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Exercise as A Heart Protector Affecting Lipid Metabolism

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Abstract
The medical community urgently needs and considers, in fact, exercise as an excellent strategy for the prevention of ischemic heart disease. It is important that physicians are familiar with the physiological and psychological effects of exercise so that they can better guide their patients to sports practices, and incorporate physical activity into the therapeutic plans of various cardiovascular and metabolic disorders. It is also important to emphasize that, as necessary as knowing the antiatherogenic "training effects", it is to know: how much exercise is sufficient to produce them, and how to develop strategies to change sedentary lifestyle attitudes, already chronically established, in patients with metabolic disorders. As for dyslipidemia, it seems that regular exercise plays an important complementary role in the treatment of metabolic disorders of blood lipids, providing significant antiatherogenic changes in plasma concentrations of total lipids, triglycerides, HDL-cholesterol and VLDL-cholesterol.

Keywords: Exercise, Heart, Lipoproteins, Atherosclerosis

Introduction

According to the recent epidemiological analyses of coronary heart disease and physical exercise, published by Lavie et al., Paffenbarger and Hyde and Sadlo and Wenger, physical inactivity is a significant cardiovascular risk factor in patients with metabolic diseases (obesity, dyslipidemia and diabetes mellitus) [1-3]. In these analyses, there was considerable evidence of favorable antiatherogenic changes in body composition, lipids and carbohydrate tolerance, with increased physical activity.

As for dyslipidemia, it seems that regular exercise plays an important complementary role in the treatment of metabolic disorders of blood lipids, providing significant antiatherogenic changes in plasma concentrations of total lipids, triglycerides (TG), High-Density Lipoprotein-cholesterol (HDL-c) and Very Low-Density Lipoprotein-cholesterol (VLDL-c).

The medical community urgently needs and considers, in fact, exercise as an excellent strategy for the prevention of ischemic heart disease [4,5,6,7-14]. It is important that physicians are familiar with the physiological and psychological effects of exercise so that they can better guide their patients to sports practices, and incorporate physical activity into the therapeutic plans of various cardiovascular and metabolic disorders.

It is also important to emphasize that, as necessary as knowing the antiatherogenic "training effects", it is to know: how much exercise is sufficient to produce them, and how to develop strategies to change sedentary lifestyle attitudes, already chronically established, in patients with metabolic disorders.

The sedentary lifestyle

Our highly mechanized civilization confronts man with a profoundly altered environment. We have machines that exempt them from any physical work, and many individuals dispense, whenever possible, with their own locomotion. In addition to the sedentary lifestyle, man adds habits of modern Western civilization. Smoking, for example, exposes to various psychological stresses, which trigger deleterious neurohumoral hyperrequests to the body. Lack of regular physical activity causes progressive atrophy and loss of organic functions throughout the body. German researchers have described a series of signs and symptoms arising from a "hypokinetic disease" resulting from a chronic sedentary lifestyle, which mainly affects the cardiorespiratory systems and the locomotor system. According to them, the lack of physical conditioning, over the years, leads to a reduction in maximum oxygen consumption (O2) and coronary reserve, and a greater tendency to myocardial hypoxia. In our hypokinetic society, coronary insufficiency is nowadays one of the most frequent diseases. The sedentary man has reduced vital capacity, maximum minute volume and maximum oxygen volume (VO2 max). Due to the lack of physical activity, the regulatory capacity of the neurovegetative system is diminished, on which the adaptation capacities depend. The sedentary man presents, very often, sleep and digestion disorders. Lack of exercise and overeating cause obesity, which leads to other metabolic disorders (hyperglycemia, dyslipidemias and hyperuricemia). Postural problems, osteoporosis and low back pain are other common sequelae of chronic sedentary lifestyle.

We believe that our society needs increasingly broad and modern physical education, with constant encouragement from public agencies, sports clubs, academies, community programs, health posts and associations. One of the successes of physical exercise as a preventive measure in recent years has been the creation of a modern physical education, in which doing physical exercise or practicing sports have become programs of leisure and pleasure. The idea that exercising regularly requires intense physical and psychological exhaustion, causing displeasure and suffering (defeats), is over. The creation of new models of exercises, whenever possible individualized, respecting sex and age, the invention of new non-complex sports games (shuttlecock, for example), the valorization of walking, the use of music in the exercise environment, the creation of reliable sports equipment, etc., have allowed our society and our culture to offer ample opportunity for every individual, including the physically disabled, practice some type of physical activity (recreational or sports-competitive).

