially referred to a physiotherapist or occupational therapist, and some were suggested to do research online. Participants who did not receive advice related to non-pharmacological management decided to look up options on their own. Therefore, it appears that

the options and resources provided to our participants during their initial interactions with a HCP either facilitated or limited the knowledge and access to non-pharmacological strategies to manage vertebral fractures. Regardless, rehabilitation at this point can be considered chronic management and included many non-pharmacological strategies, such as exercise, nutritional supplements, physiotherapy, spinal orthotics, patient education, massage or manual therapy, and occupational therapy.

Physiotherapy was one of the main non-pharmacological interventions that patients had experience with, to which they gained access through a referral or independently. Physiotherapy involved provision of two different types of exercise programs, one that focused on improving pain, and the other with the goal to increase strength, improve mobility and QOL; both were individualized to the participant and included a more patient centered approach by evaluating the participant and helping them identify goals. When participants were referred to a physiotherapist during the initial stages post-fracture and were still in a lot of pain, strategies that were provided included gentle stretches, and manual therapy.

“And he was the one that actually made a huge difference in my back pain, because he's very hands on and his specialty is back management. So he immediately could see how I was off kilter. And did a lot of work, like hands on work, which actually took away a lot of my lower back discomfort across my sacroiliac area.” (P3)

Whereas participants who seemed to be in less pain were provided strategies that usually involved weight bearing, core, and spinal extension exercises, with the main goals to improve mobility, strength, and reduce sedentary time.

So I asked my doctor to give me a referral to a physiotherapist. Then I went to a physio for

several physiotherapy sessions. And the physiotherapist gave me a programme that I should be following as far as my exercises are concerned that consisted of weight bearing. And every day, I had different exercises that I was doing... To strengthen your muscles around the spine... they're similar to the exercises that are in the Too Fit to Fracture booklet.”

(P16)

Participants found that the help and information provided by physiotherapists was extremely valuable and believed it changed their entire outcome of rehabilitation and put them on the right path to recovery.

“Well, the physiotherapists and occupational therapists were my lifelines. Because they gave me tools, they gave me guidance, they gave me stretches and exercises, they helped me develop goals, they helped me stretch and strengthen, they helped me get back in the game of life” (P4)

Participants felt that the exercises they were provided helped reduce pain by improving the way that they move, reduced the fear of falling and subsequent fracture, and improved confidence, allowing them to comfortably perform their activities of daily living, which some participants reported was related to their sense of self and identity.

“I found it helped with the pain because... if I did things incorrectly, it made the pain worse. So this didn't necessarily improve the pain, but I didn't hurt [as often], [but] I think and the biggest thing is [that] it helps build your confidence to be able to do things and navigate through your home more safely, because you're kind of at a loss of what to do and what not to do. So I found it helped with safer movements with less pain.” (P4)

“I got my identity back, I went from being a potential cripple who was helpless, and could

barely walk to myself again, like my best self, myself when I was 32.” (P2)

Although participants who had seen a physiotherapist believed that it was very beneficial and life changing, two participants had reported seeing a physiotherapist who did not seem knowledgeable in osteoporosis and vertebral fractures. When participants were seen by a physiotherapist who was perceived as not having had experience with vertebral fracture management, participants believed that the exercises made their symptoms worse and may have been harmful. However, participants only realized this once they had seen a knowledgeable physiotherapist and learned information about vertebral fractures and how to move.

“...the original physiotherapist that I'd gone to before the proper diagnosis... every time I went, it hurt more, I was in tears. And she just insisted, and I realised in hindsight that she didn't understand what I was dealing with and wasn't listening to me. So, I had a lot of fear with going to somebody, but once I met the reputable occupational therapist and physiotherapist that were more knowledgeable, then I had less fears.” (P4)

When referral to a physiotherapist was not given or was delayed, many participants turned to other educational resources to improve learn about fractures, how they can prevent further fractures, and exercises they could perform safely. We found that participants used a variety resources, which included: WebMD, Legacy Health, online osteoporosis groups, osteoporosis books and print resources, osteoporosis.ca, and online videos on YouTube. One participant believed that online resources were effective and very helpful and questioned the use of seeing a physiotherapist and did not know if seeing one would be of any extra benefit.

