

Introduction

Defined as an unpleasant sensory and emotional experience associated with, or resembling that associated with, actual or potential tissue damage,^[1] pain is not only a symptom of disease but a recognised medical condition in its own right.^[2,3] It represents a complex and multifaceted phenomenon at the intersection of physiology and psychology. Its chronic form is characterised by discomfort persisting beyond the typical healing period – defined as three months or more.^[4] Chronic pain broadly encompasses both primary pain syndromes (e.g., fibromyalgia) as well as pain secondary to an underlying disease or injury such as osteoarthritis or postherpetic neuralgia,^[5] and is estimated to affect over 27 million adults in the UK.^[6] As a result, the condition has a considerable economic impact in terms of treatment costs and the loss of productivity^[7] but the most compelling argument for treating pain is the humanitarian one. Pain is an immediately recognisable emotional phenomenon that transcends cultural boundaries; its universal regard as a negative experience establishes that its alleviation is therefore moral and worthwhile.

Chronic pain is challenging to treat successfully. Most current pharmacological therapies are ineffective,^[8] and many have adverse effects which worsen quality of life.^[9,10] Paradoxically, some even worsen pain. Opioids for example may lead to hyperalgesia,^[11] a phenomenon in which a person becomes sensitised to pain and experiences it to a greater degree. Owing to a growing recognition of the limited effectiveness of conventional pharmacological approaches, it is becoming increasingly important to explore alternative strategies to address chronic pain. This essay examines one such approach – Tai Chi – and explores its efficacy, application, and feasibility as a treatment modality for chronic pain.

What is Tai Chi?

Tai Chi is an ancient Chinese martial art based on gentle, flowing, circular patterns of movement (Figure 1). Inspired by avian elegance and feline agility observed in nature, its choreography combines dynamic routines with static postures, placing strict emphasis on faithful replication of these movements. Instruction manuals also emphasise the importance of internal thought and imagery to guide focus, such as “*the breath is even... [and] the heavenly pull is always maintained.*”^[12] A central concept during these routines is that the body remains light and agile despite being placed under strain, a phenomenon referred to

Meditation in motion: Tai Chi and its effects on chronic pain

as *Song*, loosely translated as relaxation but more accurately described as a balanced state of tone.^[13] What results is a unique form of meditative exercise that both demands and develops focus, balance, and proprioception.



Figure 1. Painting depicting various patterns of movement (*taolu*), found in Chenjiagou, a village situated in the Henan Province of Northern China, home of the Chen style of Tai Chi. Image credit: CC BY 4.0.

Tai Chi's original name is *taijiquan*, a romanised compound of *tai* (supreme), *ji* (pole, ultimate), and *quan* (fist).^[15] While this directly translates to an impactful-sounding supreme ultimate fist, the supreme ultimate instead refers to a higher understanding of the universe (*taiji*) which is then applied to the fist in martial arts form. Tai Chi's movement sequences involve harnessing the power of these principles that govern the natural world. Its core philosophy bases itself around the harmonising yet mutually opposing interactions of yin and yang (Figure 2), a core principle of the religion of Taoism.^[15] To elaborate, the Taoist belief is that *taiji* gives rise to yin and yang. Yang increases with motion and activity, yielding to stillness when at its maximum, at which point yin begins to build. Stillness similarly reaches its threshold and movement is again initiated. The two continue in opposing but

complementary actions in perpetuity. Tai Chi, using its understanding of the duality of yin and yang, guides movement to concentrate the body's internal energy to cultivate yang, leading to restfulness and tranquillity. This philosophy is exemplified in its fighting techniques; Tai Chi as a style emphasises softness, acceptance, and redirection of attacks rather than meeting an opposing force head-on.

