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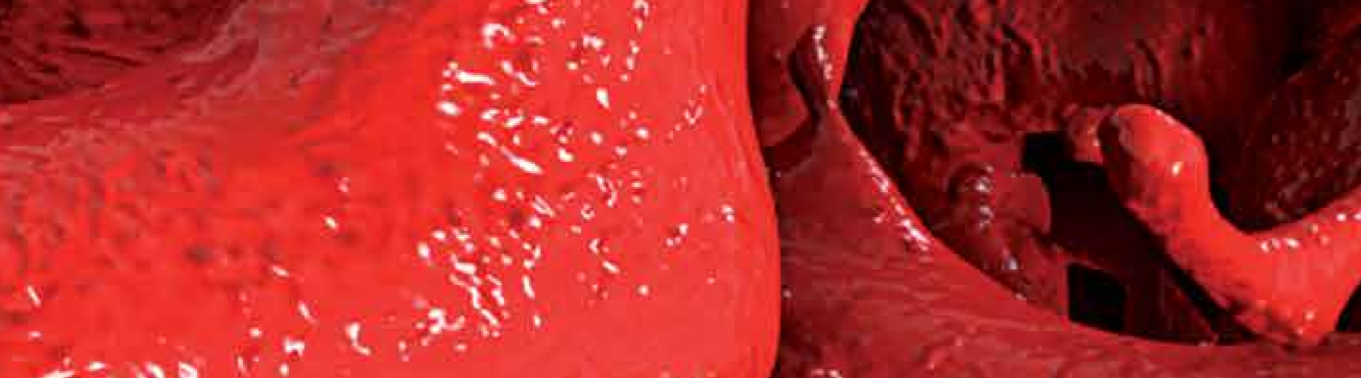
Cardiorespiratory Fitness

Edited by Hasan Sözen



Cardiorespiratory Fitness

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Meet the editor

Dr. Hasan Sözen is an assistant professor in the Department of Physical Education and Sport at Ordu University (Ordu, Turkey). His primary research focus is sport and exercise physiology. Dr. Sözen received his PhD in Health Science Institute Department of Physical Education and Sport at Ondokuz Mayıs University (Samsun, Turkey). He completed his post-doctoral fellowship at the Department of Biomedical Sciences for Health at the University of Milan (Milan, Italy) with his work titled "Electromechanical delay components assessment to disclose age, training status and gender effects on skeletal muscle electromechanical behavior during contraction: new insights from an electromyographic, mechanomyographic and force combined approach." The fellowship was supported by the Scientific and Technological Research Council of Turkey.

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and Carlos Renato Paz

Preface

Cardiorespiratory fitness is a health-related element of physical fitness. It expresses the ability of the circulatory and respiratory system to provide oxygen during physical activity. This is related to aerobic fitness. Aerobic fitness refers to the body's capacity to transport and use the oxygen taken in. Improving aerobic fitness is achieved and protected by low-intensity, long-term exercises. Improving aerobic fitness contributes not only to improving sporting performance and physical capacity, but also to improving mental and psychological performance. By increasing aerobic fitness, health risk factors are eliminated or reduced. Because aerobic exercise affects the cardiovascular system the most, it prevents or prolongs the occurrence of cardiorespiratory problems. There are numerous studies that demonstrate the positive effects of aerobic exercises on the cardiorespiratory system. Nowadays, in the prevention or treatment of cardiovascular and cardiorespiratory problems, exercise programs are frequently used. This is both a healthy and relatively inexpensive preventive/therapeutic method compared to other treatments. Another positive effect of improving cardiorespiratory fitness is on psychological structure. Chemical substances released during exercise have calming and depression-reducing effects. Maximal aerobic power (VO_{2max}) is the level of oxygen use an individual can reach in one minute. Power, as it is used herein, means the capacity of the oxidative system. Maximal aerobic power is of great importance in endurance activities where energy is largely supplied from the aerobic system. For example, a person with a higher maximal aerobic strength is more successful in endurance activities. For non-athletes, the average amount of oxygen used per minute is between 3 and 4 liters. For endurance athletes, 5–6 liters are reported. The amount of oxygen a person uses per minute is his aerobic capacity. This score provides useful information about the capacity of the cardiorespiratory system. Every individual needs adequate heart respiration resistance for health and fitness. VO_{2max} peaks at the age of 20 years, starting from childhood, and slowly decreases as a person ages. The aerobic capacity of women is 10–20% lower than that of men. Therefore, age and gender are considered for VO_{2max} assessments of healthy adults. When the respiratory system is examined, the rib cage is smaller in women. The cross-sectional area of the lungs is less. Vital capacity is less, respiratory frequency is higher. Maximal respiration minute volume, maximal voluntary respiration, and maximum oxygen consumption are lower. Improving cardiorespiratory fitness level will help individuals lead healthier and more vigorous lives. In this context, this book adds new information and insights to the literature on cardiorespiratory fitness.

The book begins with an overview of pulmonary rehabilitation in chronic obstructive pulmonary disease by Girdhar et al., with an ever-expanding understanding of the disease and its rehabilitation. The next chapter by Prof. Cabrera et al. is about ischemic preconditioning. It describes the mechanisms involved in the protective effect of exercise-induced preconditioning on the cardiovascular system, skeletal muscle, and physical performance. The chapter by Prof. Kilani et al. focuses on the fetal-neonatal lifestyle basis of adult metabolic syndrome patients. The next chapter by Prof. Valkova and Prof. Grün et al. examines cardiorespiratory fitness and intellectual disability. This study includes analysis of cardiorespiratory fitness data of some athletes participating in the Special Olympics. The fifth chapter by

Dr. Nemanja Ćopić discusses whether certain lifestyles and habits influence the characteristics of body composition of young females in Serbia. The final chapter by Dr. Ribeiro et al. compares cognitive performance among elderly people who exercise with weights and those with a sedentary lifestyle. The results suggest that physical activity represents an important non-medicinal contribution to the evolution of cognitive performance. Overall, this book provides the reader with interesting and current data about cardiorespiratory fitness.

I want to thank all the authors of this book for their amazing works. I also wish to thank publishing process manager Mr. Gordan Tot, without whom I would not be able to edit this book.

I hope that this book will be useful for anyone who wants to read about new perspectives in cardiorespiratory fitness. I also hope that it will arouse a new and great inspiration for researchers working on sport science, medicine, rehabilitation, and training.

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Chapter 1

Pulmonary Rehabilitation in Chronic Obstructive Pulmonary Disease

Ankur Girdhar, Puneet Agarwal and Amita Singh

Abstract

With an ever-expanding understanding about chronic obstructive pulmonary disease (COPD), it has been realized that it is a respiratory disease with systemic manifestations. Systemic effects of COPD lead to cardiovascular co-morbidities, muscle wasting and osteoporosis that in turn lead to inactivity and physical deconditioning. This development has a direct impact on the health-related quality of life (HRQoL) of patients suffering from this respiratory disease. Pharmacological therapy leads to improvement in shortness of breath and has limited effect on the physical deconditioning. Latest research has shown an additive effect of pulmonary rehabilitation on improving the inactivity and overall HRQoL in COPD patients. Pulmonary rehabilitation (PR) is a comprehensive multimodality program that includes strength and endurance training, nutritional education and psychosocial support. This leads to a holistic approach to management of COPD which results in symptom improvement in patients and decreased utilization of heath care resources. There are several barriers to widespread adoption of pulmonary rehabilitation as a standard treatment. This includes availability, insurance coverage and patient compliance. With inclusion of pulmonary rehabilitation in respiratory society guidelines, there has been a renewed interest among both pulmonary specialist and community physicians. This chapter aims to provide exhaustive evidence based knowledge regarding pulmonary rehabilitation and its beneficial effect on COPD patients.

Keywords: rehabilitation, deconditioning, HRQoL, comprehensive, COPD, exercise, education

1. Introduction

Chronic obstructive pulmonary disease (COPD) is among the five leading causes of death in developed world [1]. Prevalence of COPD is constantly increasing. COPD has a high impact on patients' wellbeing, healthcare utilization, and mortality [2] and causes a substantial and increasing economic and social burden [3, 4]. Cigarette smoking is clearly the predominant cause but other environmental agents including biomass fuel and air pollution may play a role as well. Common symptoms of COPD patients are chronic and progressive dyspnea, cough, and sputum production. These symptoms can be disabling and lead to activity limitation and ultimately inability to work and take care of themselves [5]. This vicious circle of inactivity that begins with breathlessness is because of peripheral muscle dysfunction [6], and dynamic hyperinflation [7].

For several decades, treatment of COPD has been focused on smoking cessation, and pharmacological but with ever-increasing literature, intense exercise programs like pulmonary rehabilitation (PR) have become an integral part of management of COPD [8]. PR has been shown to be the most effective non-pharmacological intervention for improving health status in COPD patients and has become a standard of care for these patients [2]. PR and pharmacological therapy are not competitive but rather, must work closely together, if they are to result in a more successful outcome [9].

Despite increasing awareness on positive impact of rehabilitation in COPD, it remains underutilized in most countries. Lack of understanding on the benefits of a PR program, in addition to the incremental cost to the management, has hindered the widespread adoption of comprehensive PR for COPD patients [9]. This chapter aims at highlighting the impact of PR on patients with COPD, focusing on the clinical usefulness of PR. We also hope to stimulate primary care and pulmonary physicians to use PR more often.

2. Definition of pulmonary rehabilitation

Physical therapy has been incorporated into the treatment of pulmonary patients as far back as the First World War. Winifred Linton, a British nurse, first felt the need for physical therapy while treating traumatic respiratory complications during the war. Following the war, she entered physical therapy training and began to teach localized breathing exercises to other physical therapists (PTs) and surgeons at the Royal Brompton Hospital in London. A few physical therapists in the United States were instructed in airway clearance techniques and began to use and teach them to patients during the polio epidemic of the 1940s [10, 11]. Rehabilitation programs for patients with COPD have existed for more than three decades and were incorporated into ATS official statement in 1981 [12]. Comprehensive and multidisciplinary approach to the pulmonary rehabilitation programs have remained the key to its success over several years. It involves a team effort from physical therapist, respiratory therapist, nurses, physician and other support staff.

Pulmonary rehabilitation has been defined as a comprehensive program which is individual patient focused and includes exercise training, education, and behavior change. It has been found to help improve the physical and psychological condition of people with chronic respiratory disease and to promote the long-term adherence to health-enhancing behaviors [13].

Pulmonary rehabilitation has demonstrated physiological, symptom reducing, psychosocial, and health economic benefits in multiple outcome areas for patients with chronic respiratory diseases [14]. PR is appropriate for most patients with COPD. Improved functional exercise capacity and health-related quality of life has been demonstrated across all grades of COPD severity, although the evidence is strong in patients with moderate to severe disease [15].

3. COPD as a systemic disease

Beside respiratory symptoms of dyspnea, COPD has been established to have extra-pulmonary manifestations. Some on them involve skeletal muscle dysfunction which results from physical inactivity and systemic inflammation in addition to hypoxemia, undernutrition, oxidative stress and systemic corticosteroid [16, 17].

Peripheral muscle dysfunction seen in COPD patients is a result of multitude of pathophysiological changes occurring in the skeletal muscles. Skeletal muscles in COPD patient have decreased oxidative capacity that can lead to early lactic academia [18–20], decreased muscle fiber volume [21], redistribution of the muscle fiber type (from type 1 to type 2 fibers) [21–23], and abnormal muscle fiber capillarization [23]. These changes in the structure and functioning of the skeletal muscles can lead to higher concentration of lactate for a given work. This in turn can lead to increased ventilation, resulting in dynamic hyperinflation and overall increased ventilator burden. With muscle dysfunction there is a limitation in the activity and promotion of a sedentary lifestyle. A sedentary lifestyle inevitably leads to social isolation, depression and physical deconditioning. Exacerbations of COPD also promote the reduction of exercise performance, dyspnea, and the loss of Health-related quality of life (HRQoL) [24].

PR has no direct impact on lung mechanics or gas exchange [25]. Rather, it optimizes the function of other body systems so that the effect of lung dysfunction is minimized [26]. A comprehensive PR program can help COPD patients gradually improving muscle function by changing muscle biochemical structure. This leads to improved tolerance for higher work load in the patients [27]. PR additionally reduces the central perception of dyspnea and dynamic hyperinflation [28].

4. Clinical impact of pulmonary rehabilitation

A usual pulmonary rehabilitation program can range anywhere from 6 weeks to 12 weeks at various centers which incorporate aerobic exercise, education, muscle strengthening etc. Usually patients undergo supervised training 2–3 times a week, for 30–60 minutes in each session. This could include any regimen for endurance training, interval training, resistance/strength training, walking exercises, flexibility, inspiratory muscle training and/or neuromuscular electrical stimulation. The interventions are individualized to maximize personal functional gains.

There are several benefits of PR not limited to improvement in symptoms like dyspnea, exercise tolerance and overall health status in stable patients.

4.1 Symptom control

PR results in reduction in symptoms of dyspnea and leg discomfort. Patients notice improved limb muscle strength and endurance. Most patients also experience improved functional capacity with more independence in activities of daily living (ADLs) [29]. In a Cochrane review [30] including 23 randomized controlled trials, PR was found to relieve dyspnea, and fatigue, improved emotional function and patient's sense of control over their condition. All these improvements were large and statistically significant.

4.2 Physical activity and exercise tolerance

There has been increasing interest in physical activity, as inactivity has been linked with reduced survival, poorer quality of life and increased healthcare utilization [31]. In the same Cochrane review as above [30], patients were noted to have improved exercise capacity. Other studies from Griffith's et al. and Singh et al. have suggested similar findings [32, 33].

4.3 Healthcare burden

PR has also been found to reduce unscheduled healthcare visits, COPD exacerbation and hospitalization in some literature [34]. Rubi et al. reported reduction in COPD exacerbation, hospitalization and days of hospitalization in 82 consecutive patients [35]. In fact, there is some literature to suggest reduced hospitalization in patients participating in PR programs immediately after acute exacerbation of COPD (AECOPD) beginning within 1 week of discharge [36].

4.4 Psychosocial

Anxiety and depression affect significantly in COPD patients leading to worse patient centered outcomes. Tselebis et al. conducted study in 101 consecutive patients and noted that psychological morbidity was improved with participation in PR program irrespective of severity of the disease (COPD) [37]. This was confirmed in a meta-analysis of six RCTs which indicated that pulmonary rehabilitation was more effective than standard care for the reduction of anxiety and depression [38].

HRQoL was noted to be significantly improved in patients with COPD participating in PR as well [34, 39]. The St. Georges Respiratory Questionnaire Scores were used in a meta-analysis, which showed significant improvement in HRQoL following pulmonary rehabilitation [40]. An early RCT compared pulmonary rehabilitation with education alone and demonstrated that self-efficacy improved in the intervention group [41].

4.5 Survival

COPD patients have been known to have improved mortality with cessation of smoking. There is some signal that an association exists between completion of PR and survival based on a retrospective analysis involving 1515 patients [42]. But a systematic review conducted of two randomized control trials showed significant survival benefit at 1 year in one trial but no significant benefit with another study at end of 3 years. Neither of the study was powered to really derive the desired outcome [43].

5. Indications of pulmonary rehabilitation

Patients with chronic lung condition who have symptomatic shortness of breath limiting their physical activity despite optimal medical management should be considered for pulmonary rehabilitation [44]. Patients with chronic diseases other than lung such as heart failure, musculoskeletal disease have the same benefit form pulmonary rehabilitation as patients with disabling lung conditions like chronic obstructive pulmonary disease, restrictive lung disease, and pulmonary hypertension. Pulmonary rehabilitation can markedly change the course of the disease if provided at an earlier stage of disease. This is due to improved exercise tolerance and physical activity, reduced exacerbations and improved self-efficacy and behavior change after pulmonary rehabilitation. [45]

One of the most important indicator for referral to pulmonary rehabilitation is based on the modified Medical Research Council Breathlessness (mMRC) score (see **Table 1**) [46]. The mMRC scale is a 0–4 grade scale used to establish levels of perceived respiratory disability. It allows patients to indicate the extent to which their breathlessness affects their mobility [45, 46].

It has been strongly recommended that patients with an mMRC dyspnea score of 2–4 who are functionally limited by breathlessness should be referred for pulmonary rehabilitation. However, benefits of pulmonary rehabilitation have also been seen in patients with an mMRC dyspnea score of 1 who are functionally limited by breathlessness. Patients with COPD who have an mMRC score of 4 achieve similar benefits from the pulmonary rehabilitation as those with a lower breathlessness score [47].

Grade	Level of breathlessness with the activities
0	No shortness of breath except on strenuous exercise
1	Short of breath when walking on an incline
2	Walks slower than contemporaries on a level ground because of shortness of breath or has to stop due to breathlessness when walking up at own pace
3	Stops for breath when walking 100 m or after a few minutes on level ground
4	Too short of breath to leave the house, or short of breath when dressing and undressing

Table 1.
The modified Medical Research Council Breathlessness (mMRC) score.

Other frequent indications for referral to a pulmonary rehabilitation program include poor functional status, physical deconditioning, chronic fatigue, poor health-related quality of life and difficulty performing activities of daily living. Patients who are requiring increased use of medical resources due to frequent exacerbations, hospitalizations and emergency room visits also benefit from pulmonary rehabilitation.

Candidates for lung volume reduction surgery for severe emphysema or for lung transplantation are also good candidates for PR [48]. Patients with COPD have shown improvements following a pulmonary rehabilitation program irrespective of their age or gender [49–51].

Level of functional impairment [47, 52, 53] or disease severity does not affect the benefits seen in COPD patients with pulmonary rehabilitation program [54, 55]. A program of PR may be proposed in stable COPD as well as immediately after COPD exacerbation [56].

6. Contraindications of pulmonary rehabilitation

There are very few exclusion criteria for a referral to pulmonary rehabilitation, which includes patients with the following conditions [45, 46]:

- Unstable cardiovascular disease, uncontrolled diabetes and an ongoing orthopedic illness that will refrain patient from exercising.
- Inability to do exercise safely because of any other medical illness like severe arthritis, severe peripheral vascular disease.
- Untreated psychiatric illness and cognitive impairment which makes it hard for patients to follow directions are other reasons for not referring a patient to pulmonary rehabilitation.
- Lack of motivation is another exclusion criterion for pulmonary rehabilitation.

7. Nonadherence to pulmonary rehabilitation

Adherence to pulmonary rehabilitation program is critical to see the ongoing benefits from the program. However, non- adherence and high dropout rate of 20–30% is reported in the studies listing predictive factors of non-adherence to pulmonary rehabilitation. These factors include [52, 53, 57, 58]:

- Even though current smokers obtain the same benefits from pulmonary rehabilitation, smokers generally have poor adherence to pulmonary rehab than ex-smokers. Active smoking status is not an absolute contraindication for pulmonary rehabilitation. Patients are encouraged to undergo smoking cessation prior to pulmonary rehabilitation.

