OPEN ACCESS

Current Research in Complementary & Alternative Medicine

Field T. Curr Res Complement Altern Med 7: 220.

www.doi.org/10.29011/2577-2201.100220

www.gavinpublishers.com

GAVIN PUBLISHERS

Review Article

Exercise for Reducing Pain and Stress: A Narrative Review

Tiffany Field*

University of Miami/Miller School of Medicine and Fielding Graduate University, USA.

***Corresponding author:** Tiffany Field, University of Miami/Miller School of Medicine and Fielding Graduate University, USA.

Citation: Field T (2023) Exercise for Reducing Pain and Stress: A Narrative Review. Curr Res Cmpl Alt Med 7: 220. DOI: 10.29011/2577-2201.100220

Received Date: 7 December 2023; **Accepted Date:** 18 December 2023; **Published Date:** 20 December 2023

Abstract

This narrative review of research includes summaries of 62 papers on exercise for reducing pain and stress that were published during the years 2018 to 2023. The publications of this period are primarily randomized controlled trials and systematic reviews/ meta-analyses of randomized controlled trials. Many of these are focused on exercise reducing low back pain and fibromyalgia. Other pain conditions include neck, knee and shoulder pain. Surprisingly, only one study appeared in this literature on arthritis, although it is reputedly the second most prevalent form of pain next to low back pain. Some of the researchers compared different forms of exercise including resistance training, aerobics and lower intensity exercise, as in yoga and Pilates, and the findings on exercise intensity are mixed. Many researchers have addressed potential underlying biological mechanisms for exercise effects including increased parasympathetic and dopaminergic activity and decreased inflammation, oxidative stress and pro-inflammatory cytokines including IL-6 and C-reactive protein. Methodological problems relate to the assessment of combined exercise styles and their differing intensity and the more frequent measurement of negative effects as in pain and stress, although the mechanism studies highlight the positive physiological effects of exercise.

This narrative review involved entering the terms exercise, pain and stress and the years 2018-2023 into PubMed and PsycINFO. Although the search yielded 1408 papers for the last five years. exclusion criteria, including case studies, non-English papers and study protocols, reduced the number to 62 papers. The recent literature on exercise for pain and stress features studies on reducing low back pain, neck pain, knee osteoarthritis pain and fibromyalgia pain. Underlying mechanism research on exercise effects suggests increased parasympathetic and dopaminergic activity and decreased inflammation, oxidative stress, and pro-inflammatory cytokines including IL-6 and C-reactive protein. Methodological limitations relate to the assessment of combined exercise styles and their differing intensity and the more frequent measurement of negative effects as in pain and stress, although the mechanism studies highlight the positive physiological effects of exercise. This narrative review is accordingly divided into sections on adult pain conditions, potential underlying biological mechanisms and methodological limitations of the literature.

Pain in Chronic Clinical Conditions

Back Pain

Back pain and rheumatoid arthritis are supposedly the most prevalent sources of chronic pain. In a paper, entitled "A study from a highly populated country: Risk factors associated with low back pain", the prevalence of low back pain was 44% (N= 3005 participants in Indonesia) [1]. In a paper, entitled "The prevalence of low back pain among medical students in Saudi Arabia", a significantly higher prevalence was noted at 94% [2]. In this sample of 300 medical students, low back pain was related to sitting more than eight hours and not engaging in exercise. The high prevalence also relates to specifically recruiting for low back pain. More predictor studies of this kind would help inform this literature on exercise effects.

Although only one study appeared in the exercise literature on arthritis, several studies have focused on exercise for back pain. In a review of 19 trials (N=2362 participants) on low intensity forms of exercise for nonspecific low back pain including walking, cycling and swimming, only a small effect was noted for walking/running compared to no intervention or minimal intervention [3].

In a randomized controlled trial (N=60), isokinetic exercise was compared with conventional exercise for soccer players [4]. The isokinetic exercise (treadmill or stationary bike) was more effective in decreasing pain intensity and kinesiophobia (excessive, irrational and debilitating fear of movement or physical activity). Positive changes also occurred in glucose, insulin,growth hormone, prolactin, ACTH and cortisol. The data on negative effects of kinesiophobia suggest that it needs to be controlled in exercise studies. This study also suggests that comparisons might be made between isokinetic, isometric, and isotonic exercise. In addition, it might have been more interesting to assess the effects of the soccer exercise itself. This literature is relatively lacking in naturalistic exercise assessments, except for the research on walking steps. It's also unclear why variables like glucose and insulin were measured. The growth hormone and cortisol measures were likely included to assess reduction in stress.

In a paper on another relatively low intensity exercise called qigong, a randomized controlled trial was conducted with a group of office workers experiencing chronic nonspecific low back pain (N=73) [5]. The sessions lasted one hour per week for six weeks. The participants were also encouraged to practice at home every day which was a potentially confounding factor that was not measured. Compared to a waitlist control group, the qigong group had lower pain intensity and functional impairment as well as increased range of motion, core muscle strength, and reduced heart rate and respiratory rate. This study was exemplary for its diversity of outcome measures.

Yoga has also been effective for reducing stress and pain in a randomized controlled trial on adults who had suffered low back pain for five years or more (N= 80) [6]. In this comparison between exercise for low back pain and yoga, these exercise forms were practiced for one hour per day three times per week for 16 weeks. Yoga was more effective than the specific low back exercise for reducing stress, anxiety and depression and for increasing spinal flexion, spinal extension, as well as right and left lateral flexion. If yoga is more effective for reducing low back pain, it is not clear why researchers are designing exercise programs for low back pain. Yoga would affect more spinal muscles than those located in the lower back and would require more concentration or focus on the multiple yoga poses that could then distract from feelings of stress, anxiety and depression.

