



*Department of Sport Medicine  
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# **Insulin Action in Elite Endurance and Sprint Athletes**

**7th Annual Congress of the European  
College of Sport Science**

**ATHENS 2002**

## AEROBIC TRAINING...

### Increase:

- Capillary density & muscle blood flow
- Number/activity of Glut-4
- Nonoxidative glucose metabolism - glycogen synthesis
- Oxidative enzyme activity
- Lipid metabolism

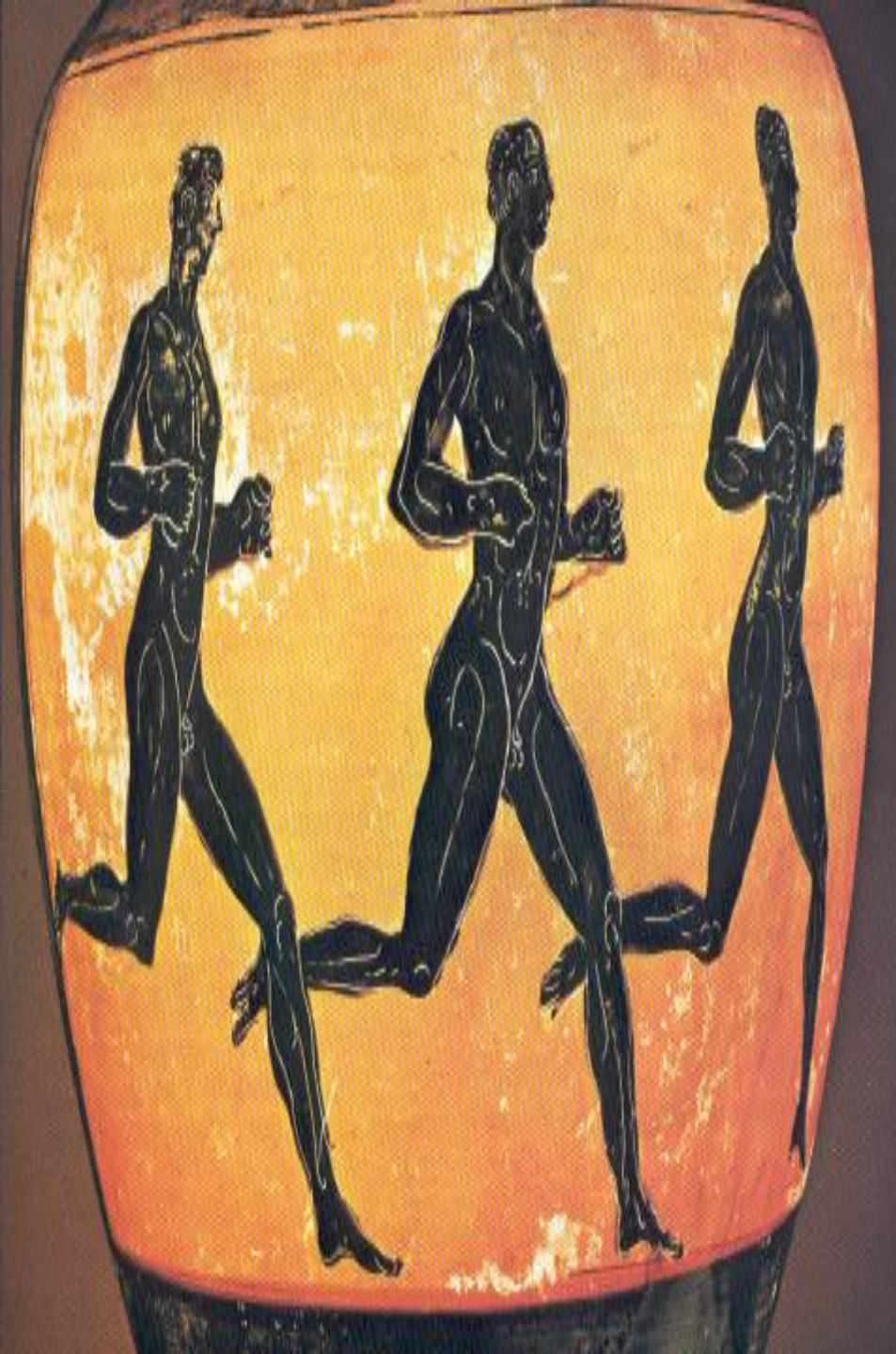
### Decrease:

