UNIVERSIDAD DE COLIMA

FACULTY OF MEDICINE

MASTER’S DEGREE IN MEDICAL SCIENCES

THESIS TO OBTAIN THE MASTER’S DEGREE IN MEDICAL SCIENCES

EFFECT OF AN AEROBIC EXERCISE PROGRAM ON METABOLIC DISORDERS LEVELS IN HIGHER EDUCATION STUDENTS AT THE UNIVERSITY OF COLIMA, RANDOMIZED CLINICAL TRIAL.

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Abbreviations

PA	Physical Activity
MD	Metabolic Disorders
ATP	Adenosine Triphosphate
AC	Abdominal Circumference
CEPT	Cholesteryl Ester Transfer Protein
ENSANUT	National Health and Nutrition Survey
NCDs	Non-communicable Diseases
GLUT2	Glucose Transporter Type 2
HD	High-Density Lipoprotein
AH	Arterial Hypertension
BMI	Body Mass Index
INEGI	National Institute of Statistics and Geography
IPA-Q	International Physical Activity Questionnaire
LDL	Low-Density Lipoprotein
WHO	World Health Organization
PAHO	Pan American Health Organization
TG	Triglycerides
UNAM	National Autonomous University of Mexico.

Resumen

Este estudio es un ensayo clínico aleatorizado simple, y tendrá como objetivo: Evaluar el efecto de un programa de ejercicio físico aeróbico sobre la disminución de los triglicéridos ,presión arterial, obesidad abdominal, glucosa alterada y el aumento en el HDL en estudiantes de nivel superior de la Universidad de Colima, ya que en esta población mexicana se ha presentado una alta prevalencia de obesidad, sedentarismo e inactividad física, factores que influyen en el alto riesgo para el desarrollo de los trastornos metabólicos y enfermedades cardiovasculares. Material y método: Se implementará un ensayo clínico aleatorizado simple. La muestra será de 48 estudiantes de nivel superior voluntarios de la Universidad de Colima, que estarán divididos en dos grupos de 24 personas. Instrumentos: Cuestionario IPA-Q (Anexo 6), circunferencia abdominal (anexo 7), presión arterial (anexo 8), extracción de sangre por punción venosa para el HDL, triglicéridos y glucemia (anexo 9) Queen´s college step test (10). Procedimiento: Una vez se reclute y se procese toda la información de las pruebas, se tomarán en cuenta los criterios de inclusión establecidos (tabla 2) para obtener el total de la muestra. Se realizará una aleatorización simple a través de una bolsa con sobres blancos sellados que contendrán por dentro la letra al grupo que pertenece el sujeto. Cada participante sacará un sobre, escribirá su nombre encima de él y lo entregará a la persona encargada, posteriormente, estos sobres se abrirán y se asignarán los participantes a los grupos siguiendo el criterio del simple ciego, de acuerdo con la letra que tenga dentro del sobre (control n=24 y experimental n=24). El Grupo experimental realizará un programa de ejercicio físico aeróbico (EFA) que involucra trote, natación (actividades acuáticas) y bicicleta estática durante 8 semanas, tres veces por semana con una duración de 60 minutos por sesión de ejercicio a una intensidad del 57% al 76% de la frecuencia cardiaca máxima (FCM). El grupo control realizará un ejercicio físico aeróbico de caminata al 57% al 76% de la FCM. Posibles resultados: Se espera de esta intervención tener cambios favorables en los trastornos que padece la muestra de intervención y corroborar la eficiencia del ejercicio físico aeróbico planificado en disminuir estos riesgos.

Palabras claves: Ejercicio, obesidad, HDL, Triglicéridos, hipertensión.

Abstract

This study is a simple randomized clinical trial, its **objective** is to evaluate the effect of an aerobic physical exercise program on the reduction of triglycerides, blood pressure, abdominal obesity, altered glucose levels, and the increase in HDL in college-level students at the University of Colima, due to the high prevalence of obesity, a sedentary lifestyle, and physical inactivity in Mexican population, all of which contribute to a high risk for the development of metabolic disorders and cardiovascular diseases. **Methods and Materials:** A simple randomized clinical trial will be conducted with a **sample** of 48 voluntary students from the University of Colima, divided into two groups of 24 people. **Instruments:** IPA-Q questionnaire *(Annex 6),* waist circumference *(Annex 7),* blood pressure *(Annex 8),* blood extraction by a venous puncture for HDL, triglycerides, and blood glucose *(Annex 9),* Queen's College Step Test (*Annex 10*). **Procedure**: Once all the information from the tests is collected and processed, inclusion criteria (*table 2)* will be taken into consideration to obtain the total sample. Simple randomization will be carried out through a bag of sealed envelopes that will contain the letter of the group to which the subject belongs. Each participant will draw an envelope, write their name on it and hand it to the supervisor. Afterwards, these envelopes will be opened and participants will be assigned to the groups following the simple blind criteria, according to the letter on the envelope. The Experimental Group will undergo an aerobic physical exercise (APE) program involving jogging, swimming, and static cycling, three times a week with a duration of 60 minutes per exercise session with a progressive intensity, which will start at 57%-63% of the maximum heart rate (HRmax) in the first 4 weeks of the study, and will increase to 64% -76% in the final four weeks, fulfilling the principle of progressive overload. The control group will perform aerobic physical exercise, which will be walking at 57% to 76% of HRmax. **Expected results:** This intervention will lead to favourable changes in the disorders experienced by the intervention population and, at the same time, confirm the effectiveness of the planned aerobic physical exercise in reducing these risks.

Keywords: Exercise, Obesity, HDL, Triglycerides, Hypertension.

1. Introduction

The World Health Organization (WHO), in 2022, defines physical activity (PA) as any bodily movement produced by skeletal muscles. Its level of effort is classified into three categories: light, moderate, or vigorous (1). The effects of PA are strongly influenced by factors such as volume, rest, quantity, and frequency of physical activity performed per week or day. It is widely known that PA has numerous benefits, including the prevention of non-communicable diseases such as overweight, obesity, type 2 diabetes mellitus, hypertension, and dyslipidemias (2).

The Pan American Health Organization (PAHO) mentions that sedentary behaviour and physical inactivity in the general population have contributed to the exponential increase in non-communicable diseases, which are the most common metabolic alterations, including dyslipidemia, hypertension, and type 2 diabetes mellitus, since more than 1.9 billion adults worldwide have reported some form of metabolic issue (3). This silent epidemic, driven by lifestyle habits and choices, has become a worrying shadow that looms over global health. Henceforth, these environmental and cultural conditions disproportionately affect countries in Latin America, particularly university students (4).

For instance, in Mexico, the National Health and Nutrition Survey (ENSANUT) in 2022 revealed that the prevalence of overweight and obesity among undergraduate students ranged from 72.5% to 75.2%. Abdominal adiposity was reported in 39.6% of the population (5). Additionally, high blood pressure values (>130/80 mmHg) were observed in 39.8% of the students (6). The National Autonomous University of Mexico (UNAM) also reported that 66% of its students across various faculties exhibited two to three metabolic alterations due to sedentary lifestyles and inactivity (7). Therefore it is estimated that 30% of adolescents and adults are inactive, while 50% spend an average of 1 hour and 40 minutes on transportation, 2 hours minimum on digital screens, and 3 hours and 30 minutes sitting (8). These data highlight the high risk of metabolic imbalances, which could lead to low HDL, elevated triglycerides, abdominal obesity, glucose alterations, and hypertension (3).

Evidence shows that adopting healthy habits through regular physical exercise significantly reduces metabolic disturbances that substantially impact overall health (4). For instance, engaging in concurrent aerobic exercise—based on a circuit of up to 10 exercises, each lasting 45 seconds, with 30 seconds of recovery for 8 weeks—may reduce visceral fat, lower blood pressure, and prevent cardiopulmonary pathologies (9). Therefore, further scientific research is necessary to maximize the evidence supporting the benefits of aerobic physical exercise for the well-being of university populations.

2. Theoretical framework

2.1.1 Definition of Metabolic Disorders

Metabolic disorders represent a medical condition group that predisposes individuals to imbalances in the body's metabolic processes. These imbalances encompass physiological, chemical, and energetic transformations within the organism. Consequently, they significantly increase the risk of developing cardiovascular diseases and type 2 diabetes mellitus (10). This group includes a spectrum of anomalies such as elevated triglycerides (TG), decreased high-density lipoproteins (HDL), arterial hypertension (AH), alterations in glucose levels, and an increase in abdominal fat. See Table 1 for details.

Table 1. Criteria for Metabolic Disorders in Adults. Ramírez 2022.

	Women	**Men**
Abdominal Obesity	>85 cm	>90 cm
Triglycerides	≥150 mg/dl	≥150 mg/dl
HDL	<50 mg/dl	<40 mg/dl
Blood Pressure	130 mmHg/ >85 mmHg	130 mmHg/ <85 mmHg
Fasting Glucose	> 100 mg/dL	>100 mg/dL

Source: Based on reference (11)

2.1.2. Epidemiology of metabolic disorders

The prevalence of these disorders has been increasing in recent years, especially in developing countries, where it is estimated that between 20% and 50% of the population may be affected (3). Cristóbal in 2021 and Ismael in 2022 have reported a high prevalence of abdominal fat among young university students in Mexico, ranging from 56.6% to 72.5% (5,7). Likewise, this population significantly exceeds the prevalence of arterial hypertension (AH), with multiple authors, such as Hidalgo in 2019 and Campos in 2022, revealing that 56.49% to 60%

of individuals present this condition (6, 12). These statistics reflect a broader health issue, as evidenced by the fact that cardiovascular diseases rank among the leading causes of death in young adults aged 15 to 24 years, according to data from the National Institute of Statistics and Geography (INEGI) in 2022 (13).

2.1.3. Aetiology of Metabolic Disorders

The factors contributing to the development of metabolic disorders are multifactorial, involving genetics, as well as environmental and cultural influences. However, environmental factors, particularly unhealthy eating habits, sedentary lifestyles, and lack of physical activity, play a predominant role (14), since the trend towards a diet high in saturated and trans fats, along with the consumption of ultra-processed foods, combined with a sedentary lifestyle, contributes greatly to the onset and progression of these disorders, increasing the chances of developing cardiovascular and cerebrovascular diseases (14).

2.1.4. Abdominal Obesity

According to Rebolledo in 2020, abdominal obesity is an excessive accumulation of lipids in the abdominal area, which is divided into two types: subcutaneous fat, located beneath the skin, and visceral fat, situated around internal organs within the abdominal cavity (10). According to the World Health Organization (WHO), the risk thresholds for abdominal circumference are 90 cm for men and 85 cm for women.

2.1.4.1. Epidemiology of Abdominal Obesity

Abdominal obesity is a multifactorial condition. Research by Flores in 2020, Cristóbal in 2021, and Ismael in 2022 revealed the prevalence of this condition among university students in Mexico, ranging from 56.6% to 72.5% (2,5,7).

Likewise, Salazar and colleagues investigated students' body mass index (BMI) and physical activity levels at the University of Colima in 2013, finding that 37.9% of students fell into the overweight or obese range. They also used the International Physical Activity Questionnaire (IPAQ) to assess physical activity levels and found that 53.7% had deficiencies in it, providing additional insight into the link between physical activity and obesity (15).

2.1.4.2. Aetiology of abdominal obesity

Abdominal obesity results from the interaction of multiple factors, encompassing biology, individual psychology, food consumption, and physical activity (10). Biological factors play a primary role in abdominal obesity, influencing not only the distribution of body fat but also the individual's metabolic response to various stimuli and conditions (16). Variations in genes that regulate appetite and satiety, such as leptin, have been identified as capable of determining a person's predisposition to accumulate fat in the abdominal region and their ability to metabolize nutrients efficiently (10).

Environmental factors, including socioeconomic, cultural, and racial aspects, significantly impact the development of abdominal obesity. Specifically, sedentary lifestyles, and physical inactivity, accompanied by diets rich in saturated fats and sugars contribute exponentially to increased abdominal fat (17).

2.1.4.3. Pathophysiology of abdominal obesity

The process begins with the ingestion of these foods, which are broken down into glucose within the small intestine. Subsequently, the pancreas receives information about high glucose concentrations in the body through the facilitated diffusion of glucose transporter type 2 (Glut 2). In response, it secretes insulin, which assists glucose entry into the cell membrane with the help of Glut 4 via exocytosis (18).

Once glucose is inside the cell, it initiates various metabolic processes. The first one is glycolysis, which functions to break down glucose into its simplest form through ten steps: (Glucose 6 phosphate, fructose 6 phosphate, fructose 1,6 diphosphate, dihydroxyacetone, glyceraldehyde 3-phosphate, 1,3 bisphosphoglycerol, 3 phosphoglycerate, 2 phosphoglycerate, phosphopyruvate and finally 2 molecules of pyruvate). In the first four steps, two ATP molecules are consumed. Following this, two pathways are formed: dihydroxyacetone and glyceraldehyde-3-phosphate, the first pathway is quickly converted into glyceraldehyde 3-phosphate by an enzyme called Triose-phosphate isomerase to continue its degradation process (17). These reactions conclude in two molecules of pyruvate, two ATP and two molecules of NADH, after this result, the pyruvate molecules start the second process in the Krebs cycle (initially converting to Acetyl-CoA), which has the function of extracting the maximum amount of energy possible through different molecules (ATP, FAD, NAD). These molecules act on another molecule called citrate (union of oxaloacetate and acetyl-CoA), which undergoes 8 changes (citrate, cis-aconitate, D-isocitrate, ketoglutarate, succinyl-CoA, succinate, fumarate, malate, and oxaloacetate). Among these changes, two involve water binding and recovery, five involve dehydrogenase production, and one produces synthetase. For each Krebs cycle, 10 NADH and 2 FADH molecules are made, and then these energy-loaded hydrogen molecules proceed to the final step of oxidative phosphorylation; This consists of extracting the hydrogen protons through four complexes located in the mitochondrial membrane to take them to the intermembranous space for them to be absorbed again in an event called Chemiosmosis, which captures the hydrogen protons in an ADP molecule to synthesize phosphate and thus create ATP with the assistance of oxygen. Subsequently, the generated ATP is directed to all body tissues to provide said energy (7,17). If this energy remains unused in any system or tissue, de novo synthesis occurs, converting it into free fatty acids, Later, three fatty acids combine with glycerol-3-phosphate to become a triglyceride, and be stored as an energy reserve at medium or long term in cells called white adipocytes (19), abdominal adipocytes are most susceptible to this process, since they have a greater capacity for hypertrophy. If an individual continues to consume such foods while leading a sedentary lifestyle, the body will induce adipocyte hyperplasia, resulting in abdominal obesity. Various authors have determined that an increase in this condition elevates the risk of cardiovascular and cerebrovascular diseases (7,10).