Another resource that was perceived as very helpful by two participants was the COPN and Osteoporosis websites. These participants believed that becoming a member of the COPN or

a volunteer for Osteoporosis Canada can be extremely helpful in increasing knowledge of osteoporosis and the importance of fracture prevention, to identify resources on non-pharmacological interventions, and provide a sense of community among individuals with osteoporosis.

“And now, in latter years, I've found the osteoporosis Canada and the COPN website, quite helpful, because they have a list of things that you can do and can't do. And, you know, other ways to tackle some of the practicalities of life. So that's been helpful. But the first time I fractured, there was none of that available. So you're just-you're in a void, which is somewhat better now. But it's still hard to find anybody that really understands how you feel, I guess, the one 800 line at osteoporosis Canada would probably be the one place where you could get somebody who understood how you felt and maybe had some practical suggestions.” (P18)

Selected participants reported using other strategies that helped alleviate pain, including: massage, spinal orthotics, heat, TENS, and homeopathic remedies. Three participants mentioned spinal orthotics and how they were helpful in reducing pain during activities of daily living. These participants reported that using the brace when they were in pain, during long periods of standing and bending, or during activities that required higher levels of physical activity was beneficial in reducing pain and increasing physical activity.

“Oh, it's definitely helpful and when my back hurts I do still wear the back brace every now and then depending when I'm-let's say when I'm in the kitchen all day and standing on my-standing and cooking and yeah, I put the back brace on. And sometimes also when I when I go hiking, I put it on.” (P16)

Though these participants found the braces helpful at times, they received conflicting advice from HCPs regarding the effectiveness of the brace during recovery, and therefore, were unsure of the effectiveness of the brace to improve consequences of vertebral fracture.

“My GP and the physiotherapist both said don't wear a back brace. They said if you can stand it all don't wear a brace try. You know the GP said he didn't know for sure, he didn't know the science. He wasn't a physiotherapist. But his recommendation would be... it would heal better if I exercised it. I remember both of them saying that. And you know, which is kind of interesting. The endocrinologist, 'get a back brace. Get a back brace'.”

(P2)

One participant reported being referred to a massage therapist and found that it was helpful in reducing their lower back pain when provided by a qualified professional who knew about spinal fractures; however, it is important to note that this strategy was only helpful later in recovery and may be dependent on patient pain and acuity of fracture.

“the doctor recommended I have a body massage, a full body massage. After I had the fall. And I went for one, but it was too soon. And... I think I had to leave early. I don't think I finished this. And I never went back again. Because that massage hurt too much. But it was too soon after the fracture. But now it feels great to have that.” (P22)

Lastly, a few participants mentioned that lying down and alternating ice and heat can be a helpful strategy to reduce pain, which typically incorporated ice packs, hot showers, or light therapy to provide heat.

“I do a lot of sitting, a lot of lying down. Hot showers are helpful. At the beginning, I use ice packs, because it takes away the pain better than anything else. Sometimes heat. You just go from one thing to the other until you find some relief.” (P18)

4. Content analysis and virtual rehabilitation: Individuals living with vertebral fractures

Perceptions, suggestions, and considerations on virtual rehabilitation, and how it can be considered feasible, acceptable, and equitable are provided in TABLE 3 and are discussed in detail in section 4.1. Content analysis of the interventions and symptoms experienced by patients are available in TABLE 5 and was used to determine the most common symptoms and interventions reported by participants.

TABLE 5. Content analysis of patient symptoms and experienced interventions

Individuals living with vertebral fractures (n=10)	
Symptoms of fracture (n)	
Mobility and movement issues	10
Back pain	8
Psychological impairments	8
Social impairments	4
Interventions self-reported by patients (n)	
Pain medication	7
Vitamin D and calcium supplements	7
Weight-bearing exercise	6
Physiotherapy	6
Education	6
Osteoporosis medication	5
Aerobic exercise	4
Gentle stretching	4
Modified yoga	3
Massage or manual therapy	3
Spinal orthotics	3
Occupational therapy	1

4.1. Virtual rehabilitation perceptions and advice

Participants reported that the components that would be most helpful to include in the educational component of an online rehabilitation program were movements to avoid, non-pharmacological strategies to help reduce pain, movement strategies to reduce pain, how to perform activities of daily living safely, and education on safe exercises and the importance of exercise. Participants reported that providing information on safe movement and movements to avoid would be beneficial in video format and suggested that written information be worded in a way that is easy to read and understand.