In a review of randomized controlled trials (N= 18 trials), yoga was compared to physical therapy, exercise and non-exercise on pain reduction [7]. Yoga and physical therapy reduced low back pain at 4 weeks, at three months, and at a 6-to-7-month follow-up assessment.

In contrast, yoga was less effective than other types of exercises in a review on 217 randomized controlled trials (N=20,969 participants) [8]. In this review, Pilates, McKenzie therapy (prone pushups with therapy bands), and functional restoration (a comprehensive care program focused on chronic pain) were more effective than yoga and stretching for reducing chronic low back pain.

Kegel exercises or pelvic floor strengthening have also been called the bridge pose in yoga. At least two reviews have summarized data on this form of exercise for low back pain. In one of these reviews, 19 randomized controls were included (N= 456 intervention participants and 470 controls) [9]. The significant predictor variable for low back pain reduction was the number of weeks that the exercises were performed.

The second review included 33 studies on exercise for low back pain (N=9588 participants) [10]. The studies on stretching of the trunk, pelvis and legs versus relaxation and postural exercise resulted in lower back pain intensity. Supervised training was the most effective.

Resistance training has been compared to aerobics in a meta-analysis on six studies on low back pain (N =333 participants) [11]. Both types of exercise led to reduced pain, although resistance training also increased psychological well-being. It would appear that almost any exercise reduces pain, but the potential underlying mechanisms for exercise effects have not been compared, for example, for aerobic versus resistance training.

In a randomized controlled trial, resistance training was compared to resistance training plus core exercise for low back pain (N =38) [12]. The resistance training plus core exercise that was practiced over four weeks led to an increase in trunk flexor and extensor strength and reduced stress, low back pain, BMI, and creatine kinase. Combining two forms of exercise would be expected to have greater effects than one form.

High intensity training has been compared with low intensity training for low back pain and has yielded mixed findings. In a randomized controlled trial (N= 51), for example, high intensity training was compared to low intensity training [13]. Two weeks of high intensity training two times per week led to a decrease in central sensitization to pain. The training also led to reduced stress on the Perceived Stress Scale and reduced pain on a numeric pain rating scale. The authors concluded that the objective and subjective measures were consistent, but it's not clear whether the decreases reported related to reduced pain per se or an increased threshold to pain. Also, the training, which basically included general resistance and increased strength training, was confounded by the exercise therapy that was also provided. In addition, limited data were presented on the specific frequency and intensity of the exercise protocol.

One of the only negative findings in this research literature was a study suggesting that exercise led to lower back pain levels, but also increased cortisol levels [12]. In this randomized controlled trial (N =85 exercise participants and 84 control participants), the exercise protocol was practiced for six weeks. Typically, reduced pain is accompanied by a reduction in cortisol, making these findings difficult to interpret. These data may highlight both the positive (decrease in low back pain) and stressful (increased cortisol) effects of exercise. The study is also a good example of group comparisons, as well as having physical, physiological and biochemical outcome variables. However, the sample (N=38) is relatively small for the number of outcome variables.

Neck Pain

Neck pain has also been reduced by various exercises. In a recent randomized controlled trial ,for example, Therabands were used for multiple different stretches in all directions and compared to trapezius massage in patients with chronic neck pain (N= 41) [14]. The exercises were practiced five times per week for four weeks. The decrease in pain and the increase in range of motion were greater for the exercise protocol versus the trapezius massage.

In contrast, in a systematic review on massage therapy effects on sports and exercise performance, massage therapy increased flexibility, muscle force and strength 48 hours after massage [15]. It also reduced pain and late onset muscle soreness, which was correlated with a decrease in creatinine kinase, depression, stress, anxiety, and fatigue.

In another randomized controlled trial on office workers with chronic non – specific neck pain (N= 60), physical exercise and ergonomic modifications were practiced twice per week for eight weeks [16]. Based on the Neck Disability Index, pain intensity and functional disability were decreased as well as work-related stress at four and at eight weeks following the intervention. Ergonomic modifications could easily be added to exercise studies for their additive effects.

Two systematic reviews of recent randomized controlled studies on exercise for neck pain have appeared in the recent literature. In one of the systematic reviews (N =26 randomized controlled trials including 2288 patients), two of the exercise protocols were the most effective [17]. These included motor control, which involved lifting the head gradually from a supine position and segmental exercises, which included moving the head in lateral and vertical directions from a position of being on your hands and knees. A second systematic review was conducted on 75 studies [18]. In this review, the frequency and duration of exercise sessions per week contributed to the reduced pain. There is a definite need for more data on the intensity, frequency and duration of different forms of exercise, as well as whether exercises are focused on the locus of pain.

Shoulder Pain

Shoulder pain has also been the focus of a couple studies on exercise for pain reduction. In a randomized controlled trial, for example, 80 adults from Korea greater than 60 years of age were given a 12-week program using elastic bands [19]. Not only was there a reduction in shoulder pain, but also an increase in shoulder range of motion and muscle thickness. As in most of these exercise-for-pain studies, the reduction in pain was accompanied by decreased stress.

In another randomized controlled study (N= 30), lower extremity aerobic exercise was used to decrease shoulder pain [20]. Mechanically induced moderate intensity pressure was applied to the shoulder. Before and after 10 minutes of this stimulation, lower extremity exercise on a recumbent exercise machine was used as the intervention. Surprisingly, the lower extremity exercise reduced shoulder pain. That lower extremity exercises helped decrease shoulder pain was a surprising result. That the institutional review board approved research on pain induction was also surprising.

