Specialised Course

polartrainingzone.com.au/courses/specialised-course

Specialised Polar Training Zone

Thank you for choosing the Polar Training Zone Specialised Course.

This course would not have been possible without the contributions of Doctor in training and exercise physiologist Jake Kilby from the Griffith University Medical School and University of Queensland Anatomy Department. Professor Gregory Scalia from University of Queensland, School of Medicine and Lachlan Johnston, Performance Scientist - High Performance Team of the Queensland Academy of Sport.

The data presented or reproduced within this course has been sourced from Australian Institute of Sport, Queensland Academy of Sport, International Universities, acclaimed authors, researchers, medical practitioners and exercise scientists from around the world including here in Australia. .

New information, new research, concepts and programming to trial are always exciting. *Please always adhere to your scope of practice relevant to your qualification, insurance, registering governing body* and consider the individual's suitability to what you are going to do and seek further understanding before application.

Training is a process. research it, implement it, test and measure it, then do it.

Make every beat count.

Enjoy being 'Specialised'!

On the Completion of the Specialised Course you will receive a "Specialised" Polar Training Certificate as an immediate downloadable certificate.

On completion of the Basic, Advanced and the Specialised Courses you will receive a certificate of Heart Rate Training SPECIALIST.

For successful completion of this Specialised course you must get 80% of the test questions correct.

There are 76 Quiz questions to be answered with majority being multiple choice and some anatomy labelling and table arrangement questions.

You will have only 2 attempts to get each question answered correctly. Therefore, please ensure all of the course material in each section is read thoroughly before commencing the test. If after the 3 rd attempt the answer is incorrect than the correct answer will be provided and highlighted.

Time to complete the course is dependent on variables like your prior knowledge, reading speed and internet connection speeds.

We must provide you with an estimated time it may take you to complete the course, but we know these time estimations are inaccurate for all sorts of reasons. So please do not stress, enjoy the content and various ways we have introduced the content into the course and if you wish take the time to investigate the additional readings we have provided links too.

The course is designed to read, understand and test. You will be asked to read each chapter, watch narrated video content within a chapter and once each chapter is completed you will be provided a quiz to demonstrate your understanding and progress through the course.

We estimate the Specialised Course will take approx 8 hours to complete.

If you logout at any time through the course, you can resume the course at any time by logging back in. You will be taken to the last completed page.

You have up to 12 months to complete the course including all online test questions and the feedback form. (Please note the feedback form must be completed to complete the course.)

Once you have successfully completed the course, your Specialised Certificate of Completion will be immediately available for download.

A special mention. If you have successfully completed the Basic, Advanced and Specialised course you will qualify as a Polar Training Zone – Heart Rate Training SPECIALIST. A Specialist certificate will be available for Download.

On completion of the course you will receive ???? CEC's or 3 PDP towards your Australian national fitness registration.

On completion of the course you will receive 3 CDP pts towards your New Zealand national fitness registration.

If you have any questions or problems please email education@polartrainingzone.com.au.

For additional support, join our community on Facebook and Instagram.
https://www.facebook.com/Polartrainingzone/
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Now that you are set.

Course Overview

1. Introduction: Discussion - What is Fitness?
2. Cardiovascular System Physiology
    1. Anatomy
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    3. Blood Supply
    4. Cardiac Electrophysiology
    5. What determines heart rate
    6. Regulation of Blood flow during exercise
3. Respiration System
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    2. Conducting Zone
    3. Respiratory Zone
    4. Respiration - Mechanical, Alveolar and Internal Respiration
    5. SpO2 Meters
4. Muscle contraction via nervous system
    1. Organisation of the nervous system
    2. Autonomic Nervous System
    3. Motor control and Pyramidal Pathway
    4. Motor Unit Recruitment and Size Principle
5. Maximal Heart Rate Formulas
6. Percentage of Maximal heart rate
7. Monitoring of Intensity Methods
8. METS
    1. What are they and how to use them?
    2. Limitations of METS
    3. METS comparisons across modes of exercise
9. Standardisation of Training Zones (AIS Physiology nomenclature)
    1. Standardisation Benefits
    2. Blood Lactate
    3. New AIS Endurance Training Zones
10. Polar Training Zones
11. Ratings of Perceived Exertion scales (RPE)
12. Anaerobic & Aerobic Threshold
13. Heart rate Transferability
14. Elite Training Methods
15. High Intensity Exercise (HIIT) V’s Low Intensity Exercise (LIE)

Scope of Practice

polartrainingzone.com.au/topic/scope-of-practice-3

Countries around the world have registered governing bodies that represent the health, recreation and fitness industry as a whole or in different ways for a certain type of profession or role/s.

In the professional landscape of working within the health and fitness industry it is expected that the registered exercise professionals practice in accordance with their national professional standards and subsequently safeguarding the health and interests of people using exercise professional services.

It is important that if you are working within the industry that you are aware of your professional scope and boundaries as a registered professional.

In Australia for example:
1. Fitness Australia
a. https://fitness.org.au/articles/policies-guidelines/scope-of-practice-for-ausreps/26/38/20
b. https://bp-fitnessaustralia-production.s3.amazonaws.com/uploads/uploaded_file/file/392024/Scope_of_Practice_June_2019.pdf

as at April 2020

2. Physical Activity Australia - https://www.physicalactivityaustralia.org.au/what-is-my-scope-of-practice/
a. https://www.physicalactivityaustralia.org.au/code-of-conduct/

3. ESSA Exercise & Sports Science Australia
a. https://www.essa.org.au/Public/Professional_Standards/ESSA_Scope_of_Practice_documents.aspx

b. - https://www.essa.org.au/wp-content/uploads/2015/09/Scope-of-Practice-for-AEP.pdf

4. ASCA The Australian Strength and Conditioning Association
https://www.strengthandconditioning.org/documents/asca-scope-of-practice.pdf

In New Zealand for Example:

1. REPS - NZ register of Exercise Professionals - http://www.reps.org.nz/scope-of-practice/

The core role of a Registered Exercise Professional is to plan and deliver safe and effective exercise programs for individuals and/or groups. A Registered Exercise Professional undertakes one or more of the following roles: Personal Trainer Gym Instructor Group Exercise Instructor Group Exercise Leader Competency in delivering specific activities within these roles is obtained through qualification and/or approved continuing education. Exercise Professional Registration practice is based on verification of initial and continuing competence. “Fitness Australia Scope of Practise – April 2020

What is Fitness?

polartrainingzone.com.au/topic/what-is-fitness

What does “get fit” actually mean?

Take a couple of seconds to consider what your definition of Fitness is.

Do you think fitness could actually be individual and different from person to person? Is it a feeling, a comparison, a task, a lifestyle, a sport or overall health and wellness?

If there is someone close to you now or later today - ask them what does “get fit” mean to them? How do you know when you are fit? What can you do when you are fit? What does getting fit involve? See how people's understanding are different and definitions actually are or could be both similar but different.

The American college of Sports Medicine (ACSM) defines fitness “as a set of attributes or characteristics that people have or achieve that relates to the ability to perform physical activity.”

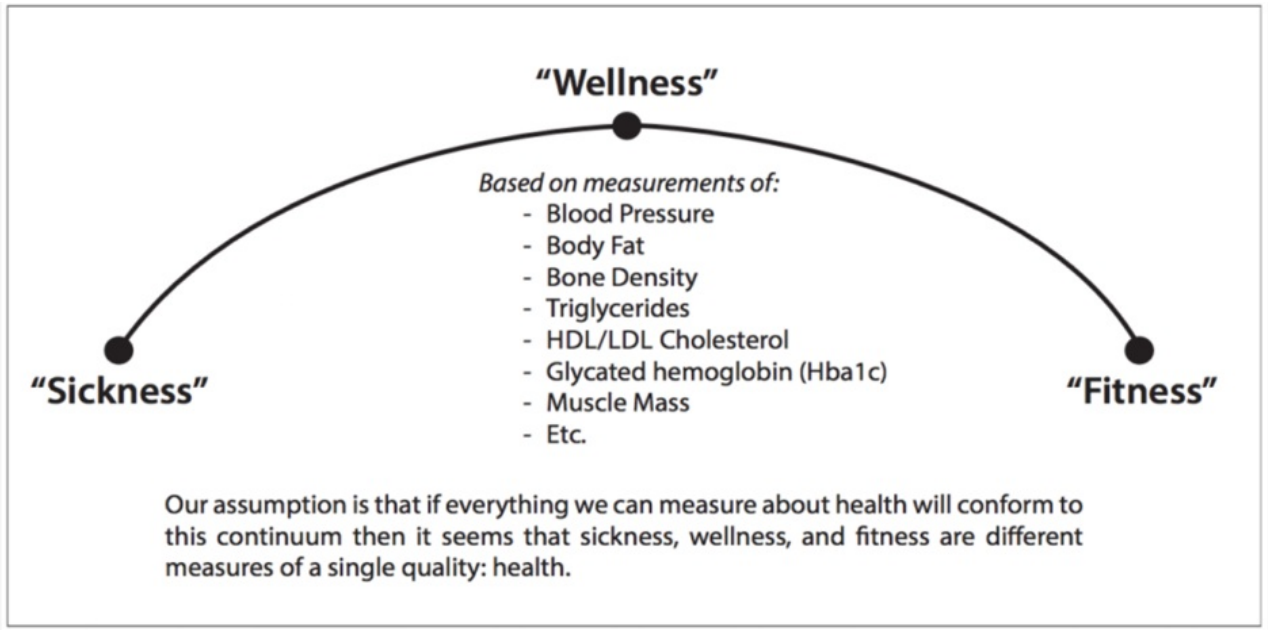
But with this definition comes scrutiny. What is physical activity? Is there a difference between attribute and characteristic? Is this fitness measurable?

CrossFit founder Glassman defines your fitness as your “work capacity across broad time and modal domains” i.e. the ability to perform work per unit time is power. Therefore, the ability to produce and sustain power equals human performance.

Dr Nathan Jenkins explains all biochemical and physiological responses to physical work are governed by the relationship between by work demands and an individual’s fitness.

Illustrating, Glassman definition provides a framework for understanding physical function, health, well-being, physiology, biochemistry and molecular biology.

Glassman observes that almost every measurable value of health can be placed on a continuum that ranges from sickness to wellness to fitness.



This continuum now considers not just what is fitness but now WHO is fit? Who can remain fit? Maybe who is Mentally fit?

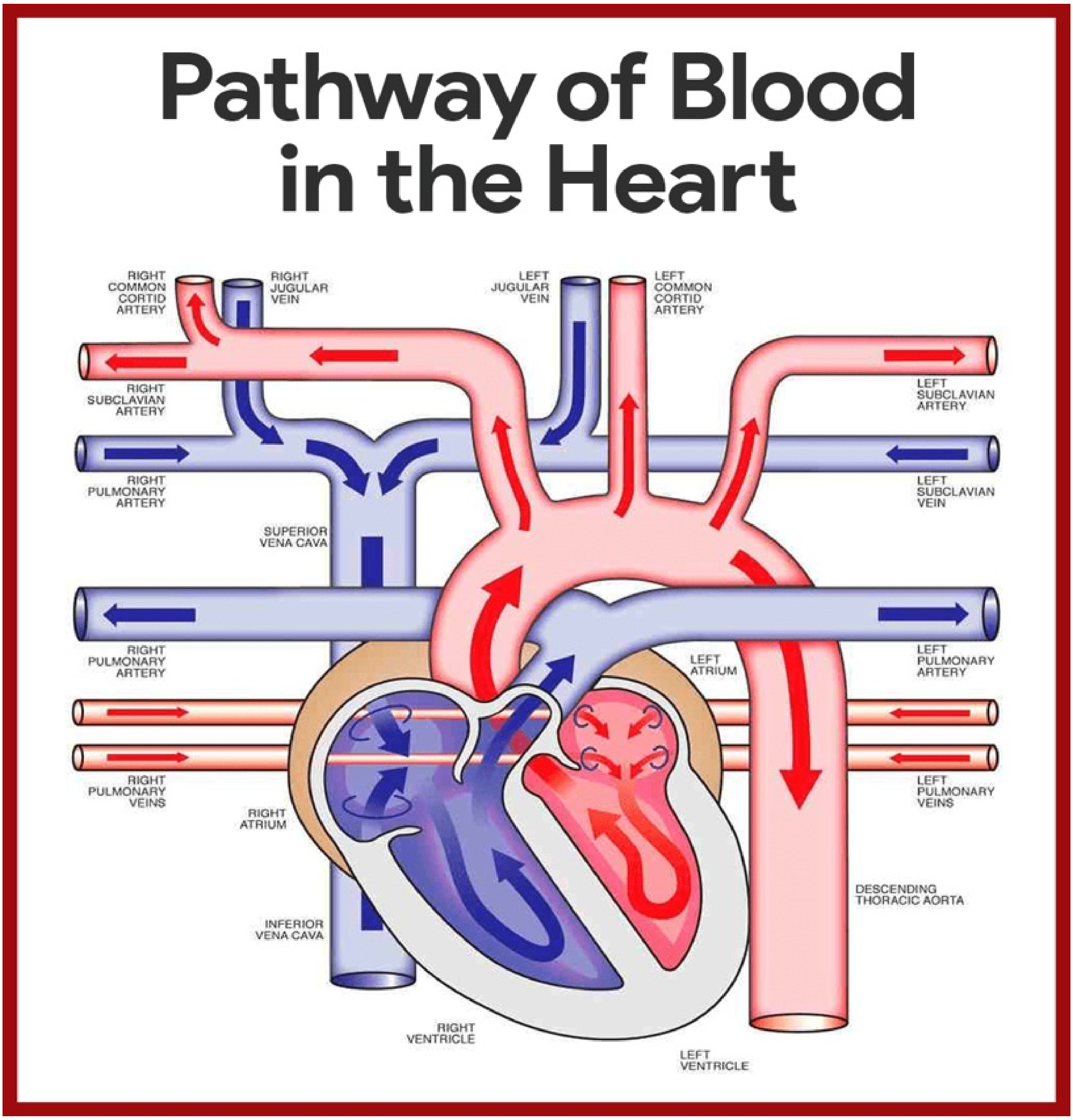
Our Fitness Journey will have its ups and downs. Stay the course, stay in the fight as the famous no 7 NRL player Johnathon Thurston used to say.

Whatever the definition - Your Fitness definition is individual. Enjoy the Journey.

For further understanding of Dr Nathan Jenkins and Greg Glassman click below:

Article - CrossFit: Forging Elite Fitness
Article - CrossFit: Forging Elite Fitness

Cardiovascular System Physiology – Introduction



Picture. Nurseslabs 2020

Your heart will probably beat over 3 million times in your lifetime.....

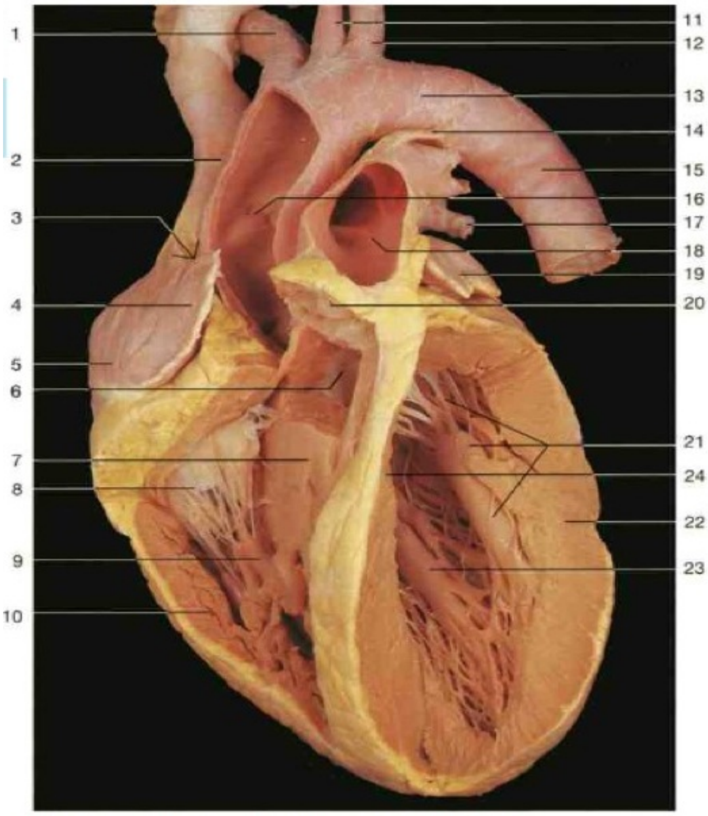
From the basic course, we learnt that the cardiovascular system has three broad components; the heart, blood vessels, and blood. We went through the basic anatomy and briefly described the physiology of the heartbeat and the term cardiac cycle, consisting of systole and diastole.

In this course we will be going deeper into the physiology of the heart, with the purpose to improve your knowledge on this critical organ so that you can inform your clients on what makes them tick and how. You will be able to explain how the heart generates its own electrical activity and how its arrangement of specialised conducting cells dictates the heart to beat in a purposeful manner.

We will explore terms like cardiac output, a term often thrown around in fitness conversations with little background knowledge of what it is and what factors affect it. You will be able to explain the changes seen in cardiac output in exercise and what determines the resting heart rate. The content covered in this course is by no means exhaustive and we will give you references to expand your knowledge if you choose to explore further.

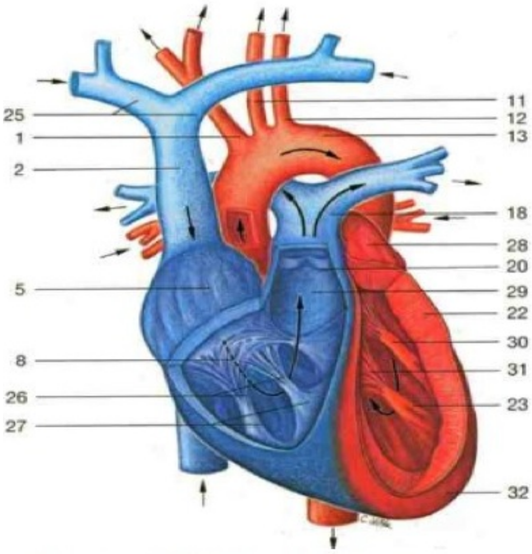
Anatomy

polartrainingzone.com.au/topic/anatomy

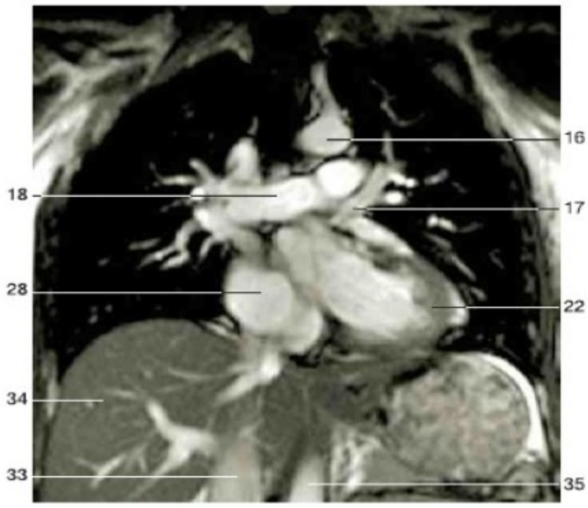


Anterior aspect of the heart. Dissection of the four valves.

1 Brachiocephalic trunk
2 Superior vena cava
3 Sulcus terminalis
4 Right auricle
5 Right atrium
6 Aortic valve
7 Conus arteriosus (interventricular septum)
8 Right atrioventricular (tricuspid) valve
9 Anterior papillary muscle
10 Myocardium of right ventricle
11 Left common carotid artery
12 Left subclavian artery
13 Aortic arch
14 Ligamentum arteriosum (remnant of ductus arteriosus)
15 Thoracic aorta (descending aorta)
16 Ascending aorta
17 Left pulmonary vein
18 Pulmonary trunk
19 Left auricle
20 Pulmonic valve
21 Anterior papillary muscle with chordae tendineae
22 Myocardium of left ventricle
23 Posterior papillary muscle
24 Interventricular septum
25 Right and left brachiocephalic veins
26 Chordae tendineae
27 Papillary muscles of right ventricle
28 Left atrium
29 Infundibulum
30 Anterior papillary muscle of left ventricle
31 Left atrioventricular (bicuspid or mitral) valve and chordae tendineae
32 Apex of heart
33 Inferior vena cava
34 Liver
35 Aorta (pars abdominalis)



Circulation within the heart (anterior aspect).
Arrows = direction of blood flow.



MRI scan of the heart (coronal section at the level of the left atrium; courtesy of Prof. W. Bautz and R. Janka, M. D., University of Erlangen, Germany).

In the basic course, there was a 40-second video on the general arrangement of the heart and how blood flows through the heart to the lungs and back to the heart and out to the rest of the body.

Your browser does not support the video tag.

Figure 1. The heart and blood circulation.

This is achieved via a 4 chambered heart connected to 2 independent circulations. Put simply, one can think of the right side of the heart and its associated vessels as the pulmonary circuit and the left side and its associated vessels as the systemic circuit.

Each side of the heart has two chambers, an atrium and a ventricle connected by atrioventricular valves - small flaps of connective tissue that are tethered to the heart wall that are pushed shut by the force of the blood being ejected from the ventricles in systole. This acts as a one way valve allowing the blood to then move on through the semilunar valves (again one of each side of the heart). The semilunar valves work differently in that the force of the blood being ejected during ventricular contraction actually opens the valves.

Interestingly the sounds of the heart are created from the closing of these valves. So that the first heart sound is the closing of the atrioventricular valves (beginning of systole) and the second heart sound the closure of the semilunar valves (beginning of diastole).

In summary each side has two valves, an atrioventricular valve and a semilunar valve.

The atrioventricular valves are open in diastole and closed in systole, whereas the semilunar valves are closed in diastole and open in systole. The overall function of this setup is to allow movement of blood in one direction in an efficient manner.

Structure

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Structure begets function

Everything in biology is built for purpose, that is, there is a tight relationship between the structure of something and it's intended function. What we mean by structure is its appearance and shape. What it is made of and how it is arranged will ultimately determine the function. You can zoom into any level and see this to be true; from organism all the way down to molecular level - the shape and material determine the function. So, by studying the structure we can have a deeper understanding of function, digging out the how's and the why's, which can be a very satisfying endeavour.

In the heart this is seen visibly in the different sizes of the pulmonary and systemic circulations. The right side of the heart (pulmonary circuit) is only pumping deoxygenated blood a short distance to the lungs via the pulmonary arteries (the term artery means blood vessel carrying blood away from the heart) where it then returns back, after being oxygenated by the lungs, to the left side of the heart via the pulmonary veins (the term vein means blood vessel carrying blood towards the heart). This is a relatively short loop when compared to the left side of the heart, which has to pump blood out of the thorax to the head, abdomen and rest of the body. Without getting into the complexities of fluid dynamics (blood being a fluid) it is simple to understand that the longer the distance to pump something at a given velocity the greater the force required to achieve this.

To get around this asymmetry of circuits the heart has evolved asymmetrically, that is the right atrium and ventricle are smaller and thinner (i.e. less muscle mass) than the larger and thicker left atrium and ventricle (more muscle mass). This extra muscle generates a greater force per contraction on the left side, this force is coined as blood pressure. Therefore, it isn't surprising to see the right side of the heart as a low-pressure system when compared to the left which is a high-pressure system. Because the two sides are arranged in series (i.e. the right connects to the left via the pulmonary circuit), cardiac output (amount of blood ejected per heartbeat) is the same for each side of the heart.

This adaptation carries forward to the associated great vessels for each side, if you were to compare the pulmonary trunk - the massive artery coming off the right ventricle - to the aorta - the largest artery in the body coming off the left ventricle - you would see that the aorta is not only bigger but thicker, built to withstand the large pressures required to ensure adequate blood flow to the body.

You have been given a small glimpse at how structure and function are interrelated. Try and find other structural properties of the body and how they might facilitate the function of that part.

Blood Supply

polartrainingzone.com.au/topic/blood-supply

Blood supply of the heart

The heart, like every other organ/tissue in the body requires a blood supply to deliver oxygen and other nutrients. The first branches off of the aorta are the left and right coronary arteries, which travel between the atria and ventricles, branching off multiple times to provide adequate blood supply to all of the heart tissue. The right coronary artery usually supplies the right side of the heart, whilst the left coronary artery supplies the left. As with everything in biology, variation does occur.

Because these vessels are so close to the aortic semilunar valve, they do not receive much blood flow during systole. This is because during systole, blood is ejecting through the semilunar valve at quite a high speed blowing straight past the openings to the coronary arteries to flow to the rest of the body. However, during diastole, the heart is not contracting and so the blood being pushed through the aorta will slow to a stall and start traveling back towards the heart (due to gravity) causing the semilunar valves to close and start pooling within the aorta, some of this blood will flow through the coronary arteries. To say this simply, the heart receives most of its oxygenated blood during diastole.

This greatly affects max heart rate. For as heart rate increases, the cardiac cycle shortens in duration. Systole changes very little, making up roughly a third of the cardiac cycle. The biggest change is seen in diastole, which makes up the other two thirds, essentially the heart is at rest less, so it makes sense that diastole becomes shorter. As the heart rate approaches maximum, there is very little time that the heart is in diastole, which means blood flow to the heart is restricted because as we said earlier the heart receives most of its fresh blood during diastole. The heart has very little anaerobic capability, meaning that it requires oxygen to create energy, so it is highly dependent on this blood supply.