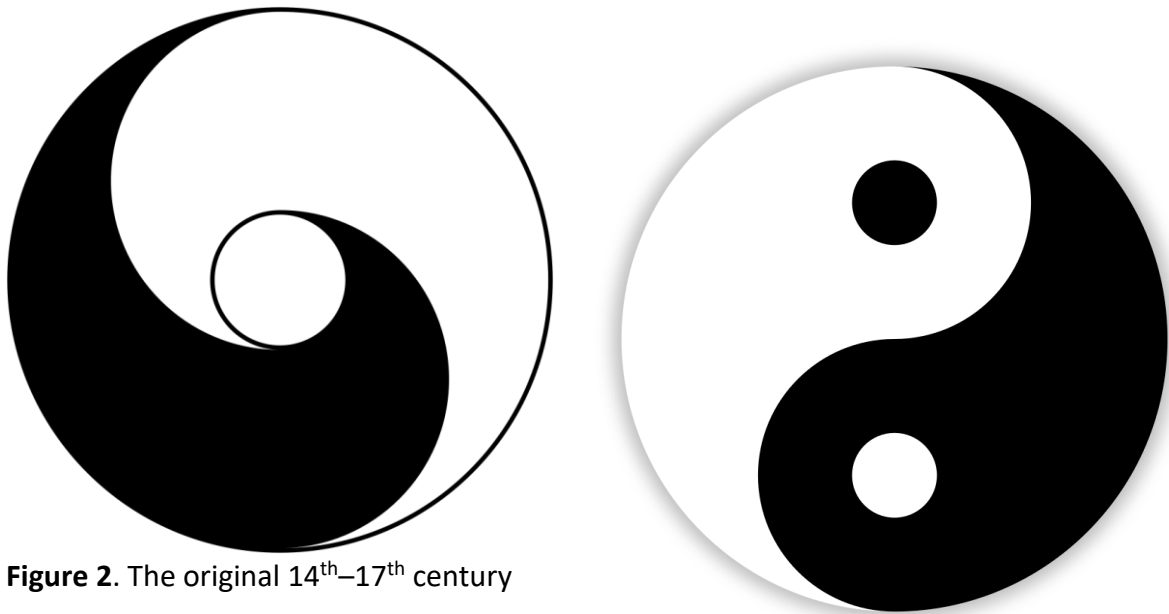


Figure 2. The original 14th–17th century *taijitu* (left) and its more modern and recognisable adaptation (right). Both depict the mutual interaction of the two opposing forces of yin and yang, the guiding philosophy of Tai Chi. Image credits: CC BY 4.0.

So, how can an ancient Chinese martial art help manage chronic pain? Despite historical scepticism by the mainstream medical community, complementary and alternative therapies – such as acupuncture – have long offered hope to chronic pain sufferers for whom conventional medical treatment has been unsuccessful. However, the evidence base for many of these alternative therapies is poor,^[16] though the same may be stated for the role of Western therapeutics in chronic pain management.^[8] Yet, there are examples of modern medications that derive from ingredients historically used in herbal medicine. The antimalarial drug artemisinin, for example, is isolated from sweet wormwood, a plant from the *Artemisia* genus known in China as *qinghao*^[17] and used for millennia in traditional Chinese medicine.^[18] While not a herbal remedy, the esoteric Eastern spiritual origins of Tai Chi might similarly attract scepticism. Despite its mystical philosophy and association with

mist-covered mountains (Figure 3), the martial art focuses on practical sequences of movements and meditation which may have direct application for the alleviation of chronic pain.



Figure 3. Taoist monastery atop the Wudang Mountains, a sacred site in Taoist religion renowned for the practice of Tai Chi. Image credit: CC BY 4.0, photograph by Seth Kramer.

Foundational Tai Chi practices focus on sequences of gentle weight-bearing movements emphasising meditation, deep abdominal breathing, and range of motion. Meditation and mindfulness may focus the mind and improve psychological wellbeing.^[19] Controlled, rhythmic abdominal respiration can modulate the autonomic nervous system,^[20] and movement patterns may increase balance, flexibility, and posture. Each of these will be discussed at length; however, to appreciate how changes in these phenomena may ameliorate chronic pain, it is first necessary to outline the intricate and interconnected physiology and psychology of pain.

The pain pathway

Pain serves as the body's internal alarm system, functioning to alert an organism to potential tissue damage and facilitate avoidance behaviours to prevent further harm.^[21] Nociceptive signals are transmitted from peripheral receptors (e.g., in the skin) along peripheral nerves into the central nervous system, where they are ultimately processed by the brain.^[22] Throughout this transmission pathway, the signals can be modulated at various stages. For instance, it is common practice to rub or apply pressure to injured areas. This action generates additional sensory impulses which may block or inhibit some of the nociceptive signals,^[23] thereby reducing the perceived intensity of the pain.

