Medical Aspects of Synchronized Swimmers

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הדסה Optimal
המרכז לרפואת ספורט

Lectures Objectives

- To describe the potential medical problems of the synchronized swimmers
- To understand how injuries and illnesses can be prevented/reduced
- To receive “tips” in Dx and Rx of these problems
- To take home ideas of how to improve performance

While keeping the swimmers healthy

Lectures Content

- Introduction
- Eating habits/disorders
- Menstrual cycle / The female athlete triad
- Injuries & illnesses – prevention & treatment
- Nutritional aspects
- Q & A

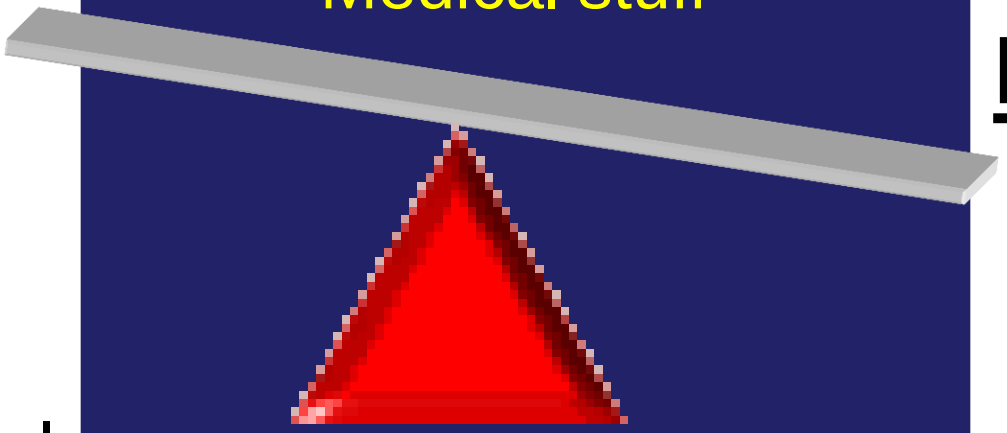
The Athlete's Health Balance

Environment:

Technical conditions
Family
Coaches
Teachers
Friends
Medical stuff

Stress

Physical
Mental
Academical
Developmental



Genetics

Recovery

Rest
Nutrition
Sleep

Synchronized Swimming

Unique sport - Few studies

- Physiology - (physique, fitness components, skills…)
- Training – (sport-specific tests)
- Medicine - (underwater, epidemiology, prevention…)
- Nutrition & Supplements

International Journal of Sport Nutrition and Exercise Metabolism, 2011
Bronwen Lundy

More research is required across all aspects of nutrition status, anthropometry, and physiology, and both sports nutrition and sports medicine support may be required to reduce risks for participants.

Physique and physiology

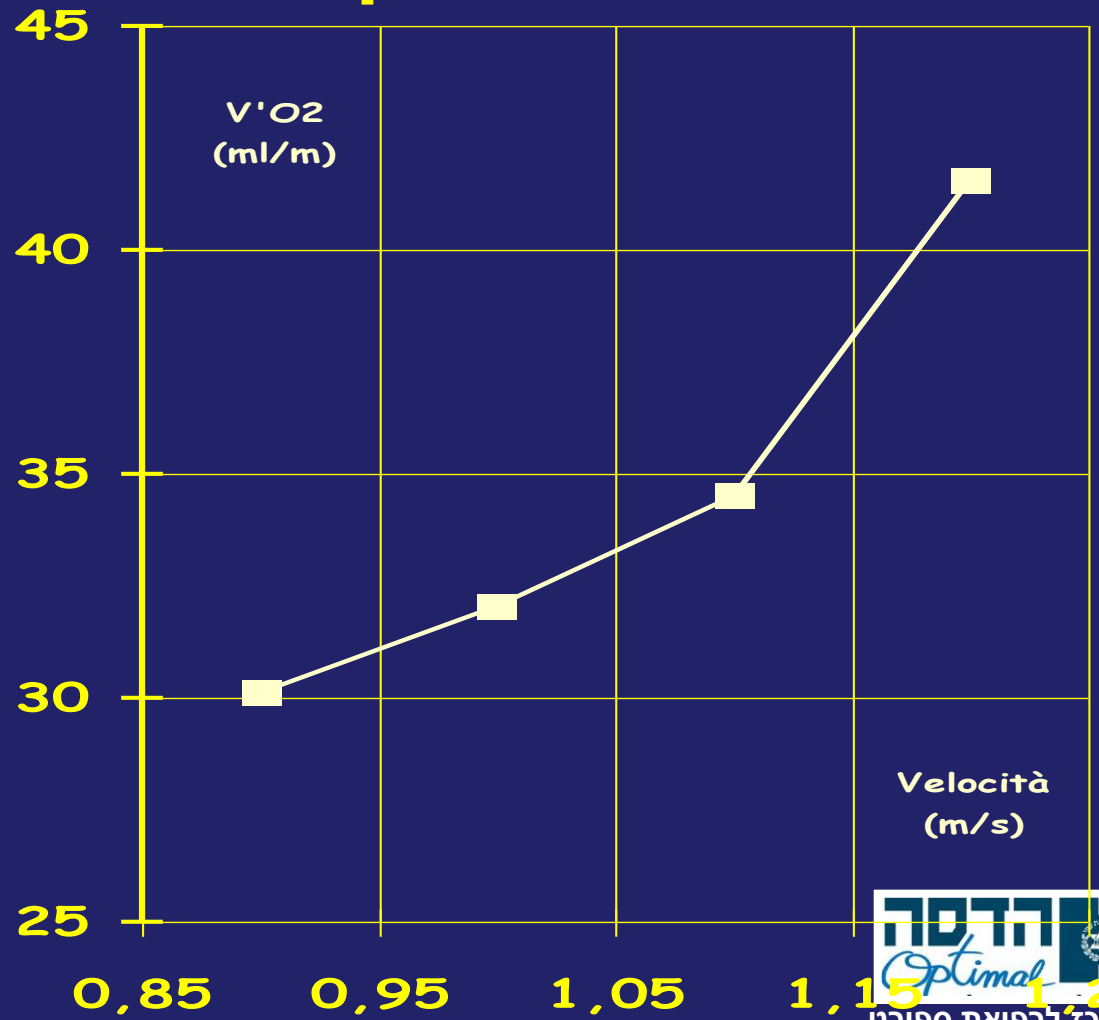
- High level of technical skills
- High level of artistic skills
- High physical fitness (VO_2)
- High lung capacity
- High metabolic demands
- High orthopedic demands
- A specific body type

High physical fitness
Aerobic capacity/Cardiopulmonary

Oxygen consumption – VO2 Max

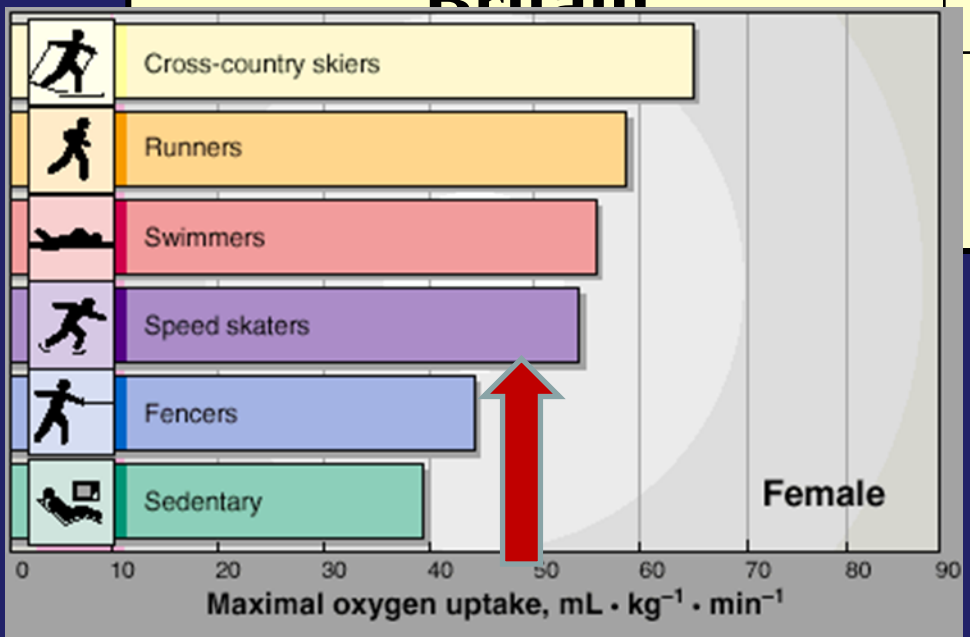
Energy cost of swimming

$V'O_2$ con backextrapolation



SS- VO2max

Chatard France 1999	52.4 ml/kg/min
Takamoto Japan 1988	43.2 ml/kg/min
Ramsay 2001 Great Britain	47.2 ml/kg/min
	50.8 ml/kg/min)



Seniors & Comen SS

- Greek study (Bunte 2007) –80% of VO2 max after routine and after 400 m. (45-47 ml/min/Kg)

Slow recovery in terms of:

- Breathing frequency – 30 per minute
- Vo2 recovery

- Blood lactate – 4-6 m/mol

Physiology: *Blood Lactate* in SS

Depends on:

- **Performance time - Free > technical**
- **Solo & duet > team**
  - **Breath holding time**
  - **Exercise intensity**
- **Age**
- **Energy requirements in the final period**
- **Training adaptation** (work economy)
- **Competition > training (12.7 vs 7.0)**

ory	Variable	TS	FS	TD	FD	TT	FT	All Routines
		(n = 9)	(n = 11)	(n = 16)	(n = 16)	(n = 14)	(n = 30)	(n = 96)
mmers	La_{peak} (mmol·L^{-1})	6.9±1.4	8.5±1.8[b]	6.8±1.8	7.6±1.8	7.1±2.4	6.2±1.9[a]	7.3±2.0
	RPE (a.u.)	7.1±1.7	8.0±0.9	7.6±0.9	8.1±0.9	6.6±1.2[d]	7.5±1.1[c,e]	7.0±1.4
	La_{peak} (mmol·L^{-1})	6.1±1.1	8.1±3.3	6.5±1.5	6.9±1.7	7.0±2.7	6.5±1.9	6.7±2.0
	RPE (a.u.)	6.7±1.2	7.4±0.9	8.1±0.6	8.2±0.9	7.4±1.1	7.9±0.8	7.8±0.9*
	La_{peak} (mmol·L^{-1})	7.4±1.5	8.8±1.7	7.0±2.2	8.8±1.4	7.2±2.2	5.3±1.7	7.4±2.1
	RPE (a.u.)	7.3±2.0	8.5±0.5[h]	7.0±0.8	7.8±1.0[i]	5.7±0.5[f]	6.1±1.1[g]	7.1±1.4

re mean ± SD. TS, Technical Solo; FS, Free Solo; TD, Technical Duet; FD, Free Duet; TT, Technical Team; FT, Free Team; a.u., arbitrary units (0–10+).
ant differences between junior and senior swimmers for all routines. Significant differences among routines in:
<0.05) for all swimmers are: [a]FT vs. FD and FS; [b]FS vs. TD.
all swimmers are: [c]FT vs. FS; [d]TT vs. FS, TD and FD; [e]FT vs. FD.
0.05) for the senior group are: [f]TT vs. TS, FS and FD; [g]FT vs. FS and FD; [h]FS vs. TD; [i]TD vs. TT.
371/journal.pone.0049098.t005

ly is that the main cardiovascular response to BH (i.e. rdia) was powerful enough to counteract the HR response he BH phases of intense exercise (figure 2). It is well known has marked effects on blood pressure (BP), cardiac output,

SS routines due to intense exercise combined with BH, which would produce a rapid development of hypercapnia and hypoxia [35]. While apnea and facial immersion increase the para- sympathetic tone causing HR reduction [34,39], exercise increases ...ulation of the heart [3] and increases HR Sc

Physiological Responses in Relation to Performance during Competition in Elite Synchronized Swimmers

Lara Rodrı´guez-Zamora, Spain, 2012

Anthropometric characteristics

- Height
- Weight
- Limb length
- Circumferences
- Body composition (%fat)

Anthropometric characteristics

- Athletic performance is, to a large degree, dependent on the athletes ability to sustain power and to overcome resistance, or drag. Both of these factors are interrelated with the athlete's body composition.

