

# The Exercise Prescription Therapeutic Applications of Exercise and Physical Activity

Ahimsa Porter Sumchai\*

\*Sports Medicine and Alternative Therapies, Certified Nutritionist, National Strength and Conditioning Association Certified Personal Trainer, Greece

From the Latin “praescribere”, the American Heritage Dictionary defines prescribe as to “set down as a rule or order the use of a medicine or other treatment.” As strength and conditioning professionals advance forward challenging traditional boundaries of scope of practice, fund of knowledge and applications of exercise science, we bring true form to the concept of the exercise “prescription [1-5].”

In 1999 the American Council on Exercise (ACE) published the Clinical Exercise Specialist Manual [2].

It forecast the emerging impact of the obesity epidemic in America and the role the Department of Health and Human Services played in inspiring the Centers for Disease Control and Prevention, the National Institutes of Health and the American College of Sports Medicine to generate evidence based guidelines on the level of exercise and physical activity necessary to produce measurable results [2].

Most experts agree caloric restriction combined with physical activity that exceeds caloric intake remains the fundamental formula for optimizing human body composition [3].

“Researchers find inactive persons are at an increased risk of becoming obese and that previous exercise prescription by organizations focus on setting guidelines for frequency, intensity and duration of exercise to optimize fitness. On the other hand, new physical activity recommendations focus on promoting lifelong physical activity for health benefits and weight control. The current recommendations of these organizations advocate that people attempt to accumulate 30 minutes or more of moderate intensity physical activity on most, and preferably, all days of the week. (National Institutes of Health, 1996; US Department of Health and Human Services, 1996) [2]. “Our mission is to standardize best practices of the fitness industry to protect and improve public health, professional education and consumer safety” [4]. The American Society for Fitness Professionals was launched in 2011 “to advance the credibility of fitness professionals through advanced education and certification and to address controversial debates over licensure and unionization.” The ASFP organizational manifesto titled Unifying the Fitness Industry for Self regulation, is available online. (<http://asfptoday.org>).

The Bureau of Labour Statistics predicts the fitness industry will experience nearly 30% growth by 2018?

New frontiers create both obstacles and opportunities for fitness professionals and spark demands for heightened scrutiny and oversight of certification for consumer protection.

Medico legal and ethical responsibilities hold the personal trainer to standards of performance approaching that of licensed health professionals. The National Strength and Conditioning Association define breach of duty as “conduct of a personal trainer that is not consistent with the standard of care [5].”

“Prescribing exercise for persons with chronic disease or disability is a complex art. The objective is to decrease physiological limitations and improve physical capacity through specific therapies. The biggest dilemmas are not in determining which therapies to use but in defining the goals and choosing the appropriate training intensity,

duration and frequency. The key question is: what is the dose response relationship of exercise training for each disease and disability?” [6].

The American College of Sports Medicine has declared May Exercise is Medicine month and in 1997 published Exercise Management for Persons with Chronic Diseases and Disabilities. This groundbreaking text provided an early construct for exercise programs grounded in evidence based science and therapeutic applications [6].

Derived from ACSM’s Guidelines for Exercise Testing and Prescription, [7] Exercise Management for Persons with Chronic Diseases and Disabilities offers expert opinion on exercise prescriptions including screening, assessment and dose response determinations.

How do we develop an exercise prescription as therapy for disability and disease? That s the question! Let’s begin by exploring the science behind the premise that exercise and physical activity can be integral components of a fitness and wellness program to prevent disease, optimize rehabilitation, augment psychotherapy and activate the most effective antiaging intervention backed by genomic research [8-12].

In keeping with the Latin “Primum non nocere first do no harm” we must commit to recognizing signs and symptoms of exercise “overdose” including overuse injuries and overtraining syndromes. Let’s begin by examining medical conditions that offer evidence based research supporting the application of exercise prescription in successful treatment and prevention. Low Back Pain the Exercise Prescription “Recent clinical guidelines have established that exercise is a first choice recommendation for the treatment of chronic LBP [9].”

