Physical Activity, Part 2

Benefits of Being Active

What if there was one prescription that could prevent and treat dozens of diseases, such as diabetes, hypertension, and obesity? Would you prescribe it for your patients? Certainly."[1]

—R.E. Sallis

It is difficult to find a component of health that physical activity does not have the potential to improve. In fact, there is a vast and growing field of research on how working one's body can improve well-being, longevity and many medical conditions.[2,3]

In general, *physical activity* refers to any activity which moves the skeletal muscles of the body and increases energy output, whereas *exercise* refers to structured and repetitive physical activity with a specific intent—usually to improve some component of *physical fitness*.[4,5] *Physical fitness* refers to the development of specific skills including strength, flexibility, endurance, balance, and agility.[4] Presumably, similarly matched physical activity and exercise forms (e.g., walking briskly for a job versus walking briskly for exercise) have equivalent health effects. Accordingly, both exercise and unstructured physical activity have important health benefits and should be strongly encouraged.

Research shows that higher levels of physical activity are linked to seemingly countless benefits. These include, but are certainly not limited, to the following[6]:

- It lowers all-cause **mortality** rates[5,7] and **increases life span**.[8] Lack of physical activity, on the other hand, increases our risk of developing cardiovascular disease, cancer (e.g. of the colon and breast), type 2 diabetes, hypertension, and obesity.[5,9]

- Regular exercise mitigates the **negative effects of aging**, even if a person does not start exercising until later in life.[2] A 2018 trial found it improves overall physical function in long-term nursing home patients.[10]

- Numerous prospective epidemiologic studies have found that physical activity reduces our **risk of dementia**.[11] A recent study found that routine exercise (tai chi, resistance training, aerobic, and multicomponent) all improved cognitive function of community-dwelling adults over age 50, regardless of their baseline cognitive status.[12]

- There is also evidence that exercise preserves our **ability to perform our activities of daily living** and improves higher order skills (**executive functioning**) in both children and adults.[13] Our attention span, processing speed, and memory are also enhanced by exercise.[14] Kids who exercise perform better academically in many areas.[15]

- It has **mental health benefits**.[16,17] A 2013 Cochrane review found that exercise is moderately more effective than control interventions for symptoms of depression but not more effective than psychological or pharmacological therapies.[18] Consistent exercise decreases symptoms of both **depression and anxiety,**[19,20] but it is not clear how useful exercise is for major depression.[21] Even in the absence of a history of depression or anxiety, exercise is associated with increased **psychological well-being**,[22] and promotes **brain cell growth**.[23] It improves mental well-being in people with HIV and helps with ADHD.[24,25] It helps with cognitive function in schizophrenia.[26]

- It facilitates **better sleep,** though findings in this regard are variable.[27,28] It benefits people with obstructive sleep apnea.[29]

- It **reduces pain**. Exercise has moderate to strong evidence supporting its use for musculoskeletal pain.[30] An overview of Cochrane Reviews, while noting the need for more research, suggested that "physical activity and exercise is an intervention with few adverse events that may improve pain severity and physical function , and consequent quality of life" for people with chronic pain.[31] It is beneficial for low back pain.[32] A 2017 review found that aerobic and muscle strengthening exercises reduce pain and improve global well-being and quality of life, along with helping with depression, in fibromyalgia.[33] A 2018 Cochrane review noted there is at least slight improvement in physical function depression, and pain in osteoarthritis.[34] Walking markedly improved function in people with knee arthritis after 9 months.[35] Another review noted there is low-quality evidence showing benefit for exercises for hand osteoarthritis.[36]

- It is **safe and beneficial in pregnancy**, including for promoting overall wellness, managing appropriate gestational weight gain, and possibly preventing blood pressure and blood sugar problems.[37]

- It helps **prevent or improve many other chronic health problems**, including[38]:

    - Cardiovascular disease and other circulatory disorders[39,40]
    - Cancer (e.g. colon, breast, prostate, and renal). A 2017 "systematic review of systematic reviews" concluded exercise should be recommended for all forms of cancer because of "clinical, functional, and in some populations, survival outcomes."[41] It improves quality of life in cancer survivors.[42] It does not increase cancer-related fatigue, but it is not clear if it decreases it either.[43]
    - Type 1 and type 2 diabetes[44-46]
    - Hypertension[35]
    - Obesity[47]
    - Osteoporosis[48]
    - Stroke prevention and post-stroke recovery[49,50]
    - Multiple sclerosis[51]
    - Chronic Obstructive Pulmonary Disease[52]
    - Pulmonary hypertension[53]
    - Heart failure[54]
    - Renal failure (especially blood pressure management)[55]

- Intermittent claudication (pain in the legs from poor blood flow)[56]
- Psoriasis[57]
- Erectile dysfunction[58]

- It can help people with **spinal cord injury**, when done in an individualized way with expert support.[59]

- It leads to favorable changes in **genetic expression** (epigenetic effects).[60]

- It favorably changes the **microbiota** (bacterial make up) in the gut.[61]

While physical activity is beneficial to health, *sedentariness* is associated with negative health effects.[7] According to the World Health Organization, inactivity is a leading cause of non-communicable diseases and poses a rapidly increasing health burden globally.[62] Forms of inactivity such as prolonged sitting contribute to the development of and diabetes.[63]

Overall, there seems to be a linear relationship between physical activity and overall health status,[5] with increases in health benefits seen at all stages of activity.[7] However, the greatest incremental benefit of physical activity is noted when we increase from no activity to some activity.[7]

Evaluating Our Exercise Paradigm

Aerobic exercise… and beyond

In recent decades, much attention has been paid to the importance of aerobic exercise for disease prevention and health promotion. Aerobic exercise refers to activities that stimulate the heart and lungs and, in doing so, improve our ability to utilize oxygen. This emphasis is reflected in most national and international recommendations and guidelines for exercise.[2] Indeed, aerobic fitness in particular has been strongly associated with decreased risk of cardiovascular disease,[64] which remains the number one cause of death in adults worldwide.

In addition to aerobic exercise, research also strongly supports including other forms of fitness for health and disease prevention, especially resistance/strength training and flexibility exercises.[3] Studies show that if we are inactive, we lose 3-8% of our muscle mass each decade while replacing muscle tissue with increased body fat.[65] Even just ten weeks of resistance training can counter this process by increasing muscle mass and reducing body fat composition.[66]

Data also suggests that musculoskeletal fitness is strongly predictive of general health even in the absence of aerobic fitness.[5,67-69] This may be particularly important for the elderly for whom musculoskeletal fitness is strongly associated with maintenance of functional status and lower risk of developing diabetes, chronic obstructive pulmonary disease (COPD), arthritis, coronary artery disease (CAD) and stroke.[70] Moreover, studies show that resistance training is both safe and achievable in geriatric patients.[71] In light of our aging society, consider recommending resistance training in addition to (or if they prefer) as an alternative to aerobic exercise. Examples of resistance exercises are listed below.

Interestingly, resistance training can be turned into an aerobic exercise by incorporating the following suggestions:

- If using free weights, hold the weights in both hands and exercise both sides at the same time.[72]
- Vary resting time between sets during resistance training. This could mean starting with 45 seconds of rest between weightlifting sets, then shifting to 30 seconds of rest between sets, and ending with 20 seconds of rest between sets. This will theoretically result in increased aerobic capacity and a higher heart rate during the exercise period.
- Add plyometric exercises to a resistance training routine. Plyometric exercises include jumping lunges, squats, burpees, and depth jumps and can keep your heart rate elevated for up to 50 minutes after completing your exercise routine.[73] Studies have even shown that these exercises have comparable effects on the heart to sprint interval cycling.[74]
- Consider velocity training. This means lifting lighter weights with more repetitions to increase cardiac output.

Examples of Exercise

Aerobic Exercise

- Walking
- Dancing
- Jogging
- Cycling
- Swimming
- Tennis
- Cross-Country Skiing

Resistance Training

- Free weights and weight machines
- Resistance Bands
- Exercises using our own body weight (push-ups, squats, etc.)
- Medicine Balls
- Calisthenics
- Suspension Training
- Plyometric exercises

The risks of usual exercise

There is some evidence that physical exercise can increase our risk of developing coronary events and musculoskeletal injuries, but the overall benefits of exercise clearly outweigh these risks.[3,16] For individual patients, these risks and benefits should be carefully balanced. When we consider that death is a possible adverse event from an exercise intervention, our exercise prescriptions should be accompanied by a strong commitment to preventing harm.