- In SS lean body is an advantage both physiologically and for appearance

What should we measure?

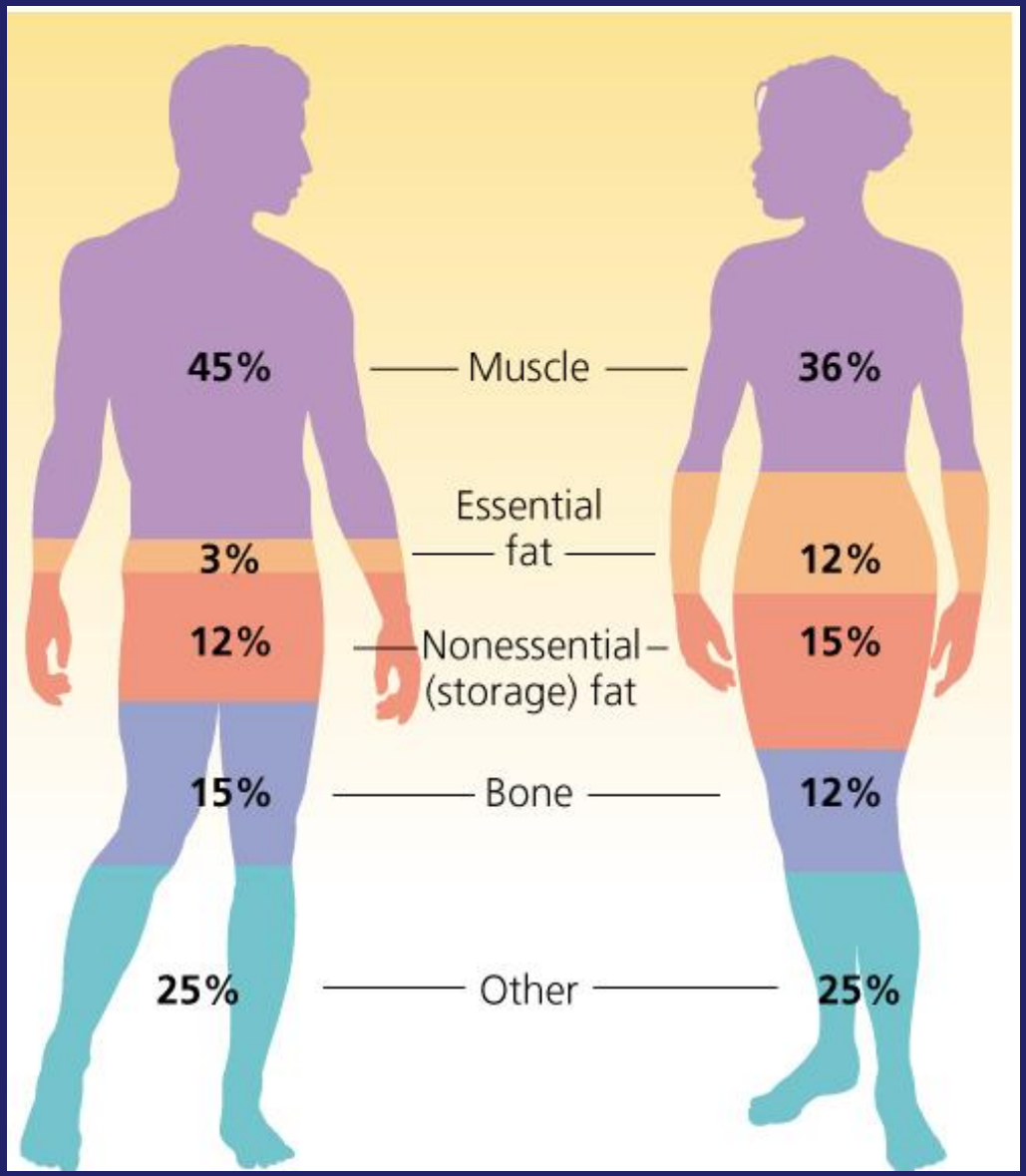
BMI – Body Mass Index

$$\frac{\text{Weight (coaches)}}{\text{Height}^2}$$

BMI – Body Mass Index

< 20	Under-weight
20 - 25	Healthy
25 - 30	Overweight
>30	Obeses

Body composition



Anthropometric characteristics of SS

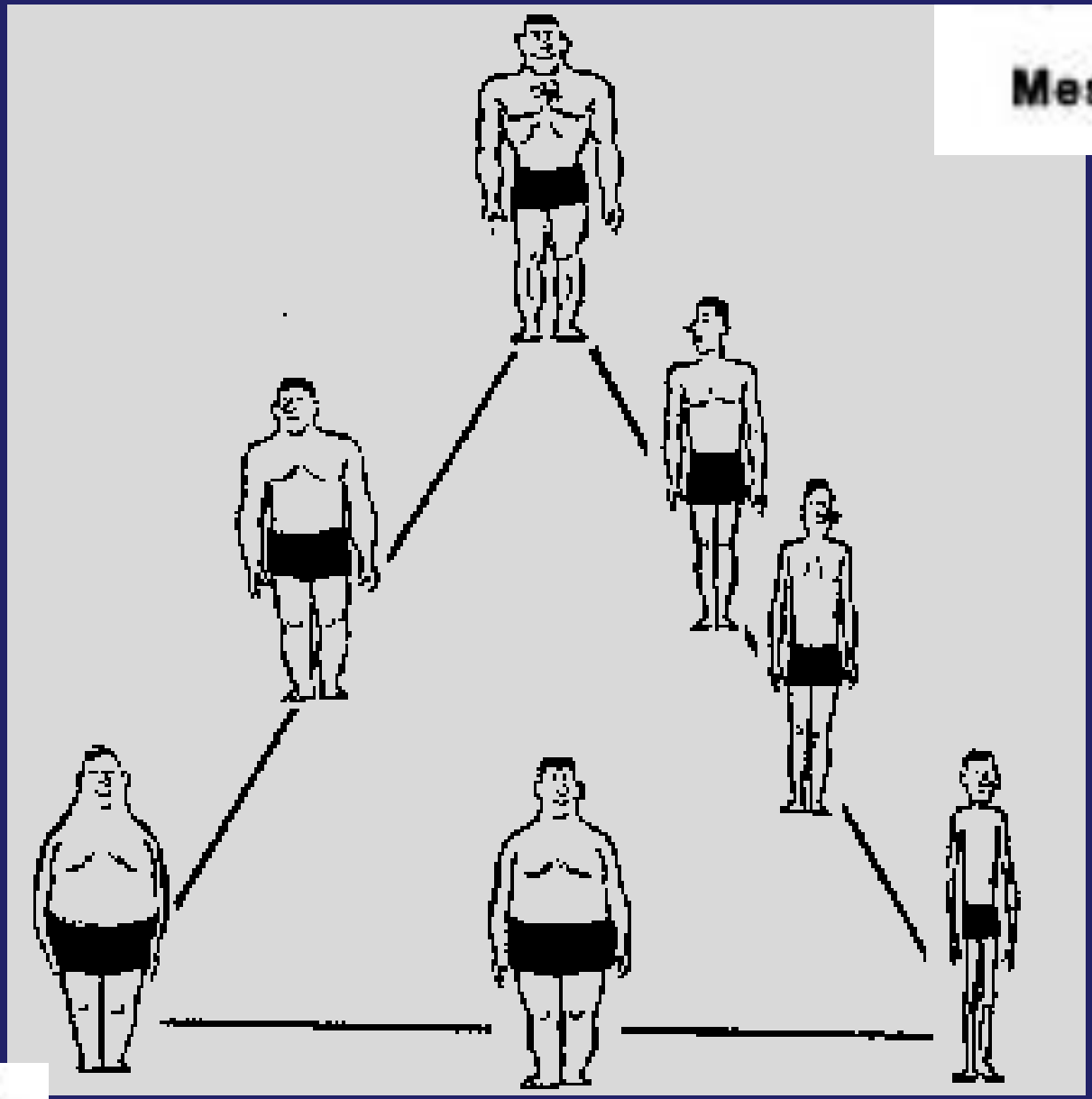
- Chu D 1999 evaluated 81 international SS, comparing them with Chinese elite SS.
- Their conclusions were that a great deal of similarity existed between SS of all countries
- Russian swimmers had the best body characteristics for the sport.

Anthropometric characteristics

- Mean height -165.2 cm
- Mean weight - 55.2 kg
- Average body fat - 19.8%

- Russian swimmers had larger shoulder breadths, longer arm length, and narrower pelvis breadth when compared with normal.
- The mean values of somatotype were 3.8-3.3-3.2

Body build



Anthropometric characteristics for senior and comen synchronized swimmers

TABLE I.—*Anthropometric characteristics for senior and comen synchronized swimmers.*

Dimension	Senior swimmers (n=8)	Comen swimmers (n=8)
Body mass (kg)	56.8±1.2	44.8±1.6**
Percentile for body mass		P20
Height (cm)	167.5±1.1	160.1±1.2*
Percentile for height		P54
BMI (kg/m^2)	20.2±0.3	17.4±0.4**
Percentile for BMI		P12
Body fat %	21.4±0.8	23.1±0.8
SUM6SF (mm)	76.1±4.9	74.3±3.2
Estimated muscle mass (kg)	25.9±0.8	21±0.6*
Sitting height (cm)	79±0.8	70.5±1.3**
Arm length (cm)	74.1±0.7	72.3±0.4
Leg length (cm)	88.5±0.8	89.6±0.7
Biacromial diameter (cm)	39.1±0.3	37.4±0.5
Bi-iliac diameter (cm)	27±0.3	24.8±0.4*
Humerus width (cm)	5.6±0.1	5.5±0.1
Femur width (cm)	8.8±0.1	8.2±0.1*
Biceps girth (cm)	25.4±0.4	22.4±0.3**
Chest girth (cm)	88±1.4	76.2±0.4**
Waist girth (cm)	67.7±0.6	61.7±0.8**
Thigh girth (cm)	47.2±0.9	42.9±0.6
Calf girth (cm)	30.8±1	27.4±0.4
Lean arm CSA (cm^2)	31.2±2	22.2±0.5**
Lean leg CSA (cm^2)	133.9±4.5	109±3.5*

Data are mean ± standard error of the mean. BMI: body mass index; SUM6SF: sum of 6 skinfolds; CSA: cross sectional area. *P<0.05; **P<0.01 senior vs comen swimmers.