Low back pain (LBP) remains a major diagnosis prompting physician visits, emergency department evaluations and a principle cause of work related disability. Low back pain accounts for fully one third of workers compensation costs. Although 70-90% of back pain episodes subside within 23 months of onset, recurrence rates of 25-60% within one year have been reported. A series of peer reviewed research articles document improvement in low back pain using core strengthening exercises and performance outcome measurements [12-18].

A lack of standardization in exercise prescription for LBP

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\*Corresponding author: Ahimsa Porter Sumchai, Sports Medicine and Alternative Therapies, Certified Nutritionist, National Strength and Conditioning Association Certified Personal Trainer, Greece, E-mail: [asumchai@gmail.com](mailto:asumchai@gmail.com)

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rehabilitation exists, stemming from a paucity of safe peer reviewed research of lumbar muscle activity during exercise in patients with chronic LBP [8].”

Differences in muscle recruitment and trunk stiffness have been found between individuals with and without LBP in exercise and non exercise experiments [9]. Individuals with LBP have been found to have greater trunk muscle activity compared to asymptomatic individuals during exercises in the frontal, sagittal and transverse planes. Increases in trunk muscle activity are associated with greater trunk stiffness [9].

From the Department of Sport and Exercise Science, University of Western Sydney, Australia, Marshall, P.W examined EMG activity and lumbar spine range of motion recorded during performance of commonly recommended core stability exercises in healthy controls and people with nonspecific chronic low back pain. Using pairs of surface electrodes, muscle activity was measured bilaterally during each exercise from rectus abdominis, external obliques and lumbar erector spine [9]. Exclusion criteria included mechanical or structural abnormalities of the spine, evidence of nerve root compression, neuromuscular or inflammatory disease, cancer and pregnancy [9].

The researchers detected no increased trunk muscle activity in subjects with chronic nonspecific low back pain compared to healthy controls and conclude the lack of worsening of symptoms in the LBP subjects proves exercises investigated in this study are of use in rehabilitating patients with low back pain [9]. The unanswered question is whether the subjects with LBP had less pain and improved function following exercise therapy.

“The Pilates Method is an excellent rehabilitation system for back, knee, hip, shoulder, and repetitive stress injuries. Pilates methods address the body as a whole, correcting asymmetries and chronic weaknesses to prevent reinjury and bring the body into balance [17].”

Two of the most well researched and interventions for chronic low back pain are yoga and the Pilates methods [16,17].

Joseph Hubertus Pilates was born in Germany in 1880, afflicted by asthma, poor health and childhood bullying. A profile in athletic “intelligence” and perseverance, Pilates conquered his physical and psychological obstacles to become an avid skier, diver, gymnast, yogi and boxer. Pilates immigrated to the United States in 1923 and established an avant garde New York Studio. He rehabilitated professional dancers and galvanizing “disciples” in a cult of fitness that remains a top industry trend. The Pilates Method is called, “an excellent rehabilitation system for back, knee, hip, shoulder and repetitive stress injuries [18,19].”

Pilates mat and reformer exercises develop strong abdominal, back, butt and deep postural muscles to support the skeletal system and act as “the powerhouse” of the body [17].

Both Pilates and general exercise produced clinical improvement in a randomized study of 87 community volunteers with low back pain for a minimum of 3 months. Both groups showed significant improvement on self reported measures of pain, disability, function and health related quality of life. One of the simplest physical maneuvers used in rehabilitation of more serious spinal disorders is inversion therapy. Inversion devices have been found to produce distraction of the lumbar spine. Many people with chronic moderate to severe low back pain have one or more compressed lumbar discs. Occupations requiring extended sitting truck drivers and office clerks may heighten the risk of lumbar disc compression. A randomized trial

was conducted at the Regional Neurosciences Centre in Newcastle, U.K on a group of patients with lumbar disc disease told they needed spinal surgery.

Instead they practiced regular inversion therapy along with conventional physiotherapy. The authors conclude, “Inversion therapy decreased the need for an operation in sciatica due to single level disc disease and were 70.5% less likely to require surgery [20-23].”

Further investigation is needed to define the specific contributions made by inversion therapy versus conventional physical therapy and to set specific parameters for the safe level of incline, frequency and duration of inversion therapy sessions.