Now think about someone with atherosclerosis (a disease which causes plaque build-up inside arteries, restricting blood flow) and what would happen to them as their heart rate increases. Like everyone else, their heart is only receiving oxygen rich blood during diastole, if their coronary arteries are congested with fatty plaques, blood flow is going to be restricted and so less blood will be making it to the heart tissue during each diastole. Their heart will go anaerobic far quicker (at a lower heart rate) than someone without atherosclerosis, which leads to hypoxia of the heart tissue and subsequent angina (chest pain). This is why careful consideration needs to be taken when training these clients, and because it is a lifestyle and age-related disease should be considered until proven otherwise, particularly in older clients.

All of the blood that the heart receives eventually drains into cardiac veins into the coronary sinus (large vein like structure on the back of the heart) and back into the right atrium where it will mix with the rest of the deoxygenated blood to hitch a ride to the lungs via the pulmonary circuit.

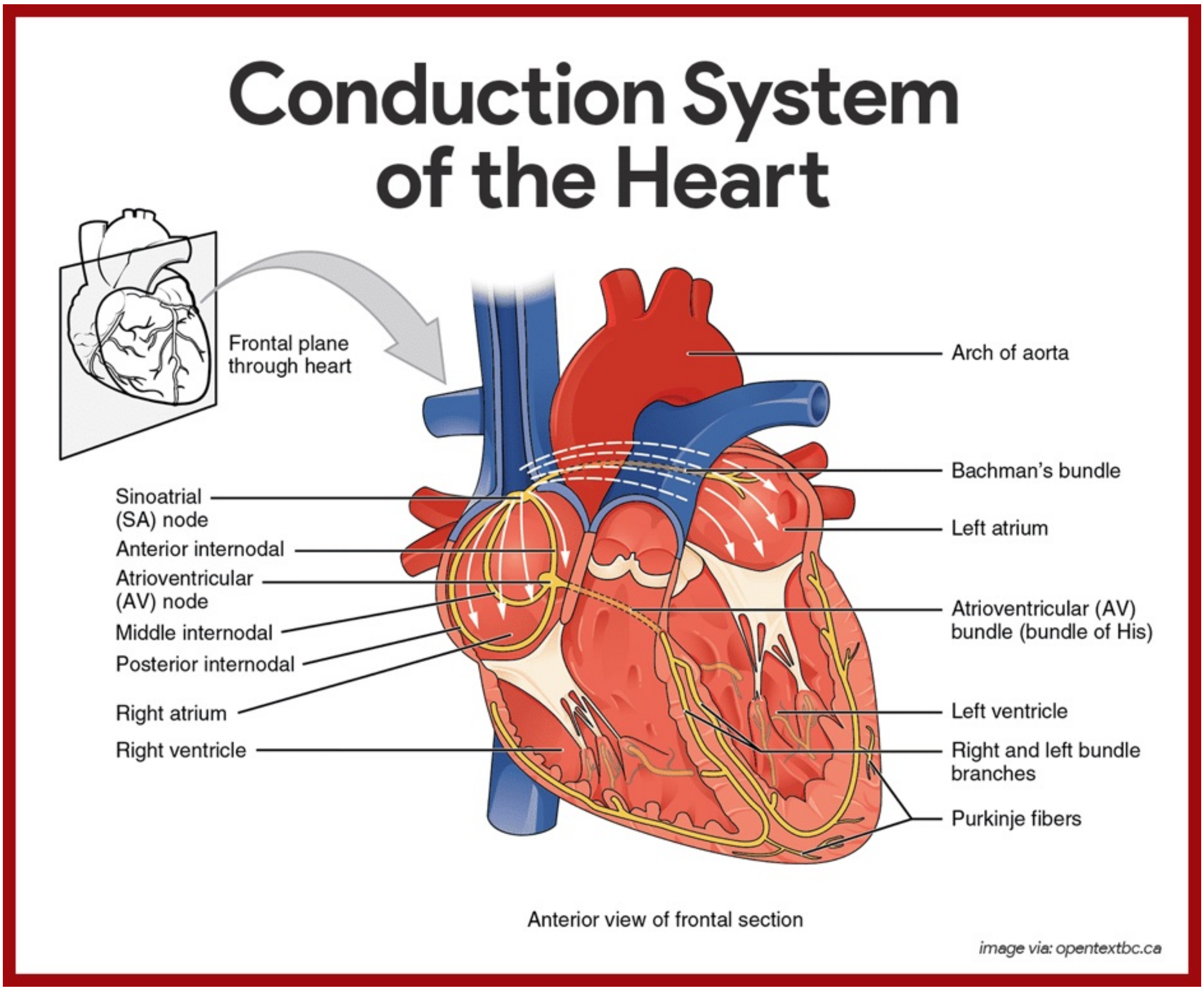
Cardiac Electrophysiology

So far, we have talked about the structure of the heart and its blood supply, but what actually makes it tick? Why do the atria contract just before the ventricles and how is this achieved?

The major function of the heart is to pump blood through the vascular system, this is facilitated via the contraction of ventricles which are electrically activated to achieve this. This electrical activity of the heart is known as the cardiac action potential which originates in the sinoatrial node (SA node). These action potentials are then conducted to the rest of the myocardium in a specific sequence, which is followed by the contraction of the heart muscle, also in a specific sequence. This sequence is important as the atria have to contract just before the ventricles and the ventricles have to contract from the apex to the base in order to maximize cardiac output.

To achieve this electrical and mechanical activity in the heart, it has two different cell types. Contractile cells are the majority of atrial and ventricular tissue, allowing the heart to undergo contraction. Conducting cells are specialized pacemaker cells that include the SA node, internodal tracts, atrioventricular node (AV node), the bundle of His and the Purkinje system. These conducting cells are still muscle cells but are not numerous enough to contribute that much to contraction, what they do is generate action potentials and distribute this electrical activity in a rapid and sequential manner to produce a smooth consistent heartbeat that is the same as the next. Think of them as the conductor of an orchestra, small in number but very important to organize the rabble of musicians (contracting cells) into a harmonious melody (heartbeat).

This conduction system is unique to the heart. It allows the heart to produce its own action potentials, essentially what this means is you could remove a heart and from the body and as long as you keep feeding it oxygenated blood it would continue to beat, independent of the nervous system.


Conduction System of the Heart
Frontal plane through heart
Arch of aorta
Bachman's bundle
Sinoatrial (SA) node
Left atrium
Anterior internodal
Atrioventricular (AV) node
Atrioventricular (AV) bundle (bundle of His)
Middle internodal
Posterior internodal
Left ventricle
Right atrium
Right ventricle
Right and left bundle branches
Purkinje fibers
Anterior view of frontal section
image via: opentextbc.ca

What Determines Heart Rate

polartrainingzone.com.au/topic/what-determines-heart-rate

The SA node is the master conductor setting the resting heart rate at roughly 70-80 bpm. Yet, you would have noticed fit athletes with a much lower heart rate and an untrained person with a potentially higher one. Genetics is a large factor of resting heart rate and variability is common even amongst the fittest athletes, this course will focus on how heart rate is regulated in the body physiologically, just be aware that genetics does play a part. The primary way the heart rate is regulated is via the autonomic nervous system, i.e. the parasympathetic (rest and digest) and sympathetic (fight or flight) nervous systems.

Basically, the parasympathetic commonly referred to as vagal (it is the vagus nerve that carries out this function), slows the heart down by inhibiting the SA node. Conversely, the sympathetic nervous system speeds things up via adrenergic (adrenalin) mechanisms. This break and accelerator ability allows the heart rate to be adjusted according to homeostatic needs, it makes sense that the heart would need to work harder and faster in times of stress (exercise is a stress) and so would be more influenced by sympathetic activity and in time of rest, the parasympathetic system would dominate. This yin and yang effect are governed by the brain and specialised cells that act as sensors throughout the body. One such sensor, called baroreceptors, detect pressure changes within the great arteries and send signals to the brain to adjust heart rate to keep blood pressure at homeostatic requirements. As the heart rate is adjusted the sensors detect the change and modulate their signal back to the brain. There are many other sensors in the body that detect a parameter (such as pressure, temperature, pH) and signal the brain to take action, usually by the autonomic nervous system.

Some factors that the autonomic nervous system responds to include:

- Emotions: Anxiety, stress and other emotional states can raise your heart rate
- Body temperature: Too hot or too cold your body detects a thermal stress load - heart rate will increase to help deliver extra blood to the peripheries in order to dissipate heat or warm the body via increased blood flow.
- Terrain: uphill = higher heart rate, downhill = lower heart rate. Because why? Gravity, muscles work harder or easier depending if they are fighting gravity or not. Harder working muscles require increased blood flow = increased heart rate.
- Dehydration: The majority of blood is water, as this water depletes, a state of dehydration occurs, meaning the blood is now thicker and harder to pump, the heart therefore has to work harder to move the same quantity of blood around. Fluid losses as low as 3% can cause heart rate to rise.
- Nutrition and sleep: insufficiencies in either of these can cause heart rate to be elevated.
- Recovery and illness: poor recovery and illness can cause increases in heart rate.

- Medications: can either increase or decrease heart rate. Be sure to ask all clients if they are on any medications that may affect the heart and refer to their prescribing doctor if unsure.

Regulation of Blood Flow During Exercise

As we exercise, our muscles contract using ATP. To keep this going we need to ensure adequate blood flow is occurring to deliver fuel, oxygen rich blood (the fuel for making ATP) and take away the trash, carbon dioxide the main unwanted by-product from ATP production.

To keep up with the demands of the exercising muscle a few major things occur:

- Cardiac output increases (ml of blood per minute leaving the heart)
  This increases the blood flow by increasing the volume of blood travelling through the heart per minute, essentially turning up the speed of the pump.
- Vasodilation and vasoconstriction of blood vessels
  - Blood vessels of working muscles vasodilate (increase in diameter) which allows more blood to flow easier to those areas of the body.
  - Conversely, blood vessels of organs that don't require as much cardiac output during exercise vasoconstrict e.g. the gut organs, kidneys and skin, these organs all undergo vasoconstriction meaning their blood vessels decrease in diameter, effectively shunting blood away from these organs to allow maximum opportunity for areas of high demand to receive optimal blood flow.
  - This vasodilation and vasoconstriction are governed by a variety of local chemical mediators as well as the sympathetic nervous system.

Summary

- The heart is divided into two circuits connected in series:
  - Pulmonary circuit = the right side of the heart
    - Shorter, lower pressure = less muscle tissue on the right side of the heart
  - Systemic circuit = the left side of the heart
    - Longer, higher pressure = more muscle tissue on the left side of the heart
- The heart's blood supply can be compromised when approaching maximal heart rate.
- The heart has the attribute of automaticity i.e. produces its own action potentials via specialized muscle cells called conduction cells.
  - The SA node is the chief conductor
  - The heart also receives innervation from the brain via the autonomic nervous system to regulate cardiac output depending on body requirements
- Regulation of blood flow during exercise a combo of heart and blood vessel changes that ultimately increases cardiac output to working muscles.

Respiratory System – Introduction

Now that we have conquered the heart, we need to talk about its neighbours, the lungs.

If the heart is the pump of the body, then the lungs are the bellows providing fresh fuel in the form of oxygen and also the chimney by blowing off unwanted carbon dioxide. The two systems are intertwined via the pulmonary vasculature, the pipes if you will that carry deoxygenated blood to the lungs and return oxygenated blood back to the heart.

The function of the respiratory system is to act as an interface between the external and internal environments in order to harvest oxygen into the body and release carbon dioxide back out. This is facilitated by its unique structure, the musculoskeletal system, and the cardiovascular system. It is also governed via the nervous system, chiefly the autonomic (would be annoying if you had to always think to breathe) but can be influenced voluntarily (you can hold your breath to test this).

Structure

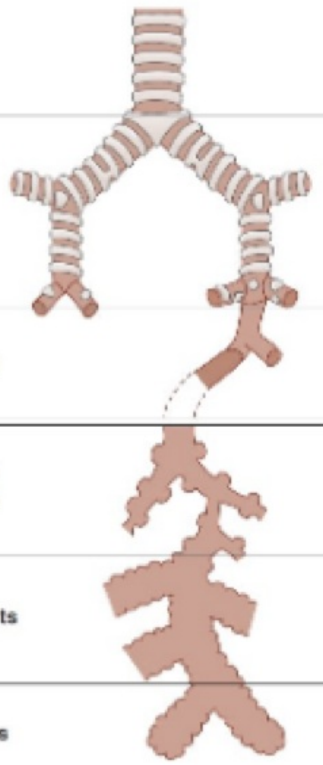
polartrainingzone.com.au/topic/structure-2

People often think of the lungs when considering the makeup of the respiratory system, but it pays to remember that it starts with the nose. We can categorize the respiratory system into two specific zones - the conducting and respiratory zones. The conducting zone facilitates air entry into the lungs whereas the respiratory zone facilitates gas exchange with the pulmonary blood vessels.

Conducting Zone – How Does Air Reach Our Lungs And Exit?

polartrainingzone.com.au/topic/conducting-zone-how-does-air-reach-our-lungs-and-exit

The conducting zone = nose, nasopharynx, larynx, trachea, bronchi, bronchioles and terminal bronchioles. The nose is important for warming, filtering and humidifying the air to prevent drying out of internal structures and unwanted particles entering the lungs. The larynx is important for vocalization and the trachea, bronchi, and bronchioles important for the conductance of air into the lungs. These tube-like structures have specialized cells lining them with hair-like structures called cilia that beat in unison to help push mucus and other debris out of the lungs keeping them clear. The trachea and bronchi are lined with tough cartilage plates/rings to prevent them from collapsing, keeping them patent at all times for smooth air entry/exit.



Zone	Structure	Number	Cilia	Smooth Muscle	Cartilage
CONDUCTING ZONE	Trachea	1	Yes	Yes	Yes
	Bronchi	2 4 8	Yes	Yes	Patchy
	Bronchioles	–	Yes	Yes	No
RESPIRATORY ZONE	Respiratory bronchioles	–	Some	Some	No
	Alveolar ducts	–	No	Some	No
	Alveolar sacs	6×10^8	No	No	No

Figure 1: Structure of the airways. The number of the various structures is reported for two lungs

The conducting zone from the trachea to the terminal bronchioles have a smooth muscle layer (smooth muscle is different to skeletal muscle, namely in that it is under autonomic control, not voluntary) that contracts and relaxes to change the diameter of the airways, allowing for regulation of air entry to different parts of the lungs. This is important for making sure air is sent to the most perfused (most blood flow) part of the lungs. It would be inefficient if a large amount of air was sent to a part of the lung that had a poor blood supply. There are many complex mediators that help achieve this, but it is simple enough to say that the tubes of the lungs have the ability to contract and relax to regulate airflow to desirable areas. Going back to our favourite part of the nervous system, the autonomic, it is able to send sympathetic signals to dilate the airways, conversely, the parasympathetic will send signals to constrict. This is also the pharmacological targets for asthma treatment, a condition that has poor airflow into the lungs due to excess mucus production and inflammation, inhibiting the parasympathetic and activating the sympathetic with specific medications can help alleviate the shortness of breath that asthmatics are all too familiar with. We will talk more about how the nervous system is able to do this in the next chapter.

At no point along the conducting zone does gas exchange occur (passive diffusion of gasses, namely oxygen and carbon dioxide across a membrane). Therefore, this part of the respiratory system is often referred to as 'anatomic dead space,' in that the volume of air that occupies it at any given time is not contributing to oxygen delivery or carbon dioxide removal.

Respiratory Zone

polartrainingzone.com.au/topic/respiratory-zone

The core difference between the two zones was mentioned earlier - gas exchange. The structures that allow this life-saving function are called alveoli, microscopic sac-like structures in which each lung has approximately 300 million alveoli each. Imagine 300 million tiny balloons, able to expand and contract as the thorax expands and contracts with each breath. The amount of air that would come into contact with an alveolar wall in this scenario is vastly greater than if we had just one giant alveolus - put simply, having a larger number of individual sacs creates a much larger surface area for air to come in contact with. This helps with diffusion of gasses across the alveoli walls, which are so thin that an oxygen molecule can diffuse across in milliseconds.

You might be wondering what is preventing all these tiny sacs from collapsing in on themselves. It is a good question, for it would happen due to surface tension if it weren't for specialised surfactant producing cells lining the alveoli. The surfactant can be thought of as detergent, breaking up water molecules that would normally be trying to collapse the alveoli due to surface tension (force between any liquid/air interface) - this effectively makes the surface tension negligible, allowing for easier expansion of the lungs and prevention of collapse.

Now that we have a basic overview of the structures that make up the lungs, let's talk now about the major function - respiration.

Respiration

To most people the term respiration simply means 'the act of breathing'. However, as with most things in the body, it is much more complicated than that. How is it that oxygen comes into the lungs? How does that oxygen then enter our bloodstream and provide sustenance to every cell in our body?

The simple answer is pressure gradients. The best way to think of a gradient is a slope that never wants to be a slope, it wants to be flat i.e. the same on each end of the slope. Things at the top of the slope have the tendency to move towards the bottom, the old adage 'what goes up must come down' is relevant but is to do with gravity. In this case, we are talking about the partial pressure of oxygen. If you breathe out and relax your lungs you come to equilibrium with atmospheric pressure, you will notice that you don't feel any airflow until you take your next breath, this is because the air inside your lungs is at the same pressure as the air outside.

Mechanical Respiration

Now, take a breath. Notice what happens to your chest, it starts to rise. This is because of muscles in between your ribs called intercostal muscles that are able to pull up on the ribs and expand the chest. At the same time, your diaphragm, which sits at the base of your lungs, pulls down. The net effect is a much larger thorax.

What this means is that as your thorax expands due to muscular contraction, your lungs are expanded along with it, this then creates a larger volume within your lungs. Without getting too bogged down in the science, it suffices to say that as volume increases pressure decreases, according to Boyle's law. At rest the pressures are the same on the inside as the outside, now we have a lower pressure in the lungs due to the increased volume, air will now rush in, down the pressure gradient, until that pressure gradient is equalized i.e. same on the inside as the outside. Take a deep breath, as far you can and hold with your mouth open, you will notice the air stops flowing as soon as you're at maximum expansion. Now breathe out and notice your diaphragm relaxing and your chest dropping, reversing that volume change and thus creating a higher pressure inside your lungs which now rushes out of your nose/mouth to equalize with the atmosphere once again.

You now have insight into how air comes in and out of the body, and this is all facilitated mechanically via intercostal muscles and the diaphragm. During times of stress, such as exercise where oxygen demands increase massively, the body recruits other muscles, such as the scalenes, pectoral and abdominal muscles to help pull and squeeze the chest to increase the amount of air entering and exiting the lungs by helping adjust the volume of the thorax.

Alveolar and Internal Respiration

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Mechanical respiration showed us how muscle contraction can change the size of the chest and thus the lungs, which in turn cause pressure differences that facilitate air movement in and out of the lungs depending on the direction of lung volume changes.

Alveolar respiration is describing how the already inspired oxygen is able to go from the lungs into the bloodstream and vice versa for carbon dioxide. It is dependent upon partial pressure differences. As we discussed before, gasses move from areas of high pressure to low pressure in order to create a state of equilibrium. In the alveoli the pressure of oxygen is higher than the pressure of oxygen in the pulmonary arteries (remember these are the vessels carrying deoxygenated blood from the right ventricle towards the lungs). As the deoxygenated blood moves into the pulmonary capillaries, it interfaces with the inspired air within the alveoli. Since the oxygen is higher in concentration/pressure in the alveoli, it naturally diffuses across into the capillaries, because why? Physics (if you really want to dive deep it is due to thermodynamics and the conservation of energy, things in a higher state of energy always want to move to a lower state, high pressures are higher in energy than low pressures)! If an area has a higher pressure of a gas than an adjacent area, then the net movement will be towards the lower pressure area - translation to the body - the oxygen in the alveoli is higher in pressure than the blood so will diffuse across the alveolar cells, through the endothelial cells into the bloodstream.

The opposite is occurring for CO2. The pressure of CO2 is higher in the pulmonary blood than in the alveoli and so the net movement is towards the alveoli.

This is because of internal respiration which is describing the movement of oxygen from systemic capillaries into the cells of the body. The cells of the body are constantly using oxygen for aerobic metabolism to produce ATP via processes within the mitochondria. The by-product is CO2. So, in this picture we have a reversal of what's happening in the lungs. The capillaries have a higher pressure of oxygen and low pressure of CO2 compared to the target cells. So, the net movement of oxygen is out of the blood into the cells and vice versa for CO2, out of the cells into the blood.

Think what happens in exercise, our muscles are working harder burning more ATP and thus producing more CO2 and requiring more O2. This requires more blood flow/cardiac output to achieve supply and removal of O2 and CO2 respectively and so the heart rate increases, blood vessels to skeletal muscle dilate and more oxygen is extracted from the blood, so that when the cycle is completed and the deoxygenated blood returns to the lungs, it has an even greater pressure differential then it did at rest. That is, it is even lower in oxygen and higher in CO2 and thus the air within the alveolar sacs will diffuse faster down the bigger gradient.

So, you can see this is one big cycle of gas exchange, governed by partial pressure differences.

The partial pressure differences are maintained by the following mechanisms:

- mechanical movements of the rib cage which renew the alveolar air with each inhale and exhale.
- Movement of the blood due to the heart contracting, pushing deoxygenated blood into the pulmonary capillaries with each heartbeat.
- Movement of oxygen rich blood from the left side of the heart to systemic capillary beds.
- Metabolism of cells utilising oxygen to create ATP and carbon dioxide.

If any of these mechanisms failed, you would essentially equalise the pressure gradients and no movement of oxygen or carbon dioxide would occur, and cells would eventually die as they utilised all available oxygen. These mechanisms ensure the pressure gradients are in place at all times, providing the cells of the body with a means to harvest fresh oxygen and dump excess carbon dioxide.

Wearables and Pulse Oximetry (SpO2%)

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In the advanced course we discussed the various ways of measuring heart rate and pulse rate along with their associated strengths and limitations. Since then, wearables have gained the ability to also measure your pulse oximetry (SpO2%) - an estimate on the saturation of oxygen in the bloodstream. Knowing a bit about this measurement could prove useful particularly if your clients start asking you about it!

This is achieved using red and infrared lights with sensors on the device. The reading is usually reported as a percentage and can give an indication of how well your respiratory and cardiovascular systems are operating. Red blood cells contain haemoglobin, a small protein that has four binding sites for an oxygen molecule. When all four sites are occupied with oxygen, we say it is fully saturated or 100% saturated. A healthy individual with normal lungs, breathing air at sea level will have an arterial oxygen saturation of 95 - 100% (WHO reference). Altitude and illness can affect these values and a value between 90 - 95% is considered mild hypoxia whereas below 90% is more severe.

Pulse oximetry has largely been a clinical domain, being measured on the fingertip in hospitals to ascertain whether oxygen be administered or to keep routine observations on patients. Wearables have yet to provide an accurate account of pulse oximetry as they require the person to be very still and can take up to several minutes to get a reading. At this stage they are being used to monitor pulse oximetry during sleeping hours, as this is when people are likely to meet that criteria of being still for minutes at a time. People who suffer from sleep apnoea or think they may suffer from sleep apnoea (bouts of no breathing during sleep) can gain useful information and may be informed of how their sleep apnoea is being managed by wearing such a device. As an exercise measure it is rather useless, until the technology can become more reliable.

Muscle Contraction via Nervous system – Introduction

We have explored the wonders of the heart and lungs and should now be able to appreciate how the two systems work together to provide nutrition and waste removal to our hard-working muscles. Along this journey we have mentioned the nervous system as a regulator, fine tuning the heart rate and other organ system functions to suit the needs of the body. A more appropriate analogy is a computer system.

Think of the brain as a processing unit; information comes in from the external environment (vision, smell, taste, touch, sound) as sensory input and is detected by specialised sensory neurons (the cells of the nervous system). This information travels along these neurons (kind of like copper wires) to the brain where it is integrated/processed to formulate a picture of what is going on in the external environment. This is the part that we are aware of and all of this takes place in the thin sheet of grey matter in the cerebral cortex of the brain. With this information the brain can then decide what to do - it can formulate a motor plan and send it off to the appropriate muscles to instigate movement, whether that be movement of the limbs, vocal cords, eye muscles or any other body part you can consciously control. This executive function is often called the motor output or motor system. Let's have a look at the following table see the similarities of the nervous system to a computer system.

Nervous System	Computer
Sensory receptors and afferent nerves	Input circuit
Effectors and motor nerves	Output circuit
Spinal cord and reflexes	Simple computers (output directly controlled by input)
Brain and brainstem (decision making, memory, emotions)	Complex computers (input modulated and memory storage)
Control mechanisms in lower brain	CPU (sequence of information processing)

Organisation of the Nervous System

Whilst we aren't asking you to become neuroscientists or computer programmers in this course, this analogy can help in understanding the basic premise of the nervous system. That is, information comes in, it is then processed, and a command is put into action. From this we can categorise the nervous system into a peripheral and central nervous system. The peripheral is pertaining to the sensory and motor neurons which gather and deliver neural information respectively. The central nervous system is the brain and spinal cord, and this is where all the sensory information is processed to deliver a desired motor command.

There are many different ways of organising the nervous system. One can look at it from a structural perspective and categorise the components into peripheral and central nervous systems or one may take a functional approach and divide the nervous system into sensory, motor and autonomic. Another way is to integrate both structure and function.