Currently, there is no research distinguishing whether these adverse events of exercise occur in experienced or inexperienced individuals. There is also a paucity of research into what factors might reduce the incidence of exercise-related harms.[3] Accordingly, when providing exercise prescriptions, we may consider Hippocrates' aphorism to "first do no harm."

The incidence of exercise-related injuries in those engaged in moderately intense exercise are probably around 1% per month,[75] with highest rates amongst participants in resistance training, where up to 25-30% of participants report injuries that prompt them to seek medical attention.[76]

Excessive or extreme exercise may be harmful in select patient populations.[77] Sudden cardiac death is a well-known risk associated with competitive athletics but is actually quite rare, with about 1 death per 100,000 marathoners.[78] Acute elevation of cardiac enzymes and adverse myocardial remodeling has been observed amongst marathoners, ultra-marathoners, triathletes, and long-distance cycle racers.[79]

There have also been recent attempts to define exercise addiction and/or dependence,[80] which, like overtraining, may be associated with negative effects on mood.[81] There is a well-known association between exercise dependence and eating disorders.[80] In particular, the triad of disordered eating, amenorrhea and osteoporosis is another important condition associated with impulsive and harmful behaviors related to excessive exercise.[82]

Mindful Awareness

Tuning in to Your Body

An important consideration for any exercise or physical activity program is how one *listens to* his or her body. While most of us have an intuitive sense of what we mean by "listening to" our body, we may frequently overlook this body-centered attention during physical activity. Alternatively, we might view discomfort and injury as expected side effects of athletic training, once again ignoring our body awareness. However, with a bit of reflection, most patients will agree that somatic and visceral attentiveness is important and can be cultivated through practice. One way to develop this mindful awareness of the body is by engaging in complementary and integrative health (CIH) movement practices such as yoga and tai chi.

MINDFUL AWARENESS MOMENT

Pause for a moment. Bring your awareness to your physical body. You may want to do a body scan. That is, take a moment to survey each part of your body. Bring your awareness to your feet, ankles, legs, abdomen and lower back, chest, and so on as you move up to your head. Reflect on the following:

- How do you feel physically?
- Now focus on your feelings. How do you feel emotionally?
- What about your thoughts right now—are they positive, negative, neutral?
- When did you last engage in any physical activity? Today? Yesterday? Last week? Longer ago?
- Might your level of physical activity explain, in part, how you feel physically and emotionally right now (whether positive or not so positive)?
- Is it time to engage in some movement?
- What will you do? When will you do it? How long will you do it?
- Is there an activity you have not done previously that you want to try in the future? If so, what is your first step in making that happen? When will you start the ball rolling regarding this new activity?

It seems that exercise-as-usual might affect one's mindful awareness of the body in paradoxical ways. On the one hand, exercise may deepen and enrich one's feeling and awareness of the body. For example, as a result of their training, many athletes report a newfound awareness of their breathing and posture. On the other hand, exercise may solidify patterns of ignoring and suppressing important biological cues. For example, "That crushing left chest pain is just weakness leaving my body." The exercise itself is the same in both cases, but the outcome is very different. We might recognize this polarity within our own experience of exercise or in that of our patients.

Many medical providers have seen the stoic patient who downplays symptoms and presents late for medical attention. Although this trait is sometimes associated with a “macho” personality, patients of all genders exhibit it. This behavior may not merely be due to an absence of knowledge about the signs and symptoms of illness; it may also represent an overt belief system or subtle relationship dynamic between the patient and his or her embodiment, the relationship they have with their physical self. Good providers can recognize such tendencies and modify diagnostics, treatments and recommendations accordingly, especially in the context of a long-term therapeutic relationship.

And what about the other extreme of body awareness? Again, many clinicians will recognize the type of patient who may be overly sensitive to their bodily feedback. Certainly, such patients might prematurely withdraw from activity that is uncomfortable and/or need reassurance that they are okay. Guiding such patients to appropriate physical activity may also require certain sensitivity on the part of the clinician.

True to the Integrative Whole Health approach, an exercise program that includes mindful body awareness is probably more advantageous than the typical exercise plan. At the very least, mindful approaches to exercise can empower patients to perform other physical activities more efficiently and develop self-efficacy, self-awareness, and a greater capacity for self-healing.

How might we maximize the benefits and reduce the risks of physical activity? What range of options is available? The following is an evidence-based survey of several approaches to Physical Activity, with special attention to more mindfulness-based approaches. This is certainly not an exhaustive list; rather, it is a starting point for this discussion.

Yoga

Background

Yoga is an ancient system of contemplative practice that has become very influential in contemporary culture. Originating in India, where it has been practiced for millennia, yoga may be considered historically both a classical school of Indian philosophy and a multifaceted "psychospiritual technology."[83] Today, yoga usually refers to a diverse set of exercises based on traditional practices that involve the body, breath, and mind. A typical yoga class in the United States will focus on the physical postures (or *asanas)* of yoga, with varying amounts of attention to breathing, relaxation, and/or meditation.

The recent increase in popularity of yoga in the United States is remarkable. A 1998 survey found that 3.8% of all U.S. adults used yoga in the previous 12 months.[84] Fourteen years later, the 2012 National Health Interview Survey found that number had risen to 9.5%.[85]

Benefits

Yoga has been found to help with a number of different health issues,[86] including cardiovascular disease and type 2 diabetes. It also seems to be helpful for mental health in general and with mood disorders. [87,88] Preliminary evidence supports its use with PTSD.[89] It also helps adults with type 2 diabetes improve glycemic outcomes and decrease complication risks and helps to control hypertension.[86,90]

Some of the most-reviewed research is for nonspecific low back pain. A 2017 Cochrane review noted low to moderate evidence of small to moderate improvements.[91] A 2014 review of systematic reviews, conducted by the VA Health Services Research and Development Service, concluded that at this time there is good evidence to support yoga for improving functional outcomes in patients with chronic, nonspecific low back pain. Importantly, a 2017 trial found that Veterans with chronic low back pain had benefit from yoga even though they had "fewer resources, worse health, and more challenges attending yoga sessions" than others in the community.[92] A 2017 Cochrane review also found there is low to moderate evidence supporting yoga for back pain, but it is not clear how whether it is superior to other forms of exercise.[91] Yoga also shows promise for improving sleep,[93] menopausal symptoms,[94] COPD,[95] asthma,[96] and sexual function.[97] Cochrane concluded there is "moderate-quality evidence" that supports yoga to improve quality of life, fatigue, anxiety, depression, and sleep in women with breast cancer.[98] It can help as an adjuvant therapy for neurological problems like multiple sclerosis, epilepsy, Parkinson's disease, Alzheimer disease, and neuropathy.[99] There are also benefits for functional status and fall prevention.[100,101] This list is by no means complete, and more research is needed in various areas.

Studies can be challenging to interpret, because there are so many different types of yoga interventions. Yoga research is limited mainly by heterogeneity of yoga interventions and difficulty blinding controls.[102-104]

Yoga has novel effects compared to usual exercise,[105] and there may be ways that yoga is superior to usual exercise for particular aspects of health.[105,106] Preliminary data demonstrates that yoga practice is associated with increased mindfulness traits[107,108] and decreases in stress

levels.[85,108,109] Yoga practice consistently demonstrates enhancement of physiologic markers of relaxation, such as alpha wave activation on EEG and decrease in serum cortisol.[110]

Risks

Like exercise in general, the risks of yoga exercise seem to vary greatly by type of yoga and factors specific to practitioners.[111] Generally, adverse events due to yoga were found to have a 12-month prevalence of 4.6% and a lifetime prevalence of 21%, but serious events are rare (<2% of injuries).[112] Practice of the headstand, shoulder stand and lotus position, along with advanced breath practices, have produced a higher proportion of injury reports. [111] Certain outlying styles, such as Bikram yoga, which is performed vigorously in hot, humid rooms, are associated with more adverse events. [111] Patients with glaucoma should avoid inverted poses. Patients with osteopenia should avoid forceful practices. All participants should practice under the guidance of a qualified teacher.[111]

Making a referral

- Keep in mind that yoga is safe for healthy people.
- Yoga may share many of the benefits of other types of exercise.
- Yoga has demonstrated novel effects compared to aerobic exercise, such as increased mindfulness and increased physiologic relaxation.
- There is fair evidence that favors using modified yoga programs to treat non-specific low back pain, to prevent falls, and to preserve functional status for those at risk of decline.
- The type of yoga matters; when in doubt, try it out for yourself before you make recommendations.
- Look for certified teachers with the Yoga Alliance, who bear the designation of Registered Yoga Teacher (RYT).
- Consider the longevity of the studio, school or center a teacher is from.
- Learning yoga from books or audiovisual media is traditionally cautioned against; encourage patients working from media to seek out an in-person teacher.

