Physiology Team Notes 3

Musculoskeletal Block

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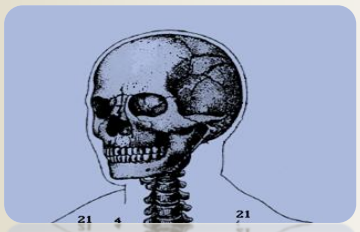

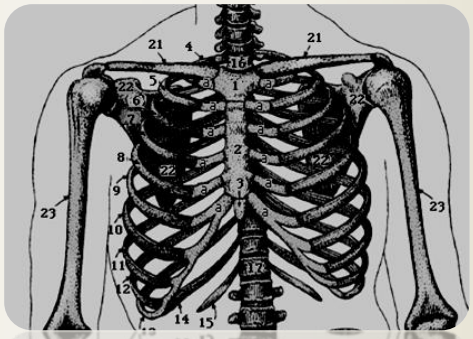

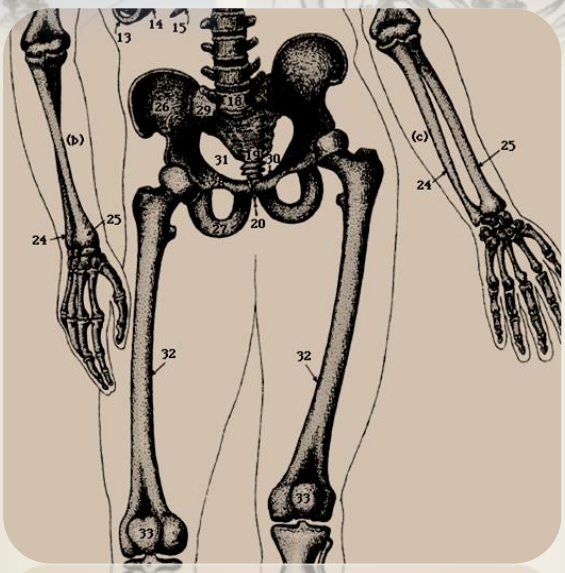

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Student Guide:

1- **The main Source of information here is the slides that was provided by the Doctors.**
2- **Everything written in Pink is from female slides**
3- **These notes for two lectures :-**
    - **Effects of training on muscle performance**
    - **Physical and Psychological Factors affecting Athletic Muscular Performance.**

4- **Anything written in Brown Square is an addition by the team.**

Example : Team Additions

Effects Of Trainings On Muscle Performance

Aerobic versus Anaerobic Exercise

Aerobic exercise

is performed :

(1) at a **moderate** level of intensity &

(2) over a relatively **long period** of time.

For example, running a long distance at a moderate pace is an aerobic exercise (but sprinting is not) , bicycling .

Anaerobic exercise

is exercise intense enough to trigger **anaerobic metabolism.**

It is used by athletes to promote strength, speed and power

and by bodybuilders to build muscle mass.

- Muscles develops differently from the case of aerobic exercise Leading to greater performance in short duration, high intensity activities, which last from mere seconds up to about 2 minutes.
- Any activity after about two minutes will have a large aerobic metabolic component.

Benefits of Exercise Training:

When properly performed, strength training can provide significant functional benefits and improvement in overall health and well-being, **including:**

- Improves motor skills.
- Increased bone density & prevention of osteoporosis .

by increase activity of **osteoblast** and deposition of Ca.(density)

- Improved joint function .
- Increased strength of muscles, tendons and ligaments .

- **These help to** improve posture, provide better support for joints & thereby to reduce the risk of falls & injury during everyday life activities.
- **Therefore** the potential for injury is reduced.

- Regular exercise increases metabolism and **promotes fat loss**.
- Elevates HDL (good, beneficial) cholesterol.
- Improves respiratory function.
- Improves cardiovascular function, & prevents or delays development of atherosclerosis.
- Prevents or delays development of diabetes.
- By increasing the levels of dopamine, serotonin and norepinephrine, intense exercise is believed to help **improve mood** and counter feelings of depression .