Autonomic Nervous System

We have talked briefly about the autonomic nervous system in previous modules and will now spend some time exploring this amazing system. Think of all the processes in your body right now that you don't have to think about, this may take some time and there will probably be quite a few that you are not even aware of. The obvious ones are your heart rate, diameter of your blood vessels and lungs but some not so obvious are the size of your pupils, or the amount of digestive juices your stomach and pancreas secretes. All of these functions and many more are under the direct influence of the autonomic nervous system.

Now that you have a better understanding, think of some ways that you can target the sympathetic and parasympathetic nervous systems in your clients.

Motor Control And The Pyramidal Pathway

You could write a giant textbook on motor control and still be left with unanswered questions. The nervous system is often viewed as the last frontier of the human body, in that we have uncovered many of its secrets but still many unanswered questions remain. This part of the course is simply to give you an insight as to how our brains are connected to our muscles aka the somatic nervous system. Remember back to how the nervous system is organised, we are now going to take a deep dive into the somatic nervous system to see how our brain controls all the skeletal muscles in the body.

Now that we have covered the basics of motor control, lets dive a little deeper and look at the pyramidal pathway more closely. We will see just how organised the brain is, with each neuron in the motor cortex somatotopically arranged so that all neurons that control the hand are in the same place; likewise, the foot, face, tongue etc. The more complex movements that are available the more neurons are found, so the face, hand and tongue have more neurons devoted to their movements than say the trunk or limb muscles which are more simplistic in their movements.

We touch on how the pyramidal pathway is a two-neuron pathway. What this means is that there is an upper motor neuron that originates in the motor cortex, that travels down the brainstem where it crosses over at the medulla (this is why it is often said that the right side of the brain controls the left side of the body) and continues down to the appropriate spinal segment. At the appropriate segment it will synapse with the next neuron in the pathway called the lower motor neuron. The lower motor neuron is part of the motor unit, that is, the motor neuron plus the muscle fibres it innervates. We will discuss the motor unit in detail later on but for now understand that the motor command originates in the motor cortex where it travels down the upper motor neuron and synapses on the lower motor neuron in the spinal cord.

Motor Unit Recruitment And The Size Principle

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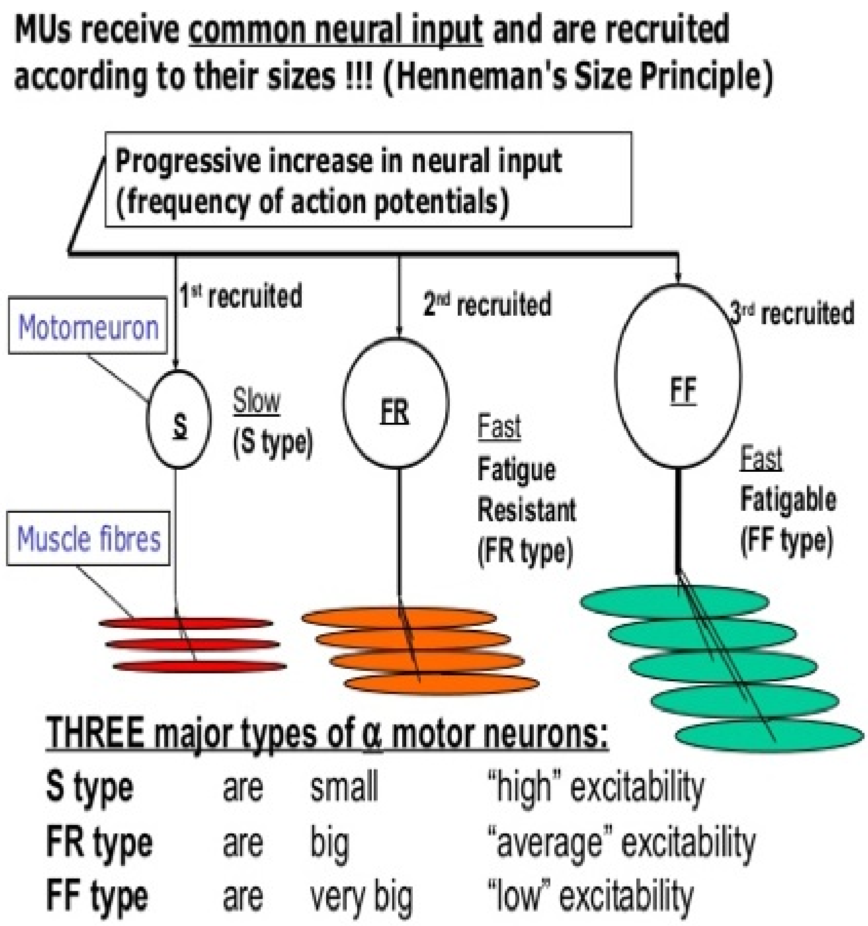

By now you should have an appreciation for how our nervous system is able to receive sensory inputs, convert them into a mental picture and then send out as a motor command via the pyramidal pathway. In this section we are going to zoom into the final part of that story, where the nervous system meets the muscles.

The term 'motor unit' was described previously as the motor neuron (it is the lower motor neuron in the pyramidal pathway that was talked about in the previous section) and every muscle fibre that it innervates. This means that a single motor neuron can innervate multiple muscle fibres. It does this by having multiple synaptic terminals at the end of its axon, we will show you what this looks like in the next video. These synapse onto muscle fibres and are called the neuro-muscular junction (NMJ), that is, the point where the nervous system meets the muscles. Once the electrical signal reaches this junction (after it has travelled all the way down the pyramidal pathway) a sequence of chemical events occur that result in the release of neurotransmitter and the transduction of the signal from the neuron to the muscle fibre which then travels across the muscle fibre down the T-tubules causing calcium release within the muscle fibre leading to contraction. This whole process has the fancy term excitation contraction coupling mechanism.

We don't want to get too bogged down into the chemical sequences, we are more interested in showing you how these motor units come in varying sizes and what this means, plus also giving you an insight into the term recruitment and the size principle.

Maximal Heart Rate Formulas

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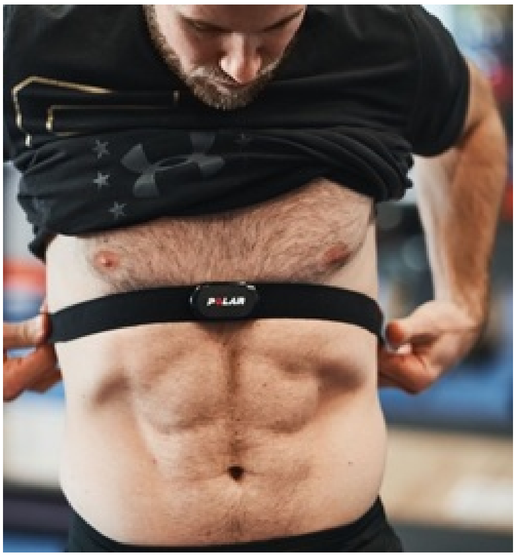
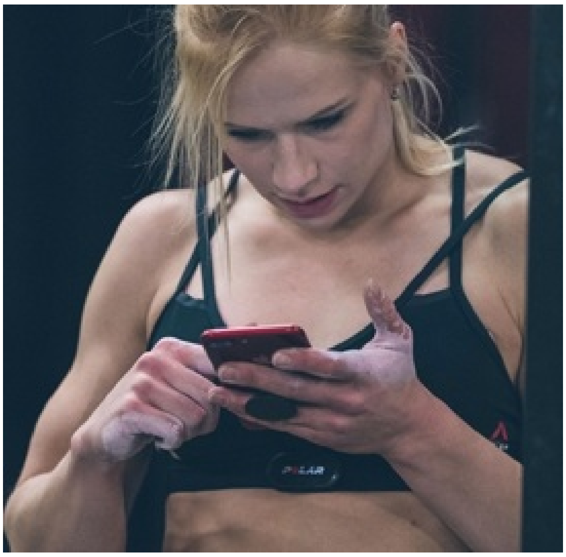


As we know using heart rate to prescribe, progress and monitor exercise data can be extremely beneficial.

The driving factor behind establishing a Max Heart Rate typically is to determine training applications like training zones to the individual.

Options include performing a maximum stress test or consider a formula to determine it?

There may be practical dangers and risks associated with accurately recording and performing an MHR maximal exercise test? Whilst a maximal test would be the most accurate way for assessing HR max, it carries risk for the non athlete.

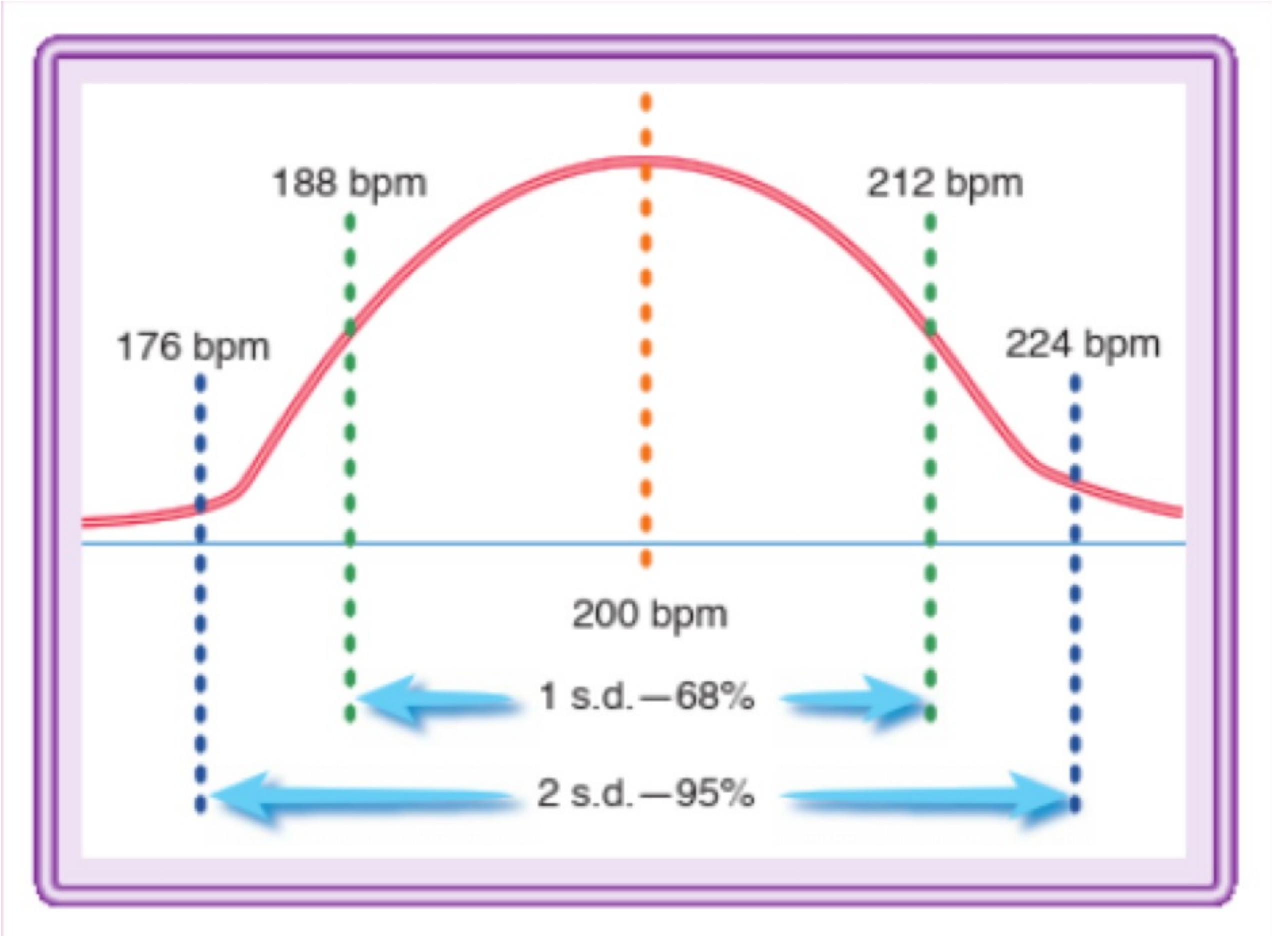


MHR is normally determined by a variety of mathematical formulas. Like the HR Max = 220 - AGE formula (Fox 1971). Such calculations can be easily calculated and provide an easy marker. Health and fitness professionals can anchor exercise intensity, (e.g., %MHR) from these formulas.

So how accurate is the HR MAX = 220 - age formula? Derived from the 1970's the HRmax= 220 - age formula was not developed from original research but resulted from observation-based data from approx. 11 references consisting of published research or unpublished scientific compilations. Consequently, the formula HRmax=220 -age has no scientific merit for use in exercise physiology and related fields with a standard deviation **error of 7 - 12 beats per minute**. Fox et al. (1971) of HRmax = 220 - age. (Robergs and Landwehr, 2002; Thompson, 2010). Other concerns according to Porcari (2015) is that overestimates MHR in younger adults and underestimates MHR in older adults. Figure 2.

(e.g. a 25 - year old may never reach 195 bpm (220 -25) whereas a 60 year old may exceed 160 bpm (220 - 60) comfortably?

Figure 2: Shows the standard deviation of 12 beats per min (bpm) for the 220 - age formula for 20 -year olds.



American College of Sports Medicine. *ACSM's Guidelines for Exercise Testing and Prescription.* 9th ed. Philadelphia, PA: Wolters Kluwer/Lippincott Williams & Wilkins; 2014.
Fox SM III, Naughton JP, Haskell WL. Physical activity and the prevention of coronary heart disease. *Ann Clin Res.* 1971;3:404–432.

Estimated MHR derived then may not be a very accurate anchor for individual exercise programming and should be questioned because of its inherent error.;

Numerous variables impact MHR, including genetics, exercise modality, medications, body size, altitude and age.

Beyond the scope of invalidity of MHR, significant concern with using a straight percentage of MHR to design and monitor training intensities stems from the fact that discrepancies and **individual RHR** (resting heart rate) are not taking into consideration and may therefore lead the health professional to overestimate or underestimate appropriate exercise intensities.

Despite the "inherent" error variations formulas will be continually used for their convenience and allow programming to begin without maximal testing.

A great review paper by Robergs and Landwehr (2002) tabled 43 different formulae for heart rate max. See table 1 below for your interest.

Table 1: The known univariate prediction equations for maximal heart rate.

Study	N	Population	Mean Age (range)	Regression (HRmax=)	r^2	Sxy
Univariate Equations						
Astrand, in Froelicher (2)	100	Healthy Men – cycle ergometer	50 (20 - 69)	211-0.922a	N/A	N/A
Brick, in Froelicher (2)	?	Women	N/A	226-age	N/A	N/A
Bruce (12)	1295	CHD	52±8	204-1.07a	0.13	22
Bruce (12)	2091	Healthy Men	44±8	210-0.662a	0.19	10
Bruce (12)	1295	Hypertension	52±8	204-1.07a	0.24	16
Bruce (12)	2091	Hypertension + CHD	44±8	210-0.662a	0.10	21
Cooper in Froelicher (2)	2535	Healthy Men	43(11 - 79)	217-0.845a	N/A	N/A
Ellestad in Froelicher (2)	2583	Healthy Men	42(10-60)	197-0.556a	N/A	N/A
Fernhall (13)	276	Mental Retardation	9-46	189-0.56a	0.09	13.8
Fernhall (13)	296	Healthy W & M	N/A	205-0.64a	0.27	9.9
Froelicher (2)	1317	Healthy Men	38.8(28-54)	207-0.64a	0.18	10
Graettinger (14)	114	Healthy Men	(19-73)	199-0.63a	0.22	N/A
Hammond (15)	156	Heart Disease	53.9	209-age	0.09	19
Hossack (16)	104	Healthy Women	(20-70)	206-0.597a	0.21	N/A
Hossack (16)	98	Healthy Men	(20-73)	227-1.067a	0.40	N/A
Inbar (17)	1424	Healthy W & M	46.7(20-70)	205.8-.685a	0.45	6.4
Jones (18)	100	Healthy W & M cycle ergometer	(15 – 71)	202-0.72a	0.52	10.3
Jones N/A	?	Healthy W &M		210-0.65a	0.04	N/A
Jones (18)	60	Healthy Women	(20-49)	201-0.63a		N/A
Lester (19)	48	W & M Trained		205-0.41a	0.34	N/A
Lester (19)	148	W & M Untrained	43(15 – 75)	198-0.41a	N/A	N/A
Londeree (20)	?	National Level Athletes	N/A	206.3-0.711a	0.72	N/A
Miller (21)	89	W & M Obese	42	200-0.48a	0.12	12
Morris, in Froelicher (2)	1388	Heart Disease	57(21 – 89)	196-0.9a	0.00	N/A
Morris, in Froelicher (2)	244	Healthy Men	45(20 – 72)	200 -0.72a	0.30	15
Ricard (22)	193	Treadmill W&M		209 -0.587a	0.38	9.5
Ricard (22)	193	W & M - cycle ergometer		200 -0.687a	0.44	9.5
Robinson 1938 in Froelicher (2)	92	Healthy Men	30(6 - 76)	212 -0.775a	0.00	N/A
Rodeheffer (23)	61	Healthy Men	25 - 79	214-1.02a	0.45	N/A
Schiller 24)	53	Women Hispanic	46(20-75)	213.7-0.75a	0.56	N/A
Schiller (24)	93	Women Caucasian	42(20-75)	207 -0.62a	0.44	N/A
Sheffield (25)	95	Women	39(19 - 69)	216 -0.88a	0.58	N/A
Tanaka (11)	?	Sedentary W&M		211 -0.8a	0.81	N/A
Tanaka (11)	?	Active W&M		207 -0.7a	0.81	N/A
Tanaka (11)	?	Endurance trained W&M		206 -0.7a	0.81	N/A

Percentage of Maximal Heart Rate

polartrainingzone.com.au/topic/percentage-of-maximal-heart-rate

Let's look at two main ways we can calculate % of MHR (Maximal heart rate).

This can be done by calculating a simple percentage of the maximal HR using 220 - age (%MHR) or by taking a percentage of the difference between the *resting heart rate* (RHR) and the maximal heart rate (MHR).

The latter method is called the percentage of heart rate reserve (%HRR) or the Karvonen formula.

Percentage of MHR

Target HR (THR) = MHR x % Intensity

Karvonen Method

THR = (HRR x % intensity) + Resting heart rate (RHR)

HRR = MHR - RHR

When applying the math, glaringly the two methods yield very different results. See Figure 3. “Doing the Math” “Joe” example below.

Figure 3.

DOING THE MATH

Joe has an MHR of 180 beats per minute (bpm) and resting HR of 75 bpm. Calculate exercise HRs that correspond to 50% to 70% of %MHR and 50% to 70% of %HRR.

%MHR

Lower limit: 180 × 0.50 = 90

Upper limit: 180 × 0.70 = 126

THR range = 90–126 bpm

%HRR

Reserve = 180 – 75 = 105

Lower limit = 105 × 0.50 = 53; 53 + 75 = 127.5, or 128 bpm

Upper limit = 105 × 0.70 = 73.5; 73.5 + 75 = 148.5, or 149 bpm

Use of the percentage MHR formula, although easier to use and apply systemically underestimates exercise heart rates by 10 to 15% compared with the % HRR formula.

Consequently, then using the percentage MHR method, is customary to use higher intensities when calculating THR's (target heart rates) example 60 to 80% vs 50 to 70%.

An advantage of the % HRR method is that it reduces discrepancies in training intensity between individuals with: - **different *resting heart rates*.** This can accommodate the training adaptation that decreases RHR (resting heart rates) therefore expanding HRR (heart rate Reserve).

Using % MHR or %HRR is acknowledged as probably the most widely used approach for programming intensity, recovery and monitoring performance but it is necessary to know an individual's MHR (maximal heart rate) for it to be useful.

Figure 4. Use of the Karvonen formula for a 20 year old man of average body shape, resting heart rate = 70bpm; HRR (heart rate reserve); MHR (maximal heart rate); RHR (resting heart rate)

Figure 4.

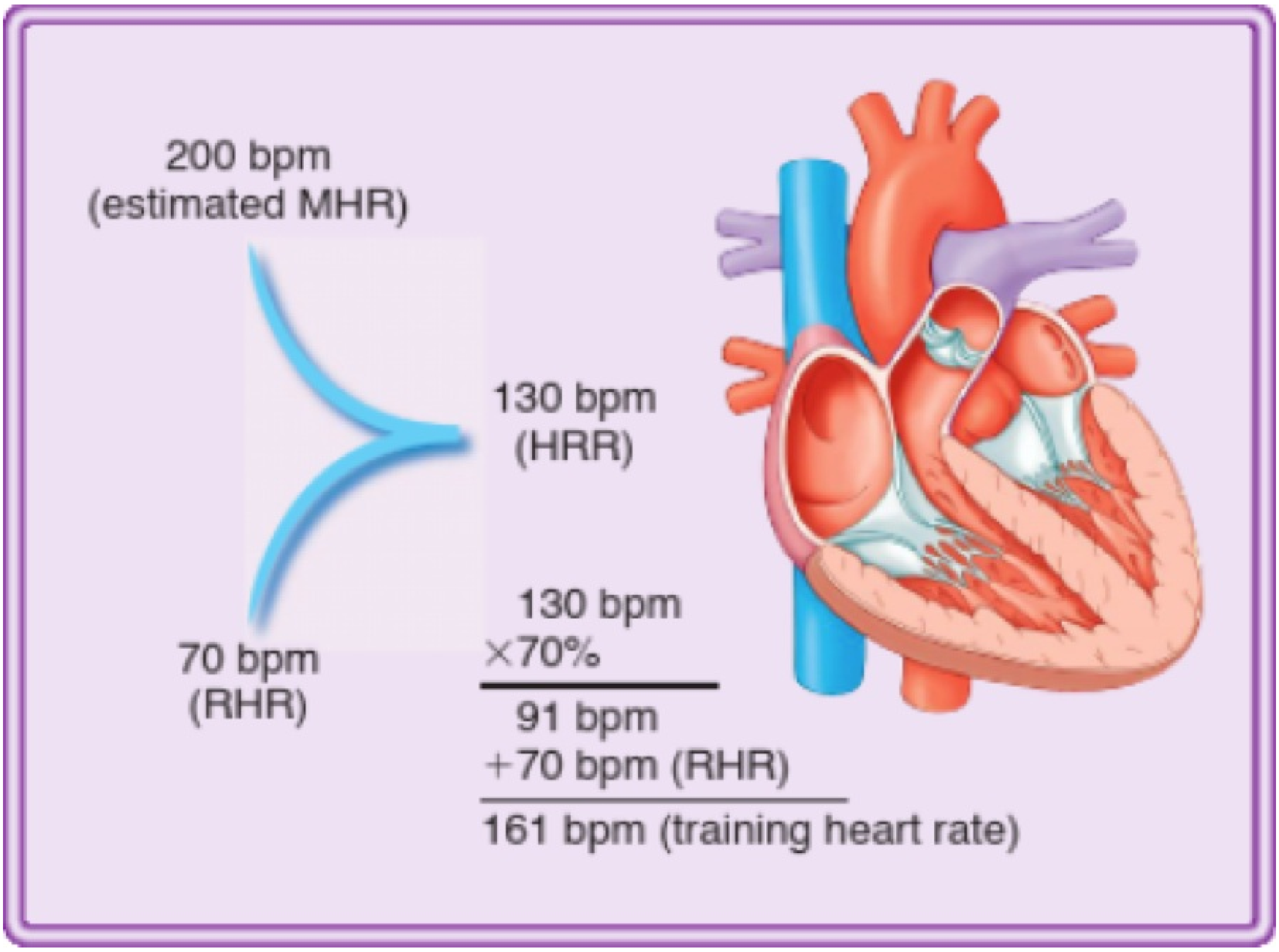


Table 2 below. Compares percentage of heart rate reserve estimation in two 30 year olds with different resting heart rates which a 220 - age formula does not account for.

	PERSON A (bpm)	PERSON B (bpm)
MHR (220 – 30)	190	190
RHR	50	80
HRR (MHR – RHR)	140	110
60% HRR	84	66
Adding RHR	84 + 50	66 + 80
Training HR	134	146 (12-beat difference)

bpm, beats per minute; HR, heart rate; HRR, heart-rate reserve; MHR, maximum heart rate; RHR, resting heart rate.

So how should the fitness professional use for Heart Rate Maximum determination and % MHR?

- Avoid predicting heart rate max in the general population - choose fitness prediction tests that do not rely on predicted heart rate max.
- Avoid prescribing heart rate training ranges based on predicted heart rate max in the general population. Instead, do a safe submaximal exercise test that measures heart rate. Use the data from these tests to inform your exercise intensity prescription.
- Athletic clients would benefit from doing a lab based VO2 max test as this has the greatest accuracy and validity in determining heart rate max. Not only is it accurate they will probably get a kick out of knowing their true VO2 max.
- Select and conduct a specific field test.
- Introduce RPE scales before heart rate zones are established.
- **Maximal Heart rate Formula** - If a formula is to be used, pick one that best represents the age, gender and population you are working with. Robergs and Lanwehr (2002) suggest the Inbar et al. (1994) formula where heart rate max = 205.8 - 0.685 * (age). Again, this is a population based formula and really not suitable for looking at individuals and most formula's will be out by at least 10 bpm.
- **Target Heart rate** Consider using the HHR% / Karvonen Method for Target Heart Rate Training.
- For further reading on history of the HRMax = 220 - Age equation and recommended formulas Journal of Exercise Physiologyonline

There is no golden formula and by no means should they all be thrown out. All that is required is knowledge into the limitations of their use, which you now have, in order for them to be useful in estimating the general population heart rate max.