- Body fat mass
- Hepatic glucose production



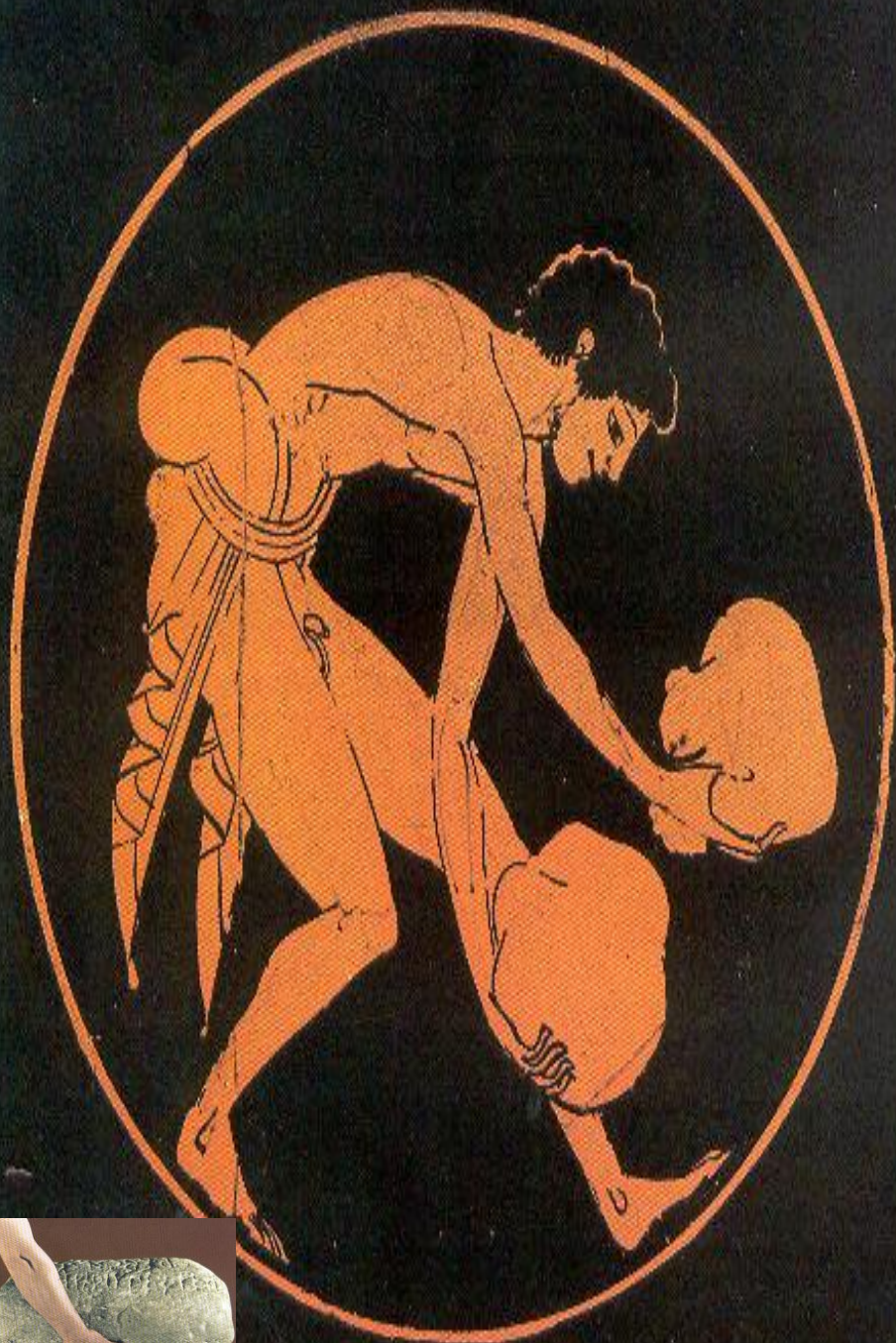
*...Blood Glucose Control*

Houmard, et. al., 1991, 1995; Hardin, et. al., 1995;  
Ebeling, et. al., 1993; Andersen & Henriksson, 1977;  
Holmang, et. al., 1992; Lillioja, et. al., 1987;  
Simoneau & Kelley, 1997; Bjorntorp, et. al., 1972;  
Yki-Jarvinen, & Koivisto, 1983; Rodnick, et. al., 1987.





## RESISTANCE TRAINING...



### Increase:

- Capillary-to-muscle-fiber ratio & muscle blood flow
- Nonoxidative glucose metabolism - glycogen synthesis
- Muscle mass
- Lipid metabolism

### Decrease:

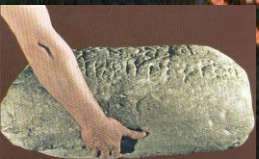
- Body fat mass

?