Knee Osteoarthritis Pain

Exercises for knee osteoarthritis pain have ranged from recording steps to actively engaging adults in exercise protocols. In a study on steps per day, associations were noted between psychological characteristics of people with knee osteoarthritis and their activity (N=167) [21]. Greater average number of steps per day over seven days was associated with less fear of movement and less pain catastrophizing. The reverse direction could also be happening here with the fear of movement and pain catastrophizing leading to activity avoidance. More studies are needed on natural unsupervised exercise like walking and the number of steps measured.

In another study, three groups of aerobic exercise combined with resistance training were compared for their effects on pain and function in patients with knee osteoarthritis pain (N=78) [22]. The three groups included resistance training plus 1) treadmill, 2) cycle ergometer (apparatus for measuring activity), or 3)arm ergometer. After eight weeks, all 3 groups had less pain, although the treadmill group had better performance on the "timed up and go test" and the arm ergometer group had greater pain relief and sports performance. That the treadmill was used in only a couple studies is surprising, as it is the most common home exercise machine.

In a review of exercise and educational interventions on adult knee osteoarthritis, 20 studies were included (N=2350) [23]. Decreased pain was reported in those studies that combined exercise with education on physical activity.

Fibromyalgia

Fibromyalgia has also responded to various intensity exercises. In a randomized controlled trial (N= 37), home exercise was paired with progressive muscle relaxation [24]. The participants experienced reduced pain as well as decreased fatigue, stress, systolic blood pressure, diastolic blood pressure and pulse rate. These results, like many others from exercise studies, likely resulted from stimulation of pressure receptors leading to increased vagal activity and the release of serotonin as an anti-pain neurotransmitter [25]. Vagal activity may be a potential underlying mechanism for the exercise effects.

In another randomized controlled study (N=62), a form of qi gong, comprised of eight simple movements, was provided for one hour two times a week for 12 weeks [26]. This protocol resulted in a decrease in pain and tender points in adults with fibromyalgia symptoms.

In a study on physical exercise for women with fibromyalgia (N= 32), low intensity exercise, including endurance training and coordination, was provided for eight weeks [27]. Decreases were reported for pain perception, pain catastrophizIng, anxiety, depression and stress. These results were attributed to increased pain thresholds, although pain thresholds were not assessed (as they are for a fibromyalgia diagnosis itself). And, the relative decrease in pain perception versus pain catastrophizing was also not measured.

Three systematic reviews/meta-analyses have been performed on studies involving aerobics for adults with fibromyalgia. In one meta-analysis of 16 trials, the Fibromyalgia Impact Questionnaire was used to measure pain [28]. These aerobics protocols were combined with exercise training sessions that were 30 to 60 minutes across 13 to 24 weeks. Aerobics combined with exercise training yielded the best effects.

In a systematic review and meta-analysis that was conducted on PubMed and Cochrane library on studies published between 2020 and 2021 (18 studies on 1184 subjects), aerobics decreased pain and depression and increased quality of life [29]. This review suggested that stretching also decreased pain and depression and increased quality of life.

In still another review on aerobics for adults with fibromyalgia including nine randomized controlled trials, aerobics was effective for pain management in patients with fibromyalgia [30]. The results of this review suggested that aerobics had similar effects to those of Pilates. Both aerobics and Pilates were more effective than stretching for reducing pain in fibromyalgia patients. That aerobics, Pilates and muscle strengthening were more effective than stretching for reducing pain in fibromyalgia probably relates to greater stimulation of pressure receptors during those exercises that would then lead to a reduction of substance P that causes pain in fibromyalgia [31].

A few studies on exercise with fibromyalgia have included immune measures. In one of these on a 15-week resistance training protocol, decreased pain was noted along with increased muscle strength [32]. Circulating proteins related to immunity, stress, mRNA stability, metabolic processes and muscle structure development were also affected.

In a review paper entitled "Acute effects of physical exercise on the inflammatory markers of patients with fibromyalgia", three resistance training and three aerobics studies were included [33]. The results of the studies suggested greater concentrations of IL-8 and TNF-alpha (pro-inflammatory cytokines), but also increased IL-10 (anti-inflammatory cytokines). Unfortunately, the interpretation of these opposite effects was ambiguous but these mixed results, both pro-inflammatory and anti-inflammatory cytokines, suggest once again that exercise has both therapeutic and stressful effects.

Miscellaneous Pain Conditions

Chronic pain conditions that only appeared once or twice in this literature include rheumatoid arthritis, stroke, PTSD and insomnia. In a study on rheumatoid arthritis, exercise therapy was given for more than 12 weeks and a decrease in disease activity was noted in addition to reduced pain [34]. Positive effects were also reported for inflammatory and respiratory activity as well as oxidative stress. More sophisticated analyses are needed to determine the variance explained on outcome variables and the differential effects of exercise on those outcomes. For example, some effects are highly related such as inflammation and oxidative stress, and together they might be expected to explain a significant amount of the outcome variance [34].

In the only study on children in this recent literature on exercise for pain and stress, lower scores were noted on physical activity in children with juvenile rheumatoid arthritis versus normal children (N.=82) [35]. Based on the Physical Activity Questionnaire for Children and Adolescents and a Juvenile Arthritis Disease score, these children showed a significant decrease in physical activity across a 24-month period, which was related to an increase in disease duration. That children with rheumatoid arthritis who have less activity have a longer disease duration highlights the expression of “no pain, no gain.”