Exercises and dyslipidemias

Superko et al. concluded, after an extensive review, that exercise treatment is a valid therapeutic approach in patients with hyperlipoproteinemia, although the results of some epidemiological studies are controversial [15]. Along with proper dietary modification, exercise can be a powerful tool and allow for a reduction in the doses of lipid-lowering drugs. Virtually all dyslipidemia treatment programs recommend an adequate low-fat diet, reduction of excess body fat, and appropriate exercise, as therapeutic measures to be used, before or concomitantly with pharmacological therapy. The current problem refers to knowing the amount and type of exercise necessary to obtain favorable lipid changes in patients with dyslipidemias, and to eliminate risks and inconveniences of regular exercise in this population.

From the excellent and extensive review of Superko et al., it is concluded [15]:

1. If physical activity improves TG metabolism, one can also expect improvement in the profile of Low-Density Lipoprotein-cholesterol (LDL-c) and HDL-c.
2. The most sedentary activity is most easily found in atherogenic high-risk dyslipidemias, such as IIb, IV and low plasma levels of HDL-c.
3. In patients with hypertriglyceridemia (type IV) there are significant reductions in TG and serum insulin levels, with the addition of physical training to the lipid-lowering diet. These reductions disappear after six weeks, with the return to a sedentary lifestyle.
4. There seems to be a clear correlation between the reduction in VLDL-c and the percentage increase in VO2 max, after physical training (continuous walks of 15 to 20 Km/week). This correlation is because training leads to increased uptake of TG by skeletal muscle and reduction of this uptake by adipose tissue. It is important to add that physical conditioning can provide significant effects on the maximum consumption of O2, (VO2 max) and body composition, before blood changes occur in lipids.
5. Globally, in the various studies analyzed, in individuals with hypertriglyceridemia, exercise treatment reduced plasma TG by approximately 37%, total cholesterol (TC) by only 7%, and increased HDL-c by 23%.
6. According to Superko et al.[15], evidences suggests that, in order to increase plasma HDL-c, a threshold of regular exercise of approximately 10 to 15 miles (16 to 24 km) of jogging per week is required. Many regular sportsmen do not reach these values weekly. However, McCunney cites two studies that recorded significant increases in HDL-c in running, jogging, or walking programs of 5 miles (8 Km) per week (on average, three sessions per week) [16].
7. In many epidemiological studies, the results indicated that neither TC nor LDL-c were related to the physical activity reported by individuals.
8. In survivors of myocardial infarction, it was found that TC was not significantly different in patients exercised after acute myocardial infarction, compared to individuals who did not exercise, although HDL-c was significantly higher in the exercised group (47.2 versus 40.1 mg/dL).
9. Prospective research on the effect of exercise on patients with hypercholesterolemia is scarce. Current research, through its results, suggests that plasma cholesterol is not modified by exercise treatment, and that the reduction in TG levels is associated with the reverse effect on HDL-c, observed in hypertriglyceridemic individuals.
10. Exercise stimulation alone does not cause significant changes in TC or LDL-c. For this and other reasons, exercise should not replace dietary strategies to reduce atherogenic, CT, and LDL-c plasma levels.

In the review studies by Cohen and Wittry, it is concluded that, in the absence of reduction in body weight, plasma TC is not altered by the regular practice of physical exercises [17]. However, HDL-c usually increases directly with the frequency and intensity of exercise, and VLDL-c is usually reduced with concomitant reduction in plasma TG. Cohen and Wittry pointed out that these changes occur after several months of physical conditioning, and that they disappear when exercise is interrupted [17].