At their final destination, sensory impulses may be perceived differently based on several factors including mood, overall wellbeing, and prior experiences with pain.^[24,25] An individual who is anxious, unwell, or otherwise distressed may experience heightened pain perception.^[26] Conscious interpretation of the pain's meaning also directly influences its severity.^[27] For example, muscle soreness the day following an intense workout is often perceived as less distressing despite its severity, because it is interpreted as a normal and beneficial consequence of exercise. The pain is understood, reducing anxiety about its meaning and subsequently dampening the emotional, suffering component of pain.^[28] The term "soreness" itself reflects this perception, indicating a milder experience compared with more distressing causes of pain. In contrast, if the same level of pain were to be felt following surgery, trauma, or in association with cancer, it may well be perceived as more severe. This phenomenon underscores the critical role of cognitive interpretation in modulating the perceived intensity of pain.

Tai Chi and the mind-body connection

In chronic pain, the mind-body connection becomes dysregulated. In a susceptible individual, peripheral pain sensitivity – an initial physiological response to injury – can lead to central sensitisation through a series of maladaptive neurobiological changes. These include the upregulation of excitatory glutamate receptors and downregulation of inhibitory γ -aminobutyric acid receptors in the spinal cord,^[29] as well as the structural and functional cerebral adaptations made in response to chronic neuroinflammation.^[22] Importantly, this does not imply that the pain is psychological in origin; rather, chronic pain is increasingly recognised as a condition involving dysfunction of the mind-body connection.

Tai Chi possesses many benefits that can address this dysfunction. Individuals who regularly perform Tai Chi exercises have modified activity in the parietal and prefrontal cortices,^[30] areas associated with pain processing and emotional health.^[31] In one study of patients with chronic lower back pain, regular Tai Chi reduced the negative association ascribed to the pain,^[32] highlighting that although the pain sensation was not eliminated, the brain's understanding and interpretation of the pain was altered. This is in line with guidance from prominent pain management organisations which emphasise that the goal of treatment should not be to eliminate chronic pain entirely, but rather to manage it to a degree sufficient to maintain an acceptable quality of life.^[33]

Neuropsychological mechanisms of Tai Chi's analgesic effect

Tai Chi has been shown to alleviate symptoms of depression, anxiety, and mental stress across a range of age groups, both in healthy individuals and in those with chronic illnesses.^[8,34-37] Additionally, it enhances positive emotions, improving happiness and contentment among those performing the exercises regularly.^[8,36] The underlying mechanisms are multifactorial. Tai Chi promotes self-efficacy and self-belief, both of which are strongly correlated with emotional wellbeing.^[38] While the sequences of movements associated with Tai Chi may be performed solo, they are often undertaken in a group setting which is well-established to improve psychological wellbeing,^[39] particularly among older adults who are more at risk of social isolation.^[40]

Often described as meditation in motion, Tai Chi places a strict emphasis on attention, focus and deep breathing during movements, helping its participants to cultivate a state of mindfulness. This mindfulness component has been demonstrated to directly modulate psychological health by decreasing feelings of low mood.^[41] A state of mindfulness enables the noticing of pain without necessarily ascribing to it meaningful significance, potentially empowering those with chronic pain to achieve greater control over their symptoms. Furthermore, the use of evocative imagery in the design and practice of Tai Chi movements – “*the white crane spreads its wings*,” “*embrace tiger and return to mountain*” (Figure 4) – not only provides a distraction from pain but has been shown to directly reduce feelings of depression and increase positive emotion.^[42]



Figure 4. Tai Chi group practice in central China, undated. Image credit: CC BY 4.0.