In a randomized controlled study on chronic stroke pain patients, aquatic therapy was explored for the reduction in pain (N=45) [36]. Participants were randomly assigned to an aquatic ai chi (aquatic therapy) group, a physiotherapy plus ai chi and a physiotherapy only control group. Both therapy groups showed a reduction in pain. Exercise plus standard treatment versus exercise versus standard treatment alone would be expected to be optimal as it includes two therapies versus one therapy. Also, having three self-report measures as in perceived pain, stress, and quality of life is not as optimal as a self-report plus a more objective physiological measure.

In a review study entitled “Is exercise/physical activity effective at reducing symptoms of post-traumatic stress disorder in adults”, 13 randomized controlled trials covering seven different exercise interventions (N= 531 patients) from four countries were included [37]. The most effective exercise was a combination of resistance training, aerobics, strength training, and yoga. These exercise protocols were offered for a 12-week period of 30-60-minute classes held three times a week. This study highlights the relationship between the pain and stress pathways in the brain. The results of nine studies documenting the relationship between post-traumatic stress syndrome and persistent pain are compelling evidence for the relationship between stress and pain.

In a randomized controlled trial (N=299), exercise was compared to an active control group for pain associated with insomnia [38]. The exercise group experienced a decrease in insomnia and anxiety while depression decreased in both the exercise and active control groups. It is interesting that in many studies that used an active control group, no differences emerged between the exercise and the active control group, likely because they are both receiving the benefits of activity.

In a randomized controlled trial comparing online exercise and a self–management guide, adults with chronic pain participated for eight weeks (N= 80) [39]. At the end of the intervention and at a 12 -week follow-up, the online exercise group showed reduced pain on several measures including the Brief Pain Inventory, the Self–efficacy Questionnaire, the Pain Disability Index, and the Pain Catastrophizing Scale.

In a systematic review on several forms of exercise for several different chronic pain conditions, 202 randomized controlled trials were reviewed [40]. The participants included patients with moderate pain intensity ranging from three months to greater than 15 years. For low back pain, a short- term reduction in pain was noted following massage, yoga, conventional exercise, acupuncture, and spinal manipulation. For intermediate effects, exercise, massage and yoga were effective. For neck pain, laser therapy, exercise, including muscle performance, mobility, muscle reeducation and aerobics were effective. For knee osteoarthritis, exercise and ultrasound reduced pain. For hip osteoarthritis, conventional exercise was the most effective. For fibromyalgia, three forms of exercise were effective including conventional, tai chi, and qi gong. For chronic tension headache, spinal manipulation and laser acupuncture were the most effective forms of therapy. It is not surprising that exercise was effective for all chronic pain conditions. That different forms of exercise were effective for different chronic pain conditions may relate to researchers’ different exercise selections.

Therapy	Condition	First Author
	Low Back Pain	
Low intensity (walking, cycling, swimming)		Pocoviet
Isokinetic (treadmill or stationary bike)		Nambi
Qigong		Phattharasupharlerk
Yoga		Singphoro, Zhu, Hayden
Kegel exercises (pelvic floor strengthening)		Kazeminia, Quentin
Resistance training and aerobics		Wewege
Resistance training plus core exercise		Barros Dos Santos
High intensity training		Verbugghe
	Neck Pain	
Therabands		Kang
Physical exercise and ergonomic modifications		Alshehre
Lifting head and segmental exercises		Price
Miscellaneous		Polaski
	Shoulder Pain	
Elastic bands		Lee
Lower extremity aerobic exercise		Wassinger
	Knee Osteoarthritis Pain	
Walking steps per day		Uritani
Aerobics plus resistance training		Kabiri
Miscellaneous		Sasaki
	Fibromyalgia	
Home exercise		Yoo
Qi gong		Joao
Endurance training and coordination		Izquierdo-Alventosa
Aerobics		Albuquerque, Couto, Manojlovic
Pilates		Manojlovic
Resistance training		Whalen, Andrade
	Rheumatoid Arthritis	
Exercise therapy		Zongpan, Heale
	Chronic Stroke Pain	
Aquatic therapy		Perez de La Cruz
	Post-traumatic Stress Disorder Pain	
Resistance training, aerobics, strength training, yoga		Jadhakhan
	Chronic Pain	
Online exercise		Deegan, Skelly

Table 1: Chronic pain conditions, therapies and first authors.

COVID Effects on Exercise and Pain

A couple studies in this literature addressed the effects of COVID on exercise and pain. In one study (N= 310 hospital staff), a reduction in activity was noted during COVID [41]. The reduction in activity was accompanied by an increase in pain and anxiety. Those with regular activity were less unhappy. The happiness scale versus measures of depression may be more representative of exercise effects.

In another study on the impact of the COVID-19 pandemic on physical activity, patients with Parkinson's disease (N= 498 from the Netherlands) were assessed for activity level [42]. 47% of the patients with Parkinson's were less physically active since the start of COVID and less physical activity was correlated with worse Parkinson's symptoms including rigidity, fatigue, tremor, pain, and concentration.

In a large international multicenter study (N =3194), COVID effects on physical exercise and pain were assessed in six countries including Brazil, Italy, France, Portugal, Germany, and Spain [43]. 80% of the participants lived in isolation. Significant predictors of inactivity were work, countries, smoking, isolation, and physical exercise levels. The countries that were most affected were Brazil and Italy. This study is an unusual cross-cultural multicenter study on social isolation. It highlights not only the cross-cultural differences in social isolation effects of COVID lockdowns, but also the positive effects of physical exercise during isolation.

