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# Exercise Therapy for Physical Therapist

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## Abstract

This chapter describes exercise therapy in terms of definition, objectives, concept, techniques, mechanisms, and equipment. Mechanisms explaining the effect of exercise training on treatments for other diseases are included. In addition, new biomarkers capable of evaluating exercise performance capacity and progress in training and early detection of overtraining are provided. Very promising are mainly small non-coding microRNAs (miRNAs). Important background knowledge for exercise therapy is also provided. The knowledge covers the exercise for healthy and unhealthy people. The former includes sedentary and sport player. The latter includes patients with various diseases, for example, metabolic diseases, cardiovascular disease, orthopedics, etc. Importantly, all the knowledge was presented in latest information.

**Keywords:** physical activity, physical therapy, movement, oxidative stress, microRNA, sports, diseases

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## 1. Introduction

Exercise therapy is defined as a regimen or plan of physical activities designed and prescribed to facilitate the patients to recover from diseases and any conditions, which disturb their movement and activity of daily life or maintain a state of well-being [1] through neuro re-education, gait training, and therapeutic activities. It is systemic execution of planned physical movements, postures, or activities intended to enable the patients to (1) reduce risk, (2) enhance function, (3) remediate or prevent impairment, (4) optimize overall health, and (5) improve fitness and well-being [2].

This therapy may relate specific muscles or parts of the body, to general and strenuous activities that can return a recovering patient to the peak of physical condition. It is highly repetitive and intensive and requires time and dedication on the part of the patients to encourage neuroplasticity. The therapy is performed by professionals with an educational background in exercise physiology, exercise science, or other similar degree. To succeed goal-oriented treatment, the personnel must [2].

1. Provide comprehensive and personalized patient/individual management.
2. Implement a variety of therapeutic interventions that are complementary (e.g., heat application before joint mobilization and passive stretch, followed by active exercise to use new mobility in a functional manner).
3. Rely on clinical decision-making skill.
4. Promote patients' independence whenever possible through the use of home management, self-management exercise programs, and patient-related instruction.

In-house physical therapy by family, friends, or caregivers to deliver the appropriate exercise therapy in the home can greatly decrease healthcare costs which may limit the intervention. Therefore, training and educating these persons are important in effective exercise therapy.

Exercise therapy can be called Activity-Based Therapy, Activity-Based Recovery Therapy, Neuro-based Therapy, and Restorative Therapy.

### **1.1. Important background knowledge to understand exercise therapy**

Background knowledge needs to be understood [3].

#### *Planes of movement*

There are three planes of movement.

- a) Movement in horizontal plane (transverse plane): This plane divides the body into upper and lower halves. Movements in transverse plane occur parallel to ground.
- b) Movement in frontal plane (coronal plane): This plane divides side to side movements, for example, bringing the head to each of the shoulders.
- c) Movement in vertical plane (sagittal plane): It is the plane that divides the body or body segment into the right and left parts. Movements in this plane include forward and backward motions such as nodding of the head.

*Kinematics* is the area of biomechanics that include description of motion without regard for the forces producing it. They include.

- a) Types of motion. There are four types of motion:
  - Rotatory motion, which is the movement of an object around a fixed axis in a curved path.

- Translatory motion, which is the movement of an object in a straight line.
  - Curvilinear motion, which is a combination of rotatory and translatory motions.
  - General plane motion, which the object is segmented and free to move.
- b) Location of motion: Motion at a joint may occur in transverse, frontal, or sagittal planes.
- c) Direction of motion: Movement may occur either in clockwise or anticlockwise direction.
- d) Magnitude of motion can be given either in degrees or radians.

*Kinetics* is biomechanics that concerned with the forces maintaining equilibrium or producing motion and are described as either external or internal forces.

*Center of gravity (COG)* is the point which the force of gravity acts effectively independently on position of body. The COG of human body lies approximately at S2, anterior to sacrum.

*Line of gravity (LOG)* is the line that lies vertically through center of gravity.

*Base of support* is the area which is supported.

*Equilibrium* results when the forces acting upon a body are balanced and the body remains at rest.

*Fixation and stabilization*: Fixation is the state of immobility, and stabilization is the state of relative immobility.