- **For all the above reasons** , properly performed physical exercise is considered beneficial because it produces improvement for overall health and well-being .

Intense workouts elevate metabolism for **several hours** following the workout, which also **promotes fat loss**.

- The **body's basal metabolic rate** increases **with increases in muscle mass** which promotes long-term fat loss and helps dieters avoid **yo-yo dieting**.

Yo-Yo Dieting: Unsuccessful weight loss, the person cannot lose weight continuously, he loses some weight then gain that weight again.

- **Weight training** also provides functional benefits. As stronger muscles improve posture, provide better support for joints, and reduce the risk of injury from everyday activities.

Weight Training: strength training for developing the strength and size of skeletal muscles. It uses the weight force of gravity**. Very good for Body shaping.**

Older people who take up weight training can **prevent some of the loss of muscle** tissue that normally accompanies aging and even regain some functional strength and by doing so become Less frail . They may be able to avoid some types of physical disability.
Weight-bearing exercise also helps to prevent **osteoporosis**.

- The ability of the body to resist the stresses that can result from an injury can be **increased by obtaining a greater amount of strength**. That is true in the athletic world and it has its advantages in performing everyday activities, such as lifting or carrying objects.

Q: What is Strength Training?

Strength training: is the use of **resistance to muscular contraction** to build the strength , anaerobic endurance and size of muscle.

There are many different methods of strength training, the most common being the use of gravity or elastic hydraulic forces to oppose muscle contraction.

Muscle Hypertrophy

Muscle hypertrophy: is the increase of the **size** of muscle cells.
It differs from muscle **hyperplasia**, which is the formation of **new muscle cells**.

Types of Hypertrophy :

There are **two** different types of muscular hypertrophy:

1-Sarcoplasmic Hypertrophy:

The **volume of Sarcoplasmic fluid** in the muscle cell increases with **No** accompanying increase in muscular strength.
Sarcoplasmic hypertrophy is characteristic of the muscles of body builders.

2-Myofibrillar Hypertrophy:

actin and myosin concentration increase in number and add to **muscular strength**, as well as a small increase in the size of the muscle.

- Myofibrillar hypertrophy is characteristic of the muscles of **weight lifters**.

In Myofibrillar hypertrophy: The muscle fiber increase in size (no increase in muscle fiber number) due the increase of contractile proteins number that found inside the muscle fiber. There is an increase in the muscular strength.

Muscle Hypertrophy & Protein Synthesis

Progressive overload: is considered the **most important principle** behind **hypertrophy**, so increasing the weight, repetitions , and sets will all have a positive impact on growth.

- The first measurable effect is an increase in the **neural drive** stimulating muscle contraction.

Progressive load: means start training with gradual increase in weights , For Example start with 1 Kg then 3 Kg , 10 kg and so on to prevent muscle tear.

Neural drive: increase number of nerve impulses that arrives to the muscle .More than one motor units work together to enhance the muscle contraction.

- As the muscle continues to receive increased demands, the protein synthetic machinery is upregulated.
- This upregulation appears to begin with the second messenger system (including phospholipases, protein kinaseC, tyrosine kinase, and others.

Repeated exercise increases the number of **contractile proteins** (actin & **myosin** filaments) within each muscle fiber.

- When number of contractile proteins increases sufficiently, myofibrils **split** within each muscle fiber > to form **new** myofibrils > increase in the number of additional myofibrils > **hypertrophy**.

Because skeletal muscle cells are unique in being multinucleate , the number of nuclei can also increase.

Microtrauma during training

Microtrauma: which is **tiny damage** to the **fibers** may play a significant role in hypertrophy

When microtrauma occurs (from weight training or other strenuous activities), the body responds by **overcompensating**, replacing the damaged tissue and adding more. So that the risk of repeated damage is reduced.

Overcompensating: when a tiny damage happens to the muscle fiber. It is useful because it induces body to increase protein synthesis to repair the damaged muscle fiber, but this step doesn't only repair the muscle fiber. protein synthesis increased to strength the whole muscle as well.