Bante et al 2007

Somatotype distribution for senior & Comen SS

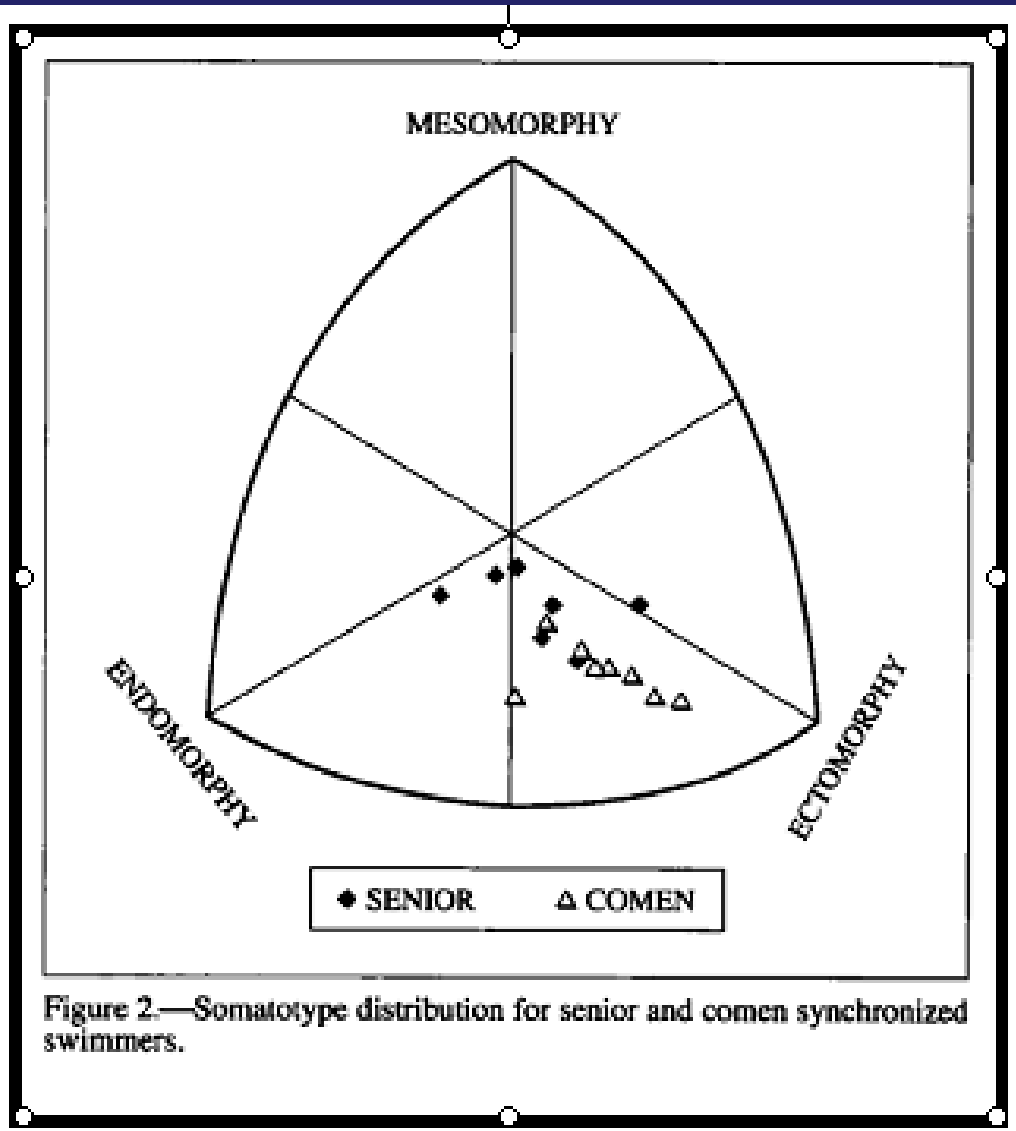


Figure 2.—Somatotype distribution for senior and comen synchronized swimmers.

Seniors - 2.9-1.9-3.4

Comen - 2.7-1.5-4.3

Ectomorphic predominant for both categories

Bante et al Greece, 2007

Eating Disorders in DSM-V

- **Anorexia Nervosa***
- **Bulimia Nervosa***
- **Binge Eating Disorder**
- **E.D. Not Otherwise Specified**
- Avoidant/Restrictive Food Intake Disorder**

Am. Psychiatric Assoc. Diagnostic and Statistical Manual of Mental Disorders, 5th ed. Washington, DC: 2013

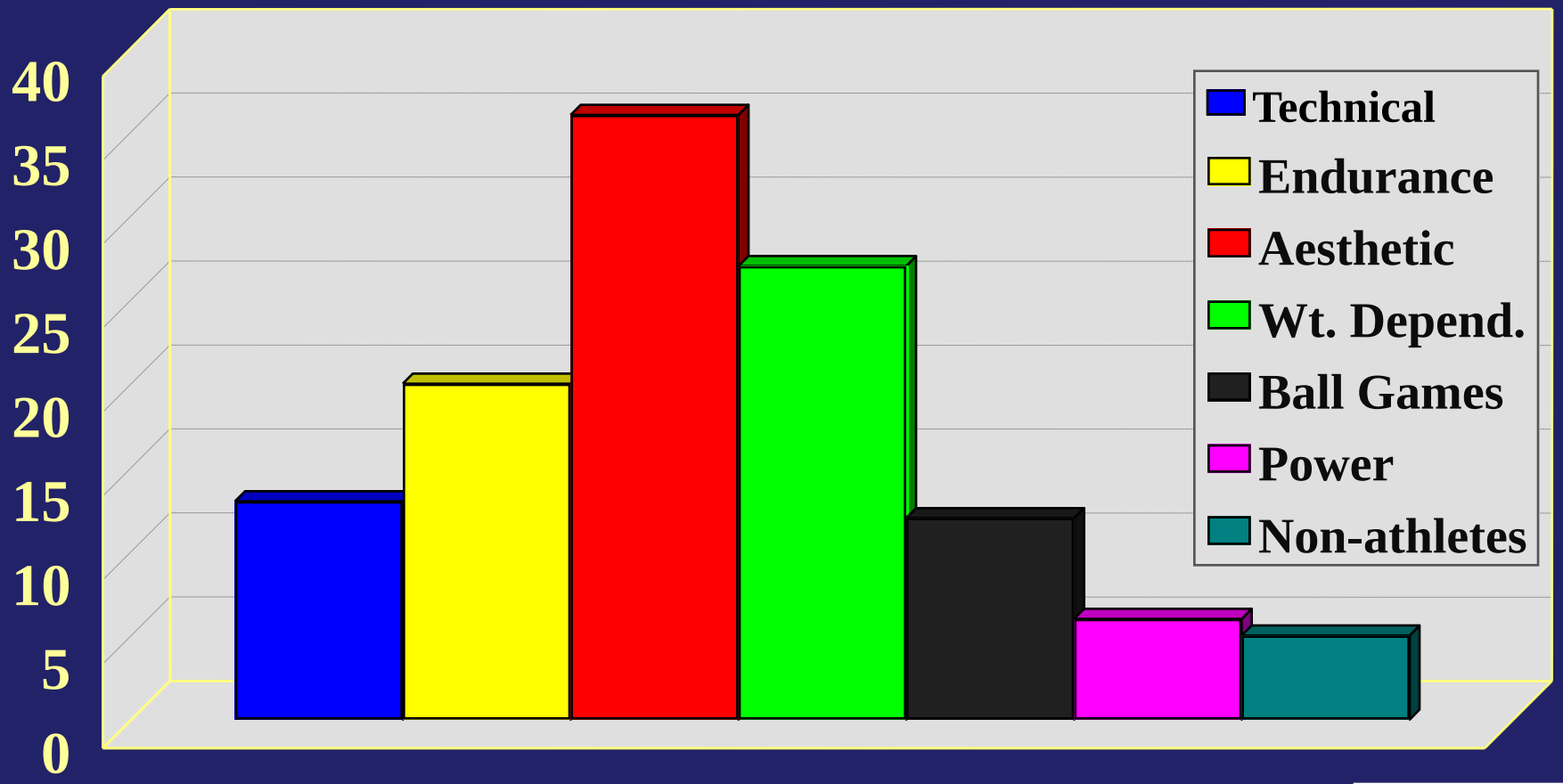
Risk factors for ED development

- Social
- Family
- Personality

Eating Disorders & Disordered eating in Athletes

- Diets , skip meals, vegetarians
- Preoccupation with food, diets, weight
- Use of pathological means to loose weight
- Anorexia nervosa, Bulimia, EDNOS

Prevalence of Eating Disorders: Female Athletes



Sundgot-Borgen, J , 1993

Prevalence of ED among Athletes

- Non Athletes 6%
- Sports that do not "demand" low weight 20%
- Track 35%
- Dancers 45%
- Gymnastics 74%
- Synchro ???

Risk factors for DE in athletes

- **Performance enhancement**
- **Body Exposure**
- **Need for specific body shape**

Risk factors for DE in athletes

- **External pressures** (coaches, peers, teachers)
- **Physiological** (diminished appetite)
- **Objective** ("no time")
- **Crisis** (injury, illness…)