VIDEO - QAS Rowing Test LAB

Watch Video At: https://youtu.be/VgfYbGuil6s

Monitoring Exercise Intensity Methods

Exercise intensity is arguably the most important element of the exercise program to monitor.

Equally it is the most difficult element to present quantitatively.

There are numerous methods by which the health & fitness professional can program and monitor exercise intensity.

- Heart rate
- Percentage of maximal Heart Rate (%MHR)
- Percentage of MHR RESERVE - Also known as **Karvonen formula**
- Oxygen consumption (VO2 max)
- Metabolic Equivalent (METS)
- VO2 reserve (VO2R)
- RPE - Rating of perceived exertion
- Caloric expenditure
- Talk tests
- Blood lactate
- Second Ventilatory threshold (VT2)

METs – What Are They And How To Use Them?

next page We are familiar with heart rates, percentages, zones, thresholds and so on. There are also other ways to measure intensity.

METs are a way of estimating the amount of work done in an activity. They were designed by researchers doing population studies to try and estimate how much energy is used in different situations, whether riding a bike, doing the gardening or any task you can think of there is probably a MET code that will allow you to gauge how much work you or your clients are doing. It can be a good alternative if you don't have a heart rate monitor as it allows you to estimate the intensity of an activity and its caloric expenditure.

It stands for Metabolic Equivalent and is a ratio of the work metabolic rate to the resting metabolic rate. In other words, 1 MET = resting metabolic rate which is usually defined as 1kcal/kg/hour, about how much energy you would consume if you were sitting quietly. So, an activity that was classed as 3 METs would be equivalent to 3 x the resting metabolic rate.

There are hundreds of activities that have been coded and are listed in a compendium that we have provided for you at the end of this section. Preview the quick video on the next page to show you how to read the tables.

Limitations of METs

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It is important when using METs to time the period you are in the activity and note it, this is only if you are trying to calculate your entire daily energy expenditure accurately. For example, you would record your periods of inactivity as well as all incidental and deliberate physical activity with the amount of time spent in each with a MET value describing the activity as close as possible. It gets tricky if you are doing an activity at variable intensities it may be better to simply guess how hard the whole activity was as a whole and use the chosen MET value. This subjectivity when selecting associated MET values can over or underestimate actual energy expenditure.

As with everything, there is individual variability on resting metabolic rate, so 1 MET for one person may be different to 1 MET for another, therefore it's important to remember that METs are only an estimate, they don't account for variances in body mass, fat mass, age, sex, efficiency of movement and the environment that the movement was performed in. All of these factors can adjust metabolic expenditure.

For a better understanding of different modalities of exercise and METS energy requirements.

Link to compendium of physical activity

https://sites.google.com/site/compendiumofphysicalactivities/

MET Comparisons across modes of exercise

polartrainingzone.com.au/topic/met-comparisons-across-modes-of-exercise

An advantage of METs as a trainer is the ease to look up the MET rating of an activity and compare it to another. The higher the MET value the more calories your client should burn in the same time period compared to a lower MET value.

Table 3 refers to some common training modalities. Review which modality delivers the best bang for your buck.

Table 3.

Activity	MET Value
Cycling stationary moderate to vigorous, 90 - 100 Watts	6.8
Rowing, stationary ergometer, general, <100 watts, moderate efforts	5.0
Running @ 6min12 s/km pace	9.8
Running @ 5min mile	19.0
Swimming, crawl, medium speed, ~50 yards/minute, vigorous effort	8.3
Health club exercise, conditioning classes	7.8
Circuit training, moderate effort	4.3
Resistance (weight) training, multiple exercises, 8-15 repetitions at varied resistance	3.5
Calisthenics (e.g., pushups, sit ups, pull-ups, jumping jacks), vigorous effort	8
Circuit training, including kettlebells, some aerobic movement with minimal rest, general, vigorous intensity	8.0
Rowing, stationary, 150 to 199 watts, vigorous effort	9.5

Findings: - As you can see, running at a reasonable pace gives a far superior MET value than most other activities of the same intensity. So, if you were short on time and wanted to burn as many calories as possible with your client, get them running or at least incorporate some running into the session to really burn some energy.

Intensity is key for achieving higher MET values, which makes sense seeing that a MET is a measure of metabolic activity per hour. So even if your client is not a runner, increasing the intensity and reducing rest times are the key variables to achieve maximal caloric expenditure

Standardisation of Training Zones (AIS – PHYSIOLOGY NOMENCLATURE)

Consistency! A myriad of terms exists and are used, sometimes erroneously, across sports as well as institutes/academies for a number of 'common' sport science and training concepts. This potentially causes confusion amongst scientists, coaches, fitness professionals and athletes. Not only for those who are required to work with a number of sports, but also for those new to the institute/academy network and or the training of ametur and professional athletes / clients achieving goals and the comprehension of research & programming.

Potential benefits for the standardisation of nomenclature and terms of reference on a national basis and the maybe more broadly the fitness industry include:

- promote consistency across sports and institutes/academies;
- assist with communication between scientists, coaches and athletes;
- provide a clear glossary of terms and definitions;
- offer strength to Australian sport science system;
- assist with the education process of scientists and coaches.

Blood lactate

The Australian Institute of Sport states that although the concept of blood lactate thresholds has been developing for over 60 years, there is still much controversy over both the explanation for and the methods that should be employed to identify them. In fact, there are probably more points of contention than agreement. To standardise terminology and detection methods for lactate thresholds on a national level for Australian sport science.

There are three main reasons for the measurement of the blood lactate response to exercise:

1. indicator of training adaptation – blood lactate thresholds have been shown to be more sensitive indicators on training adaptations than VO2max, especially in highly trained athletes where there may be little or no change in VO2max yet significant changes in endurance performance; numerous studies have also demonstrated that blood lactate thresholds can increase with training beyond the point where VO2max fails to increase.
2. correlation with endurance exercise – blood lactate thresholds are highly related to performance in various types of endurance activities and have been suggested as better indicators than the 'gold standard' VO2max.
3. optimal training stimulus – multitude of data suggesting that blood lactate thresholds may provide best indices of exercise intensity by which to prescribe training and therefore a means by which to optimise training intensity.

Accordingly, Table 4 refers to new terminology and definitions for blood lactate thresholds are now supported and recommended for implementation of a National level by the AIS.

Table 4: New Blood Lactate Thresholds Terms

Blood Lactate Threshold	***Abbreviation***	***Definition***
Lactate Threshold 1	LT1	The first intensity at which there is a sustained increase in blood lactate concentration above resting levels.
Lactate Threshold 2	LT2	The intensity indicating the upper limit of equilibrium between lactate production and lactate clearance.

Endurance Training Zones:

A variety of terms and variations for endurance training zones exist and are used across sports as well as across institutes/academies and the fitness industry. This is highlighted by the fact that various chapters in 'Physiological Tests for Elite Athletes and non-athletes' text use different terminology. Namely Heart training zones.

Table 5: Sample endurance training zone classifications (from: "Physiological Tests for Elite Athletes")

Sport	***Endurance Training Zones***
Cycling	Endurance, E1, E2, E3, E4
Kayaking	Aerobic, A1, A2, A3, A4, A5, A6
Rowing	Utilisation, U3, U2, U1, AT, Transport
Triathlon	T1, T2, T3, T4, T5, T6 * * Note different definition for zone determination applied

So, whilst different terminology, descriptions and definitions are used, there is evidence of some commonality between them. It is on these grounds that a recommendation for standardised endurance training zone terminology and definitions is based.

The following five training zones (T1 – T5) and associated descriptions and definitions are supported and recommended for implementation on a National level by the AIS. However, please note that the following table serves as a guide for prescription of training in relation to various physiological parameters. Values and ranges presented are "descriptive" and individual variations will occur. Values and ranges for individual athletes can be refined by working with an exercise physiologist.

Australian Institute of Sport Table **6: New Endurance Training Zones (AIS)**

Training Zone	*Description*	*Blood Lactate Threshold Relationship*	*Blood Lactate (mmol/L)*	*Percent HRmax (%)*	*VO_{2max} (%)*	*Borg's RPE Scale*	*Critical Duration (h:min:s)*
T1	Light Aerobic	Below LT1	< 2.0	60 – 75	< 60	Very Light	> 3 hours
T2	Moderate Aerobic	Lower half between LT1 and LT2	1.0 – 3.0	75 – 84	60 - 72	Light	1-3 hours
T3	Heavy Aerobic	Upper half between LT1 and LT2	2.0 – 4.0	82 – 89	70 – 82	Somewhat Hard	20 min – 1 hour
T4	Threshold	LT2	3.0 – 6.0	88 – 93	80 – 85	Hard	12 – 30 min
T5	Maximal Aerobic	Above LT2	> 5.0	92 – 100	85 – 100	Very Hard	5 - 8 min

Description – general classification of five training zones according to aerobic intensity;

Blood Lactate Threshold Relationship – describes relationships between five training zones and two blood lactate threshold points; also describes position of training zones on 'standard' blood lactate curve;

Blood Lactate – guide to blood lactate concentrations typically associated with intensity of exercise in each training zone; overlap in values highlight individuality of responses.

Percent HRmax – guide to percentage of maximum heart rate typically associated with intensity of exercise in each training zone; overlap in values

highlight individuality of responses.

Percent VO2max – guide to percentage of maximum oxygen uptake typically associated with intensity of exercise in each training zone; overlap in values highlight individuality of responses.

Borg's RPE Scale - ratings of perceived exertion according to Borg's 6-20 rating (15 point) of perceived exertion table; Borg, G.A.V. (1962b). A simple rating scale for use in physical work tests. Kungliga Pysiografiska Sallskapets i Lund Porhandlingar, 2, 7-15.

Critical Duration – guide to time to exhaustion typically associated with intensity of exercise in each training zone; overlap in values highlight individuality of responses.

Polar Training Zones

polartrainingzone.com.au/topic/polar-training-zones

How does these compare to Polar Heart Rate Training Zones?

General guidelines for most non-elite subjects were established by Polar based on research from the 1970s. Polar's research and development allows for personalisation of data which you can manually update and overrule figures such as max heart rate to therefore create training zones.

The Polar heart rate training zones are neatly grouped in 10% increments and share some cross over of % with the AIS.

Similarly, there are five different zones, 1–5.

Below is a breakdown of what each heart rate zone means and what the benefits of training in that heart rate zone are.

HEART RATE ZONE 1: 50–60% OF HRMAX

VERY LIGHT

- This is the very low intensity zone.
- Training at this intensity will boost your recovery and get you ready to train in the higher heart rate zones.
- To train at this intensity, pick sports during which you can easily control your heart rate, such as walking or cycling.

HEART RATE ZONE 2: 60–70% OF HRMAX

LIGHT

- Exercising in heart rate zone 2 feels light and you should be able to go on for a long time at this intensity.
- This is the zone that improves your general endurance: your body will get better at oxidizing – burning – fat and your muscular fitness will increase along with your capillary density.
- Training in heart rate zone 2 is an essential part of every runner's program. Keep at it and you'll reap the benefits later.

HEART RATE ZONE 3: 70–80% OF HRMAX

MODERATE

- Exercising In heart rate zone 3 is especially effective for improving the efficiency of blood circulation in the heart and skeletal muscles. This is the zone in which that pesky lactic acid starts building up in your bloodstream.
- Training in this HR zone will make moderate efforts easier and improve your efficiency.

HEART RATE ZONE 4: 80–90% OF HRMAX

HARD

- Heart rate zone 4 is where the going gets tough. You'll be breathing hard and exercising aerobically.
- If you train at this intensity, you'll improve your speed endurance. Your body will get better at using carbohydrates for energy and you'll be able to withstand higher levels of lactic acid in your blood for longer.

HEART RATE ZONE 5: 90–100% OF HRMAX

MAXIMUM

- Heart rate zone 5 is your maximal effort. Your heart and your blood and respiratory system will be working at their maximal capacity. Lactic acid will build up in your blood and after a few minutes you won't be able to continue at this intensity.
- If you're just starting out or have only been training for some time, you probably won't have to train at this intensity. If you're a professional athlete, look into incorporating interval training into your training plan for peak performance.

Table 7: **Polar HR Zones.**

(Please note the transferability of heart rate between sports like swimming compared to that of running or weight bearing v's non weight bearing may not be indicative of the training zone).

5 MAXIMUM	**90-100 %**	Develops maximum performance	Short intervals only
4 HARD	**80-90 %**	Increases maximum performance capacity	Shorter excercises or intervals
3 MODERATE	**70-80 %**	Improves aerobic fitness	Moderately long exercises
2 LIGHT	**60-70 %**	Improves basic endurance and fat burn	Longer and frequently repeated shorter exercises
1 VERY LIGHT	**50-60 %**	Improves overall health and helps recovery	Recovery and cool-down exercises

RPE Scales

Ratings of Perceived Exertion scales. Table 8

We would advocate along with Heart rate education and awareness to introduce a subjective method of gauging exercise intensity. “Rating of Perceived Exertion”.

As matter of progression introducing the concept of RPE to subjects for a period of training e.g. 3-4 weeks before introducing Heart rate training zones can be valid.

Often a rating of perceived exertion number will transcend across to a certain heart rate. For e.g. a 7 out of 10 may equate to 75% maximal heart rate.

This is subjective but you may find validity in this, experimenting with your clients and re-evaluating as your athlete fitness and tolerance improves.

Noting that with adaption RPE will decrease as tolerance levels increase.

Two differing RPE scales that can be used are shown below.

Table 8: Rate of Perceived Exertion Scales

RPE	CATEGORY RATIO SCALE
6	0 Nothing at all
7 Very, very light	0.5 Very, very weak
8	1 Very weak
9 Very light	2 Weak
10	3 Moderate
11 Fairly light	4 Somewhat strong
12	5 Strong
13 Somewhat hard	6
14	7 Very strong
15 Hard	8
16	9
17 Very hard	10 Very, very strong
18	*Maximal
19 Very, very hard	
20	

RPE, ratings of perceived exertion.
Data from Borg, G. (1998). *Borg's Perceived Exertion and Pain Scales.* Champaign, Ill.: Human Kinetics.

Anaerobic & Aerobic Threshold

polartrainingzone.com.au/topic/anaerobic-aerobic-threshold

Let's reintroduce you to the concept of Aerobic and Anaerobic threshold.

WHAT ATHLETES SHOULD UNDERSTAND ABOUT AEROBIC THRESHOLD

Practically speaking, aerobic threshold is a steady state heart rate effort that you could perform for hours. If you're working out in an aerobic range, your breathing will be light, and you should feel like you can keep moving for hours.

In more science-specific terms, aerobic threshold is the level of effort at which aerobic energy pathways start helping out with energy production as oxygen becomes the dominant factor to produce ATP. For endurance athletes, having an increased aerobic threshold is key for being able to go longer and further e.g. like long runs, long rides, or steady efforts in the pool – are aerobic threshold workouts. The goal to stay in the aerobic threshold is to stay comfortably burning oxygen and sustaining a specified effort for a longer period of time. One tried-and-true way to measure whether you're staying in your aerobic threshold zone is to keep an eye on your bpm and make sure it remains in the steady, moderate effort zone for the duration of your workout.

The easiest way to determine if you're in your aerobic energy system is to see how long you can sustain your effort. If you're unable to maintain your effort for longer than three minutes, your body has probably gone anaerobic."

Practically then if you're out for a run and have to drastically alter your pace within three minutes, you're no longer working out in the aerobic zone.

By the numbers, subtract 30 beats per minute from your lactate threshold heart rate, and that'll give you a rough estimate of your aerobic threshold. RPE wise looking beyond the bpm, it's the feeling at which the intensity of your workout and effort is just slightly above resting level around < 6 RPE.

WHAT ATHLETES SHOULD UNDERSTAND ABOUT ANAEROBIC THRESHOLD

Commonly thought of as the point at which lactic acid – a by-product of energy being made from glucose – starts to build up quickly in the blood and hydrogen ions become present.

This happens because hydrogen ions released from lactic acid can no longer be buffered by blood bicarbonate stores and thus metabolic acidosis results and Co2 increases. Lactic acid can no longer be removed as quickly as it was being produced and recombined with other molecules to make more energy. At this point, exercise intensity feels more difficult with elevated RPE and non-steady state heart rate accumulation. Some people feel a burning sensation in their muscles and maintenance of speed and skill becomes challenging.

Muscles burn glucose two ways: aerobically, which means with oxygen, and anaerobically, or without oxygen.

Most athletes enter the anaerobic threshold zone when they're putting in some serious work and a lot of power output over a short period of time – like during an interval or sprint. You're utilizing energy that's readily available, but that won't last long.

As you rest and recover, between intervals for example, your anaerobic system recharges, readying you for the next push.

Anaerobic threshold varies from athlete to athlete. For athletes who regularly do interval workouts, their anaerobic threshold will be much higher and more conditioned than those who only do long, steady-state workouts – or don't train at all.

The more you perform high-intensity workouts, the better you can condition your anaerobic threshold and process lactate in the body – and the faster you'll be able to swim, bike, or run.

WHAT DOES ANAEROBIC THRESHOLD FEEL LIKE?

For the majority of people, it hurts and burns a little, but it shouldn't be completely uncomfortable. If you've ever done a track workout – say 400-meter repeats – you've probably gotten into the anaerobic zone on each repeat. You will probably feel it when you're breathing heavily, feel a pronounced heartbeat, slightly gasping for air, and can't carry on a conversation.

Even as you get fitter, you'll still find yourself gasping for air during your track workouts – but you'll probably be shaving a few seconds off each repeat. So, as the effort stays consistent, your performance increases. (That means it's working!)

WHY DOES IT MATTER?

It's important for fitness professionals, coaches, teachers and athletes to understand aerobic and anaerobic energy systems. The aerobic energy system gives you more long-lasting energy because it burns predominantly fat stores. So, for endurance athletes, it's an important system to train. But the anaerobic energy system can produce energy more quickly and allows us to exercise at higher intensities whether it be for all out 400m sprint or a surge in an endurance event to break your opponent.

We recommend making sure your training plan includes high-intensity intervals and rest days to recover from both.

WINNER WINNER slow, steady, fast, and recovered are what work together to win the race.

For a better understanding of Anaerobic threshold refer to Anaerobic Threshold: Its Concept and Role in Endurance Sport

Heart Rate Transferability

polartrainingzone.com.au/topic/heart-rate-transferability

Transferability of Running and Cycling Training Zones

Training zones are great tools for setting the intensity of a session. But can you use the same zone for different modalities?

Some suggest that you can, using tools such as the MAF formula to calculate aerobic threshold - 180 minus your age. It is used to estimate HR training zones for long distance aerobic activities, the idea being if you stay below the aerobic threshold you won't dip into anaerobic metabolism which will ultimately lead to fatigue and so you should be able to potentially go further for longer. The problem with formulas such as these is that they are a crude estimate and do not take into account a whole host of factors such as:

Training status of the individual and specificity of training

- A person more proficient at a given activity will have developed neural and muscular adaptations to do the activity efficiently and thus have a different HR zone for that activity compared to one that they are not well trained in. What this translates to is that the activity you are better at will have a higher HR max that is achievable and thus your HR can climb higher at similar RPE to the untrained activity.
- Interestingly, as a person becomes equally proficient across a variety of modalities (think the elite triathlete) these aerobic threshold discrepancies across modes disappears and become insignificant and so it's possible after testing that one could have the same training zone for one activity as another. Remember this is only in the elite setting where many hours and years have been spent training in a particular mode.

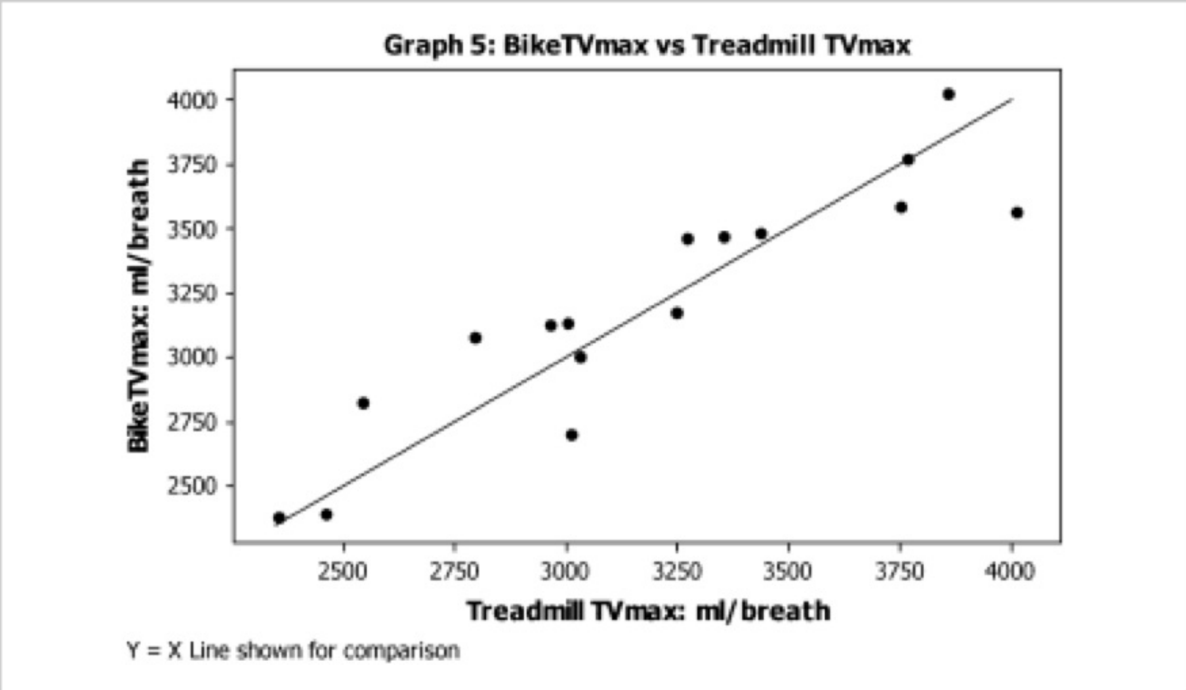


Figure 5. Bike maximal tidal volume (TVmax) vs. treadmill TVmax. Y = X line shown for comparison.

Figure 5. This graph from a study by Carey et al (2009), assesses VO2 differences across sports, namely Elite cycling and running. The figure shows no significant difference in modalities of running on a treadmill (x-axis) vs cycling on a bike (Y-axis). This is because the athletes chosen for this study were elite triathletes and equally trained in cycling and running which eliminates the confounding factor of specificity.

Other studies have shown differences but that is because their sample of athletes is confounded with training specificity i.e. if you are a trained cyclist but are being tested on a treadmill your VO2 max may appear higher in the untrained domain due to the inefficiency of muscle recruitment and thus increased energy demands of the activity when compared to a seasoned runner.

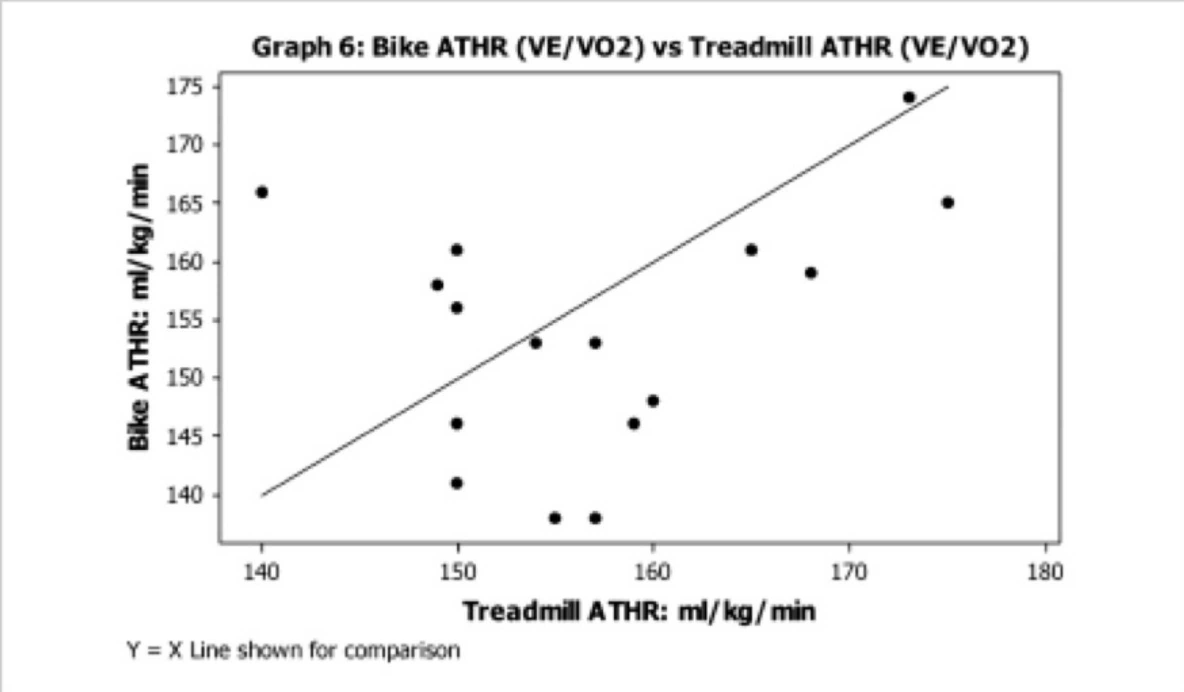


Figure 6. Bike anaerobic threshold heart rate (AT HR; $\dot{V}E/\dot{V}O_2$) vs. treadmill AT HR ($\dot{V}E/\dot{V}O_2$). Y = X line shown for comparison.

