

Physical therapy action mechanisms and effects on pain management*

Mecanismos de ação e efeitos da fisioterapia no tratamento da dor

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SUMMARY

BACKGROUND AND OBJECTIVES: Along time, physical therapy has played an important role in the treatment of painful patients. Several neurophysiological mechanisms have been proposed to explain pain modulation via physical and cognitive behavioral approaches; however they have to be further explored by the physical therapist. This study aimed at reviewing major action mechanisms and effects of physical therapy techniques to manage pain.

CONTENTS: There are studies on the action mechanisms and effects of physical therapy during pain processing stages in the nervous system. To organize information, mechanisms and theories were grouped in peripheral and central stations. Effects, however, were grouped in motor, sympathetic and hormonal systems, psychophysiological factors and placebo.

CONCLUSION: Several mechanisms and effects may be influenced by physical therapy physical and cognitive behavioral techniques, thus contributing to the treatment of painful patients and helping the choice of techniques based on identified clinical mechanisms.

Keywords: Pain, Pain perception, Physical therapy modalities.

RESUMO

JUSTIFICATIVA E OBJETIVOS: A fisioterapia vem ao longo dos anos mostrando um importante papel no

tratamento de pacientes com dor. Diversos mecanismos neurofisiológicos já foram propostos para explicar a modulação da dor por meio de abordagens físicas e cognitivas comportamentais, porém necessitam ser mais bem explorados pelo fisioterapeuta. O objetivo deste estudo foi revisar os principais mecanismos de ação e efeitos das técnicas fisioterapêuticas para o tratamento da dor.

CONTEÚDO: Estudos refletem sobre os mecanismos de ação e efeitos da fisioterapia durante as etapas de processamento da dor no sistema nervoso. Para organizar as informações, os mecanismos e teorias foram agrupados em estações periféricas e centrais. Já os efeitos foram agrupados nos sistemas motor, simpático e hormonal, efeitos psicofisiológicos e placebo.

CONCLUSÃO: Diversos mecanismos e efeitos podem ser influenciados pelas técnicas físicas e cognitivas comportamentais da fisioterapia, contribuindo para o tratamento de pacientes com dor e facilitando a escolha das técnicas com base nos mecanismos clínicos identificados.

Descritores: Dor, Modalidades de fisioterapia, Percepção da dor.

INTRODUCTION

Pain may have several clinical manifestations and be associated to different symptoms. So, some authors have suggested that physical therapists treat pain according to clinical peripheral, central and / or associated mechanisms, identified during evaluation^{1,2}. Understanding and identifying such mechanisms help evaluation judgment and clinical reasoning, treatment and prognosis of patients with pain^{3,4}.

However, to choose the treatment based on clinical mechanisms, physical therapists need to have scientific and practical knowledge⁴. Each technique has a neurophysiological explanation with its own action mechanisms. Physical therapy treatments use the specific knowledge about the effect of the techniques

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for clinical applicability. It is important to determine predominant pain mechanism for physical therapy to be more effective⁴.

Among primary objectives, inhibitory pain modulation will occur with the decrease of peripheral and central stimuli which sensitize the nervous system⁵. In addition, biopsychosocial factors provoking or perpetuating sensitization should be identified by physical therapists⁶.

Mechanisms and theories have been proposed to explain the effects of physical therapy on pain control and handling. These involve local peripheral tissues, neurophysiological and psychophysiological mechanisms, and the placebo effect. They are currently based on pain processing stages in the nervous system and on neuroplasticity changes. So, we will discuss the action of physical therapy on modulation and perception stages,

on peripheral stations, on spinal cord dorsal horn, on descending suppressor system and on cerebral cortex. In addition, techniques effects will be discussed on the motor, sympathetic and hormonal systems by means of psychophysiological and placebo effects. Chart 1 shows theories, action mechanisms and effects of some techniques on the nervous system.

This study aimed at reviewing major action mechanisms and effects of physical therapy techniques for pain handling. For such, scientific articles indexed by Pubmed and Bireme from 2000 to 2011 were queried.