Several neurological mechanisms exist to explain the utility of Tai Chi for pain relief. Physical exercise in general has a well-documented impact on psychological wellbeing,^[43] which is closely linked to the modulation of pain interpretation. Exercise induces the release of endorphins – a portmanteau of endogenous morphine used to describe naturally occurring opioid neuropeptides – which directly suppress pain signals and elevate mood.^[44] In concordance with the monoamine hypothesis – the theory that depression and other mood disorders are caused by a functional deficiency in catecholamines^[45] – neurotransmitters such as dopamine and serotonin released during exercise may contribute to reduced anxiety and depression,^[46] with mood-enhancing effects that can persist long after cessation of activity.^[47] Additionally, Tai Chi has been associated with increased levels of brain-derived neurotrophic factor,^[48] a protein which is often decreased in individuals with clinical depression,^[49] though it merits noting that other forms of exercise increase this protein as well.^[50]

Modulation of the autonomic nervous system

Pain switches on the sympathetic nervous system, increasing anxiety, respiratory rate, heart rate, and blood pressure.^[51] In the short term, this physiological response is a positive adaptation, as it alerts an organism to bodily harm and focuses the mind and body to recognise and respond to a potential threat. However, sympathetic nervous system activation is present even in the setting of chronic pain which typically manifests as increased blood pressure (and the sequelae thereof) as well as sustained levels of anxiety, which itself can worsen pain perception in a perpetual cycle. Tai Chi reduces sympathetic activity and increases parasympathetic tone,^[20] promoting relaxation of both the mind and body. This parasympathetic shift leads to reductions in heart rate and blood pressure,^[52,53] and also alleviates feelings of anxiety,^[53] which in turn can improve pain control. Individuals in a more relaxed psychological state experience less severe pain,^[54] not because the pain is eliminated, but because perception and interpretation of the pain is altered.

As with many forms of mindfulness, the deep, regular abdominal breathing that accompanies Tai Chi exercises alters intrathoracic pressure and directly increases vagal tone on expiration,^[55] which not only contributes to a state of calmness but may directly inhibit pain signalling.^[56] There is also evidence to suggest that the increases in vagal tone persist over a longer-term period outside of the exercise window,^[57] providing evidence of the lasting relaxation effect of Tai Chi. Furthermore, the stress-relieving effects of Tai Chi can be measured biochemically. Salivary cortisol is a biomarker of the activity of the hypothalamic-pituitary-adrenal axis, a neuroendocrine pathway activated during stress and illness.^[58] The fluid movements, deep breathing and gentle exercise of Tai Chi have been shown to reduce salivary cortisol,^[59] providing evidence of its efficacy for relieving not only psychological but physiological stress as well.

Inflammation, immunity, and pain relief

Tai Chi exercise has been shown to be effective for the management of multiple different forms of chronic pain, including lower back pain,^[60] osteoarthritis,^[61] rheumatoid arthritis,^[62] and fibromyalgia.^[63] However, improvements in pain are difficult to measure. The numerical 0-10 pain scale, for instance, is subject to considerable inter-individual variability and exhibits poor intra-rater reliability.^[64] A more reliable and arguably more practical measure of pain is its impact on functional ability. In the aforementioned chronic

conditions, the regular practice of Tai Chi not only reduced pain but improved disability scores and increased physical function. Other benefits include improved balance and protection against falls,^[65,66] as well as reduced inflammation and improved immunity.

The immunotherapeutic benefits of Tai Chi are highlighted in a 2007 study in which Tai Chi not only reduced the severity of postherpetic neuralgia but increased the levels of immunity against the varicella zoster (shingles) virus.^[67] Notably, Tai Chi was found to be nearly as effective as the varicella zoster vaccine at boosting immunity and, when combined with the vaccine, resulted in higher immunoglobulin levels compared to the vaccine alone.^[67] Tai Chi may also reduce inflammatory markers which are positively correlated with pain sensitivity and psychological ill health. For example, after a Tai Chi intervention there are decreased levels of inflammatory mediators C-reactive protein^[68] and interleukin-6.^[69] The well-established link between a proinflammatory state and increased pain sensitivity^[70] suggests that interventions with systemic anti-inflammatory effects may facilitate pain relief via this mechanism.