“But if it was just a learning thing about getting in and out of bed, and I think 15 minutes would probably be, you know, fine. If it was, today, we're learning how to get out of bed, or how to take your trousers off without bending down, or how to put your socks on...”

(P6)

In terms of the exercise component, most participants believed that online exercise over zoom would be one of the most effective ways to implement such a program; however, participants did mention that some older adults will struggle to access and use materials online and therefore suggested that we consider an alternative for individuals who cannot access an online resource.

“Well, it's funny a year ago, I might have answered very differently, but, you know, all of the seniors like right now are pretty Zoom competent. I mean, there's always going to be a portion that you have to consider where they either don't have access to a computer or don't want to use a computer. So that component is always going to be a problem to reach. But I think for the majority of people, certainly, zoom is great, because you can show me something, and I can see what I'm supposed to do, as opposed to having to follow a little stick drawings. I think that's number one.” (P18)

Participants also reported that to make the exercise component more effective, information on how to safely make exercise more challenging should be provided to patients, and to design the program so that they can begin at a comfortable level and improve at their own pace.

“And it's great if they do exercise in sort of components, like, for the first month, you can do this and the second month, you can do that. And I understand you know that everybody's different. And it's a real problem trying to figure out an exercise that you can give people, that is not going to mess somebody up. I understand that. And I know that there are a lot of limitations for what you can do. But I think some guidelines as to, let's say, you know, the exercises I could safely do for the first month after fracture would be great. And then moving upward, how I can determine when I can move on, and how I can check my progress to see if it's doing me any good.” (P18)

One last suggestion came from a participant who had experience with online rehabilitation. They reported that they had experienced issues with an online exercise group for women with osteoporosis, as they found that the exercises that were provided were too easy for her current fitness level, and perceived this as demoralizing, and suggested that groups be divided by fitness level or based on patient assessment.

“Like in the sense of the people who are really crippled up by their fractures versus the people who aren't too bad. I don't know, like, do a triage of some kind. So, you can have like, level one, level two, level three, I don't know... But if you put me in with a bunch of 80-year-olds, who can barely move and are 40 pounds overweight, I would have just felt so discouraged.” (P2)

Most participants believed that the program frequency and duration of 4-8 weeks once or twice a week in the beginning would be acceptable; although, some preferred that the program be for as

long as possible, as pain was considered chronic and therefore requires a maintained rehabilitation plan.

“I would say, twice a week, maybe after the first two weeks. And maybe if it runs for eight weeks, that's good. I would like a follow up call at 12 weeks to be sure that I'm still doing what I should be doing. And I'm getting some encouragement.” (P18)

If an online long term exercise class was not feasible, participants believed that having a call or meeting with a HCP to gain reinforcement on how they are progressing and ask questions would be extremely beneficial and allow them to increase their confidence in maintaining a program over time.

“I think for some people, it's very important. Well, it's just human nature, you tend to slack off, and sometimes you just need a little reminder. I think, I don't know. I can't speak for other people.” (P16)

“Quite often you get all these, you know, wonderful things, and then nobody checks up on you. Or calls you, it's this lack of personal contact that is so difficult that is missing from so many programmes, everybody thinks, you know, okay, I'll give them the information. And then that's my job done. Well, it isn't. Because unless you've got that further follow up contact, you are for the most part wasting your time, I think.” (P18)

Lastly, many participants talked about the affordability of such a program. Participants believed that if a patient valued their physical health very highly, price was not an issue for them, and had trouble putting a monetary value on it, considering that they would sacrifice something else to accommodate. However, others reported that many older individuals may be living on pensions and cannot afford to spend much money at all, and therefore should have as low of a cost as possible. Interestingly, participants believed an online rehabilitation program would be more

effective with some form of cost and should not be provided for free, as having a monetary value associated with the program may help keep participants accountable.

DISCUSSION 2

Our key findings from our interviews are that the experience of vertebral fracture recovery from the perspective of patients include: debilitating back pain, activity limitations, and other complications such as challenges with sleep or eating a healthy diet; implications on patient mental and social well-being that result in feelings of isolation and depression; delayed fracture identification due to reluctance to see a HCP, or issues obtaining a diagnosis; dissatisfaction with pharmacological interventions; non-pharmacological strategies, facilitated by a physiotherapy, are perceived as extremely helpful in the rehabilitation of vertebral fractures and may be used to support recovery; and lastly, participants believed that virtual rehabilitation would be a great support option that could increase access to non-pharmacological management but may be limited, as not all older adults will be able to access such a program due to inexperience with technology, or due to cost.