Eating Disorders in SS

- **A sport that requires leanness to improve performance**

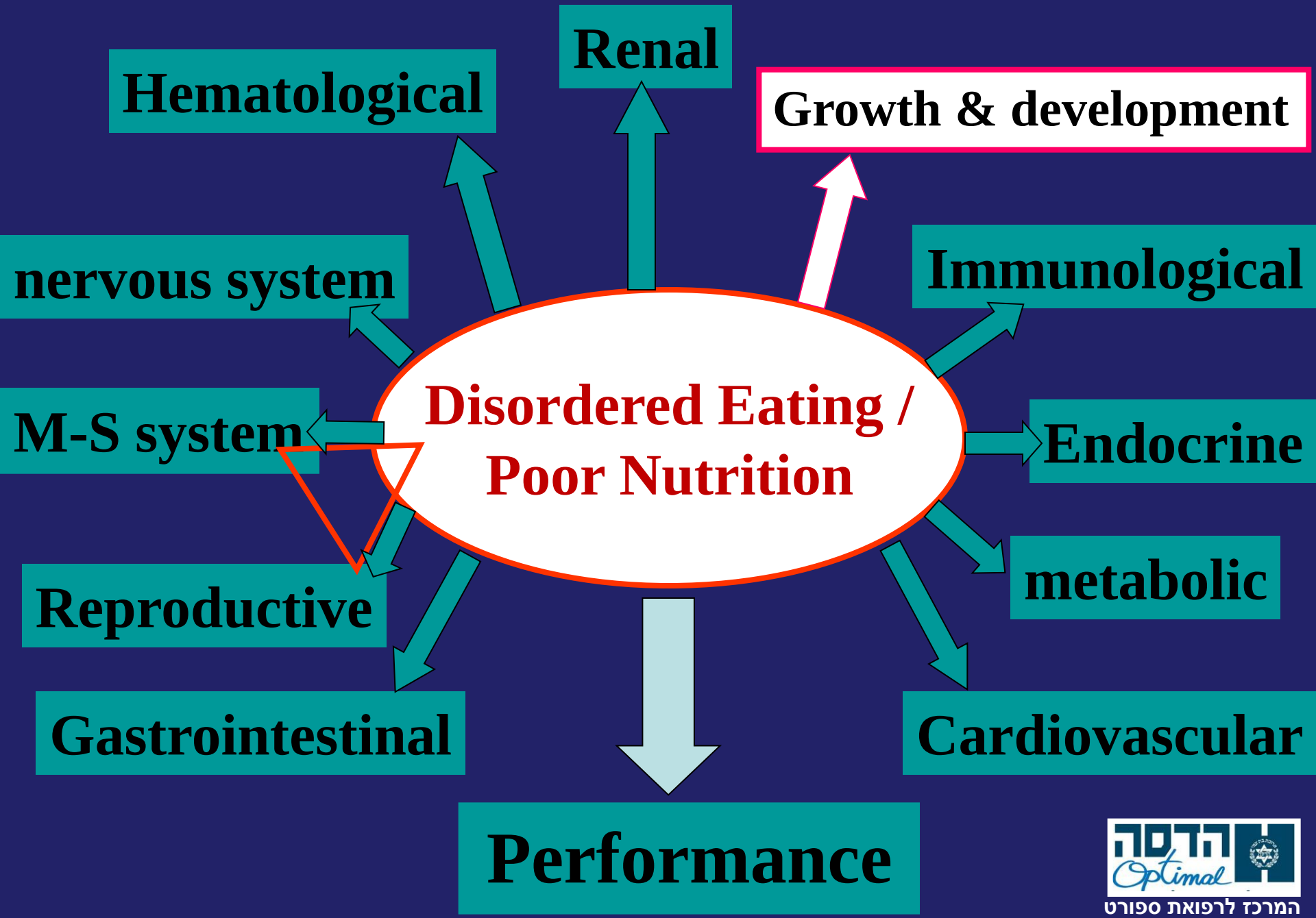
- **Sport judged by "aesthetic" appearance**

- **Team sport – need to present a precise, uniform look**

Eating Disorders in SS

- **Ferrand et al (2005) elite SS**

Reported greater negative feelings about their appearance than two control adolescent groups and low perception of how others evaluate their physical appearance.



“Fear of Obesity -
A Cause of Short Stature & Delayed Puberty”

Pugliese et al, 1983, NEJM

Anorexia Nervosa

Prepubertal Anorexia

Nervosa

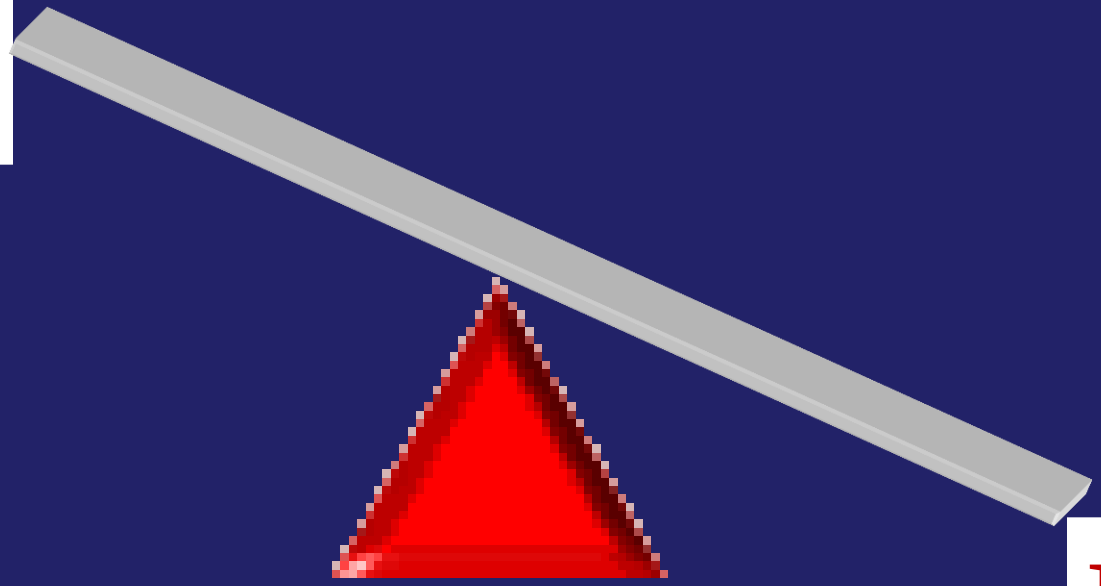
Fear of Obesity

Chronic IBD

Anorexia Athletica

“Energy Balance”

Caloric Intake



Energy Output

Intensive Exercise
does not
affect growth & maturation

As long as energy balance is maintained

Negative Energy Balance

Negative effect on Growth

Delayed Puberty

What can be done?

2 to 20 years: Girls

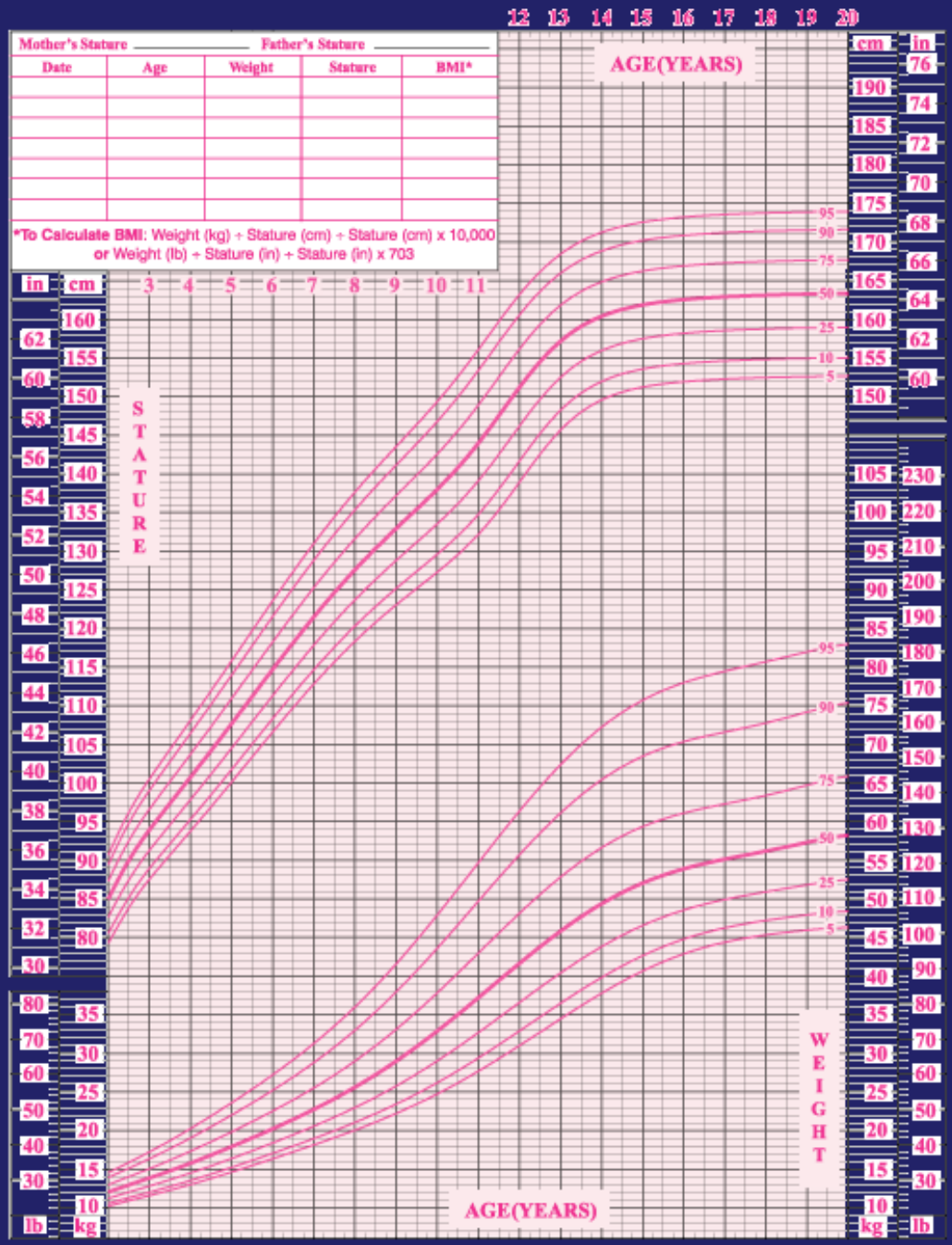
Stature-for-age and Weight-for-age percentiles

NAME _____

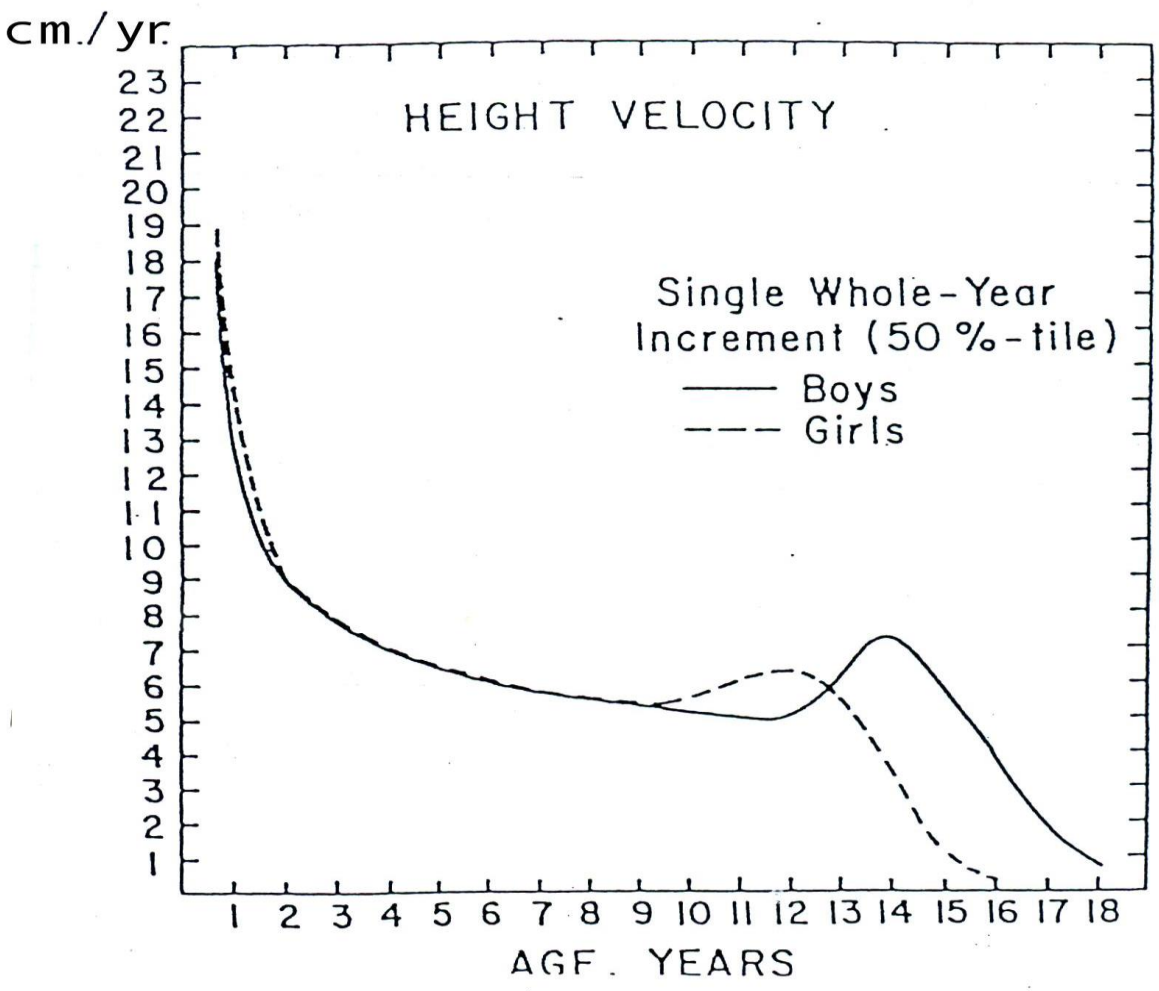
Mother's Stature _____ Father's Stature _____