2.1.5 Dyslipidemias

Dyslipidemias are imbalances or alterations in plasma lipids. They are characterized by an elevation in triglycerides (>150 mg/dL), VLDL (>30 mg/dL), and cholesterol (>200 mg/dL). As well as a decrease in high-density lipoprotein (HDL) levels (<40 mg/dL in men and <50 mg/dL in women) (20). Generally, this condition is 20% more common in individuals diagnosed with type 2 diabetes mellitus (DM2), obesity, hypertension, and polycystic ovary syndrome (PCOS) (17,21). *Table 1.*

2.1.5.1. Epidemiology of dyslipidemias

Dyslipidemias are one of the most frequent causes in the development of cardiovascular diseases (3). Ismael in 2022, and Ortega & Macheno in 2023 revealed the prevalence of dyslipidemias among university students in Mexico, which ranged from 21.1% to 37.1% (5, 22–24).

Similarly, in 2020, Ramos and colleagues investigated the prevalence of dyslipidemias among university students in southern Mexico. Their results indicated that the most significant alteration observed in these students was hypertriglyceridemia at 35.7%, followed by hypercholesterolemia at 21.4%. Thus, it is concluded that these individuals were at a high risk of complicating their health status (25)

2.1.5.2. Aetiology of dyslipidemias

Dyslipidemias can be caused by two factors: genetic or environmental. Genetic factors refer to individuals with first-degree relatives affected by this condition, making them highly susceptible to it. The primary genetically caused dyslipidemias are familial hypercholesterolemia, familial combined dyslipidemia, polygenic hypercholesterolemia, and familial hypertriglyceridemia (26). On the other hand, environmental factors stem from the unhealthy lifestyle of the aforementioned subjects (26,27).

2.1.5.3. Pathophysiology of dyslipidemias

Dyslipidemias due to environmental causes begin with an excessive accumulation of triglycerides, which undergo five different states to be formed. Among them, we can mention glycerol 3 phosphate (this molecule can come from two processes: from a Dihydroxyacetone phosphate, which is an intermediate of glycolysis, or from glycerol which is part of lipolysis). As this molecule forms, it activates the enzyme glycerol-3-phosphate acyltransferase (located in the endoplasmic reticulum), which has the function of adding an activated fatty acid (Acyl-CoA) to the molecule that then receives the name of Lysophosphatidate. In addition, another enzyme called acyl glycerol phosphate acyltransferase immediately acts to add another Acyl-CoA, but this time, an unsaturated one, resulting in a molecule named phosphatidate (28). To capture the final unsaturated fatty acid, the glycerol-3-phosphate molecule must eliminate its phosphate group through an enzyme called phosphatidate phosphohydrolase. This process leads to the formation of diacylglycerol, which can then accept the last activated fatty acid via the enzyme diacylglycerol acyltransferase, ultimately forming triglycerides. *Figure 1.*

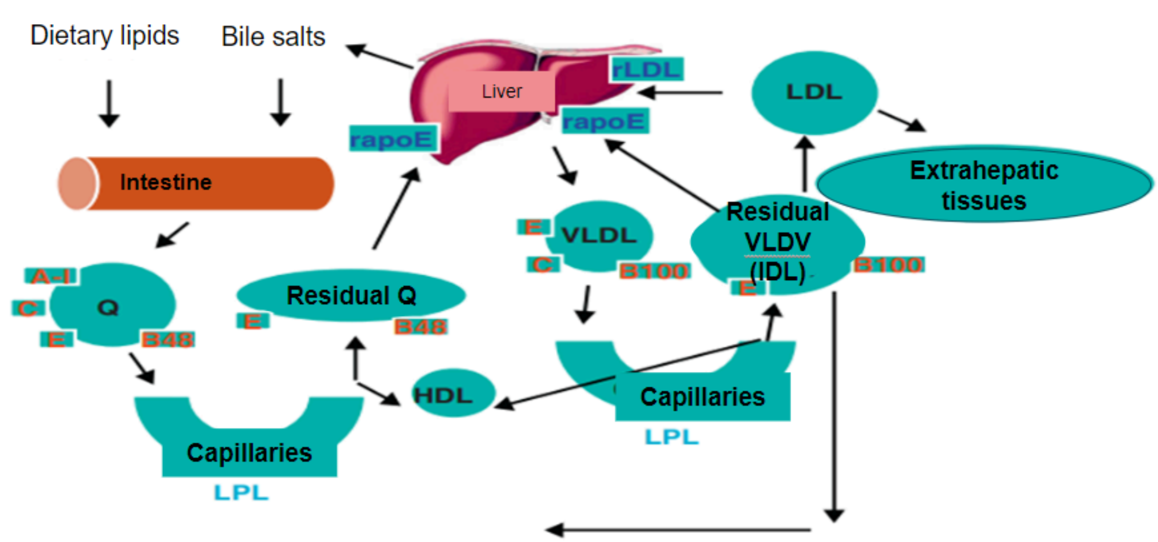


Figure: 1. Overview of lipoprotein metabolism.
Image taken from Pavia 2022(29).

Large amounts of triglycerides present in the blood can be harmful to health if they are not stored as reserve energy through the process called lipogenesis, which results in their elevation or conversion into very low-density lipoprotein (VLDL), and creates other health problems such as the decrease in HDL, since it delivers stratified cholesterol to VLDL, which in turn delivers triglycerides via a protein called CETP (cholesteryl ester transfer protein), when triglyceride-loaded HDL reaches the liver, it does not release the triglycerides but instead degrades them using pancreatic lipase. Consequently, this leads to decreased HDL concentrations (26,27). *Figure 2.*

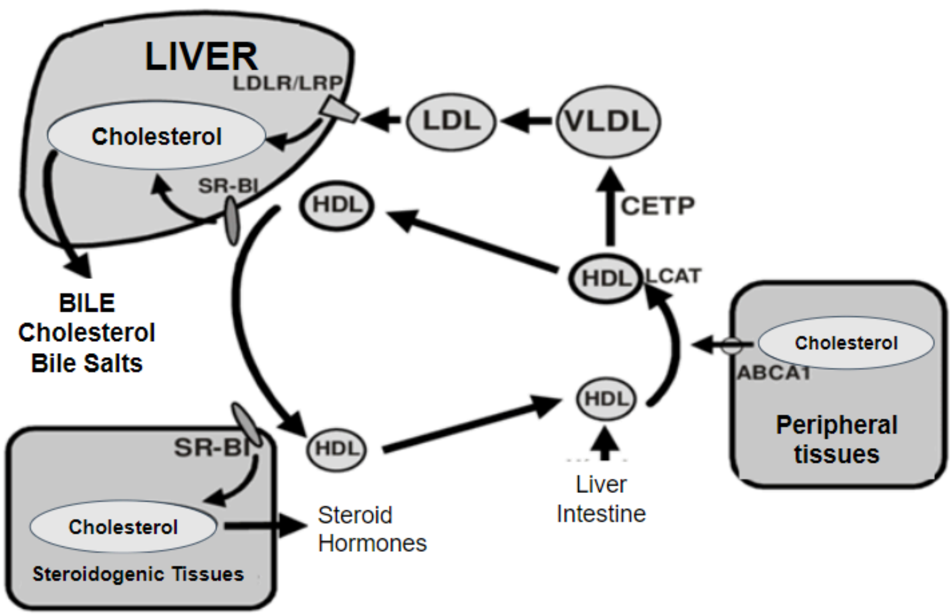


Figure 2. Behavior of HDL in the human organism.
Source: Taken from Macheno (24).

2.1.5.4 Hypertriglyceridemia

Triglycerides are a type of lipids present in the blood and adipose tissue. They function as storage for unused calories, not utilized as energy. When their levels in the body exceed 150 mg/dL, they can lead to the excessive accumulation of fat in adipocytes, and thus increase the risk of developing cardiovascular diseases such as hypertension, hyperlipidemia, and hardening of the arteries (atherosclerosis) (21). *Table 2.*

2.1.5.5. Epidemiology of hypertriglyceridemia

Triglycerides can be referred to as multifactorial. In 2022, ENSANUT, and in 2021, Gallego, reported the prevalence of this condition among university students in Mexico. According to their findings, 8.6% to 21.1% of students had this alteration, which could increase the risk of cardiovascular and cerebrovascular diseases (5,30). *Table 2*.

Table 2. Blood Triglyceride Leves in Adults

Triglyceride Level	Concentration (mg/dl)
Normal	< 149 mg/dl
Altered	≥ 150 mg/dl

Source: Adapted from ATP III (31)

2.1.5.6 High-density lipoproteins (HDL)

HDL has various functions, one of the most well-known being its role as a “scavenger” for cholesterol, removing excess cholesterol from arterial walls and returning it to the liver, where it is “discarded”, added to the bile and eliminated through feces, since the human body cannot degrade cholesterol on its own (28). According to the Adult Treatment Panel III (ATP III) guidelines for dyslipidemia, the cutoff points for potential risk are <40 mg/dL in men and <50 mg/dL in women (31).

2.1.5.7. Altered HDL epidemiology.

The epidemiology of HDL in individuals can be crucial for their overall health. Therefore, it constitutes a crucial field in cardiovascular health research among university students in Mexico. Some authors reported that the prevalence of this condition in this population ranged from 6% to 21.1% (5,30,32).

In 2020, González conducted a study to determine the prevalence of lipid profile alterations in students from two Mexican universities. Among their findings, HDL showed an alteration rate of 6.7% in the subjects. It was also emphasized that this condition could lead to the development of related diseases, which might play a decisive role in future cardiovascular and cerebrovascular conditions (33).

2.1.6. Arterial hypertension.

According to the ATP III guidelines, arterial hypertension is a multifactorial disease characterized by consistently high blood pressure, with a cutoff point of >130/85 mmHg (31). These values are associated with an increased risk of cardiovascular diseases, stroke, and chronic kidney diseases (12)

2.1.6.1. Epidemiology of high blood pressure

The 2022 ENSANUT study revealed that 39.6% of young adults in Mexico with education beyond secondary school suffered from this condition. This percentage increased to 58.8% if individuals had abdominal obesity (6).

Another study conducted by Almazán and colleagues in 2020 aimed to determine the prevalence of metabolic disorders among Mexican university students. The study concluded that 64.8% of students had systemic hypertension, which the author attributed to poor diet, sedentary lifestyle, and physical inactivity (34).

2.1.6.2. Aetiology of Arterial Hypertension

Cardona and colleagues in 2022 affirm that the causes of hypertension are classified into two categories: environmental and genetic. These, in turn, are further divided into two subtypes: primary and secondary hypertension. Primary hypertension, which represents between 90% and 95% of cases, is segmented into genetic and environmental factors (35). Genetic factors include dysfunction of angiotensin receptors, reduced renal excretion, and the effects of vasoconstrictive influences such as arterial hyperplasia or hypertrophy. These elements significantly contribute to the increase in blood pressure (35).

2.1.6.3. Pathophysiology of arterial hypertension.

On the other hand, environmental factors associated with primary hypertension include being overweight, lack of physical activity, high-stress levels, and the consumption of foods with elevated amounts of salt or sodium chloride. These habits and conditions lead to a severe imbalance in the body. Typically, this condition does not exhibit evident symptoms until blood pressure is measured using a baumanometer (35,36).

The pathophysiology of hypertension is multifactorial. However, when there is an alteration in the renal environment, sodium elimination may decrease, sequentially leading to increased blood volume, cardiac output, and peripheral vasoconstriction. Additionally, there is an imbalance in the renin-angiotensin-aldosterone axis. This axis, due to prior stability in response to a false perception of pressure decline, stimulates the adrenal glands and promotes aldosterone retention of sodium. Consequently, blood pressure within the blood vessels transitions to a state of arterial hypertension through the aortic baroreceptors (blood pressure-sensing receptors), which detect unusual pressure changes and, in turn, influence cardiac output and peripheral resistance (35,37). *Figure 3.*

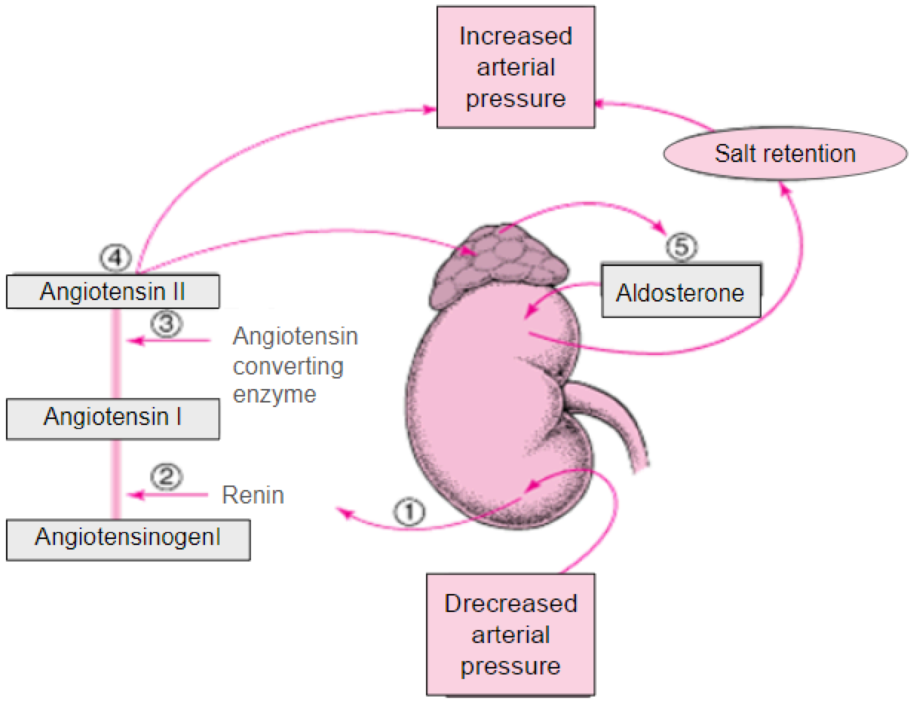


Figure 2. Regulation of blood pressure through the renin-angiotensin-aldosterone system. Taken from González in 2020. Source: Based on reference (38).

2.1.7. Hyperglycemia

Alteration in glucose refers to a permanently abnormal change in these levels. According to the ADA criteria in 2024, these alterations can be expressed through various tests, such as fasting plasma glucose with a result >100 mg/dL or glycated hemoglobin (HbA1c) with results exceeding >5.7% (39 mmol/mol) (39).

2.1.7.1. Epidemiology of Hyperglycemia

The epidemiology of blood glucose alterations is crucial for understanding the population's health status. In 2022, Baltazar in 2022 and Basto in 2023 reported the prevalence range of glucose abnormalities among higher-level students in Mexico, which ranged from 14.3% to 29% (40,41).

Similarly, in 2022, Zenteno and colleagues conducted a study in a private school in Tuxtla Gutiérrez, Chiapas, which aimed to determine the prevalence of different metabolic disorders among students at that institution. The study revealed that 25.3% exhibited hyperglycemic alterations, and 56% of them reported a sedentary lifestyle, extrapolating the risk factors for cardiovascular diseases (32).