McCunney[5], in another excellent review on the subject, demonstrated that long-distance runners (endurance), when compared with sedentary individuals, in analyses of numerous publications, present significantly higher plasma HDL-c values (Chart 1). Superko et al. has also emphasized, in another publication that only long-distance runners and vegetarians have a TC/HDL-c ratio, equal to or less than 4.0 (Chart 2) [15,18,19]. Studies conducted on soccer players, tennis players, skiers and dancers show higher plasma levels of HDL-c than control groups with sedentary lifestyles. In Brazil, Santos et al. observed that in soccer players there is a significant decrease in plasma levels of TC, total TG, and in the TC/HDL-c ratio [20].

Chart 1: HDL-cholesterol and degree of physical fitness (epidemiological studies).

Study Group	Exercise	HDL-Cholesterol
50 bottom runners	run 800 Km/year	54.8 mg% (20% higher than control group) control: 45 mg%
20 marathon runners	56 Km/week	20 mg% more than in sedentary patients (control)
220 bottom runners	32 Km	70% larger than the control group
20 bottom runners	--	56.0 mg% control: 49 mg%
85 runners	17,6 Km/week	58.0 mg%
58 marathoners	64 Km/week	64.8 mg%
74 sedentary	--	43.3 mg%

Chart 2: Total cholesterol/HDL-cholesterol ratio in selected groups.

GROUP	Cholesterol total / HDL-c
Vegetarians	2,9
Runners (Boston)	3,5
Women without coronary heart disease	4,4
Women with coronary heart disease	5,3
Men without coronary heart disease	5,1
Men with coronary heart disease	5,8
Women with IIA hyperlipidemia	6,0
Men with llA hyperlipidemia	7,3

There is much debate as to whether HDL-c concentrations would only increase at a high threshold level of exercise (e.g. running 16 Km per week) for a period of not less than 6 or 9 months. Indeed, in the study by Sartori et al., there was no correlation between HDL-c and blood pressure levels, sedentary lifestyle and diabetes mellitus in 628 employees of the Clinics Hospital of the Federal University of Paraná [21]. In the study by Coutinho and Cunha, there were no differences between athletes (88 individuals, mean of 21.2 years) and non-athletes (69 individuals, mean of 21.6 years), all non-smokers, regarding plasma levels of LDL-c and HDL-c. Athletes had lower plasma cholesterol and TG values than non-athletes, as well as VLDL-c and the less atherogenic TC/HDL-c ratio [22]. These authors concluded that the athletes presented lipid profile (lipoprotein) in antiatherogenic sense, suggesting a lower risk of developing ischemic heart disease; that the recommendation of physical exercise should be reinforced, as part of a program for the primary prevention of atherosclerosis, and that lipoprotein enzymes (lipoprotein lipase and liver lipase) and the enzyme Iecitin-cholesterol-aciI-transferase are activated by exercise, and participate in the process of favorable antiatherogenic modification of lipid and lipoprotein metabolism.

The authors explained that there were no differences in HDL-c in the athlete and non-athlete groups, because the study included young individuals and, therefore, with physical activity above that of an older adult. They emphasized that most of the studies, which show that active individuals have higher levels of HDL-c, have been conducted in middle-aged individuals, around 45 years.

Exercise and diet together can be effective in improving lipid profiles and reducing body fat. Exercise acutely reduces TG and VLDL-c, and regular exercise has been shown to chronically increase HDL (especially the HDL2 subfraction). The magnitude of this change is usually 10 to 20% with diet and exercise, so additional interventions may be necessary.

Most studies are consistent in demonstrating that all exercise intensities and durations increase HDL-c levels. Weight loss resulting from calorie and fat restriction in conjunction with exercise often results in reduced LDL-c levels.

The effect of physical activity on apoproteins A-I and B as well as lipoprotein a (Lp(a)) does not present definitive bibliographic documentation based on controlled longitudinal studies.

Correct prescription of physical exercises

We could summarize all the norms and recommendations for the prescription of physical exercises, in the nine statements below and in what is recommended in Charts 3 to 7.

Chart 3: Norms and recommendations for the prescription of physical exercises.