Date	Age	Weight	Stature	BMI*

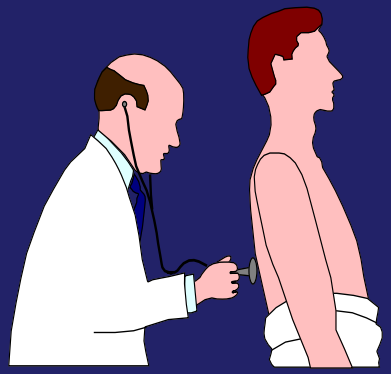
*To Calculate BMI: Weight (kg) ÷ Stature (cm) ÷ Stature (cm) x 10,000
or Weight (lb) ÷ Stature (in) ÷ Stature (in) x 703



Height Velocity curve



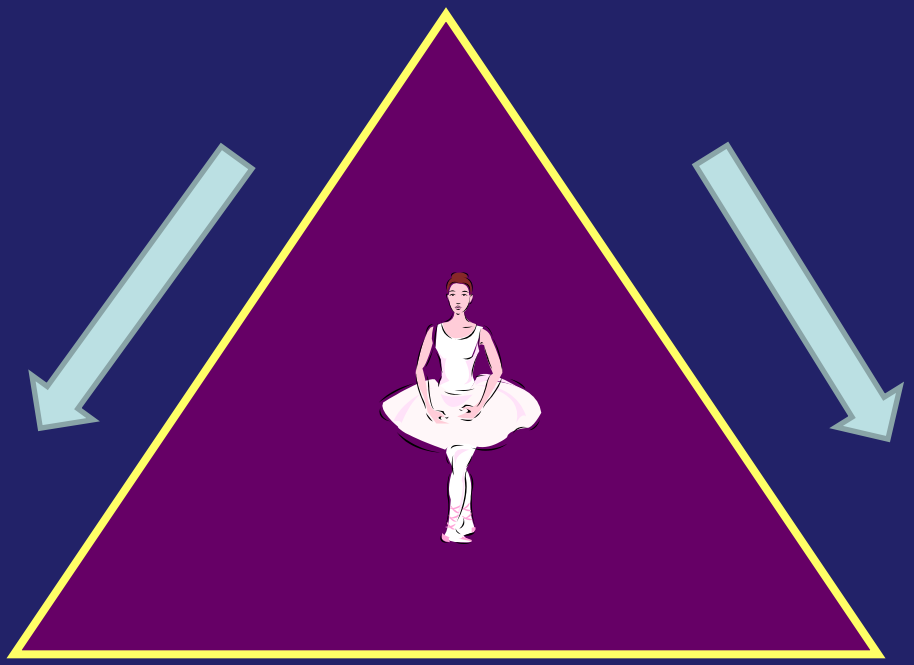
Pre-participation/season examination



FIMS + IOC: The goal of PPE
Is to prevent injury, illness and death

The Female Athlete Triad

Disordered Eating



Menstrual dysfunction → **Osteopenia**

Definition of Menstrual Irregularity

Eumenorrhea:

Menstrual cycles that occur at a median interval of 28 d.
plus or minus 7 days = between 21-35

Olygomenorrhea:

More than 35d between cycles (5 -10 cycles per year)

***Primary* Amenorrhea**:

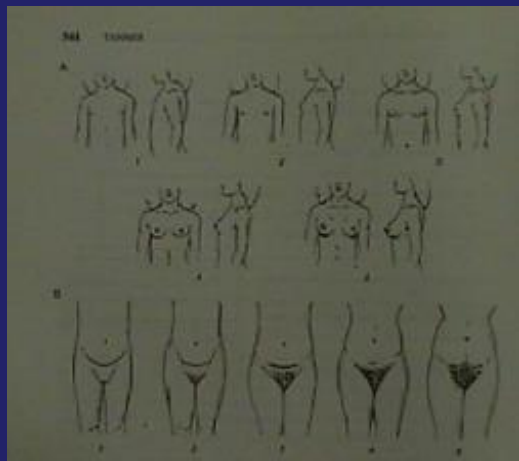
Onset of menses ≥ age 15 years

***Secondary* Amenorrhea**:

Absence of menstrual cycles for 3 or more consecutive months or <3 cycles per year

Menstrual cycle in athletes

- Delayed Puberty
- Delayed Menarche
- Primary amenorrhea
- Short Lutheal Phase (time from ovulation to bleeding)
- Anovulation
- Olygomenorrhea
- Secondary Amenorrhea



Age of Menarche in Athletes

Non Athletes	12.8
Ball games	13.0
Swimming	13.8
Ballet Dancing	14.5
Ice-skating	15.0
Gymnastic	15.6
Synchro	? (Sumbanis + 0.6, Ramsay – 13.7)

Prevalence of O/A* among Athletes

* Oligo/Amenorrhea

- Non –athletes 5%
- Ball Games 12%
- Swimming 12-30%
- Running 6-43%
- Ballet 59-70%
- Synchro ? Ramsay** 3/23, Ferrand 30.3%

**23% BF

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Exercise & Athlete's Menstrual Dysfunction

Type of activity

Training at early age

Amount & Intensity

Level of performance

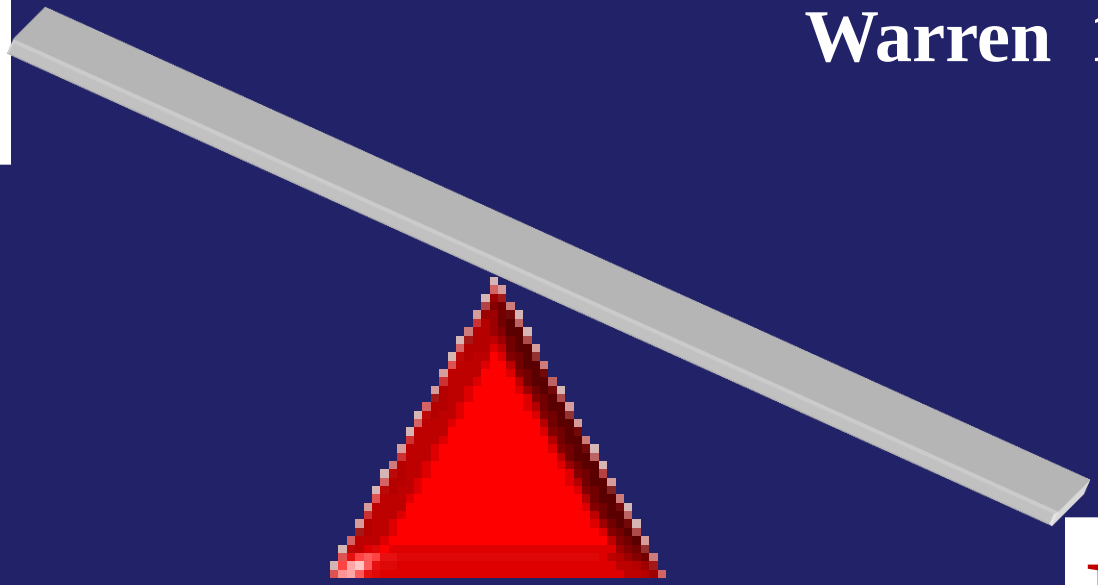
Mental stress

“Energy Availability”

Loucks 2002

Caloric Intake

“Energy drain”
Warren 1980



Energy Output

Energy Availability

- The amount of dietary energy available for all body functions after subtracting the energy required for exercise and physical activity.

- EA calculated as:
  = CALORIES IN - CALORIES OF EXERCISE
  – expressed relative to lean tissue mass

  – KEY CONCEPT: Energy Available ***must*** balance energy for basic cell function

Energy Availability

A healthy young adult is in energy balance at an **energy availability of 45 kcal/ffm/day**.

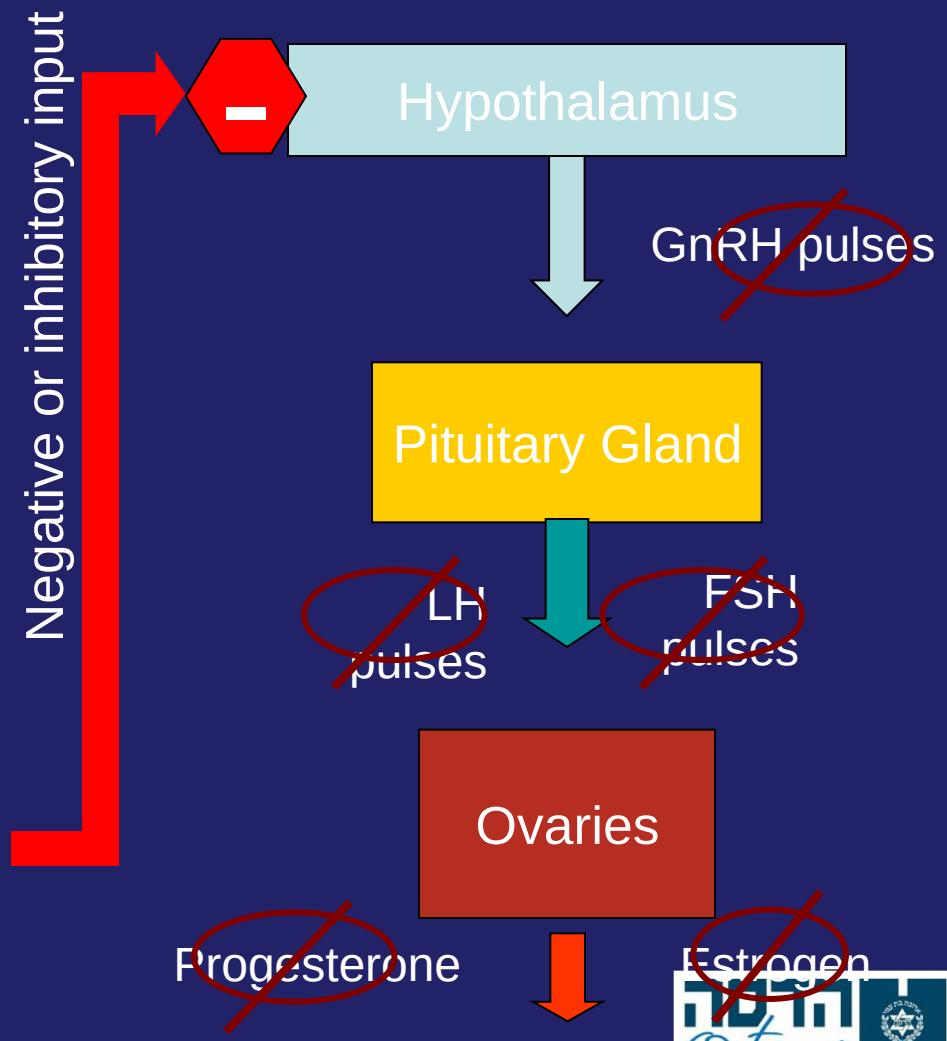
As energy availability declines the body suppresses cellular maintenance, thermoregulation, immunity, growth and reproduction to recover a **pathological energy balance**