Other investigations examining the physiological and spinal column configuration impacts of inversion therapy include research in which heart rate, blood pressure, perceived discomfort, intraocular pressure and central retinal arterial pressure were studied [21,22]. Populations excluded include pregnant women and patients with heart failure, systemic hypertension, venous stasis disease, liver disease with ascites and peripheral edema, and other conditions that compromise cardiopulmonary function. Karski concludes, “Full inversion therapy...presents no risk to normotensive healthy subjects [24].”

Exercise Prescription for Sarcopenia in Seniors NSCA’s Essentials of Personal Training defines sarcopenia as age related loss in muscle mass. By age 30... “muscle mass appear to decline progressively with time. In addition to the loss in muscle mass, some evidence suggests that muscle quality declines with age [5].”

Aging skeletal muscle experiences fiber loss more severely in the high threshold Type II fast twitch motor units. An age related decrease in muscle satellite cells by age 70 is specific to Type II fibers. Thus, anaerobic capacity and explosive high intensity physical activity requiring rapid force development is diminished, contributing to impaired performance in tasks required for activities of daily living (ADL) and increased fall risk in seniors. 23 Advanced ages reduces speed of propagation of action potentials and muscle contraction, contributing to heightened fall risk in seniors. This age related limitations can be mitigated by exercise and physical activity. Numerous studies demonstrate resistance training can increase muscle mass and strength in seniors.

Strength gains can be dramatic, up to 200% for knee extension maximum strength, and increases in muscle size can occur in both Type 1 and Type II fibers. Resistance training also increases bone density and reduces risk of fall related fractures [5].

Karski conducted a five year PubMed search for dose response effect of strength training in the elderly 25. The investigators predicated their research on the belief that seniors need strength training as they age to stay mobile and independent for everyday activities. “The dose response relationship of training intensity to training effect has not been elucidated” [25].

Based on the review of research the authors conclude that strength training in seniors increases muscle strength by increasing muscle mass and improving the recruitment of motor units by increasing their firing rate.

Muscle mass can be increased by training at an intensity corresponding to 60% to 85% of the individuals maximum strength capacity. Based on the findings of this review the authors recommend 3 to 4 bouts of resistance training weekly [25].

New studies suggest telomeres in skeletal muscles are dynamic structures under the influence of the environment. These protective regions at the end of chromosomes function like the tips of shoelaces to safeguard genetic information. Each time the cell divides the telomeres shorten, ultimately triggering cell death. Telomere length and age dependent attrition are a biological indicator of aging [26]. Karski tested the hypothesis that physical activity is associated with telomere length in a population of 2401 white twin volunteers. The investigation, published in Archives of Internal Medicine found a positive association between increased physical activity and increased telomere length.

A New York Times article titled How Exercising Keeps Your Cells Young brought the topic to the mainstream media [27,28].

The Exercise Prescription Overdose. "Although physical adaptations are best brought about by increases in training volume and intensity, at certain points in a training program, more is not better [5]."

Excessive volumes or intensity of physical training or repetitive strain or trauma can lead to overtraining or

Cumulative injury that can contribute to chronic disability and death [5, 27, 28]. "Overtraining does not enhance strength and power but results in decreased performance, staleness and general fatigue [5]." New science in the study of telomere length as a signal of skeletal muscle aging finds shortening of telomeres in subjects with symptoms of overtraining syndromes. Karski found abnormally short muscle DNA telomeres in athletes with exercise associated fatigue [29].

Applying the analogy of the medication dose response curve to the exercise prescription, a group of disorders emerge that correspond to overdose, toxicity and adverse reactions. The most serious being exercise related sudden death (ERSD) [26].

Athletic heart syndrome is a benign condition caused by physiological adaptation to the increased workloads of exercise. It must be differentiated from more serious medical conditions that adversely affect the size, function and contractility of the heart and may result in disqualification from sports activities. The most dangerous increase the risk of ERSD [26].

"Autopsy studies identify the most common conditions to be hypertrophic cardiomyopathy, concentric left ventricular hypertrophy, Marfan's syndrome, congenital coronary anomalies and myocarditis. Arrhythmias can cause death without detectable pathology at autopsy. A variety of conditions including preexcitation syndrome, long QT syndromes and mitral valve prolapse can trigger dangerous rhythm disturbances [26, 27]."