A. MANDATORY Previous medical examination Exercise testing whenever possible Assessment of basic motor skills Strength, flexibility, agility etc. Warm-up and stretching, before the main exercise session The program should develop 3 to 4 basic motor skills
B. WEEKLY FREQUENCY 3 to 5 sessions per week One session per day
C. DURATION 15 to 60 minutes
D. INTENSITY 60 to 90% of maximum heart rate 50 to 85% VO2 max
E. TYPES OF PHYSICAL ACTIVITIES 1.General - running, cycling, swimming etc. 2.Sport - tennis, soccer, volleyball, etc. 3.Special programs - bodybuilding, gymnastics, relaxation, etc.

Chart 4: Considerations for selecting the exercise modality.

Initial health status Initial degree of physical, cardiorespiratory and motor fitness Age and gender of the participant Sports preference and physical exercises Previous experience in some kind of sport or physical conditioning Educational level Reasons and goals for wanting to exercise Preference for individual or collective physical activities, in the gym or outdoors Socioeconomic conditions Degree of motivation Amount of time available to the participant to exercise

Chart 5: Eight basic principles of physical conditioning-recreation.

Warm-up and stretching are essential Progression: start with light loads and progress them with improved physical fitness. It takes 6 to 8 weeks to reach the maximum level Calculate the time (duration) and intensity of the exercise Capacity: Exercise within your physiological health limits (see principles of biological individuality and exertion tolerance) Strength, coordination, flexibility and aerobic endurance are essential motor skills Relaxation: special exercises to recover from fatigue and tension Routine: A minimum standard of routine is essential each week Interruption: It is necessary to stop the program when health problems appear

Chart 6: Physical conditioning - how to motivate participants.

Explain why exercise is beneficial and has been recommended Explain the goals of the exercises Educate them regarding what isometric, isotonic, isocyanetic means. aerobic, anaerobic, cardiorespiratory physical fitness, motor etc. Relate participants to each other, respecting those who do not desire new social relationships Suggest substitution exercises to be done at home, hotels, parks, when they can't attend classes Use statistical comparisons and show the evolution of performances Suggest low-cost activities Promote community exercises Show how exercise modifies and provides a new way of life Convince your participants to give up addictions such as cigarettes, excessive alcohol, excess food intake, drug use, frequent "night outs", etc.

Chart 7: Energy expenditure of recreational sports.

Activities	Kcal/hour	Kcal/min	Kcal/min-Kg^{-1}
Athletics			
5 mph	600	10	0,163
6 mph	750	12	----
7 mph	870	14	----
8 mph	1020	15,6	----
9 mph	1130	17,5	----
10 mph	1285	19,6	----
11 mph	1300	21,7	----
Basketball	360-660	3,7-11	0,138
Hiking			
1-2 mph	120-150	2,5	----
3,0 mph	300	3,7	----
3,5 mph	360	4,9	0,080
4,0 mph	420	5,5	----
5,0 mph	480	8,3	----
Cycling			
5 mph (leisure)	240	3,7	0,064
8 mph	300	----	----
10 mph	420	----	0,100
11 mph	480	----	----
12 mph	600	----	----
13 mph	660	----	----
Calisthenics			
Lightweight	360	3,7	0,060
Intense	360	10	----
Modern Dance	240-360	3,7-8,5	0,168
Aerobics	----	7,5-11	----
Soccer	400-900	6,15	----
Golf	240-350	5-8,5	0,085
Handball	600-660	10-15	----
Judo	----	----	0,195
Swimming	----	5-10	----
Recreation	360-500	----	0,128
Crawl	360-750	----	0,156
Backstroke	360-750	----	0,169
Breaststroke	360-750	----	0,162
Butterfly	840	----	0,170
Jump Strings			
Lightweight	300	10	----
Intense	800	14	----
Tennis			
Double	360	5	0,080
Simple	450	11	0,109
Volleyball			
Recreation	300	3,7	0,050
Competitive	450	7,5	0,060
1 mile per hour (mph) = 1.61 Km/h = 26.8 m/min = 0.45 m/s 1 Km/h = 16.7 m/min = 0.28 m/s = 0.62 mph 1 liter of O2 consumed = 5.05 Kcal			

The main standards of recommendations are:

1. The modality of exercises should be to the liking of the individual (or the group), with their prior consent.
2. Physical exercises should be pleasurable and should be physiologically and psychologically adapted to the individual.
3. Authoritarian and imposed exercise prescriptions often marry a high dropout rate.
4. The aerobic energy system is the one that should be the most emphasized in the prescription, because it is the one that most develops cardiorespiratory fitness and can prevent cardiovascular diseases.
5. It is important to perfect the movement or the sports gesture, know the rules of the game and educate yourself physically and mentally. It is not enough to run, it is important to know how to run.
6. Clothing, ambient temperature, available liquid, lighting, sufficient space, first aid bag, etc., are details of great importance and should not be forgotten.
7. Do not let participants challenge their own bodies in efforts beyond the limits of tolerance.
8. Sport is health to the extent that we take measures to prevent sports accidents.
9. Exercise testing should be done beforehand, whenever possible. This test guides the professional to properly prescribe aerobic exercises and the cardiovascular risks of physical exertion.

Weekly frequency

-3 to 5 times a week.

- One session a day.

The "training effects" will only develop with a minimum of three training sessions per week, and the ideal weekly frequency is between 3 to 5 times. A minimum of 100 Kcal per week should be spent. It takes 4 to 6 weeks to observe and feel the "training effects."

With what was mentioned above, we begin to have problems with a large number of individuals who already exercise. Among them, we can mention:

1. The Weekend Athletes, who generally do vigorous (anaerobic-aerobic) exercises with great duration, on weekends.
2. Sporadic athletes, who exercise infrequently, sometimes go up to more than 3 weeks without exercising (see principle of reversibility).
3. Supertraining Athletes exercise more than 6 times a week and sometimes two vigorous workout sessions a day. In the United States, this group is being termed "addict." They present, in general, frequent chronic musculoskeletal injuries and behavioral disorders.

It is interesting to note that most of these fake athletes have low total physical fitness. For obese participants it is better to prescribe light and moderate exercise, of longer duration, 5 times a week. After physical fitness is increased and weekly frequency reduced. It has been found that body fat is only reduced in aerobic exercise programs, performed at least 5 times a week.

Some individuals need to exercise daily to help relieve tensions, pressures and stress or to add emotional balance control. Those who exercise 5-6 times a week should alternate, in subsequent days, the muscle groups and/or modify the exercise modality. An individual will be able to play tennis on weekends and run twice in the middle of the week, or play soccer and tennis and run on alternate days to sports practices.

It has been shown that individuals with very low functional capacity (5 METs), can benefit from 2-3 sessions per day of 5-10 minutes duration. This is the case of programs for cardiac elderly, pneumopathic, obese, etc., in the early stages of physical conditioning programs. In sedentary adults, the weekly frequency of 2 times a week does not increase VO2 max beyond 10% of the initial aerobic capacity.

Duration of the exercise

The "training effects" of a fitness program only occur due to the interaction of the duration and intensity of the program. The conditioning period should last from 15 to 60 minutes, and for some individuals it can reach 1 hour and a half. This period is the continuous part of the program, and can at most suffer intervals of 2 minutes. During this period, the heart rate should be above 60% Maximum Heart Rate (MHR) and preferably between 70 and 85% MHR. It is important to reemphasize here that sports such as soccer, basketball, handball, other tennis, are characterized by short periods of intense exercise (alactic or iatic anaerobic), intervals by longer periods of light and moderate (aerobic) exercises. In these sports, the heart rate fluctuates a lot and, therefore, the training effects are different, in relation to sports in which the heart rate is continuously maintained, such as running, swimming (aerobics) and cycling (aerobic).

For the practice of these sports, intervals, it is recommended that, previously, the individual make a program to develop total physical fitness.

Regarding the duration, some points should be remembered:

- To reduce excess body fat, the minimum adequate duration is 30 minutes, and the ideal should include between 40 to 60 minutes.
- A good rule of thumb is that the session should spend at least 350 Kcal, about 1000 KcaI/week.
- Some studies emphasize that the ideal, for the prevention of cardiovascular diseases, is to spend about at least 2000 Kcal / week.
- Short, intense workouts (e.g., jumping ropes for 10 minutes) are for already trained individuals with above-average physical fitness.
- Some studies have shown that sinus bradycardia (resting heart rate of less than 60 bpm), resulting from physical conditioning, is more related to the frequency and duration of the sessions than to their intensity.
- The best option, for beginners, is the prescription of low and moderate intensity and long-duration exercises.
- The duration of the session varies with the modality of the chosen exercise and how much Kcal is spent per minute (Chart 7).