Functional Hypothalmic Amenorrhea in the Female Athlete Triad

Low Energy Availability

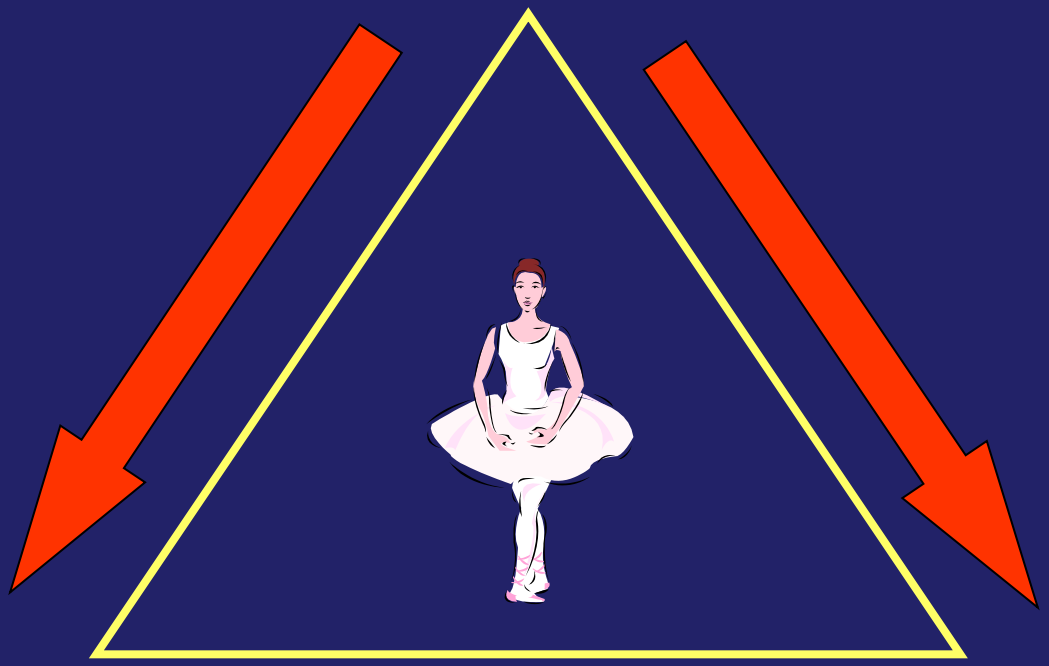
Physiological & Neuroendocrine Response

(ie. changes in leptin, cortisol, insulin, growth hormone, IGF-I, T3, glucose, fatty acids & ketones etc)



The Female Athlete Triad

Eating Disorders



Amenorrhea → **Osteoporosis**

Musculo-skeletal Problems

- **Failure to reach Peak Bone Mass**
- **Premature Bone Loss**
- **Risk of Musculoskeletal Injuries**

  (Frusztajer 90, Warren 86, Kadel 92)
- **Scoliosis**

  (Warren 86)

Bone is a dynamic tissue

- **Constant remodeling**
- **Dynamic balance between two opposing signals**
- **Osteoblasts stimulate bone formation**
- **Osteoclasts stimulate bone resorption**

Determinants of Bone Mineral Density

Genetics (60-80%)

Nutrition

Smoking

Drugs

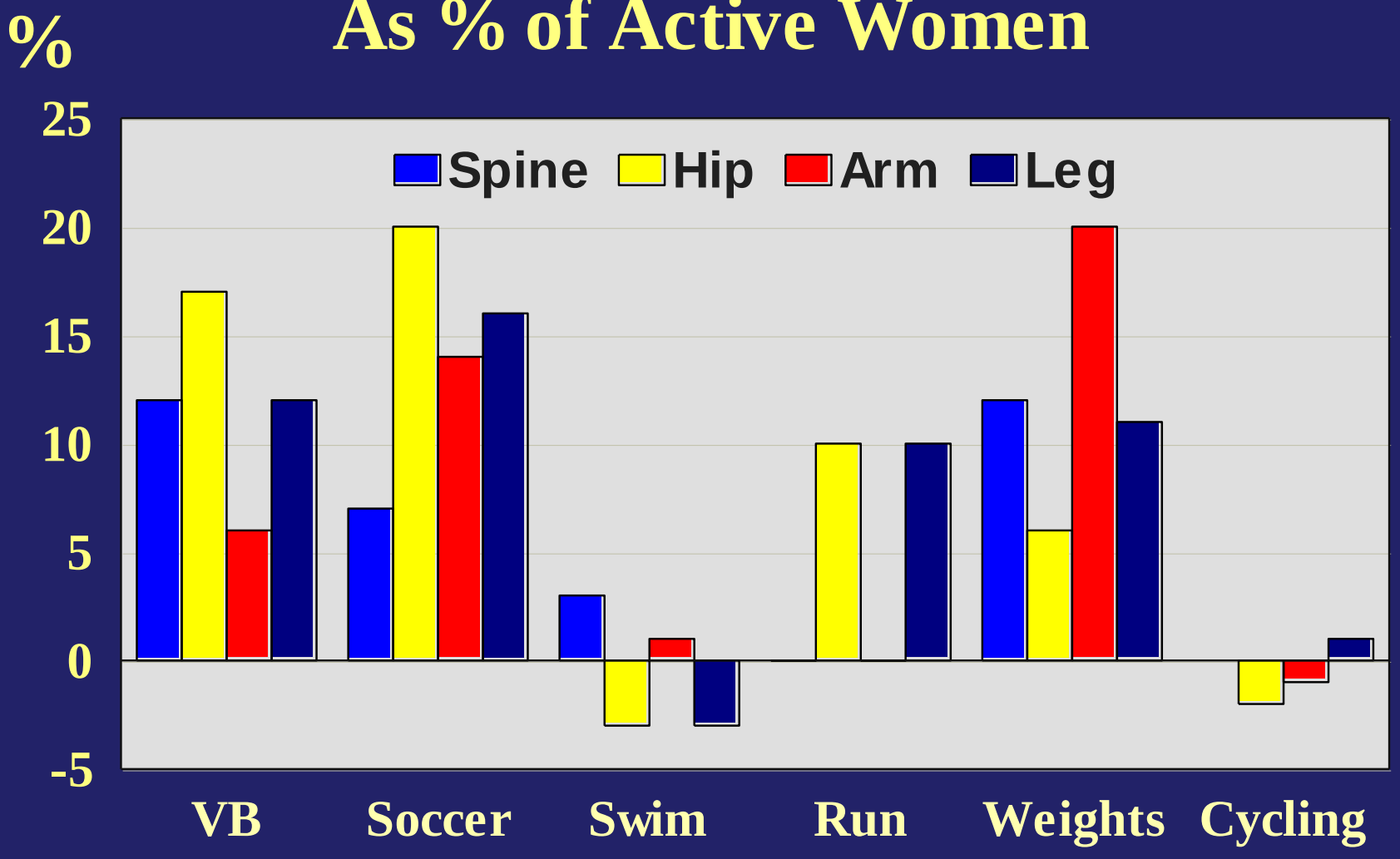
Alcohol

Exercise
Physical Activity

Hormones

BMD of Female Athletes

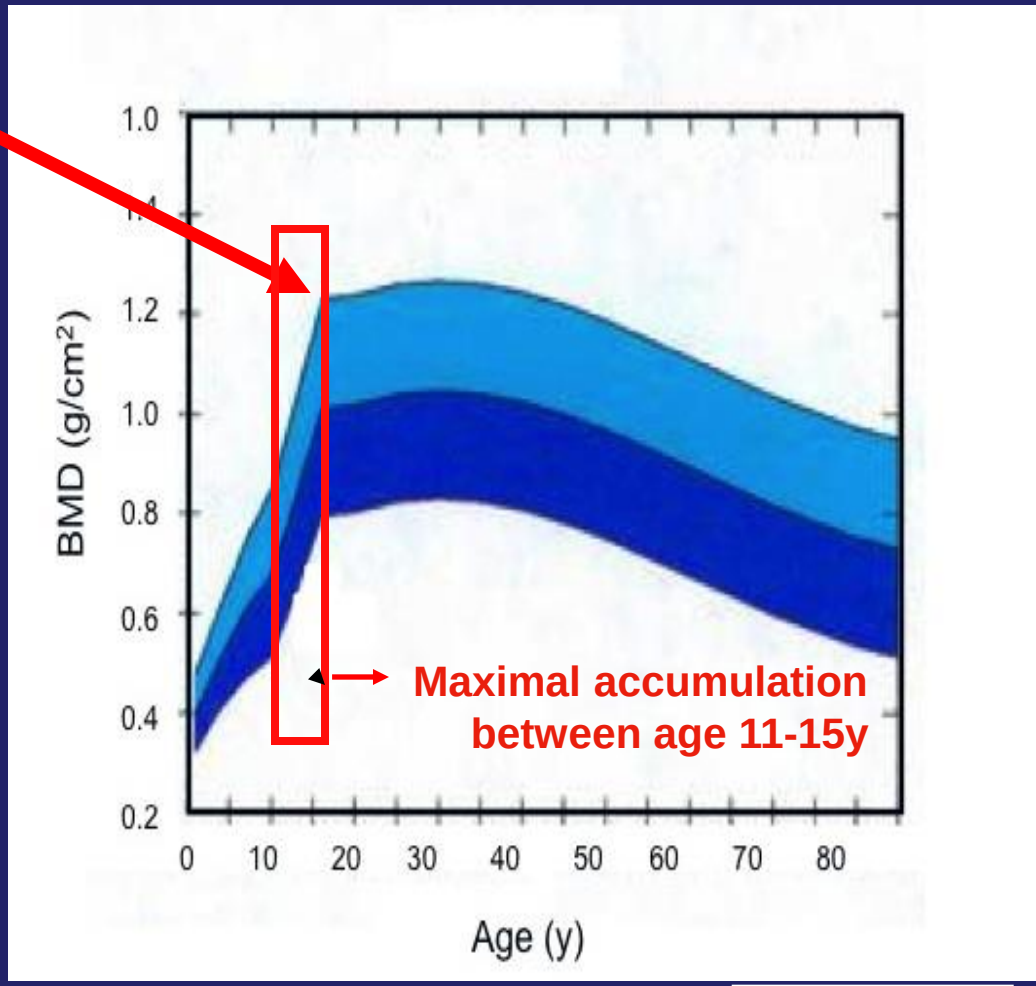
As % of Active Women



ASBMR

Stages of Bone Growth & Loss

- Peak (genetically set)
- Adolescent/pubertal growth determines whether BMD reaches genetic potential (peak)
- Adolescent bone mineral gains are modified by lifestyle, nutrition, environment & physical activity