The way that a fracture happens may influence when and how it is identified. Participants reported fractures due to falls, heavy lifting, or from minimal trauma, which resulted in back pain and movement restriction. Most vertebral fractures are radiologically identified with no history of falls and are referred to as occult fractures,¹²⁹ and 3 quarters of patients presented with a low trauma injury.¹³⁰ When a participant suffered a fracture from a low-trauma incident, we found they reported delaying a trip to be evaluated, as the pain experienced was attributed to the muscles of the back or the ribs and perceived as an injury that would improve on its own. In the cases where participants suffered a fracture from a fall and were admitted to hospital, they may or may not have received an X-ray and thus a diagnosis of a vertebral fracture. Regardless, both instances delayed

the identification of a vertebral fracture. Radiological identification of vertebral fractures is often the first presentation of osteoporosis,¹²² and considering the importance of reducing the risk of subsequent fracture, and identifying harmful habits that may contribute to fracture, this becomes extremely important. Identification can also begin without an X-ray; however, it has been previously reported that general internists and family doctors lack the education on osteoporosis and vertebral fracture identification.¹²⁵ Therefore, even if a patient identifies that something is wrong and decides to see their family doctor, they may or may not be provided with an X-ray, as low back pain is a commonly reported symptom; and even if they do receive an X-ray, it may not be properly identified, and thus a patient may not receive rehabilitation specific to vertebral fractures.

Regardless of the mechanism of injury, debilitating back pain appears to be common during the initial weeks and results in an inability to move or perform activities of daily living. Similarly, Tsuda reported that pain is typically the first symptom of vertebral fracture and can affect patients for longer than 1 year, with reoccurring fractures contributing to increased functional disability and pain.¹³¹ Chronic pain and functional limitations also appear to be related to thoracic hyperkyphosis and loss of muscle mass supporting the lumbar spine, due to a reduction in physical activity.¹³² We noticed a similar finding in relation to chronic pain, as participants reported that even though pain is reduced during the subsequent weeks, long periods of standing, and certain movements can initiate painful flare-ups. Similarly, Svensson et al., found that individuals living with vertebral fractures described the pain during the acute stages as intense and persistent, whereas chronic pain was described as less intense and more intermittent; however, it is important to note that others described their pain as constant and unchanging,⁶⁰ which may be related to times of painful flare-ups.

Pain and immobility also appear to affect mental health substantially. It has been previously reported that psychosocial consequences associated with vertebral fractures include fear of falling, anxiety, depression, loss of social roles/ role identification,^{3, 21, 27} loss of independence, increased isolation, reduced confidence and self esteem,²⁷ and feelings of isolation and humiliation.⁶⁰ We found similar findings among our participants, as they reported feelings of loneliness, isolation, and depression after having a vertebral fracture. We also found that pain and immobility affected the participants' ability to see friends and family and perform certain activities of daily living. Similarly, Hallberg et al, reported that many women experience feelings of loneliness or worry about being alone and that back pain and the inability move around comfortably led to an avoidance of social interaction with relatives and friends.¹³³ Previous studies have also acknowledged that patients with vertebral fractures are especially fearful of falls and subsequent fractures which substantially effects HRQOL,^{133, 134} and is common among our participants experiences. Interestingly, we also noticed that participants became more fearful after being diagnosed with a vertebral fracture. Therefore, it appears that the combination of pain, fear of fracture, fear of falling, loss of self-identity, and the late identification of vertebral fractures create an environment of physical inactivity, which may exacerbate the consequences of vertebral fractures and contribute to feelings of isolation and depression among patients. One other consequence of vertebral fracture and its association with hyperkyphosis, reduced mobility, and pain, is a reduction in caloric intake during the initial weeks after fracture. We noticed that a few participants reported poor caloric intake initially after fracture and were concerned about protein consumption. Even though this finding did not occur often, it has been documented that individuals living with vertebral fractures struggle to maintain appetite and a healthy diet due to progressive hyperkyphosis affecting the thoracic cavity.^{79, 80} Regardless if the reduction in appetite is due to

progressive hyperkyphosis or inactivity and inability to prepare food, limiting the amount of food that is consumed during the initial stages of recovery reduces calcium, vitamin D, and protein consumption, which contribute to sarcopenia, and frailty⁸⁶, and thus more fragile bones.^{81, 82} Therefore, it appears that the experience of a vertebral fracture may include a combination of chronic back pain, reduction in physical activity, psychological and social limitations, and changes in diet. It is important to note that the consequences of vertebral fractures may influence each other, exacerbating feelings of isolation, loneliness, and depression.