Figure 6. On the above graph by Carey et al (2009). here is the kicker...

On the X Axis you will see the Treadmill Anaerobic Heart rate and the Y Axis you will see the Bike Anaerobic heart rate. The trending linear line represents if someone had the exact same anaerobic threshold heart rate.

On X Axis we can see someone had a running anaerobic threshold heart rate of 140bpm yet had a bike anaerobic threshold of 168bpm.

On the flipside of this we can see someone had 158bpm running on but a 138bpm cycling heart rate.

So, you can see there can be large individual discrepancies and you could be one of those large discrepancies.

The moral of the story is that training zones and max heart rates are different across modalities if you are not equally trained in said modalities.

Yes, you do need different training zones for different sports and opt for sport specific testing identification for anaerobic and aerobic threshold HR.

Why? Different sports and activities have vastly different metabolic activities. An Individual's muscle mass vs different muscle fibre types play a significant role "fast twitch v's slow twitch" = influences heart rate.

We recommend sports specific testing to determine training zones for each sport. Best practice would be field testing for each sport. With training zones applied an error rate of up to 5 bpm per training zone is acceptable.

Efficiency of movement and accuracy of captured data

- In a study by Tony Rice of Rowing Australia and the Australian Institute of Sport (AIS) comparing differences in physiological responses in rowing and cycling at the elite level found that at similar power outputs different RPEs and VO2 max were found. No transferability!
- The cyclists recording lower VO2 max at the same power outputs. Interestingly both modalities ended up peaking at similar VO2 max, but peak power was almost 40 watts less on the rower than the cycler. So, the question is why doesn't rowing power = cycling power at the same VO2 max? The answer is rowing because it is a less efficient movement. Think about it for a second. On a row machine your arms are moving as well as your legs and some of that body mass will be moving but not necessarily producing power at the point where the machine measures power but is still consuming O2. Whereas on a bike your legs are in direct contact with the pedals turning pound for pound on the machine. So, whilst both are consuming the same energy (represented as VO2 max) the power generated at the machine will appear off due to these differences in movement and measurement. Thus, a rower to achieve the same power output as displayed on the rower will be working up to 3.5% harder than the cyclist at the same power output as measured on the bike.

Interestingly RPE was the same at similar power outputs but VO2 max was lower on the bike, suggesting RPE scales to be misleading when comparing the modalities. RPE's matched similar VO2 max at the peak power outputs, suggesting higher RPE's to be more accurate at estimating VO2 max. The variable that matched VO2 max the closest across both modalities was of course heart rate, so at the same HR's for both modalities, VO2 max was roughly the same. Remember this study was assessing elite rowers vs elite cyclists and so their VO2 max were similar as they were athletes in their chosen field.

- Different muscle groups used in different activities

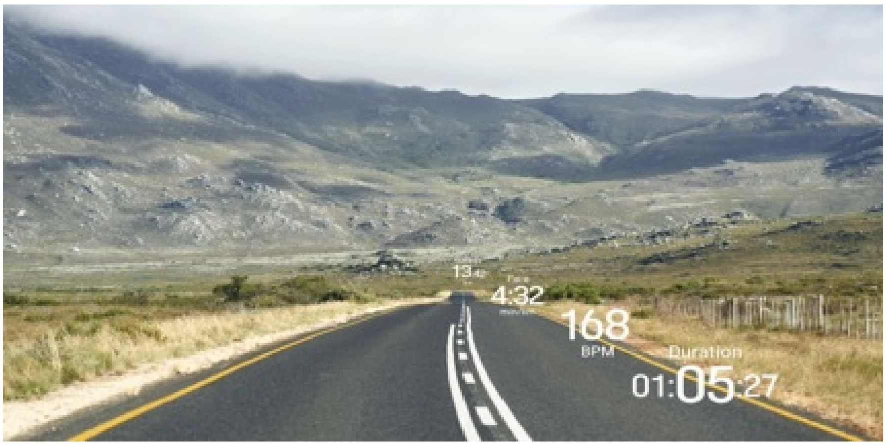
  Muscle fibre composition varies across muscle groups and so can manipulate aerobic threshold depending on if the majority of muscles involved are fast twitch or slow twitch. The more slow twitch fibres generally means more aerobic capacity.

- Environmental factors
    - As discussed previously hot weather, altitude and other external factors can manipulate HR and thus training zone choice.
    - As the duration of exercise sessions increases, so too does dehydration and heart rate will naturally increase as dehydration increases even though the same power output is occurring. In these cases, it can be more useful to use a Watt meter than heart rate monitoring to record effort, but this is more for the trained endurance athlete.
- Individuality is King

    All zones are estimates when it comes to the individual and so care always needs to be taken when using training zones to monitor intensity. If someone has a lower threshold then the zone you have chosen, then there is a good chance of overtraining if you consistently push them in this zone every session day after day with no recovery. This is where your professional reasoning comes into play and you need to look at the person in front of you to decide what is best.

The bottom line is that training zones are not transferable unless you are dealing with an elite athlete who has trained in both modalities equally. Using sport specific training zones can help minimise the error margin and help you select the desired intensity for your clients. RPE's are useful for gauging intensity but are limited in predicting VO2max unless at the higher ends of the scale. The best predictor of VO2 max is heart rate.

Elite Training Methods



What is Best Practice for Training Intensity and Duration Distribution in Endurance Athletes?

The Australian Institute of Sport presented an article in the International Journal of Sports Physiology and Performance, to Queensland Academy of Sport by Stephan Seiler from the Faculty of Health and Sport Sciences, University of Agder, Kristiansand, Norway.

In 2 - 4 year cycles of periodisation in preparation for Commonwealth games, World Cup or Olympic Games - successful endurance training involves, the manipulation of training intensity, duration, and frequency. With the implicit goals of maximizing performance, minimizing risk of negative training outcomes, timing peak fitness and performances to be achieved when they matter most.

Endurance training involves manipulation of the FITT principles of type, intensity, duration, and frequency of training sessions over days, weeks, and months. Long slow distance, lactate threshold training, and high-intensity interval training (HIIT) are all familiar terms for exercising within different regions on the intensity scale. The relative impact of different combinations of intensity and duration of endurance training has been studied and debated for decades among athletes, coaches, and scientists.

Currently, HIIT has come into focus again based in part on recent findings suggesting superior central adaptations to short-term interval programs compared with continuous exercise at lower intensity. However, the application of these findings to the long-term training of endurance athletes is unclear.

Numerous descriptive studies of the training characteristics of nationally or internationally competitive endurance athletes training 10 to 13 times per week seem to converge on a typical intensity distribution in which about 80% of training sessions are performed at low intensity (2 mM blood lactate), with about 20% dominated by periods of high-intensity work, such as interval training at approx. 90% VO2max.

Endurance athletes appear to self-organize toward a high-volume training approach with careful application of high-intensity training incorporated throughout the training cycle. Training intensification studies performed on already well-trained athletes do not provide any convincing evidence that a greater emphasis on high-intensity interval training in this highly trained athlete population gives long-term performance gains.

The predominance of low-intensity, long-duration training, in combination with fewer, highly intensive bouts may be complementary in terms of optimizing adaptive signalling and technical mastery at an acceptable level of stress.

There is reasonably strong evidence for concluding that an approximate 80-to- 20 ratio of LIT to ThT/HIIT intensity training gives excellent long-term results among endurance athletes.

Frequent, low-intensity (≤2 mM blood lactate), longer duration training is effective in stimulating physiological adaptations.

The idea of a dichotomous physiological impact of HIIT and LIT is probably exaggerated, as both methods seem to generate overlapping physiological adaptation profiles and are likely complementary.

Over a broad range, increases in total training volume correlate well with improvements in physiological variables and performance.

HIIT is a critical component in the training of all successful endurance athletes. However, about two HIIT training sessions per week seems to be sufficient for inducing physiological adaptations and performance gains without inducing excessive stress over the long term.

When already well-trained athletes markedly intensify training over weeks to months, the impact is equivocal, with reported effects varying widely. In athletes with an established endurance base and tolerance for relatively high training loads, intensification of training may yield small performance gains at acceptable risk of negative outcomes. An established endurance base built from high volumes of training may be an important precondition for tolerating and responding well to a substantial increase in training intensity over the short term.

Periodisation of training by elite athletes is achieved with modest reductions in total volume and a careful increase in the volume of training performed above the lactate threshold as athletes transition from preparation to competition training phases. Greater training intensity characterises this transition, both in terms of the net training distribution as well as within micro-and macrocycles of training. However, compared with classic training periodisation models, with large swings in volume and intensity, the basic intensity distribution remains quite similar throughout the year. Almost no research is available investigating the impact of different models of long-term training periodization for endurance athletes.

Follow the 80/ 20 RULE

80% (Volume < LTH) & 20% (High Intensity).

For better understanding of Seiler findings for runners, rowers, cyclists and skiers please refer to this journal article here.
https://journals.humankinetics.com/view/journals/ijspp/5/3/article-p276.xml

High Intensity Exercise (HIIT) V's Low Intensity Exercise (LIE)

polartrainingzone.com.au/topic/high-intensity-exercise-hiit-vs-low-intensity-exercise-lie

The debate concerning high versus low-intensity exercise continues, and although a significant amount of more recent research has focused on the aerobic benefits of high-intensity interval training (HIIT), experts cannot reach any single conclusion regarding its efficacy, because it all depends on the perspective from which they approach the argument.

As we have just covered, in the article from Seiler to the AIS in regard to the Endurance athlete suggesting the 80 / 20 rule..

However, research presented in Porcari 2015 has revealed that HIIT results in similar improvements in VO 2 max and mitochondrial density as bouts of lower-intensity exercise (LIE), but which form of exercise is more appropriate for a sprint athlete versus the overweight business executive simply seeking to improve health?

Certainly, some research demonstrates how HIIT increases levels of free fatty acids (FFA) in the blood because of greater levels of circulating epinephrine, which is supposed to drive greater aerobic metabolism in the cells. However, research also demonstrates that the increased levels of blood lactate that follow HIIT begin to inhibit hormone-sensitive lipase activity, the enzyme responsible for mobilizing fats. Furthermore, increased lactate levels act as a precursor for glycerol 3-phosphate, promoting the re-esterification of those FFAs into triglycerides within adipocytes (fat cells) if the FFAs are not taken into the muscle cells, but instead remain in the bloo

HIIT builds ventilatory power, or the speed and magnitude with which individuals move air into and out of the lungs. LIE, in contrast, builds ventilatory endurance, or the capacity of the endurance muscles to sustain work and resist fatigue. Both are critical to ventilation and the delivery of adequate levels of oxygen to the muscle cells.

Perhaps the most popular form of HIIT is what many term Tabata training, coined after the researcher who, together with his colleagues, challenged conventional thinking back in 1996 and introduced training methods for improving aerobic fitness (i.e., VO 2 max). In their study using 14 physically fit, young, male subjects, Tabata and colleagues compared two training methodologies and examined improvements in both aerobic and anaerobic fitness.

In experiment one, seven subjects performed. steady state exercise five times per week on cycle ergometers, with each session performed at 70% of VO 2 max for 60 minutes (total of 300 minutes per week).

In experiment two, seven subjects performed HIIT, 5 x week on cycle ergometers, with four sessions performed at workloads equivalent to 170% of VO 2 max.

The subjects completed 7 to 8 reps, with the workload progressing by 11 watts on subsequent sessions when 9 intervals could be attained.

Each set involved a 20-second work interval followed by a 10-second recovery interval, totalling approximately 4 minutes of work per session. (20secs : 10secs = 4mins)

On the fifth day, the subjects completed a 30-minute. interval at 70% of VO 2 max, followed by only 4 sets at 170% of VO 2 max. After 6 weeks, aerobic capacity in experiment one increased by 9% (52.9 to 58 mL/kg/min), whereas anaerobic capacity did not increase. However, after 6 weeks, aerobic capacity in experiment two increased by 13% (48.2 to 55 mL/kg/min), whereas anaerobic capacity improved by 28%.

The results of this study demonstrated that steady-state moderate-intensity aerobic training that improves maximal aerobic power does not improve anaerobic capacity, whereas HIIT may improve both anaerobic and aerobic capacity in a more time-efficient manner.

Unfortunately, the nature and results of this study have largely been misinterpreted by many fitness professionals who market Tabata training to the public. Although the study used 14 physically fit, young, male subjects exercising on bicycle ergometers, this form of training is now performed with many different population groups (e.g., deconditioned individuals, females, and older adults) and includes other forms of cardiorespiratory exercise (e.g., treadmill, elliptical, and sprints), and even resistance training (e.g., body weight and externally loaded . resistance), none of which can truly be completed at 170% of VO 2 max. The unfortunate reality is that the only real similarity of these programs to Professor Tabata's research is the 2:1 work-to-recovery ratios. Although the results achieved and the efficiency with which those results are gained are impressive, a health and fitness professional should always examine the appropriateness of such practices with each individual client.

Another more recent training method follows the research by Gunnarsson and Bangsbo in 2012, called the 10-20-30 Training Concept, more commonly known as the Copenhagen method. The study had 18 moderately trained runners (6 females, 12 males) were divided into a high-intensity training (10-20-30) group and a control group to compare the effects of both methods on the health profile, muscular adaptations, VO 2 max, and running performance of the study participants.

While the control group continued their normal training methods during the seven-week study, the 10-20-30 group implemented a format of 30 seconds of low-intensity running at less than 30% of maximal intensity, 20 seconds of moderate-intensity running at less than 60% of maximal intensity, and 10 seconds of high-intensity running at more than 90% of maximal intensity (i.e., a 60-second interval). This interval was repeated five times (i.e., 5 minutes of continuous exercise) before taking a 2-minute recovery, and the entire circuit was repeated 3 - 4 times.

At the conclusion of the study, VO 2 max in the 10-20-30 group was 4% higher, and performance in a 1,500-m and a 5-km run improved by 21 and 48 seconds, respectively.

Furthermore, in the 10-20-30 group, systolic blood pressure was lower by 5 mm Hg, and total and LDL cholesterol were lower by 0.5 and 0.4 mmol/L, (19.3 and 15.5 mg/dL) respectively, in comparison with the control group. The results demonstrated that this method of training, with short, near-maximal bouts (e.g., 10 seconds), can improve health, fitness, and performance despite large reductions in training volume.

This format of training with slightly longer recovery intervals is generally better suited for most individuals contemplating HIIT. A prevailing mentality is to exercise hard and maximize total caloric expenditure in a session to effectively promote weight loss (concept of caloric quantity). While this method largely ignores the overall exercise experience (an influential driver of exercise adherence), it also fails to consider the concept of caloric quality (i.e., what fuel is being burned). Which is more important: quality or quantity? The debate continues, and based on individual research design, experts draw different conclusions.

In a perfect world, exercisers want to achieve both caloric quantity (total number of calories) and caloric quality (absolute calories, not percentage, coming from fat).

Sweat rates, Fluid Loss and Hydration

polartrainingzone.com.au/topic/sweat-rates-fluid-loss-and-hydration

It's a hot spring day.. and the QLD Noosa Triathlon is on.. You have completed it before but this time your underdone, not the ideal training and conditioning.. It's all getting too much...

Our sweat by way of evaporation is the main mechanism that our body uses to regulate body temperature during exercise.

Sweat must evaporate for heat to leave the body. For each litre of sweat lost, the body removes approximately 580 kcal (2,428 kJ) of heat.

Sweat dripping off the body or remaining in the clothes does not contribute to cooling but does contribute to fluid losses and potential dehydration.

Figure 7. Sweat rate during activity

Sweat rates generally range between 0.5 and 1.5 L/hr during light- to moderate-intensity exercise, but can increase to 3.0 to 4.0 L/hr in well-conditioned, large male athletes who have acclimatized to hot environments.[2] Rates of fluid loss from sweat vary among individuals and according to environmental factors, but generally a person can expect to lose fluid as follows:

- Sweat rates at rest:
  - 0.05 L/hr (1.7 fluid oz/hr) at 80°F (26.7°C)
  - 0.6 L/hr (20.3 fluid oz/hr) at 110°F (43.3°C)
- Light activity:
  - 0.2 L/hr (6.8 fluid oz/hr) at 80°F (26.7°C)
  - 1.0 L/hr (33.8 fluid oz/hr) at 110°F (43.3°C)
- Moderate activity:
  - 0.4 L/hr (13.5 fluid oz/hr) at 80°F (26.7°C)
  - 1.5 L/hr (50.7 fluid oz/hr) at 110°F (43.3°C)
- Heavy activity:
  - 0.6 L/hr (20.3 fluid oz/hr) at 80°F (26.7°C)
  - 2.0 L/hr (67.6 fluid oz/hr) at 110°F (43.3°C)

Thermoregulation at Rest and Exercise

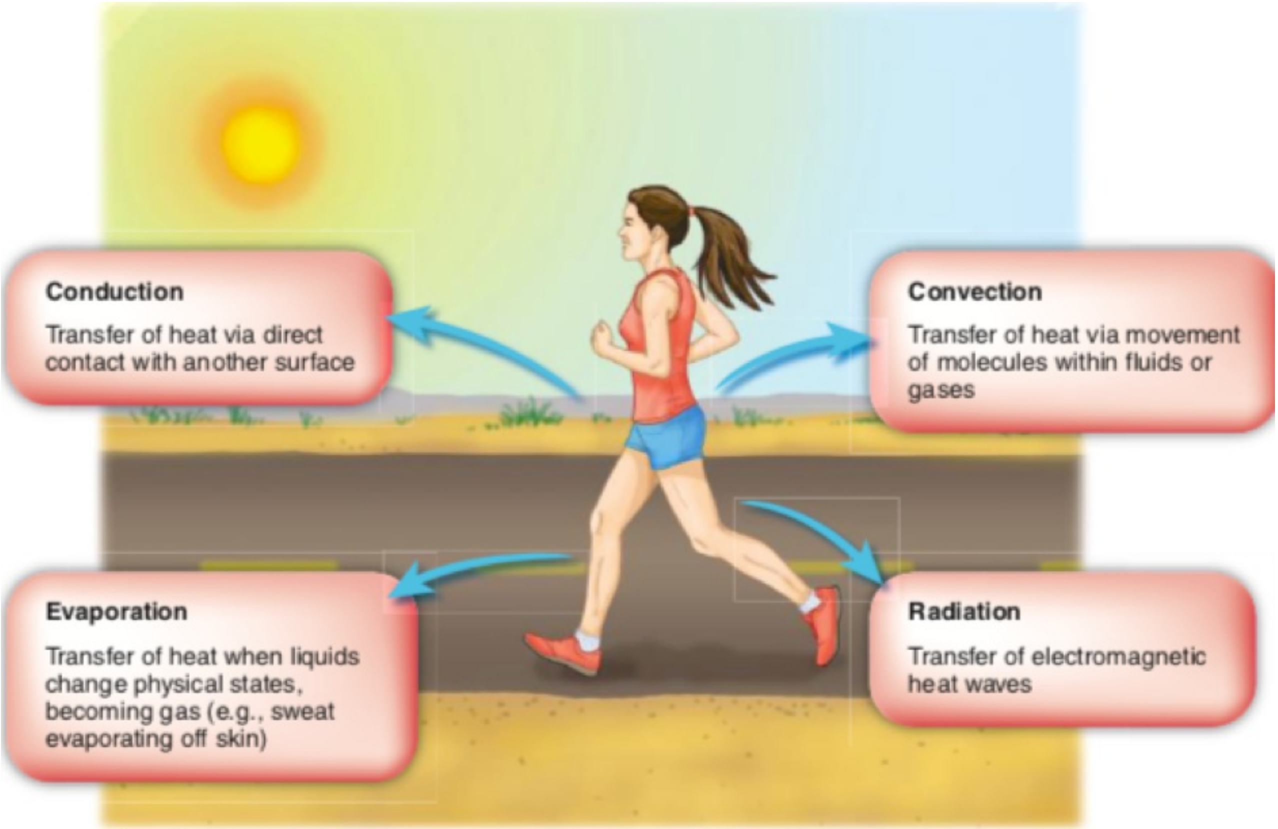


Figure 8 - The body's thermoregulatory mechanisms that primarily protect against overheating at rest and during exercise.

THERMOREGULATORY MECHANISM	REST	EXERCISE
Conduction and convection	20% of total	10%–15% of total
Radiation	55%–60% of total	5% of total
Evaporation	20% of total	80% of total
Excretion/lungs	5%–10% of total	<2% of total

Table 9 - Thermoregulation at Rest and During Exercise

According to Porcari (2015) A coach training his or her athletes in a swimming pool seeks a thermoregulatory neutral temperature that reduces additional thermoregulatory costs and maximizes performance. Researchers estimate that ideal pool temperatures for training range between 75°F and 82°F (23.9°C and 27.8°C).

In warmer environments during exercise, two competing cardiovascular demands exist:

1. The demand and need for oxygen and nutrient delivery to the exercising muscles
2. The demand and need for peripheral blood flow to the skin to remove heat

Thermoregulation costs during exercise increases the burden on the cardiovascular system, transporting blood to both the exercising muscles and the skin surface.

This essentially creates competition for the body's blood volume. This increased demand for cardiac output (CO) is met by increasing heart rate and heart contractility to ensure appropriate circulation to these two regions and by redistributing blood away from nonessential organs and systems (e.g., gastrointestinal tract, liver, and kidneys; Table 10).

This is a potential reason why different individuals are prone to purging matter orally or gastrointestinal upsets resulting in abdominal cramps / diarrhea.

Blood Flow distribution at Rest and Exercise

polartrainingzone.com.au/topic/blood-flow-distribution-at-rest-and-exercise

The SNS mediates this activity that produces vasoconstriction in nonessential organs and vasodilation of vessels in the exercising muscles and near the skin surface.

At rest, in moderate environments, approximately 6% of all blood flow reaches the skin, whereas this value declines to approximately 2% in colder environments because of peripheral vasoconstriction that redirects blood to the core for heat preservation.

During lower intensities of exercise < 6 / 7 RPE, reduced muscle demand facilitates greater blood distribution to the skin and efficiency in thermoregulation.

Whereas during heavier exercise intensities > 7RPE, during which metabolic heat production increases, real competition for blood between the exercising muscles and the skin exists. Ultimately, blood distribution to the skin will decrease in favour of delivery to the exercising muscles, which elevates the risk for thermal stress and heat illness.

Table 10 Blood flow distribution to essential and nonessential organs at rest and during exercise.

ORGAN	REST	EXERCISE
Muscles	15%–20%	70%–85%
Liver/gastrointestinal tract	20%–25%	3%–5%
Heart	4%–5%	4%–5%
Skin	Moderate environments: 6% Cold environments: 2%	Light-intensity exercise: 14%–15% Moderate-intensity exercise: 12% High-intensity exercise: 2%
Brain	14%–15%	3%–4%
Kidneys	20%–22%	2%–4%
Other	7%	3%

Heat Stress

At 104°F to 105.8°F (40°C–41°C) These changes will not continue indefinitely.

Eventually, the demands of exercise and thermoregulation will exceed the cardiovascular system's ability to meet these demands. When the body reaches this point, it becomes unable to regulate against an increasing core temperature and signals the brain to begin to cease exercise.

As prolonged cardiovascular and core temps rise...exhaustion, fatigue sets in, epinephrine triggers glycogen utilization increasing lactate production affecting a phenomenon called the "Bohr effect" which is a temporary adjustment in the blood to retard the onset fatigue under rising core temperatures. This adjustment involves a shift in the oxygen dissociation curve to increase the amount of oxygen unloaded from haemoglobin and improve its uptake into the muscle cells.

In table 11 you will see that exercising in a hot environment increases stress, heart rate, stroke volume and cardiac output.

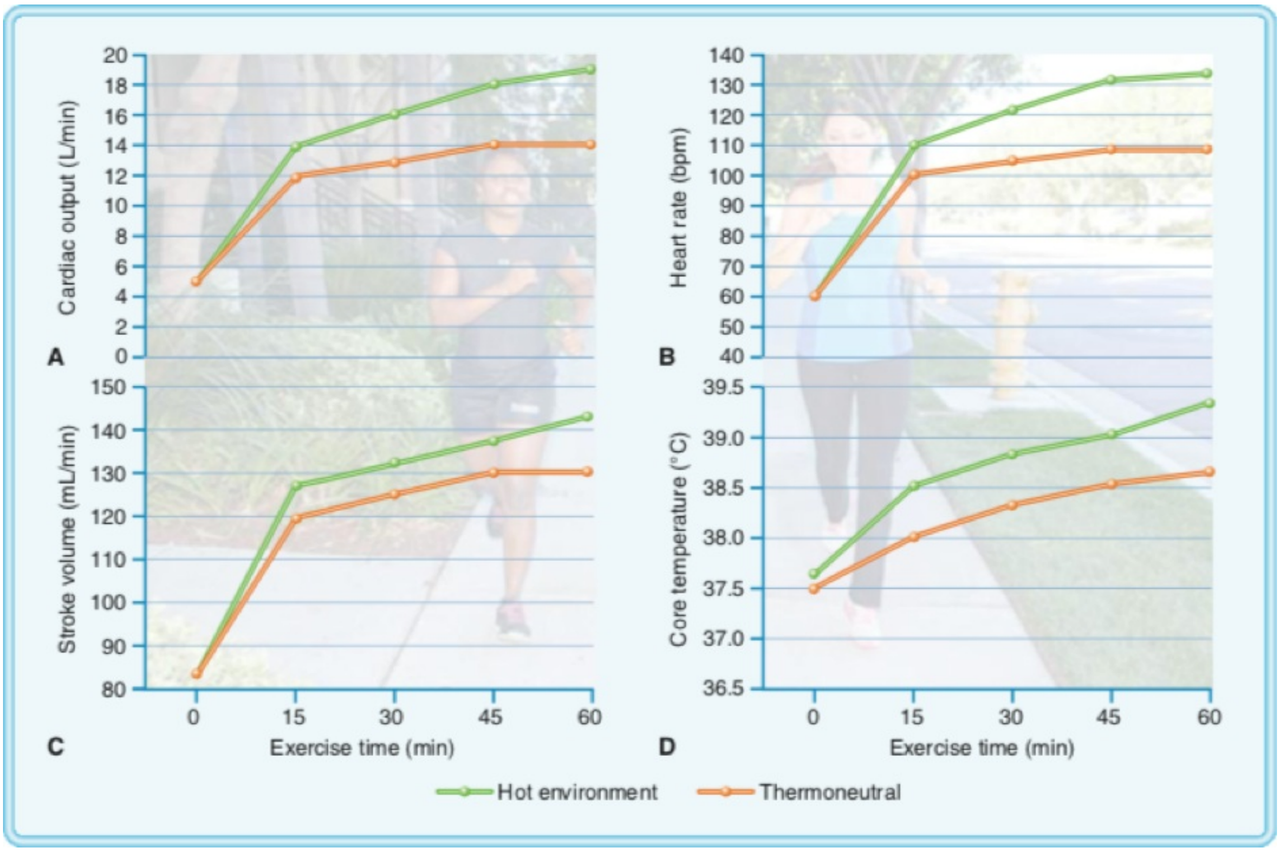


Table 11 - Physiological responses to moderate-intensity exercise across cardiac output (A), heart rate (B), stroke volume (C), and core temperature (D) in both a hot environmental condition (35°C) and a thermoneutral condition (20°C).