- Depression and social isolation.

- Lower quadriceps strength.

- COPD patients with higher mMRC score and frequent exacerbations.

- Long commute to pulmonary rehabilitation and lack of transport.

- Cost of pulmonary rehabilitation.

8. Pulmonary rehabilitation program

8.1 Pre-rehab assessment

Every patient referred for pulmonary rehabilitation should be thoroughly evaluated prior to initiation of the program. Majority of the patients have a regular pulmonary physician managing the lung disease. As a part of the management, pulmonary physicians refer the patient for pulmonary rehabilitation to supplement the pharmacological treatment. These patients when present to the pulmonary rehabilitation have already undergone an evaluation of symptoms and physical examination. Regardless, it is a good practice to perform a thorough evaluation of patient's medical problems, laboratory results, social habits and specific medications. This should be accompanied by a comprehensive physical examination with estimation of patient's functional capacity. In most of the pulmonary rehabilitation program, this assessment is performed by the physical therapists. If a pulmonologist is an integral part of the program, the physician can do this work up.

Prior to initiation of the pulmonary rehabilitation program, a careful appraisal of patient's pulmonary disease and current severity should be done. For COPD patients this will include the duration of their symptoms, current symptomatology, mMRC score [46], smoking history, pulmonary function testing, arterial blood gas analysis, inhaler therapy, oxygen supplementation and non-invasive ventilation prescription. It is imperative that a special attention should be paid to patient's co morbidities. This is essential as several other medical problems may have impact on patient's disease course and exercise capacity. These may include obesity, OSA, diabetes, cardiovascular co morbidities, hypertension, osteoarthritis, pulmonary hypertension, peripheral vascular disease and malignancy.

A detailed pre rehab assessment enables the physical therapist to devise an individualized treatment plan for the patients. This strategy is particularly helpful for patients with advanced disease, low exercise tolerance, special healthcare needs such as high oxygen requirements, pacemaker or defibrillators, walkers and cane. Information gathered at the beginning of the program will help set realistic individualized goals and alert the provider regarding the possibility of adverse effects.

Physical examination at the beginning of the pulmonary rehabilitation program is centered on measurements of patient's functional status and capacity to handle additional physical stress. Most relevant for COPD patients will be an examination of muscle wasting, joint mobility, postural deformities, and cardio-respiratory examination. Results of this examination allows physical therapist to gauge individual patient's tolerance and potential areas of improvement.

An important component of physical examination is nutritional assessment. This commonly includes measurement of weight, height and BMI. Both being underweight and overweight in a COPD patient can be detrimental. Excess weight can lead to extrinsic restriction on lung capacity as well as increased work of breathing. Weight loss and muscle wasting is a poor prognostic factor in COPD patients [59–61].

Pertinent respiratory examination in patients with COPD is directed at ability of the patients to clear their respiratory secretions, use of accessory muscles of respiration, breathing pattern, adventitious sounds on auscultation such as wheezing and crepitation. A knowledge of patients' respiratory status will help develop an educational plan regarding self-management, medication compliance and respiratory muscle training.

Reduced functional capacity due to physical deconditioning is widespread in COPD patients. This is multifactorial with poor nutritional status, systemic inflammation, cardiovascular comorbidities, postural deformities and osteoporosis [62] Interviewing the patient to ascertain their capacity to perform ADLs, sustained exercise and risk of falls is essential. Several questionnaires have also been used to objectively measure individual patient's baseline functionality. A few examples include: the Functional Independence Measure (FIM), the Assessment of Motor and Process Skills (AMPS), and a Functional Capacity Evaluation (FCE) [63].

Apart from questionnaire, various exercise tests can be used to gauge individual patient's functional capacity. These exercise tests can be done as field walking tests, on bicycle ergometer or on treadmill. In most hospital, simple walk testing can be cost effective and practical. Walk tests are considered more reflective of daily functionality of a COPD patient. Some of the commonly employed walk tests include the 6-minute walk test (6MWT) and the incremental shuttle walk testing. Standardized protocols have been established for performing the 6MWT. If done as per the set protocol, this walk test is highly reproducible and reliable test for both diagnostic and prognostic purposes. In this test, patient walk back and forth on a 30-m distance marked hallway at their own pace for 6 minutes. During the test, distance walked, vital signs, oxygen desaturation, development of dyspnea using a visual analog scale is measured [64]. The incremental shuttle walk test is performed on a 10 m marked course. It is a paced walk test to assess symptom limited maximal exercise capacity. Test is continued until patient develops symptoms of dyspnea or for 20 minutes, whichever occurs first. This is a valid and popular testing in various resource limited clinical settings [45].

If in addition to the functional limitation specific problems are identified by the physical therapists, various other tests may need to be performed. These tests address the muscle weakness, gait disturbances, and include balance testing and sit-to-stand tests [65].

8.2 Components of pulmonary rehabilitation

After an initial assessment, patient is enrolled into a pulmonary rehabilitation program. The basic aim of such a program in any COPD patient is to assist them in performing essential daily activities with independence. Independence comes from reduction in dyspnea and fatigue. COPD patient are inadvertently caught in a downward spiral where dyspnea is leading to inactivity, which in turn leads to physical deconditioning and decreased capacity to handle day-to-day stress. To save the patient from this downward spiral a pulmonary rehabilitation program focuses on improving the cardiorespiratory endurance, muscle strength, body flexibility and respiratory muscle training. With an individualized patient's clinical analysis and examination, a specific therapy plan can be built for each patient. This plan is intended to establish patient specific goals and focus on areas of functional limitation, which need to improve to achieve those goals. As the COPD patients undergo pulmonary rehabilitation, improvement in their physical deconditioning and exercise capacity needs to be measured and documented. This is achieved by using a variety of parameters, such as quantity of exercise performed or improvement in perception of dyspnea, symptoms, heart rate during exertion. Any changes seen in these parameters will be suggestive of patient's improved capacity to handle the physical stress. As discussed earlier in the chapter walk tests and questionnaires can provide an objective measure of functional improvement for COPD patients undergoing pulmonary rehabilitation.

8.2.1 Endurance training

Physical exercise training in COPD patients can be delivered in two forms: Continuous high intensity aerobic endurance training or an interval training, which alternates high intensity aerobics with low intensity exercises [66]. Continuous high intensity regimen of endurance training can be administered with constant load or incremental load. It has been shown that high intensity aerobic training (70–80% of peak work rate), will result in maximal improvement in physical fitness by increasing oxygen consumption, delaying anaerobic threshold and decreasing heart rate for a given exercise rate [27, 62, 67–69].

In patients with advanced COPD and persistent dyspnea a high intensity endurance training is difficult to sustain. These patients can be provided with interval endurance training. In this approach, high intensity aerobic training in short bouts (30–180 s) is alternated with low intensity exercises (leading to a subjective experience of exertion between 4 and 6 on the modified Borg scale) or rest [70–74].

Even though there may be less appreciable gains in aerobic parameters, this training approach has proven to be effective in improving exercise endurance in COPD patients [42, 75]. Interval endurance training leads to lesser degree of pulmonary hyperinflation allowing patients to exercise longer without excessive dyspnea. COPD patients may more easily adapt a lower intensity exercise regimen in their daily life. The choice of regimen is ultimately based on both therapist and patient preference.

Endurance training is delivered using various modalities including walking (treadmill or supported ground walking with walker or wheelchair), cycling, rowing, and swimming or modified aerobic dancing. It is recommended to provide this training 3–5 times per week at an intensity aimed at a Borg Dyspnea score of 4–6 (moderate level of exercise) [26, 44, 48, 67, 69, 76–79]. Exercise sessions can last from 30 to 120 minutes, with at least 30 minutes of continuous aerobic activity, based on each patient's capacity [26, 46, 79, 80]. General recommendation for the frequency of pulmonary rehabilitation is two supervised exercise sessions a week with third unsupervised session based on the available resources [44, 81, 82]. A minimum of 12 exercise sessions or 4 weeks of rehabilitation program is essential to achieve any improvement in physical fitness. Program length can be increased up to 72 weeks if patient is inclined and insurance coverage is favorable [48, 83, 84]. While shorter (6–8 weeks) pulmonary rehabilitation programs are more cost effective and widespread, longer duration programs have shown sustained beneficial effects. This is mostly due to fact that longer duration programs not only lead to physiological changes but also behavioral changes [85].

More specific for COPD patients it is recommended to check oxyhemoglobin saturation both prior to the start of the exercise and at peak work rate. This will not only help to ascertain the need for oxygen supplementation but also guide both therapist and the patient to know appropriate level to use with different intensity of work. Similarly, a careful attention on patient's bronchodilator therapy, both long acting and short acting, is essential during the program. Patients may require administration of short acting bronchodilator at the beginning of the exercises or during the workout. For a successful outcome of endurance training it is important that patient gets trained on similar oxygen delivery device that they use at home and are on optimal management of COPD. A stable respiratory function will allow the patients to tolerate higher intensity workout for longer duration.

8.2.2 Strength training

Apart from improvement in endurance, COPD patients benefit from increase in their muscle strength [26, 83, 86, 87] . Increased muscle strength provides the patients with an ability to handle the ADLs better, improves their gait and reduce fall risk, thereby making them more independent [88]. A recent meta-analysis investigating different methods of PR in COPD showed greater improvement in HRQoL by adding strength training than endurance training alone [89]. Physiologically improving muscle strength in COPD patients can lead to increase in physical endurance, 6-minute walk distance and maximum oxygen consumption [90, 91]. Strength training is most beneficial if directed at muscles involved in functional living. This involves training muscles in upper and lower extremities as well as the trunk.

It has been well proven that exercise training of the lower extremities leads to significant improvement in ambulatory stamina in COPD patients [42, 67, 92–94]. This is because lower extremities suffer most from disease-related muscular dystrophy in COPD patients. Additionally increasing lower extremity strength can reduce falls and maintain bone mineral density in COPD patients [45]. General recommendation to improve lower extremity strength is to provide resistance training with 2–4 sets of 10–15 repetitions of each exercise, for 2–3 days per week. Selection of weight for this type of resistance training workout is individualized based on patient's capacity. Increment in the weight is done gradually once patient is able to accomplish all sets of exercise with a prescribed weight [45]. Lower extremity training can be achieved using walking, bicycling with incremental loads, stair climbing, swimming, weight machines or elastic bands. Choice is driven by available resources at the training site.

Patients suffering from COPD who have hyperinflation and flattened diaphragm have limitation in using their upper extremities to perform ADLs. Elevation of arms can result in increased ventilatory and metabolic demands in COPD patients with low respiratory reserves. This is thought to be because some of the upper extremity muscles also serve as accessory muscles of respiration [95–97]. Majority of the published literature on pulmonary rehabilitation suggests beneficial effect of upper extremity training in COPD patients. Some of the observed benefits of this training include improved upper extremity strength, which is task specific, decreased ventilatory demands and more independence in performing ADLs. Despite these observed benefits, optimal prescription of upper extremity training remains unclear.

Physical therapists have to be mindful that in training the upper extremities, COPD patients may have elevated ventilatory work, asynchronous breathing and more dyspnea for the level of work. It is prudent to start with low resistance and frequent repetitions before gradually increasing the weight [81]. Upper extremity and trunk muscle strength training is achieved by using light weights (dumbbells, elastic bands), weight machines for stronger patients, rowing machines etc. Several of these instruments can also provide aerobic exercise training thereby improving both strength and endurance in the upper extremities.

Physical therapists may provide training of upper and lower extremities on alternate days to improve patient tolerance. Progressive improvement in muscle strength is documented using standardized lifting tests, incremental resistive load tolerated by the patient and increased capacity in performing ADLs efficiently [86].

8.2.3 Flexibility training

Many COPD patients suffer from modification in the structure of their chest wall due to hyperinflation, hypertrophy of the accessory respiratory muscles and physical inactivity. This further leads to changes in the posture and reduced mobility. To prevent this from happening, COPD patients undergo flexibility training as a part of the pulmonary rehabilitation program.

Flexibility exercises lead to improved mobility by increasing joint range of motion, reducing joint stiffness, better posture and increment in vital capacity [45]. Gentle stretching exercises with full body movements, coordinated with breathing techniques are appropriate for COPD patients [65, 98, 99].

This kind of workout teaches the patient the influence of body movements on respiration. Since these exercises are done at a slower pace without any resistive loads, they can be used during warm up or cool down periods of the program. Limited research has been done on adequate duration and intensity of stretching exercises. General recommendation are to perform stretching of major muscle groups in the upper and lower extremities 2–3 days per week at the minimum [100]. Benefits of this training can be measured by documenting reduction in subjective perception of stiffness, reduced incidence of back pain and joint injuries.

8.3 Education

8.3.1 Disease education

To provide a holistic care, every pulmonary rehabilitation program should incorporate patient education. It has been well proven that COPD patients who are well aware about the nature of their disease, its management and long-term implications are able to cope with both the disease and treatment better [101]. Education about the disease empowers the COPD patients to better recognize their symptoms, make lifestyle changes and get involved in the management of the disease. This leads to increased motivation to participate in pulmonary rehabilitation and adhere to the exercise regimen.

At the beginning of the rehabilitation program, individual educational needs of each patient are identified. This is continuously reassessed while the patients are undergoing the rehabilitation program. Instead of a didactic teaching, a patient centered and self-management teaching approach focusing on lifelong behavioral changes are adopted these days [45]. Specifically for COPD patients, a collaborative self-management plan which helps them in an identification of symptoms of onset of an exacerbation, make treatment modification and to communicate early with a healthcare provider, is highly beneficial in the long run [102]. Patient education runs alongside the exercise training. It is meant to supplement the knowledge gaps and instill confidence in the principles of ongoing training. Various topics regarding disease and its management are covered with utilization of the expertise of various specialists.

Exacerbation of COPD is an additional burden on patient's already weakened functional capacity. It leads to hospitalization, further inactivity, deterioration of lung capacity and mortality. It may also disrupt any advances the patient may have made in improving their exercise capacity and muscle strength [45, 46]. There is an emerging data suggesting that there is benefit in instituting and/or continuing with pulmonary rehabilitation during hospital admission or within a month of hospital discharge. An early initiation of pulmonary rehabilitation reduces risk of re-hospitalization and improves overall symptoms without any adverse effects [103].

8.3.2 Occupational therapy

A pulmonary rehabilitation program incorporating occupational therapy is important in COPD patients [104, 105]. Occupational therapy assists COPD patients with development of specific strategies to perform ADLs with least expenditure of energy [106]. With conservation of energy expenditure, there is an improvement in subjective perception of breathlessness, increased efficiency in performing daily basic activities, elevated sense of control and better social engagement [104–107]. Occupational therapy skills even though simple in principle, require a learning process, which is achieved through a multidisciplinary rehabilitation program. There is an ever-increasing evidence that improvement in occupation performance of COPD patients lead to a holistic improvement in their health [108]. Occupational therapist can also instruct COPD patient to use wheeled walking aids, which can result in increased functional autonomy, ventilatory capacity and waling efficiency [109–112]. Since this therapy has a major impact on social networking of COPD patients, it serves well to involve patient's family and friends [113].

8.3.3 Nutritional education

Body composition in COPD patients may change as the disease severity progresses. While obesity predominates in the milder stages of the disease, patients with advanced disease and emphysema tend to be underweight and have generalized muscle wasting [114, 115]. Factors other than the lung disease itself, which can lead to this shift, includes inactivity, systemic inflammation, osteoporosis and glucocorticoids use. Studies have shown an increase in mortality in COPD patients who are underweight, independent of their disease severity [116, 117]. These patients with decreased fat free mass have higher limitation to exercise tolerance and thereby reported a decreased HRQoL status in comparison to COPD patients with normal weight [118–121]. Various studies have shown a survival benefit with weight gain as low as 2 kg or by increase in one body mass index unit [116, 117]. This is why nutritional education are particularly essential in rehabilitation of COPD patients.

Every pulmonary rehabilitation program should include nutritional screening with measurement of BMI at the least. A more comprehensive program may also include fat free mass estimate using skinfold anthropometry or bioimpedance analysis. Estimation of osteoporosis can be done using dual energy X-ray absorptiometry (DEXA) scanning. Improvement of nutritional status requires a multi-pronged approach with utilization of both physiologic and pharmacological interventions. Endurance and strength training as described previously in this chapter can improve muscle mass as well as bone strength. Nutritional interventions include adding nutritional supplementation to patient's diet with emphasis on adequate protein intake to maintain or restore lean body mass. Patients who are unable to eat large meals due to dyspnea can switch to frequent small meals. It has been shown that a 6-month intervention involving dietary counseling, nutritional supplementation and positive reinforcement led to a significant weight gain in advanced COPD patients [60].

8.4 Psychosocial support

Many COPD patients who are referred to pulmonary rehabilitation suffer from depression and anxiety [45, 122]. Recent studies have estimated prevalence of depressed mood in about 45% and anxiety in 32% of patients with moderate to advanced COPD [123–125]. Dyspnea on exertion leads to fear and anxiety anytime a COPD patient has to exercise. This severely limits their social interaction and eventually leads to depression. COPD patients can suffer from hopelessness, sense of isolation and lack of motivation. It is essential to assess the presence of depressed mood during initial evaluation in a pulmonary rehabilitation program. Family and caregiver involvement is advisable to assess the social support system for the patient.

Identifying the mood disorders and deficit in the social support is an integral part of the program [114]. Patients in need can be provided with psychological and social support, which works to elevate mood, positive thinking and adaptive behavior towards disease and its management. This also improves the compliance with the pulmonary rehabilitation program. Psychological support can be provided by the physical therapist but often require a psychologist or a psychiatrist involvement.

9. Location of the training

Various models of PR have been adopted worldwide. An outpatient or hospital based-outpatient setting is the most widely used model to deliver PR to COPD patient in the developed countries [126]. Current body of evidence regarding effectiveness of PR in COPD patients is based on this model. In recent years an alternative model where the site of delivery of PR is at home has been studied. Home based PR setting provides the benefit of exercise training in a familiar setting to a larger patient population. Specifically for patients with severe COPD dependent on long term oxygen therapy, this model of PR has been shown to be both safe and effective [127, 128]. While home based PR model offers convenience, it lacks the group dynamics which an outpatient model can offer. Group therapy leads to socialization, mood elevation and positive reinforcement. Additionally a home based program does not have a multidisciplinary and comprehensive structure of a hospital based outpatient setting. At the present time, choice of location of PR is dependent on patient preference, disease severity and regional availability of resources.