When identification of fracture occurs, pharmacological options that consist of pain and osteoporosis medication are provided to patients, which is consistent with the clinical practice of vertebral fracture management according to Ensrud et al.¹¹⁹ Pain medication is considered important and helpful but may only dull the pain patients experience. Osteoporosis medication on the other hand was perceived negatively, and participants reported concerns on the effectiveness, side-effects, and cost of the medications. Similarly, Barcenilla-Wong et al., found that participants were reluctant to take osteoporosis medications due to fear of side-effects, especially osteonecrosis of the jaw, and decided to be abstinent from these treatments.¹³⁵ An interesting finding from our study were the interactions with primary care providers, as meetings were perceived as frustrating for patients, and believed that the lack of alternatives provided to address their daily life challenges was ineffective patient centred care. Therefore, considering that patients are skeptical about medication to reduce fracture risk, and pain medication is not perceived as enough to manage pain, it may be important to support recovery with non-pharmacological interventions.

To access more information on non-pharmacological interventions participants may be referred to a physiotherapist or seek out private physiotherapy. Online resources and other HCPs that are qualified to manage vertebral fractures can facilitate the access to non-pharmacological

interventions. Even though there is limited quality and quantity of evidence on the delivery of physical therapies to manage vertebral fractures¹²⁶, Ensud et al., recommends that physical therapy be provided to patients and incorporate postural retraining and exercises to improve the strength of back extensor musculature and mobility.¹¹⁹ Similarly, we found that participants who received physical therapy through a physiotherapist had experienced a positive impact on their rehabilitation process, and included education and exercise to help patients manage pain by reducing muscle tension, improving posture, and identifying proper body mechanics. When participants were referred to a physiotherapist during the initial stages of fracture and were still in a lot of pain, strategies provided included gentle stretching, and manual therapy and focused on reducing participant pain, whereas when participants had less pain and the fracture was considered chronic, interventions included weight bearing, core, and spinal extension exercises that were similar to items presented in the Too Fit 2 Fracture²⁰ booklets to improve mobility, strength, and reduce sedentary time. Physical therapy strategies our participants received in the acute and chronic stages seem to be consistent with physiotherapy rehabilitation, as Perracini et al., reports that hip and vertebral fracture patients benefit from high intensity exercise interventions, and suggest that early mobilization strategies be used during the acute rehabilitation, followed by usual physiotherapy.¹²⁷ However, the specifics on the interventions used in physiotherapy, such as the exercise components, intensity, frequency, and duration need further evaluation.¹²⁷ Spinal orthotics were another form of non-pharmacological management that was perceived as helpful. Participants used spinal orthotics when standing for long periods of time or during flare-ups but were used sparingly as HCPs provided patients with conflicting advice on the effectiveness of their use. Patients may have received conflicting advice on orthotics considering that the effectiveness of bracing on pain outcomes are mixed^{77,78} and the quality of evidence is weak⁶⁶ and there is a lack

of information on the type, how long they should be worn, and when to use them.⁶⁷ Therefore, considering that pharmacological management it is not perceived as effective enough, treatment supported by non-pharmacological management, especially physical therapies, appear to be beneficial regardless of limited evidence, and may represent a higher quality of care.

