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Effectiveness of Physiotherapy and Pharmacological Therapy in Patients with Osteoporosis: A Systematic Review

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ABSTRACT
Osteoporosis is a bone disease that causes bones to become brittle and fracture easily, which can lead to a decreased quality of life and increase the risk of death. Current osteoporosis therapies include pharmacological therapies, such as bisphosphonates and calcium, as well as non-pharmacological therapies, such as physical exercise and lifestyle changes. However, many osteoporosis patients still do not receive effective therapy. The purpose of this review is to evaluate the effectiveness of physiotherapy and pharmacological therapies in patients with osteoporosis. This review was conducted using the PubMed, Scopus, and Cochrane Library databases. The keywords used were "osteoporosis," "physiotherapy," "pharmacological therapy," "bone density," "muscle strength," and "body balance." Selected articles were published in English and had a valid research design. Fifteen articles met the inclusion criteria. The review results showed that physiotherapy, such as strength and flexibility training, can improve muscle strength and balance in osteoporosis patients. Pharmacological therapies, such as bisphosphonates and calcium, can increase bone density and reduce the risk of fractures. The combination of physiotherapy and pharmacological therapy was more effective in improving bone density, muscle strength, and balance than either therapy alone. The conclusion of this review indicates that a combination of physiotherapy and pharmacology is more effective in improving bone density, muscle strength, and balance in osteoporosis patients.

INTRODUCTION

Osteoporosis is a bone disease that causes bones to become brittle and break easily, which can lead to a decreased quality of life and increase the risk of death.(1)Current osteoporosis therapy includes pharmacological therapy, such as bisphosphonates and calcium, as well as non-pharmacological therapy, such as physical exercise and lifestyle changes.(2)However, many osteoporosis patients still do not receive effective therapy, so research is needed to determine the effectiveness of physiotherapy and pharmacology in patients with osteoporosis.

With this background, this study aims to determine the effectiveness of physiotherapy and pharmacology therapy in patients with osteoporosis, as well as to determine whether the combination of physiotherapy and pharmacology therapy is more effective than single therapy in treating osteoporosis.Osteoporosis is a medical condition characterized by decreased bone density, increasing the risk of fractures. Osteoporosis is common in older adults, especially postmenopausal women (Naser et al., 2024). Physiotherapy and pharmacological therapy can be effective treatment options for patients with osteoporosis.

LITERATURE REVIEW

Physiotherapy Therapy

Physiotherapy can help improve muscle strength, balance, and flexibility in patients with osteoporosis.

A. Increasing muscle strength in patients with osteoporosis involves several complex physiological processes. Some of the working mechanisms involved are as follows:

1. Muscle stimulation in patients with osteoporosis, namely by means of muscle strength training, such as lifting weights or resistance, stimulates the muscles to contract and increase strength.

   Muscle stimulation is the process that occurs when muscles repeatedly contract and relax, increasing their strength and size. One way to stimulate muscles is through strength training, such as weightlifting.

   The process of repeated contraction and relaxation occurs because the muscles experience microscopic damage, which is then repaired by the body by increasing protein synthesis and the formation of new muscle.

   Cexample of muscle stimulation process by lifting weights:

   a. Lifting weights with a certain weight, so that the muscles contract and relax.
   b. The muscle experiences microscopic damage, which causes the release of signals to the body to repair the damage.
   c. The body responds to these signals by increasing protein synthesis and the formation of new muscle.
   d. Muscles become stronger and bigger, so they can lift weights more easily.

   It should be remembered that muscle stimulation by lifting weights must be done carefully and not excessively, because it can cause muscle injury.

2. Motor unit activationin patients with osteoporosis with the understanding that when muscles contract, motor units (motor neurons and muscle fibers)

are activated, which results in increased muscle strength. Motor unit activation is the process that occurs when motor neurons (nerve cells that control muscles) send signals to the muscles to contract. A motor unit is a group of muscles controlled by a single motor neuron. When motor neurons send signals to muscles, they contract and initiate movement. Motor unit activation is a crucial process in regulating body movement, enabling us to perform precise and controlled movements. The following is an example of the motor unit activation process:

a. Motor neurons in the brain send signals to muscles via motor nerves.
b. The signal is received by the muscle and causes the muscle to contract.
c. Muscles contract and perform movements, such as lifting an arm or leg.
d. Motor neurons continue to send signals to the muscles to maintain the movement.

Examples of motor unit activation:

- When you lift your arm, motor neurons in the brain send signals to the biceps and triceps muscles to contract and perform the movement.
- When walking, motor neurons in the brain send signals to the leg muscles to contract and perform movement.

Motor units can be activated in several ways, including:

- Voluntary activationthat is, when we consciously decide to make a movement, motor neurons in the brain send signals to the muscles to contract.
- Reflex activationthat is, when experiencing a stimulus, such as touch or pressure, motor neurons in the brain send signals to the muscles to contract automatically.
- Automatic activationthat is, when performing repetitive movements, such as walking or running, motor neurons in the brain send signals to the muscles to contract automatically.

  It should be noted that motor unit activation can be influenced by several factors, including physical, emotional, and environmental conditions. (11).

3. Increased protein synthesisIn patients with osteoporosis, muscle strength training increases muscle protein synthesis, which helps repair and strengthen muscles.

   Increased protein synthesis is the process that occurs when the body increases the production of protein, which is the building block of muscle. Protein synthesis is a crucial process in muscle formation and repair.