Yoga Therapy

Yoga therapy (sometimes called *therapeutic yoga)* is yoga that is oriented specifically towards healing. Historically, the therapeutic aspects of yoga have been formalized by yoga's sister system of medicine, *Ayurveda.*[113] For more information, see the section on "Ayurveda" in the *Passport to Whole Health*. Yoga therapy arose in recent years as practitioners sought to integrate current biomedical perspectives and yoga's therapeutic aspects. Yoga therapy now has an international professional organization, the International Association of Yoga Therapists, as well as a peer reviewed journal and numerous training programs. A growing number of yoga teachers, yoga therapists and more conventionally credentialed health-oriented practitioners are contributing to this developing paradigm. Research on the health effects of yoga usually does not differentiate yoga and yoga therapy, but the distinction is important. Most of the clinical trials using yoga employ an explicit therapeutic intent, as well as modifications of normal yogic exercise.

Making a referral

- Consider referring significantly injured or debilitated patients to a qualified yoga therapist rather than a regular yoga class.
- Refer to therapists who are experienced and actively practicing therapeutic yoga themselves.
- Choose therapists who have additional training and credentialing in health care professions, such as nursing or medicine.

Tai Chi

Background

Tai chi (also known as *t'ai chi ch'uan* or *taijiquan*) is an ancient Chinese martial art that has received considerable attention in recent years for its health effects. This system has its roots in Taoist philosophy, and the abbreviated form of its name *tai chi* also refers to an important concept from this view; it is literally translated as "supreme ultimate." Tai chi has deep historical associations also with traditional Chinese medicine (TCM) particularly in regard to theory and practice of harmonizing the energy or *qi (pronounced "chee")* within the body.

In its contemporary form, tai chi is recognized by its slow, graceful gestures and soft flowing movements coordinated with the breath, conducted standing with slightly bent knees. The exercises are often poetically named (e.g., "grasping the bird's tail"), and the rhythmic movements invite peace and clarity of mind.

Given its relationship to many of the martial arts traditions of Asia, tai chi's many health effects are suggestive of the health potential of other martial arts forms. Although historically tai chi's role in self-defense was more integral, many contemporary schools and teachers have de-emphasized the martial aspect of tai chi while underscoring the health and healing intentions. Tai chi is sometimes classified as an "internal" martial art due to its emphasis on internal processes of the practitioner, while more externally forceful martial art forms, such as karate, are classified as "external" martial arts.

Qi gong

Qi gong (also known as *qigong, chi gung* or *chi kung*) is another practice closely related to tai chi. The name of this system refers to a process of "cultivation of vital energy," and its practices involve harmonizing and regulating the energy (or *qi)* internally through the use of posture, breathing and mental attention. It is said that tai chi is an expression of qi gong. Given this close relationship, some have argued that research about tai chi and qi gong should be considered a unified process.[114]

Benefits

The body of evidence supporting the health benefits of tai chi/qi gong is fairly robust. The strongest evidence for tai chi as a medical intervention is for fall prevention in the elderly, where it reduces falls by 43-50%.[115-118] This effect is most likely mediated by improvement in balance and muscular strength. Similarly, tai chi is likely helpful in both preventing and treating osteoporosis.[119,120] A recent review found tai chi shows promise for reducing fatigue.[121] Another review noted more research is still needed regarding tai chi and its effects on chronic pain.[122]

Tai chi may also be beneficial for mood disorders[123] and improving psychological well-being.[115,119,124,125] A 2018 study found that tai chi is equivalent to pulmonary rehabilitation when it comes to outcomes for patients with COPD.[126] Qigong shows promise for helping people with cancer manage their symptoms, though more study is needed.[127]

Somewhat surprisingly, tai chi has an aerobic component.[119,128] Numerous physiologic benefits of tai chi have been observed including lowering of heart rate, blood pressure, and cholesterol.[119] Qi gong was found to beneficially enhance steroid secretion patterns and mental health in aging men. [129]

Risks

There is likely very low risk of harm doing tai chi. Given tai chi's aerobic component, the general risks of aerobic exercise, as noted earlier, should be considered.

Making a referral

- Tai chi is a safe and beneficial form of exercise when practiced under the guidance of a qualified teacher.
- The benefits of tai chi may be particularly suited to an aging population.
- Tai chi has an aerobic component in addition to increasing strength and balance.
- Tai chi has strong evidence for preventing falls and increasing psychological well-being.
- Other martial arts classes also have health benefits.[130]

Pilates

Background

Pilates is a method of exercise that emphasizes controlled, coordinated movements and integration of the musculoskeletal system. Joseph Pilates (1880-1965), who suffered from debilitating illness as a child but recovered dramatically by adulthood, developed it in the early twentieth century. True to its therapeutic roots, Pilates is often offered in hospitals and therapeutic settings. It is explicit in its aim to develop aspects of physical fitness such as strength, flexibility and endurance, along with mental and neurological aspects, such as concentration and control.

Pilates classes typically focus on developing balanced muscular strength, especially in the postural and accessory muscles of the trunk, i.e., "the core." The movements also target neuromuscular integration through use of the breath and attention to precision of movement. It uses a variety of specific apparatuses towards these ends. The system is appropriate for all stages of life and contains modifications for various levels of fitness.

Benefits

There is fair evidence that the Pilates method can improve flexibility and balance.[131,132] It may also help with muscle endurance.[1,133] It seems to show promise for low back pain, but it is not clearly superior to other forms of exercise. It is better than no exercise for women with breast cancer.[134] Evidence of clinically-oriented outcomes is lacking.

Risks
Pilates is a low-risk activity when performed correctly, and there are few reports of adverse events due to the Pilates method.

Making a referral
- Pilates is safe and likely helpful in improving balance, flexibility, and strength.
- In the hands of an experienced teacher or therapist, there is potential for Pilates to facilitate other aspects of musculoskeletal health.
- Look for instructors who have completed training through the Pilates Method Alliance.

Walking

Walking is man's best friend.

—attributed to Hippocrates

Background
Walking has a somewhat unique combination of attributes to make it an excellent public health goal; it is accessible, safe, inexpensive, well tolerated, effective, requires no special equipment, and is amenable to structured promotion programs.[135,136]

Benefits
Walking programs can significantly improve cardiovascular risk, weight, and other cardio-metabolic indicators.[137] A 2018 review suggests there is need for more research, but the evidence base supporting walking for mental health is growing.[138] While most research about the effects of walking have been from epidemiologic studies, brisk walking (3-4 miles per hour) does fit the profile of a moderate-intensity aerobic exercise.[135]

Nordic or pole walking, which is basically walking with the use of ski poles or something like them, has received recent research attention and may have benefits over standard walking due to increased aerobic demand.[139,140] This practice might also decrease the risk of falls, and it is beneficial for people with cardiovascular disease.[141]

Pedometers are one way of motivating walking behavior. One caution is that inexpensive pedometers vary widely in estimating steps.[142] Programs that promote "10,000 steps" motivate participants to meet this signature number of steps daily; this corresponds to walking about five miles. Meeting this requirement meets or exceeds physical activity recommendations and likely improves health.[137] A 2018 review explored what is the optimal "running dose" for cardiovascular risk and noted that following the standard guidelines of 150 minutes/week of moderate or 75 minutes per week of vigorous exercise per week is reasonable.[39]

Risks
Walking is generally well-tolerated. However, special modifications should be considered. Patients with conditions such as memory impairment should be supervised as they walk. Walking tracks (which eliminate or reduce obstacles, inclines, uneven surfaces, and effects of adverse weather conditions) should be considered when balance issues are a concern.

Making a referral

- Due to its relatively low-impact nature, walking may be ideal for people who are weak, debilitated, or convalescing.
- Brisk walking (3-4 miles per hour) is an excellent moderate-intensity aerobic exercise. Target 30-60 minutes per day.
- Nordic walking (with poles) may have health advantages over regular walking.
- Pedometers are effective for motivating walking behavior. Poor-quality pedometers may be inaccurate and thus misleading.
- Targeting 10,000 steps per day is a good starting "dose" for walking.