10. Adjuncts to exercise training

10.1 Neuromuscular electrical training

Several COPD patients with advanced lung disease who are bed bound or wheelchair bound are unable to participate in a conventional pulmonary rehabilitation program. To help these patients, a new modality of transcutaneous neuromuscular electrical stimulation (NMES) has been devised recently [129–131]. This technology involves application of low amplitude electric current via electrodes transcutaneously to the targeted muscle groups by depolarizing motor neurons. Low intensity electric current (10–100 mA) is delivered at stimulation frequencies between 8 and 120 Hz for duration of 250–400 ms. Although no large RCTs are available, a recent meta-analysis did report improvement in quadriceps strength and exercise capacity with NMES. Unfortunately, no significant improvement in HRQoL in moderate to severe COPD was seen [132]. Apart from debilitated COPD patients, this technology has been recommended for use during COPD exacerbation, as it has low impact on ventilation, heart rate and dyspnea [133, 134].

10.2 Respiratory muscle training

A pulmonary rehabilitation programs for COPD patients usually includes respiratory muscle training. The goal of this training is to improve the abnormal breathing pattern, which may result due to increased work of breathing, chest wall changes and poor breathing habits in COPD patients [135–138]. The most commonly applied approach is through the endurance and strength training. [26]. Exercise training can lead to increase in minute ventilation, which leads to an increase in work of breathing. Constant controlled aerobic exercises of upper and lower extremities can lead to a recurrent stimulation to respiratory muscles. This helps the COPD patients to modify their breathing patterns on a day-to-day basis as well as be better prepared for an exacerbation.

Apart from exercise training, specific breathing exercises such as diaphragmatic breathing, paced breathing with exercises and pursed lip breathing has been proven to be beneficial in COPD patients. Diaphragm, which is the main inspiratory muscle, is flattened and ineffective in patients with hyperinflated lungs. This puts these patients at a mechanical disadvantage to adequately maintain and increase their minute ventilation. COPD patients who undergo the training to improve the coordination of their diaphragmatic muscle tend to fare better overall [139].

Many patients with emphysema self-discover the method of purse lip breathing for faster recovery from shortness of breath post exercise. Other patients can be instructed regarding this method. It helps patients to increase alveolar ventilation, tidal volume and CO_2 removal. It also leads to slow expiratory flow and decreased respiratory rate [140]. Using the same principle, respiratory muscles can be trained by using resistive breathing devices. This can be particularly useful in patients who continue to have dyspnea despite optimal medical management.

Additionally COPD patients specifically with chronic bronchitis occasionally have ineffectual cough leading to difficulty in respiratory secretion clearance. Instructions on special coughing techniques (huffing, autogenic drainage) combined with oscillating expiratory breathing devices (Acapella, In-exsufflator) can prove effective [141]. Patients can be instructed to perform daily chest physiotherapy to assist in respiratory secretion clearance through postural drainage techniques [142]. A meta-analysis of 32 studies focusing on respiratory muscle training showed that it leads to improvement in respiratory muscle strength, exercise capacity and perception of exertional dyspnea [143].

11. Maintenance of the training

The beneficial effects of a comprehensive pulmonary rehabilitation program are not sustained beyond 12 months [32, 42, 144, 145]. On the other hand, repeating a pulmonary rehabilitation programs has not been found to be an effective treatment option [146]. Considering this, it is challenging to maintain the changes made in physical activity and lifestyle due to a pulmonary rehabilitation. Although there is a lack of data on maintenance programs, some centers do provide these in the hope to achieve prolonged benefits gathered in a successful rehabilitation program. There are no set guidelines to establish an optimal strategy for providing maintenance pulmonary rehabilitation. Additionally other factors such as lack of transportation to the PR center, disruption of daily life routine, absence of family support, perception regarding gains from the PR program, have impact on patient's participation in the post PR programs. A recent multicenter RCT studying the long term (3 year) maintenance program after PR in severe COPD patients, showed a sustained beneficial effect on BODE index and 6MWD at 24 months. Although, the effect vanished beyond 2 years as at end of study only 66% of COPD patients were still adherent with the maintenance program [147].

Various methods adopted to provide therapy beyond a comprehensive program include weekly telephone contacts, home exercise training with or without weekly-supervised outpatient sessions and recurrent PR program [146, 148–151]. A recent meta-analysis analyzing post-PR exercise program in COPD patients suggested that such a program even though effective in maintaining a good exercise capacity with the 6 months of PR, loses its benefit beyond 1 year and has no impact on HRQoL [152]. The patient population and the interventions used were variable and results of this study need to be interpreted cautiously.

Since the structure of the most effective maintenance program remains elusive, it is important at this time to encourage the COPD patients to continue with healthy lifestyle changes. This can be achieved by a concerted effort of the PR staff, family members, and patients' healthcare team. Those COPD patients who continue with the exercise routine and lifestyle changes they had learnt in the PR program tend to accumulate gains in physical endurance and psychological functioning [153].

12. Future directions

Pulmonary rehabilitation has a major role in the management of patients with chronic lung conditions especially COPD. The need for more convenient and efficient programs using new technology would be beneficial for patients. Tele-rehabilitation to deliver rehabilitation services over telemedicine using internet or phone can provides services to patients who live in remote areas without access to transportation. Tele-rehabilitation allows video conferencing between a central control unit and a patient at home. This will also deliver health services to patients with disability who cannot travel long distances for rehabilitation programs. Both mobile phones and video conferencing have used in few studies deliver rehabilitation services. The studies have demonstrated good compliance, decrease in exacerbations and hospitalizations, improved exercise capacity and quality of life [154, 155]. Benefits of telemonitoring in COPD patients have been described in a systemic review that showed decrease in hospitalizations and emergency room visits using telephone support for telerehabilitation [156].

13. Conclusions

A comprehensive multimodality pulmonary rehabilitation program is becoming an essential part of the management of COPD patients. It is not only cost effective but also scientifically proven to improve patients' symptoms and functionality. With a gradual increase in daily activity, COPD patients are able to achieve higher HRQoL compared to pharmacotherapy alone. Despite these proven benefits, widespread utilization of PR remains poor. Multiple factors, including; physician unfamiliarity of benefits of PR, patient compliance with the exercise regimen and insurance coverage contribute to this gap. With the increasing prevalence of COPD worldwide, a safe and effective option like PR needs to be actively promoted and utilized.

Apart from standardized exercise regimens and strength training, the emphasis of an effective PR program is on behavioral modification. This result in long lasting, positive changes on the disease course. In addition, empowering the COPD patients by educating them about disease, smoking cessation and nutrition is a crucial step in the right direction. Development of home based or telerehabilitation services may assist in reducing the disparity in access to PR for many more COPD patients.

Conflict of interest

Authors declare no conflicts of interest.

Appendix

COPD	chronic obstructive pulmonary disease
AECOPD	acute exacerbation of chronic obstructive pulmonary disease
PR	pulmonary rehabilitation
HRQoL	health-related quality of life
RCT	randomized controlled trial
NMES	neuromuscular electrical stimulation
ADLs	activities of daily living
mMRC	modified Medical Research Council
6MWT	6 minute walk test
FIM	functional independence measure
AMPS	assessment of motor and process skills
FCE	functional capacity evaluation
DEXA	dual energy X-ray absorptiometry
BODE index	body mass index, airflow obstruction, dyspnea and exercise capacity

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Chapter 2

Ischemic Preconditioning in Cardiac and Skeletal Muscle Induced by Exercise

Raúl Sampieri-Cabrera, Gustavo López-Toledo, Juan Manuel Aceves-Hernández and Virginia Inclán-Rubio

Abstract

Since it was discovered, ischemic preconditioning (IPC) has motivated research groups around the world to develop preconditioning protocols capable of protecting tissues against prolonged insults. In 31 years of study, promising results have been obtained on the beneficial role of the CPI and the mechanisms involved in its regulation. Also, different preconditioning protocols that have obtained results similar to the classic CPI have been developed, among which is the exercise-induced preconditioning (EP), that has been proven to protect the heart against an insult, mitigate the atrophy of the heart muscle and increase physical performance in athletes and/or athletes.

Keywords: cardiac, skeletal muscle, exercise-induced preconditioning, ischemic preconditioning, physical performance

1. Introduction

In 1986, Reimer studied the contribution of ATP depletion in the genesis of myocardial damage in an experimental model that involved the production of a series of brief ischemic episodes, assuming that successive ischemia decreased ATP levels. Conversely, Reimer was found to initially decrease the ATP content during the first ischemic episode, but the remaining episodes did not imply significant variation in ATP levels and, in some animals, these periods of ischemia produced cardioprotection [1]. This finding, which challenged the concept of successive episodes of ischemia, produces infarction as a result of "cumulative damage" [2].

Murry postulated that the maintenance of ATP in Raimer's experiments, it could be because the myocyte needed less energy, as a consequence of the development of rapid adaptation to ischemia. To test this hypothesis, he performed a series of 4 periods of 5 minutes of ischemia and 5 minutes of reperfusion before the myocardium was submitted to a prolonged 40-minute ischemia. These brief periods of ischemia and reperfusion protect against ischemic damage and reduce 30% of the infarct size; He called this preconditioning or ischemic preconditioning (IPC) [3].

This finding contributed to the development of research lines to study the mechanisms involved in cardiac preconditioning, extending the concept of ischemic preconditioning in studies of: Arrhythmias [4], apoptosis [5] and endothelial dysfunction [6].

In addition, other non-ischemic stimuli have been studied to protect the heart, such as hypoxia [7], cell stretching [8], accelerated cardiac pacemaking [8] and physical exercise.

Exercise has been used as therapy for the treatment of stable ischemic vascular syndrome, where it has been observed that it improves perfusion in ischemic tissues. Some mechanisms involved in improving the perfusion of ischemic tissues after exercise involve:

a. shear stress-associated improvement of endothelial function [9];

b. increase in phosphorylation and expression of endothelial nitric oxide synthase [9];

c. decrease in vascular oxidative stress; and

d. collateral formation of vascular tissue.

Something that has to be clear when we talk about ischemic preconditioning is its dependence on the intensity of the stimulus (ischemia) and its duration, under this principle we can establish adequate protocols for the treatment of cardiovascular and muscular diseases; as well as, to improve the physical performance of the athletes.

Physical exercise challenges the organism to maintain stable conditions of the internal environment (homeostasis), against hypoxic conditions, oxidative stress and tissue nutrient deficiency. It is a condition of physiological stress, to be carried out continuously and through appropriate physical training programs provides benefits in the body, ranging from better control of blood glucose levels to better long-term memory.

There are multiple studies of the benefit of exercise in health, in all the virtues of exercise are praised. The result is obvious, improves and maintains the physical fitness, health and wellness of the person who performs it.

It has direct effects on muscle strengthening and cardiovascular capacity, in addition to the systemic effects involved with the release of substances into the bloodstream or the tissue that contribute to the preconditioning of the heart and skeletal muscle can be attributed to exercise.

The biochemical and physiological advantages conferred by exercise-induced preconditioning can serve to improve exercise performance. Although not all studies achieve this result, it is important not to forget that the participation of mediators produced and released during physical exercise and that are responsible for the beneficial effects in the body.

This chapter focuses on discussing the physiological mechanisms that are produced following an exercise-induced preconditioning protocol, especially those that relate to the cardiovascular system, skeletal muscle and physical performance.

2. Research methodology

An information search was carried out using the phrase “Preconditioning by exercise,” in the searcher of the database SN SciGraph Data Explorer 2019 of the springernature publishing house, finding 4, 953, 141 results, distributed in: ScholarlyArticle (3226063); Chapter (1264653); MonetaryGrant (300521); Patent (137092); MedicalStudy (19868); Book (1650); Periodical (1290); Concept (843); Subject (825); Address (99); Person (76); rdf: Property (61); rdfs: Class (38); Organization (22); Organization (10); Nonprofit (5); Facility (4);

ConceptScheme (4); Company (3); Other (3); BoardingPolicyType (2); Resource (2); EventStatusType (1); GamePlayMode (1); Archive (1); Education (1); Government (1); Healthcare (1); Ontology (1). Among these results, special interest was placed on using those that were 1 year old to date (with the exception of the classic articles that are related to clinical trials). A second filter was made, selecting only those works that were directly related to cardiac tissue, skeletal muscle and physical performance. Focusing on the representative works of the area without ruling out negative or contradictory results.

3. Mechanisms of exercise-induced preconditioning (EP)

3.1 About the cardiovascular system

The different cardiac affections, including myocardial infarction and ischemic heart diseases, are the main trigger of a high worldwide mortality, which originates in the sedentary lifestyle, chronic hyperglycemia and atherosclerosis. Although vigorous exercise itself induces a temporary hypoxia that causes damage to the myocardium, EP regulates down-pathological biomarkers and increases physiological biomarkers in both the pre-and post-myocardial infarction phase [10].

The protective effects of physical exercise on the cardiovascular system are carried out on cerebral blood flow, vascular endothelium, vascular vasodilation, endothelial progenitor cells, collateral circulation and cardiac muscle.

Despite the traditional knowledge of the benefits of aerobic exercise in health, it has not yet been introduced in the clinical setting. Knowing the benefits of exercise in cardiovascular and cerebrovascular diseases can encourage more patients with cerebral infarction and myocardial infarction and people with high-risk factors, to accept exercise interventions for prevention and treatment, and to health professionals to include exercise therapies as adjuvants in pharmacological treatment and even as independent therapies [11].

It is believed that early aerobic exercise has the potential to be a precautionary strategy for myocardial injury after myocardial infarction, through the regulation of the expression of proteins related to antioxidants and proteins associated with mitochondria [12].

In the heart one of the main harmful events produced by an insult is myocardial injury. Where, the protective role of EP has been reported, through the down regulation of KATP channels and the reduction of autophagy [13].

A mechanism of classic myocardial injury is damage by reperfusion, where, it has been reported that EP decreases oxidative stress, inflammatory cytokines and apoptosis, and increases the serum bioavailability of NO. These mechanisms are regulated by the GSK-3β pathway [14].

Interestingly, KATP channel opener drugs have been linked to cardioprotective events, where an increase in reactive oxygen species (ROS) has been reported, which downregulates the activity and expression of calcium channels in the tissue. Cardiac, which can mitigate the evolution of reperfusion damage. The positive regulation of ROS is related to the uncoupling of the respiratory chain, mainly in cardiomyocytes. Exercise, being a systemic event, activates complex mechanisms responsible for regulating body physiology, such as the vascular release of NO, which contributes to keeping the mechanical power of the heart regulated. On the other hand, as we know, an exacerbated increase in ROS, can generate tissue damage through mechanisms of cellular autophagy, so it is likely that time is a regulatory factor and of great importance in EP protocols. It is very difficult to perform an isolated study of the physiological role of EP, physiology seen as a complex system challenges us to explain the phenomena from an integrative perspective that analyzes the phenomenon and its interactions with negative and positive regulation mechanisms.

From the therapeutic point of view the possible implications of PE, can contribute to improve the treatment of cardiovascular diseases, it has been reported that in a training protocol with vibration, increases cardiac tolerance to reperfusion injury after ischemia, decreases the size of the infarction and cardiac arrhythmias and facilitates spontaneous defibrillation [15]. These data suggest that exercise helps to regulate the participation of the electrical conduction system after a cardiac insult, the mechanisms by which this happens has not yet been elucidated.

It is known that the early response to a moderate and/or exacerbated cardiac insult eventually results in the generation of cardiac hypertrophy (increase in the volume of cardiomyocytes), which if not compensated, can progress to heart failure. Exercise has been related to a type of beneficial hypertrophy known as physiological hypertrophy, in which, far from having repercussions that compromise cardiac capacity, they improve it. On the other hand, there is pathological hypertrophy, which is linked to the development of myocardial scar and low cardiac capacity.

Treatments for cardiac hypertrophy are related to stopping the causal stimulus, which prevents its progression. In this sense, recently, PE has been reported to attenuate pathological cardiac hypertrophy by increasing the functional capacity of the cardiovascular system, through the MAPK pathway [16]. Probably this protective effect is related to the systemic increase of ROS, one of the main stimuli that regulate the MAPK pathway.

On the other hand, the level of autophagy activated during EP may be partially involved in the cardioprotective effects, maintaining a basal level of normal autophagy in the myocardium during the subsequent exhaustive exercise [17]. This ability of the EP to activate autophagy processes helps to sense the cellular metabolic processes, thus maintaining the homeostasis of cardiomycites.

Although in general, it is believed that preconditioning is directly triggered by a brief ischemia–reperfusion. It is known that brief ischemia produces transient dilatation (or stretching) of the heart. Therefore, it has been postulated that the stretching of the myocardium may be responsible for preconditioning, through the ion channels activated by stretching [18]. This idea can be supported indirectly by the fact that in chronic exercise, by increasing endothelial shear stress, increases NO production and ECNOS gene expression and can contribute to the beneficial effects of exercise in the cardiovascular system (ie say, antihypertensive) [19]. Although, as mentioned above, to say that the protective effect of preconditioning is due to a particular mechanism and not to a complex process, it is risky and simplistic.

The beneficial role of exercise on the cardiovascular system inevitably involves the regulation of vasodilation and vasoconstriction. In this sense, in stable coronary artery disease (CAD), exercise has been used as a treatment due to its endothelium-dependent vasodilator capacity, induced by acetylcholine. The molecular mechanism involved is through the phosphorylation of the eNOS-induced for Akt pathway [9]. This study demonstrates the role of exercise as a therapy in cardiovascular diseases, its actual use in therapy and the mechanism of action involved. To the extent that EP protocols are standardized and establish molecular relationships between the preconditioning processes, progress may be made in the non-pharmacological and/or combined treatment (drugs and exercise) of cardiovascular diseases.

Not only has it been linked to EP for the treatment of cardiovascular diseases, but it has also been shown to be useful for the treatment of doxorubicin poisoning (DOX), where it has been described that 2 weeks of EP are sufficient to prevent cardiorespiratory dysfunction associated with DOX and prevent mitochondrial dysfunction by reducing mitochondrial DOX accumulation [20]. The role of PE in poisoning processes can focus the bases to study its implications in pharmacokinetics and thus establish therapies with better efficiency and fewer adverse reactions and/or drug interactions.

In addition, in a novel way, it has been described that PE induces a pro-angiogenic medium that can increase the therapeutic effects of stem cells derived from adipose tissue in cardiac remodeling after myocardial infarction [21], so its potential in genetic medicine, it is promising and can contribute to generating favorable tissue environments for cell insertion and even in organ transplants.

Recently, it has been described that training with 12-week exercises in patients with heart failure mitigates ischemic injury due to endothelial reperfusion, protection mechanisms can be linked to PE [22]. This result is the first of its kind in a disease as complex as heart failure, so in a few years it is highly probable that within the treatment schemes for cardiovascular diseases exercise protocols are recommended. The challenge for health professionals is still great. Multidisciplinary groups must be established to develop and execute the protocols, monitor patients, evaluate therapies and make adjustments to obtain the expected results.