*Force* is that which alters the state of rest of a body or its uniform motion in a straight line

*Lever* is a rigid bar that rotates around on axis.

*Mechanical advantage* is efficacy of force in relation to lever depends on two factors.

*Pulley* is a grooved wheel which rotates about a fixed axis by a rope that passes round it. The axis is supported by a frame work or block. There are two types of pulleys: (1) fixed pulleys and (2) movable pulleys.

*Starting position* is the first posture before the following movement during the exercise therapy. There are five fundamental starting positions: standing, kneeling, sitting, lying, and hanging. Equilibrium and stability are maintained in these positions by balance of forces acting upon the body.

## 2. Objectives of exercise therapy

The objectives of exercise therapy are as following;

- a) Promote activity and minimize the effects of inactivity, increased independence
- b) Increase the normal range of motion.

- c) Improve strength the weak muscles.
- d) Improve the performance in daily activities.
- e) Enable ambulation.
- f) Release contracted muscles, tendons, and fascia.
- g) Improve circulation.
- h) Improve respiratory capacity.
- i) Improve coordination.
- j) Reduce rigidity.
- k) Improve balance.
- l) Promote relaxation.
- m) Increased motor or sensory function.
- n) Reduction of medication, reduction of hospital visits, and increased overall health.

The most important goal of exercise therapy is an optimal level of physical fitness by the end of the intervention. The physical fitness a state characterized by good muscle strength combined with good endurance.

### 3. Concept

Exercise therapy based on the independent movement which depends on individual goals. It aims to improve the ability to achieve optimal daily functioning. To achieve the goal of exercise therapy, the practitioner needs to understand the disablement process which include [4]

The disablement process

- a) Impairment: A loss or abnormality of anatomic, physiologic, or psychologic structure or function.
- b) Functional limitation: A limitation of the whole person performance, task in an efficient, typically expected, or competent manner, or a physical action activity.
- c) Disability: The inability or a limitation to perform the performance of actions, or tasks.

There are three models of the disablement process:

- a) World Health Organization's (WHO) International Classification of Impairments, Disabilities, and Handicaps (IDICH) [5].

- b) NAGI scheme [6].
- c) Modified disablement model [2]. This model exhibits the complexity of the relationships among pathology, impairments, functional limitations, disability, risk factors, interventions, quality of life, and prevention, wellness, and fitness.

## 4. Patient management

Physical therapist's approach to patient management involves examination, evaluation, diagnosis, prognosis, and intervention [2].

### 4.1. Therapeutic exercise intervention model

A three-dimensional model has been created to assist the clinician in the clinical decision-making process regarding exercise prescription. The model includes

*Elements of the movement system:* These elements relate to the purpose of each activity or technique

- a) Support
- b) Base
- c) Modulator
- d) Biomechanics
- e) Cognitive/affective

*The specific activity or technique chosen*

- a) Posture
- b) Mode
- c) Movement

*The specific dosage*

- a) Type of contraction
- b) Intensity
- c) Speed
- d) Duration
- e) Frequency

- f) Sequence
- g) Environment
- h) Feedback

The therapist must continually monitor the exercise to determine the need for modification to increase or decrease difficulty to ensure continual progress is being made with minimal setbacks. In addition, exercise therapy can be complemented with adjunctive interventions if the additional intervention can lead to a higher level of functional outcome in a short time.

## 5. Techniques

The techniques of exercise therapy used in treatment may be classified as follows [7].

### 5.1. Passive movement

#### *Passive movements*

Passive movements (Motion Therapy, Continuous Passive) provide continuous passive motion to the applied joint. The apparatus can be used immediately after the operation to improve the range of motion, reduce pain, discomfort, and healing. This machine is adjustable, easily controlled, versatile, and usually electrically operated.

#### *a) Relaxed passive movements*

The physiotherapist performed these movements for the patients. The physiotherapist needs knowledge of the anatomy of joints. The same direction and range of the movements are the same as those performed in the active movements. The physiotherapist moves the joint through the existing free range and within the limits of pain.