Progressive overload is essential for continued improvement, as the body adapts and becomes more resistant to stress**. (No pain No gain).**

Factors Affecting Hypertrophy

(1)Age:

During puberty , in males particularly ,hypertrophy occurs at **an increased rate**. Natural hypertrophy normally stops at full growth in **the late teens**.

Puberty is the best period for training in males because testosterone is released, in males particularly.

(2) Exercise:

- Strength training, **short** duration, **high** intensity anaerobic exercises considerably **increases hypertrophy**.
- **Lower** intensity , **longer** duration aerobic exercise generally does **Not** result in very effective hypertrophy .

(3) Dietary protein : An adequate supply of **amino acids** is essential to produce muscle hypertrophy.

(4)Cortisol: decreases amino acid uptake by muscle tissue, and **inhibits** protein synthesis > prevents hypertrophy.

(5) Testosterone is one of the body's major growth hormones > promotes anabolism > consequently promotes hypertrophy.
That is why exercising males can grow bigger muscles more easily and much faster than exercising women.

- **Therefore** , in during sport competition events, testosterone is prohibited, because it is considered a performance-enhancing anabolic drug that interfers with fair & just competition.

Aerobic & Anaerobic Training

• Each muscle is composed of combination of **2 types** of muscle fibers.
but one is usually dominant.

(1) Anaerobic Fast-twitch (white , mostly glycolytic) fibers

- Have **lower capillarity**& few mitochondria because oxidative metabolism is of secondary importance.
- Are **deficient in myoglobin** & capable of anaerobic metabolism
- Are larger in size for strong & powerful contraction.
- Have **extensive sarcoplasmic reticulum** for rapid release of calcium.
- Have many **glycolytic enzymes** for rapid release of energy.
- Anaerobic fibers uses its fuel faster than the blood and intracellular restorative cycles can resupply it & the muscle fail (fatigues) fast& more easily than slow-twitch.

(2) Aerobic, Slow-twich (red) fibers

- rich in capillaries and **myoglobin** , which binds oxygen , and gives the muscle as a whole its red color . These fibers rely on
- Aerobic metabolism .
- Have **higher capillarity** & large number of mitochondria to support high level of oxidative metabolism.
- Have smaller fibers & innervated with small nerve fibers.
- Fibers are adapted for prolonged muscle activity and do **Not** fatigue quickly .

Hypertrophy occur in **an**aerobic exercise better than aerobic exercise

– **When** the goal of the exercising person is lifting heavier weights > anaerobic strength training will produces hypertrophy + increased muscle.

– **When** the goal of the exercising person is not merely lifting heavier weights , but another goal such as body shaping > aerobic exercise , and lower weights can be used , if desired.

– **At higher loads**, the muscle will recruit all muscle fibres possible, both anaerobic ("fast-twitch") and aerobic ("slow-twitch"), in order to generate the most force.

– **However,** at **maximum load**, the anaerobic fibers contract so forcefully that the aerobic fibers are **completely shut out**, and all work is done by the **an**aerobic processes.

– **In the aerobic regime**, the blood and intracellular processes can maintain a supply of fuel and oxygen, and continual repetition of the motion will not cause the muscle to fail (fatigue) easily