I attended the two days Stanford University International Symposium the Athletes Heart in June 2010.

It explored the myriad of electrophysiological conduction abnormalities that place young athletes at risk of sudden cardiac death. Coronary artery disease remains the most common cause of sudden cardiac in athletes over the age of 35. The majority of conditions linked to ERSD can be detected by simple cost effective EKG screening and preparticipation history and exam. Questions of importance include has anyone in the athlete's family died suddenly before age 50? Has the athlete experienced dizziness or passed out during or after exercise? Does the athlete have a history or physical exam findings consistent with heart disease or murmur? [26].

Perelman School of Medicine in collaboration with the American Heart Association and MedPage Today offered a physician CME course on 12/6/11 titled Endurance Athletes May Incur Heart Damage. Based on an elaborately designed research investigation by Andre' La Gerche, MBBS, Ph.D of the University of Melbourne, Australia published in the European Heart Journal, using biomarkers of myocardial injury and cardiac imaging the authors conclude that "repetitive ultra endurance exercise may lead to more extensive right ventricular change and myocardial fibrosis [27]."

Overtraining from aerobic and resistance training exercise has been well described. 5 in strength training it involves a plateau followed by decrease in strength, sleep disturbances, loss of lean body mass, decreased appetite, persistent URI or flu like symptoms, loss of interest and motivation to train, mood changes and excessive muscle soreness. In experimental situations, inducing an overtraining state requires a very severe exercise intervention but can be seen after repeated bouts of high intensity resistance training approaching 100% of 1Rm maximum. The most effective cure is rest [5].

The female athlete triad syndrome has been investigated and in a 2011 University of Wisconsin study found to be common in high school athletes. 28 The syndrome was first described over 25 years ago and consists of low BMI and low body composition as a result of energy imbalance, menstrual irregularities and bone density abnormalities [28].

The disordered eating and associated stress fractures bring this population of athletes to the attention of sports medicine physicians, orthopaedists and psychiatrists.

Having examined dozens of patients with eating disorders (ED), I am convinced an element of obsessive compulsive disorder and body dysmorphic disorder often coexist, influenced by familial, social and mass media promotions of the idealized body.

For two years I trained a cachectic woman with a Ph.D. in education. At 5'4" and 107 pounds, she resisted efforts to increase her body weight and had undergone a reduction mammoplasty. On neuropsychological screening she demonstrated obsessive compulsive traits and fulfilled criteria for ADHD, anxiety, bipolar disorder and shift work disorder.

The core focus of our training program was nutrition counselling, guided meditation and strength training at greater than 80% 1 repetition maximum to build lean body mass. After two years in training she maintained a low but nonfluctuating body weight of 110#. She began dating and ultimately entered into a long term relationship. Her body weight increased to 117#. Problem solved! Dating rituals often center around dining out and it is not unusual for couples in a romantic relationship to gain weight.

Wikipedia describes muscle dysmorphia or bigorexia as a disorder in which a person usually a young male becomes obsessed with the idea that his muscles are not big enough.<sup>29</sup> Called reverse anorexia or Adonis complex, it is a form of body dysmorphic syndrome that is difficult to treat because it involves obsessive compulsive tendencies, perfectionism and delusional thinking. Depression is common and risk factors include bullying and domestic conflict. Recent diagnostic imaging studies suggest a possible wiring of visual circuits in the brains of subjects with body dysmorphic syndrome such that their self image is incongruent with what they see when they look in the mirror [29]. Applying Exercise Dose Response Curves to Special Populations.

"Clinical exercise testing is an effective way of evaluating an

individual's cardiovascular response to controlled physiological stress exercise [2]."

Clinical exercise testing can be used to gauge the presence or severity of disease, to measure functional capacity and to evaluate the effectiveness of exercise interventions and conventional medical therapies. One of the most common reasons for clinical exercise testing is cardiovascular or pulmonary disease [2].

ACSM identifies that several medications, despite potential effects, may "improve exercise capacity through bronchodilator, relief of congestive heart failure and psychotropic effects" in supervised exercise training of persons with pulmonary diseases [30,31]. These medications include methylxanthines, sympathomimetic bronchodilators, diuretics and antidepressants.