Qualities of Exercise for Pain Reduction

Several different qualities of research have been studied including the pain threshold, the locus of the exercise, the intensity and being in an upright posture. In a meta-analysis on pain intensity being reduced by exercise, 15 studies were included [44]. This meta- analysis revealed that exercise is more effective than non-exercise interventions such as pain education, stress management and massage. Exercise was noted to increase the pressure pain threshold and was more effective when directed at the locus of pain.

In a paper entitled "No pain, no gain? Recovery and strenuousness of physical activity", two studies were conducted [45]. In the first study, a 10-day daily diary was kept on the time spent in exercise and its intensity level (N=74). In the second study after a stress - inducing task, a 20-minute moderate intensity cycling exercise was given or a 20-minute-high intensity cycling exercise (N=44). The higher intensity cycling led to less stress and rumination about the stressful task. That high intensity exercise leads to less stress and rumination highlights the distraction effects of exercise.

In another study, posture was varied during walking exercise [46]. In this study, healthy adults (N=73) were randomly assigned to a slumped or an upright posture while walking. The upright posture led to less pain, sleepiness and negative affect. That walking was included in only a couple studies is surprising inasmuch as it is the most common form of unsupervised exercise.

Qualities	First Author
Intensity, Threshold, Locus of Pain	Belavy
Higher intensity	VanHoof
Upright posture	Hackford

Table 2: Qualities of exercise for pain reduction and first authors.

Potential Underlying Mechanisms

Inflammation and Oxidative Stress

Inflammation induces oxidative stress, which, in turn, can lead to chronic diseases. Both inflammation and oxidative stress have been noted in adults who are sedentary, and exercise is reported to reduce inflammation and oxidative stress.

Exercise has suppressed inflammatory modulators including cytokines and stress hormones, (growth hormone and cortisol) while preventing migraine headaches [47]. In addition to increasing microvascular health, it also decreased depression.

In a review, entitled "The interplay between oxidative stress, exercise and pain in health and disease: Potential role of autonomic regulation and epigenetic mechanisms", the inconsistent literature about inflammation and oxidative stress is discussed [48]. Although exercise is generally noted to reduce oxidative stress, moderate to intense exercise, surprisingly, has the opposite effect of increasing oxidative stress in typically sedentary individuals. If moderate to high intensity exercise leads to oxidative stress in sedentary individuals, low intensity exercise may be needed for them.

In another critical review that addressed exercise and inflammation entitled "Running stress: Neurobiological mechanisms of exercise–induced stress resilience", exercise was noted to attenuate inflammation [49]. The authors suggested that "the energy challenge caused by physical exercise can affect the central nervous system by improving cellular bioenergetics, removing damaged molecules and attenuating inflammation processes as well as stress robustness". They also reported that following stressors there is a reduction in dopamine, norepinephrine and serotonin. Exercise, in contrast, typically has the opposite effects. The energy challenge caused by exercise might also be expected to have negative effects. Surprisingly very few human studies have addressed exercise as preconditioning for subsequent exposure to stress, likely because of concerns about not stressing humans. Most of the research is based on rat and mice studies.

Heartrate Variability

Heart rate variability has been noted to increase following exercise. In a study entitled "Relationship between exercise – induced oxidative stress changes and parasympathetic activity in chronic fatigue syndrome", an increase in vagal activity was noted following a submaximal exercise test [50]. The increase in vagal activity was negatively correlated with oxidative stress, but, surprisingly, only in healthy participants, not in those with chronic fatigue syndrome. That the expected effects like an increase in heart rate variability and a decrease in oxidative stress are correlated after exercise in healthy controls but not those with chronic fatigue syndrome is perplexing. Vagal activity may have been too low in the chronic fatigue syndrome participants for a significant correlation to be noted. That healthy controls experienced a reduction in pain, but no change in oxidative stress was also surprising, although the pain assessment is a subjective measure and the oxidative stress is a more objective variable. This study is a good model for a controlled exercise assessment. The results are suggestive of exercise increasing vagal activity which in turn reduces oxidative stress. That the relationship between exercise and reduced oxidative stress only occurred for the participants with chronic fatigue is difficult to interpret.

In a study on trends in heart rate variability signal analysis, detection of heart rate variability during exercise reached an accuracy rate as high as 85% [51]. However, the low rate of accuracy was only 59%.

Dopaminergic Activation

Research on exercise for pain management in Parkinson's disease has documented an increase in dopaminergic activity following aerobic and strength exercise [52]. The authors referred to the mechanism as "altered cortical excitability and synaptic plasticity, attenuation of neuronal apoptosis (cell death), stimulation of dopaminergic analgesic pathways and inhibition of oxidative stress". The increase in dopaminergic activity following exercise mimics the increase induced by medications for individuals with Parkinson's, although the medication is typically prescribed to reduce tremors associated with Parkinson's disease, not to inhibit oxidative stress.

Similar mechanisms are suggested in a paper entitled "Elucidation of the mechanisms of exercise-induced hypoalgesia and pain prolongation due to physical stress and restriction of movement" [53]. These authors suggested that "because pain-related and stress-related brain regions overlap, stress stimuli would be expected to induce hyperalgesia via the release of corticotropin releasing hormone (CRH) following activation of the HPA axis. Modulation of this activity can occur by exercise initiating hypoalgesia by activating dopamine neurons". Exercise also suppresses neuropathic pain by increasing levels of anti-inflammatory cytokines such as IL-4 and IL-5. Two different theories have been presented here for potential underlying mechanisms for pain including that stress leads to hyperalgesia via CRH and that reduction of CRH activity may decrease pain, but pain reduction may also result from increased dopamine following exercise. And both mechanisms may relate to the stimulation of pressure receptors by exercise.