Unfortunately, individuals living with vertebral fracture may have reduced mobility, fear of subsequent fractures and falls, and symptoms of depression that may make it challenging to attend physiotherapy sessions. According to a systematic review by Rodrigues et al., and qualitative analysis by Dohrn et al the main barriers for being inactive and not participating in physical activities outside of their homes in women with osteopenia or osteoporosis are transportation, lack of time, weather, taking care of grand children, and lack of motivation.^{100, 103} To increase patient participation in and reduce barriers of physiotherapy interventions, home-based programs may be a feasible and effective alternative. Home-based exercise programs for individuals living with vertebral fractures have been reported to have an adherence rate typical of exercise interventions in older women (40-75%).²² Home based interventions developed for frail older women with vertebral fractures have also been reported to be effective at improving QOL symptoms, emotion, leisure, and social activity.²² Virtual rehabilitation is a form of home-based programming that provides patients with face-to-face interactions with a qualified HCP online. Research on virtual rehabilitation has been reported to be safe, feasible, and effective in preventing falls in frail older adults with chronic disease¹⁰⁶; reducing dyspnea, increasing physical functioning, and improving QOL in patients with COPD and chronic heart failure¹⁰⁷; and improving fall efficacy and instrumental ADL performance in patients following a hip fracture.¹⁰⁸ However, research on virtual rehabilitation specific to vertebral fracture is lacking. To address this, we asked participants on their perceptions of virtual rehabilitation and found that a program that

incorporated easy to read and video based educational material, and an online exercise group with a qualified HCP over zoom was considered feasible and acceptable. Considering that our participants reported a need for non-pharmacological options and that virtual rehabilitation would be an effective and feasible alternative, it may be possible to reduce barriers and increase adherence to physical therapies, thus improving the delivery of non-pharmacological interventions to support recovery. However, our participants mentioned that program individualization and cost need to be considered in the development and may influence effectiveness and feasibility. Therefore, considering that there is no research on the effectiveness and feasibility specific to vertebral fractures, further research on the structure and content of a program specific to vertebral fractures may be warranted before implementation.

We went to great lengths to ensure rigour and credibility of our data collection and analysis by including the four-dimensional criteria, reflectivity, participant quotations, content analysis of the interventions, and meeting with our research team of multiple experts in different areas of osteoporosis management to discuss themes. Regardless, there are limitations to our study. In terms of the participants we interviewed, most were white females, and therefore may underrepresent the experience of males and persons of color. We also did not record the location, number, and severity of participants' fractures, as we could not verify them. The number, location or severity might influence the pain, mobility, and overall experience of vertebral fracture rehabilitation. Lastly, we acknowledge that we did not find any negative cases in the interview data, which suggests that a selection bias may have occurred, as all participants volunteered to participate and therefore may not represent all patient experiences. Even though we recognize that our findings may not represent all patient experiences, thematic saturation was observed, as no new codes or themes emerged from our data during the final stages of data analysis.

CONCLUSION 2

In conclusion, we have identified that the experience of vertebral fracture recovery among patients involves a substantial amount of back pain, mobility related issues, and psychological and social impairments. Rehabilitation provided to patients was dependent on the identification of fracture and was delayed, either from patient reluctance to see a HCP initially, or due to issues related to radiological diagnosis and access to an X-ray. Once participants were identified with a fracture, rehabilitation was focused on pharmacology, but sometimes included some physiotherapy to reduce pain and facilitate early mobility. Pain medication was perceived as helpful in reducing pain but that non-pharmacological alternatives to reduce pain and improve mobility should be advised. Perceptions on osteoporosis medication were ambiguous, as patients were not confident in effect of these medications to reduce fracture risk and were concerned about the side effects. Rehabilitation in the chronic stages of vertebral fracture recovery involved more non-pharmacological interventions and was facilitated by physiotherapy. Strategies provided by physiotherapists were perceived as helpful and included weight-bearing exercise and education on proper body mechanics to improve pain, mobility, and reduce future fractures. When participants were not referred, or did not seek out physiotherapy, online resources were used to educate patients on safe exercise and osteoporosis, but the effect of this strategy is unknown. To improve access to non-pharmacological options, education and exercise delivered online via virtual rehabilitation could be an acceptable and feasible but requires further evaluation.

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APPENDICIES

SEMI-STRUCTURED INTERVIEW GUIDE – VERTEBRAL FRACTURES PATIENTS

SECTION 1 – current practice

- 1) When you had your vertebral fracture, what type of symptoms did you have? (Prompt: Did you have back pain?)
 - a) What have you found was useful in reducing XXXX (e.g. pain)?

- 2) How did the fracture affect your daily life activities? (Prompt: How much you move about in the day; how much exercise you got; relationship with friends/family)
 - a) What concerns or fears do you have about doing your daily activities? (Prompt: What concerns did you have when you had your fracture? What movements do you consider risky or dangerous?)
 - b) How did the fracture affect your mood?
 - c) How did the fracture affect your sleep?
 - d) How did your fracture affect your eating patterns? (Prompt: Do you struggle to get enough protein? Calcium?)