3.2 About skeletal muscle

Skeletal muscle represents one of the most abundant tissues of the organism, for many years its mechanical and structural role has been studied, without studying its role in the regulation and maintenance of energy metabolism, release of humoral factors, regulation of oxidative stress, among others. Physical exercise represents the participation of the cardiovascular, respiratory and naturally skeletal muscle systems. For this reason, it is not to be expected that the protective role of the EP will positively impact the skeletal tissue. The mechanisms involved in the production of the beneficial effects of preconditioning in skeletal muscle are not yet clear, although it has recently been shown to decrease skeletal muscle atrophy induced by the discharge of the hind limbs (HU) and the mechanism that can participate it is through HDAC4/Gadd45α [23]. Although, interestingly, the mechanisms of physical training to reduce muscle atrophy are associated with the biogenesis, function and redox balance of mitochondria, the same mechanism involved in preconditioning [24]. The redox mechanism seems to be common in preconditioning processes regardless of white tissue, probably not the only shared mechanism, but certainly unlike the cardiac muscle, in skeletal muscle hypertrophy represents a greater capacity for energy regulation.

On the other hand, the mechanisms involved in changes in the markers of muscle damage and the parameters associated with running economy (ER) are not related, that is, increasing the tissue damage in skeletal muscle does not improve the ER [25]. However, it is likely that in order to represent an improvement in the ER, a chronic protocol must be performed.

EP decreases arterial circulation in skeletal muscle, this confers hypoxia in the tissue. It has been reported that hypoxic preconditioning (HPC) can protect the function of respiratory skeletal muscle during reoxygenation through signaling cascades sensitive to redox mechanisms and the regulation of mitochondrial channels [26].

The protective effect of EP on skeletal muscle can be used for the treatment of muscular atrophy and strengthening of muscle tissue. It is still necessary to study the mechanisms that can contribute to improve it and optimize the protocols that are adapted to the physiological needs of patients.

On the other hand, preconditioning reduces the fatigue associated with repeated exercise speed [27], however, it is still necessary to establish exercise protocols where the variables to be studied are identified and correlated with an increase in physical performance and/or increase of the ER.

3.3 About physical performance

The role of EP in physical performance is controversial, while some papers report that EP improves physical performance, others have not found changes with respect to control groups. In part, this is because EP protocols are not optimized.

Studies using remote IPC improve the performance of the swimming, cycling and running time test in a range of ~3–5%. However, in other studies, the CPI seems to have no effect on physical performance.

Although what most studies want to demonstrate is the increase in performance by the IPC, it is difficult to obtain promising results if the participation of the biochemical mediators produced during the IPC is overlooked and who are responsible for the beneficial effects of the exercise in the organisms, regardless of whether they confer improvements in physical performance or not. Until now, the mechanisms that contribute to the possible benefits of the IPC in physical performance are not fully defined, but they can be the same as those activated during the classic IPC. It has been described that the IPC improves the performance of supraximal exercise by increasing accumulated oxygen deficit (AOD), an indicator of glycolytic capacity, so that a greater glycolytic capacity due to the increase in AOD could be a potential mediator involved in improving physical performance [28].

It has been reported that improved metabolic stress increases ischemic preconditioning for exercise performance, amplification of the ischemic preconditioning stimulus increases the effect on exercise capacity [29].

In addition, in the aerobic function and the performance of the 4 km cycling time test, it suggests that the acute CPI shows some potential as a strategy to improve performance for well-trained cyclists before high-intensity exercise [30].

On the other hand, coupled with the molecular mechanisms associated with the beneficial effect of EP in the cardiovascular system, the nervous system through vagal cardiac control in high-strength athletes has generally been associated with adequate recovery to training and preparation to face the high-intensity training. Therefore, a method that improves vagal cardiac control in endurance athletes could be advantageous. IPC increases rapid cardiac vagal reactivation after exercise at exercise intensities below the lactate threshold in endurance runners [31].

However, some negative reports about preconditioning on physical performance indicate that remote ischemic preconditioning (RIPC) does not have a practical ergogenic impact on speed skating performance on long runs of 1000 m in elite athletes. The relevance of using RIPC during training to increase physiological stress in sprinters deserves further investigation [32].

The IPC does not improve sprint performance of 10 or 20 m in athletes [33]. Although the IPC accelerated recovery to a certain extent in the short term, the long-term recovery of the autonomous cardiac control of the repeated sprint exercise (RSE) did not change, and this accelerating effect was not accompanied by any effect of the IPC on surrogates of the responses of energy metabolism to RSE [33].

It is extremely important to standardize EP tests in order to establish adequate exercise plans to increase physical performance in athletes and improve their health conditions.

The role of EP to improve physical performance of athletes seems to be a field with many controversies, this is due to the great variability between the protocols used, the type of exercise to which the athletes are subjected, the variables studied, to name a few.

The EP confers protection to the tissues, perhaps immediately this does not translate to improve physical performance, but in a prolonged time course is likely to indirectly contribute to increase it.

4. Conclusion

This chapter describes the mechanisms involved in the protective effect of EP on the cardiovascular system, skeletal muscle and physical performance. Although EP seems to contribute to mitigate tissue damage due to ischemia, the role of calcium in PD, the molecular interactions it evokes, the contribution of pH, the role of blood volume and temperature, among others, are still to be understood.

The EP studies are constantly increasing, we can find a lot of information in the scientific literature, in much of this information we discuss the protective role of PD on tissues (even in the nervous), but there is other information that is little Clear and seems to encourage discussion between different research groups, this one speaks on the one hand of the possible role of EP in improving physical performance and on the other hand, those who document not finding improvements in physical performance after a EP protocol.

In this sense, it is important to clarify that preconditioning is a multifactorial phenomenon, and that its success depends to a large extent on the protocol used and the rigorous control of the variables, in addition it is a phenomenon highly dependent on the type, ie there are windows temporary in which we can observe preconditioning and others where we have damage. In addition, preconditioning is a reversible phenomenon, that is, its protective role can only be observed in periods of time, although there has been talk of a muscle memory, it seems to exist only if the ability to challenge the body to activate it is preserved. Sequential.

EP is undoubtedly one of the most interesting phenomena of exercise physiology, its therapeutic potential is real, it is being used in the clinic, it is used in the exercise protocols, but if we want to understand the phenomenon we must work seriously to elucidate the mechanisms that participate and how they relate to each other, that is, to study the complexity of the system with the greatest control of the variables and under standardized protocols.

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Conflict of interest

The authors declare no conflict of interest.

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Chapter 3

Fetal-Neonatal Lifestyle Basis of the Adult Metabolic Syndrome Patients

Hashem Kilani, Abdulsalam Al-Za'abi, Areej Kilani and Laila Kilani

Abstract

Information on the health status in modern society and developed countries depicts an increase in noncommunicable diseases (NCDs) such as diabetes, overweight, obesity, and metabolic syndrome. An examination of factors related to this increase shows that there is a shift in the daily practices of the people, and especially children in all ages, as they grow older toward a more sedentary lifestyle. This chapter concentrated on the term used to describe lifelong changes in function that follow a particular event in an earlier period of the life span, which is called programming. These include the lifestyle in the fetus, pregnant woman, and parents; all of which affect pronounce metabolic syndrome in later life of adult. Therefore, regular physical activity and living systematic healthy lifestyle in the prenatal stages are of importance to genetic modification of inheritance for future generations.

Keywords: lifestyle, adult, metabolic syndrome

1. Introduction

For more than a decade, high blood pressure, arteriosclerosis, smoking, high blood sugar, and lack of movement have been dangerous factors leading to morbidity and mortality. Today, recent studies indicate that the first risk factor to rush to death is the lack of physical activity and time of daily sitting in addition to the poor selection of healthy food [1–5]. It may be the responsibility of everyone in us not to follow a healthy lifestyle that is inherited by generations, the most important factor that has led to a negative acceleration of human health. This would not have been possible without the negative use of technology for human life.

The sedentary life experienced by most people has led to an increase in such risks and a marked increase in noncommunicable diseases. So, the most important issues that urge them to take the initiative in the marketing of sports and physical activity that the movement blessing and health crown on the heads of healthy cannot be achieved without beginning to modify the behavior and the adoption of a healthy lifestyle. This includes regular physical activity and stay away from pressure exercise relaxation and selection of appropriate food and early sleep with sufficient hours (quality of sleep) [5]. Therefore, in order to do so, school sports are a productive educational activity that is of great physical interest to the student [6]. Educational institutions and organizations have converged in recognition of the importance of school sports in maximizing the use of the time available to activate the lesson of physical education. This interest emphasizes the inclusion in many studies of its recommendations on the importance of school sports and its role in the development of students from the mental, psychological, and physical aspects [6–9].

Physical activity has much health, psychological, and social benefits. It helps to raise the level of fitness for better health and more active life. It also helps prevent many diseases or metabolic symptoms. It also reduces the risk of heart disease, diabetes, low back pain, and obesity, as well as the development of health and nutrition knowledge and the development of positive attitudes toward physical activity [2, 9–11].

Metabolic syndrome is a combination of medical disorders that increase the risk of cardiovascular disease and diabetes, which refers to all the biochemical processes that occur in the body; it is a group of metabolic abnormality-related risk factors that greatly increase the risk of developing type 2 diabetes and health problems in the heart and blood vessels. Also, their biochemical processes in the body that leads to abdominal obesity and insulin resistance causing type 2 diabetes and Cardiovascular (hyperlipidemia) [12].

2. Obesity facts

While the prevalence of obesity appears to have plateau in the United States, emphasis is not only placed in treatment but also prevention as only 8% of normal weight children will become obese adults, while those who are obese during childhood tend to be obese adults. Also, a longitudinal change in percentages of obese children in Jordan, KSA, UAE, Kuwait, and Oman has similar trends. The increased rate of obesity in childhood and in the overall population is also present in the Arab world [13]. Data from this study done by students in Seeb, Muscat, demonstrate how the proportion of children who grew into adolescents that became overweight or obese increased from a single digit (about 7 percent) to more than 20% (so we are talking that in the same cohort of children when they were 6–7 years old only one in ten was classified as obese, but by the time they are late teens, one in five is classified as overweight). Participants were assessed at the beginning of the school year during the screening that took place before entering the different levels of education [14].

Kilani et al. have also presented a similar prevalence of college students who are overweight at SQU, with a much higher proportion of students who present an unhealthy level of body fat [14]. In another survey, males and females had similar values for BMI and WC, and they maintained a normal BMI of <25 Kg/m^2. The genetic predisposition might synergize with environmentally driven factors like physical activity and diet in the etiology of obesity and overweight among Omani and Jordanian adolescents [4, 15]. So, what are some differences between normal weight and obese people? Hormone research agenda is divided into two aspects: exercise endocrinology (hormonal responses to exercise) and the role of physical activity in promoting a healthy lifestyle.

The main characteristics of the syndrome store excess fat in the abdomen as visceral fat (abdominal obesity) and "insulin resistance" [16, 17]. Firstly, obesity generally can be inherited or acquired, especially when an individual lives in an incubator environment to increase the number and size of fat cells. Prader-Willi syndrome (PWS) is rarely caused by a genetic defect that leads to physical, mental, and behavioral problems. One of the factors that contribute to childhood obesity great feeling of hunger and lack of control over eating which leads to chronic overeating (hyperphagia) and obesity [18].

Defined etiology of obesity is accounted for (3-5%) with issues related to hormonal diseases, lesions in the hypothalamus, and altered genes (Early-onset hyperphagia caused the pathologic obesity) [18].

The second is Multi-factorial obesity which results from an interaction between inherited predisposition and environment (epigenetic). PWS results from all alteration in the expression of the paternal chromosome 15, in the regions 11–13, and there are three main genetic alterations that result in the syndrome: paternal deletion, maternal uniparental disomy, and imprinting defect [19]. These causes that people with syndrome although share some common characteristics also present a wide range of abilities and disabilities. As babies, individuals with the syndrome are what we call floppy babies because of their decreased muscle tone, most of them have to be intubated as they fail to thrive, and somewhere between ages 4 and 8, an exacerbated seeking for food behavior begins which turns into hyperphagia that if it is uncontrolled it can turn into obesity [19]. Physically, they could be shorter than normal if not on growth hormone replacement therapy and have small hands and feet; some present intellectual disability, deficit in their sensorial systems and in their motor behavior [19]. Many researchers recommend to reduce weight by 10% of body weight in the first 6 months to a year and continued losing weight after reaching less than 25 in BMI. In general, recommendations include reducing calories including reducing 500–1000 calories per day [20–22].

In some studies, 9007 men and 1491 women aged 44 +/−9 years free of metabolic syndrome took measurements of waist circumference and blood pressure and fat and sugar glucose as documented in the baseline and follow-up checks. Cardiorespiratory fitness was measured by maximal treadmill test duration. During the average follow-up of 5.7 years, 1346 men and 56 women developed metabolic syndrome. Inverse associations between fitness and metabolic syndrome incidence were found, suggesting that greater cardiorespiratory fitness levels may be beneficial in the primary prevention of metabolic syndrome [23]. The purpose of this paper was to review through scientific research published to respond on to the following question: Can the conditions during fetal development program the system to result in a survival advantage, yet increase vulnerability for adult diseases?

3. Developmental plasticity

The developmental plasticity is the ability of an organism to develop in various ways, depending on the particular environment or setting [24]. This can be based on the interaction of cellular cells, which refers to direct interactions between cell surfaces that play a crucial role in the development and functions of multicellular organisms, such as complex, structural humans. These interactions allow the cells to communicate with one another in response to changes in the microbial environment [25]. This ability to send and receive signals is essential for cell survival. For instance, normal embryonic and postnatal development requires a fine regulation of cell proliferation, differentiation, migration, and apoptosis. During organogenesis, cell–cell interactions trigger events such as epithelial-mesenchymal transition (thin protective layer) and tubulogenesis (kidney development) that describes tissue that forms a thin protective layer on exposed bodily surfaces and forms the lining of internal cavities, ducts, and organs. Another example is related to cystogenesis, tubulogenesis, and kidney development [26]. Cystogenesis and tubulogenesis are important for many complex biological processes such as organ development. Again, if we compare an epidermal keratinocyte and a pancreatic acinar cell, the same genome, yet their profound morphological, physiological, and biochemical differences are entirely the product of epigenetic modification. Keratinocyte cells are the building blocks of the skin. They are the most common type of skin cell and make keratin, a protein found in the skin, hair, and nails.

One condition that causes the pancreas to stop producing adequate enzymes is pancreatic acinar atrophy. This occurs because the disease hurts slowly and without obvious symptoms. The ability of many animals is adaptability to environmental evolution. This can make small size and slow metabolism to live and survive, while the enlarged size and accelerated metabolism are advantages of reproductive success when resources are available. Often this occurs early in life or even through inheritance from parents and even grandparents. However, fetuses who are adjusting to one environment, such as the uterus, may be at risk when exposed to other environment when they become adults [27]. Effects of prenatal exposure to the Dutch famine on adult disease in later life. Bees determine the number of larvae within the appropriate age group and begin to place these larvae to become queens. The only difference between the honeybees and the queen is the food received during the process of maturity: the workers feed potential queens royal jelly throughout their lives, while the bees are working on royal jelly during the first 2 days of the larvae [28].

4. Biological evidences

Biological evidence may be relevant to understanding human development and susceptibility to disease. With the improved nutritional status of many mothers around the world, the characteristics of their offspring—such as body size and metabolism—also changed. Their mother's prenatal response may generally respond to individuals so that they are more appropriate to the environment's expectations through the signals available in early life. If the mother is a smoker during pregnancy, it is possible that the third generation of her offspring will be smokers. Ironically, however, rapid improvements in nutrition and other environmental conditions may have adverse effects on the health of those whose parents and grandparents lived in poor conditions, as happened in World War II in Europe [29] and the famine in India early in the last century [30]. The full understanding of the patterns of human plasticity in response to early nutrition and other environmental factors will have implications for public health management.

5. Thrifty hypothesis

The thrifty gene hypothesis indicates that certain populations may have genes that determine increased fat storage, which in times of famine represent a survival advantage, but in a modern environment result in obesity and type 2 diabetes. An example of the thrifty hypothesis showed by Dutch famine study which has shown that the offspring of mothers who were pregnant during the famine have more diabetes and those who were exposed in early gestation have more atherogenic lipid profile, altered clotting, more obesity, and a threefold increase in cardiovascular disease. Explanations for the heritability of these syndromes and the environmental contribution to disease susceptibility are addressed by the "thrifty genotype" and the "thrifty phenotype" hypotheses [27]. The underlying scientific hypothesis has been developed by epidemiology studies and emphasized by Dr. David Barker in the United Kingdom. During development fetuses respond to severe malnutrition by favoring the metabolic demands of the growing brain/CNS and heart at the expense of other tissues [31, 32]. In addition, the growing brain/CNS and heart tissue may not, however, escape entirely unscathed. The fetus is protected from death and is live-born but is more prone to diseases later in life [33]. Various studies have supported barker hypothesis.

6. Epidemiology studies

Epidemiology studies have shown that markers of malnutrition such as frank intrauterine growth retardation (IUGR), low birth weight, or small for gestation age (SGA) strongly predict the subsequent occurrence of hypertension, hyperlipidemia, insulin resistance, type 2 diabetes, and ischemic heart disease, in adult life.

It has been shown that fetuses that are growth retarded during the first trimester of development are three times more likely to be obese as adults. In the case of premature infants, at the age of 4–10 years, these children who had been born prematurely had an increase in their acute insulin response, which compensated for insulin resistance. This decrease in insulin sensitivity may predispose premature infants to type 2 diabetes mellitus in adulthood, as already demonstrated among infants born at term who are SGA [33, 34], that compared with young people from the same region of Finland who are born after a pregnancy, and young people who ranged from 18 to 27 years of age who were preterm infants have become higher in chronic insulin resistance and more prone to glucose and high blood pressure [35]. Preterm births happen on their own early means that some of what would be the third trimester is lost. This is typically a sensitive period for programming and certainly a time during which the final aspects of organogenesis occur. This is explained by spending in the more difficult environment of a hospital setting in which there are many toxic substances as well as nutritional challenges. Now that many more extremely premature babies are surviving to adulthood, ensuring their health is crucial [36]. On the other hand excessive energy supply to the fetus or infant also has adverse consequences so a U shape works similarly at the tow ends of the malnutrition (**Figure 1**).

Maternal hyperglycemia may lead to fetal hyperinsulinemia and fat deposition that influence the fetus. Offspring of obese women or women with diabetes are at greater risk for developing metabolic disorders themselves, even during childhood [37–39].