2.1.7.2. Aetiology of Hyperglycemia

Blood glucose alterations have different degrees. The first degree refers to genetic modifications, which may involve changes in the TCF7L2 gene (which plays a role in insulin control), the CAPN10 gene (calpain 10) which is linked to glucose homeostasis, and the KCNJ11 gene (a potassium channel, Subfamily J11). The latter gene encodes a potassium channel subunit associated with insulin secretion. Additionally, (42). The environmental degree refers to diets with high consumption of saturated fats, excessive intake of sugary products, and other components, such as a sedentary lifestyle and physical inactivity (43).

2.1.7.3. Pathophysiology of Hyperglycemia

The hormone responsible for regulating blood glucose is insulin, which is produced in the pancreas, an organ that consists of two types of tissue: exocrine and endocrine. The endocrine tissue includes Langerhans islets (these islets are composed of Alpha, Beta, and Delta cells). Beta cells play a crucial role in this process, as they can produce up to 60% of active insulin and Amylin (44). Whereby, If there is any disruption in the production of active insulin by pancreatic cells, it directly leads to permanently elevated blood glucose levels. This, in turn, can result in potential health complications for the individual. *Figure 4*.

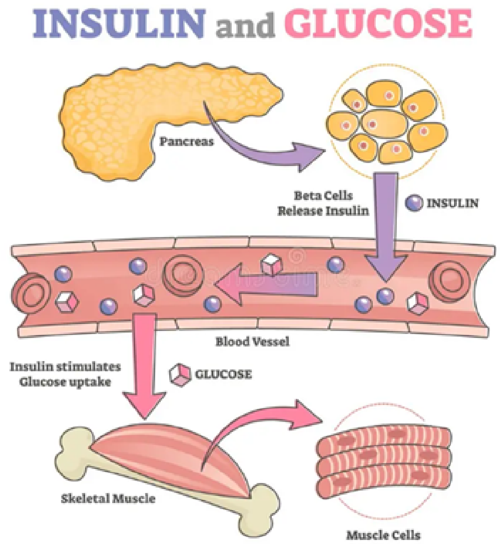


Figure 3. Behaviour of glucose in the human body. Based on González in 2020
Source: Based in León in 2023(38).

2.2. Diagnosis and evaluation of metabolic disorders

2.2.1. Tests and Diagnosis for Determining Abdominal Obesity

There are two widely established methods for measuring abdominal fat parameters. One of them is bioimpedance (a scale that quantifies body composition using electrodes), and the second method is abdominal circumference measurement using a measuring tape, with results given in centimetres. In order to perform the abdominal circumference test, the patient should be in the anatomical position. Subsequently, the mid-axillary line is located, at the midpoint between the costal margin and the iliac crest, which has to be marked with a pen, to serve as a guide to place a certified measuring tape, to measure the circumference at the end of a normal expiration. Making at least two measurements and calculating their average (45) is recommended. The results are compared with the WHO cut-off points: >90 cm in men and >85 cm in women (46).

2.2.2. Testing and diagnosis of factors (TG and HDL) involved in dyslipidemia.

For an initial detection of dyslipidemia, it is essential to consider the following: A comprehensive medical history, including family history of cardiovascular diseases, pancreatitis, obesity, arterial hypertension, dyslipidemias, smoking, alcoholism, as well as an evaluation of diet and physical activity (47).

Additionally, laboratory testing is a better option. The lipid profile is a laboratory analysis that aims to determine the concentrations of various fats in the blood, including total cholesterol, LDL, HDL, and triglycerides. These analyses are crucial for assessing the risk of vascular and cardiovascular diseases (48). It is essential that the patient undergoes this analysis after fasting (8 to 12 hours before the test) and abstains from alcohol consumption for 24 hours. The test involves a venous puncture to collect a blood sample, which will be analyzed by authorized equipment (48). The obtained results should be correlated with established cutoff points. *Table 1*. There is a close relationship between dyslipidemia and increased hypertension, as cholesterol, LDL, and triglycerides can cause damage and blockages in arterial walls (47).

2.2.3. Test and diagnosis of systemic arterial hypertension

For the diagnosis of systemic arterial hypertension (SAH), the test must be performed with a stethoscope and a sphygmomanometer (Baumanometer) with a properly calibrated band. The process begins with the patient sitting for 5 to 10 minutes to stabilize blood pressure. Afterwards, the Baumanometer band will be wrapped around the arm, it should be 2 or 3 cm above the fold of the elbow joint. Next, the brachial artery must be palpated to be able to place the bell of the stethoscope at the level of the brachial artery (The centre of the camera must align with the brachial artery). Once these steps have been completed, the handle of the manometer will be inflated until a pressure of 160 mmHg is reached. After reaching this reference, the valve will be opened gradually with a speed of 2 to 3 mmHg/second, listening in turn to the pulsations emitted by the body to determine systolic and diastolic blood pressure

(35). If the patient obtains a systolic blood pressure of >130 mmHg and diastolic blood pressure of >80 mmHg, an alteration in blood pressure must be confirmed (36). Annex 5.

2.2.4. Testing and Diagnosis of Blood Glucose Alterations

To determine blood glucose alterations, a step-by-step process should be followed, starting with general recommendations. One of the most important steps is to fast for a minimum of 8 hours(49). The blood sample will be obtained through a venous puncture technique, filling a clinical tube specifically for fasting glucose testing. After collection, the tube will be taken to the laboratory for analysis(50). If the patient's results show >100 mg/dL to 125 mg/dL, they may be diagnosed with prediabetes(39).

2.3. Factors Associated with Metabolic Disorders in Higher Education Students

In 2022, the Pan American Health Organization (PAHO) reported that cardiovascular diseases accounted for the majority of deaths due to non-communicable diseases (NCDs), totalling 17.9 million deaths annually, while diabetes contributed to 1.6 million deaths worldwide(3). The risks that can exacerbate these figures include metabolic alterations such as Abdominal obesity, hypertension, HDL, triglycerides, glucose alterations, sedentary lifestyle and physical inactivity (51). These factors significantly impact young people and adolescents, since, worldwide, over 80% of them exhibit insufficient levels of physical activity (52). The WHO recommends adopting healthy practices, including quitting smoking, maintaining a balanced diet, achieving a healthy weight, reducing alcohol consumption, and minimizing sedentary behaviour and physical inactivity to mitigate the risks associated with these metabolic disorders(7,52,53).

2.3.1. Unbalanced diet as a risk factor in metabolic disorders among higher education students

Diet, in addition to serving as a fundamental human need, fulfils various societal functions related to cultural customs, socioeconomic factors, and even shared events that reflect collective well-being (54).

PAHO determined that eating habits are established during childhood and adolescence, influenced by various channels of interaction, including family dynamics. However, over time, social circles, lifestyle, and dietary patterns evolve to align with sociocultural trends and demands (55). When students enter university life, they often move away from their family nucleus, leading to an adjustment to new living situations. Economic circumstances, cooking skills, and dietary customs shared with peers all play a role in this adaptation (54).

Therefore, the lifestyle changes associated with the start of university life significantly impact both physical and mental health. Many young individuals exhibit inadequate eating habits, characterized by excessive consumption of fast food, skipping breakfast, irregular meal times, and high intake of meat, sweets, pastries, and sodas as their main beverages. These dietary patterns negatively affect overall nutritional status and health (54, 56).

According to perspectives from Ramos 2020, Lozano 2021, and ENSANUT 2022, nutrition surveys reveal that Mexican higher education students have obesity rates ranging from 48.6% to 72.5%, which is highly detrimental to cardiovascular health, especially when combined with the widespread physical inactivity and sedentary behaviour observed among young individuals (5, 25).

2.3.1. Sedentary lifestyle and physical inactivity as a risk factor in metabolic disorders in higher education students.

The World Health Organization (WHO) and Silveira in 2022 define physical inactivity as failing to engage in 150 minutes of moderate-intensity physical activity or 75 minutes of vigorous-intensity activity per week. Likewise, they define sedentary behaviour as engaging in activities with a basal energy expenditure equal to or less than 1.5 METs (unit of measurement for metabolic rate or energy consumed while at rest) (annexe 12). Examples of such activities include sitting for long hours at university or home, lying down, looking at a cell phone, or doing desk work (52,57).

According to the PAHO and the National Health and Nutrition Survey (ENSANUT) in 2022, physical inactivity levels in Latin America increased from 33% to 39% (58). In Mexico, there has been a growth from 14% in 2016 to 20.8% in 2018(59). The latest ENSANUT report reveals that 42.6% of adolescents aged 15 to 19 don't accumulate an average of at least 60 minutes per day of moderate or vigorous physical activity (MVPA), 90.8% of them spend >2 hours daily in front of screens, and 48.1% of adolescents aged 14 to 17 do not get the recommended sleep duration for their age (8 to 10 hours per day) (60).

In a study conducted by the National Autonomous University of Mexico (UNAM), researchers identified the precursor factors for metabolic alterations that students at the university might experience. Upon collecting this information, the results revealed that 56% of the university population is sedentary, and 90% reported inadequate dietary habits. With such compelling parameters, the author asserts that this population is at high risk of developing metabolic disorders in the short or long term, thereby compromising their cardiovascular health(7). Additionally, a study assessed the cardiorespiratory fitness VO2max of medical students using the Queens College Step Test (a method to determine cardiorespiratory fitness based on maximum oxygen consumption). The results indicated that the subjects had moderate cardiorespiratory fitness, associated with physical inactivity, sedentary behaviour, and unhealthy dietary changes, further increasing the risks of metabolic alterations(61).

Therefore, in 2022, the World Health Organization (WHO) and the Pan American Health Organization (PAHO) recommended engaging in physical activity for at least 150 minutes per week. This can be broken down into 75 minutes of vigorous activity and another 75 minutes following the aerobic metabolic pathway to maximize oxygen transport across different body systems(1,58). Likewise, there is evidence that aerobic exercise, adhering to the principles of

Frequency, Intensity, Time, and Progress (FIIT), can positively influence the reduction of these metabolic alterations, potentially restoring balance(62).

Silveira in 2022, and Basto and Medina in 2023 have highlighted that inactive individuals who gradually transition to moderate physical activity (MPA) do not face known risks of sudden cardiac events, decrease metabolic alterations and have minimal chances of bone, muscle, or joint injuries(40,57,60). Individuals accustomed to MPA can gradually progress to vigorous physical activity (VPA)(63).

2.4. Impact of physical exercise on metabolic disorders

Physical activity (PA) encompasses any bodily movement generated by skeletal muscles, requiring energy expenditure and is categorized into intensity levels: light, moderate, and vigorous(1). In 2022, the World Health Organization (WHO) recommends engaging in PA through planned, repetitive, and directed physical exercise. The goal is to improve and maintain physical fitness, involving body and muscle movement to enhance strength, speed, endurance, or flexibility, thereby promoting cardiovascular health(52). Likewise, PA aims to tailor exercise to individual needs, considering diverse physical capacities, since each person may have their advantages and limitations. Not least, PA aims to maintain proper warm-up, central exercise, and cool-down phases for effective and safe practice, ultimately promoting an active and healthy lifestyle(64).

Sequi in 2020 and Primo in 2022 reaffirmed the importance of physical exercise (PE) in individuals with morbidities related to cardiovascular diseases, as it brings considerable health benefits for those with these disorders(63,64). For instance, a study conducted by Chávez and colleagues in 2021 demonstrated that implementing an aerobic physical exercise program (such as walking, jogging, swimming, and dancing) for 20 to 30 minutes over 13 weeks among higher education students in Mexico could significantly reduce parameters associated with metabolic disorders. At the end of his intervention, he led to a considerable reduction of these parameters in this population. The results showed a decrease in abdominal circumference from 110.88cm ±14.27 in the pretest to 106.90cm ±14.41 in the posttest, as well as a reduction in triglycerides from 131.31 mg/dl ±22.53 to 116.90 mg/dl ±12.88 and a reduction of the alteration in glucose, that went from 94.69 mg/dl ±7.98 to 92.50 mg/dl ±5.52. The author attributes these results largely to the adequate application of the Frequency, Intensity, Time, Type of activity, and Progression of load (FITT) principles, which are part of exercise prescription(65).

2.5 Principles of FITT-VP

Exercise prescription is the process by which a systematic and individualized physical activity regimen is recommended based on an individual's needs and preferences, to achieve maximum benefits while minimizing risks. This prescription follows an organized and systematic approach, designed in terms of Frequency, Intensity, Time, Type, Volume, and Progression, known as the FITT-VP principle (66). The goals of an exercise prescription vary based on individual functions and interests, the person's health status, and environment, but in most cases these goals involve; improvement in physical fitness and improvement in health by reducing risk factors for suffering from chronic diseases(65,66).

The components of FITT-VP begin with Frequency, which refers to the number of days per week that an individual engages in physical exercise, for example, one, two or five days a week. According to the World Health Organization (WHO) guidelines from 2022, a minimum exercise frequency of three days per week is recommended to maintain reasonably optimal health (58,63).

The next component related to FITT-VP is Intensity, which is defined as the effort exerted by an individual to maintain an activity. It is typically measured on a scale from 0 to 10, where 5 to 6 corresponds to moderate-intensity aerobic exercise and 7 to 8 corresponds to vigorous-intensity aerobic exercise. Intensity is closely related to the concept of heart rate reserve (HRR), which can be calculated by subtracting the resting heart rate (RHR) ((the minimum heart rate at rest, it is usually determined mainly by taking the HR upon awakening) from the maximum heart rate (MHR) (This can be obtained through the theoretical maximum frequency, which consists of having a maximum of 220 beats and from this the age of the subject is subtracted, obtaining the MHR)(67,68). Having these two results, the formula proposed by Karvonen can be used (HR%= (HRR * % work intensity) + RHR). This result shows greater accuracy regarding the heart rate at which the subject must perform the physical exercise depending on the area in which they want to work. On the other hand, time refers to the duration in which the session should be performed (30 min to 60 min with a moderate intensity)(58).

The type of exercise is determined by the specific physical activity an individual wants to engage in. For instance, if you intend to perform continuous aerobic exercise, the following cyclic activities are recommended: walking, jogging, swimming, cycling or dancing, since these activities are particularly suitable for individuals who want to initiate an active lifestyle through physical exercise (58, 68).

Likewise, volume is one of the components of the FITT-VP. It is defined as the total amount of physical exercise measured in repetitions, sets, distance, or time. For cardiovascular health maintenance, a minimum of 150 minutes per week of physical exercise is recommended according to the criteria established by the World Health Organization (WHO) in 2022(52). Finally, one of the pillars of exercise prescription is progression, which is also part of the FITT-VP components. Progression involves gradually increasing either the frequency (number of days of activity) or intensity (exercise intensity zone based on heart rate) in an individual's physical exercise. This progression occurs at the end of a prescribed exercise period and takes into account the individual's cardiorespiratory capacity, perceived effort before potential modifications, and tolerance to exposure (intensity or frequency). These modifications contribute to improving overall health (6).

2.6 Zones of physical exercise according to intensity

In the prescription of physical exercise, there are different heart rate zones in which the person can determine the intensity of work (using the Karvone formula mentioned above), these zones are generally divided into five(70).