SECTION 2 – non-pharmacological treatments

- 3) What types of non-surgical and non-medicinal treatments have you tried? (Prompts: Pain management, exercise, nutrition, surgery, medication)
 - a) What worked well? What did not work well?
 - b) Were there any treatments you did not agree with or did not want to try?
 - c) Tell me about any issues you had with accessing treatment. (e.g., trouble with accessing the hospital (ED), primary care provider care, PT if recommended, were they recommended a Brace)
 - d) What concerns or fears do you have about exercise? Thinking back to right after your fracture, what concerns might you have had about exercise then?

SECTION 3 – virtual rehabilitation

- 4) We want to develop tools that could be used by health care professionals to do online education and rehabilitation for people with vertebral fractures. It would involve joining online meetings (like this one if online) in a 1:1 or group session.
 - a) What do people with vertebral fractures need to learn more about when it comes to pain and how to move or do daily activities?
 - i) We are considering the following topics: moving safely, education, pain management, improving eating habits and nutrition, and exercise. What do you think about those topics? (Prompt: Is anything missing? Do you feel comfortable with these options?)
 - b) What advice do you have for us in designing this program?

- c) We plan to deliver it online but might also use online videos or other materials. What formats would be feasible and acceptable to you? (Prompt: What do we need to consider when selecting ways to communicate?)
 - i) Programs like this often run for 4-8 weeks once or twice a week. What would be acceptable to you?
 - ii) How do you feel about using an app to access your exercises and track your progress? What about printed or emailed materials?
 - d) How much would you be willing or able to pay to receive education on rehabilitation after a vertebral fracture?
- 5) Is there anything else you want to share?

Thank you for participating. Your input will be greatly appreciated. If you have any questions or concerns, please contact me at: ntibert@uwaterloo.ca or 519-888-4567 ext. 38779.

SEMI-STRUCTURED INTERVIEW GUIDE – HCPs

SECTION 1 – current practice

1. What are your goals of treatment for someone with a vertebral fracture?
2. What types of treatments do you use with patients?
 - a) What have you found to be effective?
 - b) How is your treatment plan different with an acute vertebral fracture compared to chronic, if at all?
 - i. How do you define acute vs chronic?
 - c) What do you use for managing pain?
 - i. What do you think about spinal orthotics? (Prompts: Effective? Feasible?)
3. What do you think are the nutrition or food challenges of your patients with vertebral fracture?
 - a) Dietitians are often beneficial in chronic care management. How could you see incorporating dietitians into the care of patients with vertebral fractures?

SECTION 2 – non-pharmacological treatments

4. What experience do you have with rehabilitation or non-pharmacological treatments post fracture? (Prompts: Exercise? Spinal orthotics? Nutrition? Safe movement advice?)
5. What are the barriers to providing rehabilitation post vertebral fracture?
 - a) What are your concerns/fears related to the care of patients with vertebral fracture?
 - b) What concerns do you have when prescribing exercise for people with vertebral fracture? What about concerns with prescribing it online?

SECTION 3 – virtual rehabilitation

6. We want to develop a toolkit that could be used by health care professionals to do online education and rehabilitation for people with vertebral fractures. Patients would join online meetings (like this one if online) in a 1:1 or group session.
 - a) What do we need to provide to patients to help them manage their fracture?
 - i. What do they need to learn about: a) exercise; b) pain management; c) nutrition; or d) safe movement?
 - b) How can we add value beyond what is available to you or your patients now?
 - c) We plan to deliver it as virtual rehab but might also use online videos or other materials. How can we make it feasible and acceptable?
 - i. A comparable chronic disease group education program (i.e., GLAS Canada) runs once a week for 8 weeks. What are your thoughts on duration and frequency?

- ii. How might we need to address eHealth literacy, gender differences, socioeconomic status, ethnicity or other factors in rehabilitation or educational tools?
- d) A program like this would have costs and may not be covered by our health care system. We will need to balance the cost to deliver it with what people are willing to pay or what insurance coverage they may have. How can we make it affordable?

7. Is there anything else you want to share?

Thank you for participating. Your input will be greatly appreciated. If you have any questions or concerns, please contact me at: ntibert@uwaterloo.ca or 519-888-4567 ext. 38779.