#### *b) Accessory movements*

These movements are parts of any normal joint movement but may be absent or limited in abnormal joint conditions. They consist of rotational or gliding movements which cannot be separately performed as a voluntary movement but can be performed by the physiotherapist.

#### *Passive manual mobilization techniques*

#### *a) Mobilizations of joints*

The physiotherapist performed these movements which are usually small repetitive oscillatory, rhythmical, localized functional, or accessory in various amplitudes within the available range. These can be done quite strongly or very gently and are graded according to the part of the available range in which they are performed.

*b) Manipulations of joints*

*- Physiotherapists*

The movements are performed by the physiotherapist. They are accurately localized, single, quick decisive movements, which have small amplitude and high velocity completed before the patient can stop it.

*- Surgeon/physician*

The movements are performed by a surgeon under anesthesia or physician to receive further range. The maintaining of the increase in movement must be performed by the physiotherapist.

*c) Controlled sustained stretching of tightened structure:*

The increase in range of movement can be done by passive stretching of muscles and other soft tissues. The stretching adhesions in these structures and lengthening of muscle increase the movement by inhibition of the tendon protective reflex.

## **5.2. Active exercise**

Movement performed or controlled by the voluntary action of muscles, working in opposition to an external force

*Voluntary*

*a) Assisted active exercise*

In this type of exercise, the patient tries to perform the movement by himself/herself. However, his/her muscular action is insufficient for the production or control of full range of movement. To complete it, an external force needs to be added. If the muscle power increases, the assistance given must decrease.

*b) Free exercise*

Free exercises are those which are performed by the patient's own muscular efforts without the assistance or resistance of any external force, other than that of gravity.

*c) Assisted-resisted exercise*

This type of exercise constitutes a combination of assistance and resistance during a single movement.

*d) Resisted exercise*

The external force may be applied to the body levers to oppose the force of muscular contraction and there will be increase in muscle power and hypertrophy.



Resisted exercise technique is classified into six major categories:

- Endurance training
- Resistance training
- Muscle stretching exercises (flexibility training)
- Balance training
- Coordination training
- Agility training
- Body mechanics and awareness training
- Enhance function
- Gait and locomotion training
- Plyometric exercise (power training)

#### *Exercise preparation*

Before exercise training, a patient should be evaluated by a physician. It is important to exclude patients with ventricular hypertrophy, valvular heart disease, dangerous arrhythmias, and malignant hypertension. Other cardiac cases, and patients at risk, such as those with exercise-induced asthma, obesity, or diabetes, should perform an exercise stress test under careful medical supervision. Blood pressure and heart rate and the electrocardiogram (ECG) must be monitored throughout the exercise to confirm their cardiovascular function.

#### *Aerobic or endurance training*

In endurance training program, there are three important variables, including frequency, intensity, and duration. The recommendations by the American College of Sports Medicine (ACSM) are as follows:

- Frequency—Appropriate frequency of the aerobic exercise should be 3–5 days per week.
- Intensity of training—64/70–94% of maximum heart rate (HR max), or 40/50–85% of maximum oxygen uptake reserve ( $\text{VO}_2\text{R}$ ) or heart rate reserve (HRR).
- Duration of training—The appropriate duration of training should be intermittent or continuous aerobic exercise for 20–60 min (minimum of 10-min bouts accumulated throughout the day).

The duration of training is dependent on the intensity of the exercise. Thus, lower-intensity exercise should be performed over longer duration ( $\geq 30$  min), and conversely, higher levels of intensity should be performed at least 20 min or longer. Moderate-intensity exercise of longer duration is recommended for untrained adults, because total fitness is more readily attained with exercise sessions of longer duration and because potential hazards and adherence problems are associated with high-intensity activity.

### *Exercise for healthy individuals*

Continuously aerobic exercises that use large muscle groups are recommended including western and eastern style:

#### Western style

- Cycling
- Swimming
- Walking
- Running
- Jogging
- Aerobic dance/exercise classes
- Dancing
- Stair climbing
- Rowing
- Skating
- Jumping rope
- Cross-country skiing

#### Eastern style

- Tai chi
- Yoga
- Arm swing exercise (**Figure 1**)
- Wand exercise (**Figure 2**)

The maximal HR can be calculated by the following formula:  $HR_{max} = 220 - \text{age}$ .