Pro-inflammatory Cytokines

When the pro-inflammatory cytokine IL – 6 responds to stress, inflammation increases and C-reactive protein is released. In a study on the dose response effects of exercise on change in C-reactive protein, participants were given three 60-minute sessions per week across 26 weeks (N=76) [54]. The exercise regime resulted not only in decreased C-reactive protein but also decreased anxiety, fatigue, and pain. More dose response studies are needed.

Sensitivity to physical activity has been calculated as the difference between post and pre-– exercise pain levels following a one-hour exercise session (N=27 low back pain and 21 healthy controls) [55]. Sensitivity to activity was positively correlated with IL–6 reactivity but not with cortisol reactivity.

In a review on the neurobiological mechanisms underlying physical activity effects, several theories were discussed [56]. These included inflammation, oxidative stress, the glutamate hypothesis (exercise-induced lactate release as potential precursor for glutamate) and endorphin as well as endocannabinoid activity leading to pain relief. Several theories have been presented in this review but have not been compared or weighted in the studies included here.

Mechanisms	First Author
Inflammation and oxidative stress	Barber, Hendrix, Nowacka-Chmielewske
Heartrate variability	Polli, Shaque
Dopaminergic activation	Yu, Tanaka
Pro-inflammatory Cytokines	Ricci, Fegg, Chen

Table 3: Potential underlying mechanisms for pain reduction and first authors.

Methodological Limitations

Several methodological limitations can be cited for this recent literature. They include sampling limitations, exercise variability and the absence of longitudinal and prevention studies. In this very large literature of 1402 studies, only 62 studies met inclusion criteria. Many of the studies that were excluded were controlled experimental animal studies.

The human studies were almost exclusively samples of individuals with chronic clinical conditions. These seemed to be convenience samples. Surprisingly, only one study compared the effects of exercise on pain resulting from different conditions. Despite the frequency of arthritis as the second most prevalent pain condition (second to low back pain), only one study sampled arthritis. Samples were also limited to adults including only one study on children and one study on older adults.

Other methodological problems relate to the combined assessment of multiple exercise styles and their differing intensity and the more frequent measurement of negative effects as in stress and pain, although the mechanism studies highlight the positive physiological effects of exercise. The exercises that have been researched in this recent literature have typically been aerobics or resistance training. Only a few studies compared different exercise protocols. Active control groups were rarely included and literally no longitudinal or prevention studies could be found in this recent literature.

Despite these limitations, the literature highlights the importance of physical activity/exercise for alleviating and even improving chronic pain conditions. Much of the recent literature has also documented potential underlying mechanisms for the exercise effects on pain which supports the credibility and the interpretation of the research results.

References

1. Makkiyah FA, Sinaga TA, Khairunnisa N (2023) A Study from a Highly Populated Country : Risk Factors Associated with Lower Back Pain in Middle-Aged Adults. J Korean Neurosurg Soc 66:190-198.
2. Taha YA, Al Swaidan HA, Alyami HS, Alwadany MM, Al-Swaidan MH, et al., (2023) The Prevalence of Low Back Pain Among Medical Students: A Cross-Sectional Study From Saudi Arabia. Cureus 15:e38997.
3. Pocovi NC, de Campos TF, Christine Lin CW, Merom D, Tiedemann A, et al., (2022) Walking, Cycling, and Swimming for Nonspecific Low Back Pain: A Systematic Review With Meta-analysis. J Orthop Sports Phys Ther 52:85-99.
4. Nambi G, Basuodan RM, Alwhaibi RM, Ebrahim EE, Verma A, et al., (2023) Clinical and Endocrinological Responses to Different Exercise Training Methods in Chronic Low Back Pain: A Randomized Controlled Trial. Endocr Metab Immune Disord Drug Targets 23:801-810.
5. Phattharasupharerk S, Purepong N, Eksakulkla S, Siriphorn A (2019) Effects of Qigong practice in office workers with chronic non-specific low back pain: A randomized control trial. J Bodyw Mov Ther 23:375-381.
6. Singphow C, Purohit S, Tekur P, Bista S, Panigrahy SN, et al., (2022) Effect of Yoga on Stress, Anxiety, Depression, and Spinal Mobility in Computer Users with Chronic Low Back Pain. Int J Yoga 15:114-121.
7. Zhu F, Zhang M, Wang D, Hong Q, Zeng C, et al., (2020) Yoga compared to non-exercise or physical therapy exercise on pain, disability, and quality of life for patients with chronic low back pain: A systematic review and meta-analysis of randomized controlled trials. PLoS One 15: e0238544.
8. Hayden JA, Ellis J, Ogilvie R, Stewart SA, Bagg MK, et al., (2021) Some types of exercise are more effective than others in people with chronic low back pain: a network meta-analysis. J Physiother 67:252-262.
9. Kazeminia M, Rajati F, Rajati M (2023) The effect of pelvic floor muscle-strengthening exercises on low back pain: a systematic review and meta-analysis on randomized clinical trials. Neurol Sci 44:859-872.
10. Quentin C, Bagheri R, Ugbolue UC, Coudeyre E, Pélissier C, et al., (2021) Effect of Home Exercise Training in Patients with Nonspecific Low-Back Pain: A Systematic Review and Meta-Analysis. Int J Environ Res Public Health 18:8430.
11. Wewege MA, Booth J, Parmenter BJ (2018) Aerobic vs. resistance exercise for chronic non-specific low back pain: A systematic review and meta-analysis. J Back Musculoskelet Rehabil 31:889-899.
12. Barros Dos Santos AO, Pinto de Castro JB, Lima VP, da Silva EB, de Souza Vale RG (2021) Effects of physical exercise on low back pain and cortisol levels: a systematic review with meta-analysis of randomized controlled trials. Pain Manag 11:49-57.
13. Verbrugghe J, Agten A, Stevens S, Vandenabeele F, Roussel N, et al., (2023) High intensity training improves symptoms of central sensitization at six-month follow-up in persons with chronic nonspecific low back pain: Secondary analysis of a randomized controlled trial. Braz J Phys Ther 27:100496.
14. Kang T, Kim B (2022) Cervical and scapula-focused resistance exercise program versus trapezius massage in patients with chronic neck pain: A randomized controlled trial. Medicine (Baltimore) 101: e30887.
15. Dakić M, Toskić L, Ilić V, Đurić S, Dopsaj M, et al., (2023) The Effects of Massage Therapy on Sport and Exercise Performance: A Systematic Review. Sports (Basel) 11:110.
16. Alshehre YM, Pakkir Mohamed SH, Nambi G, Almutairi SM, Alharazi AA (2023) Effectiveness of Physical Exercise on Pain, Disability, Job Stress, and Quality of Life in Office Workers with Chronic Non-Specific Neck Pain: A Randomized Controlled Trial. Healthcare (Basel) 11:2286.
17. Price J, Rushton A, Tyros I, Tyros V, Heneghan NR (2020) Effectiveness and optimal dosage of exercise training for chronic non-specific neck pain: A systematic review with a narrative synthesis. PLoS One 15: e0234511.
18. Polaski AM, Phelps AL, Kostek MC, Szucs KA, Kolber BJ (2019) Exercise-induced hypoalgesia: A meta-analysis of exercise dosing for the treatment of chronic pain. PLoS One 14: e0210418.
19. Lee JG, Kim WJ, Kyoung KJ (2022) Effects of Resistance Exercise Program on Pain, Stress, Range of Motion, and Body Composition of Older Adults: A Randomized Controlled Trial. Altern Ther Health Med 28:95-103.
20. Wassinger CA, Lumpkins L, Sole G (2020) Lower extremity aerobic exercise as a treatment for shoulder pain. Int J Sports Phys Ther 15:74-80.