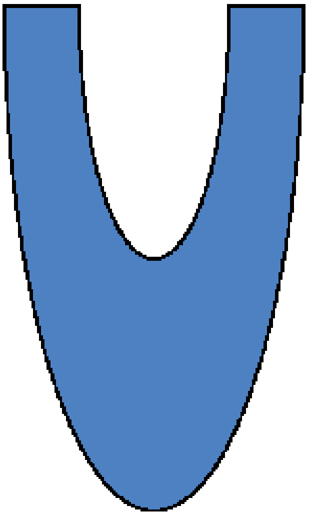

Figure 1.
Excessive energy supply to the fetus or infant also has adverse consequences.

As a consequences, an infant usually has about 5–6 billion fat cells during the third trimester when a mother is pregnant. This number increases during early childhood and puberty, resulting in a healthy adult body possessing 25–30 billion fat cells [40]. Meanwhile, excessive energy supply to the fetus or infant will increase the potential of becoming obese. Babies who depend on milk factory have the highest amount of energy, leading to an increase in body weight than children who were breastfed; it can affect the increase in obesity and its risks later in life [41]. This complicate the long-term effects due to Prenatal and postnatal nutrition during early infancy. In one study, carotid intima-media thickness at 9 years of age in 216 children of European ancestry whose mothers had energy intake in the lowest quartile during early or late pregnancy was higher than that of children whose mothers had intake in the highest quartile, implying that maternal nutrition during pregnancy can affect the subsequent risk of atherogenesis in the offspring [42].

Thus, obesity comes from an increase in the numbers of fat cells, or adipocytes, and is hence due to a shift in the activity of certain genes during development. Because to maternal malnutrition during pregnancy, the offspring later suffering from obesity in the middle of the abdomen and lack of muscle mass, change the sensitivity of insulin, change in hepatic metabolism, decreased number of nephrons, high blood pressure, with a change in appetite regulation, activity level, and control of nerve endocrine glands [42]. There are critical periods in the differentiation and maturation of the tissues and cells involved in organogenesis throughout gestation and early postnatal life. The examples of the kidney, heart, and pancreas were obvious since their functional units are formed prenatally in the human fetus [43].

7. Animal studies

Embryos of pregnant rats fed with a low-protein diet during the preimplantation period (0–4.25 days) show altered development in multiple organ systems; the offspring had reduced birth weights, relatively increased postnatal growth, and adult-onset hypertension [44].

Obviously, the preconception period is particularly sensitive, so that even the required nutrient deficiencies (B12 or folate or methionine) can have an effect on metabolism and blood pressure later in sheep [45]. It has recently been reported that the imbalance in B12 folic acid status and pain during pregnancy contributes to insulin resistance in childhood in humans [46].

Glucocorticoid management to pregnant rats at specific times during pregnancy to cause high blood pressure [47], insulin resistance in offspring later in life [48], changes in gene expression in the developing brain of offspring, and increased sensitivity to stress after the birth have been reported. The administration of glucocorticoids to the pregnant rat at specific points during gestation has been reported to cause hypertension [47], insulin resistance in the offspring in later life [49], alterations in gene expression in the developing brain of the offspring, and increased sensitivity to postnatal stress [50].

In mice, it may lack nutrition during pregnancy to breed showing later the following: visceral obesity, reduced lean body mass, changes in insulin sensitivity, different hepatic metabolism, decreased numbers of nephrons, high blood pressure, and altered endothelial function, together with altered appetite regulation, level of activity, and neuroendocrine control [51–54].

There are critical periods in the differentiation and maturation of the tissues and cells involved in organogenesis throughout gestation and early postnatal life. The examples are seen in the kidney, heart, and pancreas, since their functional units are formed prenatally in the human fetus.

In the kidney, maternal dietary imbalance may lead to developmentally induced deviations from the optimal ratio of body mass to nephron number. This increased risk of inadequate renal function and hypertension in later life [54]. A predisposition to renal failure and a potentially reduced life span are predicted [55]. In the pancreas insulin secretion is also affected. Nutritional stress in pregnant rats reduces the growth of the endocrine pancreas during organogenesis and increases beta-cell apoptosis [55], leading to hyperglycemia and impaired insulin secretion when the offspring become adults. In the adult male rat offspring of mothers on a protein-restricted diet, low birth weight is associated with reduced expression of components of the insulin signal transduction pathway in the skeletal muscle [56]. Similar abnormalities have been reported in infants of low birth weight, and together with the developmentally induced reduction in skeletal muscle mass, these abnormalities might contribute to later insulin resistance.

8. Programming

Developmentally induced epigenetic modifications of DNA are generally stable during the mitotic cell divisions that continue throughout a lifetime. So, developmental plasticity of fetus through cell-cell interaction can be understood as a set of programs. “Programming” is the term used to describe lifelong changes in function that follow a particular event in an earlier period of the life span. Evolutionary plasticity requires a constant modification of genetic expression that appears to be mediated, at least in part, by genetic processes such as epigenetic mechanisms as cells use to control gene expression by virtue of DNA methylation. The role of DNA methylation in gene expression can be found in Phillips [57], and by a histone modification which is a histone protein includes methylation that can impact gene expression [58].

Several studies show that skeletal muscle can be programmed, where early exposure to environmental stimuli leads to a constant change in the skeletal muscle phenotype in later life. This has been demonstrated in mammalian models where reduced nutrient availability during pregnancy weakens muscle fibers, muscle and skeletal formation (white/red fiber ratios), and birth size [59]. Epidemiological studies in human aging groups also suggest that low birth weight and gestational malnutrition are closely related to reduced muscle size, skeletal strength, and aging [59, 60].

This refers to changes in gene expression due to nongenetic structural alterations of DNA and/or histones [58]. So, remember that cell-cell interaction can be transferable in the fetus so memory of active person eventually will be available later in life for the offspring babies [58]. Thus, developmental plasticity requires both the genome and the genetic variability of the environment interactively by the mature phenotype and determines the sensitivity and subsequent environmental factors and the subsequent risk of the disease affects [61]. The effects of maternal nutrition and behavior clearly target the promoter regions of specific genes rather than being associated with global changes in DNA methylation. DNA modulates the rate of transcription to messenger RNA. The phenotypic effects of epigenetic modifications during development may not manifest until later in life [62].

9. Hormones

It plays an important role in childhood growth and continues to have anabolic effects in adults. As the stress hormone, norepinephrine affects the brain’s amygdala, where attention and responses are controlled. It is also based on norepinephrine response to fight or flight, in addition to epinephrine, which raises the heart rate directly, leading to the release of glucose from energy stores and increasing blood flow to the skeletal muscles. It increases the supply of oxygen to the brain [63]. Glucagon is a peptide hormone, produced by alpha cells of the pancreas that raises blood glucose levels. Its main tasks are to increase blood sugar through protein conversion in the liver (gluconeogenesis). Suppress the immune system and help with fat, protein, and carbohydrate metabolism [64]. It also affects the density of the bones negatively, and it is possible to use cortisone in various forms to treat a variety of diseases.

10. Conclusion

The term used to describe lifelong changes in function that follow a particular event in an earlier period of the life span is called programming. Nevertheless, the previous information may have a significance of pediatric obesity endocrine abnormality. GH-IGF-1 axis is partially responsive for the signal to enhance muscle and bone development. Growth hormone (GH) response to exercise may be weak in obesity and may not appear until later in life, especially if they affect genes that are responding to subsequent environmental responses, such as high-fat diet. I do not know how the genetic change instigated development window in the main systems. Exercise is the best way to do this when you exercise regularly, and you build stronger muscles, even if you do not work out with weights. Muscles use more calories than fat throughout the day, even while you are resting. Fat cells of unhealthy obese were larger than those of any other group. It was swollen and full of inflammation. The collapse and filling of their fat stores were disabled and showed a closer look that their mitochondria were not functioning well causing loss of muscle power. This is due to fat cell accumulation which reduces its ability to burn fuel and produce adenosine triphosphate, or ATP, the body's energy currency. It is natural that the behavior of the human being and his attitude of life inert to be aware of the importance of physical activity and live in the healthy lifestyle system in the prenatal stages. Thus, healthy genetic modification will be inherited for future generations.

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Chapter 4

Cardiorespiratory Fitness and Intellectual Disability

Vojtěch Grün, Marta Gimunová and Hana Válková

Abstract

This study discusses the heart rate (HR) in people with intellectual disability (ID) comparing the resting HR and HR after 2 minutes of exercise of athletes participating in Special Olympics (SO) in table tennis (TT) and cross-country (XC) skiing (XC skiing, 50 m, 1 km, and 3 km). The results showed a similar increase between the resting HR and HR after 2 minutes of exercise for TT players and XC skiers competing in 3 km race. Changes in HR in XC skiers competing in 50 m and 1 km races between the rest and exercise were noticeably higher indicating their lower fitness. Future studies focused on the relationship of HR variables, and training quality will provide a more detailed knowledge of the cardiorespiratory fitness and ID relationship.

Keywords: intellectual disability, cardiovascular fitness, cross-country skiing, table-tennis

1. Introduction

1.1 Intellectual disability

Approximately 200 million people, 1–3% of the global population, have an intellectual disability (ID) characterized by difficulties in learning and adapting to new environments. According to the American Association of Intellectual and Developmental Disabilities, ID is a condition characterized by IQ below 70–75 points, significant limitations in two or more adaptive areas such as communication or self-care, and manifests before the age of 18 [1].

Adults with ID are at increased risk of health decline associated with aging, low physical fitness, and related chronic diseases [2]. People with ID are not a homogeneous group as in many cases ID is not associated with a known biological etiology [3]. Some causes of ID happen before the delivery or soon after the birth due to genetic conditions, pregnancy complications, or toxic exposure, e.g., Down syndrome, fetal alcohol syndrome, fragile X syndrome, birth defects, and infections; other causes happen when the child is older, and these causes include severe head injuries, infections, or stroke [4].

In previous studies similar lifestyles were observed in persons with ID. Among the ID population, levels of smoking and regular alcohol intake are low compared to general population. Nevertheless, also the adherence to physical activity and healthy diet is poor [2, 5–8]. In sports, ID reduces the capacity to learn tactical concepts and to make correct decisions in constantly changing sport context. Besides, technical ability was found to be negatively correlated with the level of ID as technical skills are dependent on cognitive processes such as information processing, visualization, and memory capacity [9]. Furthermore, the levels of physical activity among ID population are usually insufficient to achieve health benefits [3]. Previous studies on physical activity interventions show significant improvement in coronary heart disease risk factors after 12-week physical activity intervention [7], and the engagement in physical activity has been observed to improve also the social and general life competences needed for community inclusion [10, 11]. However, several barriers to engage physical activity such as lack of resources, limited options, or transportation constrain have been recognized [12].

2. Special Olympics

> *"Let me win. But if I cannot win, let me be brave in the attempt."*
> *(Special Olympics Athletes Oath)*

Special Olympics (SO), the world's largest sport organization for both children and adults with ID, included in word Olympic network, holds many sport events every year at both national and world levels and provides all year-round sport training for a continuous physical fitness development. SO offers more than 30 individual and team sports and gives people with ID a chance to discover new strength, abilities, skills, social inclusion, and success through sports [13].

The worldwide SO movement was started in the 1950s in the USA, when Eunice Kennedy Shriver held a summer day camp for young people with ID and recognized that through sports, people with ID can develop their mental and adaptive capacities. In 1968 the first SO competition was held, and the abilities of athletes with ID were highlighted instead of their disabilities to create the atmosphere for acceptance and inclusion for all people. Nowadays, SO includes 5 million athletes from more than 170 countries [14]. In the Czech Republic, approximately 3000 athletes participate in trainings and competitions within the Czech Special Olympics Movement. SO sport program includes athletes with ID below 75 IQ points, including athletes with Down syndrome, cerebral palsy, and perception impairment. Therefore, various sports or events with a differently demanding relation to sports are available, e.g., cross-country skiing 50 m or 3 km race, table tennis (TT), and bowling. Coaches or parents are responsible for appropriate choice of sport event according to the level of athlete executive functions, healthy status, athlete interest, and external environment. Coaches or parents are also responsible for regular training and motivation to compete with maximum effort and fair play behavior. The competitions are based on the principle of relativity, when athletes compete in groups depending on their actual abilities and limitations [15].

Additional programs of SO are oriented on families, independent behavior of the athletes, public awareness, education, research, and Healthy Athletes program including, e.g., FUNfitness, FitFeet, or Health Promotion screening [13, 16, 17]. Healthy Athletes program was started in 1997 and offers a free health screenings and healthy lifestyle education to SO athletes in a welcoming and fun environment including the area of podiatry, physical therapy, audiology, vision, dentistry, emotional well-being, sport physical exam, and better health and well-being. The aim of this program is to improve the access to health service for people with ID [18].

Benefits of physical activities for athletes with ID are similar to those for general population: (1) improved physical factors, e.g., aerobic capacity, gross motor function, balance, and muscle strength; (2) improved psychological factors, e.g., self-concept, self-esteem, satisfaction, quality of life, and reduced aggression; and (3) improved social factors, e.g., social competence, popularity, and parent satisfaction [19].

3. Heart rate in people with ID

Heart rate (HR), expressed by a number of cardiac cycles per minute, is a commonly used indicator of intensity, cardiorespiratory fitness, and sympathetic activation in sports and exercise. The long-term endurance training should lead to a reduced resting HR [20]. Furthermore, individuals with Down syndrome exhibit reduced peak HR, and in severe and profound ID, HR can be used to assess the information about emotions as a lower HR in the first 6 seconds of stimulus presentation was observed when presenting a negative stimulus [21, 22].

3.1 Table tennis in SO

Table tennis is a complex and demanding game with many technical and tactical aspects. This game has specific requirements on attention, visual perception, executive functions, learning, and adaptation skills of the athlete [23, 24]. Eye-hand coordination and knowledge of tactics, e.g., appropriate stroke for the situation, are needed. Besides, top TT players study their opponents to attack their opponents' weakness to win [9, 24]. The aim in the TT in Special Olympics is to improve eye-hand coordination and quickness [13].

TT is characterized by short-term maximal efforts with passive resting intervals. The intensity during the game depends on the level and type of player (attacker-defender), gender, and age [25]. During the match in TT professional players, HR reaches the 90.3% of the players' maximal HR [26].

3.2 Cross-country skiing in SO

In SO cross-country skiing athletes with ID propel themselves across snow-covered terrain using skis and poles, and the distance differs from 50 m XC skiing race classical technique up to 10 km XC skiing race according to each athlete's skills [27]. Fifty and 100 m events are held on a flat terrain; 500 m to 10 km race respects the terrain plasticity (uphill, downhill, flat, and curves) [28].

During XC skiing HR values were described to depend on the terrain (uphill, downhill, flat section) [29], and during the race, the average HR of professional XC skiers is approximately 90% of the maximal HR [20].

4. Aim

The purpose of this study was to evaluate the difference between resting HR and HR after 2 minutes of exercise and to compare the cardiovascular fitness between table tennis players and in XC skiers with ID competing in 50 m, 1 km, and 3 km races.

5. Methods

Ten TT players (six males, 27 years of age; four females, 29.5 years of age; described in [30]) participated in the heart rate screening at the Czech National Table Tennis Tournament in 2015. Their pre-match HR was measured 1 minute before

		50 m XC skiing	1 km XC skiing	3 km XC skiing	TT
Male	n	11	20	8	6
	BMI	25.2	24.2	24.9	23.81
Female	n	5	8	2	4
	BMI	27.5	25.1	24.04	30.00

Table 1.
The number of female and male participants in each group and their BMI.

the match, and match HR was measured after 2 minutes of the play by sporttester Forerunner® 15, Garmin Ltd. Two matches of each participant were analyzed.

Fifty-four XC skiers (30.79 years of age; 15 females, 30.78 years of age; described in [15]) were measured during the Czech National Winter Games in 2015. Their resting HR was measured immediately before the exercise, and the exercise HR was measured after a 2-minute long step test by tonometer Omron M3.

The data collection was provided by the Healthy Athletes Clinical Directors and trained volunteers. All participants were in the spectrum of moderate levels of intellectual disability (below 70 points of IQ) and practiced the sports for at least 1 year as according to the Special Olympics rules participants of the national SO games have to pass minimum 1 year training before the competition. Their characteristics are shown in **Table 1**. The informed consent with Healthy Athletes noninvasive screenings is provided by athletes and their caregivers prior the sport events. The athletes with ID liked to participate in Healthy Athletes screening as the HR measurement was a new attraction for them.

6. Results

Resting HR, i.e., HR before the first and second match in TT (resting HR1 TT, resting HR2 TT) and before the step test in XC skiers, is shown in **Figure 1** and **Table 2**. As shown in **Figure 2**, the difference in resting HR between TT players and XC skiers competing at 1 km and 3 km race is slight. Only in the case of XC skiers competing in 50 m race, resting HR was noticeably lower than the other athletes. In

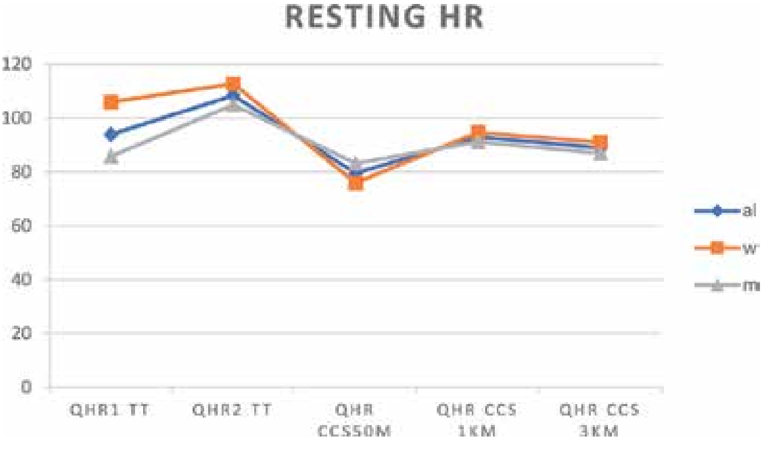

Figure 1.
The comparison of resting heart rate between XC skiers and the first and second match in TT players.

	Resting HR1 TT	Resting HR2 TT	Resting HR XC skiing (50 m)	Resting HR XC skiing (1 km)	Resting HR XC skiing (3 km)
Female + male	93.9	108.4	79.6	93.0	89.0
Female	106.0	112.8	76.0	94.7	91.0
Male	85.8	105.0	83.2	91.2	87.0

Table 2.
Resting HR in TT players and XC skiers.