The exercise session should consist of three periods. Starting with a warm-up period of approximately 10 min which combines calisthenic-type stretching exercises (without equipment). This follows by progressive aerobic activity that should increase the heart rate close to the prescribed heart rate for the session. Then, endurance training at the targeted heart rate for 20–60 min is performed and following by a cool-down period of 5–10 min.

### *Exercise for patients*

A less strenuous exercise training regimen must be used, with the training heart rate not exceeding 50–60% of maximum  $O_2$  uptake ( $VO_{2max}$ ) or a heart rate of 130 beats per minute (/min). In elderly patients and patients at risk, the intensity, frequency, and duration of therapeutic exercise should be established for each patient individually with medical evaluation before.



Figure 1. Arm swing exercise.

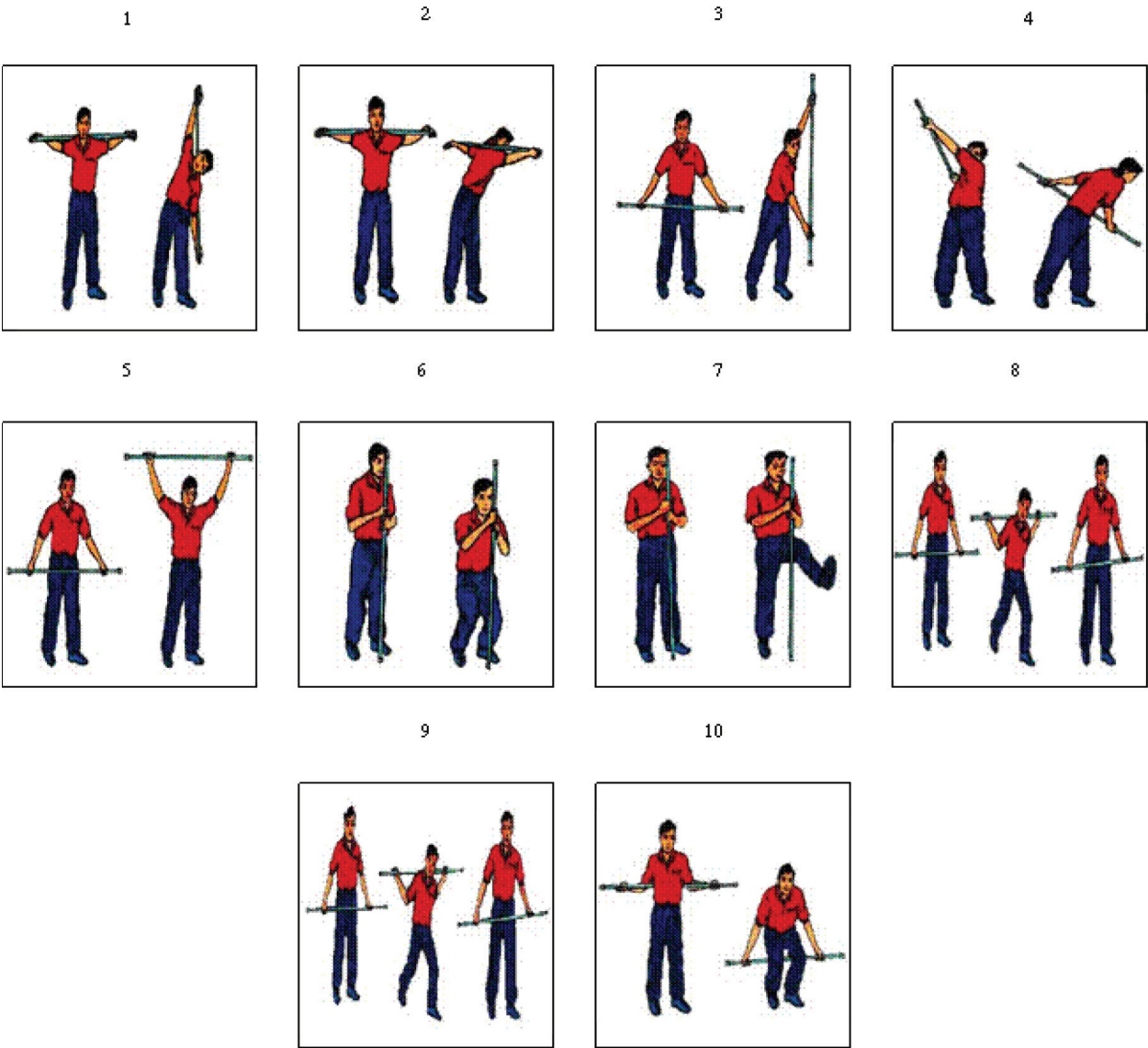


Figure 2. Wand exercise.

Karvonen method should be employed to determine the target heart rate for the ill or elderly patient: Target HR =  $(220 - \text{age} - \text{resting heart rate} \times \% \text{ intensity selected}) + \text{resting HR}$ .

### *Progression*

In endurance training, progression can happen by increasing the intensity or the duration. Several factors affecting the suitable rate of progression including age, current activity levels, exercise goals, and physiologic limitations should be considered. Most importantly, progression rate should be used that results in long-term participation. Being too aggressive can increase dropout rates because of injuries and/or perceived excessive discomfort. In addition, a progression of balance ability can be enhanced more by the exercise on the unstable support surface than exercise on the stable support surface.

*a) Special techniques There are many special techniques used in exercise therapy [6]*

- Frenkel's exercises are used to treat the incoordination which results from many other diseases, for example, disseminated sclerosis. Dr. H.S. Frenkel was Medical Superintendent of the Sanatorium "Freihof" in Switzerland toward the end of the last century.
- Proprioceptive neuromuscular facilitation (PNF) is an approach in which treatment is directed at a total human being, not just at a specific problem or body segment. This method was developed by Dr. Herman Kabat and Ms. Margaret Knott in 1946 and 1951 [7].
- Hydrotherapy refers to the use of multi-depth immersion pools or tanks that facilitate the application of various established therapeutic interventions including stretching, joint mobilization, strengthening, etc.