Risks and drawbacks

Tai Chi is a safe, low-impact exercise modality with a relatively low risk of injury. Nevertheless, adverse events have been reported in the literature. Initial increases in back, hip, and knee pain may occur upon starting a new Tai Chi regimen,^[60,71] although most of these symptoms resolve after a few weeks of the training programme. This indicates that there may be an initial flare-up of pain symptoms which resolves with continued activity. Despite its gentle and fluid movements, many Tai Chi exercises are performed with the knee in a flexed position with the quadriceps engaged, placing strain on the quadriceps and patellar tendons as well as the ligaments of the knee.^[72] Movements may also involve torsion at the knee with a fixed foot, subjecting the knee to shearing forces which may pose a risk for individuals with pre-existing ligamentous injury. Moreover, for an increasingly comorbid population, the prospect of embarking on an exercise programme may give pause to those with chronic disease. However, Tai Chi is an exercise of low cardiovascular intensity and the evidence shows it can be undertaken safely by individuals with low levels of fitness including those with chronic cardiovascular, pulmonary, and musculoskeletal disease.^[73]

Conclusion

Tai Chi was founded on the principles of yin and yang, balance, and harmony. Lao Tzu, the founder of Taoism on which Tai Chi is based, stated that the “*soft and gentle overcome the hard and rigid.*”^[74] Tai Chi relies on anticipating an opponent’s hard force before yielding and redirecting rather than meeting with opposing force. This principle is an excellent allegory for the treatment of chronic pain, which may be conceptualised as a hard force that will itself not respond to the similarly rigid opposition of pharmacological management. Thus, perhaps there is a role for the soft, fluid, and meditative motions of Tai Chi to enable patients to meet, accept, and redirect the opposing force of chronic pain.

References

1. International Association for the Study of Pain. IASP Announces Revised Definition of Pain, <https://www.iasp-pain.org/publications/iasp-news/iasp-announces-revised-definition-of-pain/> (2020, accessed 10 September 2024).
2. World Health Organisation. ICD-11 for Mortality and Morbidity Statistics, <https://icd.who.int/browse/2024-01/mms/en> (2024, accessed 10 September 2024).
3. Faculty of Pain Medicine. UK Pain Key Messages, <https://fpm.ac.uk/patients/uk-pain-key-messages> (2024, accessed 10 September 2024).
4. Dydyk AM, Conermann T. Chronic Pain. Treasure Island (FL): StatPearls Publishing; 2019.
5. Treede RD, Rief W, Barke A et al. Chronic pain as a symptom or a disease: the IASP Classification of Chronic Pain for International Classification of Diseases (ICD-11). *Pain* 2019;160(1):19-27.
6. Fayaz A, Croft P, Langford RM et al. Prevalence of chronic pain in the UK: a systematic review and meta-analysis of population studies. *BMJ Open* 2016;6(6):e010364.
7. Stubhaug A, Hansen JL, Hallberg S et al. The costs of chronic pain – Long-term estimates. *European Journal of Pain* 2024;28(6):960-977.
8. Shetty A, Delanerolle G, Cavalini H et al. A systematic review and network meta-analysis of pharmaceutical interventions used to manage chronic pain. *Scientific Reports* 2024;14(1):e1621.
9. Derry S, Bell RF, Straube S et al. Pregabalin for neuropathic pain in adults. *Cochrane Database of Systematic Reviews* 2019;1(1):e007Q76.
10. Paul AK, Smith CM, Rahmatullah M et al. Opioid Analgesia and Opioid-Induced Adverse Effects: A Review. *Pharmaceuticals* 2021;14(11):e1091.
11. Yi P, Pryzbylkowski P. Opioid Induced Hyperalgesia. *Pain Medicine* 2015;16(1):32-36.
12. Chia M, Li J. The Inner Structure of Tai Chi: Mastering the Classic Forms of Tai Chi Chi Kung. Rochester, VT: Destiny Books; 2005.
13. Osypiuk K, Thompson E, Wayne PM. Can Tai Chi and Qigong Postures Shape Our Mood? Toward an Embodied Cognition Framework for Mind-Body Research. *Frontiers in Human Neuroscience* 2018;12(1):e174.
14. Zheng G, Xiong Z, Zheng X et al. Subjective perceived impact of Tai Chi training on physical and mental health among community older adults at risk for ischaemic