PERIPHERY

Any technique having contact with the skin and mobilizing tissues activates Ab mechanoreceptor fibers, which are faster than C and Aδ fibers, and interneurons

Chart 1 – Action mechanisms and peripheral, central and associated effects of physical therapy.

| Peripheral | Central | Associated |
|--|--|---|
| <p>Somatic and visceral tissues</p> <ul style="list-style-type: none"> • Competitive inhibition e.g.: any technique with contact with skin and / or mobilizing tissues • Removal of mechanical irritating agents e.g.: manual joint therapy, bandages, posture alignment techniques • Removal of chemical irritating agents e.g.: massage, ultrasound, laser, muscle contraction, stretching, tissue mobilization | <p>Spinal cord dorsal horn</p> <ul style="list-style-type: none"> • Counter-irritating effect e.g.: acupuncture, dry needling, manual therapy grades III and IV, ice spray, deep warming ointments, miofascial release • Gates theory e.g.: massage, skin brushing, TENS, acupuncture <p>Descending suppressor system</p> <ul style="list-style-type: none"> • Opioid activation e.g.: aerobic and / or regular exercises, TENS, acupuncture, relaxation • Non-opioid activation e.g.: joint and muscular therapy, strength exercises <p>Cerebral cortex</p> <ul style="list-style-type: none"> • Cortical reorganization e.g.: functional training, strengthening, mirror Box, motor control, <i>biofeedback</i> • Psychophysiological e.g.: touch, physical exercise, education • Placebo e.g.: all physical therapy techniques | <p>Motor system</p> <ul style="list-style-type: none"> • Neuromuscular balance • Behavioral changes e.g.: manual therapy, physical exercise, motor control, activity grading and operating conditioning. • Sympathetic system • Autonomic balance Anxiety control e.g.: painless manual therapy, diaphragmatic breathing, deep relaxation • Hormonal system • Hormonal balance Stress control e.g.: regular physical exercise, repairing sleep, perform pleasant activities |

TENS = transcutaneous electric nerve stimulation.

of lamina IV in spinal cord dorsal horn, in the so-called competitive inhibition³. Skin touch may be a powerful modulator, and proprioceptive stimuli speed may help the inhibition of painful stimuli in the central nervous system (CNS).

In cases such as complex regional pain syndrome (CRPS) or in other peripheral nerve injuries, physical therapy uses skin stimulation with materials of different textures to increase tolerance to touch, decreasing hyperalgesia and allodynia⁷. It is known that mechanical and chemical factors are responsible for the sensitization of peripheral nociceptors.

So, it is necessary to remove irritating mechanical and chemical agents to decrease nociceptors sensitization and the arrival of noxious stimuli in upper centers⁸. Examples are manual therapy, muscle contraction techniques, thermotherapy, ultrasound and laser. These techniques are effective for nociceptive pain control, however they should be carefully used for neuropathic pain because they may increase nociceptive sensitization⁹. Other techniques, such as bandages and orthoses promoting joint alignment minimize nociceptors activation and the effects of hysteresis and tissue cavitation¹⁰. Allogenic substances from the acute inflammatory process, from neurogenic inflammation and edema, make difficult tissue repair and have to be removed to control nociceptive pain^{8,10}.

SPINAL CORD DORSAL HORN

With the strong stimulation of dorsal horn medullar laminae directly from the periphery, interneurons are activated to modulate pain in inhibitory way. According to the gates theory, these interneurons depend on the competition between noxious and proprioceptive stimuli.

Since proprioceptive stimulus is faster, its arrival in the dorsal horn will activate interneurons and help the release of opioid substances and GABA^{3,4}. Techniques such as TENS and acupuncture are still based on this theory, although it does not explain several pain mechanisms. In the counter-irritating theory, a painful irritating mechanical, thermal or chemical stimulus is applied to promote pain relief. Studies have shown that the counter-irritating effect is related to opioid substances release; however this is poorly described in the literature of physical therapy modalities¹¹. Acupuncture, ice spray, manual therapy, miofascial release and massage with deep warming ointments are common examples. Applying techniques aiming at this effect depends on the level of tolerance of pa-

tients. For neuropathic pain, increased painful stimuli may have a negative effect on patients⁹.