The first zone (referred to as the moderate activity zone) ranges from 50% to 59% of the maximum heart rate (FCM). This zone is characterized by low intensity and aids in quicker recovery for individuals. It is suitable for sedentary people with very low activity levels. Activities associated with this zone include walking, jogging, and cycling (71). The second zone (known as the weight control zone) spans from 60% to 69% FCM. In this zone, changes occur in the body as overall endurance begins to improve. The body becomes more efficient at oxidizing fats for energy utilization, and muscular capacity increases along with capillary density(71). The third zone (referred to as the aerobic zone) covers 70% to 79% FCM. It is characterized by improved aerobic capacity, strengthening of the cardiorespiratory system, and producing adaptations and enhancements in cyclic speed. Fat oxidation is still maintained in this zone (70). The fourth zone (known as the anaerobic threshold zone) ranges from 80% to 89% FCM. In this zone, the body's ability to metabolize lactic acid improves, and muscular power increases. Activities in this zone are typically of short duration, as fat oxidation decreases, and there is an increased reliance on phosphogens and carbohydrates(71). Finally, the fifth zone (referred to as the maximum intensity zone) is characterized by improved maximum speed and power. It also involves oxygen debt and significant accumulation of lactate, which later transforms into lactic acid(70). See Table 3.

Table 3. Exercise zones according to intensity. Garber 2011.

Intensity	% H. R. R.	% Max. H. R.
Very light	< 30%	<57%
Light	40% – 59%	57% – 63%
Moderated	40% - 59%	64% – 76%
Vigorous	69% - 89%	77% – 95%
Maximum	>90 %	>96%

Source: Adaptation based on reference(72)

2.7 Perceived Effort Scale

The Borg Scale, also known as the Perceived Exertion Scale, is a numerical tool used in conjunction with objective evaluation of heart rate. It is expressed on a scale from 0 to 10(73,74). The higher the number, the greater the effort the individual perceives while maintaining the activity (annexe 10). This scale indirectly measures the individual's state during execution and helps determine whether to increase or decrease work intensity to achieve specific exercise objectives.

2.8 Training Methods

Various authors have determined that exercise training (EF) is planned and structured, a concept known as periodization. The goal is to acquire, maintain, or improve an individual's physical condition (75,76). This concept encompasses essential elements such as volume, which includes to the total amount of physical activity performed in a session, including duration, distance, weight lifted, and repetitions executed (75). Intensity, on the other hand, quantitatively represents the work performed within a specific period. Meanwhile, frequency relates to how often an exercise prescription is carried out per week or month (76).

2.8.1 Continuous training methods

Continuous training is characterized by applying an uninterrupted training load during the session, which can be prolonged and leads to constant physiological adaptations. These training methods are generally based on cyclic exercises (walking, jogging, swimming, cycling, and hiking), and classified into different forms (Variable Continuous Method and Continuous Method)(75). The variable continuous method is characterized by intensity variations during the performed work. These variations can occur through changes in the athlete's movement speed and/or due to irregularities in the terrain(75). On the other hand, uniform continuous training is applied during preparatory periods of physical training to improve cardiovascular capacity in subjects. One of the principles is to maintain a constant load, meaning no breaks or rest periods during the training. This method is divided into two sub-methods: extensive continuous method and intensive continuous method(58,77,78).

This latter method is characterized by being performed at moderate to moderate-high intensity, falling within the aerobic and super-aerobic zones (70-80% of VO2max) and with a medium to medium-high workload (between 30 and 90 minutes). Among its effects are the improvement of glycogen metabolism, increased speed in anaerobic threshold situations, increased maximum oxygen volume, cardiac hypertrophy, and improved lactate production-reutilization(75). On the other hand, the extensive continuous method is an aerobic physical training performed at low intensity, within the regenerative or sub-aerobic zone (50-70% of VO2max) and with a high volume (from 30 minutes up to more than two hours). Its effects include the utilization of free fatty acids, increased peripheral circulation, glycogen savings, cardiac hypertrophy, and enhanced recovery(79).

2.8.2. Aerobic Physical Excercise

Aerobic physical exercise (APE) involves activities that raise the heart rate to improve the body's efficient utilization of oxygen. These exercises include sustained activities at moderate intensity, such as running, swimming, jogging, cycling, and dancing. During aerobic exercise, the body increases heart rate and respiration to supply more oxygen to the working muscles. This strengthens the heart and lungs, improves blood circulation, and enhances overall aerobic capacity. Additionally, APE is beneficial for weight loss and the prevention of chronic diseases such as cardiovascular conditions(75,80).

The ADA in 2024 revealed that performing at least 150 minutes of moderate aerobic activity or 75 minutes of vigorous activity each week is essential for maintaining good cardiovascular and overall health(39). The physical activity guidelines from the WHO and the American College of Sports Medicine (ACSM) recommend 20-60 minutes of aerobic exercise 3 to 5 days per week at an intensity of 64% to 70% of maximum heart rate, and 40% to 50-85% of heart rate reserve (HRR)(58,81,82).

From a physiological perspective, aerobic training involves various activities to achieve its primary goal: improving an individual's cardiovascular capacity while simultaneously utilizing lipid reserves found in adipose tissue through the process of lipolysis. This process converts lipids into energy for aerobic exercise, allowing sustained energy release over longer periods, which is essential for this type of training(67,75). The lipolysis process is closely linked to the energy expenditure required to sustain aerobic exercise, which, in turn, is closely related to oxygen uptake in the respiratory system through alveoli, red blood cells, and haemoglobin(62,74).

Habibzadeh conducted a study in 2010 with female students from the University of Guilan, Iran, who presented alterations related to metabolic syndrome, including obesity. He developed an aerobic physical training program lasting 30 minutes, three times a week for two months, with an intensity ranging from 50% to 70% of maximum heart rate. Upon completing the intervention, the results showed that the women experienced an improvement in their BMI, which decreased from 30.20 kg/m² ±1.83 to 28.88 kg/m² ±2.10. Additionally, other altered parameters included total cholesterol, which decreased from 190.01 mg/dL ±3.25 to 179.01 mg/dL ±0.55, and triglycerides, which decreased from 104.01 mg/dL ±2.30 to 82.01 mg/dL ±1.21(83).

Therefore, maximizing the conditional capacity of physical endurance through exercise positively impacts the production of red blood cells, enhancing oxygen transport via hemoglobin. This, in turn, results in increased ATP synthesis for energy production through the breakdown of stored fatty acids in adipocytes. Ultimately, this event contributes to improving body composition(84).

2.8.3. Aerobic physical exercise in university students with metabolic disorders

Jaramillo and colleagues conducted a literature review in 2019 on the effects of aerobic, anaerobic, and mixed physical exercise in individuals over 18 years old, focusing on risk factors associated with metabolic syndrome (LDL, HDL, cholesterol, triglycerides, hypertension, type II diabetes, and obesity). After completing their review, they found that individuals aged 18 to 25 who engaged in aerobic activity (10 to 12 weeks, 3 to 4 times per week for 20 to 30 minutes) experienced an improvement in heart rate, decreasing from 136 ±

5.9 mmHg to 124.5 ± 6.8 mmHg. Additionally, they observed an improvement in BMI, which decreased from 36.45 ± 3.36 to 30.01 ± 2.56(85).

Likewise, Suárez conducted a study in 2020 where he proposed a physical activity program for adults with various metabolic disorders, including visceral fat, high blood pressure, cardiopulmonary pathologies, and sedentary lifestyles. After implementing a concurrent physical training plan consisting of 10 circuit exercises with moderate aerobic intensity (45 seconds of exercise followed by 30 seconds of recovery) over 8 weeks, they observed a significant improvement in body fat. The average body fat measurements decreased from 43.1±6.7 at the beginning to 42.3±6.5 at the end of the study, along with improvements in metabolic imbalances (9).

Additionally, combining the findings from studies conducted by Kalley in 2004, Wang in 2017, and Igarashi in 2019, a meta-analysis of 140 studies demonstrated that an APE program lasting more than 8 weeks—based on activities such as walking, running, swimming, and cycling at an intensity of 50% to 70% of Vo2max—resulted in reductions in total cholesterol from 2% to 3%, triglycerides up to 9%, and a notable increase in HDL cholesterol from 2% to 3%)(86–88).

2.8.4. Cardiovascular adaptations during aerobic physical exercise

The adaptations of aerobic exercise in the human body are primarily reflected in the cardiovascular system, due to that various events are triggered during the period of such activity. One of these events is the continuous delivery of oxygen and other nutrients to the exercised muscles through the bloodstream. This process also leads to the elimination of metabolites and other waste products (53). These events collectively benefit the human body, including an increase in cardiac output, meaning the amount of blood the heart pumps per minute (89).

When the body transitions from a resting state to a state of continuous extensive aerobic exercise under lactate-stable conditions, cardiac output may increase rapidly initially, then more gradually, and then reach stability(67). During maximal exercise, cardiac output may increase up to four times the resting level, ranging from approximately 5 L/min to a maximum of 20 to 22 L/min(89).

Other adaptations observed with aerobic capacity training include a reduction in resting heart rate and heart rate during submaximal exercise, and an increase in capillary and mitochondrial density since this type of training facilitates oxygen transport and delivery, as well as the removal of waste products and carbon dioxide. Additionally, it significantly reduces body composition in terms of adipose tissue (90).

A study conducted by Aristizábal in 2021, determined the efficiency of high-intensity interval training (HIIT) and moderate-intensity continuous training (MICT) in adults with metabolic syndrome-related disorders, using a 12-week protocol. The MICT sessions were performed for 36 minutes at 60% of maximum oxygen consumption (VO2max). The HIIT training sessions included 6 intervals at 90% of VO2max for one minute, followed by 2 minutes at 50% of VO2max. The results of this research revealed significant changes in both groups. One of these changes was a decrease in body fat percentage after MICT training by -0.9% (95% CI), and in the HIIT group by -1.0% (95% CI). Another result was the reduction in fat mass for individuals: MICT showed a decrease of -0.14 kg (95% CI), while HIIT increased to 0.9 kg (95% CI). Based on these findings, it can be affirmed that both training methods are effective (74).

2.8.5. Methods or tests to evaluate aerobic resistance capacity and level of physical activity.

There are various alternatives to measure and evaluate people's cardiovascular condition, one of the most used is: Queens College, which aims to determine aerobic capacity based on cardiorespiratory tolerance(91).

The test consists of going up and down a step for three continuous minutes, following these parameters: During the test, the same foot has to be used to go up and down, legs should fully extend once on top of the step, and arms should be kept by the sides throughout the test, all while maintaining the correct cadence per cycle (91).

To complete one execution or cycle, you must have gone up and down the step while adhering to a metronome. For males, the metronome should be set at 96 beats per minute, and for females, it should be set at 88 beats per minute. It is important for the subject to practice the correct cadence for each completed execution or cycle: males – 24 executions per minute, and females – 22 executions per minute. After completing the test, the subject remains standing for 5 seconds, and then their pulse is taken for 15 seconds. Then, the palpated beats during those 15 seconds are then multiplied by 4(91).

The interpretation of the results is not complex, as this test is quite straightforward for those who perform it. The results can be estimated based on maximum oxygen consumption per unit of body weight. Simply find the recovery heart rate (HRrec) result in this table and read the estimated value of maximum oxygen consumption relative to weight in the next column. It's important to note that these ranges are for university students, as this population has different conditions compared to other populations (91). For a more precise estimation, the following regression equations should be used: Males: Vo2 max, ml x Kg-1 x min -1 = 111.33 – (0.42 x HRrec), Females: Vo2 max, ml x Kg-1 x min -1 = 65.81 – (0.1847 x HRrec) (Anex 11).

Similarly, there is a questionnaire known as the International Physical Activity Questionnaire (IPAQ), which, according to Palma in 2022, aims to assess an individual's level of physical activity. It collects information through questions that inquire about time spent on moderate and vigorous activities, as well as the time spent sitting or being inactive in daily life. The IPAQ consists of two forms: a lengthy one and a short one(92).

Furthermore, the responses obtained from this questionnaire allow for the estimation of energy expenditure (METs) during a typical week of physical activity. This information can be valuable for evaluating the overall physical activity levels of a population and contributing to scientific or clinical research aimed at determining the risk of diseases related to sedentary behavior and physical inactivity(92).

According to Bustamante in 2022, METs (Metabolic Equivalent of Task) is the unit of measurement for the metabolic energy index consumed by an individual at rest. It corresponds to 3.5 ml O2/kg x min, which represents the minimum oxygen consumption required by the body to maintain vital functions. METs are classified into three levels: Very light: < 3 METs/min, which can be associated with activities such as sleeping or sitting. The second Light to moderate: 3 to 6 METs/min, examples of this level of expenditure include gardening or cycling. And finally, intense or vigorous: > 6 METs/min, such as high-intensity exercise (93), (See annex 12).

In 2020, Valdez conducted a study to determine the effect of a physical activity (PA) program on cardiorespiratory capacity, considering METs (Metabolic Equivalent of Task) and metabolic risks in university academics. The overall program focused on cardiorespiratory endurance and included aerobic activities such as walking, swimming, stationary cycling, and dancing. The study results revealed that 50% of overweight subjects improved their condition. Additionally, at the beginning of the protocol, 20% of the population had altered triglyceride levels, however, by the end of the intervention, 100% of the subjects were within a stable range. These findings suggest that a properly structured PA program, adhering to fitness training criteria, can lead to positive outcomes in the population(94).

3. Justification

The prevalence of metabolic disorders has been increasing, especially in developing countries. According to the WHO in 2022, 20% to 50% of the population could be affected by these disorders (51). In Mexico, the prevalence of metabolic disorders is equally evident among higher education students, according to the National Health and Nutrition Survey (ENSANUT) 2022, 72.5% of the population had obesity, 25.5% had hypertension, and 21.1% had some form of dyslipidemia. Additionally, Almazán reported in 2020, that 13.8% of the population had hyperglycemia (5,6,34).

The importance of moderate and vigorous aerobic physical exercise could reduce the risk of cardiovascular and cerebrovascular diseases in individuals with metabolic alterations(94,95).

Jaramillo in 2019, Sequi in 2020, and Primo in 2022 determined that MVPA can decrease various metabolic disorders (such as triglycerides, hypertension, abdominal obesity, and hyperglycemia) by 3% to 10% over 10 weeks (63,64,85). Along the same lines, Chávez in 2021 implemented an aerobic exercise program to assess its effect on reducing metabolic disorders in university students over thirteen weeks. The program involved four weekly sessions, each lasting 20 to 30 minutes. The results showed changes in triglycerides (131.31 mg/dl, post 116.90 mg/dl), heart rate (143.20 mmHg, post 127.40 mmHg) and abdominal obesity (110.88 cm, post 106.90 cm) (65).

Considering the execution timeline and findings from Chávez's study and other mentioned research, this study proposes an improvement: reducing the intervention duration from 13 to 8 weeks and decreasing the intervention frequency from 4 to 3 days. Considering that the volume of work will increase from 30 minutes to 60 minutes per session, complemented by personalized physical exercise planning for each subject. The objective of this modification is to achieve the same beneficial changes in metabolic alterations while reducing the intervention time.