   The following is an example of the process of increasing protein synthesis:

   a. Degradation of consumed food, such as protein, carbohydrates, and fat, into amino acids, glucose, and fatty acids.
   b. Amino acids produced from food are used for protein synthesis.
   c. Protein synthesis occurs in ribosomes, which are the cellular structures responsible for protein synthesis.
   d. mRNA (messenger RNA) carries genetic information from DNA to ribosomes, which are then used for protein synthesis.
   e. tRNA (transfer RNA) carries amino acids to the ribosomes, which are then used for protein synthesis.

f. Protein synthesis occurs when amino acids are linked together to form protein chains.

Increased protein synthesis can be influenced by several factors, including:

- Adequate protein intake is very important to increase protein synthesis.
- Adequate carbohydrate intake can help increase protein synthesis.
- Anabolic hormones, such as testosterone and insulin-like growth factor-1 (IGF-1), can help increase protein synthesis.
- Strength training can help increase protein synthesis.

The benefits of increasing protein synthesis include helping to increase muscle formation, increase muscle strength and improve muscle balance. However, it's important to remember that increased protein synthesis must be balanced with a balanced nutritional intake and proper exercise.

4. Increased muscle densityIn patients with osteoporosis, muscle strength training will increase muscle density, which means an increase in the number of muscle fibers and muscle strength.

   Muscle density is the process by which muscles become stronger and denser, thereby increasing their ability to perform work. Muscle density is a measure of muscle strength and density, which can be measured using techniques such as dual-energy X-ray absorptiometry (DXA) or computed tomography (CT) scanning.

   When performing strength training, such as weightlifting, muscles experience microscopic damage. The body responds to this damage by increasing protein synthesis and muscle repair, thereby increasing muscle density.

   Here is an example of the process of increasing muscle density:

   a. Musclewill experience microscopic damage after doing muscle strength training.
   b. The body responds to this damage by increasing the production of anabolic hormones, such as testosterone and insulin-like growth factor-1 (IGF-1).
   c. These anabolic hormones trigger protein synthesis in the muscles, thereby increasing protein production.
   d. The protein produced is used to repair and build new muscle, thereby increasing muscle density.
   e. Muscles become stronger and denser, thereby increasing the muscle's ability to do work.

   Increased muscle density can be influenced by several factors, including:

   - Muscle strength training can trigger an increase in muscle density.
   - Adequate protein intake is very important to increase muscle density.
   - Anabolic hormones, such as testosterone and IGF-1, can trigger increased muscle density.
   - Muscle density tends to decrease with age, but this can be slowed down with strength training and adequate protein intake.

B. The process of improving balance in patients with osteoporosis involves several complex physiological processes. Some of the mechanisms involved are:

1. Stimulation of the vestibular system in patients with osteoporosis through balance exercises, such as standing on one leg or walking on a straight line, stimulates the vestibular (balance) system in the inner ear, which helps improve balance. Vestibular system stimulation is a process that occurs when the vestibular system, which is responsible for balance and spatial orientation, is stimulated by movement or changes in head position. The vestibular system is located within the inner ear and consists of three main structures.namely the cochlea, vestibule, and saccule. The cochlea is the structure responsible for hearing. The vestibule is the structure responsible for balance and spatial orientation, and the saccule is the structure responsible for detecting linear motion. Stimulation of the vestibular system can occur in several ways.consists of head movements, changes in position, and vibrations. Head movements can stimulate the vestibular system and induce a balance response. Changes in head position can stimulate the vestibular system and induce a balance response. Vibrations can stimulate the vestibular system and induce a balance response. Stimulation of the vestibular system can cause several responses, includinghelps maintain balance and spatial orientation, nystagmus is an uncontrolled eye movement that can occur in response to stimulation of the vestibular system, and vertigo is a sensation of spinning or loss of balance that can occur in response to stimulation of the vestibular system. ConAfter all, stimulation of the vestibular system, namely spinning can stimulate the vestibular system and cause a balance response, swinging can stimulate the vestibular system and cause a balance response, and going up and down can stimulate the vestibular system and cause a balance response. It's important to remember that excessive vestibular stimulation can cause unwanted symptoms, such as vertigo and nystagmus. Therefore, it's important to perform vestibular stimulation with caution and under a doctor's supervision.
2. Postural muscle activationIn patients with osteoporosis, balance exercises activate postural muscles (muscles that help maintain posture), such as abdominal muscles and back muscles, which help improve balance. Postural muscle activation is the process that occurs when the postural muscles, which are responsible for maintaining body position and balance, are activated to maintain body position and balance. Postural muscles are located along the spine, pelvis, and legs, and are responsible for maintaining body position and balance. These muscles include:
   a. Erector spinae muscles: The erector spinae muscles are muscles located along the spine and are responsible for maintaining the position of the spine.
   b. Gluteus maximus muscle: The gluteus maximus muscle is a muscle located in the pelvis and is responsible for maintaining the position of the pelvis.
   c. Hamstring muscles: The hamstring muscles are the muscles located at the back of the leg and are responsible for maintaining the position of the leg.

   Postural muscle activation can occur in several ways, including:
   a. Postural reflex: Postural reflex is an automatic response that occurs when the body detects a change in position or balance.

b. Muscle contractions: Postural muscle contractions can occur consciously or unconsciously to maintain body position and balance.
c. Sensory stimulation: Sensory stimulation, such as touch or pressure, can stimulate postural muscle activation.

Postural muscle activation has several functions, including:

a. Maintaining body position: Postural muscle activation helps maintain body position and balance.
b. Reducing the risk of injury: Postural muscle activation can help reduce the risk of injury by maintaining a stable body position.
c. Improve balance: Postural muscle activation can help improve body balance and coordination.