Nutrition & Training

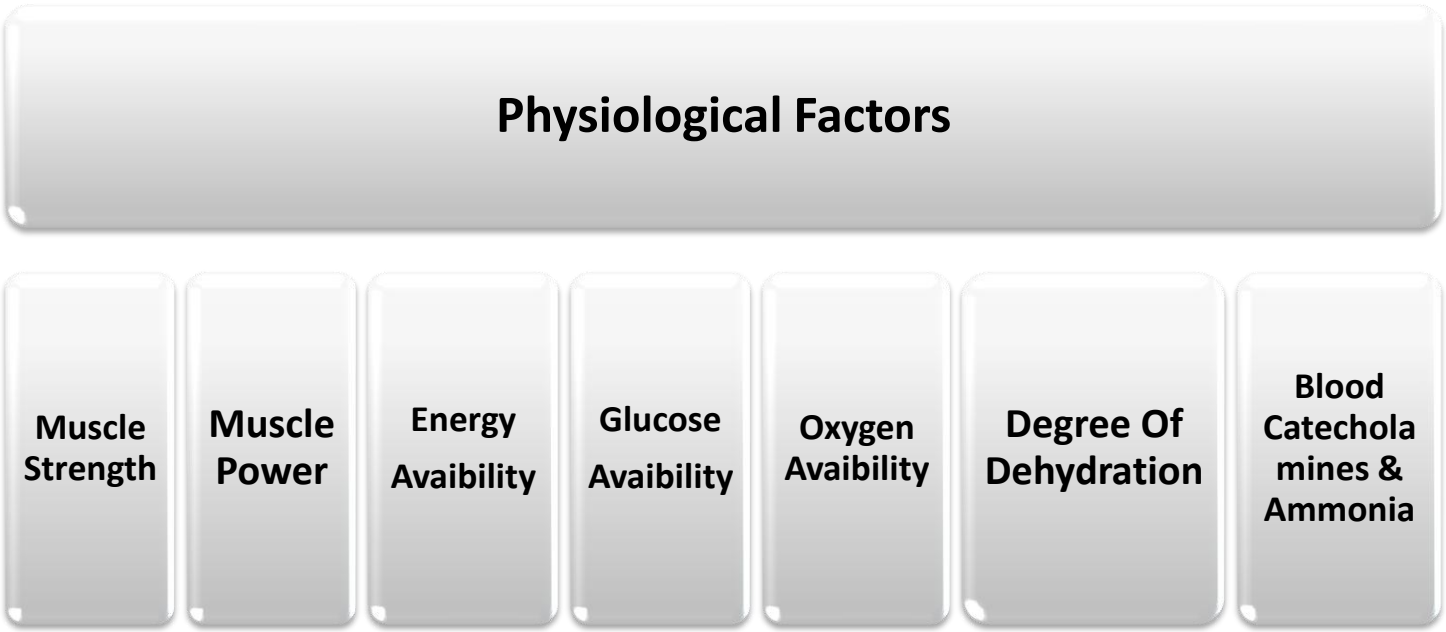
- **Muscular training** must be matched by **good diet Adequate proteins** > for building skeletal muscle .

- **High-protein** diet does **Not** impair kidney function, unless the person has pre-existing kidney diseases .

- An adequate supply of **carbohydrates** (5-7g per kg) is also needed as a source of energy and for the body to restore glycogen levels in muscles.

- Water is consumed **throughout** the course of the workout **to prevent** poor performance due to **dehydration** .

Physical And Psychological Factors Affecting Athletic Muscular Performance



Muscle Strength

Muscle strength has mechanical & neural components:

(1) Mechanical strength : the maximum force a muscle can exert.
This depends upon the muscle cross-sectional area.

- So if after a period of training, an athlete increases his muscle size by **50 %,** he will also increase the force the muscle can develop by **50%**.

There is **proportional relationship** between the **cross section** of the muscle and the **Strength** of the muscle,(Increasing the cross section of the muscle by **myofibril hypertrophy**)

(3) **Neurological strength** : meaning how many of the AHC motor neurons supplying that muscle are recruited + frequency of action potentials in them.

- In **diseases involving the AHCs** (e.g., poliomyelitis , MND) the number of active AHCs may be considerably reduced.

Poliomyelitis (شلل الأطفال)
MND: **M**otor **N**euron **D**iseases (group of **neurological** disorders that selectively affect motor neurons)

- A severely **depressed person** (or athlete) , who lost his motivation , may, unconsciously , recruit less AHCs than normal > decreased Performance.

Exercising help to use **more** AHCs (Anterior horn cells) that innervates the muscle.
= More AHCs recruited (used) by exercise = more **Electrical impulses**= stronger contraction.