Laboratory tests and anthropometric measurements in each patient are part of the assessment protocol at both the primary and secondary levels of care for screening non-communicable diseases, which is reflected in the feasibility of the study. It should be noted that the laboratory reagents available are easy to use and essential for comprehensive diagnosis, complying with the operational definitions of each of the suspected diseases, taking into account the clinical practice guide or international guides such as ADA or ATP III. Additionally, the research team possesses the experience and infrastructure necessary for screening and monitoring subjects participating in the study (39, 95)

The vulnerability of the study lies in patient recruitment, as it involves a young population that may not recognize risk factors for non-communicable diseases, and those who participate, often lack adherence to interventions due to various factors such as time constraints related to work, school activities, and extracurricular commitments.

4. Problem statement

According to the PAHO in 2022, cardiovascular diseases remain the second leading cause of death, with the number of affected individuals increasing from 1.9 million to 2 million in 2022(55). In 2021, PAHO and the American Diabetes Association (ADA) in 2024, reported that Disability-Adjusted Life Years (DALYs) totalled 40.8 million, of which 36.4 million represented Years of Life Lost due to premature death (YLLs), accounting for 89% of DALYs. Additionally, the Years Lived with Disability (YLDs) for these individuals averaged 4.5 million(55,96). It is evident that both life expectancy and quality of life significantly decrease when individuals experience these diseases.

Nowadays, metabolic disorders represent a significant risk for Mexico's young population, leading to substantial complications for cardiovascular health and overall well-being in adulthood. Some authors reported the prevalence of different metabolic disorders among university students in Mexico in 2022. They found that 72.5% of these students were overweight or obese, and there was a marked incidence of hypertension, with 37.1%, additionally, the prevalence of type 2 diabetes mellitus was 37%(98-101).

On the other hand, a study by Salazar and colleagues in 2013 revealed that students at the University of Colima had 29.5% overweight and 8.4% obesity rates. The researcher associated these results with the subjects' high prevalence of physical inactivity and sedentary behaviour (15). In 2018, Colima State ranked first in obesity nationwide(101). Furthermore, epidemiological bulletins from the Colima State Health Services, published in 2023, indicated that obesity was one of the six most common comorbidities seen in health centres in the Colima municipality, affecting 2,212 individuals(102). Exploring the underlying causes that condition these epidemiological data is crucial, as this population may develop non-communicable diseases in the medium term. Therefore, this research project represents an opportunity for practical, objective, and timely intervention in evaluating physical fitness and its impact on metabolic and anthropometric levels in a young population.

5. Methodological Design

5.1. Research Question

What is the effect of an aerobic physical exercise program on reducing blood pressure, abdominal obesity, altered glucose levels, and increasing HDL in college-level students at the University of Colima?

5.2 Objectives

5.2.1 General Objective

To evaluate the effect of implementing an aerobic physical exercise program on the reduction of blood pressure, abdominal obesity, altered glucose levels, and increasing HDL in college-level students at the University of Colima.

5.2.2. Specific Objectives

1. To establish the prevalence of metabolic disorders (abdominal obesity, triglycerides, HDL, hypertension, and glucose alterations).
2. To determine and compare the post-intervention level of physical activity using the long version of the International Physical Activity Questionnaire (IPAQ).
3. To determine and compare the post-intervention level of cardiorespiratory fitness through the Queen's College Step Test.
4. Compare post-intervention prevalence levels of metabolic disorders (HDL, triglycerides, abdominal fat, hypertension, blood glucose alterations) in higher education students.
5. Determine the level of association between metabolic disorders and cardiorespiratory fitness pre- and post-intervention.

5.3 Hypothesis

Hi. The implementation of an aerobic physical exercise program for eight weeks will have effects on at least one of the levels of metabolic disorders such as: he reduction of blood pressure, abdominal obesity, altered glucose levels, and increasing HDL in the study population

H0. The implementation of an aerobic physical exercise program for eight weeks will not have effects on any of the levels of metabolic disorders such as: he reduction of blood pressure, abdominal obesity, altered glucose levels, and increasing HDL in the study population

6. Methods and materials

6.1 Study design

Single-blind randomized clinical trial.

6.2 Sample size

The sample size was calculated with a formula to compare two means:

$$n=\frac{K(\sigma_1{}^2+\sigma_2{}^2)}{(\mu_1-\mu_2)^2}$$

Figure 5. Applied formula to calculate the sample size.
Source: Taken from García in 2013(104).

The sample size was determined through a study that assessed the impact of physical training on metabolic alterations. The pre-intervention measurements were 131.31 ± 22.53, and the post-intervention measurements were 116.90 ± 12.88 (65)

Error α= .05

Error β= 0.2 (20%)

Power 1- β= .8 (80)

K= 6.2

σ^2= 22.53

σ^2= 12.88

μ_1= 131.31

μ_2= 116.90

n= 20 ± 20%.

n= 24 subjects per group

6.3. Selection criteria

Table 4. Selection criteria

Inclusion	Exclusion	Elimination
University of Colima students linked to the central campus. Students aged between 18	Motor limitations that may hinder the performance of physical exercise.	Musculoskeletal injuries during the study period. Unforeseen Medical Events: Unexpected medical

and 25 years old. Authorization to participate in the project with a signed informed consent. Suffer from at least one of the parameters of metabolic disorders or cardiovascular risk (Hyperglycemia, decreased DHL, elevated triglycerides, abdominal obesity or hypertension) following the clinical assessment (Considering the criteria established by the ADA and ATPIII).	Pregnancy or lactation. High Vigorous Physical Activity Level according to the IPA-Q. To be currently under pharmacological treatment to manage altered metabolic levels.	situations that could influence study results, such as hospitalizations, serious illnesses, or surgeries. Non-Compliance with Follow-Up: Subjects failing to meet a minimum of 80% (19 out of 24 sessions) of the stipulated physical conditioning program time. Initiation of clinical treatment that may affect protocol results, such as medications that reduce alterations. Participants who voluntarily withdraw from the study.

Source: self-made.

7. Variable operationalisation.

Table 5. Dependent variables**.**

Dependent variables	**Operational definition**	**Nature**	**Scale**	**Instrument**
Glucose Alterations	Fasting plasmatic glucose concentration determination:	Quantitative Continuous Ratio	It is considered an alteration >110 mg/dl	Fasting serum glucose

Abdominal Circumference	Total abdominal perimeter Abdominal obesity based on abdominal circumference.	Quantitative Continuous Ratio	It is considered an alteration when: Males >90cm Females >85 cm	Circumferential measurement with ISAK tape measure
HDL (High-Density Lipoprotein)	Serum concentration of high-density lipoprotein in milligrams per deciliter (mg/dl)	Quantitative Continuous Ratio	It is considered an alteration when: Males < 40 mg/dl, Females < 50 mg/dl	Lipid profile test
Triglycerides	Serum concentration of triglycerides in milligrams per deciliter (mg/dl)	Quantitative Continuous Ratio	It is considered an alteration when: Males >150 mg/dl Females >150 mg/dl	Lipid profile test
Arterial Hypertension	Subject's systolic and diastolic blood pressure measured in mercury millimeters (mmHg)	Quantitative Continuous Ratio	It is considered an alteration when: Males > 130/85 mmHg Females > 130/85 mmHg	Sphygmomanometer
Physical Activity Level	Physical Activity performed by the subject 7 days before the survey	Qualitative Ordinal	PA: Low, Medium, High	IPA-Q (International Physical Activity Questionnaire)
Physical Fitness Test: Aerobic	Subject's cardiorespiratory capacity using an	Qualitative Ordinal	Very Poor Poor Average	Quee's College Step Test

Capacity	effort test.		Good Excellent Superior	

Source: self-made based on the reference (11,105).

Table 6. Independent variables

Variable	Operational definition	Nature	Scale	Instrument
Aerobic physical exercise	Individually adapted aerobic physical exercise program meeting the WHO 2021 criteria and the FITT Principles.	Quantitative Continuous Ration	57% - 76%	Prescription

Source: self-made.

Table 7. Intervinient variables

Variable	Operational definition	Nature	Scale	Instrument
Age	Chronological age in years	Quantitative Continuous	18 - 24 years	Survey
Sex	Genetically corresponding sex	Qualitative Dichotomous nominal	Male and Female	Survey

Source: self-made.

8. Location for carrying out the protocol

University of Colima's Sports Center (central campus).

9. Study Procedure

Once the project is approved by the Bioethics Committee from the Faculty of Medicine at the University of Colima (Annex 1) and the Ethics Committee from Colima's Regional Hospital (Annex 2), annexing a no-conflict of interest letter (Annex 3), letters of intent will be prepared and sent to the directors of the faculties within the central campus of the University of Colima (Annex 4). Their purpose is to inform them about the project's generalities, obtain permission to share it with the students and address any questions they may have

Those who agree will receive an informed consent form (Annex 5) for their respective signatures. They will be informed about the appropriate attire for the study (for women, this includes sports shoes, leggings, and a top or T-shirt, and for men, shorts and a T-shirt), the requirement to fast for a minimum of 8 hours on the data collection day, and the date (Saturdays), time (8:00 am to 12:00 pm) and place (Faculty of Medicine, University of Colima) of the initial tests (these tests will also be considered the baseline for people who are found to have a metabolic alteration).

On assessment day, the project team will execute the following tests: application of the IPA-Q questionnaire (*annexe 6*), abdominal circumference (*annexe 7*), blood pressure (*annexe 8*), blood collection by venipuncture for HDL, triglycerides and glycemia (*annexe 9*), and the Queen's College step test (3 minutes) to determine their cardiorespiratory capacity (*annexe 10*), (after completing all the tests, every participant will receive refreshments and will be asked if they are in good condition to conclude their assessments, if not, they will be monitored until their answer is affirmative).

Once all blood samples are collected, they will be taken to the laboratory at the Faculty of Chemical Sciences, University of Colima, for processing. Simultaneously, data from the other assessments will be synthesized. When the final results from all 5 tests are collected, a sample of 48 subjects will be selected for the protocol, considering the established inclusion criteria (*Table 2*). With this sample, simple randomization will be performed in a new meeting, using sealed envelopes (each containing a letter indicating group assignment that will not be seen by participants). Participants will draw an envelope and mark it with their names, and they will hand the envelope to the designated person (principal investigator).

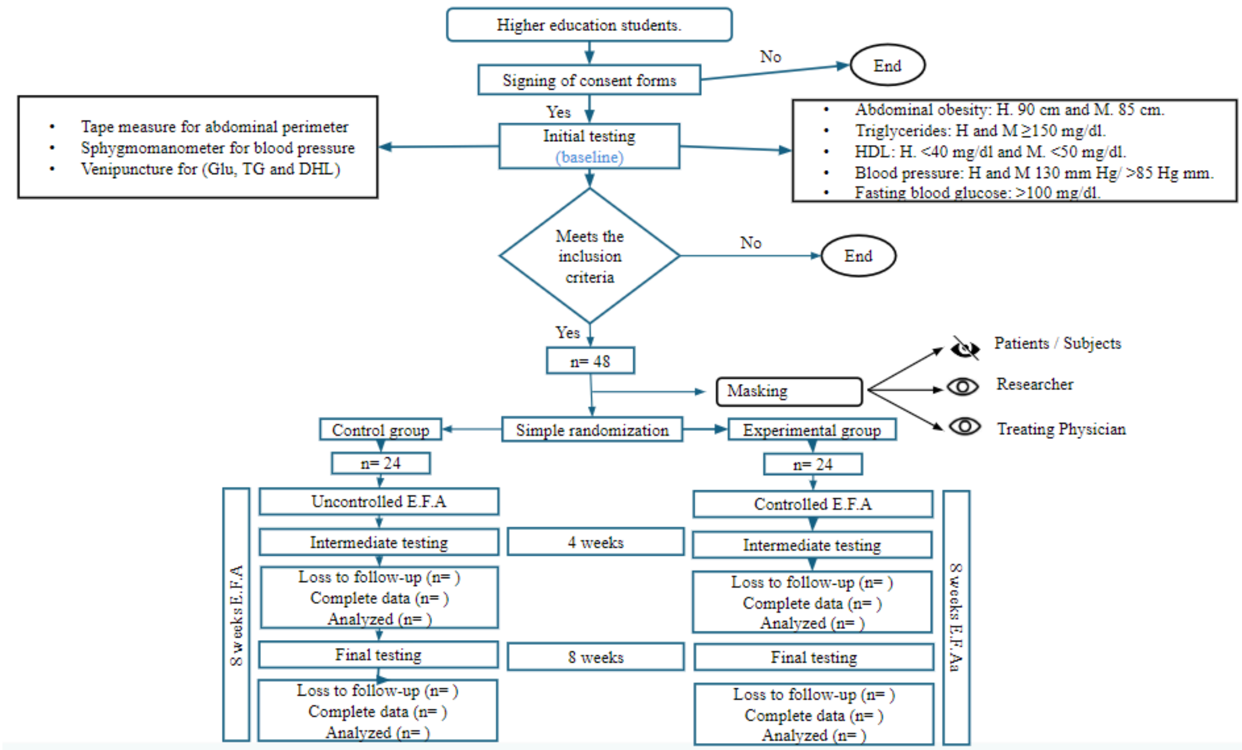
At the end of the meeting, the envelopes will be opened by the organizers in the absence of the participants to reveal whether they belong to the (A) control or (B) experimental group. This process ensures single-blind criteria, where participants do not know their group assignment.

After forming the (A) control and (B) experimental groups, they will be divided to provide them instructions for compliance with the exercise program while maintaining single-blind conditions. In the control group (A), the exercise prescription used by Habibzadeh in 2010 will be implemented: which involves walking for 30 minutes at an intensity of 57% to 76% of the maximum heart rate, three times per week (Monday, Wednesday, and Friday) for eight weeks (*annex 11*). They will always be accompanied by a previously trained physical education student (Monitoring the intensity range in which the subjects must be during the session, will be done through the effort perception scale *(Annex 12)*, heart rate at 15 seconds multiplied by 4 or the H10 polar monitor) (83). On the other hand, the experimental group (B) will engage in an aerobic exercise program (jogging, aquatic activities, and stationary cycling) lasting 40 to 60 minutes, three times per week (Monday, Wednesday, and Friday) for eight weeks, always under the supervision of the principal investigator. Each participant in the experimental group will receive a structured exercise prescription tailored to their specific condition, considering the established aerobic training ranges (57% to 63% of maximum heart rate) (*annexe 11*). (Monitoring the intensity range in which the subjects must be during the session will be done through the effort perception scale (Annex 12), heart rate at 15 seconds multiplied by 4 or the H10 polar monitor).

By the end of the first four weeks, the second round of assessments and samples will be done, taking into consideration: Abdominal circumference *(annexe 7),* blood pressure *(annexe 8),* blood collection by venipuncture for HDL, triglycerides and glycemia *(annexe 9),* and the Queen's College step test will be performed (3 minutes) *(annexe 10),* (after completing all the tests, every participant will receive refreshments and will be asked if they are in good condition to conclude their assessments, if not, they will be monitored until their answer is affirmative). Subsequently, after completing sample collection and assessments, the control group (A) will continue with the same dynamics as in the initial weeks. The experimental group (B) will maintain the same exercises (jogging, aquatic activities, and stationary cycling), but their intensity may be adjusted from 64% to 76% of the maximum heart rate if favourable results are obtained from the cardiorespiratory fitness test *(annexe 11)*, since this shows the level of evolution of the subject after the initial intervention and thus, the FITT-VP principle in exercise prescription would be fulfilled.