In Practice then: -

High humidity prevents sweat from evaporating.

Sweat that does not evaporate does not cool the body.

At 90°F (32.2 Degrees) outdoor temperature is relatively safe at 10% humidity, the heat stress of 90°F at 50% humidity is the equivalent of 96°F. (35 Degrees).

When the heat stress index increases to more than 90°F (32.2 Degrees), you may put yourself at risk of cramps and other complaints. Postpone your exercise session until later in the evening. Or, plan ahead and beat the day's heat by working out early in the morning.

Table 12. Refers to the Heat Stress Index which evaluates the combined effect of air temperature and relative humidity to determine an apparent temperature, or how hot it actually feels. (Porcari 2015)

Table 12. Heat Stress Index

B

	Air temperature (°C)										
	21	24	26.5	29.5	32	35	38	40.5	43	46	49
Relative humidity	Heat sensation (°C)										
0%	18	20	23	25	28	30	32	35	37	39	41
10%	18	21	24	26	29	32	35	37	40	43	46
20%	19	22	25	28	30	34	37	40	44	48	54
30%	19	23	25	29	32	35	40	45	50	57	64
40%	20	23	26	30	34	38	43	50	58	65	
50%	20	24	27	31	35	41	48	57	65		
60%	21	24	28	32	37	45	55	64			
70%	21	25	29	34	41	51	62				
80%	21	25	30	36	45	57					
90%	21	26	31	39	50						
100%	22	26	32	42							

<32°C	No discomfort
32°C–39.9°C	Heat cramps—possibility
40°C–53.9°C	Heat cramps, heat exhaustion—likely; heat stroke—possibility
54°C+	Heat stroke—high risk

Fluid loss has the potential to impair cardiovascular function.

Did you know that over half of your body weight is water?
In Men about 60 - 65% and Women about 50-60%?
Water Balance is controlled by a constant feedback loop between the Brain and Kidneys.

We lose about 2.5L a day of water through Urine, Respiration, Faeces and sweat.

So, it's difficult to assess the exact amount of water an individual needs + sporting prehydration, during and post. A sports dietician can work this out for you.

However, we should start with at the very least replacing what we have lost. (2.5L)

According to Porcari (2015) It is estimated that the sensation of thirst in adults younger than 50 years normally begins when a person reaches approximately 1% loss of body weight. For example, if a 180-lb (81.8-kg) man lost 1.8 lb (0.82 kg), this would initiate the sensation of thirst.

Aging is associated with a gradual reduction in the mechanisms that drive the sensation of thirst.

The effects of dehydration on exercise performance are complex as fluid losses whilst participating in training vary between individuals and the performance tasks. This makes it difficult to develop universal recommendations for fluid intake.

Studies however find that fluid loss of 2% of body mass appears to have negative effects on endurance capacity during exercise performed at a fixed intensity whilst adverse effects on endurance time trial performance may not occur until fluid losses exceed 4% of body mass.

For optimal performance, athletes should always be well hydrated before exercise. This is best achieved several days before an event because the intake of large fluid volumes immediately before exercise are not always well absorbed and can cause gastrointestinal discomfort. Athletes can monitor their hydration status by checking the colour of their urine, monitoring acute fluctuations in body weight or using more sophisticated measures such as urine specific gravity.

If you are a Personal Trainer, inform your client ahead of time with the type of session that is going to be conducted and encourage hydration in a timely manner around when the session will occur perhaps even requiring 24 hrs to pre hydrate.

For individual guidance on hydration requirements please consult a Sports Dietician and member of Sport Dietician Australia or of a registered sports dietician body of your country.

Did you know, it's actually harder for women to sweat than men?

Caffeine

polartrainingzone.com.au/topic/caffeine

The benefits of caffeine are related to effects on the central nervous system. Increasing arousal and reducing the perception of exercise effect and exertion.

The dose required to achieve optimal performance gains are 3mg / kg of body mass consumed approximately 60minutes before exercise. Approx. 2 standard cups of Coffee. The average cup of coffee is 100mg but can range from 25 - 200mg on how its prepared. Energy drinks 80mg in a 250ml can. Caffeine tablets 100mg / tablet.

For further understanding of Caffeine ingestion for performance:
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4213371/

Creatine

polartrainingzone.com.au/topic/creatine

Creatine monohydrate increases the creatine pool in muscles - allowing for rapid ATP regeneration during repeated bouts of high intensity exercise. This supplementation positively affects anabolic processes within muscles and results in an increase in lean muscle mass / strength. Also improving high intensity intermittent speed training and aerobic endurance performance lasting more than 150 seconds.

Dosage protocols involve a short loading phase lasting five to seven days. 20g / day (4 daily intakes of 5g each / evenly spaced throughout the day) Followed by a maintenance phase of the duration of training cycle of 3-5g / day.

For better understanding of intake and benefits of Creatine/s refer to: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3407788/

Bicarbonate

polartrainingzone.com.au/topic/bicarbonate

Not all studies show performance benefit. Side effects can be associated with gastrointestinal discomfort which offset potential benefits. The principle is that increasing bicarbonate in the blood enhances the capacity to buffer acid production by the working muscles. Potentially delaying fatigue during high intensity exercise. Effectiveness of Bicarbonate may be less in well trained / elite athletes.

Dosage: 200 - 400mg / kg body mass. 60 - 90 minutes before exercise. Subjects should trial this dosage on several occasions to ensure adverse gastrointestinal effects.

For better understanding of Bicarbonate inconsistencies:
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6544001/

Beta – Alanine

polartrainingzone.com.au/topic/beta-alanine

Beta-Alanine plays a role buffering acid produced in the muscle during high intensity exercise. Supplementation for several weeks may result in muscle carnosine and improved performance in short duration (1 - 4 minutes), high intensity exercise e.g. Anaerobic sprints. Beta Alanine can also provide benefits in resistance training.

Dosage: Daily dose of 6.4g ~ at least < 4 weeks to evaluate muscle carnosine. The daily dose 6.4g is normally spread with multiple doses split up into equal parts throughout the day as some individuals experience side effects, such as tingling, prickly sensation on the skin, when large doses are consumed. Adherence to this protocol can be difficult, so beta-alanine supplementation is only recommended for highly motivated athletes

For further understanding for effects of Beta-Alanine read: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3257613/

Nitrate. (Beetroot Juice)

polartrainingzone.com.au/topic/nitrate-beetroot-juice

Nitrate concentrate within foods can vary due to growing conditions and loss of nitrate through soil, preparation and cooking. So, it makes it difficult to predict and have reliable concentrations. Enter Beetroot juice that contains a known amount of nitrate. Once ingested. Dietary nitrate is converted into nitrate by bacteria in the mouth. Circulating nitrate is then converted into nitric oxide in blood and tissue. The increase in nitric oxide improves muscular function ~ exercise performance.

Nitrate supplementation then specifically enhances the efficiency of oxygen use during exercise and allows individuals to perform greater workloads for the same energy cost.. Therefore, improving the capacity to exercise for set intensities for a longer period of time before fatigue and exhaustion.

Dosage: Daily intake of 400 - 500 mg of nitrate for 7 days. Or single dose 2 -3 hours before the event.
NB: Effects may be contraindicated with Caffeine.

For further understand of Nitrate please read:
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5295087/

For the use of supplementation, we recommend referring to the AIS and asada website.

THE AIS SPORTS SUPPLEMENT FRAMEWORK
https://www.asada.gov.au/
https://www.asada.gov.au/substances/supplements-sport

Why do people put on weight (energy balance, genetics, proteins)

The simplest way to explain this is that there has been a disruption to energy balance. If energy intake is greater than energy expenditure, then the excess energy will be stored in the body as fat and weight gain will occur. However, the regulation of energy balance is complex. There are Physiological factors at play such as hormones that increase hunger and the desire to eat, empty stomach and gastric contractions. There are also external sensory factors such as taste, smell and sight of food that drive hunger. Our cognitive responses to different environments or settings such as training environments, social situations, celebrations, cravings, time of day and favourite foods can influence our food intake. There are many different factors that influence our desire to eat which can make it difficult to maintain energy balance. It is important to understand that for some being overweight or obesity is far more complex than simply an imbalance between the amount of energy coming into the body and the amount being used by the body.

Genetics can also influence the likelihood of being overweight or obesity for an individual. Our genes can code for specific proteins that act like hormones to help regulate our food intake. These include: **ghrelin** which is released from the stomach and stimulates appetite; **adiponectin** which is released by adipose tissue and reduces inflammation as well as protecting against insulin resistance; **leptin**, **peptide YY** and **pancreatic polypeptide (PPY)** which all suppress appetite. If the production of any of these protein hormones is out of balance, it can be more difficult to regulate food intake and manage body weight.

Energy Expenditure

polartrainingzone.com.au/topic/energy-expenditure

Individually how much we expend energy differs. The energy expended by the body includes the energy used for physiological functions at rest, during physical activity and everything in between. The amount of energy spent in a day differs for each individual but is broken up into three components. These components are basal metabolism, physical activity and the thermic effect of different foods.

The basal metabolic rate (BMR) is the amount of energy used for all of the basic physiological processes that keep us alive. The thermic effect of food is the energy expended in the process of digesting and absorbing the food that we eat. This is the least variable component of energy expenditure. The third and most variable component of energy expenditure is physical activity and depends on a person's activity patterns.

In general, basal metabolism is the largest component of energy expenditure and the thermic effect of food is the smallest. Basal metabolism can vary depending on age, body composition, growth, stress and circulating hormone levels. In general, a person who weighs more will have more total energy expended via basal metabolism, but the amount of energy per kilogram of body weight may be lower. Men tend to have a higher BMR compared with women as muscle or lean mass is more metabolically active than fat mass.

Adaptive Thermogenesis

polartrainingzone.com.au/topic/adaptive-thermogenesis

Have you noticed, some people stop losing weight or regain the weight they lost? The body has mechanisms in place to prevent rapid weight loss or weight gain, even when there is a big change in our food intake or physical activity. This process is called adaptive thermogenesis, where the body changes its basal metabolism to prevent large amounts of weight being lost or gained over a short period of time.

After some time, the weight loss while on a "diet" or eating less energy triggers the body to adjust and lower its metabolic rate through this adaptive thermogenesis to be in line with the new lower food intake and smaller weight. This is how the classic yo -yo weight loss starts and where it becomes very easy for the individual to exceed the new lower food intake requirement, which often leads to the individual putting the weight back on easily. This can make sustained long-term weight loss very difficult for many people.

To develop a deeper understanding of adaptive thermogenesis, click this link: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4989512/

Fat Storage in the body

polartrainingzone.com.au/topic/fat-storage-in-the-body

Fat cells are required in the human body as they provide a way of storing the energy from food, as only a limited amount of carbohydrate can be stored. The amount of fat in a person's body reflects both the number and the size of the fat cells. Fat cells increase in number as we grow during childhood and adolescence. When energy is consumed in excess of what is required, fat cells increase in their size and number. Eventually weight gain and potential future obesity develops as both the number and the size of fat cells increases. Conversely weight loss results in a decrease only in the size of fat cells, not a reduction in the number of fat cells. The location of fat storage in the body is particularly important for health. Fat tissue located under the skin is called subcutaneous fat, whereas fat tissue located around the abdominal organs is called visceral fat. Visceral fat is more closely associated with disease risk than subcutaneous fat.

Lipid digestion ends with chylomicrons lipoproteins delivering triglycerides from the small intestine into the bloodstream. The lipoprotein lipase (LPL) enzyme releases fatty acids from the triglycerides within the lipoproteins. The enzyme LPL promotes fat storage in both adipose and muscle cells. Obese or larger weight people particularly, generally have much more LPL activity in their fat cells than lean people do, therefore making fat storage very efficient. Consequently, even a modest increased energy intake has a far more dramatic impact on obese people than on lean people. The activity of LPL in different parts of the body can determine where fat is stored. Women have fat cells in the hips and thighs that produce lots of lipoprotein lipase, which means more fat is stored in these areas. Whereas men have fat cells in the abdomen that produce a lot of LPL. Enzyme activity may also explain why some people who lose weight regain it so easily. After weight loss, LPL activity increases, and it does so most dramatically in people who were most overweight prior to weight loss.

Exercise and Energy Intake Guidelines

polartrainingzone.com.au/topic/exercise-and-energy-intake-guidelines

As we know exercise is one of the best things that can be done to improve health and wellbeing. However, moderate amounts of exercise appear to be less effective than might be expected for weight loss, particularly when not accompanied by dietary changes.

To prevent weight gain and support weight losses, recommendations for exercise can vary with up to 60 minutes of moderately intense physical activity per day required to promote effective weight management.

The table 13 below summarises the current guidelines for physical activity and weight management by the ACSM.

Table 13: ACSM guidelines for physical activity and weight management

Preventing weight gain	Physical activity of 150 - 250 minutes / wk. with an energy equivalent of 5000 - 8500 KJ per wk. will prevent weight gain greater than 3% in most adults
Promoting weight loss	• Physical activity < 150mins per week promotes minimal weight loss • Physical activity > 150 mins per week results in modest weight loss Approx. 2-3kg • Physical activity > 225 - 420 mins per week results in 5-7 kg weight loss and a dose response exists

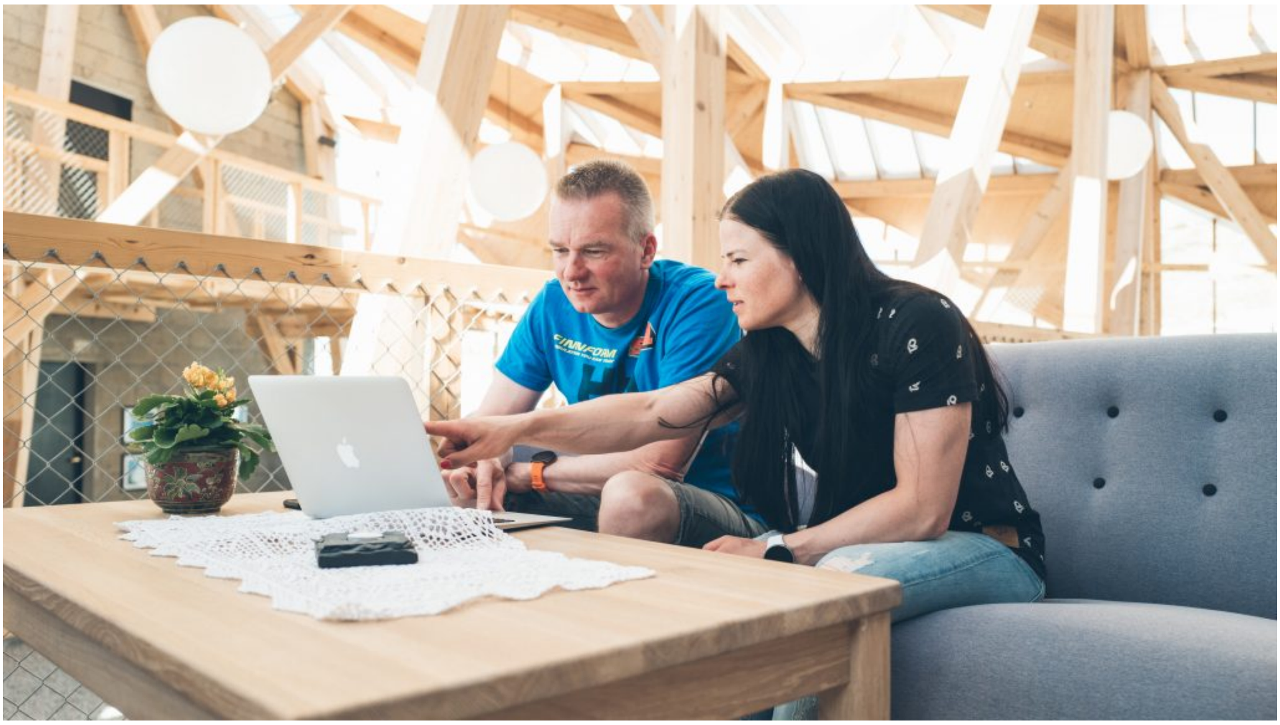
Evidence graded by the American College of Sports Medicine, Appropriate Activity intervention Strategies for Weight Loss and Prevention of Weight Regain for Adults, Medicine & Science in Sports and Exercise 41 (2009).

People who combine diet and exercise typically have more success, lose more fat mass, retain more muscle mass and regain less weight than those who only follow a weight-loss diet. These subjects are more likely to have created a new pattern and or lifestyle leading to longer term success.

To develop a deeper understanding about Body Composition and Weight management refer to The Role of Exercise and Physical Activity in Weight Loss and Maintenance by swift et.al 2015. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3925973/ and Whitney 3rd Edition. Understanding Nutrition2017.

Personal Training Hacks

polartrainingzone.com.au/lessons/personal-training-hacks



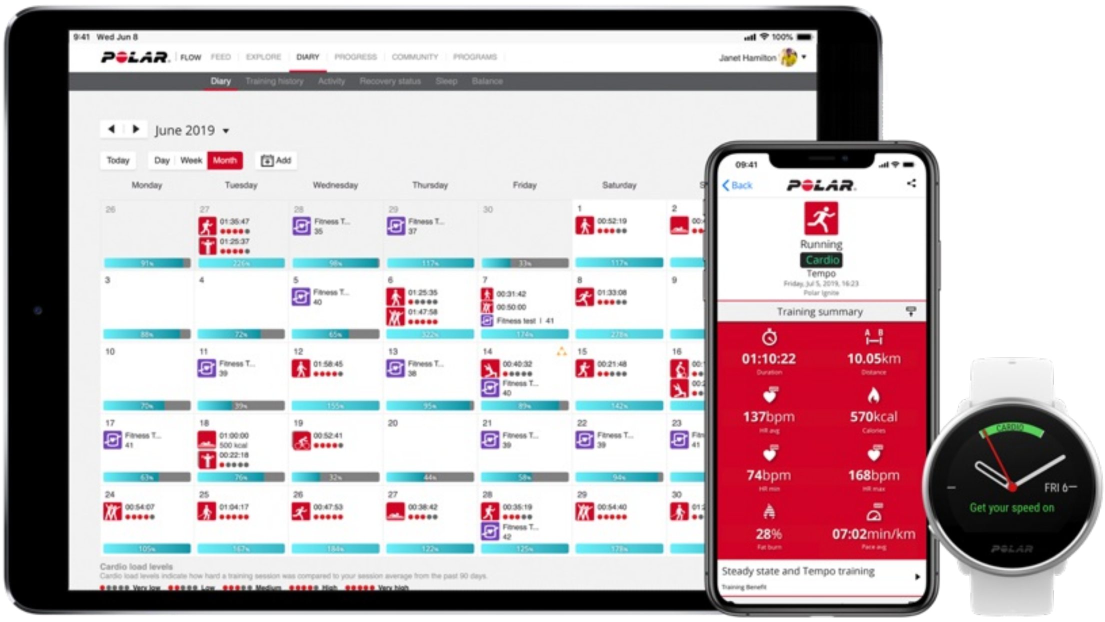
We hope this section of the course can provide some research, ideas, programming and statistics that you can implement into your clients programming.

The following pages will present to you many personal training hacks and snap shots of different papers that have been presented in the attending differences conferences around the world that we feel are current and effective. It is recommended that you do your research and testing on the suitability to your own situation and or clients.

Polar Training Zone are not the authors of the following materials; however, we present them to you and have added commentary in questions in some areas of relevance.

Periodisation

polartrainingzone.com.au/topic/periodisation-2



Periodisation - Coming through your Certificate III, IV, Diplomas and Degrees would have become familiar with the concept of Periodisation.

Athletes do require periodised programming and coaches in this framework become very good at manipulating spreadsheets and formulas for athletes around pre-season, competition and transition phases. But what about the everyday personal trainer? Best practice and the gold standard would say personal training clients deserve the same.

From a personal training perspective, clients sometimes aren't reliable on how long they will commit to a program. Therefore, investing time into a detailed periodisation model may prove to be an inefficient way to spend time.

Table 14: Resource.

Personal Training Macro Periodised Plan that you can use, interchange and manipulate.

Note: 1. Initial RT phase preparation phase should be a range of 12 - 15 reps

2. Fitness Evaluation to take place monthly
3. Interchange between CV activities on land and water.
4. Other options - Boxing

- Body Weight Exercises

- Lactic Acid Tolerance Training (15+ reps or 30 - 150 secs repeats)

Resource: Periodisation Plan

Month	Resistance Training	Cardio - Vascular Training
January	Hypertrophy - Straight Sets (8-12 reps)	LSD / Fartlek
February	Hypertrophy - High Intensity (drop sets, negatives, supersets)	LSD
March	Strength - 2 - 6 reps	Interval
April	Power - 2-15 reps	LSD
May	Hypertrophy - Straight Sets (8-12 Reps)	Fartlek
June	Hypertrophy - High Intensity (drop sets, negatives, supersets)	Tempo Threshold
July	Strength - 2 - 6 reps	Interval
August	Power - 2- 15 reps	LSD
September	Hypertrophy - Straight Sets (8-12 Reps)	Fartlek
October	Hypertrophy - High Intensity (drop sets, negatives, supersets)	Tempo Threshold
November	Strength - 2 - 6 reps	Interval
December	Power - 2 - 15 Reps	LSD

Fat Loss Programming

There are a range of tests that can be performed in collaboration with medical staff in which some parameters and goals can be set according to Tony Boutagy.

1. **Goal setting and testing**

Therapeutic goals

- fasting blood glucose: 3.8- 4.1 mmol/l
- ldl cholesterol: less than 1.5mmol/l
- Triglycerides: less than .85mmol/l
- C- reactive protein (high sensitivity): less than 1 mg/L
- Homocysteine: 5 umol / L
- Waist Circumference: less than 75 cm for female and 100cm for men
- Percentage of Body Fat: 19% for females, 14% for males
- blood pressure: 110-155 / 70-75mmHg

Other laboratory test to consider

1. Fasting insulin
2. C- peptide
3. HbA1c
4. OGTT

Nutrition and lifestyle intervention (please consult your Dietitian Australia accredited practitioner for advice before making any decisions)

Nutritional principles for insulin resistant patients

- Control postprandial hormonal Flux: eat every 2-3 hours
- Control insulin from the first meal: eat lean protein for breakfast
- Improve insulin control via increased fibre consumption: 50 g of fibre a day
- Increase antioxidant status: 8 serves of a day of vegetables and two serves of fruit a day
- Control postprandial glucose/ insulin Flux: choose foods that have a low glycemic load and do not overeat.
- Increase Satiety & thermogenesis: Consume 20-40 grams of protein with each meal + vegetables.
- 70% of people that have an increased subscapular skinfold it's likely they are insulin resistant

For further understanding refer to Associations of Trunk Fat Depots with Insulin Resistance, β Cell Function and Glycaemia - A Multiple Technique Study

Supplementation recommendations for the insulin resistance clients (please ensure you have a chat to your doctor or integrative medical professional before taking as blood testing may be required for specific circumstances)

- Stabilized R alpha lipoic acid: 100 mg with 8 mg of Biotin twice a day
- Chromium: 8 micrograms per kilogram per day
- Green tea (EGCG): 500 mg twice a day
- Magnesium 500 mg with vitamin B6 52100 mg twice per day
- Cinnamon: 1- 2 grams 3 times a day
- Omega- 3 fatty acids: 3 g a day in divided doses
- L-carnitine 1.5 g twice a day-best to take in the morning
- Taurine 3 g twice a day - take it towards the night, taurine can decrease blood pressure.
- Bitter Melon: 150mg, 3 times /day (can use in stir frys a couple times a week)
- Fenugreek: 1 gram, 3 times a day

Goals and Medical Tests

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1. **Goal setting and testing**

Therapeutic goals

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Nutrition and lifestyle intervention (please consult your Dietitian Australia accredited practitioner for advice before making any decisions)

Nutritional principles for insulin resistant patients

- Control postprandial hormonal Flux: eat every 2-3 hours
- Control insulin from the first meal: eat lean protein for breakfast
- Improve insulin control via increased fibre consumption: 50 g of fibre a day
- Increase antioxidant status: 8 serves of a day of vegetables and two serves of fruit a day
- Control postprandial glucose/ insulin Flux: choose foods that have a low glycemic load and do not overeat.
- Increase Satiety & thermogenesis: Consume 20-40 grams of protein with each meal + vegetables.
- 70% of people that have an increased subscapular skinfold it's likely they are insulin resistant

For further understanding refer to Associations of Trunk Fat Depots with Insulin Resistance, β Cell Function and Glycaemia - A Multiple Technique Study

Supplementation recommendations for the insulin resistance clients (please ensure you have a chat to your doctor or integrative medical professional before taking as blood testing may be required for specific circumstances)

- Stabilized R alpha lipoic acid: 100 mg with 8 mg of Biotin twice a day
- Chromium: 8 micrograms per kilogram per day
- Green tea (EGCG): 500 mg twice a day
- Magnesium 500 mg with vitamin B6 52100 mg twice per day
- Cinnamon: 1- 2 grams 3 times a day
- Omega- 3 fatty acids: 3 g a day in divided doses
- L-carnitine 1.5 g twice a day-best to take in the morning
- Taurine 3 g twice a day - take it towards the night, taurine can decrease blood pressure.
- Bitter Melon: 150mg, 3 times /day (can use in stir frys a couple times a week)
- Fenugreek: 1 gram, 3 times a day

High intensity interval training (HIIT)

polartrainingzone.com.au/topic/high-intensity-interval-training-hiit

High intensity interval training (HIIT)

HIIT is time effective and can also be used before strength training. It is recommended to do HIIT 2 to 3 days per week. After one session you'll be a better fat loser!

