PERFORMANCE ENHANCEMENT IN SPORTS

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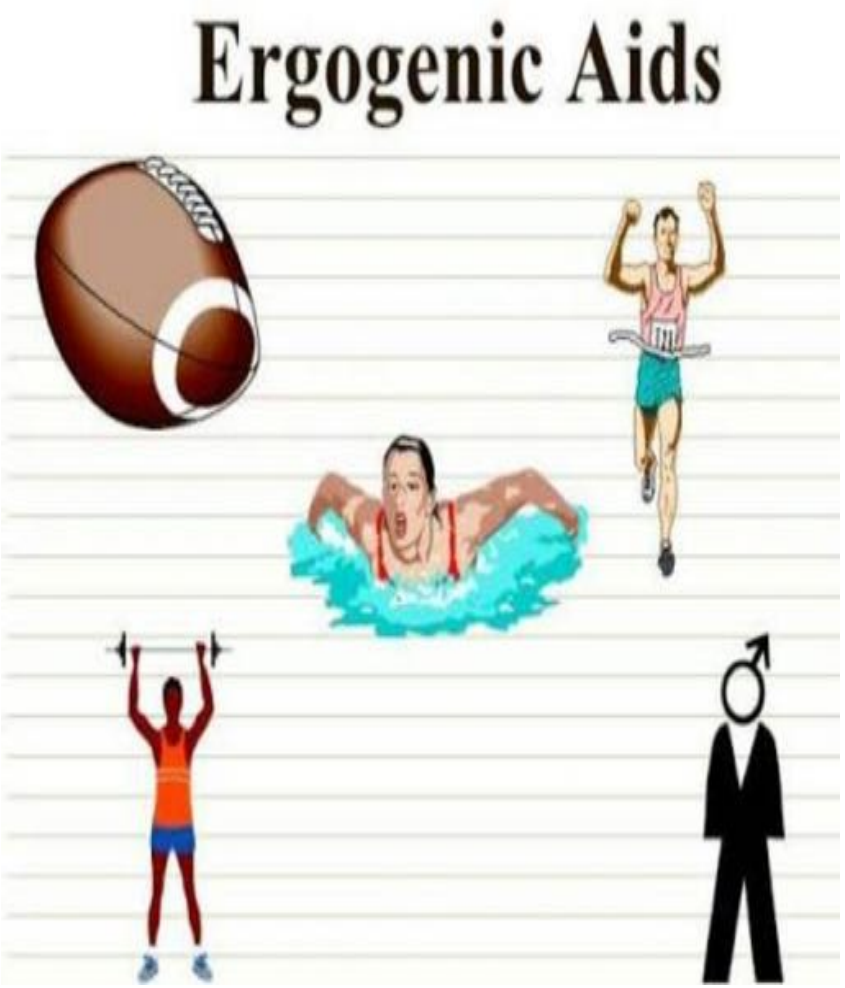
ERGOGENIC AIDS