- stroke: a qualitative study. *BMC Complementary Medicine and Therapies* 2017;17(1):e221.
15. Liu HH, Nichols C, Zhang H. Understanding Yin-Yang Philosophic Concept Behind Tai Chi Practice. *Holistic Nursing Practice* 2023;37(5):75-82.
 16. Eigenschink M, Dearing L, Dablander TE et al. A critical examination of the main premises of Traditional Chinese Medicine. *Wiener Klinische Wochenschrift* 2020;132(9-10):260-273.
 17. Graziose R, Lili MA, Raskin I. Merging Traditional Chinese Medicine with Modern Drug Discovery Technologies to Find Novel Drugs and Functional Foods. *Current Drug Discovery Technologies* 2010;7(1):2-12.
 18. Li Y, Wu YL. An over four millennium story behind qinghaosu (artemisinin)—a fantastic antimalarial drug from a traditional Chinese herb. *Current Medicinal Chemistry* 2003;10(21):2197-2230.
 19. Jahnke R, Larkey L, Rogers C et al. A Comprehensive Review of Health Benefits of Qigong and Tai Chi. *American Journal of Health Promotion* 2010;24(6):1-25.
 20. Motivala SJ, Sollers J, Thayer J et al. Tai Chi Chih acutely decreases sympathetic nervous system activity in older adults. *Journals of Gerontology. Series A, Biological and Medical Sciences* 2006;61(11):1177-1180.
 21. Chen J, Kandle PF, Murray IV et al. *Physiology, Pain*. Treasure Island (FL): StatPearls Publishing; 2023.
 22. de Ridder D, Adhia D, Vanneste S. The anatomy of pain and suffering in the brain and its clinical implications. *Neuroscience & Biobehavioural Reviews* 2021;130(1):125-146.
 23. Melzack R, Wall PD. Pain Mechanisms: A New Theory. *Science* 1965;150:3699.
 24. Michaelides A, Zis P. Depression, anxiety and acute pain: links and management challenges. *Postgraduate Medicine* 2019;131(7):438-444.
 25. Yoo H, Cho Y, Cho S. Does past/current pain change pain experience? Comparing self-reports and pupillary responses. *Frontiers in Psychology* 2023;14(1):e1094903.
 26. Bushnell MC, Čeko M, Low LA. Cognitive and emotional control of pain and its disruption in chronic pain. *Nature Reviews Neuroscience* 2013;14(1):502-511.
 27. Leknes S, Berna C, Lee MC et al. The importance of context: When relative relief renders pain pleasant. *Pain* 2013;154(3):402-410.

28. Meints SM, Edwards RR. Evaluating Psychosocial Contributions to Chronic Pain Outcomes. *Progress in Neuropsychopharmacology and Biological Psychiatry* 2018;87(2):168-182.
29. Greenwald JD, Shafritz KM. An Integrative Neuroscience Framework for the Treatment of Chronic Pain: From Cellular Alterations to Behaviour. *Frontiers in Integrative Neuroscience* 2018;12(1):e00018.
30. Kang H, Yang M, Li M et al. Effects of different parameters of Tai Chi on the intervention of chronic low back pain: A meta-analysis. *PLoS One* 2024;19(7):e0306518.
31. Yao Y, Ge L, Yu Q et al. The Effect of Tai Chi Chuan on Emotional Health: Potential Mechanisms and Prefrontal Cortex Hypothesis. *Evidence Based Complementary and Alternative Medicine* 2021;2021(1):e5549006.
32. Hall AM, Kamper SJ, Emsley R et al. Does pain-catastrophising mediate the effect of tai chi on treatment outcomes for people with low back pain. *Complementary Therapies in Medicine* 2016;25(1):61-66.
33. Faculty of Pain Medicine. Core Standards for Pain Management Services in the UK, Second Edition, <https://www.britishpainsociety.org/static/uploads/resources/files/FPM-Core-Standards-2021.pdf> (2021, accessed 10 September 2024).
34. Burschka JM, Keune PM, Oy UH et al. Mindfulness-based interventions in multiple sclerosis: beneficial effects of Tai Chi on balance, coordination, fatigue and depression. *BMC Neurology* 2014;14(1):e165.
35. Zhang J, Qin S, Zhou Y et al. A randomised controlled trial of mindfulness-based Tai Chi Chuan for subthreshold depression adolescents. *Neuropsychiatric Disease and Treatment* 2018;14(1):2313-2321.
36. Li F, Duncan TE, Duncan SC et al. Enhancing the psychological well-being of elderly individuals through tai chi exercise: a latent growth curve analysis. *Structural Equation Modelling: A Multidisciplinary Journal* 2001;8(1):53-83.
37. Zhang S, Zou L, Chen LZ et al. The Effect of Tai Chi Chuan on Negative Emotions in Non-Clinical Populations: A Meta-Analysis and Systematic Review. *International Journal of Environmental Research and Public Health* 2019;16(17):e3033.
38. Nedeljkovic M, Wepfer V, Ausfeld-Hafter B et al. Influence of general self-efficacy as a mediator in Taiji-induced stress reduction – Results from a randomised controlled trial. *European Journal of Integrative Medicine* 2013;5(3):284-290.