At the end of the last 4 weeks of the aerobic physical exercise program, the same sampling will be concluded; Abdominal circumference *(annexe 7)*, arterial pressure *(annexe 8),* blood collection by venipuncture for HDL, triglycerides and glycemia *(annexe 9)*, and the Queen's College step test will be performed (3 minutes) *(annexe 10)* (after completing all the tests, every participant will receive refreshments and will be asked if they are in good condition to conclude their assessments, if not, they will be monitored until their answer is affirmative), finishing the proposed intervention protocol.

10. Study flowchart



11. Statistical analysis

The statistical analysis will be conducted using the Statistical Package for the Social Sciences (SPSS) Statistics 26 from Business Machine (IBM). Descriptive statistics will be carried out, including measures of central tendency for the variables of age, sex and IPA-Q. Normality tests will be applied such as Kolmogorov-Smirnov for samples >50, and Shapiro-Wilk for samples <50. For the levels of triglycerides, glucose, HDL (High-Density Lipoprotein), abdominal circumference, and cardiorespiratory fitness, paired-sample T-tests will be used if the data follow a normal distribution, but if they do not, the Wilcoxon signed-rank test will be employed. To compare the control and experimental groups, independent-sample t-tests will be used if the data is normally distributed, otherwise the Mann-Whitney U test will be used. Likewise, a multivariate analysis will be carried out to relate the influence of physical exercise on metabolic alterations. A significance level of $p \leq 0.05$ will be considered statistically significant.

12. Ethical considerations

According to international and national principles for research involving human subjects, as outlined in the Declaration of Helsinki and the General Health Law in its Articles 100 and 101 of Chapter V, Research for Health, and in the General Health Regulation regarding Research to Promote Health, specifically in Article 17, Section I, it is determined that this research is classified as a minimal-risk study. This categorisation is based on its approach: a study involving controlled and voluntary exercise intervention and blood extraction through venipuncture. The blood extraction will not exceed a maximum frequency of twice a week or a maximum volume of 450 ml, limited to only three samples during the identification of the protocol sample, at the midpoint, and upon completion (106). Additionally, Article 15 of the regulation stipulates that random selection methods will be adopted for experimental designs involving human subjects with multiple groups. Impartial assignment of participants to each group will be ensured, taking necessary measures to prevent risks or harm to research subjects. Immediate attention will also be provided by the team implementing this protocol if any adverse effects caused by exercise are observed. These criteria have been incorporated into the research planning (106).

Following the guidelines established by the Declaration of Helsinki, the privacy and confidentiality of information provided by participants will be safeguarded. An informed consent form (Annex 1) has been prepared, detailing the exclusive use of data for research purposes. This consent will be subject to approval by the Ethics and Research Committee (107).

The questionnaires, tables, and formulas used are scientifically validated and publicly available, affirming the certainty of the process and its results. Considering the above, this research protocol will undergo evaluation and approval by the Honourable Bioethics Committee of the Faculty of Medicine at the University of Colima. Following approval by this committee, it will be submitted to the Ethics Committee of the University Regional Hospital of Colima, which will issue an opinion for its implementation, with the support of the Federal Commission for Protection against Sanitary Risks (Cofepris).

13. Human resources, financing and feasibility

13.1 Human Resources

- Dr. Fabián Rojas Larios
- Dr. Pedro Julián Flores
- Bachelor of Physical Education, Nelson Enrique Ramos Cuevas
- Nursing staff assigned for blood pressure measurement
- Nursing staff assigned for blood extraction
- Nutrition staff assigned for waist circumference measurement
- Bachelor of Physical Education staff for conducting the Queens College test
- Bachelor of Physical Education staff for administering the IPAQ survey
- Bachelor of Physical Education staff for supporting the control group.

13.2 Material Resources

Table 8. Materials and costs

Resource Type	Unit	Amount	Cost per unit	Total cost	Elements are available.
Computer	Piece	1	$ 7,000	$ 7,000	✓
Printer	Pieza	1	$ 3,794	$ 3,794	✓
Paper	Pack of sheets	4	$ 500	$ 2,000	

Pens	Pack of 20	2	$ 130	$ 260	✓
Speaker	Piece	1	$ 2,000	$ 2,000	✓
USB	Piece	1	$ 100	$ 100	✓
40 cm Bench	Piece	1	$ 750	$ 750	
Lipid Profile Test	Unit	150	$ 17,250	$ 17,250	
Fasting Plasma Glucose Test	Unit	150	$ 8,304	$ 8,304	
BD Vancutainer SST Yellow Cap Tube	Box	100	$350	$350	
Green Flash Pulse Needle / BD Ancuntainer 216x1-1/1m 0.8x30 mm	Box	1	$ 600	$ 600	
Centrifuge; Centrifuge 580412-15 amp EPPENDOR Version	Unit	1	$15,142.17	$15,142.17	✓
Pipette Tips for 1000 Microliter Transferpette	Unit	1	$ 1,000	$ 1,000	

Axygen 1.5ml Microtube, Eppendorf Type, 500 pcs	Box	1	$ 900	$ 900	
Autoclave/ Sterilizer	Unit	1	$ 45,321	$ 45,321	✓
Wrist Digital Blood Pressure Monitor	Piece	1	$ 800	$ 800	
Metallic Measuring Tape	Piece	1	$ 100	$ 100	
Uline Silent Tape - 3.1 Mil Thickness, 3" x 55 yards, Transparent, 75 mm x 50 M	Unit	1	$ 300	$ 300	
Folio labels	Box	1	$ 150	$ 150	
Powder-Free Nitrile Examination Gloves, Blue	Box	1	$ 140	$ 140	
Multitube Sample Rack	Unit	10	$ 30	$ 300	
-40° Freezer	Unit	1	$ 123, 455	$ 123,445	✓

Soft Tor Medimetrics Venous Tourniquet for Blood Extraction	Unit	1	$ 100	$ 100
Cotton Swabs 500g with 1000 Protec Pellets	Box	1	$ 170	$ 170
8.5 L Plastic Container for Infectious Biological Sharps	Unit	1	$ 150	$ 150
Red Bag for Biological Waste 50x60 cm, Pack of 20	Unit	4	$ 100	$ 400
3m Steam Sterilization Indicator Tape, 18mm x 55m	Unit	2	$ 130	$ 260
Kraft Wrapping Paper Roll, 80 cm, 17.5 kg (227.50 m), 125gsm	Unit	1	$ 800	$ 800
Cones	Piece	1	$ 175	$ 175
Ropes	Piece	5	$50	$250

Hoops	Piece	10	$38	$380	
Training Steps	Piece	3	$ 235	$ 705	
Stopwatch	Piece	1	$ 500	$ 500	
Polar H10 Heart Rate Monito	Piece	4	$2.499	$9,996	
Total Investment:				$ 237,602	$ 44,602

Source: Self-made based on reference (108)

14. Schedule of activities

SCHEDULE OF ACTIVITIES

Numero	Activities	Months - programed calendar																							
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	Continuous modifications for document improvement.	■	■	■	■	■	■	■	■																
2	Protocol presentation to the Medicine Bioethics Committee									■	■														
3	Protocol presentation to the Colima's Regional University Hospital Bioethics Committee											■													
4	Protocol pilot test												■												
5	Sending letters of intent to Faculties												■												
6	Invitation and presentation of the project												■												
7	Signature of consent forms, baseline testing ans dormation of groups "A" and "B"													■											
8	EFA training program													■											
9	Second round of testing and continuity of the EFA training program														■	■									
10	Third round of testing																■								
11	Tests results analysis																	■	■	■					
12	Writting of conclusions and discussion																				■	■			
13	Result discussion, thesis presentation and obtention of Degree.																						■	■	■

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Annexes

Annexe 1. Annex 1: Approval from the Bioethics Committee of the Faculty of Medicine, University of Colima.

University of Colima
Faculty of Medicine
Bioethics Committee

Researcher: Phd Fabián Rojas Larios

PROJECT: EFFECT OF AN AEROBIC PHYSICAL EXERCISE PROGRAM ON METABOLIC DISORDERS IN COLLEGE-LEVEL STUDENTS AT THE UNIVERSITY OF COLIMA: A SIMPLE RANDOMIZED CLINICAL TRIAL.

Reg. 2024-6

In response to your application on March 20th 2024 for the revision of the project under your direction mentioned above by the Research Ethics Committee at the Faculty of Medicine. You are hereby informed that said project has been:

APPROVED WITH MINIMAL CORRECTIONS

Based on the current regulations for this commission and according to the General Law of Health Research.

This is extended on April 23rd 2024, for any relevant paperwork.

SINCERELY THE COMMITEE

(SIGNATURES:)

PHD. CARMEN ALICIA SÁNCHEZ RAMÍREZ

PHD. IVÁN DELGADO ENCISO

PHD. BENHAMÍN TRUJILLO HERNÁNDEZ

PHD. MARIO RAMÍREZ FLORES

PHD. JOSÉ GUZMÁN ESQUIVEL

PHD. EFRÉN MURILLO ZAMORA

PHD. EMILIO PRIETO DÍAZ CHAVEZ

DIRECTOR OF THE FACULTY OF MEDICINE

UNIVERSIDAD DE COLIMA
FACULTAD DE MEDICINA

COMITÉ DE BIOÉTICA

C. Investigador: **D en C. Fabián Rojas Larios**

PROYECTO: EFECTO DE UN PROGRAMA DE EJERCICIO FÍSICO AERÓBICO SOBRE LOS NIVELES DE TRASTORNOS METABÓLICOS EN ESTUDIANTES DE NIVEL SUPERIOR EN LA UNIVERSIDAD DE COLIMA, ENSAYO CLÍNICO ALEATORIZADO

Reg. **2024-6**

En atención a su solicitud del día 20 de marzo de 2024 para que el proyecto arriba mencionado, bajo su dirección, se sometiera a revisión por parte del Comité de Ética en Investigación de la Facultad de Medicina, se le comunica que dicho proyecto ha sido:

APROBADO CON CORRECCIONES MÍNIMAS

En base al reglamento vigente para esta comisión y en concordancia con la Ley General de Salud en materia de Investigación.

Se extiende la presente a los 23 días del mes de abril de 2024, para los trámites a que haya lugar.

ATENTAMENTE EL COMITÉ:

DRA. CARMEN ALICIA SÁNCHEZ RAMÌREZ

DR. IVÁN DELGADO ENCISO

DR. BENJAMÍN TRUJILLO HERNÁNDEZ

DR. MARIO RAMÍREZ FLORES

DR. JOSE GUZMAN ESQUIVEL

DR. EFREN MURILLO ZAMORA

Vo.Bo.

D. EN C. EMILIO PRIETO DÍAZ CHAVEZ
DIRECTOR DE LA FACULTAD DE MEDICINA

CERTIFICADA CON NORMAS ISO
Pertinencia que transforma

Avenida Universidad 333, colonia Las Víboras • C.P. 28040 • Colima, Colima, México • Teléfonos 312 316 10 99 y 312 316 10 00, extensiones 37501 y 37502
medicina@ucol.mx

Annex 2. Approval from the Ethics Committee of the Regional University Hospital of Colima

RULING. RESEARCH COMMITTEE. UNIVERSITY REGIONAL HOSPITAL

PRINCIPAL RESEARCHER: Nelson Enrique Ramos Cuevas, PhD. Pedro Julián Flores, PhD Fabián Rojas Larios

ANALIZED PROJECT'S TITLE: EFFECT OF AN AEROBIC PHYSICAL EXERCISE PROGRAM ON METABOLIC DISORDERS IN COLLEGE-LEVEL STUDENTS AT THE UNIVERSITY OF COLIMA: A SIMPLE RANDOMIZED CLINICAL TRIAL.

The Reseach Committe at the University Regional Hospital (COFEPRIS 17CI06002152) based on the faculties and atributios given by the articles 41 Bis and 98 to 103 from the General Law of Health, as well as the General Law of Health Regulation for Health Research regarding functioning and operation of the Research Committees, informs you that said document has been revised, analized and taken into consideration at an ordinary session celebrated on June 13th 2024, at the designated space for Committee meeting, located at Highway Colima-Guadalajara Kilometer 2, Col. El Porvenir, Colima, Colima, being the duty of these collegiate body to inform you that OBSERVING that derived from the review made by the members of these committee to the mentioned protocol, a) Complies with the fundamental theoretical conceptual elements and partially the methodological desing for the correct research development; b) Complies with the team trained from the clinical point of view and partially for the methodological part; c) Complies with the substantial ethical parameters. Therefore, this Committee resolve that the protocol meets the requirements, which is why this resolution is issued as follows:

FAVOURABLE with register number CI 2024/1/CR/EFD/242

Along with this document, we attach certain observations that require your attention, for their analysis and, in their case, modification or correction. This project will be sent for evaluation by the Research Ethics Committee from this Hospital. After this Committee's authorization, you may include patients in your study. Given that this research protocol will not be done in this Hospital, you must solicit authorisation for its implementation from the responsible at the unit where it is intended to be done. Once the research is concluded, you must notify this Research Committee, attaching a written structured summary about the work done. This ruling is emitted in Colima City, Colima, on June 17th 2024.

PhD. Fabián Rojas Larios
Director at the University Regional Hospital

COLIMA
Gobierno del Estado

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CONTIGO

DICTAMEN. COMITÉ DE INVESTIGACIÓN. HOSPITAL REGIONAL UNIVERSITARIO.

INVESTIGADOR PRINCIPAL: Nelson Enrique Ramos Cuevas; D en C Pedro Julián Flores
D en C Fabián Rojas Larios

TÍTULO DEL PROTOCOLO ANALIZADO: Efecto de un programa de ejercicio físico aeróbico sobre los niveles de trastornos metabólicos en estudiantes del nivel superior en la Universidad de Colima, ensayo clínico aleatorizado simple.