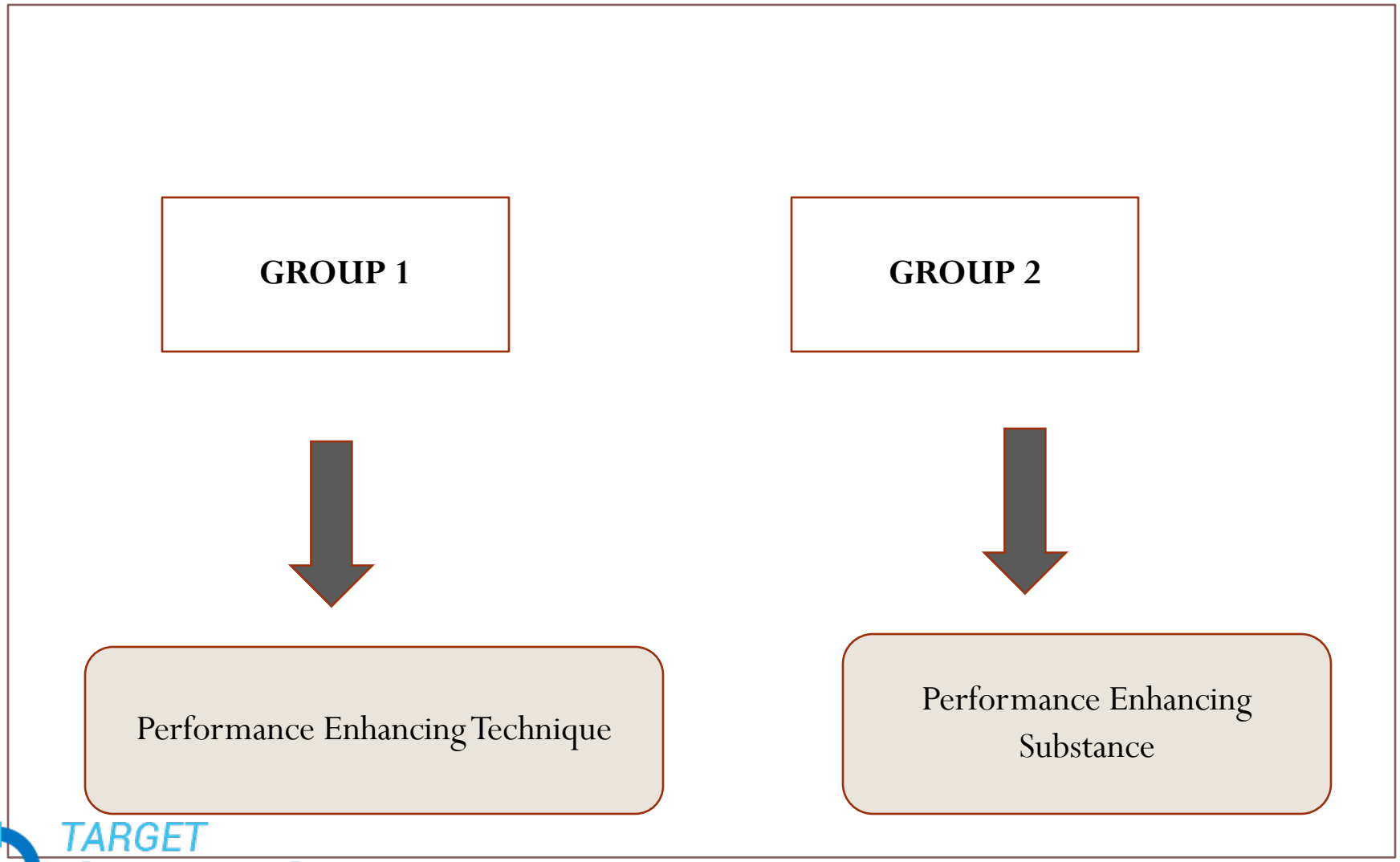
- Ergogenics is defined as "tendency to increase work performance"
- Any substance or treatment that directly improves
- 1) physiological variables a/w exercise performance or
- 2)removes subjective restraints that may limit physiological capacity.



ERGOGENIC AID

Any substance that helps or claims to help enhance athletic performance by

- Improving strength
- Improving endurance
- Increasing exercise efficiency
- Achieve a performance goal more quickly.
- Increasing tolerance for more intense training.
- Preparing the body for exercise.
- Reducing the chance of injury during training.
- Enhancing recovery



TYPES OF ERGOGENIC AIDS

1. Psychological
2. Mechanical
3. Pharmacological
4. Physiological
5. Nutritional

Psychological Factors

- Hypnosis
- Imagery
- Cheering
- Music
- Yoga
- Placebo Effect/ Superstitions

Common Ergogenic Aids in Sports

AIDS	POSSIBLE EFFECTS	LEGALITY
Wicking clothing	Transfer moisture from skin through clothing. Aids in cooling and thermoregulation.	Legal
Compression garments	May prevent post exercise tissue edema. Limited information on performance enhancement	Legal
Drag resistant swim suits(specially designed compression suits)	Inc buoyancy and reduces drag improving speed in water	Regulated by International swimming Federation for International competition
Clap skates(speed skate to keep more surafce area of skate on ice)	Provide added accleration and speed during push-off phase.	Legal and widely used in speed skating
Running shoes	Improves running speed due to improved traction and better foot support	
[illegible] cycle and helmet	Reduce drag and allows for greater race speed	Legal

Pharmacological Supplements

LEGAL

- Creatine Monohydrate
- Caffiene

ILLEGAL

- Amphetamines
- Anabolic steroids
- Growth hormones
- Ephedra
- Beta-2 agonist
- Hormones and metabolic agents
- Diuretics and other masking agents

MECHANICAL FACTORS

- Sports clothing and foot wears
- Weights
- Elastic Cords
- Nasal strips
- Equipment-used to analyze Vo2 max, test results, heart rate monitors
- Heat and Cold Applications
- Improved body mechanics
- Environment (playing conditions and surfaces)

PHARMACOLOGICAL AGENTS

OVER THE COUNTER DRUGS :