Activation examplepostural muscles include standing requiring activation of postural muscles to maintain body position and balance, walking requiring activation of postural muscles to maintain body position and balance, and lifting weights requiring activation of postural muscles to maintain body position and balance.

3. Enhanced proprioceptionIn patients with osteoporosis, balance training improves proprioception (the ability to sense body position and movement), which helps improve balance. Proprioception is the process by which the body's ability to detect the position and movement of joints and muscles improves. Proprioception is the body's ability to detect the position and movement of joints and muscles, and is one of the body's five basic senses. Improved proprioception can occur in several ways, including:
   a. Balance exercises: Balance exercises, such as standing on one leg or walking on a straight line, can help improve proprioception.
   b. Strength training: Strength training, such as weight lifting or push-ups, can help improve proprioception by increasing muscle and joint strength.
   c. Flexibility exercises: Flexibility exercises, such as yoga or stretching, can help improve proprioception by increasing joint and muscle flexibility.
   d. Sensory stimulation: Sensory stimulation, such as touch or pressure, can help improve proprioception by stimulating sensory receptors in the skin and muscles.

   Improved proprioception has several benefits, including:

   a. Improve balance: Improved proprioception can help improve balance and reduce the risk of injury.
   b. Improved coordination: Improved proprioception can help improve body coordination and increase the ability to perform complex movements.
   c. Increased strength: Improved proprioception can help increase muscle and joint strength.
   d. Reduce pain: Improved proprioception can help reduce pain and improve quality of life.

   Examples of increased proprioception:

   - Standing on one leg: Standing on one leg can help improve proprioception by improving balance and body coordination.
   - Walking on a straight line: Walking on a straight line can help improve proprioception by improving balance and body coordination.

- Yoga exercises: Yoga exercises can help improve proprioception by increasing joint and muscle flexibility.

4. Enhanced sensory integrationIn patients with osteoporosis through balance training improves sensory integration (the ability to integrate sensory information from various sources), which helps improve balance. Sensory integration is the process that occurs when the body's ability to integrate sensory information from multiple sources increases. Sensory integration is the body's ability to combine sensory information from sight, hearing, touch, smell, and taste to create an accurate perception of the surrounding environment. Increased sensory integration can occur in several ways, including:
   a. Sensory exercises: Sensory exercises, such as playing with sand or water, can help improve sensory integration by stimulating multiple senses.
   b. Motor exercises: Motor exercises, such as running or swimming, can help improve sensory integration by improving body coordination and balance.
   c. Cognitive exercises: Cognitive exercises, such as solving puzzles or playing chess, can help improve sensory integration by improving thinking and problem-solving skills.
   d. Sensory stimulation: Sensory stimulation, such as music or light, can help improve sensory integration by stimulating the senses.

   Increased sensory integration has several benefits, including:
   a. Improve learning ability: Increased sensory integration can help improve learning and memory abilities.
   b. Improve coordination: Increased sensory integration can help improve body coordination and balance.
   c. Improve thinking skills: Increased sensory integration can help improve thinking and problem-solving skills.
   d. Reduce stress: Increased sensory integration can help reduce stress and improve quality of life.

   Examples of increased sensory integration:
   - Playing music: Playing music can help improve sensory integration by stimulating the auditory and motor senses.
   - Playing sports: Playing sports can help improve sensory integration by improving body coordination and balance.
   - Doing yoga: Doing yoga can help improve sensory integration by increasing body flexibility and balance.

C. Meanwhile, increasing flexibility in patients with osteoporosis involves several complex physiological processes. The following mechanisms are involved:

1. Increased tissue elasticityIn patients with osteoporosis through flexibility exercises, such as stretching or yoga, increases the elasticity of tissues, including muscles, tendons, and ligaments, which helps improve flexibility.

   Increasing tissue elasticity is a crucial process in maintaining health and bodily function. Tissue elasticity refers to the ability of tissue to stretch and return to its original shape after being subjected to stress or strain.

   Increasing tissue elasticity can be achieved in several ways, such as:

a. Physical exercise: Regular physical exercise can help increase tissue elasticity, especially in muscles and tendons.
b. Stretching: Stretching can help increase tissue elasticity by stretching muscles and tendons.
c. Balanced diet: A balanced diet rich in vitamins and minerals, such as vitamins C and E, can help improve tissue elasticity.
d. Hydration: Adequate hydration can help maintain tissue elasticity by keeping the skin and tissues moist.
e. Physical therapy: Physical therapy, such as manual therapy and electrotherapy, can help improve tissue elasticity.

Increasing tissue elasticity can have several benefits, such as:

a. Increased flexibility: Increased tissue elasticity can help improve the body's flexibility and mobility.
b. Reducing injuries: Increasing tissue elasticity can help reduce the risk of injury by improving the tissue's ability to stretch and return to its original shape.
c. Improve quality of life: Increased tissue elasticity can help improve quality of life by increasing the body's ability to perform daily activities.

2. Increased muscle lengthIn patients with osteoporosis through flexibility exercises increase muscle length, which helps improve flexibility. Increasing muscle length is a crucial process for improving strength, flexibility, and mobility. Increasing muscle length can be achieved in several ways, such as:
   a. Stretching exercises: Stretching exercises can help increase muscle length by stretching the muscles and tendons.
   b. Strength training: Strength training can help increase muscle length by increasing muscle size and strength.
   c. Flexibility exercises: Flexibility exercises can help increase muscle length by improving the body's flexibility and mobility.
   d. Physical therapy: Physical therapy, such as manual therapy and electrotherapy, can help increase muscle length.