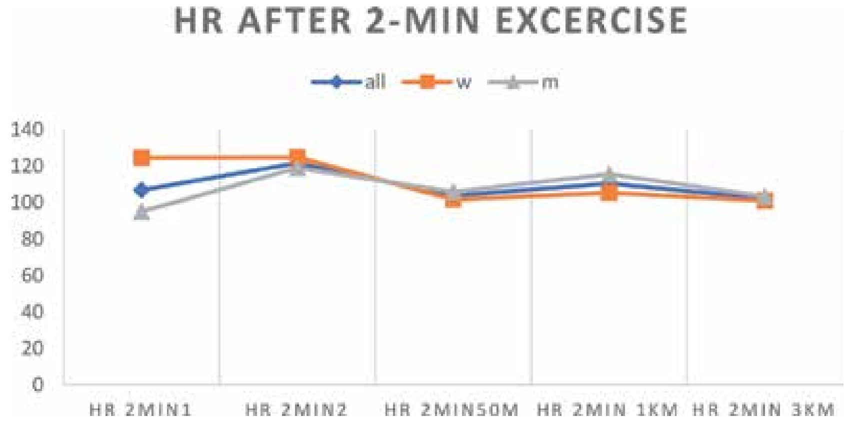

Figure 2.
The comparison of HR after 2 minutes of exercise between XC skiers and the first and second match in TT players.

	HR 2 min1	HR 2 min2	HR 2 min (50 m)	HR 2 min (1 km)	HR 2 min (3 km)
Female + male	106.8	121.6	103.7	110.4	102.2
Female	124.5	124.8	101.6	105.3	101.0
Male	95.0	119.0	105.8	115.5	103.3

Table 3.
HR after 2 minute of exercise in TT players and XC skiers.

the gender comparison, female participants had on average a higher HR than males, with the exception of XC skiers competing in 50 m race.

When comparing HR after 2 minutes of exercise, the values are similar for all sport groups. An interesting finding for HR after 2 minutes of exercise was observed in male TT players whose HR after 2 minutes of exercise differed noticeably between the first and second analyzed match, the difference consisted of 26 beats per minute. In female TT players, no difference in the HR after 2 minutes of exercise was observed between the matches. Additionally, in TT a significant difference between female and male players in HR after 2 minutes of exercise was observed, whereas XC skiers had HR very similar in both men and women depending on the distance they specialized. The values and differences are shown in **Table 3** and **Figure 2**.

The difference between the resting HR and HR after a 2-minute exercise was the most distinctive in XC skiers competing in 50 m race, for both men (23.6 beats per

	Dif TT1	Dif TT2	Dif Cross-country skiing (50 m)	Dif Cross-country skiing (1 km)	Dif Cross-country skiing (3 km)
Female + male	12.9	13.1	23.1	17.4	13.2
Female	18.5	12.0	25.6	10.6	10.0
Male	9.2	14.0	23.6	24.3	16.3

Table 4.
The average difference between the resting HR and HR after 2 minutes of exercise.

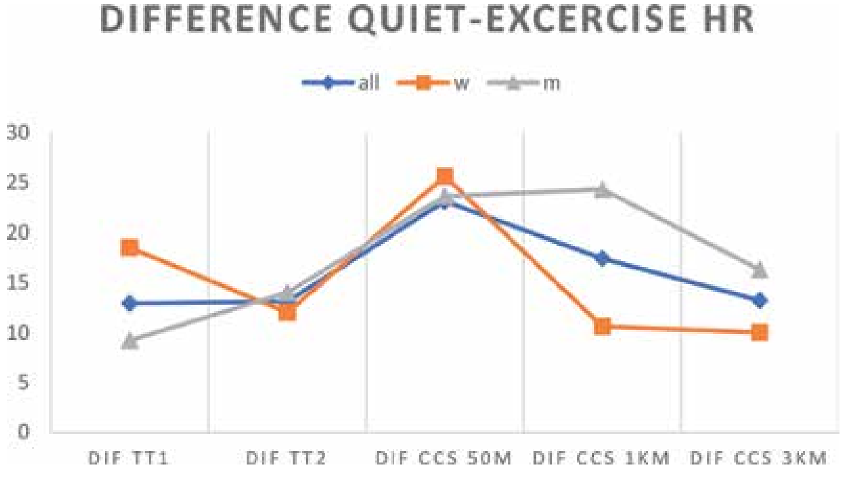

Figure 3.
The average difference between the resting HR and HR after 2 minutes of exercise in male and female TT players and XC skiers.

minute) and women (25.6 beats per minute). Nevertheless, also in male 1 km XC skiers, HR increased by more than 20 beats per minute (24.3) on average. Greater increase in HR after exercise may indicate a lower aerobic fitness in aforementioned athletes. The difference between the resting HR and HR after 2 minutes of exercise is shown in **Table 4** and **Figure 3**.

7. Discussion

This study discusses the HR in people with ID comparing the resting HR and HR after 2 minutes of exercise of athletes participating in SO in two different sports. Table tennis and cross-country skiing at different distances (50 m, 1 km, and 3 km) were compared. Results of this study show increase in HR after 2 minutes of exercise in all compared groups. Furthermore, resting HR was increased before the second match in TT player compared to resting HR before the first match, probably associated with fatigue from the previous match or with the prestart condition and their prestart readiness during the tournament. However, future studies are needed to evaluate the prestart conditions in athletes with ID.

The heart rate changes with every heartbeat and its increase may be observed in a stressful situation. As a stressful situation, we can consider mental and physical strain or fatigue. In case of athletes, physical exercise is associated with psychological pressure, and HR therefore may vary considerably in each individual. This applies both to healthy people and to people with ID. Sperlich et al. focused on monitoring metabolic and cardiorespiratory parameters during training and matches of adolescent elite table tennis players, and their results showed that the average HR during the match is approximately 126 beats per minute [31]. Compared with our measured results, elite adolescent TT players have an average HR higher than TT players competing in SO (107 beats per minute). In elite adult TT players during national and international tournaments, the HR reaches 164 beats per minute [32], differing greatly from values observed in our study in athletes with ID whose TT skills are limited.

If we compare the difference between the resting HR and HR after 2 minutes of exercise, the results show a similar increase for TT players and XC skiers competing in 3 km race. Changes in HR in XC skiers competing in 50 m and 1 km races between the rest and exercise were noticeably higher. This observation may be caused by the fact that athletes with a severe mental handicap compete in shorter distances, whereas both TT and 3 km race require advanced cognitive skills to manage the required technique (up and down terrain in XC skiing, eye-hand-ball coordination in TT) and maintain the intrinsic motivation for a longer time. Additional aspect may be the training—better trained individuals shows lower HR during the submaximal load; however the training of athletes with severe ID, who compete in shorter XC skiing distances, may not create a sufficient training load as the lower level of fitness performance was observed in athletes competing in short XC skiing distances in the previous study [15].

At the same time, people with mental disabilities are more likely to be overweight or obese compared to the general population [33, 34]. Also, in our participants, BMI of female skiers competing in 50 m and 1 km race indicates the overweight; in TT players the BMI shows class I obesity. In males, the overweight was observed in XC skiers competing in 50 m race. Female sex was observed to be a risk factor for obesity in both general population and in population with ID also in previous studies [5, 35–37].

8. Conclusion

This study discusses the HR in people with ID comparing the resting HR and HR after 2 minutes of exercise of athletes participating in SO in table tennis and cross-country skiing (50 m, 1 km, and 3 km). The results showed a similar increase between the resting HR and HR after 2 minutes of exercise for TT players and XC skiers competing in 3 km race. Changes in HR and in XC skiers competing in 50 m and 1 km races between the rest and exercise were noticeably higher indicating their lower fitness. Additionally, the high prevalence of overweight and obesity highlights the need for healthy lifestyle education in athletes with ID, especially in 50 m XC skiers. Despite the limitation of this study consisting of a small number of participants, the results highlight the coach's responsibility to select appropriate event according to the athlete's abilities and limits, but a more demanding training should be necessary. Future studies focused on the relationship of HR variables and training quality will provide a more detailed knowledge of the cardiorespiratory fitness and ID relationship.

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Chapter 5

Relation between Lifestyle and Body Composition among Young Females in Serbia of 18–29 Years of Age

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Abstract

The aim of this study is to determine if certain lifestyle and habits influence the characteristics of body composition among young females in Serbia. The research included 248 randomly chosen females between 18 and 29 years of age. Data about physical activity were collected via validated questionnaire. In determining body composition, we relied on the instrument InBody 720, which enabled us to define the variables: body height (BH), body weight (BW), body fat mass percentage (BFM%), skeletal muscle mass percentage (SMM%), and visceral fat (VFA). In addition, we determined variables indexed for body height (BMI, FFMI, and FMI). On the basis of the results of regression analysis, we selected a mathematical model with the highest degree of prediction for body composition (BSC) = −64.554 + (0.092 × BW) + (−0.107 × BMI) + (−1.001 × FMI) + (1.353 × SMM%) + (−0.626 × BFM%) + (−0.079 × VFA) + (4.894 × FFMI). Our correspondents had normal BMI, above average % BFM, VFA—50.8 cm^2, FFMI in the range of normal and high and normal FMI. The score of physical activity (LSS) stood at the moderate level (9.29 ± 3.72). LSS statistically correlated significantly with all tested variables of body composition, except with BW. The highest degree of correlation has been between LSS in relation to BFM% and SMM% (−0.408 and 0.461, respectively).

Keywords: mathematical model, point score, questions, linear regression, index indicators

1. Introduction

Modern humans usually spend their free time with technical devices (car, computer, smartphone, remote controller, etc.) or passive entertainment such as watching television, surfing the Internet, all of which moves them away from daily activities requiring movement. Thereby, people progressively lose the need to move at all and be physically active. Be it workplace, fun or rest, contemporary humans, therefore, spend most of their time in an unhealthy environment. Such way of sedentary lifestyle faces each person with a number of risk factors, above all with hypokinetisia [1]. It has been determined that most non-infectious diseases have prevalence at either high level or constantly rising. Despite a growing advancement in the last 30 years, coronary diseases, or more precisely coronary artery disease, remains the number one cause of death in Serbia, equally present among both males and females alike [2, 3]. The lack of physical activity has been recognized as one of the main causes of these diseases, and is considered as the primary risk factor, alongside with smoking, high cholesterol, and high blood pressure (hypertension) [4].

Obesity figures as one of—if not the—consequence of such lifestyle/insufficient physical activity that represents a well-known cause of early death [5], hypertension, coronary heart disease, lower quality of life and sleeping problems [6], and the World Health Organization rightfully deals with it as a global epidemic [7]. Therefore, obesity has become one of the biggest public health problems in the world [8] and it could develop into the leading public health problem in this century [9]. Since obesity can be defined as an excessive body fat content, and overweight as an excess of body mass relative to height [10], it can be closely related to the estimation of body composition which is very important not only for the determination of nutritional status in health conditions and in disease [11], but also in various fields such as nutrition, medicine, and sports sciences [12, 13].

1.1 Contemporary lifestyle

The lifestyle of certain population groups, especially of young people, can lead to eating habits and insufficient physical activity that behave as risk factors in chronic diseases [14]. Modern societies then become characterized by the inactivity and sedentary lifestyle [15], which in turn gets reflected in the greatest amount of body fat, overweight, and obesity among the population, which are associated with a higher degree of risk of adverse health events and higher mortality [16, 17]. Young adults from 18 to 30 years of age are often in transition, graduating from high school, going to college, starting a new job, getting married, and forming a family. Often, these transitions are accompanied by potentially detrimental changes in lifestyle such as decreased physical activity, poor eating habits, increased alcohol consumption, and other unfavorable risk behaviors [18–20]. Nutrition and physical activity are of the utmost importance for health promotion. Eating habits and attitudes toward physical activity shape the lifestyle of an individual to the greatest extent, thus determining health, that is, the most common diseases of a modern man [21]. Regular physical activity has many health benefits for adults [22, 23]. But, surveillance data indicate that there is an age-related decline in physical activity and that females are less active than males [23, 24]. Only 16% of female participants of the National Health Interview Survey (NHIS) aged between 18 and 29 reported an adequate amount of vigorous physical activity [23]. Longitudinal data from young adults further attests to the decline in physical activity in this age group [25, 26]. A significant drop in physical activity and increased sedentary habits largely influence the relation between body composition factors.

1.2 Body composition

Body composition is the term that defines the phenomenon of the biological-material composition of the body, that is, the set of substances that constitute the materially manifest structure of the human body [27]. The macro-level composition of the human body is represented by four biologically measurable segments of matter:

- water, as liquid;
- the fat component, as the basic reserve of energy;
- the mineral component, as the solid body component; and,

- the protein component, as the basis for the contractile component responsible for locomotion, that is, movement [28].

In addition to these basic components of body composition, index indicators can be defined with the task of determining the relation between individual elements or even segmented relations between the same elements.

In existing research, the BMI has been presented as one of the crucial and basic parameters of obesity. The BMI presents the ratio of body high and body weight and is the simplest and most commonly used measure for determining body state of observed population and samples. Even though the BMI does not allow a detailed insight into the state and mutual relations of structural components such as the overall amount of fat or the distribution of fat in particular segments of the body, which can vary significantly within a normal values of body mass index [29], it has been shown that the values of this index had great influence on inflammatory and lipid markers (cardiovascular biomarkers) in a research that included a large number of women [30]. On the basis of results published by the Serbian Institute for Public Health, adult population in Serbia is among the highest worldwide by the number of persons and deaths from heart and blood vessels conditions, metabolic and malignant diseases, etc. [31, 32].

Owing to technological advancements, it is nowadays simple, fast, reliable, reproducible, and non-invasive to systematically follow morphological characteristic. Various methods are available to estimate or directly measure body composition. Measuring body composition with electric multichannel bioimpedance is a new generation technology that enables the direct measurement of the basic components of body composition. In addition to that, InBody 720 provides valid data in the simplest and non-invasive manner [27, 33].

Body fat, that is, the percentage of body fat, is the only component of body composition that has the tendency of increasing almost through entire lifespan [34, 35]. In addition to the biological influences related to aging [36], the change of the lifestyle of modern humans (reduced physical activity and increased energy intake) have caused an enormous increase of body fat to be one of the basic determinants of health or illness. As Gába et al. argue [37], the prevention of excessive gain in body mass-fat has become a public health priority in the developed countries, and in Serbia alike [38]. In contrast, the reduced muscle components of body composition are inevitable side effects of aging, whereby body mass remains the same or increases on the expense of fat [34, 39].

Besides the basic elements gained through a direct measurement of body composition, such as body fat, muscle mass, a very important scientific and medical role belongs to index indicators like muscle mass index and fat tissue index (SMM, FFMI, or FMI) [40].

Following the changes of body composition with different age groups is important not only for controlling the current status, but also for determining the trends of changes of the overall mass or particular parts of the given structure. At present, there is an increasing importance and need to systematically follow relevant indicators of body composition of sportspersons, persons exercising for recreational purposes or persons who do not exercise alike [41–43].

The aim of this article is to determine the influence of lifestyle and living habits to the characteristics of body composition among young females in Serbia. It is well-known that the habits one acquires from childhood to early adulthood are very important, since they present a fundamental personal foundation for a lifestyle one has in adulthood and maturity. Thus, this particular age group is a turning point for the final adoption of healthy or unhealthy life habits. Our secondary aim is defining a multidimensional model of dependence between body composition, lifestyle, and nutrition, which would enable programming of optimal patterns of behavior in both spaces, as a planned corrective measure.

2. Methodology

2.1 Subject samples

This research included 248 females aged 18–29. The group comprised professionals, students of the University of Belgrade, and secondary school students. The average age of young females was 24.40 ± 3.34 years. The research was conducted in accordance with the "Declaration of Helsinki for recommendations guiding physicians in biomedical research involving human subjects" [44] and with the permission of the Ethics Committee of the Faculty of Sport and Physical Education, University of Belgrade. Each subject was well informed about the purpose of the study, and all invitees agreed to participate.

2.2 Body composition measuring method

Body composition measurement was done by multisegmental bioelectrical impedance analysis (BIA). We relied on a professional measurement equipment—In Body 720 Tetrapolar 8-Point Tactile Electrode System (Biospace, Co., Ltd.) and DSM-BIA method (direct segmental multi-frequency bioelectrical impedance analysis). BIA is a widely used standard method for determining whole body composition and segmental lean mass measurements. InBody [45] body composition analyzer has high test-pretest reliability and accuracy (ICC 0.9995) [46]. Compared with DXA as a golden standard, the interclass correlation coefficient of BIA was between 0.96 and 0.99 in the normal-weight population [47]. All measurement had been performed between 2013 and 2016, in the morning hours. The procedure and course of analysis have been described in previous studies [33, 48].

2.3 Variables

We used a validated questionnaire [49] in order to collect data about lifestyle, living habits, and physical activity of young females. The participants were given five questions about their physical activity, with four close-ended answers to each question. Each response was validated from 0 to 3, which thus gave the maximum total score of 15. The higher scores indicated healthier behavior.

Questions:

- **do you exercise?** (0—never; 1—occasionally, 2—only seasonally; 3—regularly)
- **how often?** (0—never; 1—1–2 h per week, 2—3–4 h per week; 3—more than 4 h per week)
- **how do you spend your free time?** (0—watching TV, listening to music, using computer, reading books; 1—shopping, 2—walking; 3—practicing sport)
- **how much time do you spend behind a computer?** (0—over 6 h per day; 1—5–6 h per day, 2—2–4 h per day; 3—1–2 h per day)
- **how would you describe your daily lifestyle?** (0—too sedentary; 1—sedentary, 2—moderately active; 3—very active)

Body composition variables:

- **BH—body height**, expressed in cm;
- **BW—body weight**, expressed in kg;
- **BMI—body mass index**, expressed in kg/m^2;
- **BFM%—body fat mass percentage,** calculated as: (BW/BFM) × 100, expressed in %;
- **SMM%—skeletal muscle mass percentage**, calculated as: (BW/SMM) × 100, expressed in %;
- **VFA—visceral fat area**, expressed in cm^2;

Index:

- **FFMI—fat-free mass index**, presented as fat-free mass (FFM) relative to body size, calculated as: FFM/BH^2, expressed in kg/m^2;
- **FMI—fat-mass index**, presented as Body Fat Mass (BFM) relative to body weight, calculated as: BFM/BH^2, expressed in kg/m^2;

Point score:

- **BCS—body composition score**, a mathematical model with the highest degree of prediction has been selected on the basis of regression analysis (a more detailed description has been provided in Section 3);
- **LSS—lifestyle score**, representing the sum of points scored on the basis of the five questions, with the maximal sum of 15.

2.4 Statistical analyses

Basic descriptive statistical parameters were calculated for all results in order to define the basic measures of central tendency and level of data's dispersion (mean, SD, cV%, min, max, 95% confidence interval). The criteria variable for assessing multivariate body composition score was calculated by using factorial analysis and following statistical procedures. The relation between lifestyle and body composition variables has been determined by the Pearson's probability coefficient. The threshold of statistically significant statistical difference stood at 95% probability level, $p = 0.05$. All statistical procedures were carried out by the Microsoft® Office Excel 2007 and the SPSS for Windows, Release 17.0 (Copyright © SPSS Inc., 1989–2002).