Caffeine,Nicotine,Amphetamine,Melatonin .....etc

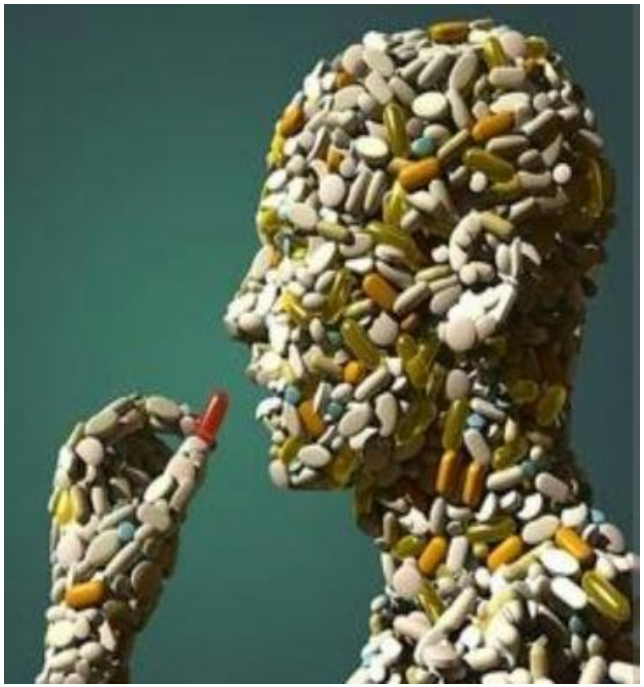
"RECREATIONAL DRUGS :

Alcohol, Marijuana, Cocaine.....etc

PRESCRIPTION DRUGS :

Anabolic Steroids,

Benzodiazepines, Beta-Adrenergic agents....etc



Prevalence of substance abuse in sports

- Most of the studies have focused on ALCOHOL AND STEROID use:

  Alcohol use: 55-90% of high school athletes, over 80% of college athletes.

Performance-enhancing drugs: upto 5% of high school and college athlete report using them(higher % among elite athlete, especially in past).

CAFFEINE's Proposed Ergogenic Effect

- The most highly consumed drug in North America and Europe
- IOC initially banned caffeine in 1962, then removed from list in 1972.
- Urinary caffeine >12microg/l is an IOC Infringement.
- 1 cup coffee provides 80mg.
- Ergogenic benefit :
- 330mg/80=4.1 cups
- IOC banned dosage :
- 1012mg/80=12.7 cups
- (assumes 75kg body)

- Effect depends on :
- Individual caffeine status
- Individual variability
- Caffeine dosage and administration
- Illegal(>12ug/ml)
- Approx..5-6 cups of strong coffee or 4 vivar for a 150 pound person when consumed 2-3 hours before performance
- Problems:
- Tremors, palpitation, headache, disrupted sleep
- Caffeine is diuretic; impairs heat tolerance
- Stomach upset and nervousness

ALCOHOL as an Ergogenic Aid

- Theory : Although a depressant, use can elicit paradoxical opposite effects, may relieve stress and anxiety, inc self confidence and performance.
- Effectiveness: Dart throwers improve balance and accuracy at BAC of 0.02 but impaired at BAC of 0.05.
- Safety : moderation is key, excess can lead to death
- Legal and ethical : Use is specifically banned for MODERN PENTATHLON. Use for sports in which anxiety may interfere with performance is unethical(skating, diving, sky jumping etc)
- Recommendations: though improve some sports but use is banned. Not recommended.

- PSYCHOLOGICAL effect : reduced anxiety, less muscle tremor(archery, not supported by research),greater self confidence.

Negative effects on performance

- Inc heart rate and oxygen consumption
- Inc Bp and blood lactate
- Inc reaction time
- Impaired hand eye coordination and visual perception
- Currently not banned by IOC except for shooting competitions.