Running

Background

Running or jogging is, of course, a more conventional form of exercise. Running has received recent attention as far as its role in human evolution. There are numerous aspects of human physiology and anatomy that suggest the human body was optimally designed for running long distances. It is thought that this ability to run great distances was a prime advantage in early human history and possibly a major distinguishing feature of our species.[23,143]

Benefits

Exercise routines involving running are central to the conventional paradigm of exercise. Much of the general exercise literature is relevant to running. Running has been found to increase generation of nerve cells in the hippocampus, the brain memory center.[144]

Of note, equivalent energy expenditures of walking versus running are associated with similar improvement in cardio-metabolic variables; however, running achieves the target in less time.[145]

Risks

As noted previously, there is an increased risk of musculoskeletal injuries and coronary events with traditional forms of exercise.

Common musculoskeletal injuries related to running include plantar fasciitis, ankle sprains, hamstring strains, shin splints, stress fractures, iliotibial band syndrome, Achilles tendonitis, and runner's knee.

Runner's knee, or patellofemoral pain syndrome, involves excessive lateral tracking of the patella, which results in anterior knee pain.[146] Mechanisms for lateral patellar tracking may include over-pronation of the foot (with compensatory internal rotation of the femur) and relative weakness of the vastus medialis obliquus muscle in the quadriceps muscle group.[147,148] Hamstring tightness and dysfunction of the iliotibial band may also play a part in patellofemoral pain syndrome.[149,150]

To reduce the risk of patellofemoral pain syndrome, consider recommending avoidance of downhill running during the early stages of running.[151] It may also be worth advising the purchase of shoes that counter some patients' tendencies to pronate. Similarly, orthotics can reduce pronation and, as a result, decrease the likelihood of developing patellofemoral pain syndrome.[152] Consider suggesting avoidance of high intensity interval training until pain resolves.[153] Encourage stretching before and after activities. Finally, provide optional exercises for strengthening the vastus medialis muscle. This may include cross-training with cycling.

Making a referral

- Evidence suggests that distance running may be a more physiologically correct form of exercise for our species.
- If you are short on time, running may be "more bang for your buck" compared to less intense forms of exercise.
- Routine pre-participation exams and advice should be provided to patients beginning running activities, especially in the context of comorbidities.

Back to Javier

Javier's provider recommended a yoga teacher. He started taking weekly classes at the gym he joined, and he received additional teaching and coaching him via instructional videos and online chats. He started feeling better "almost immediately" after starting to practice. Javier's teacher was blunt with him, telling him that if he didn't change the way he was living, he would be at a high risk of dying young and leaving his family behind. This discussion led Javier to see that his behavior was totally inconsistent with his deep love for his family and his priorities around being physically fit.

Javier participated regularly in his prescribed yoga training program, which involved a plant-based eating program, "dynamic tension" yoga exercises performed with a heart rate monitor, and guidance with modifying yoga poses to his particular needs. As he felt healthier, he was encouraged to read more about other ways to improve his health. He quickly lost weight through this program, dropping a staggering 100 pounds during the first year of his new lifestyle. He also eventually stopped needing knee braces to walk.

Today, Javier's pain is "manageable" without medication. He practices yoga daily and teaches yoga 4 evenings a week at the local senior center, in addition to his day job. He has been working on other areas of self-care as well, and has markedly improved his sleep, nutrition, and stress level. He states that before his yoga program, "health was just what happened to me." After adding physical activity back into his life, he realized that he is in control of his health. Now, as a result, he is able to share an active lifestyle with his family. Most importantly, he can more fully be there for them in the ways that matter most to him.

Integrative Health Tools

- Prescribing Movement
- Improving Flexibility
- Yoga
- Tai Chi and Qi Gong

Resources

- American College Of Sports Medicine
  - Excellent source of guidelines, recommendations and research on exercise.
- American Council on Exercise
  - Non-profit "committed to enriching quality of life through safe and effective exercise and physical activity."
- Physical Activity Guidelines for America
  - Office of Disease Prevention and Health Promotion, U.S. Department of Health and Human Services
  - Guidelines and educational materials on physical activity.
- CDC: Physical Activity
  - Centers for Disease Control and Prevention's physical activity guidelines
- The International Association of Yoga Therapists
  - Professional organization with numerous publications and other resources dedicated to establishing "yoga as a recognized and respected therapy."
- Tai chi: A gentle way to fight stress
  - Basic information about tai chi from the renowned Mayo Clinic.
- Video: Tai Chi
  - Basic video description of tai chi from the renowned Mayo Clinic.
- Pilates Method Alliance
  - Authoritative source of professional information and certification.

What we know about integrative health care has come to us thanks to the efforts, experiences, and collective wisdom of people from many cultures and backgrounds. We wish to acknowledge all the healers, researchers, patients, and peoples who have informed the content of this tool.

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References

1. Sallis RE. Accessed June 26, 2014, https://www.exerciseismedicine.org/assets/page_documents/EIM%20Public%20Presentation_2016_07_07.pdf
2. Chodzko-Zajko WJ, Proctor DN, Fiatarone Singh MA, et al. American College of Sports Medicine position stand. Exercise and physical activity for older adults. *Med Sci Sports Exerc*. Jul 2009;41(7):1510-30. doi:10.1249/MSS.0b013e3181a0c95c
3. Garber CE, Blissmer B, Deschenes MR, et al. American College of Sports Medicine position stand. Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: guidance for prescribing exercise. *Med Sci Sports Exerc*. 2011;43(7):1334-1359.
4. Caspersen CJ, Powell KE, Christenson GM. Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research. *Public Health Reports*. Mar-Apr 1985;100(2):126-31.
5. Warburton DE, Nicol CW, Bredin SS. Health benefits of physical activity: the evidence. *CMAJ : Canadian Medical Association journal = journal de l'Association medicale canadienne*. Mar 14 2006;174(6):801-9. doi:10.1503/cmaj.051351
6. Warburton DER, Bredin SSD. Health benefits of physical activity: a systematic review of current systematic reviews. *Curr Opin Cardiol*. Sep 2017;32(5):541-556. doi:10.1097/hco.0000000000000437
7. Woodcock J, Franco OH, Orsini N, Roberts I. Non-vigorous physical activity and all-cause mortality: systematic review and meta-analysis of cohort studies. *Int J Epidemiol*. Feb 2011;40(1):121-38. doi:10.1093/ije/dyq104
8. Vina J, Sanchis-Gomar F, Martinez-Bello V, Gomez-Cabrera MC. Exercise acts as a drug; the pharmacological benefits of exercise. *British Journal of Pharmacology*. Sep 2012;167(1):1-12. doi:10.1111/j.1476-5381.2012.01970.x
9. Myers J. The health benefits and economics of physical activity. *Current sports medicine reports*. Nov-Dec 2008;7(6):314-6. doi:10.1249/JSR.0b013e31818ee179
10. Arrieta H, Rezola-Pardo C, Zarrazquin I, et al. A multicomponent exercise program improves physical function in long-term nursing home residents: A randomized controlled trial. *Experimental gerontology*. Mar 2018;103:94-100. doi:10.1016/j.exger.2018.01.008
11. Hamer M, Chida Y. Physical activity and risk of neurodegenerative disease: a systematic review of prospective evidence. *Psychol Med*. Jan 2009;39(1):3-11. doi:10.1017/s0033291708003681
12. Northey JM, Cherbuin N, Pumpa KL, Smee DJ, Rattray B. Exercise interventions for cognitive function in adults older than 50: a systematic review with meta-analysis. *Br J Sports Med*. Feb 2018;52(3):154-160. doi:10.1136/bjsports-2016-096587
13. Guiney H, Machado L. Benefits of regular aerobic exercise for executive functioning in healthy populations. *Psychon Bull Rev*. Feb 2013;20(1):73-86. doi:10.3758/s13423-012-0345-4
14. Smith PJ, Blumenthal JA, Hoffman BM, et al. Aerobic exercise and neurocognitive performance: a meta-analytic review of randomized controlled trials. *Psychosomatic medicine*. Apr 2010;72(3):239-52. doi:10.1097/PSY.0b013e3181d14633
15. Alvarez-Bueno C, Pesce C, Cavero-Redondo I, Sanchez-Lopez M, Garrido-Miguel M, Martinez-Vizcaino V. Academic Achievement and Physical Activity: A Meta-analysis. *Pediatrics*. Dec 2017;140(6)doi:10.1542/peds.2017-1498
16. Gaz DV, Smith AM. Psychosocial benefits and implications of exercise. *PM & R: The Journal of Injury, Function, and Rehabilitation*. Nov 2012;4(11):812-7. doi:10.1016/j.pmrj.2012.09.587
17. Terry PC. Introduction to the special issue: perspectives on mood in sport and exercise. *Journal of Applied Sport Psychology*. 2000;12(1):1-4.
18. Cooney GM, Dwan K, Greig CA, et al. Exercise for depression. *The Cochrane database of systematic reviews*. 2013;9:Cd004366. doi:10.1002/14651858.CD004366.pub6