ISSN: 2577-2201

21. Uritani D, Kasza J, Campbell PK, Metcalf B, Egerton T (2020) The association between psychological characteristics and physical activity levels in people with knee osteoarthritis: a cross-sectional analysis. BMC Musculoskelet Disord 21:269.
22. Kabiri S, Halabchi F, Angoorani H, Yekaninejad S (2018) Comparison of three modes of aerobic exercise combined with resistance training on the pain and function of patients with knee osteoarthritis: A randomized controlled trial. Phys Ther Sport 32:22-28.
23. Sasaki R, Honda Y, Oga S, Fukushima T, Tanaka N, et al., (2022) Effect of exercise and/or educational interventions on physical activity and pain in patients with hip/knee osteoarthritis: A systematic review with meta-analysis. PLoS One 17:e0275591.
24. Yoo SA, Kim CY, Kim HD, Kim SW (2022) Effects of progressive muscle relaxation therapy with home exercise on pain, fatigue, and stress in subjects with fibromyalgia syndrome: A pilot randomized controlled trial. J Back Musculoskelet Rehabil 35:289-299.
25. Field T (2021) Massage therapy research: A narrative review. International Journal of Psychological Research and Reviews 4:45.
26. Andrade A, Vilarino GT, Sieczkowska SM, Coimbra DR, Steffens RAK, et al., (2018) Acute effects of physical exercises on the inflammatory markers of patients with fibromyalgia syndrome: A systematic review. J Neuroimmunol 316:40-49.
27. Izquierdo-Alventosa R, Inglés M, Cortés-Amador S, Gimeno-Mallench L, Chirivella-Garrido J, et al., (2020) Low-Intensity Physical Exercise Improves Pain Catastrophizing and Other Psychological and Physical Aspects in Women with Fibromyalgia: A Randomized Controlled Trial. Int J Environ Res Public Health 17:3634.
28. Albuquerque MLL, Monteiro D, Marinho DA, Vilarino GT, Andrade A, et al., (2022) Effects of different protocols of physical exercise on fibromyalgia syndrome treatment: systematic review and meta-analysis of randomized controlled trials. Rheumatol Int 42:1893-1908.
29. Couto N, Monteiro D, Cid L, Bento T (2022) Effect of different types of exercise in adult subjects with fibromyalgia: a systematic review and meta-analysis of randomised clinical trials. Sci Rep 12:10391.
30. Manojlović D, Kopše EI (2023) The effectiveness of aerobic exercise for pain management in patients with fibromyalgia. Eur J Transl Myol 33:11423.
31. Field T, Diego M, Cullen C, Hernandez-Reif M, Sunshine W, et al., (2002) Fibromyalgia Pain and Substance P Decrease and Sleep Improves After Massage Therapy. J Clin Rheumatol 8:72-76.
32. Wåhlén K, Yan H, Welinder C, Ernberg M, Kosek E, et al., (2022) Proteomic Investigation in Plasma from Women with Fibromyalgia in Response to a 15-wk Resistance Exercise Intervention. Med Sci Sports Exerc 54:232-246.
33. Andrade A, Vilarino GT, Sieczkowska SM, Coimbra DR, Steffens RAK, et al., (2018) Acute effects of physical exercises on the inflammatory markers of patients with fibromyalgia syndrome: A systematic review. J Neuroimmunol 316:40-49.
34. Li Z, Wang XQ (2023) Clinical effect and biological mechanism of exercise for rheumatoid arthritis: A mini review. Front Immunol 13:1089621.
35. Heale LD, Houghton KM, Rezaei E, Baxter-Jones ADG, Tupper SM, et al., (2021) Clinical and psychosocial stress factors are associated with decline in physical activity over time in children with juvenile idiopathic arthritis. Pediatr Rheumatol Online J 19:97.
36. Pérez-de la Cruz S (2020) Influence of an Aquatic Therapy Program on Perceived Pain, Stress, and Quality of Life in Chronic Stroke Patients: A Randomized Trial. Int J Environ Res Public Health 17:4796.
37. Jadhakhan F, Lambert N, Middlebrook N, Evans DW, Falla D (2022) Is exercise/physical activity effective at reducing symptoms of post-traumatic stress disorder in adults - A systematic review. Front Psychol 13:943479.