- Breathing exercises are designed to retrain the muscles of respiration, improve ventilation, lessen the work of breathing, and improve gaseous exchange and patient's overall function in daily living activities.

## **6. Mechanisms**

Uptodate, there are many mechanisms explaining the beneficial effects of exercise therapy. These include enhancing antioxidant defenses. Very promising are mainly small non-coding microRNAs (miRNAs).

### **6.1. Mechanisms that enhance antioxidant defenses**

An important mechanism that contributes to many disease is oxidative stress [8], although exhaustive and/or unaccustomed exercise in both aerobic and anaerobic exercise can generate excessive reactive oxygen species (ROS) according to mitochondrial enzymes, NADPH oxidases, and xanthine oxidases. This results in oxidative stress-related tissue damages and impaired muscle contractility. Moderate exposure to ROS is needed to induce adaptive responses of the body such as the activation of antioxidant defense mechanisms [9]. Regular

exercise is well known to benefit health by enhancing antioxidant defenses in the body [10], thereby leading to a reduced generation of free radicals both at rest and in response to exercise stress. Therefore, exercise training-induced antioxidant activity decreases risk of many diseases.

In the elderly, sarcopenia is characterized by structural, biochemical, molecular and functional muscle changes. An imbalance between anabolic and catabolic intracellular signaling pathways and an increase in oxidative stress both play important roles in muscle abnormalities.

Regular exercise is promoted as a therapeutic strategy for age-associated endothelial dysfunction. However, sex was shown to affect the antioxidant response in the elderly. Improvements in endothelial function are found with endurance exercise in older men, but are reduced or absent in older women. This may be due to sex hormones modulating vascular adaptations to exercise training by influencing antioxidant defense systems, mitochondrial function, oxidative stress, and intracellular signaling [11].

## **6.2. Mechanisms that decrease the risk of developing cancer**

In addition, exercise is known to be one of several lifestyle factors that lower the risk of cancer and is associated with lower relapse rates and better survival. The indirect effects included changes in vitamin D, weight reduction, sunlight exposure and improved mood. The direct effects included insulin-like growth factor, epigenetic effects on gene expression and DNA repair, vasoactive intestinal peptide, and antioxidant pathways, heat shock proteins, testosterone, irisin, immunity, chronic inflammation and prostaglandins, energy metabolism and insulin resistance [12].