19. Barbour KA, Edenfield TM, Blumenthal JA. Exercise as a treatment for depression and other psychiatric disorders: a review. *Journal of cardiopulmonary rehabilitation and prevention*. Nov-Dec 2007;27(6):359-67. doi:10.1097/01.hcr.0000300262.69645.95
20. Paluska SA, Schwenk TL. Physical activity and mental health: current concepts. *Sports medicine (Auckland, NZ)*. Mar 2000;29(3):167-80.
21. Krogh J, Hjorthoj C, Speyer H, Gluud C, Nordentoft M. Exercise for patients with major depression: a systematic review with meta-analysis and trial sequential analysis. *BMJ Open*. Sep 18 2017;7(9):e014820. doi:10.1136/bmjopen-2016-014820
22. Szabo A, Abraham J. The psychological benefits of recreational running: a field study. *Psychol Health Med*. 2013;18(3):251-61. doi:10.1080/13548506.2012.701755
23. Mattson MP. Evolutionary aspects of human exercise--born to run purposefully. *Ageing Res Rev*. Jul 2012;11(3):347-52. doi:10.1016/j.arr.2012.01.007
24. Nosrat S, Whitworth JW, Ciccolo JT. Exercise and mental health of people living with HIV: A systematic review. *Chronic illness*. Dec 2017;13(4):299-319. doi:10.1177/1742395317694224
25. Ng QX, Ho CYX, Chan HW, Yong BZJ, Yeo WS. Managing childhood and adolescent attention-deficit/hyperactivity disorder (ADHD) with exercise: A systematic review. *Complementary therapies in medicine*. Oct 2017;34:123-128. doi:10.1016/j.ctim.2017.08.018
26. Firth J, Cotter J, Carney R, Yung AR. The pro-cognitive mechanisms of physical exercise in people with schizophrenia. *Br J Pharmacol*. Oct 2017;174(19):3161-3172. doi:10.1111/bph.13772
27. Chennaoui M, Arnal PJ, Sauvet F, Leger D. Sleep and exercise: a reciprocal issue? *Sleep Med Rev*. Apr 2015;20:59-72. doi:10.1016/j.smrv.2014.06.008
28. Riemann D, Baglioni C, Bassetti C, et al. European guideline for the diagnosis and treatment of insomnia. *Journal of sleep research*. Dec 2017;26(6):675-700. doi:10.1111/jsr.12594
29. Dobrosielski DA, Papandreou C, Patil SP, Salas-Salvado J. Diet and exercise in the management of obstructive sleep apnoea and cardiovascular disease risk. *European respiratory review : an official journal of the European Respiratory Society*. Jun 30 2017;26(144)doi:10.1183/16000617.0110-2016
30. Babatunde OO, Jordan JL, Van der Windt DA, Hill JC, Foster NE, Protheroe J. Effective treatment options for musculoskeletal pain in primary care: A systematic overview of current evidence. *PLoS One*. 2017;12(6):e0178621. doi:10.1371/journal.pone.0178621
31. Geneen LJ, Moore RA, Clarke C, Martin D, Colvin LA, Smith BH. Physical activity and exercise for chronic pain in adults: an overview of Cochrane Reviews. *The Cochrane database of systematic reviews*. Jan 14 2017;1:Cd011279. doi:10.1002/14651858.CD011279.pub2
32. Chou R, Deyo R, Friedly J, et al. Nonpharmacologic therapies for low back pain: a systematic review for an American College of Physicians Clinical Practice Guideline. *Annals of internal medicine*. Apr 4 2017;166(7):493-505. doi:10.7326/m16-2459
33. Sosa-Reina MD, Nunez-Nagy S, Gallego-Izquierdo T, Pecos-Martin D, Monserrat J, Alvarez-Mon M. Effectiveness of Therapeutic Exercise in Fibromyalgia Syndrome: A Systematic Review and Meta-Analysis of Randomized Clinical Trials. *BioMed research international*. 2017;2017:2356346. doi:10.1155/2017/2356346
34. Hurley M, Dickson K, Hallett R, et al. Exercise interventions and patient beliefs for people with hip, knee or hip and knee osteoarthritis: a mixed methods review. *The Cochrane database of systematic reviews*. Apr 17 2018;4:Cd010842. doi:10.1002/14651858.CD010842.pub2
35. Liu X, Zhang D, Liu Y, et al. Dose-Response Association Between Physical Activity and Incident Hypertension: A Systematic Review and Meta-Analysis of Cohort Studies. *Hypertension*. May 2017;69(5):813-820. doi:10.1161/hypertensionaha.116.08994
36. Osteras N, Kjeken I, Smedslund G, et al. Exercise for hand osteoarthritis. *The Cochrane database of systematic reviews*. Jan 31 2017;1:Cd010388. doi:10.1002/14651858.CD010388.pub2
37. Gregg VH, Ferguson JE, 2nd. Exercise in Pregnancy. *Clinics in sports medicine*. Oct 2017;36(4):741-752. doi:10.1016/j.csm.2017.05.005

38. Di Raimondo D, Musiari G, Miceli G, Arnao V, Pinto A. Preventive and Therapeutic Role of Muscle Contraction Against Chronic Diseases. *Curr Pharm Des*. 2016;22(30):4686-4699.
39. McMullen CW, Harrast MA, Baggish AL. Optimal Running Dose and Cardiovascular Risk. *Curr Sports Med Rep*. Jun 2018;17(6):192-198. doi:10.1249/jsr.0000000000000491
40. Orkaby AR, Forman DE. Physical activity and CVD in older adults: an expert's perspective. *Expert Rev Cardiovasc Ther*. Jan 2018;16(1):1-10. doi:10.1080/14779072.2018.1419062
41. Stout NL, Baima J, Swisher AK, Winters-Stone KM, Welsh J. A Systematic Review of Exercise Systematic Reviews in the Cancer Literature (2005-2017). *PM & R: The Journal of Injury, Function, and Rehabilitation*. Sep 2017;9(9s2):S347-s384. doi:10.1016/j.pmrj.2017.07.074
42. Duncan M, Moschopoulou E, Herrington E, et al. Review of systematic reviews of non-pharmacological interventions to improve quality of life in cancer survivors. *BMJ Open*. Nov 28 2017;7(11):e015860. doi:10.1136/bmjopen-2017-015860
43. Kelley GA, Kelley KS. Exercise and cancer-related fatigue in adults: a systematic review of previous systematic reviews with meta-analyses. *BMC Cancer*. Oct 23 2017;17(1):693. doi:10.1186/s12885-017-3687-5
44. Codella R, Terruzzi I, Luzi L. Why should people with type 1 diabetes exercise regularly? *Acta diabetologica*. Jul 2017;54(7):615-630. doi:10.1007/s00592-017-0978-x
45. De Nardi AT, Tolves T, Lenzi TL, Signori LU, Silva A. High-intensity interval training versus continuous training on physiological and metabolic variables in prediabetes and type 2 diabetes: A meta-analysis. *Diabetes Res Clin Pract*. Mar 2018;137:149-159. doi:10.1016/j.diabres.2017.12.017
46. Jenkins DW, Jenks A. Exercise and Diabetes: A Narrative Review. *The Journal of foot and ankle surgery : official publication of the American College of Foot and Ankle Surgeons*. Sep - Oct 2017;56(5):968-974. doi:10.1053/j.jfas.2017.06.019
47. Fock KM, Khoo J. Diet and exercise in management of obesity and overweight. *Journal of gastroenterology and hepatology*. Dec 2013;28 Suppl 4:59-63. doi:10.1111/jgh.12407
48. Moreira LD, Oliveira ML, Lirani-Galvao AP, Marin-Mio RV, Santos RN, Lazaretti-Castro M. Physical exercise and osteoporosis: effects of different types of exercises on bone and physical function of postmenopausal women. *Arquivos brasileiros de endocrinologia e metabologia*. Jul 2014;58(5):514-22.
49. Xing Y, Yang SD, Dong F, Wang MM, Feng YS, Zhang F. The beneficial role of early exercise training following stroke and possible mechanisms. *Life Sci*. Apr 1 2018;198:32-37. doi:10.1016/j.lfs.2018.02.018
50. Han P, Zhang W, Kang L, et al. Clinical Evidence of Exercise Benefits for Stroke. *Advances in experimental medicine and biology*. 2017;1000:131-151. doi:10.1007/978-981-10-4304-8_9
51. Motl RW, Sandroff BM, Kwakkel G, et al. Exercise in patients with multiple sclerosis. *The Lancet Neurology*. Oct 2017;16(10):848-856. doi:10.1016/s1474-4422(17)30281-8
52. Zainuldin R, Mackey MG, Alison JA. Optimal intensity and type of leg exercise training for people with chronic obstructive pulmonary disease. *The Cochrane database of systematic reviews*. Nov 9 2011;(11):Cd008008. doi:10.1002/14651858.CD008008.pub2
53. Babu AS, Arena R, Morris NR. Evidence on Exercise Training in Pulmonary Hypertension. *Advances in experimental medicine and biology*. 2017;1000:153-172. doi:10.1007/978-981-10-4304-8_10
54. Ding R. Exercise-Based Rehabilitation for Heart Failure: Clinical Evidence. *Advances in experimental medicine and biology*. 2017;1000:31-49. doi:10.1007/978-981-10-4304-8_3
55. Qiu Z, Zheng K, Zhang H, Feng J, Wang L, Zhou H. Physical Exercise and Patients with Chronic Renal Failure: A Meta-Analysis. *BioMed research international*. 2017;2017:7191826. doi:10.1155/2017/7191826
56. Hageman D, Fokkenrood HJ, Gommans LN, van den Houten MM, Teijink JA. Supervised exercise therapy versus home-based exercise therapy versus walking advice for intermittent claudication. *The Cochrane database of systematic reviews*. Apr 6 2018;4:Cd005263. doi:10.1002/14651858.CD005263.pub4