From Chart 7, we can see that 30 minutes of jogging (slow running) is equivalent to 50 minutes or 1 hour of recreational tennis match, or 1 hour and 15 minutes of volleyball (recreational) and 20 minutes of jumping rope intensely. The values in Chart 8 refer to mean values, and consider the continuous participation of the exercise. Thus, if the individual plays 1 hour of tennis, it is considered the period in which he was playing on the court, and should not be computed the periods in which he had to wait or remain talking in the canteens. Many "fake athletes" delude themselves into telling that they played 3 hours of tennis, last Sunday, when they did not play much beyond 30 minutes.

Another utility of Chart 7 is to show the energy cost of physical activities. The efforts begin to be considered intense, when they have an energy cost above 7.5 Kcal/min. A tennis match (singles) at a competitive level may require 11 Kcal/min, played by two good tennis players, and may require, at a recreational level, about 5 Kcal/min, by two lazy and slow tennis players. This means that tennis is a sport that can be exhausting as a competitive sport and a light intensity sport if played slowly. In anaerobic-aerobic team sports, the intensity of the sum of efforts varies greatly, as it depends on how players are requested during the match. If the game is much disputed and the opponent presents good technical level, the energy expenditure will be high, and if the game is slow and the opponent is of low technical level, the energy cost will be low.

Exercise intensity

50-85% VO2 max; 60-90% of MHR.

To know the intensity of a physical exertion, and if it adapts to the individual, it is necessary to know: the age of the individual, the predicted MHR (Table 1), the energy (caloric) cost of physical activity, know how to correctly measure the heart rate after exertion, measure the initial cardiorespiratory fitness through standardized tests [18,19,23-30].

All the above reasoning and deductions are valid, for people who do not use medications that alter the behavior of the heart rate during exertion, as is the case of beta-blockers, ephedrine and hormones.

After graduated exercise testing, with progressive loads, on a cycle ergometer or treadmill, it is easier to calculate the intensity of the physical conditioning program, through the chronotropic curve and VO2 during exercise.

Cardiac patients using beta-blockers should have their intensities controlled by the level of individual exercise tolerance, and by safe heart rate limits to be reached.

In sedentary adults, of low physical fitness, 60% MHR should be prescribed in the first week, 65% in the second phase and third weeks, 70% in the fourth and fifth and then, according to individual tolerance.

The intensity of physical exercise is extremely important to increase cardiorespiratory fitness (VO2 max) and is, for many, the most difficult part of prescribing. The reason for the difficulty is that the calculation of this intensity depends on measures and assessments of total physical fitness in the initial phase (preconditioning). Many professionals do not make these prior evaluations, preferring to make prescriptions empirically based on day-to-day experience. Many physical educators, technicians and physiotherapists are thus able to correctly and prudently prescribe fitness programs for healthy young people and adults. However, many empirical prescriptions, without scientific basis, become dangerous, when it comes to physical conditioning for the elderly, heart patients, lung disease, diabetics, etc.

Table 1: Recommended heart rates during exercise.

Age	MHR	85% HRM intensity for athletes	80% HRM for sedentary healthy adults	75% HRM for cardiac (do not exceed)
20	200	170	160	150
22	198	168	158	148
24	196	167	157	147
26	194	165	155	145
28	192	163	154	144
30	190	162	152	143
32	189	161	151	142
34	187	159	150	140
36	186	158	149	140
38	184	156	147	138
40	182	155	146	137
45	179	152	143	134
50	175	149	140	131
55	171	145	137	128
60	160	136	128	120
+60	150	128	120	113

Abbreviations

- **HDL-c:** High-Density Lipoprotein-cholesterol
- **LDL-c:** Low-Density Lipoprotein-cholesterol
- **MHR:** Maximum Heart Rate
- **TC:** Total Cholesterol
- **TG:** Triglycerides
- **VLDL-c:** Very Low-Density Lipoprotein-cholesterol

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Conflicts of interest

No conflict of interest.

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