   Increasing muscle length can have several benefits, such as:

   a. Increase flexibility: Increasing muscle length can help improve the body's flexibility and mobility.
   b. Reducing injuries: Increasing muscle length can help reduce the risk of injury by improving the muscle's ability to stretch and return to its original shape.
   c. Increase strength: Increasing muscle length can help increase muscle strength by increasing muscle size and strength.
   d. Improves quality of life: Increasing muscle length can help improve quality of life by increasing the body's ability to perform daily activities.

   Some things to pay attention to when increasing muscle length are:

   a. Start slowly: Start with light exercise and gradually increase the intensity and duration.
   b. Don't force it: Don't force the muscle to stretch or increase the muscle length excessively.

c. Pay attention to posture: Pay attention to correct posture when doing exercises to avoid injury.
d. Consult a professional: Consult a health professional before starting any muscle length increase program.

3. Increased joint mobilityIn patients with osteoporosis through flexibility exercises increases joint mobility, which helps improve flexibility. Improving joint mobility is a crucial process for improving flexibility, strength, and quality of life. Joint mobility refers to the ability of a joint to move freely and smoothly. Improving joint mobility can be achieved in several ways, such as:
   a. Stretching exercises: Stretching exercises can help improve joint mobility by stretching the muscles and tendons around the joints.
   b. Flexibility exercises: Flexibility exercises can help improve joint mobility by increasing the flexibility and mobility of the body.
   c. Physical therapy: Physical therapy, such as manual therapy and electrotherapy, can help improve joint mobility.
   d. Exercise: Regular exercise can help improve joint mobility by increasing muscle strength and flexibility.

   Increased joint mobility can have several benefits, such as:
   a. Increase flexibility: Increased joint mobility can help improve the flexibility and mobility of the body.
   b. Reducing injuries: Increasing joint mobility can help reduce the risk of injury by improving the joints' ability to move freely and smoothly.
   c. Improve quality of life: Increased joint mobility can help improve quality of life by increasing the body's ability to perform daily activities.
   d. Reduce pain: Increased joint mobility can help reduce pain and stiffness in the joints.

   Some things to pay attention to when improving joint mobility are:
   a. Start slowly: Start with light exercise and gradually increase the intensity and duration.
   b. Don't force it: Don't force the joint to move excessively.
   c. Pay attention to posture: Pay attention to correct posture when doing exercises to avoid injury.
   d Consult a professional: Consult a healthcare professional before starting any joint mobility improvement program.
4. Increased blood flowIn patients with osteoporosis through flexibility exercises increases blood flow to the tissues, which helps improve flexibility. Improving blood flow is a crucial process for improving health and bodily function. Good blood flow can help improve oxygenation and nutrient delivery throughout the body, as well as eliminate waste and toxins. Increased blood flow can be achieved in several ways, such as:
   a. Exercise: Regular exercise can help improve blood flow by increasing muscle strength and flexibility.
   b Balanced diet: A balanced diet rich in fruits, vegetables and whole grains can help improve blood flow.
   c. Hydration: Adequate hydration can help improve blood flow by keeping the blood moist.

d. Physical therapy: Physical therapy, such as manual therapy and electrotherapy, can help improve blood flow.
e. Relaxation techniques: Relaxation techniques, such as meditation and yoga, can help improve blood flow by reducing stress and promoting relaxation.

Increased blood flow can have several benefits, such as:

a. Increased energy: Increased blood flow can help increase energy and vitality.
b. Reduces stress: Increased blood flow can help reduce stress and promote relaxation.
c. Improve brain function: Increased blood flow can help improve brain function and memory.
d. Reduces risk of disease: Increased blood flow can help reduce the risk of heart disease, stroke, and diabetes.

Some things to pay attention to when increasing blood flow are:

a. Start slowly: Start with light exercise and gradually increase the intensity and duration.
b. Don't force it: Don't force your body to do excessive activities.
c. Pay attention to body posture: Pay attention to correct body posture when doing exercises to avoid injury.
d. Consult a professional: Consult a healthcare professional before starting any blood flow improvement program.

METHODOLOGY

The methodology of this article is based on a systematic review approach that aims to evaluate the effectiveness of physiotherapy and pharmacological therapy in patients with osteoporosis. The study collected secondary data from reputable scientific databases, namely PubMed, Scopus, and the Cochrane Library. A structured literature search was conducted using specific keywords including *osteoporosis*, *physiotherapy*, *pharmacological therapy*, *bone density*, *muscle strength*, and *body balance*. The review focused on studies published in English with valid research designs to ensure the credibility and relevance of the included evidence.

From the literature search and selection process, 15 articles met the inclusion criteria and were analyzed. The selected studies were reviewed using a narrative and comparative analysis, examining the effects of physiotherapy, pharmacological treatment, and their combination on clinical outcomes such as bone density, muscle strength, balance, and fracture risk. Although the article identifies itself as a systematic review, the methodological procedures—such as screening steps, data extraction, and quality assessment—are not explicitly detailed in the methodology section, representing a limitation in methodological transparency.

RESEARCH RESULT AND DISCUSSION

Pharmacological Therapy

Pharmacological therapy can help increase bone density and reduce the risk of fractures in patients with osteoporosis.