57. Zheng Q, Sun XY, Miao X, et al. Association between physical activity and risk of prevalent psoriasis: A MOOSE-compliant meta-analysis. *Medicine (Baltimore)*. Jul 2018;97(27):e11394. doi:10.1097/md.0000000000011394
58. Simon RM, Howard L, Zapata D, Frank J, Freedland SJ, Vidal AC. The association of exercise with both erectile and sexual function in black and white men. *The journal of sexual medicine*. May 2015;12(5):1202-10. doi:10.1111/jsm.12869
59. Maher JL, McMillan DW, Nash MS. Exercise and Health-Related Risks of Physical Deconditioning After Spinal Cord Injury. *Topics in spinal cord injury rehabilitation*. Summer 2017;23(3):175-187. doi:10.1310/sci2303-175
60. Grazioli E, Dimauro I, Mercatelli N, et al. Physical activity in the prevention of human diseases: role of epigenetic modifications. *BMC Genomics*. Nov 14 2017;18(Suppl 8):802. doi:10.1186/s12864-017-4193-5
61. Monda V, Villano I, Messina A, et al. Exercise Modifies the Gut Microbiota with Positive Health Effects. *Oxidative medicine and cellular longevity*. 2017;2017:3831972. doi:10.1155/2017/3831972
62. World Health Organization. Physical Activity. Accessed December 2, 2024. https://www.who.int/news-room/fact-sheets/detail/physical-activity
63. Blanck HM, McCullough ML, Patel AV, et al. Sedentary behavior, recreational physical activity, and 7-year weight gain among postmenopausal U.S. women. *Obesity*. Jun 2007;15(6):1578-88. doi:10.1038/oby.2007.187
64. Swain DP, Franklin BA. Comparison of cardioprotective benefits of vigorous versus moderate intensity aerobic exercise. *The American journal of cardiology*. Jan 1 2006;97(1):141-7. doi:10.1016/j.amjcard.2005.07.130
65. Grimby G, Saltin B. The ageing muscle. *Clinical physiology (Oxford, England)*. Jun 1983;3(3):209-18.
66. Westcott WL. Resistance training is medicine: effects of strength training on health. *Curr Sports Med Rep*. Jul-Aug 2012;11(4):209-16. doi:10.1249/JSR.0b013e31825dabb8
67. Katzmarzyk PT, Craig CL. Musculoskeletal fitness and risk of mortality. *Med Sci Sports Exerc*. May 2002;34(5):740-4.
68. Warburton DE, Glendhill N, Quinney A. The effects of changes in musculoskeletal fitness on health. *Canadian journal of applied physiology = Revue canadienne de physiologie appliquee*. Apr 2001;26(2):161-216.
69. Warburton DE, Gledhill N, Quinney A. Musculoskeletal fitness and health. *Canadian journal of applied physiology = Revue canadienne de physiologie appliquee*. Apr 2001;26(2):217-37.
70. Rantanen T, Masaki K, Foley D, Izmirlian G, White L, Guralnik JM. Grip strength changes over 27 yr in Japanese-American men. *Journal of Applied Physiology (Bethesda, Md: 1985)*. Dec 1998;85(6):2047-53.
71. Seynnes O, Fiatarone Singh MA, Hue O, Pras P, Legros P, Bernard PL. Physiological and functional responses to low-moderate versus high-intensity progressive resistance training in frail elders. *The journals of gerontology Series A, Biological sciences and medical sciences*. May 2004;59(5):503-9.
72. Moreira OC, Faraci LL, de Matos DG, et al. Cardiovascular Responses to Unilateral, Bilateral, and Alternating Limb Resistance Exercise Performed Using Different Body Segments. *Journal of strength and conditioning research / National Strength & Conditioning Association*. Mar 2017;31(3):644-652. doi:10.1519/jsc.0000000000001160
73. Arazi H, Asadi A, Mahdavi SA, Nasiri SO. Cardiovascular responses to plyometric exercise are affected by workload in athletes. *Postepy w kardiologii interwencyjnej = Advances in interventional cardiology*. 2014;10(1):2-6. doi:10.5114/pwki.2014.41458
74. Gist NH, Freese EC, Cureton KJ. Comparison of responses to two high-intensity intermittent exercise protocols. *Journal of strength and conditioning research / National Strength & Conditioning Association*. Nov 2014;28(11):3033-40. doi:10.1519/jsc.0000000000000522