- Hepatic glucose production
- Number/activity of Glut-4



*...Blood Glucose Control*



Tesch, 1988; Miller, et. al., 1994; Miller, et. al., 1984;  
Craig, et. al., 1989; Yki-Jarvinen, & Koivisto, 1983;  
Houmard, et. al., 1995



(A)

Chronic  
Aerobic Training  
or  
Chronic  
Anaerobic Training

(B)

Body Fat and  
Muscle Mass role

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# Methodological approach...



## HOMEOSTATIC SYSTEM

Insulin Release

Peripheral Resistance

OGTT

Glucose Load

GUP-factors  
• insulin action  
• glucose-mass action

Insulin Curve

Metabolized Glucose

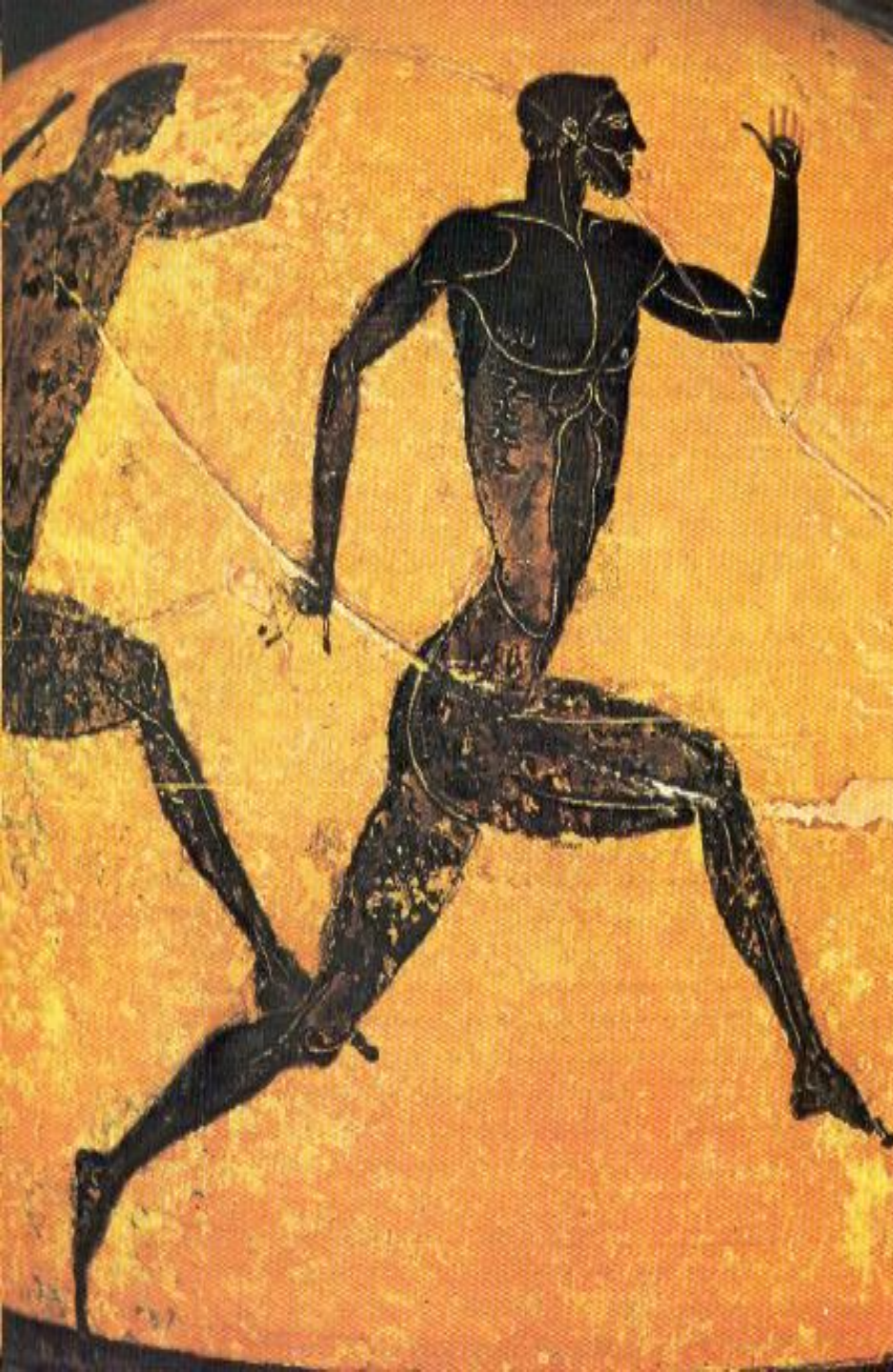
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## THE SUBJECTS...