Bone Mineral Density in Athletes

- P.A. does not compensate for poor nutrition and hormonal status
- Trabecular bone is the most affected

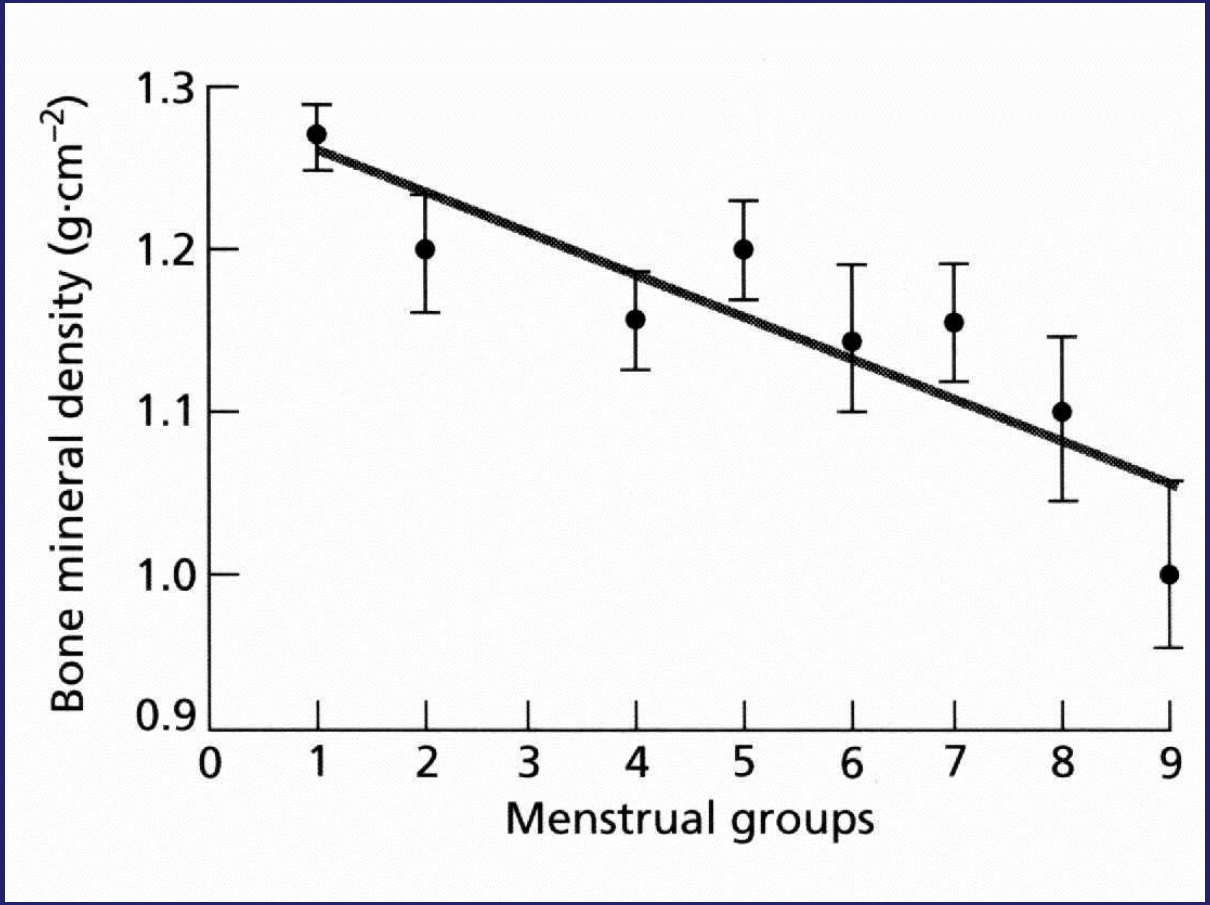
Bone Mass in Amenorrheic Females

Longitudinal Studies – Loss of 3-4%/year!

Drinkwater (runners), 1986

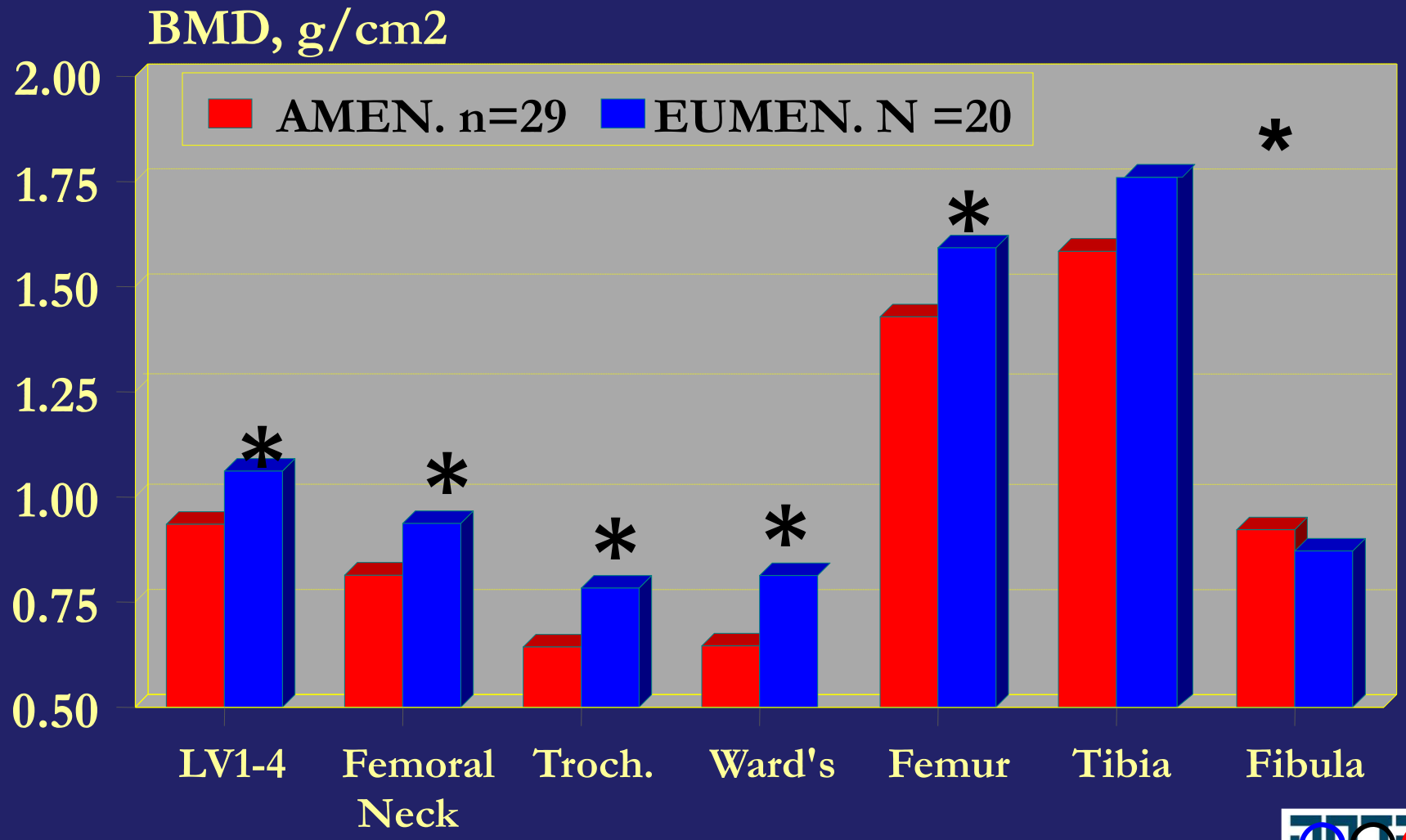
Cann (runners), 1988

Johnavithula & Warren (dancers), 1993



Drinkwater, JAMA, 1990: Regression of LBMD on menstr
history of 97 active women (from Regular to Amenorrheic)

Rencken, JAMA 96 : 29 amenorrheia (grey) & 20 eumenorrheic athletes av. age 26.3, mostly runners



BMD in SS

Roby – 1988
Lower forearm BMD than controls

Tanaka - 2006
Lower limb + LS lower than norms

Bone Speed of Sound, Bone Turnover and IGF-I in Adolescent Synchronized Swimmers

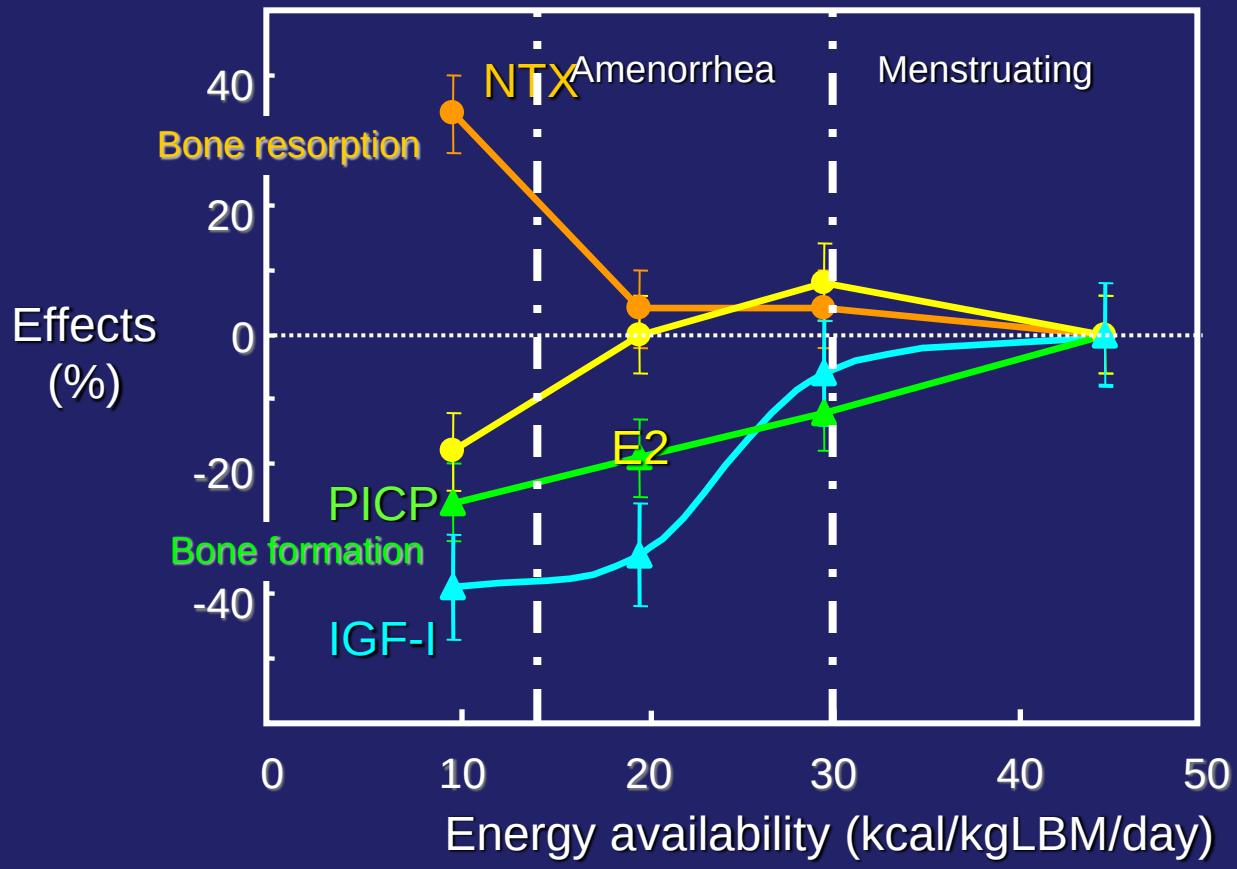
Izabella A. Ludwa, Bareket Falk, Matthew Yao, Lauren Corbett, Panagiota Klentrou