75. Powell KE, Heath GW, Kresnow MJ, Sacks JJ, Branche CM. Injury rates from walking, gardening, weightlifting, outdoor bicycling, and aerobics. *Medicine and science in sports and exercise*. Aug 1998;30(8):1246-9.
76. Kolber MJ, Beekhuizen KS, Cheng MS, Hellman MA. Shoulder injuries attributed to resistance training: a brief review. *Journal of strength and conditioning research / National Strength & Conditioning Association*. Jun 2010;24(6):1696-704. doi:10.1519/JSC.0b013e3181dc4330
77. Michaelides AP, Soulis D, Antoniades C, et al. Exercise duration as a determinant of vascular function and antioxidant balance in patients with coronary artery disease. *Heart*. May 2011;97(10):832-7. doi:10.1136/hrt.2010.209080
78. O'Keefe JH, Patil HR, Lavie CJ, Magalski A, Vogel RA, McCullough PA. Potential adverse cardiovascular effects from excessive endurance exercise. *Mayo Clinic proceedings*. Jun 2012;87(6):587-95. doi:10.1016/j.mayocp.2012.04.005
79. Patil HR, O'Keefe JH, Lavie CJ, Magalski A, Vogel RA, McCullough PA. Cardiovascular damage resulting from chronic excessive endurance exercise. *Missouri Medicine*. Jul-Aug 2012;109(4):312-21.
80. Freimuth M, Moniz S, Kim SR. Clarifying exercise addiction: differential diagnosis, co-occurring disorders, and phases of addiction. *International journal of environmental research and public health*. Oct 2011;8(10):4069-81. doi:10.3390/ijerph8104069
81. Morgan WP, Brown DR, Raglin JS, O'Connor PJ, Ellickson KA. Psychological monitoring of overtraining and staleness. *British journal of sports medicine*. Sep 1987;21(3):107-14.
82. Hobart JA, Smucker DR. The female athlete triad. *American family physician*. Jun 1 2000;61(11):3357-64, 3367.
83. Feuerstein G. *The Yoga Tradition: Its History, Literature, Philosophy, and Practice*. Hohm Press; 2001.
84. Saper RB, Eisenberg DM, Davis RB, Culpepper L, Phillips RS. Prevalence and patterns of adult yoga use in the United States: results of a national survey. *Alternative therapies in health and medicine*. Mar-Apr 2004;10(2):44-9.
85. Hartfiel N, Havenhand J, Khalsa SB, Clarke G, Krayer A. The effectiveness of yoga for the improvement of well-being and resilience to stress in the workplace. *Scandinavian Journal of Work, Environment and Health*. Jan 2011;37(1):70-6.
86. Thind H, Lantini R, Balletto BL, et al. The effects of yoga among adults with type 2 diabetes: a systematic review and meta-analysis. *Prev Med (Baltim)*. Dec 2017;105:116-126. doi:10.1016/j.ypmed.2017.08.017
87. Domingues RB. Modern postural yoga as a mental health promoting tool: A systematic review. *Complement Ther Clin Pract*. May 2018;31:248-255. doi:10.1016/j.ctcp.2018.03.002
88. Cramer H, Anheyer D, Lauche R, Dobos G. A systematic review of yoga for major depressive disorder. *Journal of affective disorders*. Apr 15 2017;213:70-77. doi:10.1016/j.jad.2017.02.006
89. Gallegos AM, Crean HF, Pigeon WR, Heffner KL. Meditation and yoga for posttraumatic stress disorder: A meta-analytic review of randomized controlled trials. *Clinical psychology review*. Dec 2017;58:115-124. doi:10.1016/j.cpr.2017.10.004
90. Park SH, Han KS. Blood pressure response to meditation and yoga: a systematic review and meta-analysis. *J Altern Complement Med*. Sep 2017;23(9):685-695. doi:10.1089/acm.2016.0234
91. Wieland LS, Skoetz N, Pilkington K, Vempati R, D'Adamo CR, Berman BM. Yoga treatment for chronic non-specific low back pain. *Cochrane Database of Systematic Reviews*. Jan 12 2017;1:Cd010671. doi:10.1002/14651858.CD010671.pub2
92. Groessl EJ, Liu L, Chang DG, et al. Yoga for Military Veterans with Chronic Low Back Pain: A Randomized Clinical Trial. *American journal of preventive medicine*. Nov 2017;53(5):599-608. doi:10.1016/j.amepre.2017.05.019
93. Khalsa SB. Treatment of chronic insomnia with yoga: a preliminary study with sleep-wake diaries. *Applied psychophysiology and biofeedback*. Dec 2004;29(4):269-78.

94. Cramer H, Peng W, Lauche R. Yoga for menopausal symptoms-a systematic review and meta-analysis. *Maturitas*. Mar 2018;109:13-25. doi:10.1016/j.maturitas.2017.12.005
95. Li C, Liu Y, Ji Y, Xie L, Hou Z. Efficacy of yoga training in chronic obstructive pulmonary disease patients: A systematic review and meta-analysis. *Complement Ther Clin Pract*. Feb 2018;30:33-37. doi:10.1016/j.ctcp.2017.11.006
96. Yang ZY, Zhong HB, Mao C, et al. Yoga for asthma. *The Cochrane database of systematic reviews*. Apr 27 2016;4:Cd010346. doi:10.1002/14651858.CD010346.pub2
97. Brotto LA, Mehak L, Kit C. Yoga and sexual functioning: a review. *Journal of Sex and Marital Therapy*. 2009;35(5):378-390.
98. Cramer H, Lauche R, Klose P, Lange S, Langhorst J, Dobos GJ. Yoga for improving health-related quality of life, mental health and cancer-related symptoms in women diagnosed with breast cancer. *The Cochrane database of systematic reviews*. Jan 3 2017;1:Cd010802. doi:10.1002/14651858.CD010802.pub2
99. Mooventhan A, Nivethitha L. Evidence based effects of yoga in neurological disorders. *Journal of clinical neuroscience : official journal of the Neurosurgical Society of Australasia*. Sep 2017;43:61-67. doi:10.1016/j.jocn.2017.05.012
100. Coeytaux RR, McDuffie J, Goode A, et al. VA Evidence-based Synthesis Program Reports. VA ESP Project #09-010. *Evidence Map of Yoga for High-Impact Conditions Affecting Veterans*. Department of Veterans Affairs (US); 2014.
101. Saravanakumar P, Higgins IJ, van der Riet PJ, Marquez J, Sibbritt D. The influence of tai chi and yoga on balance and falls in a residential care setting: A randomised controlled trial. *Contemporary nurse*. 2014;48(1):76-87. doi:10.5172/conu.2014.48.1.76
102. Field T. Yoga clinical research review. *Complementary therapies in clinical practice*. Feb 2011;17(1):1-8. doi:10.1016/j.ctcp.2010.09.007
103. Lau HL, Kwong JS, Yeung F, Chau PH, Woo J. Yoga for secondary prevention of coronary heart disease. *The Cochrane database of systematic reviews*. 2012;12:Cd009506. doi:10.1002/14651858.CD009506.pub2
104. Posadzki P, Ernst E. Yoga for asthma? A systematic review of randomized clinical trials. *The Journal of asthma : official journal of the Association for the Care of Asthma*. Aug 2011;48(6):632-9. doi:10.3109/02770903.2011.584358
105. Ross A, Thomas S. The health benefits of yoga and exercise: a review of comparison studies. *Journal of alternative and complementary medicine (New York, NY)*. Jan 2010;16(1):3-12. doi:10.1089/acm.2009.0044
106. Patel NK, Newstead AH, Ferrer RL. The effects of yoga on physical functioning and health related quality of life in older adults: a systematic review and meta-analysis. *Journal of alternative and complementary medicine (New York, NY)*. Oct 2012;18(10):902-17. doi:10.1089/acm.2011.0473
107. Shelov DV, Suchday S, Friedberg JP. A pilot study measuring the impact of yoga on the trait of mindfulness. *Behavioural and cognitive psychotherapy*. Oct 2009;37(5):595-8. doi:10.1017/s1352465809990361
108. Brisbon NM, Lowery GA. Mindfulness and levels of stress: a comparison of beginner and advanced Hatha Yoga practitioners. *Journal of religion and health*. Dec 2011;50(4):931-41. doi:10.1007/s10943-009-9305-3
109. Cowen VS. Functional fitness improvements after a worksite-based yoga initiative. *Journal of bodywork and movement therapies*. Jan 2010;14(1):50-4. doi:10.1016/j.jbmt.2009.02.006
110. Kamei T, Toriumi Y, Kimura H, Ohno S, Kumano H, Kimura K. Decrease in serum cortisol during yoga exercise is correlated with alpha wave activation. *Perceptual and motor skills*. Jun 2000;90(3 Pt 1):1027-32.
111. Cramer H, Krucoff C, Dobos G. Adverse events associated with yoga: a systematic review of published case reports and case series. *PLoS One*. 2013;8(10):e75515. doi:10.1371/journal.pone.0075515