Muscle Power

When muscles contract or stretch in moving a load they do work , and energy is **transferred from one form to another.**

Energy is transferred from one form to another , what are they**?**

From **Electrical Form** (Electrical Impulses) to **Mechanical Form** (Mechanical work)

- The **" power "** of muscles refers to how quickly the muscles can do this work and transfer the energy.

Work = Force X Distance

Power = Work / Time

- The **shorter** the time used to perform a piece of work , the **more** power is needed.
- Hence , if a weightlifter lifts a given weight explosively over a **short** time (say 0.5 seconds) he needs his muscles to produce **much more** power than if he did that while taking more time.

Note that there is a difference between **Muscle power** and **Muscle strength**:

- **Muscle Strength:** The maximum force the exerted by the muscle.
- **Muscle Power:** How quickly muscle can do a work and transfer energy in certain time. (related to time , If you do a work in a short time , so you need more power)

Energy Availability

When humans utilize energy to perform muscular exercise , the energy is expended to: **(1) doing work** , & **(2) generating heat** .

- For short-term , intense exercise e.g., when the person is jumping up from a squatting position , energy expenditure can be much more than for long- term exercise .

Energy Sources:

(1) Energy needed to perform short-lasting, high-intensity bursts of activity is derived from anaerobic sources within the cell , whereas

(2) Longer –lasting , less intense exercise (Aerobic Exercise) utilizes oxygen & depends on aerobic respiration.

The quick energy sources consist of the :

(1) Phosphocreatine system .

(2) Glycolysis , &

(3) Adenylate Kinase

- **The most rapid source,** but the most readily depleted of the above sources is the **Phosphocreatine** .

Glucose Availability

Plasma glucose is maintained by an **equal rate of glucose appearance** (entry into the blood) and **glucose disposal** (removal from the blood).

- In the healthy individual, rate of appearance and disposal are essentially **equal** during exercise of moderate intensity and duration.

- However, prolonged , intense exercise can result in a fall in blood glucose level and the onset of fatigue .

- During exercise , rate of glucose appearance depends mainly on the liver (**glycogenloysis & gluconeogenesis**) , and to a lesser extent , on absorption from the gut .

Oxygen Availability

Which depends upon :
(1) cardiac output (the quantity of blood distributed by the heart) ,
(2) the ability of the lung **to oxygenate** the blood ,
(3) arterio-venous (a-v) oxygen **difference** (i.e., the ability of the exercising muscle to take up oxygen from blood).

Degree of Hydration

- Intense prolonged exercise produces metabolic waste heat . The heat is removed by sweating which , if intense , may cause dehydration .

- A male marathon runner loses each hour around 0.8 L in cool weather and 1.2 L in warm weather.

- A female marathon runner loses about **70%** of what the male loses .
- However , in **hot weather** , heavy exercise can cause much more losses of fluid from the body >**dehydration.**
- Dehydration leads to constant rise in body temperature , increase in heart-rate , and decreased **stroke volume and cardiac output .**

Stroke volume : amount of blood pumped by heart in one heartbeat .