- 8 elite endurance runners
- 8 elite sprint runners &
- 7 untrained subjects-control

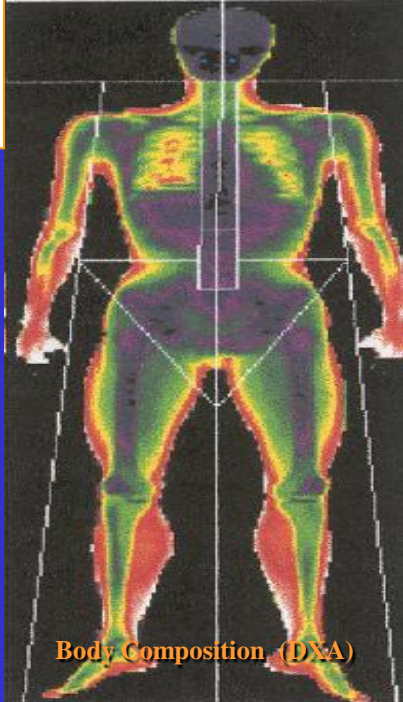
### Profile of the Athletes

	Endurance runners	Sprint runners	n
Age (yr)	24±3,16	23,75±1,67	23
Training ( yr)	7,63±3,66	7,25±3,06	16
100m (")	--	10,64±0,22	4
110m (")	--	14,00	1
200m (")	--	21,71±0,32	5
400m (")	--	47,64±1,68	2
H. Jump (m)	--	7,64	1
5000m (')	15,02±0,84	--	8
10000m (')	30,51±1,23	--	6





# Physiological Tests...



Fat (kg)	Lean (kg)	PVO2 (mL/kg/m)	AVT (%)	PP (W/kg)	MP (W/kg)	Lact (mmol/L)
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**Endurance runners**

4.9±2.2	52.9±3.1	72.6±4.9*	79.6±7*	11.4±0.6	8.6±0.6*	14±2
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**Sprint runners**

6.2±1.6	68.7±5.4*	51±2.8	68.7±5.3*	13.6±0.6*	9.2±0.3*	18.3±2*
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**Control**

16.1±7.3*	55.4±5.6	44.8±6.6	59.4±6.8	11.8±1.2	7.6±0.8	18±2*
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## Preconditions

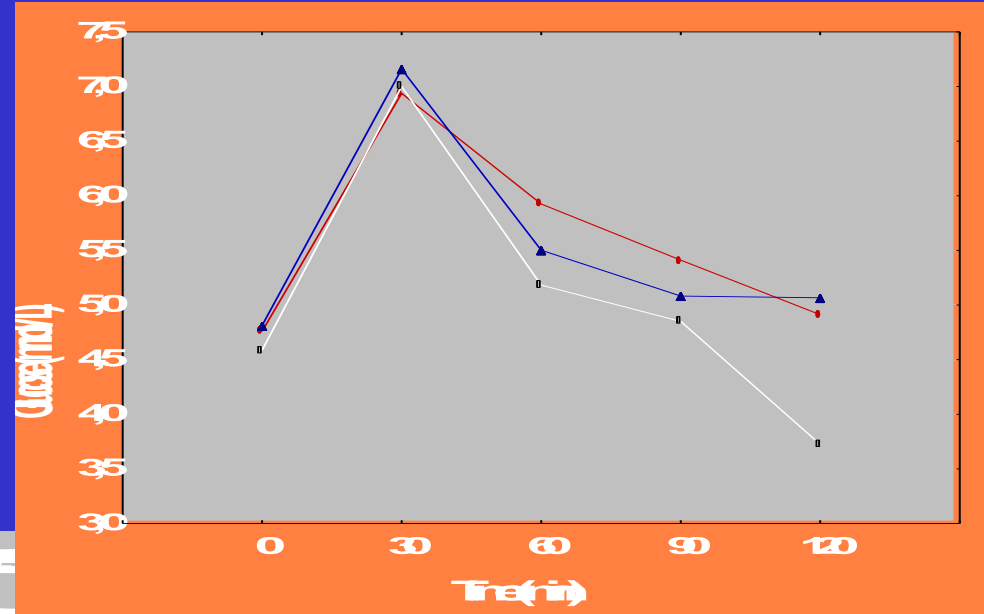
- **Diet** ... (250-300 g/d CHD)
- **Fasting** ... (12.24±1.53 h)
- **Refraining from exercise** ... (52.21±10.24 h)