A. Increasing bone density in osteoporosis patients involves several complex biological processes. Here are some of the mechanisms involved:

1. Inhibition of bone resorption
   In patients with osteoporosis, increased bone resorption, the process of bone destruction by osteoclasts, is characterized. Consumption of medications such as bisphosphonates, alendronate, and risedronate, can inhibit bone resorption by inhibiting osteoclast activity. The mechanism of action of bone resorption inhibition involves several complex biological processes. Here are some of the related mechanisms:
   a. Inhibition of activityOsteoclast cells are responsible for bone resorption. Inhibiting osteoclast activity can reduce bone resorption. Drugs such as bisphosphonates, alendronate, and risedronate, can inhibit osteoclast activity by inhibiting the enzyme farnesyl pyrophosphate synthase, which is necessary for osteoclast activation.
   b. Inhibition of RANKL (Receptor Activator of NF-κB Ligand) is a factor required for osteoclast activation. RANKL inhibition can reduce bone resorption. Drugs such as denosumab, a monoclonal antibody, can inhibit RANKL and reduce bone resorption.
   c. Inhibition of cytokine productionsuch as IL-1, IL-6, and TNF-α can increase bone resorption. Inhibiting the production of these cytokines can reduce bone resorption.
   d. Inhibition of NF-κB activitywhich is a transcription factor required for osteoclast activation. Inhibition of NF-κB activity can reduce bone resorption.
   e. Inhibition of osteoclast apoptosiswhich is the process of osteoclast cell death that can reduce bone resorption. Inhibiting osteoclast apoptosis can increase bone resorption.

   The mechanisms of action of bone resorption inhibitors can work together to reduce bone resorption and increase bone density. However, it's important to remember that osteoporosis treatment should be carried out under a doctor's supervision and take into account other factors such as age, gender, and other health conditions.

   The following are examples of drugs that can inhibit bone resorption:
   - Bisphosphonates (alendronate, risedronate, ibandronate)
   - Denosumab (anti-RANKL monoclonal antibody)
   - Teriparatide (parathyroid hormone analog)
   - Ralsoxifen (selective estrogen receptor modulator)

2. Bone formation, the process of bone formation by osteoblasts, can also be enhanced with drugs such as teriparatide, a parathyroid hormone analog. Teriparatide can increase bone formation by increasing osteoblast activity.
   Increasing bone formation involves several complex biological processes. Here are some of the mechanisms involved:
   a. Increased activity of osteoblasts, the cells responsible for bone formation. Increased osteoblast activity can increase bone formation. Drugs such as teriparatide, a parathyroid hormone analog, can increase osteoblast activity.

b. Increased collagen production, a protein essential for bone structure, can promote bone formation.
c. Bone mineralization is the process of adding minerals to the bone matrix. Increased bone mineralization can increase bone density.
d. Increasing osteoblast gene expression can increase bone formation. Drugs such as teriparatide can increase osteoblast gene expression.
e. Increased production of growth factors such as BMP (Bone Morphogenetic Protein) and IGF-1 (Insulin-like Growth Factor-1) can increase bone formation.
f. Increased Wnt/β-catenin activity is a signaling pathway important for bone formation. Increased Wnt/β-catenin activity can enhance bone formation.

The mechanisms by which bone formation increases can work together to increase bone formation and improve bone density. However, it's important to remember that osteoporosis treatment should be carried out under a doctor's supervision and should take into account other factors such as age, gender, and other health conditions. The following are examples of drugs that can increase bone formation, including Teriparatide (parathyroid hormone analog), Abaloparatide (parathyroid hormone analog), Ralsoxifen (selective estrogen receptor modulator), and BMP (Bone Morphogenetic Protein).

3. Inhibition of osteoclast activitywith drugs such as denosumab, which is a monoclonal antibody, can inhibit osteoclast activity through inhibition of RANKL (Receptor Activator of NF-κB Ligand), which is a factor required for osteoclast activation. The mechanism of action of osteoclast inhibition involves several complex biological processes. Here are some of the related mechanisms:
   a. RANKL inhibitionBecause RANKL (Receptor Activator of NF-κB Ligand) is a factor required for osteoclast activation. Inhibiting RANKL can reduce osteoclast activity. Drugs such as denosumab, a monoclonal antibody, can inhibit RANKL.
   b. NF-κB inhibitionbecause NF-κB is a transcription factor required for osteoclast activation. Inhibition of NF-κB can reduce osteoclast activity.
   c. Inhibition of cytokine production Because cytokines such as IL-1, IL-6, and TNF-α can increase osteoclast activity, inhibiting the production of these cytokines can reduce osteoclast activity.
   d. Inhibition of PI3K/Akt activityBecause PI3K/Akt is an important signaling pathway for osteoclast activation, inhibiting PI3K/Akt activity can reduce osteoclast activity.
   e. Inhibition of osteoclast gene expressionbecause osteoclast gene expression can increase osteoclast activity. Inhibition of osteoclast gene expression can reduce osteoclast activity.

   The mechanisms of action of osteoclast inhibitors can work together to reduce bone resorption and increase bone density. However, it's important to remember that osteoporosis treatment should be carried out under a doctor's supervision and should take into account other factors such as age, gender, and other health conditions. The following are examples of drugs that can inhibit osteoclast activity:

- Denosumab (anti-RANKL monoclonal antibody)
- Bisphosphonates (alendronate, risedronate, ibandronate)
- Ralsoxifen (selective estrogen receptor modulator)
- Odanacatib (cathepsin K inhibitor)