## **6.3. Mechanisms that are responsible to cardioprotection**

Importantly, exercise protects cardiovascular system through the modulation of

- a) cardiac performance directly,
- b) endothelial and vascular functions,
- c) systemic risk factors. Both moderate- and high-intensity exercise training were shown to improve aerobic capacity of metabolic syndrome patients [13].

Moreover, Wand Exercise which is Thai mode of exercise significantly reduced body mass, total fat mass, waist and hip circumferences and increased flexibility, functional capacity (determined by 6MWD), physical health dimension and vitality of mental health dimension of the QOL [14]. The results showed that Thai Wand Exercise training decreased obesity, improved physical health status, and vitality. Therefore, this easy and low impact exercise program is a good approach to reduce cardiovascular risks. Data on cardioprotective effects of low-intensity exercise are controversial. This could be due to the fact that low-intensity exercise may not meet the recommended minimum threshold of exercise intensity for improving cardiorespiratory endurance [15]. However, our research group found that



low-intensity exercise improved aerobic capacity of overweight and normal weight sedentary young adults [16]. Exercise also mediated improvement in hyperglycemia-induced cardiovascular dysfunction in patients with type 2 diabetes [10]. Exercise training also improved insulin resistance-induced lipotoxicity, mediated protection against pro-inflammatory cytokines and improved pro-survival signaling cascade. An appropriate duration and intensity of exercise can decrease myocardial dysfunction through the improvement of maximum oxygen consumption ( $VO_{2max}$ ), left ventricular ejection fraction (LVEF), LV diastolic and systolic volumes, ventilatory threshold, cardiac output and diastolic function (E/A ratio) [13, 17–25].

#### **6.4. Mechanisms that improve respiratory function**

Exercise training has been shown to improve pulmonary function in patients with type 2 diabetes [26]. Exercise training improves exercise tolerance and health-related quality of life in patients with very severe COPD [27]. RME training led to a significant increase in respiratory muscle endurance in children with CF [28]. In addition, pulmonary rehabilitation reduced expiratory flow limitation (EFL) in COPD patients [29].

#### **6.5. Mechanisms that treat orthopedic patients**

A systematic review revealed that short-term Traditional Chinese exercise (TCE) was potentially beneficial in terms of reducing pain, improving physical function and alleviating stiffness for patient [30]. In individuals operated with total knee arthroplasty, the 12-month progressive home exercise program starting 2 months after the operation comparing to usual care improved maximal gait velocity, cadence and stance time [31]. This may be due to exercise loading in the cartilage-subchondral bone (SB) unit in attenuation of post-traumatic osteoarthritis development [32].

#### **6.6. Mechanisms that mediate differential expression of microRNAs**

MicroRNA is a non-coding RNA which is increasingly interesting from scientists in many fields including Physical therapist [33]. It has been shown to regulate many process in our body, for example, muscle-specific miRs (miR-1, miR-133 and miR-499), the vascular wall of the vascular smooth muscle cells miR-222, EC miR-126, and the pathophysiology of Diabetic heart disease.

Exercise training, both acute endurance and resistance in healthy male volunteers, was shown to enhance miR-133 expression in the vastus lateralis muscles [34, 35]. Moreover, endurance exercise elevated circulating levels of miR-133 in healthy individuals after either an acute bout of aerobic exercise, or endurance training [36, 37]. Marathon training also increased miR-133 level which is appeared to be associated with improved  $VO_{2max}$  [38]. Similarly, T2DM mice which did a 10-week swimming exercise had increased miR-133 expression in cardiac tissue. Their contractile function improved and matrix metalloproteinase-9 (MMP-9), an extracellular matrix regulator protein decreased [39]. Since miR-133 is reported to be expressed and enriched in both cardiac and skeletal muscles [40], it is possible that miR-133 is secreted from

skeletal muscle into the circulation after a bout of exercise, which then travels to the cardiomyocytes to suppress fibrotic markers and reduce cardiac hypertrophy.