Table 1 Baseline Characteristics and Bone Speed of Sound (SOS) of Adolescent Synchronized Swimmers and Nonswimmers

	Synchronized Swimmers (n = 20)	Non-Swimmers (n = 20)
Age (yrs)	15.3 ± 1.2	15.2 ± 1.1
Age at menarche (yrs)	12.5 ± 1.2	12.1 ± 0.8
Height (cm)	166.1 ± 6.0	165.5 ± 5.7
Body Mass (kg)	56.8 ± 6.2	55.8 ± 7.3
Lean Body Mass (kg)	44.3 ± 4.2	42.8 ± 4.8
Segmental Lean Mass–Arm (kg)	2.1 ± 0.1	2.0 ± 0.1
Segmental Lean Mass–Leg (kg)	6.8 ± 0.2	6.7 ± 0.2
Relative Body Fat (%)	21.6 ± 5.4	22.8 ± 5.1
Radial SOS (m/s)	3956.5 ± 108.7	3964.3 ± 97.5
Tibial SOS (m/s)	3850.8 ± 80.5	3874.0 ± 70.9

Pediatric Exercise Science, 2010, 22, 421-430

Dose-Response Relationship Between Energy Availability and Bone Turnover in Young Women



Ihle & Loucks 2004

Iron deficency

with or without

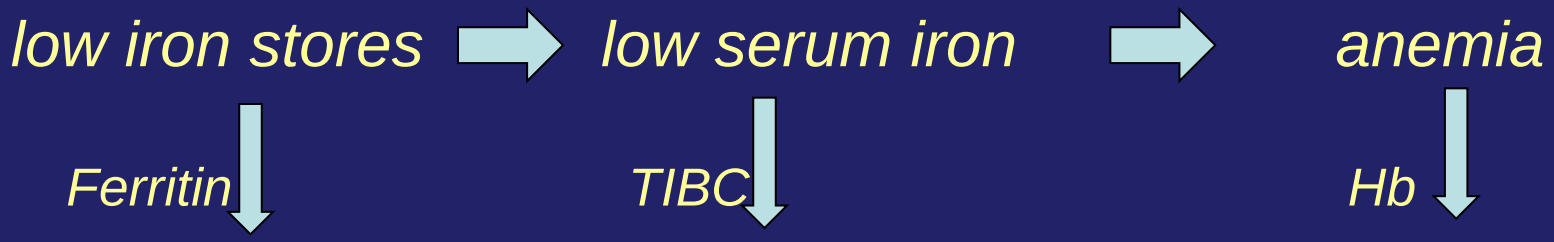
Anemia

Anemia

Men:
Hemoglobin< 14 gr%

Women:
Hemoglobin< 12 gr%

Iron def.



In Israel – High prevalence of poor iron stores among athletes of all disciplines (up to 50%!!)

Negative effect on mental & physical performance

Reasons for iron def.

Nutrition

Menstruation

Others

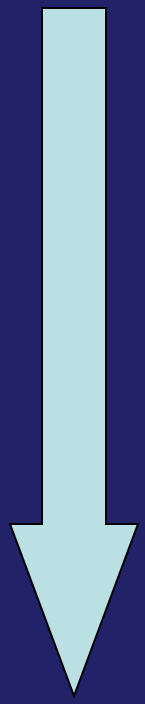
Recommendation

- Education
- Nutritional counseling
- Monitoring
- Treatment if Ferritin < 20

Poor eating habits in Athletes

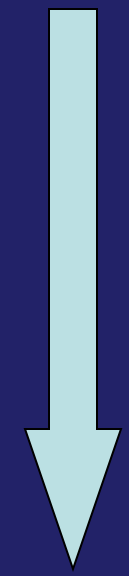
- Caloric deficit
- Minerals (Ca, Fe, Mg., Zinc)
- Vitamins
- Food composition
- Meals frequency
- Electrolytes Imbalance
- Hydration

Effects of ED on Performance

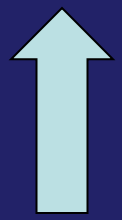


- Muscle Strength & Endurance
- Muscle Glycogen Stores
- Aerobic Capacity & O2 Consumption
- Blood Volume
- Cardiac Output
- Slow Recovery
- Coordination

Effects of DE on Performance



- Concentration
- Irritability
- Depression
- Impaired Judgment
- Impaired Thermogenesis



- Injury Risk

Prevention by:
Optimizing Energy Availability

Educate, Educate and Educate some more!

Educate the athlete, physician, coach, parent, other allied health professionals, athletic program administrators

Policy Change

National and international governing bodies for sports need to develop policies and procedures to eliminate potentially harmful weight loss practices

Prevention: Change The Mindset

- **Food is needed to meet the energy availability needs for basic cell function (growth, cellular activity, healing) *in addition to calories* or energy need for activity & performance**

Food is not the enemy….

The Female Athlete Triad-Prevention

- Awareness
- Education
- Realistic Weight goal (%fat)
- Nutritional guidance
- Growth & development f/u
- Early Intervention in cases of amenorrhea
- Professional help

"IOC Triad Prevention Program
"Hungry for Gold"

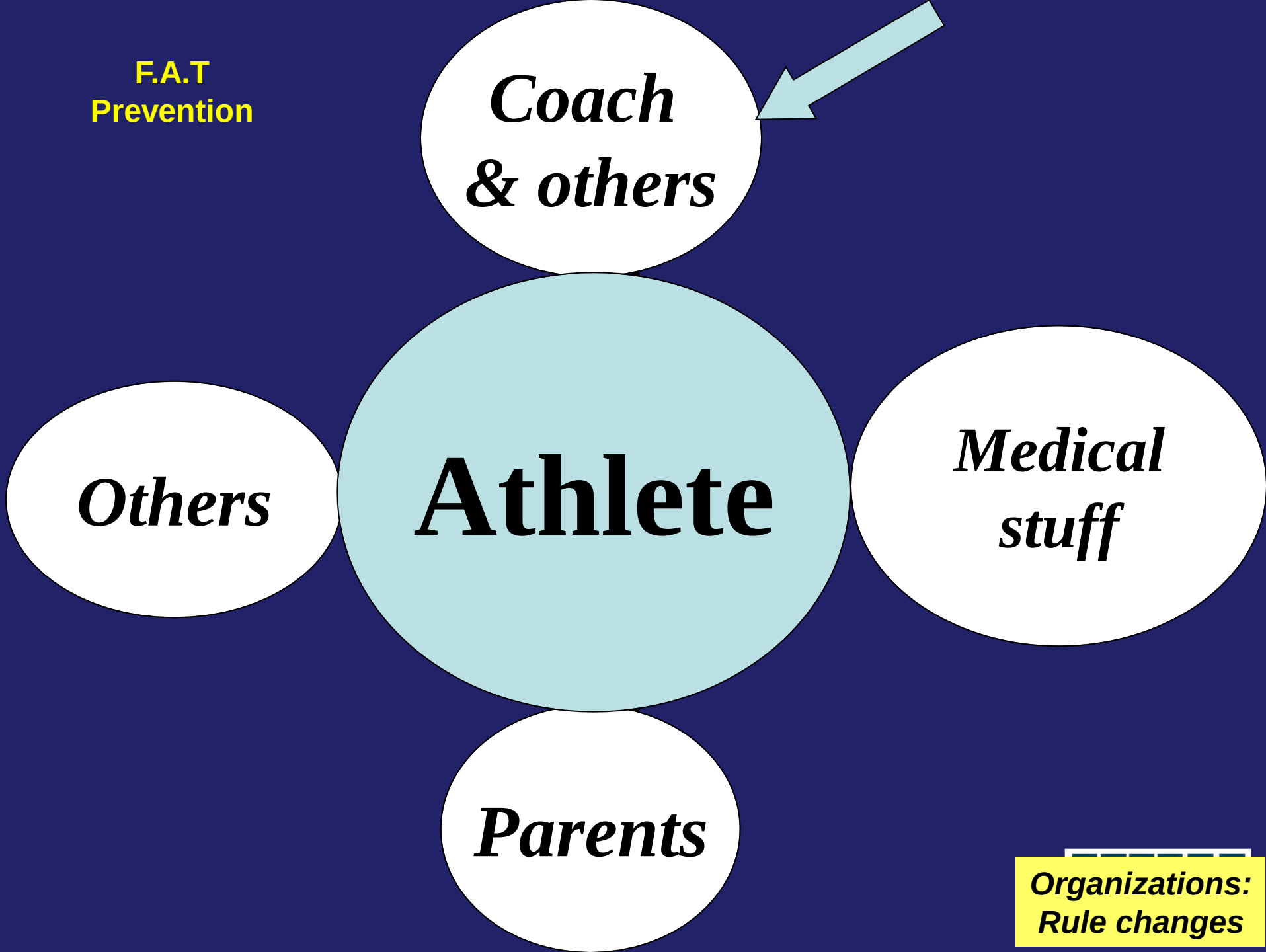
www.olympic.org

Anezka Ruzicka

International Olympic Committee

IOC World Conference on Prevention of Injury & Illness in Sport

F.A.T
Prevention



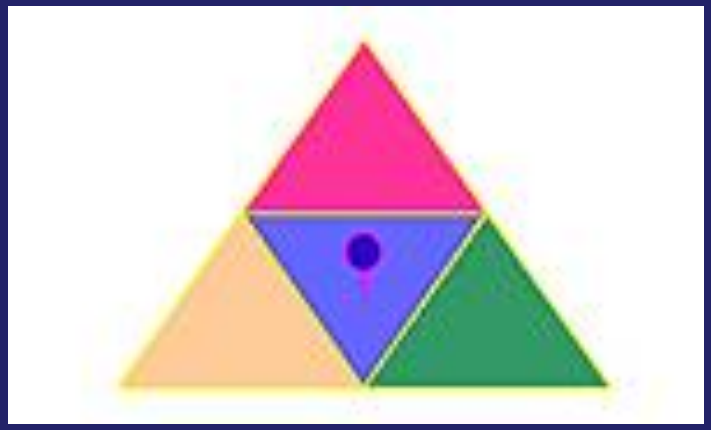
Organizations:
Rule changes

Changing Rules

- Age limitation (16….15)
- Scoring system
- Dress code
- Weight categories
- Anthropometric limitations?
- Medical clearance?

IOC CONSENSUS STATEMENT ON THE FEMALE ATHLETE TRIAD

Lausanne, November, 2005



November 2013

המרכז לרפואת ספורט

Thank-you!

Rakefet Arieli

Ran Shabtai

Shiri Weinberg

Margo Montjoy