DESCENDING SUPPRESSION SYSTEM

Neuronal activation in areas of the descending suppression system, such as thalamus, gray periaqueductal matter and raphe nucleus magnus, cause the release of opioid and non-opioid substances^{3,12,13}. Chronic pain patients have difficulty to activate the suppression system due to structural and anatomic nervous system changes^{3,14}.

So, physical therapy techniques may stimulate descending pathways by the lateral (opioid) and ventrolateral (non-opioid) system, releasing inhibitory neurotransmitters. With TENS, joint manipulation, regular physical exercise, aerobic exercise and acupuncture, studies have shown preference for opioid activation with endorphins release^{12,13,15-17}. With general exercises, transcutaneous electric nerve stimulation, manual joint and muscle therapy, studies have shown activation of non-opioid substances such as serotonin, norepinephrine, dopamine, GABA and growth hormone^{12,13,17,18}.

CEREBRAL CORTEX

Recent studies have shown that patients with fibromyalgia, chronic low back pain, SCDR and phantom pain show major structural and functional corticoid changes, such as cortical atrophy and excessive neuronal hyperactivity²⁰⁻²². Within painful neuromatrix concepts, there are changes in areas of movement, sensations, memory and emotions^{5,23}.

This negative cortical reorganization in painful conditions causes distorted pain perception, changing body sensory and motor scheme and leading to laterality problems^{24,26}.

It is believed that such changes help the maintenance of pain, of alertness and of central sensitization^{9,26}. Physical therapy may positively reorganize the cortex through active and integrated modalities with cognitive behavioral approaches.

This has been shown in recent studies with functional resonance and transcranial magnetic stimulation of motor and sensory cortex^{24,26}. Treatments such as motor control, biofeedback, imagetics, mirror therapy, distraction tasks, functional tasks training, physical exercise, muscle strengthening and education strategies, in addition to placebo effect, are able to activate relevant cortical areas for positive cortical reorganization^{16,24,26,27}.

EFFECTS ON OTHER SYSTEMS

Motor

When pain is influenced by motor planning, the muscle system may maintain increased activity even at rest, as if it were functioning to fight, flight or protection^{4,25}. Avoidance and fear behaviors, such as kinesiophobia, cause this abnormal pattern, in addition to anxiety and stress^{28,29}. So, it is necessary to look for neuromuscular function balance through physical and cognitive behavioral approaches which will be commented below. Literature shows that manual therapy with joint mobilization at the cervical region decreases superficial muscles activity and helps the activation of deep stabilizing muscles. It is suggested that this response is due to decreased stimuli of alpha and gamma motor neurons, by stimulation of tendinous organs through joint mobilization^{30,31}. However, painful manual therapy causes protective muscle hyperactivity in patients with low tolerance to skin pressure, such as in neuropathic pain^{3,12}.

Sympathetic

Physical therapy techniques applied around sympathetic nervous system (SNS) structures may cause neurovegetative phenomena such as sweating, changes in skin color, tachycardia, anxiety and fear^{19,31,32}. So, painful techniques should be carefully used. In addition, patients with pains associated to SNS activation mechanisms have a constant release of norepinephrine and prostaglandins, which potentiates the action of several organs, including muscles, maintaining constant muscle hyperactivity⁵.

Autonomic nervous system balance depend on factors such as minimizing painful stimuli with physical therapy, minimizing fear and anxiety and the use of techniques to decrease SNS hyperactivity, such as deep relaxation, diaphragmatic breathing training and painless manual therapy.