### **6.7. Mechanisms that treat neurological patients**

In Parkinson's disease patients, aerobic exercise training [28] may be altering central nervous system pathways that regulate the physiologic or cognitive processes controlling olfaction [41]. In spinal cord injury patients, the exercise training has been considered to improve spinal cord function not only through enhancement, compensation, and replacement of the remaining function of nerve and muscle but also improve the function in different levels from end-effector organ such as skeletal muscle to cerebral cortex through reshaping skeletal muscle structure and muscle fiber type, regulating physiological and metabolic function of motor neurons in the spinal cord and remodeling function of the cerebral cortex [42].

## **7. New biomarkers capable of evaluating exercise performance capacity and progress in training**

1. Blood biomarkers—include glutamine, glutamate, cortisol, IL-6, testosterone, cholesterol, glucose, leptin, cortisol, ACTH, hematocrit, hemoglobin, norepinephrine, epinephrine, immunological parameters, and creatinine kinase.
2. Physiological measurements—include resting heart rate, resting systolic blood pressure, and resting diastolic blood pressure but not heart rate variability.
3. Psychological measurements—include mood states for tension, fatigue, confusion, reaction time, vigor, anger, and depression. Such parameters may reflect a highly individual nature of the psychological response to overtraining. However, a trend for impaired sleep patterns, increased wakefulness, decrements and stability in sleep quality and increased levels of stress may be observed.

miRNAs meet most of the requirements for good biomarkers, such as easily accessible sample collection, minimally invasive and remarkable stability in body fluids. In addition, miRNAs affect many processes and play a crucial role not only in cell differentiation, proliferation and apoptosis, but also affect extracellular matrix composition and maintaining processes of homeostasis. They play significant role in the regulation of physiological adaptation to exercise, such as skeletal muscle and cardiomyocyte hypertrophy, mitochondrial biogenesis, vascular angiogenesis and metabolic processes [33].

## **8. Early detection of overtraining**

Some patients may perform the prescribed exercise program too hard leading to overtraining [43, 44]. Such overload can result in fatigue and acute decreases in performance either directly

after a single intense training session, or following the training. However, in the normal course of training and recovery, this overload then leads to a positive response, adaptation, and consequent improvement in performance. If the balance between overload and recovery is not managed properly, a positive training response does not occur and performance is not enhanced. To reach a true diagnosis of overtraining syndrome, it is necessary to exclude the presence of non-communicable diseases (e.g., disorders involving the thyroid or adrenal gland, anemia, diabetes, and iron deficiency), infectious diseases (e.g., hepatitis, myocarditis and glandular fever), and other major disorders or feeding behaviors (e.g., bulimia and anorexia nervosa). In addition, Psychomotor speed: possibly a new marker for overtraining syndrome.

## Additional information

However, up-to-date there has been slight improvement in the tools available for the diagnosis of overtraining syndrome [45, 46]

## 9. Equipment

There are many kinds of equipment for exercise therapy including [7]:

- a) Hydrotherapy equipment (tank, bath, chair).
- b) Electrotherapy (shortwave medical diathermy, muscle stimulator, interferential therapy unit, ultrasound therapy unit, transcutaneous nerve stimulation).
- c) Heat and cold therapy equipment (paraffin wax bath, moist heat therapy unit, moist heat therapy unit, steam/hot pack, infrared lamp).
- d) Treatment equipment (massage cum treatment table, hi-low mat platform, tilt table, activity mattress, continuous passive motion unit, medicine ball, parallel bar, equilibrium board).
- e) Multi exercise therapy unit (complex exercising unit).
- f) Shoulder, arm, hand, leg, knee, foot exercise unit.
- g) Suspension unit.
- h) Mobility aids (Walkers, crutch, cane).
- i) Massage: Massage signifies a group of procedures, which are usually done with hand on the external tissue of the body in a variety of ways either with a curative, palliative or hygienic point of view.
  - To improve mobility of the soft tissues.
  - To reduce muscle spasm and pain under abnormal conditions.



- To reduce edema.
- To increase circulation.
- To mobilize secretions in the lung.
- To induce local and general relaxations.

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