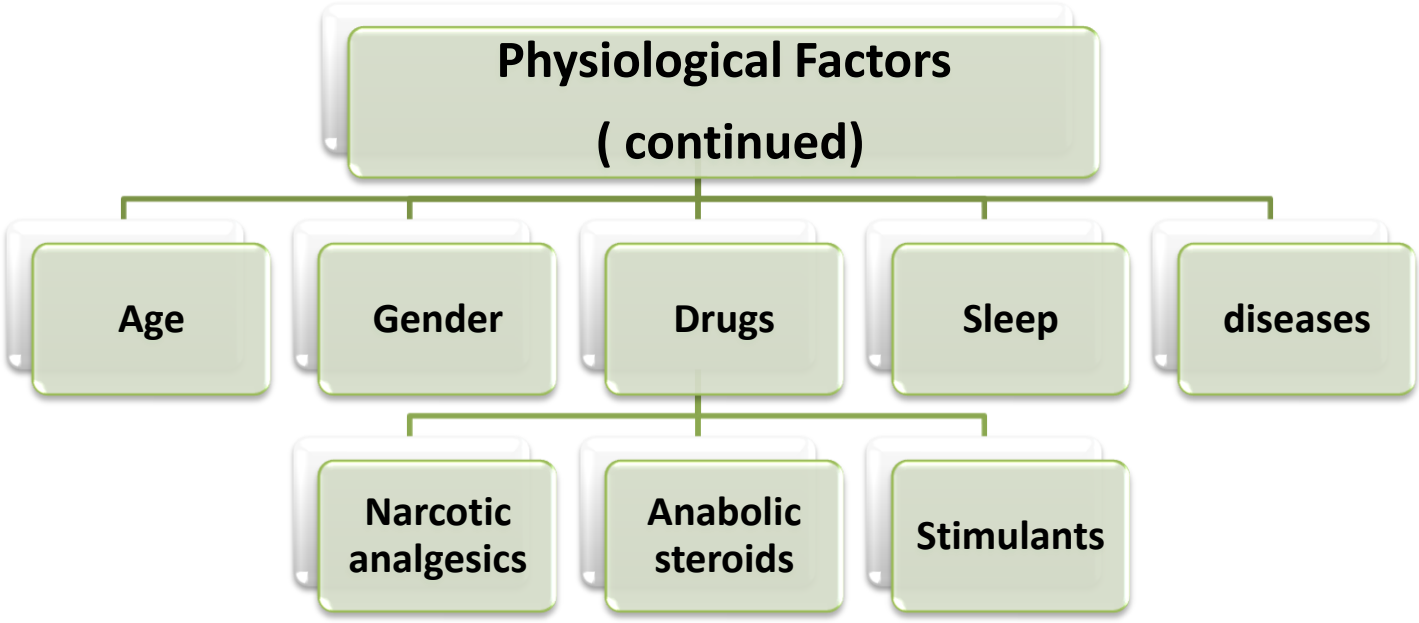
Cardiac output: amount of blood pumped by heart in one minute.

Blood Catecholamines & Ammonia

Plasma catecholamine concentrations can increase by 10 times .
Ammonia , which is produced by the exercising muscles from ADP is released into the bloodstream , leading to increased circulating levels .

Catecholamines : adrenaline and **noradrenalin** from Adrenal Medulla.

Amonia : a product resulting from Protein degradation during Exercise. (this is harmful because it cause a overload in kidney and liver)



Age : youth are **better** in sport performance than elderly e.g., a footballer getting old may retire or be a coach.

Gender

(i) Because of **difference** between genders of in body build and physical ability , men can perform **better** than women in contact sports such as boxing , rugby and wrestling .

(ii) **Menstruation :** women may perform differently at different times during their menstrual cycle.

Drugs

(1) Anabolic steroids (e.g., **Testosterone**) :

These are used by some athletes (of both sexes) to **increase their muscle mass** and thereby enhance their physical performance . They have harmful side-effects such as raised blood pressure and increased facial hair in female athletes. Their use in sport competitions is illegal.

(2) Stimulants

– Stimulants increase **reaction speed** (i.e., decrease **reaction-time**) , reduce perception of pain and raise aggression.

– They are highly **addictive** and have side-effects including high blood pressure, cardiac problems , strokes, and liver disease .