39. Kanbara S, Taniguchi H, Sakaue M et al. Social support, self-efficacy and psychological stress responses among outpatients with diabetes in Yogyakarta, Indonesia. *Diabetes Research & Clinical Practice* 2008;80(1):56-62.
40. Sebastião E, Mirda D. Group-based physical activity as a means to reduce social isolation and loneliness among older adults. *Aging Clinical and Experimental Research* 2021;33(7):2003-2006.
41. Sephton SE, Salmon P, Weissbecker I et al. Mindfulness meditation alleviates depressive symptoms in women with fibromyalgia: results of a randomised clinical trial. *Arthritis and Rheumatism* 2007;57(1):77-85.
42. Wayne PM, Kaptchuk TJ. Challenges inherent to t'ai chi research: part I—t'ai chi as a complex multicomponent intervention. *Journal of Alternative and Complementary Medicine* 2008;14(1):95-102.
43. Scully D, Kremer J, Meade MM et al. Physical exercise and psychological well being: a critical review. *British Journal of Sports Medicine* 1998;32(2):111-120.
44. Chaudhry SR, Gossman W. Biochemistry, Endorphin. Treasure Island (FL): StatPearls Publishing; 2023.
45. Heninger GR, Delgado PL, Charney DS. The revised monoamine theory of depression: a modulatory role for monoamines, based on new findings from monoamine depletion experiments in humans. *Pharmacopsychiatry* 1996;29(1):2-11.
46. Craft LL, Perna FM. The Benefits of Exercise for the Clinically Depressed. *The Primary Care Companion to the Journal of Clinical Psychiatry* 2004;6(3):104-111.
47. Mikkelsen K, Stojanovska L, Polenakovic M et al. Exercise and mental health. *Maturitas* 2017;106(1):48-56.
48. Sungkarat S, Boripuntakul S, Kumfu S et al. Tai Chi Improves Cognition and Plasma BDNF in Older Adults With Mild Cognitive Impairment: A Randomised Controlled Trial. *Neurorehabilitation and Neural Repair* 2018;32(2):142-149.
49. Porter GA, O'Connor JC. Brain-derived neurotrophic factor and inflammation in depression: Pathogenic partners in crime. *World Journal of Psychiatry* 2022;12(1):77-97.
50. Naveen GH, Thirthalli J, Rao MG et al. Positive therapeutic and neurotropic effects of yoga in depression: A comparative study. *Indian Journal of Psychiatry* 2013;55(3):400-404.
51. Hamunen K, Kontinen V, Hakala E et al. Effect of pain on autonomic nervous system indices derived from photoplethysmography in healthy volunteers. *British Journal of Anaesthesia* 2012;108(5):838-844.