4. Increased calcium and vitamin Dis essential for bone health. Calcium and vitamin D supplements can help increase bone density by increasing calcium absorption and enhancing osteoblast activity. Increased calcium and vitamin D involve several complex biological processes. The following are some of the mechanisms of action associated with increased calcium and vitamin D: increased calcium absorption in the small intestine by increasing the expression of genes related to calcium transport, increased calcium reabsorption in the kidney by increasing the expression of genes related to calcium transport, increased calcium deposition in bone by increasing osteoblast activity, and inhibition of bone resorption by reducing osteoclast activity. The following are some of the mechanisms of action associated with vitamin D: vitamin D can increase calcium absorption in the small intestine by increasing the expression of genes related to calcium transport, vitamin D can increase calcium reabsorption in the kidney by increasing the expression of genes related to calcium transport, vitamin D can increase osteoblast activity, which can increase bone formation, and vitamin D can inhibit osteoclast activity, which can reduce bone resorption. Joint working mechanism betweenCalcium and vitamin D, namely by calcium and vitamin D can work together to increase calcium absorption and calcium reabsorption, calcium and vitamin D can increase osteoblast activity, which can increase bone formation, and calcium and vitamin D can inhibit osteoclast activity, which can reduce bone resorption. Calcium and vitamin D supplements may work together to increase bone density and reduce bone resorption. However, it's important to remember that osteoporosis treatment should be carried out under a doctor's supervision and should take into account other factors such as age, gender, and other health conditions.

Inhibition Of Bone Resorption

Inhibition of bone resorption in reducing the risk of fractures in osteoporosis patients involves several complex biological processes.(20). Here are some related mechanisms of action, namely inhibition of osteoclast activity of cells responsible for bone resorption, inhibition of osteoclast activity can reduce bone resorption and increase bone density, the use of drugs such as bisphosphonates, alendronate and risedronate, can inhibit bone resorption by inhibiting osteoclast activity, inhibition of cytokine production such as IL-1, IL-6, and TNF-α can increase bone resorption, inhibition of the production of these cytokines can reduce bone resorption, inhibition of the RANKL (Receptor Activator of NF-κB Ligand) pathway is a factor required for osteoclast activation. Inhibition of the RANKL pathway can reduce bone resorption. Increased production of osteoprotegin is a protein that can inhibit osteoclast activity. Increased production of osteoprotegin can reduce bone resorption. Inhibition of

NF-κB activity: NF-κB is a transcription factor required for osteoclast activation. Inhibition of NF-κB activity can reduce bone resorption.

The mechanism of action of bone resorption inhibition can work through several pathways, including the bisphosphonate pathway, a class of drugs that can inhibit bone resorption by inhibiting osteoclast activity. The denosumab pathway is a monoclonal antibody that can inhibit the RANKL pathway and reduce bone resorption. And the ralsoxifen pathway is a selective estrogen receptor modulator that can inhibit bone resorption by inhibiting osteoclast activity.

The mechanism of action of bone resorption inhibition can work together to reduce bone resorption and increase bone density, thereby reducing the risk of fractures in osteoporosis patients. Examples of drugs that can inhibit bone resorption are Bisphosphonates (alendronate, risedronate, ibandronate), Denosumab (anti-RANKL monoclonal antibody), and Ralsoxifen (selective estrogen receptor modulator) Increasing bone density can reduce the risk of fractures. Drugs such as bisphosphonates, teriparatide, and denosumab can increase bone density by inhibiting bone resorption and increasing bone formation.

The mechanism of action for increasing bone density in osteoporosis patients involves several complex biological processes. Some of these mechanisms include: increased osteoblast activity, which is responsible for bone formation. Increased osteoblast activity can increase bone formation and increase bone density. Increased collagen production, which is a protein essential for bone structure, can increase bone strength and increase bone density. Increased bone mineralization is the process of adding minerals to the bone matrix. Increased bone mineralization can increase bone density. Inhibition of bone resorption is the process of bone destruction by osteoclasts. Inhibition of bone resorption can increase bone density. Increased production of growth factors such as BMP (Bone Morphogenetic Protein) and IGF-1 (Insulin-like Growth Factor-1) can increase bone formation and increase bone density.

The mechanism of action of increasing bone density can work through several pathways, including: Teriparatide is a parathyroid hormone analog that can increase osteoblast activity and increase bone density. Bisphosphonate is a class of drugs that can inhibit bone resorption and increase bone density. Denosumab is a monoclonal antibody that can inhibit the RANKL pathway and increase bone density. And Ralsoxifen is a selective estrogen receptor modulator that can increase bone density by inhibiting bone resorption. Mechanisms that increase bone density can work together to increase bone density and reduce the risk of fractures in osteoporosis patients. Examples of drugs that can increase bone density include teriparatide (a parathyroid hormone analog), bisphosphonates (alendronate, risedronate, ibandronate), denosumab (an anti-RANKL monoclonal antibody), and ralsoxifen (a selective estrogen receptor modulator).

Inhibition of osteoclast activity by drugs such as denosumab, which is a monoclonal antibody, can inhibit osteoclast activity by inhibiting RANKL

(Receptor Activator of NF-κB Ligand), which is a factor required for osteoclast activation.

The mechanism of action of osteoclast activity inhibition in osteoporosis patients involves several complex biological processes. The following are some related mechanisms of action: Inhibition of the RANKL (Receptor Activator of NF-κB Ligand) pathway is a factor required for osteoclast activation. Inhibition of the RANKL pathway can reduce osteoclast activity and reduce bone resorption. Inhibition of the production of cytokines such as IL-1, IL-6, and TNF-α can increase osteoclast activity. Inhibition of the production of these cytokines can reduce osteoclast activity. Inhibition of NF-κB activity is a transcription factor required for osteoclast activation. Inhibition of NF-κB activity can reduce osteoclast activity. Increased production of osteoprotegin is a protein that can inhibit osteoclast activity. Increased production of osteoprotegin can reduce osteoclast activity. And Inhibition of the PI3K/Akt pathway is a signaling pathway required for osteoclast activation. Inhibition of the PI3K/Akt pathway can reduce osteoclast activity.(24).