CREATININE MONOHYDRATE

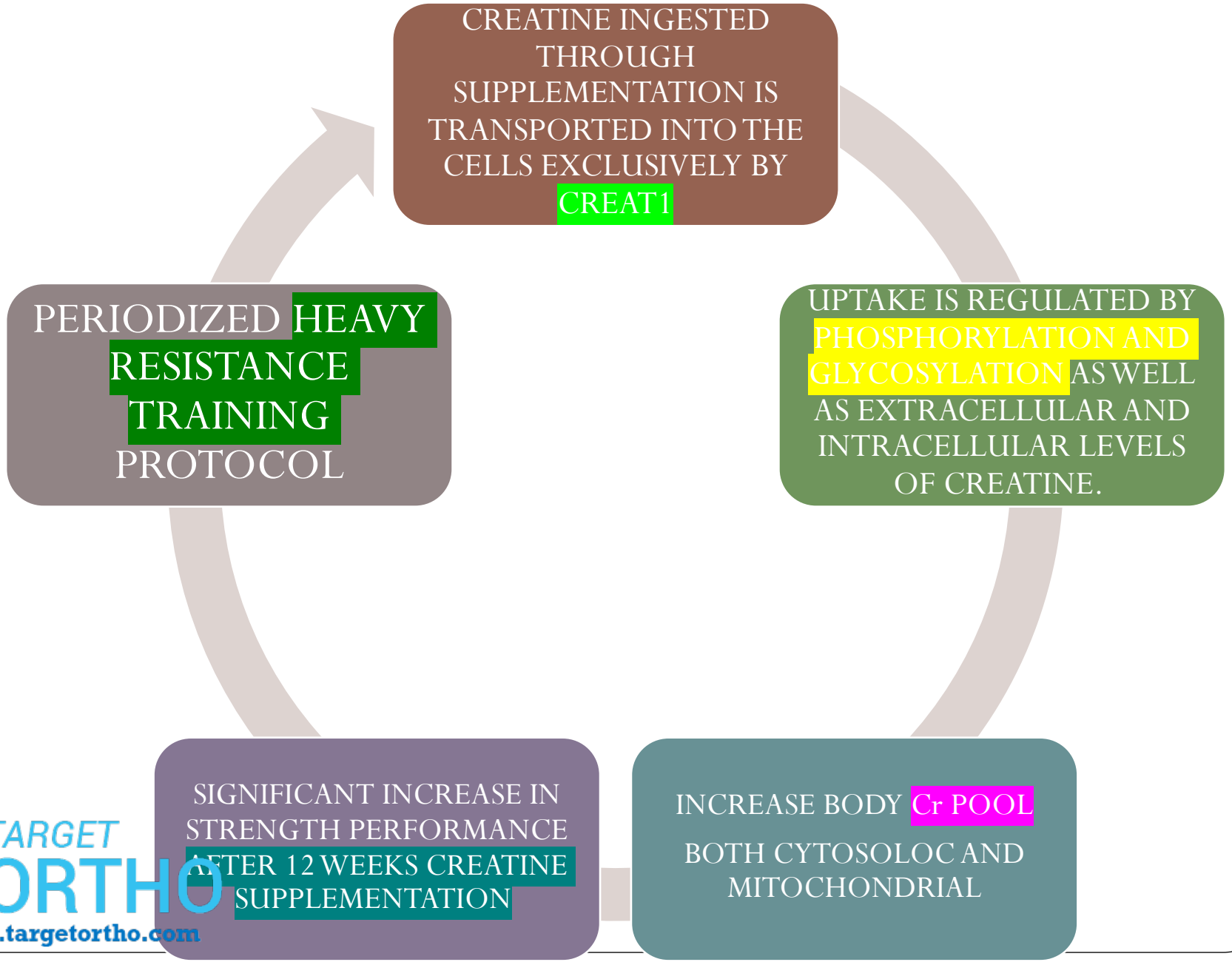
- Improve exercise performance and increase fat free mass.
- Phosphorylated form making up 60% of the stores or in the FREE form which makes up 40% of the stores.
- Creatine synthesis.

- Three amino acids

✓ GAM--- (GLYCINE, ARGININE AND METHIONINE) and

- Three enzymes

✓ L-arginine: glycine amidino transferase,
✓ Guanidinoacetate methyltransferase
✓ Methionine adenosyl transferase)



- Creatine supplementation may facilitate the reuptake of Ca^{2+} into the sacroplasmic reticulum by the action of the Ca^{2+} adenosine triphosphatase pump, which could enable force to be produced more rapidly through the faster detachment of the actomyosin bridges.
- Greater improvements when resistance training was combined

✓ 1RM

✓ lean body mass

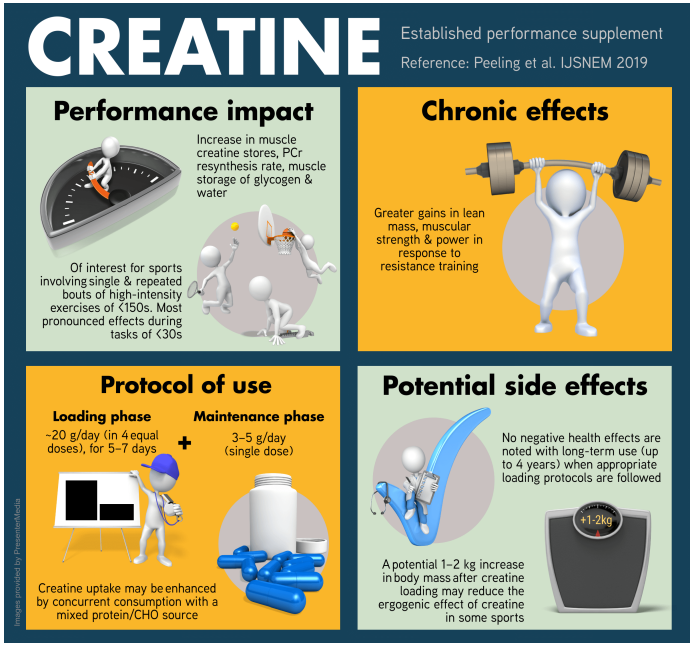
✓ fiber cross sectional area

✓ contractile protein

CREATINE SUPPLEMENTATION PROTOCOL

- Loading phase of 20 g CM/d or 0.3 g CM/kg/d split into 4 daily intakes of 5 g each,

- followed by a Maintenance phase of 3-5 g CM/d or 0.03 g CM/kg/d for the duration of the supplementation period



ANABOLIC STEROIDS

- Result in both Anabolic (increasing protein synthesis) and Androgenic (expressing male secondary sex characteristics) effects.
- increases in muscle size resulting from both hypertrophy and the formation of new muscle fibre.