Table 15. The contributions of different energy systems to intense Exercise

Duration	% Anaerobic Glycolytic	% Aerobic Glycolytic
30 secs	60	40
60	50	50
120	35	65
60MIN	~	92
4 Hours	~	50%

Table 15. Bangsbo et al. (1990) Journal of Physiology

Relevant Studies

Talanian et al (2007) demonstrated that 7 sessions of high-intensity interval training of 10 X 4 minutes with 2 minutes rest over 2 weeks increased VO2max by 13% and whole body fat oxidation by 36%.

Burgomaster et al (2005) demonstrated that 4 - 6 x 30 seconds interval efforts with 4.5 minutes recovery, 3 days per week resulted in similar mitochondrial markers for skeletal muscle carbohydrate and lipid oxidation, with decreased whole body carbohydrate oxidation and increased whole-body lipid oxidation post training when compared to 40 - 60 minutes of continuous exercise, 5 days per week. The weekly time commitment was 1.5 hours V 4.5 hours.

Tremblay et.al 1990 demonstrated that high intensity interval training was 9 times more effective than continuous exercise at reducing subcontainers body fat levels.

How to incorporate high intensity interval training into a fat loss program

- Frequency 2 - 3 times per week
- Intensity: best pace a client can sustain for the duration of the interval
- Duration 30 seconds to 4 minutes
- Recovery: 60 seconds to 3 minutes
- Periodisation: change parameters every 6 sessions

High Intensity Sample Program (3 days per week)

Week 1-3:	8 - 10 x 30 seconds, rest 3 mins
Week 4 - 6:	8 -10 x 45 secs, rest 3 mins
Week 7 - 9:	6 -8 x 60 secs, rest 2.5 mins
Week 10 -12:	6 - 8 x 90 secs, rest 2.5 mins
Week 13 - 15:	5 - 7 x 2 mins, rest 2 mins
Week 16 - 18:	5 - 7 x 4 mins, rest 2 mins

Strength Training

polartrainingzone.com.au/topic/strength-training

- Exercise selection; exercises which recruit large muscle mass, total body workouts
- exercise order; large to small, upper body alternated with lower body
- number of sets; 30-40 total sets, 2 -5 per muscle group.
- number of repetitions: 8 -30 ~ 250 - 500 total reps (time under tension 40 -120 secs)
- rest between sets and exercises: short (10 - 60 secs)
- frequency 2 to 4 days per week

Sample Program - You will be sore

Day 1

Super sets

A1. squats back barbell, 3 x 10-12 on a 40 10 tempo, rest 30 seconds

A2. chin ups / assisted , 3 x 6 - 8 on a 5010 Tempo rest 30 seconds

B1. Dumbbell side steps, 3 x 25 on a 1010 tempo, rest 30 seconds

B2. Incline Dumbbell Press with wrist rotation, 3 x 10-12 on a 4010 tempo, rest 30 seconds

C1. low cable Chest Flys on incline bench, 3 x 8 - 10 on a 3020 tempo, rest 30 seconds

C2. Lying Dumbbell Pullover , 3 x 8 - 10 on a 2110 tempo, rest 30 seconds

D1. Seated Good Mornings, 3 x 8 - 10 on a 3030 tempo, rest 30 seconds

D2. 60 - degree hammer curls, 3 x 8 -10 on a 3020 tempo, rest 30 seconds

<u>Day 2</u>

A1. Deadlifts, 3 x 8 -10 on a 4010 tempo, rest 30 seconds

A2. Standing Dumbbell press, 3 x 10 - 12 on a 4010 tempo rest 30 seconds

B1. Leg Press, 3 x 25 - 30 on a 2010 tempo, rest 30 seconds

B2. Bent Over Row, medium - pronated grip, 3 x 10 -12 on a 4010 tempo, rest 30 secs

C1. QL muscles - Side Bends from Incline bench, 3 x 8 -10 on a 3020 tempo, rest 30 secs

C2. Close grip Bench Press, 3 x 8 -10 on a 3110 tempo, rest 30 secs

D1. Dumbbell Squats, heels elevated, 3 x 15 -20 on a 2010 tempo, rest 30 secs

D2. Reverse Grip curls on a Preacher, 3 x 8 -10 on a 3020 tempo, rest 30 secs.

Try topping and tailing. Try training 2 a day for effective fat loss.

CV - AM / CV - PM

RT - AM / CV - PM

40 min sessions with 6 hours rest

Heaviest in the morning.

Continuous Cardiovascular Training

polartrainingzone.com.au/topic/continuous-cardiovascular-training

- Current guidelines 25 - 60mins of continuous exercise on most days of week. Intensity is key
- Ross & Janssen (2001) demonstrated that you can expect about .5kg of weight loss a week with 50mins of moderate aerobic exercise per day / week.
- LSD Continuous exercise is recommended for the deconditioned and novice exercisers
- Continuous exercise is however time expensive and yields slower rates of fat loss compared to intervals and strength training and results in chronic elevations in cortisol and overuse injuries.

Recommendations: perform 40 to 60 minutes of continuous aerobic exercise at best sustainable pace 2 to 3 times per week every 6 to 8 weeks. “periodisation”

Circuit Training

polartrainingzone.com.au/topic/circuit-training

Fat Loss Circuit training for Energy Expenditure #1

1.	Chest Press	10. Lateral Raise
2.	Leg Press	11. 3 Min of Aerobic Work
3.	Incline Press	12. Triceps Extension
4.	3 Mins of Aerobic Work	13. Reverse Curls
5.	Row Pull	14. 3 mins of Aerobic Work
6.	Dumbell Fly	15. Traveling Lunge
7.	Wide Row Pull	16. Heel raise
8.	Shoulder Press	17. Step back Lunge
9.	Lat Pull	18. 6 mins of Aerobic Work

Fat Loss Circuit training for Energy Expenditure #2

1.	Chest Press	9. 3 min Aerobic work
2.	Leg Press	10. Tricep Extension
3.	3 Mins of Aerobic Work	11. Bicep Curl
4.	Row Pull	12. 3 min Aerobic work
5.	Dumbell Fly	13. Heel Raise
6.	3 min of Aerobic Work	14. Step Back
7.	Shoulder Press	15. 3 min Aerobic work
8.	Lat Pull Down	

Studies

polartrainingzone.com.au/topic/studies

This is the first longitudinal 12-week study to complete such an exhaustive analysis of PHA training, as compared to HIIT training.
Table 16 synthesizes many of the study results. Most interestingly, the improvement in maximal aerobic capacity for PHA is higher than that reported in traditional circuit training studies. The PHA concept of alternating upper and lower body exercises, performed at a medium exercise intensity (with no rest between exercises), stimulates several variables of cardiovascular function. Piras and colleagues hypothesize that PHA training appears to provide the appropriate stress for the cardiovascular system to adapt. The researchers believe that PHA training may likely have a beneficial effect on peripheral blood flow (i.e. in the arms, hands, legs and feet) during the training as well as improving cellular metabolic activity.

With PHA, the heart rate variability makers of autonomic activity (controlling heart rate) were reduced for the sympathetic modulation and increased for the vagal modulation. These results indicate a very positive response for improving cardiac control, and they were more favourable in the PHA group (as compared to the HIIT group). The baroreflex sensitivity markers showed equal improvement in the 12-week study for the PHA and HIIT training groups.

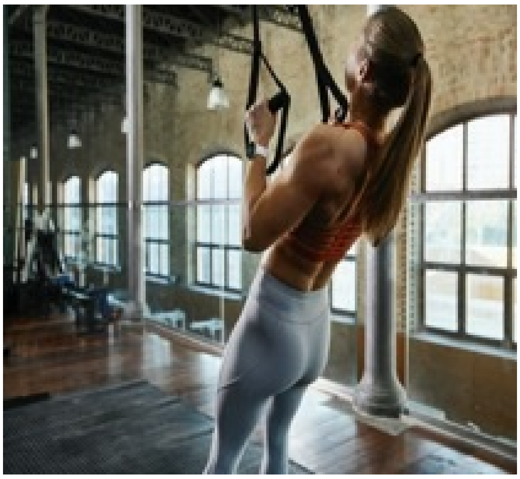
As expected, the PHA training group showed much better muscular strength improvements in the lower body and upper body musculature. Piras et al. (2015) highlight the importance of these findings may be most beneficial in the prevention or management of metabolic syndrome, obesity, sarcopenia and osteoporosis.

After 12 weeks of training, PHA training showed meaningful lower systolic blood pressure changes that were greater than the HIIT training. Piras et al. (2015) propose that PHA training should be considered as a viable option for persons with elevated blood pressure or with clinical pathology health conditions that do not allow them to train at high intensities. Piras continue that combining HIIT training with PHA may very likely even have greater benefits when it comes to reducing elevated blood pressure in persons with hypertension.

For better understanding of this study, visit:
http://www.unm.edu/~lkravitz/Article%20folder/PeripheralHeartAction.html

HIIT Revisited

How Long Does It Take for the Body to Start Improving Fat Metabolism with HIIT?



This question has been addressed in two investigations. Talania et al. (2006) examined the effect of 7 HIIT workouts over a 2-week period with eight healthy females (22 yrs. old).

Results indicated that 7 sessions of HIIT over a 2-week period resulted in marked increases in whole body and skeletal muscle capacity for fatty acid oxidation in the moderately active women.

In the second study, Jacobs et al (2013) examined the effect of 6 HIIT sessions over a 2-week period with 16 untrained males (27 yrs. old).

Results indicated that 6 sessions of HIIT over a 2-week period resulted in significant increases in skeletal muscle mitochondria (energy powerhouse of the cell), content, function and oxidative capacity.

Summary study results indicate that HIIT offers:

1. In obese, sedentary women, a 12-week HIIT program of 4-min work alternating with 3-min passive recovery attained comparable body composition and aerobic capacity results in half the amount of time it took for a continuous exercise group.
2. Meaningful benefits in reducing abdominal and total body fat in 50% of the time as compared to steady-state training programs. For time-efficiency, HIIT is a big hit!

Table 17. Percent Changes in Body Fat Parameters and VO2max of the HIIT, MICT and control groups

	HIIT Group	**MICT Group**	**Control Group**
Body Mass	-4%	**-4%**	**No Change**
% Body Fat	-6%	**-6%**	**+1%**
AVFA	-13%	**-13%**	**-4%**
ASFA	-14%	**-12%**	**+0.05%**
Vo2Max	+26%	**+25%**	**-4%**

AVFA = abdominal visceral fat; ASFA = abdominal subcutaneous fat

Peripheral Heart Action Training

polartrainingzone.com.au/topic/peripheral-heart-action-training

Peripheral heart action (PHA) training is a system of conditioning developed by Dr. Arthur Steinhaus in the 1940's (Piras et al., 2015).

The concept is to complete a resistance training type circuit keeping blood consistently circulating.

5-6 exercises are performed sequentially (and with no rest between exercises) at a medium-intensity to alternately stress the upper and lower body muscles (Piras et al.). Interestingly, despite the early introduction of PHA to the fitness world, very little investigation has been conducted to examine its effect on cardiovascular and autonomic function (branch of nervous system that controls internal organs and regulates heart rate, respiration and cardiac function). Recently, Piras and colleagues compared the cardiovascular and autonomic function effect of PHA to high intensity interval training in a young, untrained population.

Let's compare the PHA results to that of the HIIT training Group.

HIIT Training Group

- For the HIIT training, 5-min warm-up on a cycle ergometer.
- HIIT training with a 1-min high intensity work bout at the level of their maximal aerobic capacity.
- Followed by a 2-minute (no load on the cycle) recovery cycle interval.
- The work and recovery intervals were repeated 5 times with a 5-min cool-down at the end of the workout.

PHA Training Group

- 5-min warm-up & 5-min cool-down.
- The PHA consisted of 6 exercises strictly ordered in this circuit sequence: pectoralis major, leg extension, latissimus dorsi pull-down, leg curl, shoulder press and calf machine (See table 16). There was no rest between exercises.
- 15 repetitions for each exercise that was at 55-60% of their 1-repetition maximum (1-RM). Rested 1 minute at the end of each round.
- Then another circuit in the precisely same fashion until a total of 4 circuits were completed. Subjects also wore heart rate monitors during the PHA training. Heart rates were held consistently during the PHA training at 60-80% of their maximal heart rate (calculated from their maximal aerobic capacity pre-test).

Table 16: Exercises Performed in this Order

Exercise x 4 Circuits / 1 min rest after each round	Reps	Intensity

Bench Press	15	55- 60% RM
Leg Extension	15	55- 60% RM
Latissimus dorsi pull-down	15	55- 60% RM
Leg Curl	15	55- 60% RM
Shoulder Press	15	55- 60% RM
Seated Heel Raise	15	55- 60% RM

Study Results: Table 16.

Table 17

Variable	**PHA Training**	**HIIT Training**
Vo2 Max	8.0% Increase	18.7% Increase
BMI	No Change	No Change
Body Weight	No Change	No Change
Baroreflex Sensitivity	19.9 % Increase	18.2 % Increase
Systolic Blood Pressure	2.59% Lower	0.75% Lower
Diastolic blood pressure	No Change	No Change
Chest Press Strength	46% Increase	13% Increase
Shoulder Press Strength	73% Increase	1% Increase
Lattissimus Dorsi Pull-down Strength	40% Increase	6% Increase
Leg Extension Strength	30% Increase	16% Increase
Leg Curl Strength	28% Increase	13% Increase
Calf Machine Strength	23% Increase	18% Increase

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For better understanding of this study
http://www.unm.edu/~lkravitz/Article%20folder/PeripheralHeartAction.html

Studies – Part 2

Does carbohydrate mouth rinsing improve exercise performance?

The Study: Does a Carbohydrate Mouth-rinse Improve Endurance Exercise Performance? S.S. Conger et al., University of Pittsburg, Pittsburg, PA.

The idea of swishing a sports drink around in a persons' mouth (and then spitting it out) has been an endurance performance boost concept for over a decade. It is hypothesized that the carbohydrates swirling in the mouth provide a neural stimulus to the brain, which plays a central command role to enhance endurance training as well as to combat exercise fatigue. The rinsing carbohydrate training aid is particularly helpful to endurance enthusiasts who get indigestion from swallowing drinks or solids during a workout or competition. In this study the researchers did a systematic review combined with a meta-analysis to assess the efficacy of a carbohydrate mouth-rinse on endurance performance. After an extensive review of 180 studies the researchers selected 15 studies that met their strict inclusion criteria. Findings indicated that studies using a greater concentration of carbohydrate in the mouth-rinse had the best effect on improving endurance performance.

Take Home Message: Competitive endurance training clients, particularly those who have difficulty digesting foodstuffs during exercise, may realize a slight boost in endurance performance (2-3%) using a carbohydrate rinse product with greater than 6.4% carbohydrate.

How effective is battle rope training for improving cardiorespiratory and muscular fitness?

Battle rope (BR) training is a very popular modality currently being utilized in personal training and small group training programs. BR sizes typically range from 1 to 2 inches in diameters and are approximately 30 to 50 feet in length. BR workouts typically involve wrapping the single BR around a fixed anchor point. Thus, a 50 ft battle rope means the exerciser has 25 ft in each arm. Currently, very little published data exist identifying the physiological responses to this type of training.

The Study: The Energy Cost of Battle Rope Exercise J. Verdisco et al. Adelphi University, Garden City, NY

Investigators on this research team recruited 14 college students (7 males, 7 females, age=22 yrs.) to perform two different BR movements: alternating-whip (also called alternating waves) and double-whip (also called double waves) with simultaneous squats. Both BR exercises were performed at two different cadences (50 and 70 beats per minute). Each trial consisted of 10 sets of 30 seconds of work (to a metronome) followed by 60 seconds of recovery (14 minutes total trial length) using a 1.5-inch diameter 40-ft rope.

Results are summarized below:

VO2 (ml/kg/min)

1. Double-whip with Squat at 70 b/min: 27.2 ml/kg/min
2. Double-whip with Squat at 50 b/min: 22.4 ml/kg/min
3. Alternating-whip at 70 b/min: 18.3 ml/kg/min
4. Alternating-whip at 70 b/min: 16.0 ml/kg/min

Heart Rate (b/min)

1. Double-whip with Squat at 70 b/min: 164 b/min
2. Double-whip with Squat at 50 b/min: 152 b/min
3. Alternating-whip at 70 b/min: 131 b/min
4. Alternating-whip at 70 b/min: 138 b/min

Caloric Expenditure (kcals for entire trial and 5 min post exercise)

1. Double-whip with Squat at 70 b/min; 169 kcals
2. Double-whip with Squat at 50 b/min: 138 kcals
3. Alternating-whip at 70 b/min: 105 kcals
4. Alternating-whip at 70 b/min: 94 kcals

The researchers summarize that BR exercise provides a moderate energy expenditure stimulus that appears to elicit a slightly disproportionately high heart rate response due to the intense involvement of the upper body.

Take Home Message: BR training, as a component of a total body workout, provides a meaningful intervention for improving weight loss results and a moderate stimulus for cardiovascular fitness. Many more exercises with BRs can be performed and need to be quantified for their physiological and metabolic values.

Is there a best repetition training zone to optimize hypertrophy with undulating periodisation?

Two Studies:
Volume-Equated High and Low Repetition Daily Undulating Periodization Models for Lower Body C. Dolan et al., Florida Atlantic University, Boca Raton, FL.
Volume-Equated High and Low Repetition Daily Undulating Periodization Models for Upper Body Muscle Hypertrophy J. Quiles et al. Florida Atlantic University, Boca Raton, FL.

Determining the best repetition zone to optimize hypertrophy is a constant debate with personal trainers. This question has not been investigated using the popular undulating periodisation model. Researchers from Florida Atlantic University conducted two different 8-week studies (a lower body and an upper body study) on this topic. The lower body study included 13 males (age=23.14 yrs, wt= 182 lbs) while the upper body study included 15 males (age=22.9, weight=183 lbs). In both studies all subjects had a minimum of 2 yrs. resistance training experience with regular resistance training frequency of 3 day/wk. Daily undulating protocols for both studies included randomly dividing the subjects into two different groups:

1) Daily undulating periodisation HIGH repetition (DUP-HR): 12 repetitions (Mon), 10 repetitions (Wed), and 8 repetitions (Fri).
2) Daily undulating periodisation LOW repetition (DUP-LR) 6 repetitions (Mon), 4 repetitions (Wed), and 2 repetitions (Fri).

Both studies were 8 weeks in length, with the first week being a familiarisation and pre-testing week followed by weeks 2-7 of training and concluding on week 8 with a taper and post-testing. Hypertrophy was assessed pre- and post-training with measures of muscle thickness via ultrasonography (an ultrasound-based diagnostic imaging technique used for visualizing internal body structures such as muscles). In the upper body study, measurements were taken of the left chest and right chest and then summed for total chest. In the lower body study measurements were taken at the vastus lateralis and vastus medialis muscles in the left and right thigh and summed for total thigh muscle thickness. Results in the upper body study showed that both groups had significant improvements in hypertrophy with the DUP-HR increasing 10.8% and DUP-LR improving 8.9%. However, there was no difference between the groups for hypertrophy increase. Similarly, in the lower body study, the DUP-HR and DUP-LR increased muscle thickness 8.2% and 10.8%, respectively. However, no difference was observed between groups.

Take Home Message: Both studies suggest that daily undulating periodization is a very effective approach to increase hypertrophy in previously trained individuals, and not necessarily optimized to a particular repetition zone. Overall training Volume is a significant contributor to hypertrophy and strength adaptations independent of specific repetitions zones.

For further reading on this topic:
https://bayliskeystrength.files.wordpress.com/2016/08/equatedvolumefinalprintnonplus.pdf

To Burn More Fat - Burn more Calories ~ but what about the fat burning zone?

The fat burning zone! Is there such a thing? You have most likely come across this in your educational pathways of 'fitness claims' that the best type of aerobic training to burn fat is lower intensity exercise, referred to as the 'fat burning zone'. Thompson and colleagues (1998) have confirmed that at lower intensities (50% VO2max) there is a greater 'percentage' of energy from fat than at higher intensities (70% VO2max). However, at the higher training intensity the TOTAL energy expenditure (calories burnt) will be greater, and a person will almost always burn the same amount (or more) fat calories as s/he would exercising at the lower intensities, providing the workouts are the same length in time.

Dr Krvitz says another way of stating this is, the selective use of fat as fuel, such as in low intensity exercise, does not translate into greater fat loss.

To further explain this association, Dr Kravitz did a simple experiment where an 87kg physically fit male student do treadmill exercise under two conditions for 30 minutes. Trial one was at a leisurely pace at 55% of his heart rate maximum and condition two was at 85% of his heart rate maximum. Here are the results of this experiment.

%Heart Rate	Total Calories	Fat Calories	Carbohydrate Calories
55%	209.8	121.1	88.7
85%	457.1	191.3	265.8

At the higher intensity, the subject burned more total calories, more fat calories and more carbohydrate calories. Yet this student is a very fit individual. For those clients and students who are sedentary and/or perhaps at orthopedic, cardiac or health risk, high intensity exercise may be contraindicated.

For their weight loss exercise plan, lower-intensity exercise, for a progressively longer duration would be recommended.

Most people can't do 'high intensity' exercise on a daily basis due to potential overtraining and overuse concerns, perhaps the best strategy is to integrate and balance the long duration workouts with the high intensity workouts for optimal calorie (fat) burning.

Does Aerobic Exercise Actually Make You a Better 'Fat Burner'?

Reproduced from Dr L Kravitz Fat Facts UNM:
http://www.unm.edu/~lkravitz/Article%20folder/fatfacts.html

Horowitz and Klein (2000) indicate that a number of physiological and metabolic adaptations occur with cardiovascular exercise that distinctively enhance fat metabolism.

Adaptations include:
1) An increased oxygen delivery (via blood flow) and extraction system (via capilarisation) helps the cell oxidize (burn) fat more efficiently.
2) An enhanced sensitivity of muscle and fat cells to epinephrine leads to an improved release of fatty acids (disassembled triglycerides from their glycerol backbone structure) into the blood and within the muscle (where fat is in its triglyceride storage form).
3) An augmented circulatory blood flow system aids in the delivery of fatty acids to the muscle to be used as fuel.
4) An improvement in the specialized protein transporters that move the fatty acids into the muscle cell, thus making the fat more readily available for fuel.
5) An increase in the amount of fatty acids allowed to enter the muscle, which thus makes more fat available for fuel.
6) A meaningful increase in the number and size of the mitochondrion. The mitochondrion is the only place in a cell where fat is oxidized. It is the cell's 'fat burning furnace.'
7) Finally, an increase in the oxidative enzymes that 'speed up' the breakdown of fatty acids molecules to be used during aerobic exercise.

Take home message is that consistent, progressively challenging aerobic exercise will truly develop one's body to be much better 'fat burners.

Where Does Resistance Training Factor Into this Fat Burning Debate?

Research by Bryner and colleagues (1999) has demonstrated that one of the most important benefits of resistance exercise in a weight loss program is the preservation of muscle mass, even on very low-calorie diets. In addition, Andrew Hill has shown that diet only programs can lower a person's resting metabolic rate (RMR) by 20% (which may be approximately 300 less calories expended per day). Bryner's research demonstrated that resistance training is one of the best protective interventions to maintain the RMR during a caloric restrictive weight loss program.

Fat Burning Summary Solution
It may be very gratifying for your clients to know that with consistent endurance exercise they truly will develop better 'fat burning' furnaces (mitochondria) in their bodies as we take advantage of our athletic and participational abilities !