52. Wolf SL, O'Grady M, Easley KA et al. The influence of intense Tai Chi training on physical performance and haemodynamic outcomes in transitionally frail, older adults. *Journals of Gerontology. Series A, Biological and Medical Sciences* 2006;61(2):184-189.
53. Tsai JC, Wang WH, Chan P et al. The beneficial effects of Tai Chi Chuan on blood pressure and lipid profile and anxiety status in a randomised controlled trial. *Journal of Alternative and Complementary Medicine* 2003;9(5):747-754.
54. Goli Z, Asghari A, Moradi A. Effects of Mood Induction on the Pain Responses in Patients with Migraine and the Role of Pain Catastrophising. *Clinical Psychology and Psychotherapy* 2016;23(1):66-76.
55. Lu WA, Kuo CD. The Effect of Tai Chi Chuan on the Autonomic Nervous Modulation in Older persons. *Medicine and Science in Sports and Exercise* 2004;35(12):1972-1976.
56. Forte G, Troisi G, Pazzaglia M et al. Heart Rate Variability and Pain: A Systematic Review. *Brain Sciences* 2022;12(2):e153.
57. Wei GX, Li YF, Yue XL et al. Tai Chi Chuan modulates heart rate variability during abdominal breathing in elderly adults. *Psychiatric Journal* 2016;5(1):69-77.
58. Miller WL. The Hypothalamic-Pituitary-Adrenal Axis: A Brief History. *Hormone Research in Paediatrics* 2018;89(4):212-223.
59. Nedeljkovic N, Ausfeld-Hafter B, Streitberger K et al. Taiji practice attenuates psychobiological stress reactivity—a randomised controlled trial in healthy subjects. *Psychoneuroendocrinology* 2012;37(8):1171-1180.
60. Hall AM, Maher CG, Lam P et al. Tai chi exercise for treatment of pain and disability in people with persistent low back pain: a randomised controlled trial. *Arthritis Care & Research* 2011;63(11):1576-1583.
61. Kang JW, Lee MS, Posadzki P et al. T'ai chi for the treatment of osteoarthritis: a systematic review and meta-analysis. *BMJ Open* 2011;1(1):e000035.
62. Wang C. Tai Chi improves pain and functional status in adults with rheumatoid arthritis: results of a pilot single-blinded randomised controlled trial. *Medicine and Sport Science* 2008;52(1):218-229.
63. Peng PWH. Tai chi and chronic pain. *Regional Anaesthesia & Pain Medicine* 2012;37(4):372-382.
64. Haefeli M, Elfering A. Pain assessment. *European Spine Journal* 2006;15(1):17-24.
65. Jacobson BH, Chen HC, Cashel C et al. The effect of T'ai Chi Chuan training on balance, kinesthetic sense, and strength. *Perceptual and Motor Skills* 1997;84(1):27-33.

Meditation in motion: Tai Chi and its effects on chronic pain

66. Lomas-Vega R, Obrero-gaitán E, Moline-Ortega F et al. Tai Chi for Risk of Falls. A Meta-analysis. *Journal of the American Geriatrics Society* 2017;65(9):2037-2043.
67. Irwin MR, Olmstead R, Oxman MN. Augmenting immune responses to varicella zoster virus in older adults: a randomised, controlled trial of Tai Chi. *Journal of the American Geriatrics Society* 2007;55(4):511-517.
68. Lavretsky H, Altstein L, Olmstead RE et al. Complementary Use of Tai Chih Augments Escitalopram Treatment of Geriatric Depression: A Randomised Controlled Trial. *American Journal of Geriatric Psychiatry* 2011;19(10):839-850.
69. Irwin MR, Olmstead R. Mitigating Cellular Inflammation in Older Adults: A Randomised Controlled Trial of Tai Chi Chih. *American Journal of Geriatric Psychiatry* 2012;20(9):764-772.
70. Zhang JM, An J. Cytokines, Inflammation and Pain. *International Anaesthesiology Clinics* 2007;45(2):27-37.
71. Brismée JM, Paige RL, Chyu MC et al. Group and home-based tai chi in elderly subjects with knee osteoarthritis: a randomised controlled trial. *Clinical Rehabilitation* 2007;21(2):99-111.
72. Wayne PM, Berkowitz DL, Litrownik DE et al. What do we really know about the safety of tai chi? A systematic review of adverse event reports in randomised trials. *Archives of Physical Medicine and Rehabilitation* 2014;95(12):2470-2483.
73. Chen YW, Hunt MA, Campbell KL et al. The effect of Tai Chi on four chronic conditions—cancer, osteoarthritis, heart failure and chronic obstructive pulmonary disease: a systematic review and meta-analyses. *British Journal of Sports Medicine* 2016;50(1):397-407.
74. Lao Tzu. *Tao Te Ching* [Mitchell S trans.]. New York: Harper Collins; 1992.