High intensity exercise has been shown to stimulate the sympathetic division of the autonomic nervous system fuelling release of the adrenal hormones epinephrene and norepinephrene [5]. During exercise an increased stimulation or excitation of the heart occurs in order to supply blood to parts of the body where it is needed, such as skeletal musculature. The increased cerebral, skin and skeletal muscle blood flow combined with the release of activating sympathetic neurotransmitters and endorphins contributes to the anxiolytic and mood elevating effects of exercise and physical activity [5,26].

Long term sympathetic nervous system activation has been shown to increase circulating levels of the catabolic hormone cortisol. It is my belief that excess circulating cortisol levels play a role in the signs and symptoms evident in many overtraining syndromes [5,28].

Controversy has stirred over recent ACSM recommendations promoting high intensity exercise for short intervals in deconditioned populations [32-37].

Kokavec et al. ask the question Walk or run? Is high intensity exercise more effective than moderate intensity exercise at reducing cardiovascular risk? The investigators contend there is evidence that exercise intensity, rather than duration or frequency, is the most important variable in determining cardio protection [30].

Recent ACSM recommendations place greater emphasis on shorter duration minimum

20 minutes higher intensity exercise (HIE) performed a minimum of 3 times a week. Hassane Zouhal, Ph.D cites research in the ACSM Sports Medicine Bulletin that high intensity exercise for overweight and obese people may be a time efficient alternative for optimizing fitness and cardiovascular health [31].

McMasters University researchers found, in a small study of 8 diabetic patients, control of blood sugar was achieved after 30 minute bouts of HIE [32].

Lead investigator Professor of Kinesiology Martin Gabala concludes, "This is the first study to show intense interval training may be a potent, time efficient strategy to improve glycemic regulation in people with Type II diabetes."

In as few as 6 sessions in 2 weeks the 30" intermittent HIE lowered 24 hour blood sugar, reduced postprandial blood sugar spikes and increased skeletal muscle mitochondrial capacity marker of metabolic health [32].

Stair climbing can be a moderate to high intensity physical activity. In a 2011 investigation researchers found a 6 minute bout of stair climbing performed 90 minutes after meals in sedentary

middle aged men with insulin resistance ameliorated postprandial hyperglycemia [33].

"Our study is one of the first to report on the favorable dose response effects of muscular strengthening activity (MSA) and various metabolic markers in a nationally representative sample of the U.S. population [35]."

Churilla and Majyari analyzed 5, 618 U.S. adults aged 20 years and older from the 1999-2004.

National Health Nutrition Exam Survey to establish the relationship between lifting weights and metabolic syndrome as defined by the American Heart Association and the National Heart Lung and Blood Institute. Reporting in the Journal of Diabetes and the Journal of Strength & Conditioning Research, the authors found metabolic syndrome to be significantly lower among U.S. adults who reported regularly lifting weights [34,35].

They found U.S. adults who engage in MSA two days a week statistically less likely to have impaired fasting glucose, dyslipidemia, abdominal obesity or hypertension [35].

The role of exercise in the therapy of degenerative osteoarthritis has been studied. Flexibility and stretch expands range of motion and elasticity of joints and connective tissues and decreases stiffness. Low impact aerobics aids in optimizing body composition and weight. Aerobics and moderate intensity endurance activities trigger the release of endorphins that decrease pain. Resistance training increases muscular strength burns fat and can reduce the load on arthritic joints [36]. Recreational jogging in people aged 60 and older has not been found to increase the risk of osteoarthritis of the hip and knee in several studies, however, Lane and Buckwalter cite a case control study of women with hip osteoarthritis that increased twofold with high levels of participation in recreational activities before the age of 50 years and fourfold for women with a history of high impact physical and occupational loading of joints [36].

Clearly body weight must be included in determining the risks and benefits of activities that may adversely load the spine and major weight bearing joints.

A recent case study examined the impact of resistance training on the cachexia and joint inflammation seen in rheumatoid arthritis [37]. Eccentric exercise the action that occurs when a muscle is overcome by an external load and lengthens may be beneficial in the therapy of tendinopathy [38]. Patients with fibromyalgia did not experience worsening of muscle related pain with moderate exercise in a population of 170 volunteers, and after 12 weeks showed improvements in sleep, chronic fatigue and memory loss. A broad compendium of neuromuscular disorders including cerebral palsy, traumatic spinal cord injury, hemiplegia, peripheral neuropathies, fibromyalgia, restless leg syndrome (RLS) and multiple sclerosis have been found to benefit from physical therapy along with moderate intensity exercise and physical activity [39].