Hormonal

Studies have shown that hormonal unbalance is a sensitization factor^{5,9}. Hormones, such as growth hormones, have a critical role in pain modulation. Decreased testosterone, estrogen and progesterone have been the subject of still poorly conclusive studies. On the other hand, norepinephrine and cortisol, when constantly released, cause muscle hyperactivity throughout the body and maintenance of alertness^{5,9}. Regular physical exercises, improved sleep quality, adequate feeding and enjoyable activities may be a way to look for the balance of such hormones and decrease central sensitization.

PSYCHOPHYSIOLOGICAL EFFECTS

Physical therapy and psychology go hand in hand. Physical interventions associated to cognitive behavioral approaches promote interesting responses. Both touch and exercise produce motor, autonomic, neuroendocrine, emotional, behavioral and corporal perception responses regulated by the limbic system. Responsible for the organization of somatic expressions of emotional states and experiences, the limbic system is highly relevant for painful patients^{5,9}. Due to major structural and functional nervous system changes and associated to emotional and behavioral factors, some persistent pain patients become intolerant to touch and exercise^{25,28}.

Passive techniques, that is, applied by the physical therapist, have fast however short analgesic effect, varying from some hours to weeks. In addition to already described neurophysiological effects, responses will directly depend on patients' interpretation of the manual stimulus on their bodies. In patients with pain, body touch may bring enjoyable sensations such as relaxation, well being and relief, but also negative sensations such as fear of pain, muscle tension, irritation, anxiety and worsening of symptoms^{28,29}. For example, although manual therapy has direct action on primary hyperalgesia and indirect action on secondary hyperalgesia and allodynia, skin pressure may be uncomfortable for sensitized patients. So, techniques using touch, such as manual therapy, are not always the best first choice.

Active techniques, on the other hand, that is, those performed by the patient with or without physical therapist help, have long-term analgesic effects. Some patients may take months to feel the analgesic effects. Keeping the example of the exercises, it is known that they are a modulation source, especially in people performing regular exercises^{16,29}. Exercises, in addition to releasing analgesic substances, promote functional autonomy. For patients with major limitations, function gain encourages the change of abnormal pain-related behaviors, increasing self-efficacy, motivation, well-being and satisfaction. On the other hand, the association of the exercise to pain or injury favors behaviors such as avoidance and fear, kinesiophobia, isolation and immobility^{28,29,34,35}.

Physical therapists should be educator therapists, regardless of choosing passive or active techniques²⁷. Education strategies to fight dysfunctional beliefs, abnormal behaviors, negative thoughts and attitudes are able to modulate pain and increase functional capacity of patients^{27,33}. Associated to other cognitive behavioral techniques, such as pacing of activities, they encourage

patients to be active participants of their healthcare, being able to understand chronic pain, its impact on health and recover pain control^{127,33,34}.

PLACEBO

All physical therapy techniques have placebo effect. Authors have shown that passive techniques, such as electrotherapy and manual therapy may have variations of 5% to 100% in placebo effect, depending on the study methodology. However, it is believed that approximately 30% of patients have symptoms improvement^{25,36}. Authors believe that the explanations for the analgesic mechanisms of the placebo effect are more related to the classic conditioning role and to psychological factors. Among explanations, there are expectations and positive beliefs about efficacy and symptoms relief, decreased anxiety and desire to improve. Authors discuss the associated opioid substances release^{25,36}. The placebo effect is still a mystery for physical therapists, however patients may benefit for a short period of time. It is important to remember that physical therapists are prohibited to use the placebo effect in their clinical practice.

Attention and concern with patients' health status, combined with the desire to improve, optimism and the way to deal with pain are independent effects of physical therapy techniques^{26,37}. The best result for pain management is expected when there is integration among physical modalities, cognitive behavioral approaches such as education, and with the help of other health professionals^{27,33,38}.

CONCLUSION

Different mechanisms and effects may be influenced by physical therapy physical and cognitive behavioral techniques, contributing for the treatment of painful patients and helping the choice of techniques based on identified clinical mechanisms.

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