Effects of AAS on muscle and performance

- An increase in muscle size using supraphysiologic doses of testosterone in combination with a high protein diet and weight training in previously trained subjects
- AAS do in fact increase lean body mass in normal subjects.

- Types of AAS-

  EXOGENOUS AND ENDOGENOUS COMPOUNDS.

- Endogenous AAS are are naturally produced by the body in some amounts
- Drug testing diificult because their chemical structure is identical to that of naturally occurring compounds.
- The most commonly used endogenous AAS is testosterone
- Natural testosterone precursors, such as androstenedione and androstenediol, were available for sale in the USA until 2005 as nutritional supplements. ….transiently increase testosterone levels
- Dehydroepiandrosterone (DHEA) was not included in the 2004 US Anabolic Steroid Control Act and is still legally available as a nutritional supplement in the USA. (It has been on the WADA/IOC list since 1987.)

Method of distinguishing endogenous from pharmaceutical testosterone

- Testosterone : epitestosterone (T:E ratio in Urine)
- The median T : E in males who have not used testosterone range from 0.2 to 6.0
- Epitestosterone levels above 200 ng·mL–1 urine constitute a doping offense.
- According to WADA, a ratio greater than 4 : 1 requires investigation.
- In many WADA laboratories, GAS CHROMATOGRAPHYCOMBUSTION-ISOTOPE RATIO MASS SPECTROMETRY (GCC-IRMS OR IRMS) is used to confirm that a banned substance was used.

- AAS affect virtually EVERY ORGAN in the body
- Most affected are the cardiovascular and gastrointestinal systems….LIVER **HEPATOCELLULAR DYSFUNCTION AND PELIOSIS HEPATIS.**
- AAS affect the cardiovascular system by

-  total cholesterol, low-density lipoprotein (LDL) cholesterol and blood pressure,  High-density lipoprotein (HDL) cholesterol.
- When these are combined with the **PROTHROMBOTIC** effects of AAS, the risk of coronary artery disease dramatically increases users suffering myocardial infarctions.

- Increase the risk of tendon rupture through MUSCLE HYPERTROPHY without a corresponding increase in TENDON STRENGTH.

- PSYHOLOGICAL- aggressiveness, rage, delirium, depression, psychosis, and mania

- Males produce about 7 mg/day testosterone and females about one-tenth of that amount.
- MALES- Oligospermia, Azoospermia, Gynecomastia etc
- Females will experience all of the virilizing effects of AAS, including Male Pattern Alopecia, Clitoromegaly, Hirsutism, Breast Atrophy, As Well As Menstrual Disturbances
- Evidence that AAS also impair THYROID FUNCTION

- WHICH OF THE FOLOWING IS EFFECT OF AAS

a) ALOPECIA

b) GYNAECOMASTIA

c) OLIGOSPERMIA

d) THYROID FUNCTION TEST

e) ALL OF THE ABOVE

Ergogenic effect and side effects of AAS

EFFECTS

- Inc muscle mass

(by inc body's nitrogen level); dec body fat

- Inc protein synthesis

- Inc synthesis of creatine phosphate

SIDE EFECTS(AAS)

- Acne ; hair loss; male secondary sex characteristics like deepening of voice
- Inc aggression, depression, hostility, suicide attempts, tendency to commit violent acts
- Elevated blood pressure and cholesterol
- Severe liver damage

- Legal and Ethical Issues: one of the most abused drug in sports. Is possible to test positive if eat meat that was injected with AAS to promote growth.
- Recommendations: not recommended as it is illegal, unethical and may inc health risk.

Tibolone

- Tibolone is a synthetic steroid with estrogenic, progestogenic, and mild androgenic properties when given via the oral route.
- It is used in females as a treatment for post-menopausal symptoms.

- POST MENOPAUSAL WOMEN----- HAND GRIP STRENGTH

GROWTH HORMONE-(rHuGH).

- Naturally occurring human growth hormone (hGH) is a polypeptide hormone of 191 amino acids that is produced in the anterior pituitary gland at a rate of 0.4–1.0 mg/day in healthy adult males.
- Natural hGH is secreted as multiple isoforms with the predominant one being a 22-kD monomer and about 10% being the 20-kD form. This is in contrast to rHuGH, which contains only the 22-kD isomer.
- The amount of 20 kD is suppressed when rHuGH (22 kD) is given; thus, a high ratio of 22–20 kD will indicate use of synthetic GH.

Relative abundance of hGH molecular forms in circulation (Strasburger–Bidlingmaier group).