In over 13 years as a certified personal trainer I have restored and optimized functional capacity in a population of clients with musculoskeletal and neuromuscular disabilities using the Pilates Allegro reformer and other conventional exercise modalities.

In both the workplace and the sports arena, occupational repetitive strain and overuse injuries have emerged as the major cause of work force disability 40 Michael Leahy, D.C. is credited with introducing active release techniques in 1998 when he incorporated ART Soft Tissue Management Systems [40].

Leahy published an “encyclopedia” of ART, applying his trademark treatments to the spine, upper and lower body with emphasis on sports related Cumulative Trauma Disorder or CTD. 40 CTD may result from acute injury, repetitive strain or a constant pressure tension injury. A keyboard operator may perform 10, 000 finger repetitions in one day with a muscle relaxation time of zero [40].

Leahy attributes the mechanism of injury in CTD to, constant pressure tension injuries that decrease circulation and compromise cell recovery. In the cumulative injury cycle repetitive effort produces weak and tight muscles due to constant friction, pressure and tension. Decreased circulation and cellular hypoxia leads to edema, adhesions and fibrosis [40].

“Walking is man’s best friend.” Hippocrates Greek Physician (460 BC377BC) [41].

Exercise has been hailed as both a panacea and a fountain of youth. Sports, exercise and physical activity have been linked to greater confidence and high intelligence, reduced anxiety and high self esteem, improvement in cognitive function and amelioration of depression, slowing of cognitive decline in seniors with Alzheimer’s and senile dementia, antiaging effects on human chromosomes, reduced blood pressure in hypertensives, a healthy sex life, reduced risk of cancer and cancer recurrence and improvement in symptoms of inflammation in a spectrum of musculoskeletal disorders [42-49]. People sleep significantly better and feel more alert if they get at least 150 minutes of exercise a week.

According to a large population study of 2, 600 men and women aged 18 to 85 [50].

The fundamental questions raised by evidence based research documenting the effectiveness of any alternative therapy remains that will pay for it and how much is needed to produce measurable results.

Despite an enormous body of research establishing the safe and effective role of exercise and physical activity as therapeutic interventions in the mitigation of disease and prolongation of quality of life, there remains a need for randomized controlled trials assessing the clinical effectiveness and cost effectiveness of exercise referral schemes (ERS).

Rehak et al. analyzed the clinical effectiveness and cost effectiveness of exercise referral schemes. The methodology involved analysis of data from 7 randomized controlled trials conducted from 1990-2009. Four economic evaluations found ERS to be a cost effective intervention [45].

Other studies examining the effectiveness and utilization of exercise prescriptions identify the need for more specific recommendations based on BMI and evidence based research [51, 52].

In 1994, former Surgeon General C. Everett Koop founded Shape Up America! The website <http://www.shapeup.org/> generates over 100, 000 visitors a month. In December of 2011, Shape Up America! urged the Department of Health and Human Services to extend existing Medicare coverage to the estimated 70 million Americans who are obese with a BMI of 30 or above, to include exercise and physical activity [7].

A groundswell of alternative health and wellness practitioners and institutions have emerged committed to integrating conventional medical and surgical interventions with the basic healing properties of exercise and nutrition first proposed by the Greek physician in the Hippocratic Collection [53].

In 1990 I worked as a research consultant at the Palo Alto Veterans Administration Hospital Rehabilitation, Research and Development Center on an investigation of the biomechanics of falls in the elderly. Our control population consisted of fit octogenarians 80 year olds on no medications and with normal EKG’s.

California is home to the largest population of people over 80 years old in the U.S. The world’s fastest growing age group is 80+ according to the National Institutes of Health and the U.S. Census Bureau [54].

Aging well and staying healthy is a paramount concern for the modern adult and key to preparing for good health and increased life expectancy comes my personal dictum...“You gotta’ move it...move it!” [55]. For more details go through the supplementary material.

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