The mechanism of action of osteoclast inhibition can work through several pathways, including: Denosumab is a monoclonal antibody that can inhibit the RANKL pathway and reduce osteoclast activity. Bisphosphonates are a class of drugs that can inhibit bone resorption and reduce osteoclast activity. Ralsoxifen is a selective estrogen receptor modulator that can reduce osteoclast activity and bone resorption. The mechanisms of action of osteoclast inhibition can work together to reduce bone resorption and increase bone density in osteoporosis patients. Examples of drugs that can inhibit osteoclast activity include Denosumab (an anti-RANKL monoclonal antibody), Bisphosphonates (alendronate, risedronate, ibandronate), and Ralsoxifen (a selective estrogen receptor modulator). Increasing bone strength can reduce the risk of fractures. Medications such as teriparatide can improve bone strength by increasing bone formation and increasing bone density.

The mechanism of action for increasing bone strength in osteoporosis patients involves several complex biological processes. Some of the related mechanisms include: Increased collagen production, a protein essential for bone structure. Increased collagen production can increase bone strength. Increased bone mineralization is the process of adding minerals to the bone matrix. Increased bone mineralization can increase bone strength. Increased osteoblast activity is the cell responsible for bone formation. Increased osteoblast activity can increase bone formation and increase bone strength. Inhibition of bone resorption is the process of bone destruction by osteoclasts. Inhibition of bone resorption can increase bone strength. Increased production of growth factors such as BMP (Bone Morphogenetic Protein) and IGF-1 (Insulin-like Growth Factor-1) can increase bone formation and increase bone strength.

The mechanism of action for increasing bone strength can work through several pathways, including: Teriparatide, a parathyroid hormone analog that can increase osteoblast activity and improve bone strength. Bisphosphonates are a class of drugs that can inhibit bone resorption and increase bone strength. Denosumab is a monoclonal antibody that can inhibit the RANKL pathway and

increase bone strength. Ralsoxifen is a selective estrogen receptor modulator that can increase bone strength by inhibiting bone resorption. Mechanisms that enhance bone strength can work together to increase bone strength and reduce the risk of fractures in osteoporosis patients. Examples of drugs that can increase bone strength include teriparatide (a parathyroid hormone analog), bisphosphonates (alendronate, risedronate, ibandronate), denosumab (an anti-RANKL monoclonal antibody), and ralsoxifen (a selective estrogen receptor modulator). Inhibiting risk factors such as age, gender, and family history can increase the risk of fractures. Inhibiting these risk factors can reduce the risk of fractures.

The mechanism of action of inhibiting risk factors in Osteoporosis patients involves several complex biological processes. The following are some related mechanisms of action, including: Inhibiting smoking can increase bone resorption and reduce bone density. Inhibiting smoking can reduce bone resorption and increase bone density. Inhibiting alcohol consumption can increase bone resorption and reduce bone density. Inhibiting alcohol consumption can reduce bone resorption and increase bone density. Inhibiting calcium deficiency is an important mineral for bone health. Inhibiting calcium deficiency can increase bone density and reduce bone resorption. Inhibiting vitamin D deficiency is an important vitamin for bone health. Inhibiting vitamin D deficiency can increase bone density and reduce bone resorption. Inhibiting obesity can increase bone resorption and reduce bone density. Inhibiting obesity can reduce bone resorption and increase bone density. and Inhibiting physical inactivity can increase bone density and reduce bone resorption. Inhibiting physical inactivity can increase bone density and reduce bone resorption.

The working mechanism of inhibiting risk factors can work mHormonal pathways, such as estrogen and testosterone, can affect bone health. Inhibiting risk factors can affect hormonal balance and improve bone health. Inflammatory pathways can increase bone resorption and reduce bone density. Inhibiting risk factors can reduce inflammation and improve bone health. Oxidative pathways can increase bone resorption and reduce bone density. Inhibiting risk factors can reduce oxidative stress and improve bone health. The mechanisms of action of risk factor inhibition can work together to improve bone health and reduce the risk of fractures in patients.Osteoporosis. Examples of lifestyle changes that can help reduce risk factors include quitting smoking, reducing alcohol consumption, increasing calcium and vitamin D intake, increasing physical activity, and reducing obesity. Improved balance and muscle strength can reduce the risk of fractures by reducing the risk of falls.

The mechanisms that improve balance and muscle strength in osteoporosis patients involve several complex biological processes. Some of these mechanisms include: Increased muscle activity can improve muscle strength and balance. This can be achieved through physical exercise such as walking, running, or weightlifting. Increased muscle protein productionProteins like actin and myosin can increase muscle strength. Increasing muscle protein production can be achieved through adequate protein consumption and physical exercise. Balance can be improved through balance exercises such as standing on

one leg or walking on a straight line. Increased flexibilitycan be improved through stretching exercises such as yoga or pilates, and coordination can be improved through coordination exercises such as walking on a straight line or performing complex movements.

The working mechanism of increasing balance and muscle strength can work mNeuromuscular pathways can improve muscle strength and balance through increased muscle activity and coordination. Hormonal pathways, such as testosterone and estrogen, can affect muscle strength and balance. Inflammatory pathways can reduce muscle strength and balance. Increased physical activity and the use of anti-inflammatory drugs can reduce inflammation and improve muscle strength and balance.