(3) Narcotic analgesics

• These are **pain killers** which athletes use to mask pain from an injury or

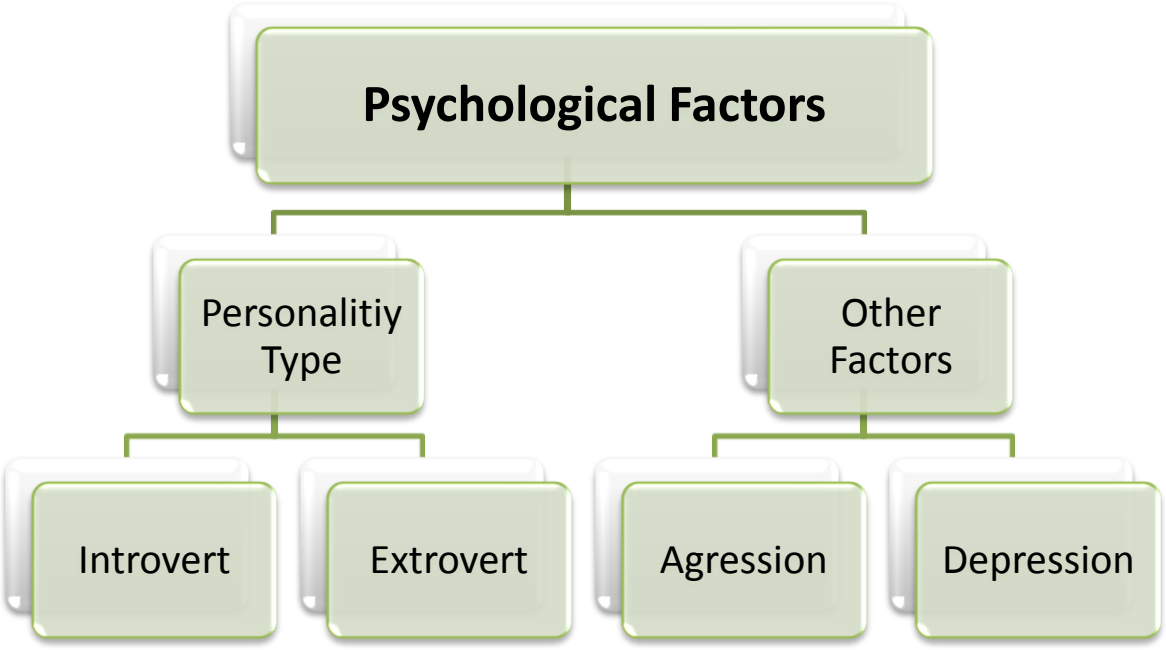
overtraining.

- They are also highly **addictive** and cause withdrawal symptoms when the athlete stops using them.

Sleep: Sufficient, restful sleep is important for physical and mental health . Lack of sleep makes the athlete nervous and irritable , & deteriorates physical performance.

Disease : Musculoskeletal disease e.g., sprain , disk etc , or General disease e.g., bronchial asthma , colds , flu , etc
All may affect muscular exercise performance .

- **A sprain** is an injury to a **ligament** by stretching or a tearing.
- **A strain** is an injury to either a **muscle** or a **tendon**.



Personality type

(i) Introverts

Tend to like sports which require:, precision , self-motivation , need low arousal levels & Individual performances e.g., archery, golf and snooker

(ii) Extroverts

Prefer team sports, which are exciting , need high arousal level and require large, simple motor skills e.g. rugby and boxing.

Other Psychological Factrors

(i) Aggression can sometimes be useful and sometimes harmful

(ii) Depression and lack of motivation are harmful.

The Overtraining Syndrome

This is an important, mixed, psychosomatic/musculoskeletal condition being increasingly observed in competitive sport .
With increasing competitiveness in local, national & international sport, it may be on the rise .

Overtraining occurs when the athlete, while **stale** (with impaired in vigor and effectiveness) is pushed/**forced** (e.g. by a coach) to continue training at high intensity > leading to development of "**Overtraining Syndrome** ".

This syndrome is a **chronic**, **debilitating** (body-weakening) condition.
Overtraining syndrome may impair an athlete during training or daily work, with signs of

(1) decreased concentration,
(2) irritability and increased anger,
(3) slowed mental function, and
(4) diminished self-esteem.

Symptoms of overtraining include fatigue (feeling of tiredness) , inability to exceed former levels of performance, and a decreased ability to recover are typical symptoms of overtraining.

Disadvantageous incremental stages of overtraining include:
(a) overreaching, > (b) overtraining, > (c) staleness, > (d) burnout, and > (e) injury/withdrawal.

- These conditions are not limited to mature adult athletes.
- **Young athletes** are continuously confronted with increasing expectations, often resulting in unrealistic demands on time and physical performance.
- This may lead to early withdrawal from the sport environment.