3. Results

3.1 Results of descriptive statistics among young females

Table 1 provides the results of descriptive statistics of body composition.

Figure 1. provides the distribution of results of the correspondents' responses in relation to physical activities habits.

	Mean ± SD	%cV	Min.	Max.	95% confidence interval for mean	
					Lower bound	Upper bound
BH	169.89 ± 6.95	4.09	151.70	193.70	169.020	170.759
BW	64.44 ± 11.74	18.23	44.60	143.70	62.969	65.906
BMI	22.42 ± 4.00	17.85	17.40	48.63	21.922	22.924
BFM%	24.14 ± 8.69	36.00	5.90	55.28	23.057	25.231
SMM%	41.11 ± 4.58	11.13	24.80	50.70	40.555	41.700
VFA	51.83 ± 32.09	61.91	11.80	254.50	47.817	55.844
FFMI	16.45 ± 1.35	8.24	12.63	22.23	16.276	16.615
FMI	5.87 ± 3.28	55.91	1.93	26.40	5.463	6.284
LSS	9.29 ± 3.72	40.05	0	15	8.821	9.751
BCS	50.00 ± 16.67	33.33	−5.10	84.30	47.914	52.083

BH—body height; BW—body weight; BMI—body mass index; BFM—body fat mass; BFM%—body fat mass percentage; SMM—skeletal muscle mass; SMM%—skeletal muscle mass percentage; VFA—visceral fat area; FFMI—fat-free mass index; FMI—fat-mass index; LSS—lifestyle score; BCS—body composition score.

Table 1.
Basic descriptive indicators of body composition among young females.

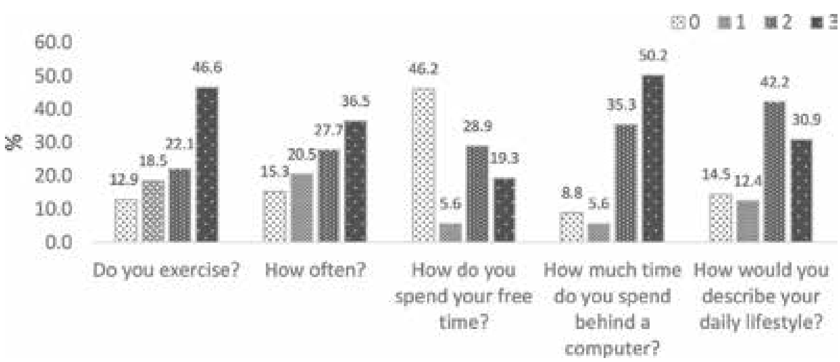

Figure 1.
Percentage of the responses given to each question from the questionnaire.

3.2 Results of regressive analysis among young females

On the basis of results gathered via multidimensional modeling and regressive analysis, we selected a mathematical model with the highest degree of prediction of the optimal model of our correspondents' body composition. Within this model, *body composition score* (*BCS*) presents a criterion variable, while body composition variables (BW, BMI, FMI, SMM%, BFM%, VFA, FFMI) present the most discriminative variable of body composition that makes up a predictive part of the defined model.

Body composition score has been given quantitatively, that is, by a numerical value calculated in the following way: all body composition variables applied here were subjected to the factorial analysis, and on that basis a reduced set of singular variables that statistically best describe correspondents' body composition has been selected. For each correspondent, BCS has been selected on the basis of specification equation that has the following form:

$$\text{Body composition score (BCS)} = -64.554 + (0.092 \times \text{BW}) + (-0.107 \times \text{BMI}) + (-1.001 \times \text{FMI}) + (1.353 \times \text{SMM\%}) + (-0.626 \times \text{BFM\%}) + (-0.079 \times \text{VFA}) + (4.894 \times \text{FFMI}). \quad (1)$$

3.3 Results of correlation analysis among young females

Table 2 presents the results of Pearson's coefficient of correlation between lifestyle in relation to body composition among young females.

Statistically, most prominent correlations were found between lifestyle score and body composition score (r = 0.505, $p < 0.01$), while the highest negative statistically relevant correlation was between the body fat mass percentage and lifestyle score (r = 0.408**).

Figure 2 presents the relation between body composition score and lifestyle score, which is explained by applying the method of mathematical modeling. The change of trend of relation between body composition score and lifestyle score has been defined by the following ratio:

- $y = 2.26x + 28.99$

In relation to the model body composition score, we could claim that the intercept stood at 28.99, while the trend of change (curve inclination) was defined by the coefficient of regressive constant of 2.26. In other words, this means that the increase of lifestyle score by 1 point led to the increase in the value of body composition score by 2.26 points on average, that is, to its rise for as much as 2.3%.

On the basis of the value of determination coefficient (R^2 = 0.255), we conclude that 25.5% of the overall variability of body composition score results was determined by lifestyle score, that is, by the variability of an independent variable. The rest of variability of 74.5% has not been explained by the regression model, that is, it is influenced by other factors.

	Do you exercise?	How often?	How do you spend your free time?	How much time do you spend behind a computer?	How would you describe your daily lifestyle?	Lifestyle score
BW	−0.131*	−0.121	−0.071	−0.046	−0.117	−0.139*
BMI	−0.159*	−0.151*	−0.091	−0.036	**−0.208****	**−0.184****
BFM%	**−0.311****	**−0.322****	**−0.209****	**−0.204****	**−0.395****	**−0.408****
SMM%	**0.353****	**0.378****	**0.252****	**0.188****	**0.451****	**0.461****
VFA	**−0.222****	**−0.243****	−0.136*	−0.082	**−0.306****	**−0.281****
FFMI	0.144*	**0.207****	0.163*	**0.164****	**0.174****	**0.242****
FMI	**−0.264****	**−0.277****	**−0.180****	−0.115	**−0.324****	**−0.331****
BCS	**0.371****	**0.416****	**0.281****	**0.235****	**0.474****	**0.505****

BW—body weight; BMI—body mass index; BFM%—body fat mass percentage; SMM%—skeletal muscle mass percentage; VFA—visceral fat area; FFMI—fat-free mass index; FMI—fat-mass index; BCS—body composition score.
*p < *0.05.*
**p < *0.01.*

Table 2.
Correlation between lifestyle and body composition among young females.

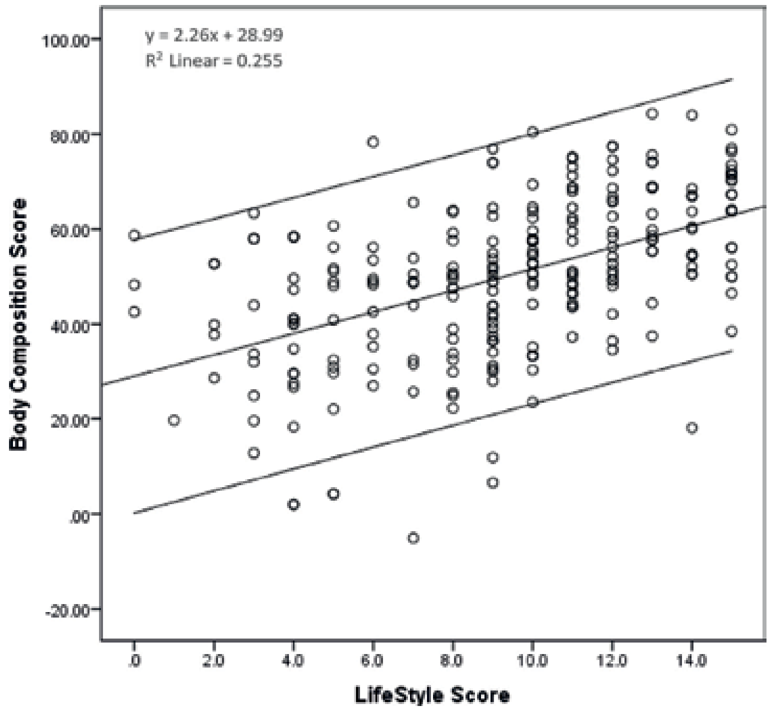

Figure 2.
Linear regression of body composition and lifestyle scores.

4. Discussion

Within this study, we aimed to explore the relationship between physical activity and body composition among young females. The results showed expected correlation. Specifically, most results (SMM%, BFM%, VFA, FMI, FFMI) showed statistically relevant correlation ($p > 0.001$) with lifestyle variables, with lifestyle score being a somewhat stronger predictor in comparison to other variables.

This cross sectional study determined the existence of correlation between physical activity and certain parameters of body composition, as well as of the constructed mathematical model of body composition score for young women.

Our correspondents had normal (some say optimal) weight according to BMI (22.42 kg/m^2). A large scale sample (n = 1023) of female students of the University of Belgrade aged 21.3 years on average, average BMI was 20.7 kg/m^2 [50]. This difference could be explained by the fact that our correspondence are not only older by 3 years on average, but also by the fact that our sample includes working women, women who gave birth in addition to students, which can influence their health habits related to physical activity, nutrition, etc.

According to cutoffs % fat Heyward [51], young women from our research belong to the category of above average fat occurrence, which is unfavorable considering the likely increase in body fat during aging, especially related to the menopause [52]. Gába and Přidalová [53] applied the same method of measuring body composition among Czech women of the same age group (18–30 years). The correspondents had lower values of all variables that have fat component, that is, BM, BMI, %BFM, and VFA. There is a clear correlation between excess body fat, which is a basic characteristic of obesity and increased mortality among different ethnic groups around the world. Yet, it is clinically relevant that obesity is heterogeneous, and there are individual differences in regional fat distribution, especially in visceral adipose tissue [54]. There is a strong relation among visceral fats, metabolic syndrome, and the most common chronic non-infectious diseases of contemporary humans [55]. Enzi et al. [56] found that among lean or obese young women, subcutaneous abdominal fat dominates in relation to abdominal visceral fat, both measured by CT at the upper renal pole. There are no clearly defined standards for the visceral fat content. According to the measuring technique applied here, a VFA of 100 cm^2 [45] is considered as a risk, but this needs to be taken with caution as further studies are needed. Among our correspondents, the average value was 51.83 ± 32.09 cm^2, while it was lover by 10 cm^2 in the study of Gába and Přidalová [53].

Fat-free mass index is the indicator indexed according to the body height (FFMI —kg/m^2) and is considered as not only a good indicator of the body composition of healthy, but also ill persons [57]. FFMI retains stable values among young and middle-aged women and men, and then drops after 74 years of age. Average FFMI value of our correspondents (16.45 ± 1.35 kg/m^2) corresponded to the values obtained by the research of Kyle et al. [57] (14.6 and 16.8 kg/m^2) and belonged to the category of normal and high values. According to the these authors, BMI increase that comes with aging has been complemented with the increase in BF and FFM, and thereby with FFMI.

Fat-mass index (FMI) is significantly higher among sedentary than physically active men than women, and the difference rises with age [57]. Average FMI value of our correspondents (5.87 ± 3.28 kg/m^2) corresponded to the values obtained by the research of Kyle et al. [57] (3.9–8.1 kg/m^2) and belong to the category of normal.

4.1 Lifestyle

Out of the maximum score of 15 for physical activity, our correspondents had 9.29 ± 3.72, which can be considered to be a moderate activity. Close to 50% of them said to be active over 4 h per week, which could be said to correspond to the recommendation of 30 min of exercising each day [58]. Still, only a third has been continuously active throughout the year, which is near to the percentage of those who described their lifestyle as very active. Half of the correspondents spend their free time in sedentary activities (using the phone, computer, watching TV, reading and the like).

With regard to the mathematical model, the results of the combined influences of individual variables of body composition showed that FFMI and SMM% (4.894 vs. 1.353) had the greatest influence on the point score of body composition, while BW = 0.092 had the lowest influence (please see the formula). Apparently, taken overall variability of the point score, the most influential to the optimal model of body composition were those variables that define fat-free muscle mass dependent on longitudinality (FFMI), or the percentage of muscle tissue in the organism independent of voluminosity (SMM%). As both cases apply to contractile components, that is, body components most responsible for motorical quality, that is, movement, the results clearly showed that fat-free body structure was the most sensitive body component for defining the optimal body composition within the defined optimal body model among young females from the investigated sample. In addition, the two abovementioned most sensitive variables of the model are body components that are directly developed by physical activity, regardless of that activity being endurance training or resistance or weight training. Thereby, it has been directly shown that young females were no different in relation to the occurrence of body fat in the body—as a variable directly linked to diet and sedentary lifestyle, but dominantly differed by the occurrence of contractile component—as a variable directly dependent of the amount of physical activity or exercising.

4.2 Correlation between lifestyle score and body composition score

Lifestyle score (LSS) in this research statically significantly correlated with all the tested variables of body composition, as well as with the calculated score of body composition (BCS), except with weight (**Table 2** and **Figure 2**). The correlation coefficient was the highest between LSS and BFM%, SMM%, and BCS ($r = -0.408$, 0.461, and 0.505, respectively, **Table 2**). The vast amount of previous studies about the influence of various modalities of physical activity and exercising on BW, BMI, and the occurrence of body fat among females applied to overweight/ obese women, which were either middle-aged or postmenopausal. Donnelly et al. [59] conducted a cognate research that included young, sedentary, overweight/ obese women. As they persuasively showed, controlled exercising lasting 16 weeks showed significant effects on preserving the existing BW and reducing total and visceral fat among them in comparison to the physically inactive control group. An optimal exercising among women with sedentary habits, regardless of the modality (high or low intensity, aerobic, or resistance training) significantly reduces body fat [60–62]. The aerobic training was shown to be more effective than resistance training at improving visceral and liver fat and also abdominal subcutaneous fat among women and men of various age [62]. Therefore, the positive effect of aerobic exercising on reducing visceral fat among overweight/obesity subjects is connected with the improved insulin resistance and cardio-metabolic health [55, 63]. Even though our research did not involve the modality of physical activity practiced by young correspondence, the results showed statistically relevant correlation between their physical activity and VFA and FMI (**Table 2**).

Higher level of muscle mass in body composition significantly correlates with a number of health parameters [64]. It is also known that exercising, and especially resistance training, leads to an increase in muscle mass [60, 65]. Our research showed prominent correlation of SMM% with all variables of physical activity, in the first place with LSS ($r = 0.461, p < 0.05$) (**Table 2**).

Kyle et al. [57] found that physical activity increased FFMI by 0.32 kg/m^2 among men and women combined. In addition to that, the effect of age on FFMI was -0.007 kg/m^2 among physically active men and women. Our research confirmed significant correlation of physical activity and FFMI ($r = 0.242, p < 0.01$) by analyzing a general level of dependence between BCS, as an optimal modeled score of body composition, and LSS, as a score of lifestyle in relation to the level of physical activity and sedentary habits. On the basis of our results, it could be claimed that each standardized value, that is, each point more for improving lifestyle and physical activity, leads to increase in optimizing body composition of young females by 2 points, that is, it doubles (**Figure 2**).

5. Conclusions

This research set the task to investigate the correlation between lifestyle and body composition among young females. The results showed the existence of significantly relevant correlation among a large number of variables. This chiefly applies to the correlation between BFM% and SMM% in comparison with lifestyle score ($r = -0.408, p < 0.01$; $r = -0.461, p < 0.01$). As far as the relation between body composition and lifestyle point score is concerned, that correlation stood at the level of $r = 0.505, p < 0.05$. In addition, on a general level of correlation between BCS and LSS conducted by applying the method of mathematical modeling, it has been shown that the body score would rise by 2 points, that is, twice, if lifestyle score rises by 1 point. This is a clear evidence that a particular attention in further research on these subjects should be given to people's lifestyle and habits, and that increase in physical activity and making it into a regular, daily part of one's lifestyle, brings serious health benefits and reduces several risks arising from the contemporary sedentary habits.

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Chapter 6

Comparison of Cognitive Performance between Elderly Training Practices with Weights and Sedentaria

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Abstract

Comparison of cognitive performance among elderly people practicing training with weights and sedentary lifestyle. Estudy descriptive, cross-sectional and comparative, composition for 24 elderly between 60 and 70 years, divided into 2 groups, (G1) submitted to weight training and sedentary (G2). The G1 was submitted to 32 training sessions with traditional weight. Both groups were submitted to CogState® computerized cognitive testing batteries. The data were not parametric, using the Kolmogorov-Smirnov test for the analysis of the dispersion curve and the Mann-Whitney test in the comparison of the cognitive performance variables. The results were performed with a significance level of 0.05 by the Statistical Package for the Social Sciences (SPSS®), version 16.0. The best cognitive performance was observed among the elderly practicing resistance exercises, as well as significant differences in the TRS and TRE variables. Elderly people who exercise with weights when compared with cognitive performance demonstrate results of the paradigms when compared to the elderly. With this, he concludes that weight training is effective in improving cognitive performance.

Keywords: weight training, CogState®, cognitive performance, aging, elderly

1. Introduction

There is great variability in cognitive aging among individuals, given the heterogeneity of biological, socioeconomic, cultural, and environmental aspects which can modulate this process. Advanced activities of daily living (AADLs) are a set of leisure activities performed on free time, independently from work, which includes volunteering, educational activities, and social participation in the community, being this dependent on personal motivation. The effects of retrogenesis are a natural process to which every individual may or may not pass, due to a number of circumstances. The effects arising from retrogenesis are cognitive and motor slowness, followed by behavioral and psychic changes, with structural and functional changes taking place, causing neural impoverishment and irreversible functional decline, which cannot be regarded as a disease but rather as a natural aging process that subsequently will induce a new process, which will form a new organization for compensating for cognitive declines [1, 2] of psychomotor function, attention, visual learning and working memory (MT). These cognitive domains are fundamental variables for a healthy life for us human beings, the psychomotor function.

In gerontological literature, AADLs may indicate good physical and mental health, and reduced engagement in these activities may suggest the onset of functional decline, cognitive impairment, and frailty. The science today aims to study the body in motion in relation to the world, with the conception of integrated and organized movements improving body movements as motor coordination, balance, and attention, which in turn is an essential skill for good adaptive and oriented functioning, are associated with the cognitive domain that enables the elderly to process all information or actions relevant to the thinking of certain tasks, leaving distracting and irrelevant stimuli aside [3], and constituting a facilitating mechanism for neural responses according with the centralization of the mental processes of a given task [4].

Rowe and Kahn [5] suggested that commitment to life is one of the essential aspects of successful aging and may delay the onset of chronic diseases and high physical and cognitive performance. Walking independently requires cognitive and motor processing whose mechanisms involved are related to attentional resources, executive functions, and the sensory and musculoskeletal systems. It is a consensus in the literature that locomotion is a factor directly related to the preservation of physical independence, performance of activities of daily living, and social interaction. The visual learning in the elderly has a key role in motor development, placing it with the external reality, providing various stimuli that help in orientation, and in their body control, enabling the ability to know, interpret, and differentiate various stimuli visually received. Vision has a direct participation in the organization and conscious and safe voluntary motor action.