- **The percentages are approximate**

ISOFORMS	PERCENTAGE
22 kDa monomer	48
20 kDa monomer	9
Modified hGH (dimers and oligomers)	30
Acidic hGH (desaminated and acylated forms)	7
Fragmented hGH (17, 12, 5, 30 kDa)	variable

- In the 2006 Prohibited List, hGH in listed under class S2 of hormones and related substances.
- Erythropoietin (EPO)
- corticotrophin
- insulin-like growth factor (IGF)-1
- insulin.

- Increases lean body mass and decreases the fat mass.
- Protein synthesis is favored over fat synthesis
- Parenteral administration of rHuGH peaks in 1–3 h and is imperceptible at 24 h.
- rHuGH seems to work as a PARTITIONING agent, rather than a true anabolic agent.

- Short-term use has been reported to cause fluid retention and muscle edema
- Long-term use - arthralgias, diabetes, myopathies, carpal tunnel syndrome, and acromegaly.

GROWTH HORMONE AND EXERCISE

- The concentration of hGH in blood can increase 10-fold during prolonged moderate exercise.
- During more intensive exercise (with accumulation of lactate at 70% VO_2 max for a short term period such as 10–20 minutes) hGH will increase by 5–10-fold.
- With short exercise durations, levels of GH will generally peak at 15–30 minutes after the exercise.

- hGH response is more closely related to the peak intensity of exercise than the total work output.
- Endurance training amplifies +++++ the pulsatile release of growth hormone, ELEVATING THE GH AMPLITUDE.

THERAPEUTIC GH

- ANABOLIC, LIPOLYTIC, AND ANTINATRIURETIC

- INC the body cell mass (muscles) and total body water (extracellular);
- DEC in the body fat REDISTRIBUTION FROM CENTRAL TO PERIPHERAL DEPOTS.
- The hGH dose in 1–2 IU/day administered SUBCUTANEOUSLY EVERY EVENING.

MISUSE- DOPING

- 10–25 IU/days three to four times a week to increase their lean body mass.
- Acromegaly…. diabetes mellitus and hypertension
- Swelling of the hands and feet, coarsened facial appearance, dentition problems, arthralgias, fluid retention, and excessive sweating.
- Cardiomyopathy, Osteoporosis, Menstrual irregularities, and Impotence
- decreased high density lipoprotein (HDL)-cholesterol.
- high risk of developing Creutzfeldt–Jakob disease, slowly progressive dementia.