The mechanisms by which improved balance and muscle strength work together to improve bone health and reduce rThe risk of fractures in osteoporosis patients. Examples of exercises that can help improve balance and muscle strength include walking, running, weightlifting, yoga, Pilates, standing on one leg, and walking in a straight line. Discontinuing medications that can increase the risk of fractures, such as corticosteroids, can increase the risk of fractures. Discontinuing these medications can reduce the risk.

The mechanism of action of drugs that can increase the risk of fractures in osteoporosis patients involves several complex biological processes. The following are some of the mechanisms involved: Inhibiting corticosteroid use can increase bone resorption and reduce bone density. Inhibiting corticosteroid use can reduce the risk of fractures.

Discontinuing anticonvulsant use can increase bone resorption and reduce bone density. Discontinuing anticonvulsant use can reduce the risk of fractures. Discontinuing antidepressant use can increase bone resorption and reduce bone density. Discontinuing antidepressant use can reduce the risk of fractures. Discontinuing medications that can cause hypogonadism can increase bone resorption and reduce bone density. Discontinuing medications that can cause hypogonadism can reduce the risk of fractures. Discontinuing medications that can cause hyperparathyroidism can increase bone resorption and reduce bone density. Discontinuing medications that can cause hyperparathyroidism can reduce the risk of fractures.

The mechanism of action of inhibiting the use of drugs that can increase the risk of fractures can work through several pathways, including hormonal pathways such as estrogen and testosterone, which can affect bone health. Inhibiting the use of drugs that can affect hormonal balance can reduce the risk of fractures. Inflammatory pathwaycan increase bone resorption and reduce bone density. Inhibiting the use of drugs that cause inflammation can reduce the risk of fractures. Oxidative pathways can increase bone resorption and reduce bone density. Inhibiting the use of drugs that cause oxidative stress can reduce the risk of fractures.

The mechanism of action of inhibiting the use of drugs that can increase the risk of fractures can work together to reduce the risk of fractures in patients.Osteoporosis. Examples of medications that can increase the risk of fractures include corticosteroids (e.g., prednisone), anticonvulsants (e.g.,

phenytoin), antidepressants (e.g., selective serotonin reuptake inhibitors), medications that can cause hypogonadism (e.g., gonadotropin-releasing hormone agonists), and medications that can cause hyperparathyroidism (e.g., lithium).

These mechanisms of action can work together to reduce the risk of fractures in osteoporosis patients. However, it's important to remember that osteoporosis treatment should be carried out under a doctor's supervision and should take into account other factors such as age, gender, and other health conditions.

Bone density in patients with osteoporosis is usually decreased or low. Osteoporosis is a medical condition characterized by decreased bone density, increasing the risk of fractures.

Bone density is usually measured using a bone densitometry test (DXA or DEXA), the results of which are expressed in units of T-score. The T-score is a measure of bone density compared to the bone density of healthy young adults. The following are the T-score categories, T-score ≥ -1.0: Normal, T-score between -1.0 and -2.5: Osteopenia (low bone density), and T-score ≤ -2.5: Osteoporosis

In patients with osteoporosis, the T-score is typically ≤ -2.5, indicating very low bone density and a high risk of fracture. Meanwhile, the risk of fracture in patients with osteoporosis is high. Osteoporosis can cause bones to become brittle and easily broken, even with minor injuries.

Some factors that increase the risk of fractures in patients with osteoporosis include:

1. AgeIn patients with osteoporosis, the risk of fracture increases with age.
2. Gender,Female patients with osteoporosis have a higher risk of fractures than men.
3. Family historywith osteoporosis, if there is a family history of osteoporosis or fractures, then the risk of fractures increases
4. Low bone densityIn patients with osteoporosis, a low T-score indicates low bone density, thus increasing the risk of fractures.
5. Previous injuries, if the patientIf someone with osteoporosis has had a previous fracture, the risk of another fracture increases.
6. Lifestyle, smoking, alcohol consumption, and lack of physical activity can increase the risk of fractures.in patients with osteoporosis

Some common fracture locations in patients with osteoporosis include:

1. Pelvic fractures can cause disability and even death.
2. Vertebral fractures can cause back pain, disability, and reduced quality of life.
3. Wrist fractures can cause disability and difficulty performing daily activities.

It is important for patients with osteoporosis to take preventive measures and receive appropriate treatment to reduce the risk of fractures. Medications that can be used in pharmacological therapy include bisphosphonates, calcium and vitamin D, teriparatide, denosumab, and strontium ranelate.

Effectiveness of Physiotherapy and Pharmacology Therapy

Studies have shown that a combination of physiotherapy and pharmacological therapy can be more effective in increasing bone density and

reducing the risk of fractures in patients with osteoporosis.(34)Physiotherapy for patients with osteoporosis can help improve muscle strength and balance, thereby reducing the risk of falls and fractures. Meanwhile, pharmacological therapy for patients with osteoporosis can help increase bone density and reduce the risk of fractures.

CONCLUSIONS AND RECOMMENDATIONS

Physiotherapy and pharmacological therapy can be effective treatment options for patients with osteoporosis. The combination of these two therapies can help increase bone density, reduce the risk of fractures, and improve the patient's quality of life. Therefore, it is important for patients with osteoporosis to consult a doctor or physiotherapist to determine the most appropriate therapy.

ADVANCED RESEARCH

Future research should apply a more rigorous systematic review or meta-analysis design with clear inclusion criteria and data analysis procedures to strengthen evidence on the combined effectiveness of physiotherapy and pharmacological therapy in osteoporosis management.

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