38. Wiklund T, Linton SJ, Alföldi P, Gerdle B (2018) Is sleep disturbance in patients with chronic pain affected by physical exercise or ACT-based stress management? - A randomized controlled study. BMC Musculoskelet Disord 19:111.
39. Deegan O, Fullen BM, Casey MB, Segurado R, Hearty C, et al., (2023) Mindfulness Combined With Exercise Online (MOVE) Compared With a Self-management Guide for Adults With Chronic Pain: A Feasibility Randomized Controlled Trial. Clin J Pain 39:394-407.
40. Skelly AC, Chou R, Dettori JR, Turner JA, Friedly JL, et al., (2020) Noninvasive Nonpharmacological Treatment for Chronic Pain: A Systematic Review Update [Internet]. Rockville (MD): Agency for Healthcare Research and Quality (US); 2020 Apr. Report No.: 20-EHC009.
41. Efe Is E, Sahillioglu A, Demirel S, Kuran B, Mustafa Ozdemir H (2021) Effect of COVID-19 Pandemic on Physical Activity Habits, Musculoskeletal Pain, and Mood of Healthcare Workers. Sisli Etfal Hastan Tip Bul 55:462-468.
42. van der Heide A, Meinders MJ, Bloem BR, Helmich RC (2020) The Impact of the COVID-19 Pandemic on Psychological Distress, Physical Activity, and Symptom Severity in Parkinson’s Disease. J Parkinsons Dis 10:1355-1364.
43. Sonza A, da Cunha de Sá-Caputo D, Sartorio A, Tamini S, Seixas A, et al., (2021) COVID-19 Lockdown and the Behavior Change on Physical Exercise, Pain and Psychological Well-Being: An International Multicentric Study. Int J Environ Res Public Health 18:3810.
44. Belavy DL, Van Oosterwijck J, Clarkson M, Dhondt E, Mundell NL, et al., (2021) Pain sensitivity is reduced by exercise training: Evidence from a systematic review and meta-analysis. Neurosci Biobehav Rev 120:100-108.
45. van Hooff MLM, Benthem de Grave RM, Geurts SAE (2019) No pain, no gain? Recovery and strenuousness of physical activity. J Occup Health Psychol 24:499-511.
46. Hackford J, Mackey A, Broadbent E (2019) The effects of walking posture on affective and physiological states during stress. J Behav Ther Exp Psychiatry 62:80-87.
47. Barber M, Pace A (2020) Exercise and Migraine Prevention: a Review of the Literature. Curr Pain Headache Rep 24:39.
48. Hendrix J, Nijs J, Ickmans K, Godderis L, Ghosh M, et al., (2020) The Interplay between Oxidative Stress, Exercise, and Pain in Health and Disease: Potential Role of Autonomic Regulation and Epigenetic Mechanisms. Antioxidants (Basel) 9:1166.
49. Nowacka-Chmielewska M, Grabowska K, Grabowski M, Meybohm P, Burek M, et al., (2022) Running from Stress: Neurobiological Mechanisms of Exercise-Induced Stress Resilience. Int J Mol Sci 23:13348.

50. Polli A, Van Oosterwijck J, Nijs J, Marusic U, De Wandele I, et al., (2019) Relationship Between Exercise-induced Oxidative Stress Changes and Parasympathetic Activity in Chronic Fatigue Syndrome: An Observational Study in Patients and Healthy Subjects. Clin Ther 41:641-655.

51. Ishaque S, Khan N, Krishnan S (2021) Trends in Heart-Rate Variability Signal Analysis. Front Digit Health 3:639444.

52. Yu WY, Yang QH, Wang XQ (2022) The mechanism of exercise for pain management in Parkinson's disease. Front Mol Neurosci 15:1039302.

53. Tanaka K, Kuzumaki N, Hamada Y, Suda Y, Mori T, et al., (2023) Elucidation of the mechanisms of exercise-induced hypoalgesia and pain prolongation due to physical stress and the restriction of movement. Neurobiol Pain 14:100133.

54. Ricci JM, Flores V, Kuroyama I, Asher A, Tarleton HP (2018) Pilot Study of Dose-Response Effects of Exercise on Change in C-Reactive Protein, Cortisol, and Health-Related Quality of Life Among Cancer Survivors. Biores Open Access 7:52-62.

55. Flegg D, Lima LV, Woznowski-Vu A, Aternali A, Gervais A, et al., (2023) Are biomarkers associated with sensitivity to physical activity? Eur J Pain 28:120-132.

56. Chen C, Nakagawa S (2023) Recent advances in the study of the neurobiological mechanisms behind the effects of physical activity on mood, resilience and emotional disorders. Adv Clin Exp Med 32:937-942.