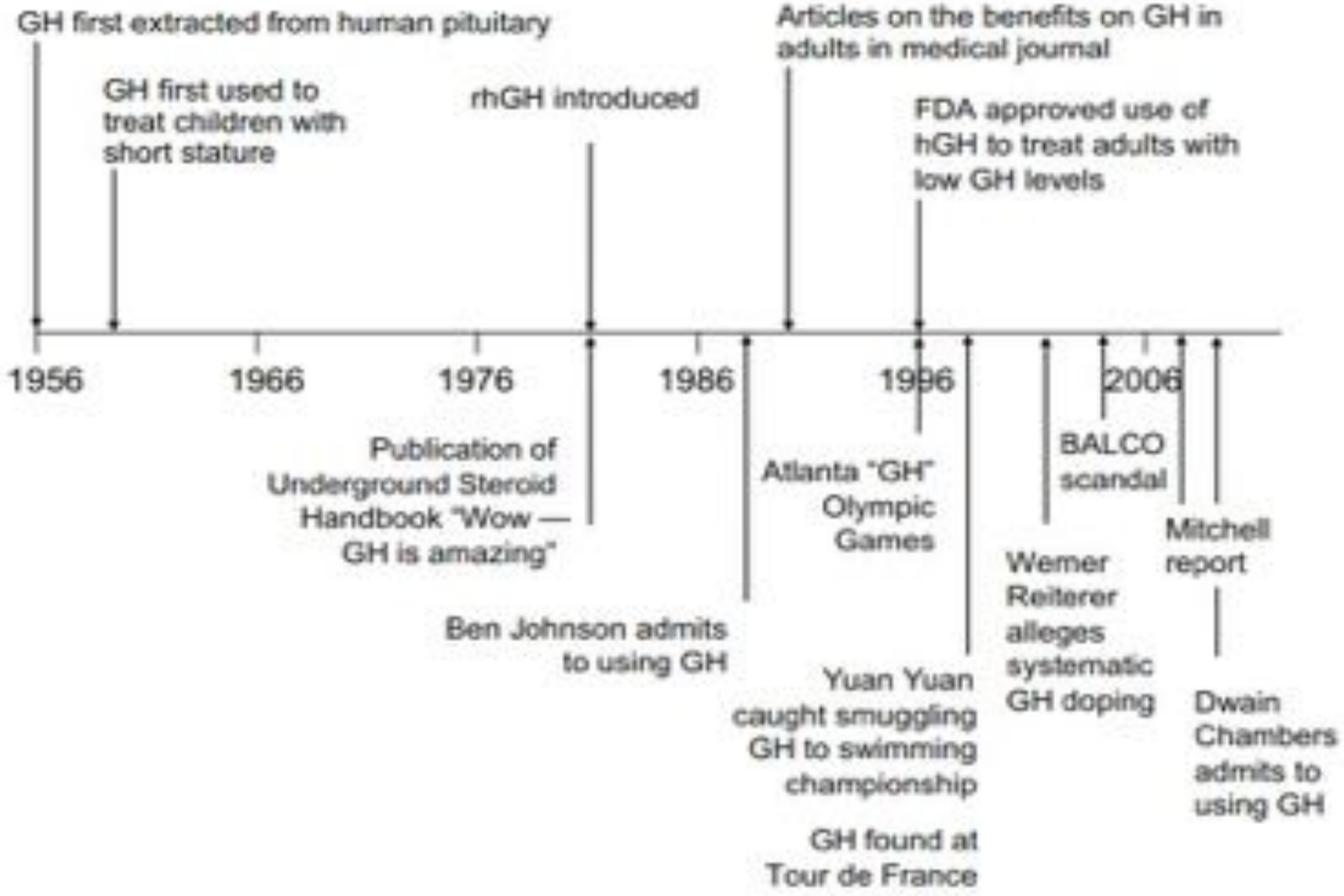


Fig. 1. Time-line of GH in clinical practice and abuse by professional sportsmen and women.

TESTING

- Immunoassays to estimate high ratio of 22–20 kD
- Short detection period within 24 h of the last dose.
- Serum Markers of IGF-1, and procollagen type III

short half-life of circulating GH (about 20 minutes).

GH concentrations returned to baseline 8–16 hours after intramuscular injection and

11–20 hours after subcutaneous injection

- TWO DOUBLE TESTS were applied to serum samples:
  - the first test quantified specifically the 22 kDa form and
  - the second -comprehensive assay measuring all forms present in the serum.
  - **A ratio is then calculated between the signal given by assay 1 to the signal given by assay 2.**
  - The time window of detection for these tests is claimed to be between 24 hours and 36 hours after the last injection, depending on the dosage used.

QUES- FOR GH TESTING WHICH OF THE FOLLOWING NOT CONSIDER AS MARKER OF TESTING??

- ratio of 22–20 Kd
- Serum Markers of IGF-1
- Serum procollagen type III
- transport proteins (IGFBP-3)
- Serum hGH

CONFUSION IN Hgh DOPING

- Apart from exercise related increase, hGH secretion can be affected by other factors—

✓ increased in hypoglycaemia,

✓ increased temperature

✓ stress,

decreases in obesity, or with a carbohydrate-rich diet and intake of β_2 adrenergic agonists.

It is hard to differentiate between the physiological increase in hGH levels seen in exercise and what can be from external hGH administration (as in doping).

Quantitative approach of measuring directly the total circulating GH not feasible in case of doping.

β2-Agonists

- The IOC now requires that the diagnosis of asthma or EIA be established on the basis of eucapnic voluntary hyperpnea testing------ Asthma and exercise-induced asthma (EIA)

β2-Agonists

- Beta-2 Agonists are banned unless:
  - Inhaled salbutamol - a maximum of 1600 micrograms taken over a 24-hour period in divided dose and dose exceeds 800 micrograms over a 12-hour period.
  - Inhaled formoterol - a maximum delivered dose of 54 micrograms over a 24-hour period
  - Inhaled salmeterol - a maximum of 200 micrograms over a 24-hour period
  - Inhaled vilanterol - maximum 25 micrograms over a 24-hour period
- Not all inhaled beta-2-agonists are allowed. Athletes needing to use these substances may apply for a TUE.

Clenbuterol effects and side effects

- Illegal beta adrenergic agonist
- Inc lean muscle mass and strength; dec body fat…REPARTITIONING AGENT
- Less potent than anabolic steroid
- s/e
- Tachycardia
- Muscle tension
- Headache and dizziness

- Clenbuterol -muscle hypertrophy, FAVORING TYPE 2 FAST-TWITCH MUSCLE over slow-twitch muscle and increasing the glycolytic capacity.

CHRONIC NEPHROTOXICITY

Physiologcal Agents

- Bicarbonate Loading
- Carbohydrate Loading
- Blood Doping
- Erythropoetin(EPO)
- Altitude Training
- Glycerol
- Phosphate Loading

Bicarbonate Loading

- Inc blood bicarbonate and buffering potential
- Inc performance during intense intermittent exercise.
- During high intensity anaerobic events muscle fatigue and energy supply is compromised because of build up of lactic acid from glycolysis.
- Soda loading is done to neutralize lactic acid that accumulates in blood.
- It is currently not banned by any athletic organization but likely to be banned in future.

CARBOHYDRATE LOADING

- It is a strategy used by endurance athlete(runners) to maximize storage of glycogen in muscles and liver.
- It is recommended for ENDURANCE event lasting longer than 90 minutes.
- Many endurance athletes prefer low GI(fruits,vegetables,wheat pasta) food because of there low effect on serum glucose.