El Comité de Investigación del Hospital Regional Universitario (COFEPRIS 17CI06002152), con fundamento en las facultades y atribuciones que nos otorgan los artículos 41 Bis y 98 al 103 de la Ley General de Salud, así como el Reglamento de la Ley General de Salud en Materia de Investigación para la Salud respecto al funcionamiento y operación de los Comités de Investigación, le comunica que ha sido revisado y analizado el documento ya descrito y puesto a consideración del pleno en sesión ordinaria celebrada el 13 de junio de 2024, en el espacio destinado para las juntas del Comité, ubicado en carretera Colima-Guadalajara kilómetro 2, Col. El Porvenir, Colima, Colima, siendo deber de este cuerpo colegiado informarle que OBSERVANDO que derivado de la revisión hecha por los miembros del presente Comité al protocolo mencionado, a) Cumple con los elementos conceptuales teóricos fundamentales y parcialmente los metodológicos de diseño para el adecuado desarrollo de la investigación; b) Cuenta con el equipo capacitado desde el punto de vista clínico y parcialmente la parte metodológica; c) Cumple con los parámetros éticos sustantivos. Por lo tanto, este Comité resuelve que el protocolo da cumplimiento a los requisitos necesarios, por lo que se emite la presente resolución con carácter de:

FAVORABLE con número de registro CI 2024/1/CR/EFD/242

Junto con este documento, adjuntamos ciertas observaciones que requieren su atención, para su análisis y en su caso, modificación o corrección. El presente proyecto se enviará a evaluación por el Comité de Ética en Investigación de este Hospital. Posterior a la autorización de ese Comité podrá realizar la inclusión de pacientes a su estudio. Dado que el presente protocolo de investigación no se realizará en este Hospital, deberá de solicitar autorización para su implementación de parte del responsable de la Unidad donde se pretende llevar a cabo. Una vez concluida su investigación, es esencial que notifique a este Comité de Investigación anexando un resumen estructurado por escrito del trabajo realizado. Este dictamen se emite en la ciudad de Colima, Colima, a los 17 días del mes de junio de 2024.

D. en C. Fabián Rojas Larios.
Director del Hospital Regional Universitario.

Servicios de Salud del Estado de Colima
ESTADOS UNIDOS MEXICANOS
HOSPITAL REGIONAL UNIVERSITARIO

c.c.p.- Archivo / Comité de Investigación.
JAME

Annex 3: No-Conflict of interest letter

Colima, Col., May 17th 2024

Dr. Fabián Rojas Larios
Principal of the University Regional Hospital

Dr. José Jorge Marentes Etienne
President of the Research Ethics Committee
at the University Regional Hospital

No-Conflict of interest letter

Through this letter, I, B.S. Nelson Enrique Ramos Cuevas, Principal Investigator and licensed physical education professional, currently pursuing a Master's degree in Medical Sciences at the Faculty of Medicine, University of Colima, along with thesis advisors PhD. Fabián Rojas Larios (Medical Specialist A, affiliated with the Hospital Directorate) and PhD. Pedro Julián Flores Moreno (Bachelor's degree in Exercise Science, external associate researcher), declares that we have no conflicts of interest related to the research protocol titled "EFFECT OF AN AEROBIC PHYSICAL EXERCISE PROGRAM ON METABOLIC DISORDERS IN COLLEGE-LEVEL STUDENTS AT THE UNIVERSITY OF COLIMA: A SIMPLE RANDOMIZED CLINICAL TRIAL."

We confirm that we have no financial, personal, or professional relationships with individuals or organizations that could inappropriately influence our work. This study has been conducted using our own funds, and we have not received any external funding for its execution.

We commit to promptly inform the Research Committee (CI) and the Ethics and Research Committee (CEI) of any changes to the study protocol or the investigators' circumstances that may lead to a conflict of interest. We appreciate your attention and remain available for any additional information you may require.

Sincerely,

B.C. Nelson Enrique Ramos Cuevas	PhD. Fabián Rojas Larios	PhD. Pedro Julián Flores Moreno
Research Candidate	Methodological Advisor	Clinical Advisor

Annex 4. Letter for Faculty Principals

Date:_______________

Proffessor. ______________________

Principal: ______________________

Subject: Invitation to students to participate in the research protocol entitled: EFFECT OF AN AEROBIC PHYSICAL EXERCISE PROGRAM ON METABOLIC DISORDERS LEVELS IN HIGHER LEVEL STUDENTS AT THE UNIVERSITY OF COLIMA, SIMPLE RANDOMIZED CLINICAL TRIAL.

I am Nelson Enrique Ramos Cuevas, a Master's student in Medical Sciences at the Faculty of Medicine (nramos6@ucol.mx), assessed by the **CLINICAL ADVISOR: D. C. FABIÁN ROJAS LARIOS and the BASIC ADVISOR: D. C. PEDRO JULIÁN FLORES.**

The reason for this document is to request your honourable authorization to share with your students the initiative of voluntary participation in the project: EFFECT OF AN AEROBIC PHYSICAL EXERCISE PROGRAM ON METABOLIC DISORDERS LEVELS IN HIGHER LEVEL STUDENTS AT THE UNIVERSITY OF COLIMA, SIMPLE RANDOMIZED CLINICAL TRIAL, which aims to determine the effect of implementing an **eight-week aerobic physical exercise program** on metabolic levels (HDL, triglycerides, abdominal obesity, glucose disturbance, hypertension) in higher level students (University of Colima), the protocol intervention is estimated upon returning from the Easter holidays, having the due approval of the respective bioethics committees of the university to intervene with the students.

Therefore, your support is essential for the execution of this project in favour of the health and well-being of the university students.

Without further ado, I look forward to your response.

Student signature	Clinical Advisor Signature	Basic Advisor Signature
Nelson Enrique Ramos Cuevas	PhD. Fabián Rojas Larios	PhD. Pedro Julián Flores

Annex 5. Informed Consent

INFORMED CONSENT LETTER

RESEARCHER. NELSON ENRIQUE RAMOS CUEVAS
CLINICAL ADVISRO: PhD. FABIÁN ROJAS LARIOS
BASIC ADVISOR: PhD. PEDRO JULIÁN FLORES
Research Project Name: EFFECT OF AN AEROBIC PHYSICAL EXERCISE PROGRAM ON METABOLIC DISORDERS LEVELS IN HIGHER LEVEL STUDENTS AT THE UNIVERSITY OF COLIMA, SIMPLE RANDOMIZED CLINICAL TRIAL.

Dear participants, the main objective of this work is to include all young university students from the University of Colima who are pursuing higher-level studies and who suffer from some type of metabolic disorder (decreased HDL, increased concentration of triglycerides, abdominal circumference, blood pressure and glucose), the staff will be responsible for providing and guiding:

- Blood tests before, during and at the end of the protocol
- Blood pressure before, during and at the end of the protocol
- The international physical activity questionnaire to complete
- Queens College test before, during and at the end of the protocol

This project will evaluate the effect of an aerobic physical conditioning program on factors associated with indicators of metabolic alteration in higher education students, which will not have negative effects on health, since the guidelines for the applicability of the physical exercise program are taken into account.

If you participate voluntarily, the team that makes up this study (nutritionists, doctors and physical educators) will be taking different data, tests and samples to determine your progress in the protocol before, during and at the end. A responsible person (Nelson Enrique Ramos Cuevas) will safeguard all the information provided and will ensure its discretion and confidentiality.

People who wish to participate in the project have the following rights:

7. Be fully informed of the project's objectives.
8. Receive detailed information on the procedures that will be carried out during the intervention.
9. Receive clear information on the possible benefits and/or risks that may arise when carrying out the intervention.
10. Have the opportunity to ask any type of question that may arise during the sample collection, physical test or during aerobic physical exercise.
11. Be informed about the process for voluntary withdrawal at any time during the process, without any harm or aggravation.
12. Receive a copy of this informed consent signed by the parties and filed.
13. Participate of your own free will without any reasons, lies, pressure or influence that may affect your decision.

By signing, you acknowledge that you have read and understood the entire content of this letter. You also confirm that you have asked the relevant questions, which have been answered appropriately. You also acknowledge that you agree to participate in the established protocol, based on the information provided. Finally, you are informed that a copy of this consent has been delivered to you via email: nramos6@ucol.mx. Likewise, if at any time you have any doubts or questions, you can contact us via the same email so that we can respond appropriately.

Participant's signature: ________________________________

Participant's name: ________________________________

Witness 1 Name: __________________ Witness 2 Name: ____________________

Witness 1 Addres: __________________ Witness 2 Addres: ____________________

Principal Researcher signature. ______________________________

Principal Researcher Name. ____________________________

Annexe 6. Application of the IPA-Q questionnaire and format.

Application of the IPA-Q questionnaire

The purpose of this questionnaire, in its extended version, is to evaluate the level of physical activity and cardiac output of study participants during the last 7 days before completion. This is administered before and after the intervention and is aimed at individuals aged 15 to 69 years (92). Participants will receive a detailed introduction on the purpose of the questionnaire, followed by a step-by-step breakdown of the questionnaire, and will be provided with clarity on how to complete it (minutes or hours). All information will be provided, all questions or concerns of the participants will be answered, and then they will be provided with a designated space with a chair, table, pen, and the corresponding questionnaire to complete it. At all times, participants will have the support of a highly trained professional in the questionnaire, available to resolve any questions that arise during the process.

INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE
(October 2002)

LONG LAST 7 DAYS SELF-ADMINISTERED FORMAT

FOR USE WITH YOUNG AND MIDDLE-AGED ADULTS (15-69 years)

The International Physical Activity Questionnaires (IPAQ) comprises a set of 4 questionnaires. Long (5 activity domains asked independently) and short (4 generic items) versions for use by either telephone or self-administered methods are available. The purpose of the questionnaires is to provide common instruments that can be used to obtain internationally comparable data on health–related physical activity.

Background on IPAQ
The development of an international measure for physical activity commenced in Geneva in 1998 and was followed by extensive reliability and validity testing undertaken across 12 countries (14 sites) during 2000. The final results suggest that these measures have acceptable measurement properties for use in many settings and in different languages, and are suitable for national population-based prevalence studies of participation in physical activity.

Using IPAQ
Use of the IPAQ instruments for monitoring and research purposes is encouraged. It is recommended that no changes be made to the order or wording of the questions as this will affect the psychometric properties of the instruments.

Translation from English and Cultural Adaptation
Translation from English is encouraged to facilitate worldwide use of IPAQ. Information on the availability of IPAQ in different languages can be obtained at www.ipaq.ki.se. If a new translation is undertaken we highly recommend using the prescribed back translation methods available on the IPAQ website. If possible please consider making your translated version of IPAQ available to others by contributing it to the IPAQ website. Further details on translation and cultural adaptation can be downloaded from the website.

Further Developments of IPAQ
International collaboration on IPAQ is on-going and an ***International Physical Activity Prevalence Study*** is in progress. For further information see the IPAQ website.

More Information
More detailed information on the IPAQ process and the research methods used in the development of IPAQ instruments is available at www.ipaq.ki.se and Booth, M.L. (2000). *Assessment of Physical Activity: An International Perspective.* Research Quarterly for Exercise and Sport, 71 (2): s114-20. Other scientific publications and presentations on the use of IPAQ are summarized on the website.

INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE

We are interested in finding out about the kinds of physical activities that people do as part of their everyday lives. The questions will ask you about the time you spent being physically active in the **last 7 days**. Please answer each question even if you do not consider yourself to be an active person. Please think about the activities you do at work, as part of your house and yard work, to get from place to place, and in your spare time for recreation, exercise or sport.

Think about all the **vigorous** and **moderate** activities that you did in the **last 7 days**. **Vigorous** physical activities refer to activities that take hard physical effort and make you breathe much harder than normal. **Moderate** activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal.

PART 1: JOB-RELATED PHYSICAL ACTIVITY

The first section is about your work. This includes paid jobs, farming, volunteer work, course work, and any other unpaid work that you did outside your home. Do not include unpaid work you might do around your home, like housework, yard work, general maintenance, and caring for your family. These are asked in Part 3.

1. Do you currently have a job or do any unpaid work outside your home?

☐ Yes

☐ No ➔ ***Skip to PART 2: TRANSPORTATION***

The next questions are about all the physical activity you did in the **last 7 days** as part of your paid or unpaid work. This does not include traveling to and from work.

2. During the **last 7 days**, on how many days did you do **vigorous** physical activities like heavy lifting, digging, heavy construction, or climbing up stairs **as part of your work**? Think about only those physical activities that you did for at least 10 minutes at a time.

_____ **days per week**

☐ No vigorous job-related physical activity ➔ ***Skip to question 4***

3. How much time did you usually spend on one of those days doing **vigorous** physical activities as part of your work?

_____ **hours per day**
_____ **minutes per day**

4. Again, think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **moderate** physical activities like carrying light loads **as part of your work**? Please do not include walking.

_____ **days per week**

☐ No moderate job-related physical activity ➔ ***Skip to question 6***

5. How much time did you usually spend on one of those days doing **moderate** physical activities as part of your work?

_____ **hours per day**
_____ **minutes per day**

6. During the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time **as part of your work**? Please do not count any walking you did to travel to or from work.

_____ **days per week**

☐ No job-related walking → ***Skip to PART 2: TRANSPORTATION***

7. How much time did you usually spend on one of those days **walking** as part of your work?

_____ **hours per day**
_____ **minutes per day**

PART 2: TRANSPORTATION PHYSICAL ACTIVITY

These questions are about how you traveled from place to place, including to places like work, stores, movies, and so on.

8. During the **last 7 days**, on how many days did you **travel in a motor vehicle** like a train, bus, car, or tram?

_____ **days per week**

☐ No traveling in a motor vehicle → ***Skip to question 10***

9. How much time did you usually spend on one of those days **traveling** in a train, bus, car, tram, or other kind of motor vehicle?

_____ **hours per day**
_____ **minutes per day**

Now think only about the **bicycling** and **walking** you might have done to travel to and from work, to do errands, or to go from place to place.

10. During the **last 7 days**, on how many days did you **bicycle** for at least 10 minutes at a time to go **from place to place**?

_____ **days per week**

☐ No bicycling from place to place → ***Skip to question 12***

11. How much time did you usually spend on one of those days to **bicycle** from place to place?

_____ **hours per day**
_____ **minutes per day**

12. During the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time to go **from place to place**?

_____ **days per week**

☐ No walking from place to place → ***Skip to PART 3: HOUSEWORK, HOUSE MAINTENANCE, AND CARING FOR FAMILY***

13. How much time did you usually spend on one of those days **walking** from place to place?

_____ **hours per day**
_____ **minutes per day**

PART 3: HOUSEWORK, HOUSE MAINTENANCE, AND CARING FOR FAMILY

This section is about some of the physical activities you might have done in the **last 7 days** in and around your home, like housework, gardening, yard work, general maintenance work, and caring for your family.

14. Think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **vigorous** physical activities like heavy lifting, chopping wood, shoveling snow, or digging **in the garden or yard**?

_____ **days per week**

☐ No vigorous activity in garden or yard → ***Skip to question 16***

15. How much time did you usually spend on one of those days doing **vigorous** physical activities in the garden or yard?

_____ **hours per day**
_____ **minutes per day**

16. Again, think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **moderate** activities like carrying light loads, sweeping, washing windows, and raking **in the garden or yard**?

_____ **days per week**

☐ No moderate activity in garden or yard → ***Skip to question 18***

17. How much time did you usually spend on one of those days doing **moderate** physical activities in the garden or yard?

_____ **hours per day**
_____ **minutes per day**

18. Once again, think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **moderate** activities like carrying light loads, washing windows, scrubbing floors and sweeping **inside your home**?

_____ **days per week**

☐ No moderate activity inside home → ***Skip to PART 4: RECREATION, SPORT AND LEISURE-TIME PHYSICAL ACTIVITY***

19. How much time did you usually spend on one of those days doing **moderate** physical activities inside your home?

_____ **hours per day**
_____ **minutes per day**

PART 4: RECREATION, SPORT, AND LEISURE-TIME PHYSICAL ACTIVITY

This section is about all the physical activities that you did in the **last 7 days** solely for recreation, sport, exercise or leisure. Please do not include any activities you have already mentioned.