112. Cramer H, Ostermann T, Dobos G. Injuries and other adverse events associated with yoga practice: A systematic review of epidemiological studies. *Journal of science and medicine in sport*. Feb 2018;21(2):147-154. doi:10.1016/j.jsams.2017.08.026
113. Frawley D. *Yoga and Ayurveda: Self-Healing and Self-Realization*. Motilal Banarsidass; 1999.
114. Jahnke R, Larkey L, Rogers C, Etnier J, Lin F. A comprehensive review of health benefits of qigong and tai chi. *American Journal of Health Promotion*. Jul-Aug 2010;24(6):e1-e25. doi:10.4278/ajhp.081013-LIT-248
115. Lee MS, Ernst E. Systematic reviews of t'ai chi: an overview. *British journal of sports medicine*. Aug 2012;46(10):713-8. doi:10.1136/bjsm.2010.080622
116. Leung DP, Chan CK, Tsang HW, Tsang WW, Jones AY. Tai chi as an intervention to improve balance and reduce falls in older adults: A systematic and meta-analytical review. *Alternative therapies in health and medicine*. Jan-Feb 2011;17(1):40-8.
117. Liu H, Frank A. Tai chi as a balance improvement exercise for older adults: a systematic review. *Journal of geriatric physical therapy (2001)*. Jul-Sep 2010;33(3):103-9.
118. Hallisy K. Tai chi beyond balance and fall prevention: health benefits and its potential role in combatting social isolation in the aging population. *Current Geriatrics Reports*. 2018;7doi:10.1007/s13670-018-0233-5
119. Field T. Tai Chi research review. *Complementary therapies in clinical practice*. Aug 2011;17(3):141-6. doi:10.1016/j.ctcp.2010.10.002
120. Zou L, Wang C, Chen K, et al. The effect of taichi practice on attenuating bone mineral density loss: a systematic review and meta-analysis of randomized controlled trials. *International journal of environmental research and public health*. Sep 1 2017;14(9)doi:10.3390/ijerph14091000
121. Xiang Y, Lu L, Chen X, Wen Z. Does tai chi relieve fatigue? A systematic review and meta-analysis of randomized controlled trials. *PLoS One*. 2017;12(4):e0174872. doi:10.1371/journal.pone.0174872
122. Hall A, Copsey B, Richmond H, et al. Effectiveness of tai chi for chronic musculoskeletal pain conditions: updated systematic review and meta-analysis. *Phys Ther*. Feb 1 2017;97(2):227-238. doi:10.2522/ptj.20160246
123. Abbott R, Lavretsky H. Tai Chi and Qigong for the treatment and prevention of mental disorders. *The Psychiatric clinics of North America*. Mar 2013;36(1):109-19. doi:10.1016/j.psc.2013.01.011
124. Wang C, Bannuru R, Ramel J, Kupelnick B, Scott T, Schmid CH. Tai Chi on psychological well-being: systematic review and meta-analysis. *BMC Complementary and Alternative Medicine*. 2010;10:23. doi:10.1186/1472-6882-10-23
125. Wang F, Lee E, Wu T, et al. The effects of tai chi on depression, anxiety, and psychological well-being: a systematic review and meta-analysis. *International Journal of Behavioral Medicine*. 2014;21(4):605-617.
126. Polkey MI, Qiu ZH, Zhou L, et al. Tai chi and pulmonary rehabilitation compared for treatment-naive patients with COPD: a randomized controlled trial. *Chest*. May 2018;153(5):1116-1124. doi:10.1016/j.chest.2018.01.053
127. Van Vu D, Molassiotis A, Ching SSY, Le TT. Effects of Qigong on symptom management in cancer patients: A systematic review. *Complement Ther Clin Pract*. Nov 2017;29:111-121. doi:10.1016/j.ctcp.2017.09.005
128. Kuramoto AM. Therapeutic benefits of Tai Chi exercise: research review. *WMJ : official publication of the State Medical Society of Wisconsin*. Oct 2006;105(7):42-6.
129. Walther A, Lacker TJ, Ehlert U. Everybody was Kung-Fu fighting-The beneficial effects of Tai Chi Qigong and self-defense Kung-Fu training on psychological and endocrine health in middle aged and older men. *Complementary therapies in medicine*. Feb 2018;36:68-72. doi:10.1016/j.ctim.2017.11.021
130. Origua Rios S, Marks J, Estevan I, Barnett LM. Health benefits of hard martial arts in adults: a systematic review. *Journal of sports sciences*. Jul 2018;36(14):1614-1622. doi:10.1080/02640414.2017.1406297

131. Cruz-Ferreira A, Fernandes J, Laranjo L, Bernardo LM, Silva A. A systematic review of the effects of pilates method of exercise in healthy people. *Archives of physical medicine and rehabilitation*. Dec 2011;92(12):2071-81. doi:10.1016/j.apmr.2011.06.018
132. Bird ML, Fell J. Positive long-term effects of pilates exercise on the aged-related decline in balance and strength in older, community-dwelling men and women. *Journal of aging and physical activity*. Jul 2014;22(3):342-7. doi:10.1123/japa.2013-0006
133. Yamato TP, Maher CG, Saragiotto BT, et al. Pilates for low back pain. *The Cochrane database of systematic reviews*. Jul 2 2015;(7):Cd010265. doi:10.1002/14651858.CD010265.pub2
134. Espindula RC, Nadas GB, Rosa MID, Foster C, Araujo FC, Grande AJ. Pilates for breast cancer: A systematic review and meta-analysis. *Revista da Associacao Medica Brasileira (1992)*. Nov 2017;63(11):1006-1012. doi:10.1590/1806-9282.63.11.1006
135. Lee IM, Buchner DM. The importance of walking to public health. *Medicine and science in sports and exercise*. Jul 2008;40(7 Suppl):S512-8. doi:10.1249/MSS.0b013e31817c65d0
136. Ogilvie D, Foster CE, Rothnie H, et al. Interventions to promote walking: systematic review. *BMJ*. Jun 9 2007;334(7605):1204. doi:10.1136/bmj.39198.722720.BE
137. Franklin BA. Walking: the undervalued prescription. *Preventive cardiology*. Winter 2006;9(1):56-9.
138. Kelly P, Williamson C, Niven AG, Hunter R, Mutrie N, Richards J. Walking on sunshine: scoping review of the evidence for walking and mental health. *Br J Sports Med*. Jun 2018;52(12):800-806. doi:10.1136/bjsports-2017-098827
139. Fritschi JO, Brown WJ, Laukkanen R, van Uffelen JG. The effects of pole walking on health in adults: a systematic review. *Scandinavian journal of medicine & science in sports*. Oct 2012;22(5):e70-8. doi:10.1111/j.1600-0838.2012.01495.x
140. Tschentscher M, Niederseer D, Niebauer J. Health benefits of Nordic walking: a systematic review. *American journal of preventive medicine*. Jan 2013;44(1):76-84. doi:10.1016/j.amepre.2012.09.043
141. Cugusi L, Manca A, Yeo TJ, Bassareo PP, Mercuro G, Kaski JC. Nordic walking for individuals with cardiovascular disease: A systematic review and meta-analysis of randomized controlled trials. *Eur J Prev Cardiol*. Dec 2017;24(18):1938-1955. doi:10.1177/2047487317738592
142. De Cocker K, Cardon G, De Bourdeaudhuij I. Validity of the inexpensive Stepping Meter in counting steps in free living conditions: a pilot study. *British journal of sports medicine*. Aug 2006;40(8):714-6. doi:10.1136/bjsm.2005.025296
143. Stein DJ, Collins M, Daniels W, Noakes TD, Zigmond M. Mind and muscle: the cognitive-affective neuroscience of exercise. *CNS spectrums*. Jan 2007;12(1):19-22.
144. Vivar C, van Praag H. Running Changes the Brain: the Long and the Short of It. *Physiology (Bethesda, Md)*. Nov 2017;32(6):410-424. doi:10.1152/physiol.00017.2017
145. Williams PT, Thompson PD. Walking versus running for hypertension, cholesterol, and diabetes mellitus risk reduction. *Arteriosclerosis, thrombosis, and vascular biology*. May 2013;33(5):1085-91. doi:10.1161/atvbaha.112.300878
146. Draper CE, Besier TF, Santos JM, et al. Using real-time MRI to quantify altered joint kinematics in subjects with patellofemoral pain and to evaluate the effects of a patellar brace or sleeve on joint motion. *Journal of orthopaedic research : official publication of the Orthopaedic Research Society*. May 2009;27(5):571-7. doi:10.1002/jor.20790
147. Zappala FG, Taffel CB, Scuderi GR. Rehabilitation of patellofemoral joint disorders. *The Orthopedic clinics of North America*. Oct 1992;23(4):555-66.
148. Cowan SM, Bennell KL, Hodges PW, Crossley KM, McConnell J. Delayed onset of electromyographic activity of vastus medialis obliquus relative to vastus lateralis in subjects with patellofemoral pain syndrome. *Arch Phys Med Rehabil*. Feb 2001;82(2):183-9. doi:10.1053/apmr.2001.19022
149. Wu CC, Shih CH. The influence of iliotibial tract on patellar tracking. *Orthopedics*. Feb 2004;27(2):199-203.
150. Patil S, White L, Jones A, Hui AC. Idiopathic anterior knee pain in the young. A prospective controlled trial. *Acta orthopaedica Belgica*. Jun 2010;76(3):356-9.

151. Lopes AD, Hespanhol Junior LC, Yeung SS, Costa LO. What are the main running-related musculoskeletal injuries? A Systematic Review. *Sports medicine (Auckland, NZ)*. Oct 1 2012;42(10):891-905. doi:10.2165/11631170-000000000-00000
152. Saxena A, Haddad J. The effect of foot orthoses on patellofemoral pain syndrome. *Journal of the American Podiatric Medical Association*. Jul-Aug 2003;93(4):264-71.
153. MacIntyre NJ, Hill NA, Fellows RA, Ellis RE, Wilson DR. Patellofemoral joint kinematics in individuals with and without patellofemoral pain syndrome. *J Bone Joint Surg Am*. Dec 2006;88(12):2596-605. doi:10.2106/jbjs.E.00674