Carbohydrate Loading:How it's done

DEPLETING GLYCOGEN STORES(0-2days)

Training= heavy

Diet =mixed

Starving Glycogen Stores(2-5days)

Training=reduced

Diet =fat +protein

Super-loading glycogen stores(5-8days)

Training=light/taper

Diet =high carbohydrate content

Race Performance(Day8)

Super inc glycogen stores

SIDE EFFECTS OF CARBOHYDRATE LOADING

- GI Discomfort
- Slugginesh
- Inc body weight

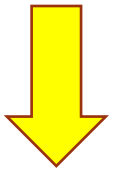
- Normal athlete=80-120 milli moles of stored glycogen/kg of BW

Carb load athlete have 200 milli moles per kg

This can improve endurance by 2-3%

ERYTHROPOETIN-EPO-- rHuEPO

- Natural EPO is produced by the kidneys in response to changes in oxygen tension.



+++formation of proerythroblasts and reticulocyte release from the bone marrow and increases red blood cell mass.

rHuEPO increased Vo2max by 6.0% to 7.7% after 3–4 weeks of subcutaneous administration of 150 IU·kg/week.

enhance platelet activation, increase endothelin production by the vascular endothelium, and augment vascular smooth muscle response to norepinephrine and angiotensin II, all of which increase the risk of thrombosis

ERYTHROPOETIN-EPO

- Hormone produced by kidney in response to hypoxia,anemia and blood loss to produce RBC's by stimulating bone marrow(erythropoesis).
- EPO is widely used by elite endurance athletes, but cause deaths due to organ damage resulting from excessive inc in blood viscosity
- Has same effect as "BLOOD DOPING" and "altitude training"(more efficient use of oxygen).

TESTING

- The first test for rHuEPO was an INDIRECT BLOOD - elevated **red blood cell mass, in conjunction with increased of erythropoiesis and high EPO concentrations,**

- DIRECT TEST URINE test

The test reveals the ISOFORM PATTERNS of urinary EPO.

The ISOFORM pattern of rHuEPO is distinctively different from ENDOGENOUS EPO.

BLOOD DOPING

- The removal of 1-4 units of blood, storage for 4-8 weeks, and then reinfusion of RBC's.
- Reinfusion usually occurs 1 week prior to competition.
- Blood doping can double the Hb, but cause too much of an inc in blood viscosity

Altitude Training

- It is practice done by endurance athletes:

(training for several weeks at high altitude,2400mtrs(8,000ft) to allow there bodies to produce extra RBC's.)

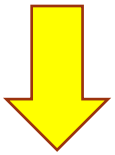
Altitude training can be simulated through use of an

- ✓ altitude simulated tent
- ✓ altitude simulation room
- ✓ mass based hypoxication system.

Hypoventilation training which consist of reducing the breathing frequency while exercising can also mimic altitude training by significantly decreasing blood and muscle oxygenation.

- Live high-train high(LH-TH) first ------ live and train at altitude
- Live high-train low (LH-TL) ----Athletes can live in a natural HYPOBARIC HYPOXIC environment, or use nitrogen dilution or oxygen filtration to create a normobaric hypoxic environment
- Live low-train high (LL-TH) ---- athletes live under normoxic conditions and train in a natural, hypobaric, or simulated normobaric hypoxic environment.
- Exposure to acute hypoxia is too short (1–2 h per day), and insufficient to modify hematological variables

- EPO level increases significantly after the first to third days/nights at altitude.



- After the peak, the EPO level start to fall gradually, but stays above initial values for a few days to weeks.

- Changes of EPO level become non-significant compared to baseline values after the first, second and third week at altitude.

Diuretics and other masking agents

1 Dilute the urine and thus the concentration of a banned substance

2 Reduce the excretion of a banned substance

3 Reduce the fluid-retaining effects of a banned substance (e.g., AAS)

4 Eliminate fluid in order to reach a lower weight class in sports such as boxing or wrestling

5 Lose weight in sports where thinness is an advantage (e.g., gymnastics).

- Diuretics can be detected by a combination of LIQUID CHROMATOGRAPHY AND TANDEM MASS SPECTROMETRY (LC-MS-MS) that is able to detect diuretics for up to 4 days after ingestion.
- Masking agents

1. Probenecid is used to extend the half-life of penicillin by preventing elimination of the drug, and is also used by athletes to prevent the presence of AAS in the urine.
2. EPITESTOSTERONE, quickly reduce an elevated T : E ratio or to camouflage the daily use of testosterone.

- 3. HYDROXYETHYL STARCH (HES) AND ALBUMIN. --- PLASMA EXPANDER
- Volume expansion may improve performance in endurance events and help resist heat illness, the use of plasma expanders is mainly prohibited for its role in masking the use of illegal methods of red blood cell expansion.

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