20. Not counting any walking you have already mentioned, during the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time **in your leisure time**?

_____ **days per week**

☐ No walking in leisure time → ***Skip to question 22***

21. How much time did you usually spend on one of those days **walking** in your leisure time?

_____ **hours per day**
_____ **minutes per day**

22. Think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **vigorous** physical activities like aerobics, running, fast bicycling, or fast swimming **in your leisure time**?

_____ **days per week**

☐ No vigorous activity in leisure time → ***Skip to question 24***

23. How much time did you usually spend on one of those days doing **vigorous** physical activities in your leisure time?

_____ **hours per day**
_____ **minutes per day**

24. Again, think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **moderate** physical activities like bicycling at a regular pace, swimming at a regular pace, and doubles tennis **in your leisure time**?

_____ **days per week**

☐ No moderate activity in leisure time → ***Skip to PART 5: TIME SPENT SITTING***

25. How much time did you usually spend on one of those days doing **moderate** physical activities in your leisure time?
_____ **hours per day**
_____ **minutes per day**

PART 5: TIME SPENT SITTING

The last questions are about the time you spend sitting while at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading or sitting or lying down to watch television. Do not include any time spent sitting in a motor vehicle that you have already told me about.

26. During the **last 7 days**, how much time did you usually spend **sitting** on a **weekday**?

_____ **hours per day**
_____ **minutes per day**

27. During the **last 7 days**, how much time did you usually spend **sitting** on a **weekend day**?

_____ **hours per day**
_____ **minutes per day**

This is the end of the questionnaire, thank you for participating.

Annexe 7. Test and cut-off points for abdominal obesity

For this test, a certified measuring tape will be used and it will also have the objective of determining the abdominal circumference taking into account the morphophysiological parameters established by the International Society for the Advancement of Kinanthropometry (ISAK) and a marker (109). The subject must be placed in an anatomical position and then will be told to raise his arms crossed at chest height, then the upper edge of the iliac crest will be identified by marking it with the marker, and after that the lower edge of the last rib will be identified, so a marking will be made, then the two established references will be taken to identify the middle area of the markings, then the abdomen will be surrounded with the tape and the subject will be told to breathe normally and at the end of this the circumference will be taken (Table 1).

Annexe 8. Blood pressure cut-off points.

Tabla 9. Estadios de la presión arterial.

X	Systolic (mmHg)	Diastolic (mmHg)
Normal blood pressure	<120	< 80
High	Between 120 – 129	< 80
Hypertension stage 1	Between 130 – 139	Between 80 - 89
Hypertension stage 2	>140	> 90

Source: Reference table for classification of hypertension based on reference (35,110)

Annexe 9. Test and cut-off points for hyperglycemia.

For the venous blood extraction, the subject will be informed that he/she must attend the test after fasting for at least eight hours, to decrease the probability of test alterations. Once the subject is at the blood extraction location, a health professional will take the sample using the venipuncture technique in the radial area, extracting about 10 ml (111). From this sample, the DHL sample, triglycerides and the glycosylated haemoglobin sample will be extracted. After the procedure, the participant will be told to remain seated for at least 5 minutes, after which he/she will be asked again about their condition. If they are feeling fine, they will leave the designated area. If they are not, they will remain monitored by the staff until stabilized. See Appendix 7. When all the samples from the participants are obtained, they will be taken to the University of Colima laboratory for centrifugation, extraction of the pertinent components, labelling and freezing for shipment, which will give the final results (112).

Tabla 10. Pruebas para el diagnóstico de la hiperglicemia.

Test name	Acronym	Normal Valeus	Altered Valeus
Glycosylated hemoglobin	HbA1c	5.6%	>5.7% 39 mmol/ml
Fasting plasma glucose	FPG	99 mg/dl	>100 mg/dl
Tolerancia a la glucosa	2H- PG	139mg/dl	140 mg/dl

Source: Cut-off points for an alteration in blood glucose by the different laboratory tests ADA2023 taken based on reference (50).

Annexe 10. Test, data sheet and results for Queens College test

Application of the Queen College step test.

This test aims to monitor the maximum oxygen consumption of the study subjects in 3 continuous minutes, Lopategui in 2014 stated that to perform this test it is necessary to have a 16-inch or 40.64 cm bench, a digital stopwatch, a metronome and an assistant during the test (113).

Previously trained personnel demonstrate the correct way to ascend and descend the step. Subjects should be instructed during the test to always lead with the same foot, fully extend their legs once on the step, and keep their arms at their sides at all times.

Following the explanation of the performance, the subject will be allowed a 15-second practice session. The correct cadence for each completed performance or cycle must be checked. To complete a performance or cycle, the step must have been ascended and descended once, to a count of four: up-up-down-down! setting the metronome to: men - 96 beats min-1 and women - 88 beats min-1. The subject must practise the correct cadence for each completed performance or cycle: men - 24 performances/min, 2.5 seconds for each cycle and women - 22 performances/min, 1 second for each cycle (113).

Set the watch for the test: 3 minutes for both men and women. Activate the metronome: for men, the metronome is set at 96 beats/min, and for females it should be 88 beats/min. At the beginning of the test, the step is ascended and descended at a rate of 24 (men) and 22 (women) times per minute. After the 3-minute test has been completed, the participant remains standing for 5 seconds and immediately afterwards the pulse is taken for 15 seconds, then the beats felt during these 15 seconds are multiplied by 4 (pulse-15 sec x 4) to convert it into beats/minute. This resulting value is known as the Recovery Heart Rate (HRrecup) (113).

Percentile ranks and classification for the Queens College Step Test recovery heart rate and its estimate of maximal oxygen uptake for male and female college students.

Percentile rank	Women's heart rate frequency (Lat/min)	VO2max	Men's heart frequency (lat/min)	VO2max
Rango Percentil	**FCrecup. Mujeres (lat·min^{-1})**	**VO_2máx (mL • kg^{-1} • min^{-1})**	**FCrecup. Varones (lat·min^{-1})**	**VO_2máx (mL • kg^{-1} • min^{-1})**
100	128	42.4	120	61.0
95	140	40.0	124	59.3
90	148	38.5	128	57.6
85	152	37.7	136	54.3
80	156	37.0	140	52.6
75	158	36.6	144	50.9
70	160	36.3	148	49.2
65	162	35.9	149	48.7
60	163	35.7	152	47.5
55	164	35.5	154	46.7
50	166	35.1	156	45.9
45	168	34.8	160	44.2
40	170	34.4	160	43.4
35	171	34.2	164	42.5
30	172	34.0	166	41.7
25	176	33.3	168	40.8
20	180	32.6	172	39.2
15	182	32.2	176	37.5
10	184	31.8	178	36.6
5	196	29.6	184	34.1
0	-	-	-	-

NOTA: De: ***Laboratory Experiments in Exercise Physiology***. (p. 45), por J. Magel, & W. McArdle, 1976, New York: Queens College of the City University of New York. Copyright 1976 por J. Magel, & W. McArdle.

Annexe 11. Sports planning for intervention and control groups

Table 11. General physical exercise prescription for the control group (A)

	Means	Day of the week	Duration	First four weeks intensity	Last four weeks intensity
Cardiorespiratory endurance	Walk	Monday	60 min	57% - 76% of HR Frequency	57% - 76% of HR Frequency
Cardiorespiratory endurance	Walk	Wednesday	60 min	57% - 76% of HR Frequency	57% - 76% of HR Frequency
Cardiorespiratory endurance	Walk	Friday	60 min	57% - 76% of HR Frequency	57% - 76% of HR Frequency

Source: Based on reference (83)

Table 12. General physical exercise prescription for the Experimental group (B).

	Means	Day of the week	Duration	First four weeks intensity	Last four weeks intensity
Cardiorespiratory endurance	Jogging	Monday	60 min	57% - 63% of HR Frequency	64% - 76% of HR Frequency
Cardiorespiratory endurance	Swimming	Wednesday	60 min	57% - 63% of HR Frequency	64% - 76% of HR Frequency
Cardiorespiratory endurance	Static Bicycle	Friday	60 min	57% - 63% of HR Frequency	64% - 76% of HR Frequency

Source: Self-made based on references (72, 114, 115)

Note: This planning will be adjusted in volume after the first 4 weeks, considering the subject's adaptations in the second test session.

Annexe 12. Borg Scale

Table 13. Modified Borg Scale

Modified Borg Scale	
0	Total rest
1	Very low effort
2	Soft
3	Moderated effort
4	A bit hard
5	Hard
6	Hard
7	Very hard
8	Very hard
9	Very hard
10	Maximal effort

*Source:*Self-made based on reference (116)

Annexe 13. Aerobic or Cardiorespiratory Fitness. Classification Scale. Estimated Maximum Oxygen Consumption (ml • kg-1 • min-1).

Aerobic or Cardiorespiratory Fitness. Classification Scale. Estimated Maximum Oxygen Consumption (ml • kg-1 • min-1).

Classification	Age groups (years)					
	13 - 19	20 - 29	30 - 39	40 - 49	50 - 59	Sobre 60
Men						
Very Poor	< 35.0	< 33.0	< 31.5	< 30.2	< 26.1	< 20.5
Poor	35.0-38.3	33.0-36.4	31.5-35.4	30.2-33.5	26.1-30.9	20.5-26.0
Average	38.4-45.1	36.5-42.2	35.5-40.9	33.6-38.9	31.0-35.7	26.1-32.2
Good	45.2-50.9	42.5-46.4	41.0-44.9	39.0-43.7	35.8-40.9	32.2-36.4
Excellent	51.0-55.9	46.5-52.4	45.0-49.4	43.8-48.0	41.0-45.3	36.5-44.2
Superior	> 56.0	> 52.5	> 49.5	> 48.1	> 45.4	> 44.3
Women						
Very Poor	< 25.0	< 23.6	< 22.8	< 21.0	< 20.2	< 17.5
Poor	25.0-30.9	23.6-28.9	22.8-26.9	21.0-24.4	20.2-22.7	17.5-20.1
Average	31.0-34.9	29.0-32.9	27.0-31.4	24.5-28.9	22.8-26.9	20.2-24.4
Good	35.0-38.9	33.0-36.9	31.5-35.6	29.0-32.8	27.0-31.4	24.5-30.2
Excellent	39.0-41.9	37.0-40.9	35.7-40.1	32.9-36.9	31.5-35.7	30.3-31.4
Superior	> 42.0	> 41.0	> 40.1	> 37.0	> 35.8	> 31.5

NOTE: Adapted from: "El Camino del Aeróbics" (pp- 295-296), by K.H.Cooper, 1979, Mexico: Editorial Diana S.A. Copyright 1979 by K.H.Cooper

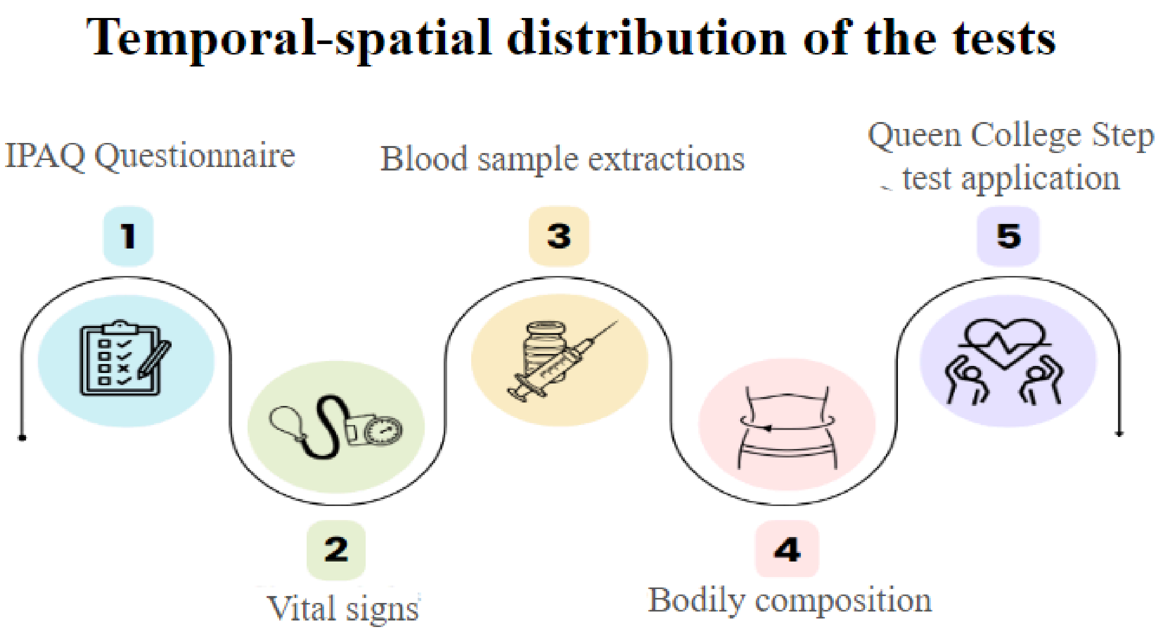
Annexe 14. Mests and their equivalence by physical activity

Table 14. Relationship between physical activity and mets.

Daily activities			
Activity	kcal/kg*min.	kcal/kg*30 min.	MET
Sleep	0,015	0,45	0,9
Being relaxed	0,018	0,54	1,08
Read	0,018	0,54	1,08
Talk	0,024	0,72	1,44
Remain seated	0,025	0,75	1,5
Write	0,027	0,81	1,62
Remain standing	0,029	0,87	1,74
Eat	0,03	0,9	1,8
Swipe the floor	0,031	0,93	1,86
Wash dishes	0,037	1,11	2,22
Drive	0,04	1,2	2,4
Cook	0,045	1,35	2,7
Shower	0,046	1,38	2,76
Get dressed	0,05	1,5	3
Make the bed	0,057	1,71	3,42
Clean windows	0,061	1,83	3,66
Iron clothes	0,063	1,89	3,78
Wash floors	0,066	1,98	3,96
Vacuuming	0,068	2,04	4,08
Gardening	0,09	2,7	5,4
Go down the stairs	0,101	3,03	6,06
Go up the stairs	0,254	7,62	15,24

Source: Taken from reference (57, 86, 102)

Annexe 15. Temporal-spatial distribution of the tests



Annexe 16. Turnitin Similarity Report

turnitin

Similarity report identification: oid:8109:353497888

Work's Name	Author
Documento para enviar el jueves 8 de mayo.docx	Nelson Enrique Ramos Cuevas
Word count	**Characters count**
20264 Words	116436 Characters
Page count	**File size**
89 Pages	1.7MB
Turn-in date	**Report date**
May 8, 2024 5:31 PM CST	May 8, 2024 5:32 PM CST

● **21% of general similitude**

The combined total of all coincidences, including overlapped sources, por every database

- **19% Internet's database**
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- **21% Turned-in work**
- **14% publications database**
- **Content posted on Crossref database**