Try to always focus workout designs on burning the MOST calories possible with the exercise plan––record it, use the Polar Beat free Ap, provide variety, whether it be harder, longer or a combination of both types of aerobic workouts. Additionally, among the many benefits of resistance training is the fact that it helps to preserve the body's muscle mass and resting metabolic rate in caloric restrictive states. Lastly, remember to exclaim to your client "To burn more fat, burn more calories."

Side Bar 1. How many Calories are Really in a Pound of Fat?
One pound of fat is 3, 500 calories. However, one gram of fat is equivalent to 9 calories. Therefore, multiplying 9 calories/gram x 454 grams = 4,086 calories. Why the difference? Fat stored in adipocytes (fat cells) contains minerals, water and small amounts of protein, reducing the caloric content of one pound of body fat to roughly 3,500 calories.

Side Bar 2. Why is Carbohydrate the Preferred Energy Fuel of Exercise?
From a caloric standpoint it seems that fat (at 9 calories/gram) should be a much better source of fuel for exercise than carbohydrate (at 4 calories/gram). However, carbohydrate is the most important fuel source for exercise. It is the only fuel source used proficiently in anaerobic and aerobic exercise. As well, there are two major reasons the body prefers carbohydrate to fat during endurance exercise. First and most prominently, the metabolic pathways of carbohydrate breakdown (glycolysis) are much more efficient than those for fat (mobilization, lipolysis, and beta oxidation). Second, more oxygen is required to oxidize (burn) fat. The energy yield of fat from one litre of oxygen is 4.69 calories as compared to the yield of 5.05 calories from carbohydrate. Thus, carbohydrate is approximately 7% more efficient fuel than fat.

Side Bar 3. Does EPOC the Exercise 'After-burn' Help Burn Fat?
The exercise after-burn, or EPOC (excess post-exercise oxygen consumption), is the number of calories expended above resting values after a workout. Although intensity

dependent, both aerobic and resistance training programs may elicit an EPOC from 65-150 (primarily fat) calories post workout. Many fitness professionals suggest that since one pound of fat is equal to 3,500 calories, EPOC is an insignificant factor in the fat burning process. However, let's do the math…if someone exercises 5 days/week, over the course of the year EPOC would be calculated as follows: 5 workouts/week x 52 weeks x 100 EPOC calories/ workout totally 26,000 calories or 7 lbs or 3.2kgs of fat––that's meaningful!

The Rise of CrossFit®

CrossFit® CULTURE IS STRONG.. There is now even a CrossFit® Games.

The CrossFit® community is loyal and has provided a wonderful opportunity to train and compete in yet another way.

Let's have a look a little more closely at CrossFit® with the presentation of these two articles.

CrossFit could be defined as training that incorporates both aerobic and anaerobic elements, which in turn improve cardiovascular fitness, anaerobic capacity, and body mass and composition (e.g., reduction in body fat, BMI, waist circumference) of individuals of all levels of fitness. CrossFit exercises are considered to be of moderate to high intensity, which can lead to moderate to high HRmax scores (53.5–95%) , high RPE scores (7.3/10–19/20), increased blood lactate (mean values 1.2 to > 10mmol− 1) and increased %VO2max (mean values 56.7–66.2%). CrossFit training can also have psychological and motivational benefits on athletes and individuals, such as exercise enjoyment, challenge, satisfaction, and goals achievement, which can lead to high levels of retention and adherence of participants to CrossFit programs. *Gianzina and Kassotaki (2019)*

CrossFit®-based exercise may result in greater aerobic energy expenditure than traditional exercise

CrossFit® V’s Treadmill Running:

Based on a study conducted by Brisebois, Matthew F.; Biggerstaff, Kyle D.; and Nichols, David L. (2016)
Each workout consisted of a 5 min warm-up (light aerobic exercise and stretching), resistance exercise (both focused on leg exercises), cardiorespiratory exercise (a treadmill run for the traditional exercise and circuit training for the CrossFit®-based exercise) and 5 min cool-down (walking). The cool-down was followed by 10 min of sitting to record recovery values. During each workout the participants wore a K4b2 Cosmed unit to measure energy expenditure and VO2, and a Polar heart rate monitor to measure heart rate. Each measure was compared using a Dependent t-Test. Energy expenditure (468 ± 116 vs. 431 ± 96 kcal, p<0.001), peak heart rate (189 ± 8 vs. 172 ± 8 bpm, p<0.001), peak VO2 (3.22 ± 0.73 vs. 2.81 ± 0.63 L/min, p<0.001) and average 15 min recovery VO2 (0.89 ± 0.24 vs. 0.78 ± 0.18 L/min, p<0.001) were significantly greater in the CrossFit®-based workout. The present study suggests that CrossFit®-based exercise may result in greater aerobic energy expenditure than traditional exercise.

For better understanding of this study refer to: "Energy Expenditure In Traditional and CrossFit exercise" by Matthew F. Brisebois, Kyle D. Biggerstaff et al.
https://journal.crossfit.com/article/vo2-max-effort-lift-2
https://journal.crossfit.com/article/vo2-max-effort-lift-2

A study published article in the Sport Sciences for health by Elina A.Gianzina and OlgaA.Kassotaki (2019) found that CrossFit training improves the six out of ten general physical skills of athletes, which are cardiovascular/respiratory endurance, stamina, strength, flexibility, power and balance, whereas the other four physical skills, such as speed, coordination, agility, and accuracy, are yet to be verified. It's worth noting that CrossFit training also includes risks and may cause injuries to athletes. With the review revealing that CrossFit may lead to multiple musculoskeletal injuries occurring in different body parts, with most common being shoulder, lower back and knee injuries, as well as other more severe but less common injuries.

CrossFit training can change brain-derived neurotrophic factor (BDNF) and irisin levels at rest and if it can improve aerobic capacity and body composition.

The findings of this study indicate that intense CrossFit training improves the six out of ten general physical skills of athletes, as proposed by CrossFit Inc., such as cardiovascular/respiratory endurance, stamina, strength, flexibility, power and balance. The other four physical skills, such as speed, coordination, agility, and accuracy, are yet to be verified.

Something to consider: Gianzina and Kassotaki (2019) summarise

In practice, CrossFit athletes and especially novice, untrained individuals should be in close cooperation with experienced coaches, so that the exercises are correctly executed, the movements are controlled, the load is low, and thus the risks of injuries are diminished, as some of the exercises demand not only the appropriate technique, but also considerable skill, balance, and strength (e.g., kettlebells, suspended rings, or hand-stand push-ups). Accordingly, elite athletes should adhere to individualized training methods with clearly defined objectives, periodicity in training with rest periods, while hydrating at regular intervals and implementing a proper nutrition protocol to avoid severe homeostatic imbalances.

For better understanding of the Gianzina and Kassotaki (2019) study refer to: https://link.springer.com/epdf/10.1007/s11332-018-0521-7?author_access_token=s00ZbWgRNvoO7qgH2wXJHPe4RwlQNchNByi7wbcMAY7TcMKJRV1lhfkf9U1W0QfAf49S6b0v-91-1JKWe8YaIL7id22XYmKhlP0XA9NXAQzGXM4Y4dHY-_ut6LJsEONPteUVOAGI0WdmhA4uxo4sjw%3D%3D

For better understanding of the physiological differences of different individuals refer to Physiological Differences Between Advanced CrossFit Athletes, Recreational CrossFit Participants, and Physically-Active Adults

Exercise and the Body's Immune System

polartrainingzone.com.au/topic/introduction-3

Does exercise improve your immune system?

Immune and lymphatic system health is essential for protecting our body from germs and diseases. They are our body's first line of defence. "The lymphatic system produces and carries white blood cells containing antibodies that fight off infection and transports and destroys dead or damaged cells and cancer cells, removing these substances from the blood stream." That previous sentence is fraught with misconception namely the idea that it produces anything and that there is some active force removing things from the blood stream?? The lymphatics is a component of the circulatory system and houses components of the immune system in what are called lymph nodes. Within these nodes exist B cells and T cells which are basically waiting out for some pathogen to arrive via the lymph (lymph is the remainder of the extracellular fluid that isn't reabsorbed via the venous capillaries – so it is basically plasma but filled with particles that are either too big to fit back into capillaries such as bacteria or cell components that need to be phagocytosed). The B cells were actually produced in the bone marrow with all the rest of the blood cells (white and red) whilst the T cells originated in the Thymus. Both of these cell lines migrated to lymph nodes and colonised them during early infant, child development. (Kilby 2020)

The white blood cells, specifically plasma cells produce antibodies in response to antigen presentation from a pathogen. T cells and Natural killer cells are responsible for destroying cancer cells and other abnormal cells. Macrophages clean up debris, kinda like the vacuum cleaner of the immune system. (Kilby 2020)

So perhaps we could summarise by saying "The lymphatic system drains excess extracellular fluid, which passes through important structures called lymph nodes that house B cells and T cells, the main players in the adaptive immune system that carry out important functions such as identification of pathogens for destruction and the production of antibodies that allow the body to defend itself from would be invaders." (Kilby 2020)

Just for fun: Check these out:

What then are the benefits of exercise, if any, with regard to boosting the human body's immune system? In the context of the Covid-19 outbreak, this question has gained urgency and also, thanks to recent research, emergent answers.

Hypothesis: The latest science suggests that being fit does in fact boosts the body's immune systems, and that even a single workout can strengthen and improve our ability to fight off germs.

This chapter will address the following:

- Does exercise improve the Immune system? If So how?
- What is the best intensity level of exercise to boost the immune system?
- What exercise if any decreases the immune system to fight infection?

Does exercise improve the Immune system

Epidemiological evidence suggests that regular physical activity reduces the incidence of many chronic diseases in older age, including communicable diseases such as viral and bacterial infections, as well as non-communicable diseases such as cancer and chronic inflammatory disorders. (Campbell & Turner, 2018). Other research by (Nieman and Wentz, 2016) support these findings, suggesting that acute exercise (moderate-to-vigorous intensity, less than 60 min) improves the antipathogen activity of tissue.

How does exercise improve the immune system?

It is noted that this is such a complex space and exercise comes in so many different expressions it is hard for science to deliver concrete answers. However can generically agree that overall exercise done within the limits of the athlete is good for immune function and overall health.

Exercise promotes positive changes within the body. Listed below are some of the changes:

- decreased levels of inflammatory biomarkers in adults with higher levels of physical activity and fitness
- there is a circulation surge in cells with each exercise bout and the anti-inflammatory and antioxidant effect of exercise training have a summation effect over time in modulating tumorigenesis, atherosclerosis, and other disease processes.
- Recent studies indicate that exercise and physical fitness diversifies the gut microbiota, but more human research is needed to determine potential linkages to immune function in physically fit individuals and athletes. (Campbell & Turner, 2018).
- it is now widely proposed that exercise redeploys immune cells to peripheral tissues where they are thought to identify and eradicate other cells infected with pathogens, or those that have become damaged or malignant.
- habitual exercise improves immune regulation, delaying the onset of age-related dysfunction. (Nieman & Wentz 2019).
- Each bout of moderate physical activity promotes immune responses and improved but transient immunosurveillance and, when repeated on a regular basis, confers multiple health benefits including decreased illness incidence and dampened systemic inflammation.

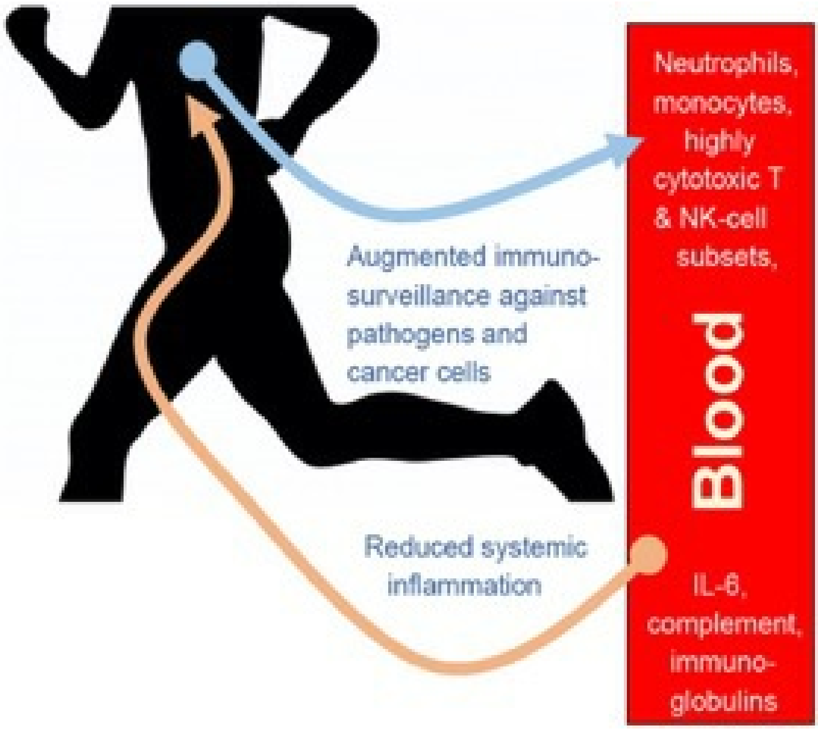


Fig. 1 . Acute exercise stimulates the interchanging of innate immune system cells and components between lymph tissues and the blood compartment. Although transient, a summation effect occurs over time, with improved immunosurveillance against pathogens and cancer cells and decreased systemic inflammation.
Nieman and Wentz (2019)

What is the best intensity level of exercise to boost the immune system and what exercise if any decreases the immune system to fight infection?

Acute exercise (moderate-to-vigorous intensity, less than 60 min) is now viewed as an important immune system adjuvant to stimulate the ongoing exchange of distinct and highly active immune cell subtypes between the circulation and tissues.

In contrast, high exercise training workloads, competition events, and the associated physiological, metabolic, and psychological stress are linked with transient immune perturbations, inflammation, oxidative stress, muscle damage, and increased illness

Researchers have found a link between moderate regular exercise and reduced frequency of Upper respiratory tract infections (URTIs). Recent research concluded that participating in 1-2 hours of moderate exercise per day was associated with a one third reduction in the risk of getting a URTI compared with individuals that had an inactive lifestyle (Nieman et al. 2011).

Other studies have reported a 2 to 6-fold increase in risk in developing an URTI in the weeks following marathon (42.2 km) and ultra-marathon (90 km) races. This is due, in part, to increased levels of stress hormones like adrenaline and cortisol that suppress white blood cell functions.

After strenuous exercise, athletes enter a brief period of time in which they experience weakened immune resistance and are more susceptible to viral and bacterial infections, in particular URTIs. Post-exercise immune function depression is most pronounced when the exercise is continuous, prolonged (>90 minutes), of moderate to high intensity (55-75% of aerobic capacity), and performed without food intake (Gleeson et al. 2013).

Figure 2 below illustrates the relationship between the exercise workload continuum and risk for a URTI. Other factors such as travel, pathogen exposure, sleep disruption, mental stress, and diet may influence this relationship.

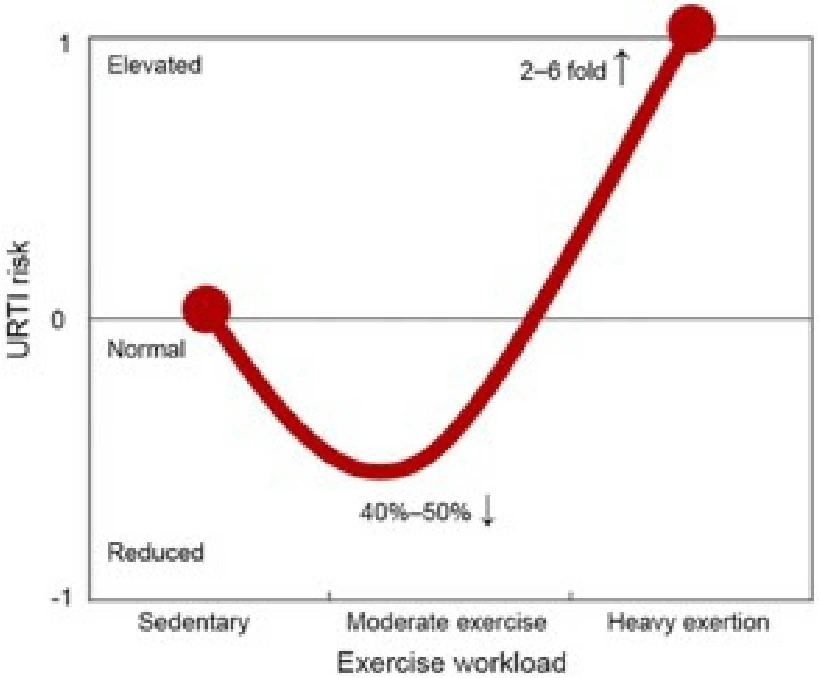
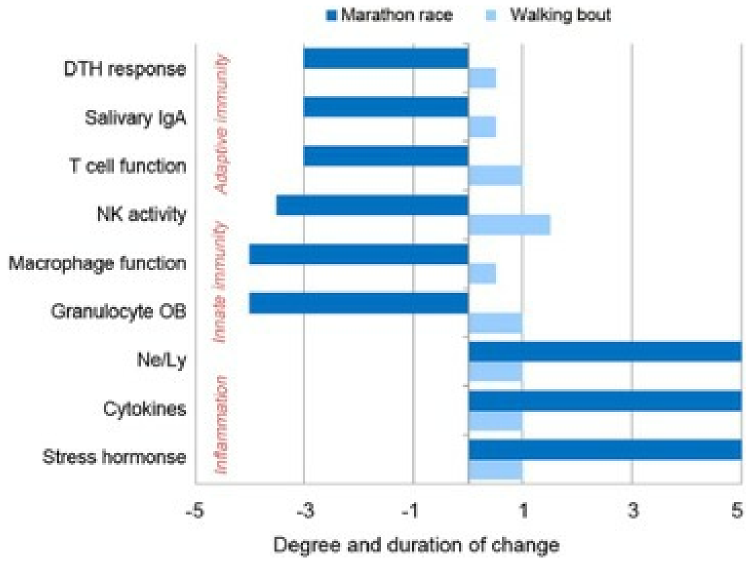


Figure 2 Research on the relationship between moderate exercise and illness.

There is growing evidence to suggest that high exercise training workloads, competition events, and the associated physiological, metabolic, and psychological stress are linked with transient immune perturbations (dysfunction), inflammation, oxidative stress, muscle damage.

Refer to Figure 3 below.

Figure 3. The contrast in acute immune responses to heavy exertion (e.g., a marathon race) and a 30- to 45-min walking bout. DTH = delayed-type hypersensitivity; IgA = immunoglobulin A; Ne/Ly = neutrophil/lymphocyte ratio; NK = natural killer; OB = oxidative burst.



So, what should a personal trainer do?

- Develop a detailed, individualized training and competition plan that also provides for sufficient recovery using sleep, nutrition, hydration, and psychological strategies.
- It is therefore recommended to use small increments when changing the training load (typically less than 10% weekly).
- Develop a competition event calendar that is based on the health of the athlete.
- Monitor for early signs and symptoms of over-reaching, overtraining, and illness.
- Avoid intensive training when ill or experiencing the early signs and symptoms of illness (which can make the illness more severe and prolonged).
- Develop Hygienic, Lifestyle, Nutritional and behavioural strategies
- Minimize pathogen exposure by avoiding close contact with infected individuals in crowded, enclosed spaces, and not sharing drinking or eating implements. Avoid exercise sessions in poorly ventilated clubs and gymnasium facilities. The medical staff should isolate infected athletes.
- Limit hand-to-face contact (i.e., self-inoculation) and wash hands regularly and effectively. The medical staff should educate the athletes to minimize pathogen spread to others (e.g., sneezing and coughing into the crook of the elbow).
- Follow other hygienic practices to limit all types of infections including safe sex and the do not wear open footwear when using public facilities to limit skin infections, using insect repellents and covering the arms and legs with clothing at dawn or dusk.
- Maintain vaccines needed for home and foreign travel, with a focus on annual influenza vaccination.
- Follow strategies that facilitate regular, high-quality sleep.
- Avoid excessive alcohol intake.

- Consume a well-balanced diet with sufficient energy to maintain a healthy weight, with a focus on grains, fruits, and vegetables to provide sufficient carbohydrate and polyphenols that reduce exercise-induced inflammation and improve viral protection.
- Stress, Anxiety and Depression. Being stressed out, trait anxious and depressed can be associated with acute and chronic of being unwell. Psychologists in the field of "psychoneuroimmunology" have shown that state of mind affects one's state of health. Segerstrom and Miller (2004) Seek help.
  Stress Weakens the Immune System (2006).

Conclusion

Campbell and Turner (2016) conclude the contemporary evidence from epidemiological studies shows that leading a physically active lifestyle reduces the incidence of communicable (e.g., bacterial and viral infections) and non-communicable diseases (e.g., cancer), implying that immune competency is enhanced by regular exercise bouts.

However, to this day, research practice, academic teaching, and even physical activity promotion and prescription continues to consider a prevailing myth that exercise can temporarily suppress immune function which is not “intensive”.

Evidence showing us the “moderate exercise” has a positive influence on the immune system epidemiologically. Let alone the physiological positive impacts is has on us allowing us the opportunity to improve our mental health - feel better about our achievements, progressions, competence, self-concepts and self-efficacy.

We have critically reviewed related evidence, and conclude that regular physical activity and frequent exercise are beneficial, or at the very least, are not detrimental to immunological health.

Campbell and Turner (2016) also show evidence that regular physical activity and frequent exercise might limit or delay immunological aging.

Therefore our Hypothesis based on the evidence provided and data available has proved that the latest science suggests that being fit does in fact boost the body’s immune systems, and that even a single workout can strengthen and improve our ability to fight off germs!

Footnote

Physical activity” refers to activities undertaken during leisure time, at home, as part of employment, or for transport purposes. “Exercise” is a component of physical activity within the leisure time domain and refers to physical activities that are planned, structured, repetitive, and undertaken for the purpose of improving or maintaining components of physical fitness and/or sporting performance. When individuals are referred to as being “active” or “inactive,” the description infers that these people undertake (or fail to undertake) a defined level of exercise or physical activity (e.g., age-specific physical activity recommendations, such as those published by the World Health Organisation). In this review, the term “exercise” will generally be used to describe the effects that active behaviours have on immune competency. Individuals described as being “sedentary” accumulate prolonged periods of behaviour eliciting low energy expenditure (e.g. sitting and lying. (Campbell & Turner, 2018)

To further develop your understanding on the immune system and exercise consider reading:
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5911985/
https://www.apa.org/research/action/immune
https://www.apa.org/research/action/immune
https://www.ncbi.nlm.nih.gov/pubmed/15250815
https://www.ncbi.nlm.nih.gov/pubmed/9129266

Summary

polartrainingzone.com.au/lessons/summary

Well Done! You Did it! You have completed the Polar Training Zone Specialised Course.

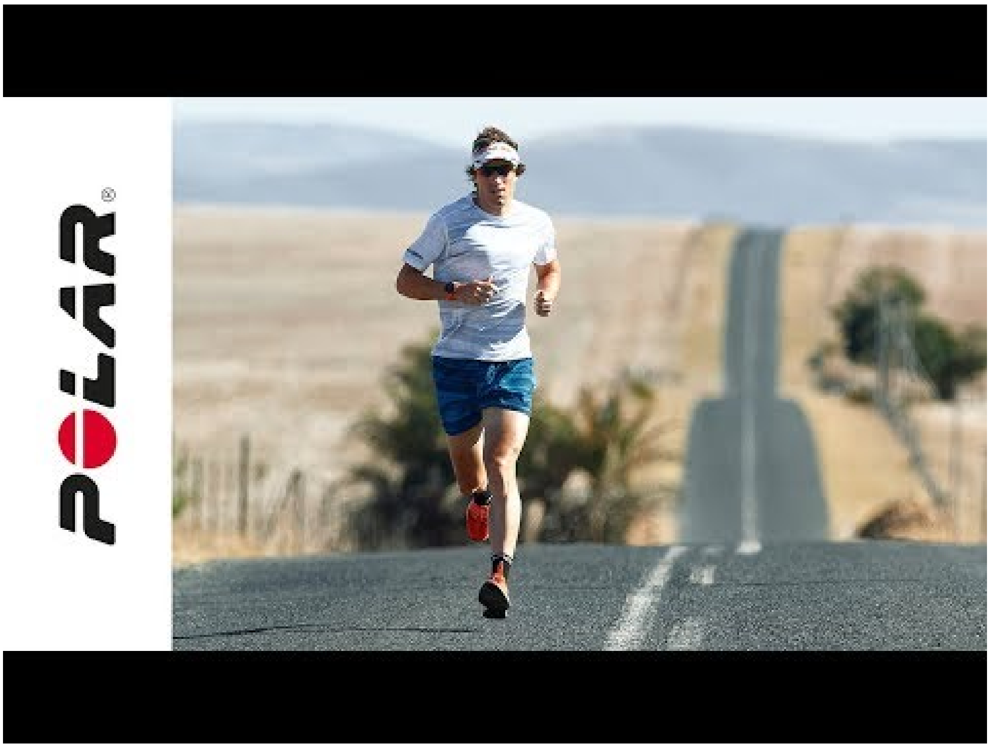
Congratulations!

We hope we have presented you with world class unbiased research which has motivated you to strive and achieve your own definitions of fitness, develop further understanding around your specificity, goals, training and apply this education for performance successes.

There is a lot of information out there. Do your research, plan, seek feedback and judge its suitability to your training, the goal and the athlete or client.

If you follow a process you will ensure success.

Make every beat count.



Watch Video At: https://youtu.be/P8B1Il8lls8

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