Working memory enables the elderly to keep information in their mind at the moment they use it, searching for information relevant to their activities and performing other tasks, such as the relationship of different ideals, such as mental calculations, ordering and sequencing current and past events including consideration of facts or ideas that may come from different points of view. Once this decline is detected through testing, then we can organize cognitive and physical exercises to maintain a healthy life for the elderly and research on cognitive interventions indicating that cognitive training can lead to increased performance and maintenance of cognitive skills in healthy elderly [6–8].

Aging is a natural and inherent process, being associated with several physical, physiological, psychological, and social changes. Among these changes, there is a decline in cognitive performance, being negatively associated with age and cognitive degenerative diseases such as Alzheimer's disease, causing impairment in the autonomy, independence, and quality of life of the elderly, being aggravated by the sedentary lifestyle. These damages are even greater in women, which caused aging process to be more complex due to hormonal and cultural factors. However, research conducted in recent years has shown the efficacy of physical activities on the morphological, responses, and cognitive performance of the elderly of both sexes [9–11]. Successful aging goes beyond disease-free and maintenance of functional capacity. AADLs depend on the preservation of physical and cognitive functions and are influenced by gender, age and health conditions, education, marital status, and place of residence [12].

Physical activity has become a non-pharmacological and efficient approach in the prevention and treatment of elderly people suffering from degenerative diseases, besides generating benefits in balance, strength, endurance, and flexibility. Within the vast modalities of physical activity, being the training with weights (TW) or bodybuilding, as it is popularly known, the number of elderly people of this modality is increasing, providing autonomy and independence. In TW programs, when supervised by trained professionals, they have beneficial effects on memory performance and cognitive functioning and in waveform protocols of weekly bodybuilding overloads and demonstrate the effectiveness in the expansion of maximal muscle strength, proving that the active lifestyle influences the maintenance of the functional capacity of the elderly [13–16].

According to Antunes et al. [17], the stages of information processing of cognitive function or cognitive functional system are memory, learning, attention, perception, reasoning, vigilance, and problem-solving; in addition, psychomotor functioning, reaction time, and time of movement and performance have been consistently included in this concept. The practice of physical activity has shown benefits in the quality of life of the elderly as well as improvement in cognitive performance, when compared to the sedentary ones [11]. Given the assumption, the objective of the present study was to compare the performance of elderly practicing training with weights with sedentary.

Although accumulated knowledge allows us to understand that activities establish associations with cognitive performance in old age, the way these variables interact generates debate. One of the questions asked is whether there would be a cause-and-effect relationship between AADL performance and cognitive performance and predisposing factors for participation. The question is whether the elderly who engaged in cognitively complex activities would have greater cognitive or cerebral reserve or if they demonstrate gains from participation even with low cognitive reserve.

2. Methods

2.1 Detection test

The detection test uses a simple reaction time paradigm to measure processing speed in healthy volunteers in just 3 min and cognitive domain and psychomotor function. The detection test is applied with the supervision, in this case, the researcher. The test includes virtual card by computer, iPad, or tablet, universally understood, regardless of language or age; after reading, the test is started by pressing the "enter" key. In the center of the screen, a sequence of cards will appear, and the volunteer has to press the "yes" key, whenever the presented card is correct, as quickly and accurately as possible, for example, should try not to press the "yes" key. Before the card is flipped, if this happens or is not answered, this time is counted, and you will hear an error sound.

The average reaction times are transformed by the log10 unit of measurement for correct answers. The result of the detection test is the average reaction time to which the elderly responded correctly; a higher value indicates a slower response.

2.2 Identification test

The identification test (T.Id) uses a reaction time (or reaction time of choice) paradigm to measure attention, administration time in healthy and only 3-minute volunteers, and cognitive mastery and attention. In this test the objective is to identify if the card is "red" or "black." If the card is red, the elderly should press the "yes" key as soon as possible; if not red, the elderly should press the "no" key. In this test, the senior should not try to press the "yes" or "no" key before the card turns; if this happens, he will hear an error sound and so on.

There is no other way as the program measures by units. The result of the identification test is the performance speed at which the elderly responds to the test; the response performance speed time is transformed into an average of log10, where the correct answers with a lower score will indicate better performance.

2.3 One-card learning test

The visual learning test uses a standard separation paradigm to measure visual memory and administration time in healthy volunteers in just 6 minutes. In this test the objective is to identify if the card that is revealed had appeared before, so the first answer will be "no." Each time a card is revealed, the senior must decide if the card that is being presented appeared before, always answering as quickly and accurately as possible "yes" or "no"; the volunteer should not try to answer before the card is turned, and the volunteer should try to remember all the cards that are presented in this test. If an incorrect answer is given (e.g., "no" or anticipates the answer), an error noise is heard.

The outcome measure of the test is the performance accuracy when the elderly responds to the test, the square root arc transformation of the proportion to the responses, where a higher value indicates better performance.

2.4 One-back test

The one-lap test uses an n-back paradigm to measure working memory; administration time in healthy volunteers is only 4 min, and the measured cognitive domain is working memory. Learning test application is done with the supervision of the test supervisor. The instructions for the test are the same as the previous tests.

The average reaction times are transformed by log10 for correct responses, and the performance assumption is the square root arc transformation of the proportion of correct responses, where a higher value indicates worse performance.

The main body is where the author explains experiments and presents and interprets data of one's research. This research had a descriptive, cross-sectional, and comparative characteristic, which compared the cognitive performance of elderly exercising with weight and sedentary exercises [18]. The study population consisted of male seniors enrolled in the bodybuilding extension of the physical education course of UNIPÊ. The sample consisted of 40 elderly individuals, selected by non-probabilistic and random procedure, with age range between 60 and 70 years of age and with 20 training practitioners with weight and 20 sedentary.

The evaluations were carried out in the physical evaluation laboratory LAF-UNIPÊ/SANNY of the physical education course of UNIPÊ, for presenting favorable conditions and adequate material that allows the reliable application of the research. Participants received an informative report with all the procedures performed in the research. Then, an information document containing all the details regarding the date, time, and place of the research, along with the free and informed consent term, was delivered. The study included elderly between 60 and 70 years old, completed high school and has basic computer skills. The following elderly were excluded from the study: they lacked at least three weight training sessions and did not attend the morphological, neuromuscular, and cognitive tests.

After the selection, 24 elderly subjects were divided into 2 groups, being G1 submitted to weight training and G2 control group (sedentary). The G1 underwent 32 training sessions weighing 3 times a week, lasting 40 min, with weekly load progression. The program was developed with a goal of muscular strength (range of three to six repetitions—2 min intervals between the series), developed by a traditional methodology (weights, repetitions series, and fixed intervals), system located by articulation (execution of exercises for lower limbs and upper limbs on separate days), and dynamic work (execution of isotonic exercises), while G2 remained sedentary.

The present work complied with the norms for conducting research on human beings, resolution 466/12 of the National Health Council, following the recommendations of the Statute of the Elderly, Law 10741/2003. CAAE: 51751415.0.0000.5176.

One of the CogState® computerized cognitive testing batteries was used to evaluate cognitive performance, which consists of four tests: simple reaction time (SRT), reaction time of choice (CRT), working memory, and sustained attention (SA), where the four tests were applied in the study. The tests were composed of the following variables: detection test (DET) (Det_Rap = speed detection, Det_Pr = precision detection, Det_Ac = detection hits, Det_Er = error detection, and

Figure 1.
Image acquired during research.

Performance cognitive tests	Variables	Elderly WT (n = 20)		Sedentary (n = 21)		Mann-Whitney	
		M ± Sd	Min_Max	M ± Sd	Min_Max	"U"	Sig.
Simple reaction time (SRT)	Det_Spee (ms)	359.8 ± 83.52	266_494	639.25 ± 330.02	238_1202	68,000	0.022
	Det_Pr (ms)	95.68 ± 5.65	84.4_100	81.00 ± 21.91	20.6_100	70,000	0.025
	Det_Hit (ms)	35.46 ± 1.13	35_39	34.25 ± 3.75	23_39	114,500	0.507
	Det_Er (ms)	0.38 ± 0.65	0_2	4.60 ± 6.12	0_20	67,500	0.014
	Det_Ant (ms)	1.50 ± 2.11	0_6	8.00 ± 18.80	0_85	86,000	0.093
Choice reaction time (CRT)	Det_Spee (ms)	534.45 ± 86.67	388_741	765.71 ± 321.21	443_1605	121,500	0.021
	Det_Pr (ms)	89.05 ± 18.35	37.3_100	72.65 ± 30.54	1.5_100	147,500	0.099
	Det_Hit (ms)	29.10 ± 3.06	17_30	27.90 ± 8.06	1_37	177,000	0.284
	Det_Er (ms)	3.45 ± 7.61	0_27	8.43 ± 11.15	0_40	153,500	0.132
	Det_Ant (ms)	1.60 ± 4.11	0_18	8.90 ± 16.99	0_57	138,000	0.043
Sustained attention (SA)	Lac. Spee (ms)	904.70 ± 125.87	756_1137	1265.10 ± 550.64	799_2225	31,000	0.151
	Lac. Pr (ms)	56.25 ± 7.80	42.9_68,2	59.92 ± 9.49	39.8_74.4	33,500	0.212
	Lac._Ac (ms)	50.70 ± 6.67	39_60	53.40 ± 8.50	35_67	37,500	0.344
	Aoc_Er (ms)	37.30 ± 6.67	28_49	34.60 ± 8.50	21_53	37,500	0.344
	Aoc_Ant (ms)	2.30 ± 3.56	0_10	1.10 ± 1.66	0_5	44,000	0.608

Performance cognitive tests	Variables	Elderly WT (n = 20)		Sedentary (n = 21)		Mann-Whitney	
		M ± Sd	Min_Max	M ± Sd	Min_Max	"U"	Sig.
Working memory (MT)	Speed_Rap (ms)	1002.65 ± 294.18	662_1732	1178.40 ± 421.6	667_2169	152,000	0.194
	Speed_Hit (ms)	28.75 ± 6.95	2_31	27.85 ± 7.40	10_36	197,000	0.924
	Speed_Er (ms)	8.30 ± 7.79	0_31	9.40 ± 8.62	0_29	192,000	0.828
	Speed_Sot An (ms)	0.55 ± 1.39	0_5	6.40 ± 13.35	0_50	112,000	0.006
	Sp_oT (ms)	77.63 ± 21.87	5.6_100	68.54 ± 25.82	23.8_100	164,500	0.336

*Legend: Elderly WT = elderly exercise practitioners with weight; M = mean; Sd = standard deviation; Min = minimum; Max = maximum; DET = detection test (Det_Speed = speed detection, Det_Pr = precision detection, Det_Hits = detection hits, Det_Er = error detection, and Det_Ant = detection of anticipation); T.Id = identification test (Id_Speed = speed identification, Id_Pr = precision identification, Id_Hit = identification of hit, Id_Er = error identification, and Id_An = identification in anticipation); LC = learning from a card (L. SC = learning speed card, L. CA = learning card accuracy, L. CS = learning card successes, and LC_Er = learning card errors; LA = learning anticipation, Speed Er = speed of errors; Sp A = speed of anticipation; Sp oT = Sig = Significance; **

Table 1.
Descriptive and comparative values of cognitive performance among elderly weightlifters and sedentary trainers.

Det_Ant = detection of anticipation); identification test (Id_Rap = speed identification, Id_Pr = precision identification, Id_Ac = hit ID, Id_Er = error identification, and Id_An = Idle ID); learning from a card (AC) (AC_Cap = learning speed card, AC_Pr = learning card accuracy, AC_Ac = learning card successes, AC_Er = learning card errors, and AC_An = learning anticipation card); and one volta (UV) (Vel_Rap = Fast speed, Pr_Volta = precision velocity, Vel_Ac = speed of hits, Vel_Er = speed of errors, and Vel_An = speed of anticipation). The values obtained from the tests will be presented in milliseconds (ms).

The tests were composed of the following variables: detection test (speed detection; precision detection, detection hits, error detection, and detection of anticipation), identification test (speed identification, precision identification, identification of hit, error identification, and identification in anticipation), learning from a card (learning speed card, learning card accuracy, learning card successes, learning card errors), and learning anticipation (LA) (speed of errors and speed of anticipation). The values obtained from the tests will be presented in milliseconds (ms).

The data were collected in two stages, the first one after the selection of the elderly, who passed the battery of the four tests, taking from this result the mean, standard deviation, and maximum and minimum time reached in each test. The second stage was produced with elderly practicing resistance exercises, where they passed the same battery of the four tests, thus also generating the mean, the standard deviation, and the maximum and the minimum of time in each test. Prior to the application of the tests, it was necessary to perform a demonstration of the protocol to facilitate the understanding and learning of the test; later, it was applied in a definitive character with duration of 10 min.

The CogState® computerized cognitive evaluation battery is composed of the identification tests, with the purpose of measuring attention, using the reaction time of choice paradigm (RTC); its cognitive domain is attention and the performance measure is the speed of performance. The detection test aims to measure performance velocity using the simple reaction time paradigm, and its cognitive domain is the psychomotor function and has performance velocity as the measure of results. The learning test mediates visual memory using the pattern separation paradigm (SP); its cognitive domain is visual learning, and the measure of result is performance accuracy. The one-turn test mediates working memory. The number of laps (NV) paradigm has cognitive domain as the working memory; its performance measure is performance speed [19] as shown in **Figure 1**.

The information presented underwent quantitative analyzes, and the number of positive and negative responses was evaluated, divided by the number of attempts. The data were classified as no-parametric with the Kolmogorov-Smirnov test of the dispersion curve, and the cognitive performance variables were compared with the Mann-Whitney U test (**Table 1**). The procedures were performed with significance level of $p < 0.05$ using the Statistical Package for the Social Science, Version 25.

3. Discussion

Elderly practicing weight exercises, demonstrated better cognitive performance than the sedentary ones in the detection tests with the simple reaction time, Identification paradigm with the time paradigm of Reaction of Choice and the One Turn (UV) test that has the working memory paradigm.

In the present study, in the investigations of Dias et al. [20] with 104 elderly people, where the differences in the cognitive aspects between physical exercise practitioners (G1) and non-practitioners (G2) were evaluated, it was observed that

G1 showed better than G2, in the tests that evaluated the reaction time of choice paradigms where they obtained a reduction of 104.45 ms; in the time of simple reaction, the reduction was of 86.54 ms. However, the results differed according to the working memory paradigm, when G1 showed worse performance than G2. The study used the same battery of cognitive tests as the present study.

In a comparative study of active, intermediate, and sedentary elderly women presenting different histories of physical and intellectual activity, a trend was observed among sedentary elderly women, presenting a lower performance in the tests with SRT and SRT paradigms than the physically active elderly women. However, the study did not show statistically significant differences, differing from the present study where there were significant differences in the SRT and SRT paradigms. Luft et al. [21] point out that this may have occurred due to the aging process being more complex in the elderly.

Contrasting to the results of the present study, the Rossato et al. [22] analysis, where they investigated the correlation between the reaction time and cognitive status in 77 elderly women practicing physical activities, presented a satisfactory performance in the Mini score (MNSE), which averaged 26.56 points, and for the simple reaction time paradigm, it was unsatisfactory where the mean was 605.65, and it was found that there was a statistically significant correlation between the SRT paradigm (ms) and the cognitive state of $p = 0.023$, however, the weak relation.

It is worth mentioning that the protocol performed in the mentioned study is different from the current one, being considered gold standard. The same case occurs in the analyses of Corazza et al. [23], performed with 90 elderly, called (G1) practitioners of regular physical exercises and (G2) non-practitioners, in which the simple response time tests were compared (RTC), where there were no significant differences between groups G1 and G2; for the TRS paradigms obtained only a reduction of 0.33 ms and for ERT of 1 ms, diverging from the present study. These results can be explained by the virtue of the instrument used; in addition to that, the above study correlated reaction time with cognitive status exclusively in elderly women practicing physical activity.

Findings by Lachman et al. [24], with 210 elderly practicing resistance training, obtained an improvement in the working memory paradigm, only in the group with the greatest evolution of loads during training. The same occurs in the study of Cassilhas et al. [25]; however, 62 elderly subjects were submitted to 24 weeks of training in 2 intensities. Meanwhile, in the study by Busse et al. [15], a significant improvement was verified in the tests of mental behavior of memory and muscular strength, in addition to the occurrence of an improvement in the performance of the memory and work paradigm.

It is understood as working memory, the cognitive component connected to memory, which allows the temporary storage of information with limited capacity. According to Alloway [26], the limited capacity of working memory varies greatly between individuals and is closely related to learning skills. In addition to manipulating new information from the sensory pathways, it connects with long-term memory, that is, with the knowledge already stored.

Thus it is evident that the practice of resistance exercises can contribute significantly to improvement or at least to maintenance of some components of cognitive function, when compared to non-practicing elderly.

4. Conclusions

Physical activity represents an important non-medicinal contribution to the evolution of cognitive performance. However, it is necessarily based on literatures, the analysis of the intellectual activity of the elderly, when subjected to treatments through specific physical exercises to improve cognitive performance.

Weighing elderly individuals undergoing cognitive performance assessment demonstrates better results for the simple reaction time, choice reaction time, and working memory paradigms than the sedentary elderly. Thus, we conclude that weight training is effective for improving cognitive performance.

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Conflict of interest

There is no conflict of interest between the authors.

Acronyms and abbreviations

DET	detection test
Det_Spee	speed detection
Det_Pr	precision detection
Det_Hits	detection hits
Det_Er	error detection
Det_Ant	detection of anticipation
T.Id	identification test
Id_Spee	speed identification
Id_Pr	precision identification
Id_Hit	identification of hit
Id_Er	error identification
Id_An	Id in anticipation
LA	learning from a card
L. SC	learning speed card
L. CA	learning card accuracy
L. CS	learning card successes
LC_Er	learning card errors
L A	learning anticipation
Speed Er	speed of errors
Speed A.	speed of anticipation
ms	the values obtained from the tests will be presented in milliseconds

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Cardiorespiratory fitness reflects the ability of the cardiovascular and respiratory systems to transport oxygen to the working muscles of the human body during exercise. It is influenced by factors such as age, genetic structure, body composition, and gender. This book provides the reader with interesting and current data about cardiorespiratory fitness. Chapters cover such topics as pulmonary rehabilitation in chronic obstructive pulmonary disease, ischemic preconditioning, metabolic syndrome in adults, cardiorespiratory fitness and intellectual disability, influence of lifestyle on body composition, and effect of exercise on cognitive performance in the elderly.

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