## Procedure

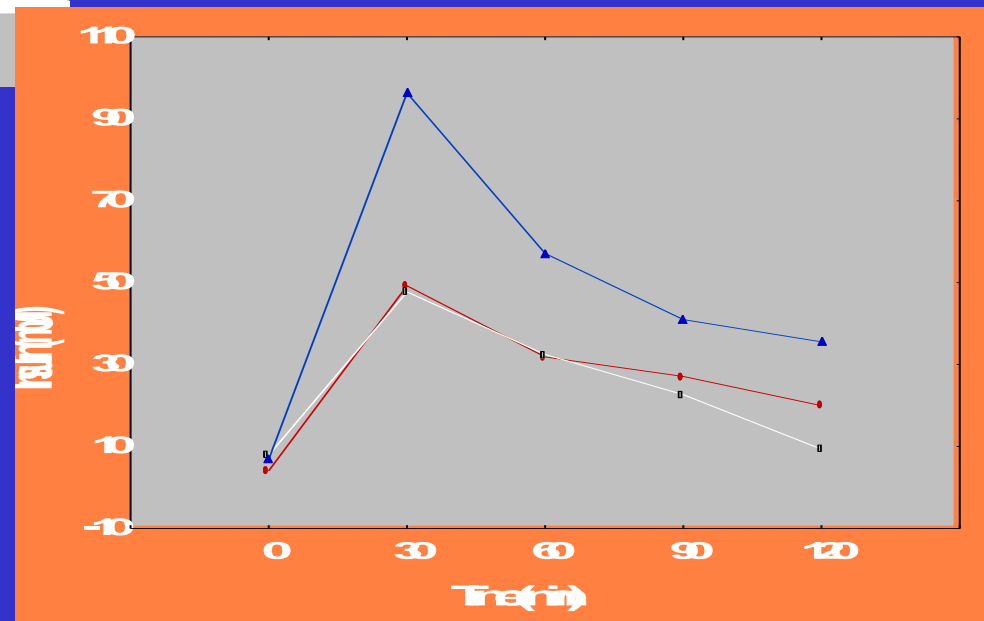
- **Glucose Load** ... 75g anhydrous glucose in 400 ml water
- **Blood Samples** ... 0', 30', 60', 90' & 120'
- **Time of the first blood sample** ... 11.09±1.18 a.m



## Glucose Curves



## Insulin Curves

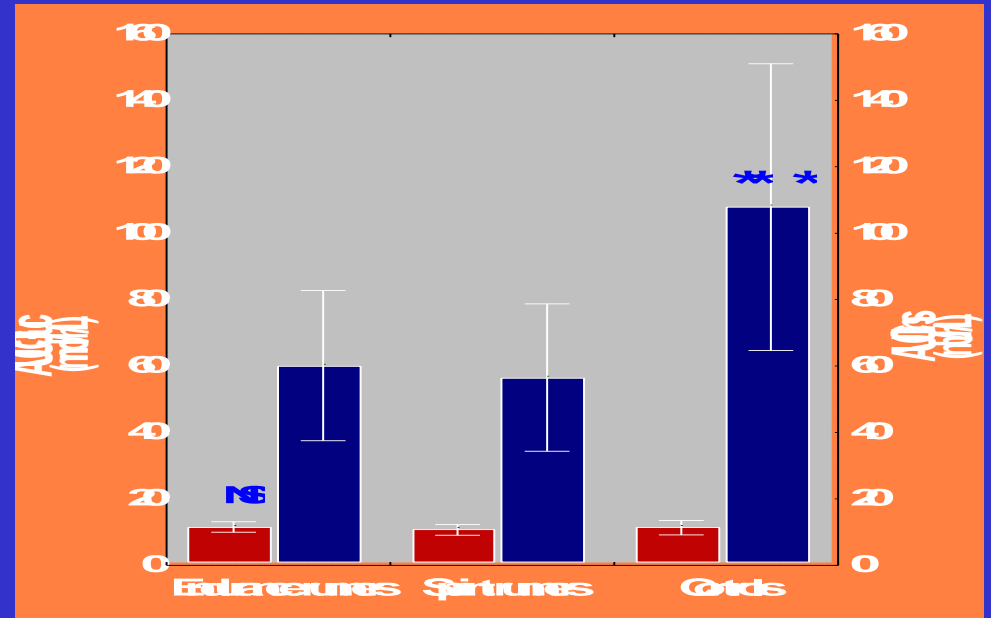


# Insulin Release...

Total Areas  
under the Curves:

Glucose ■

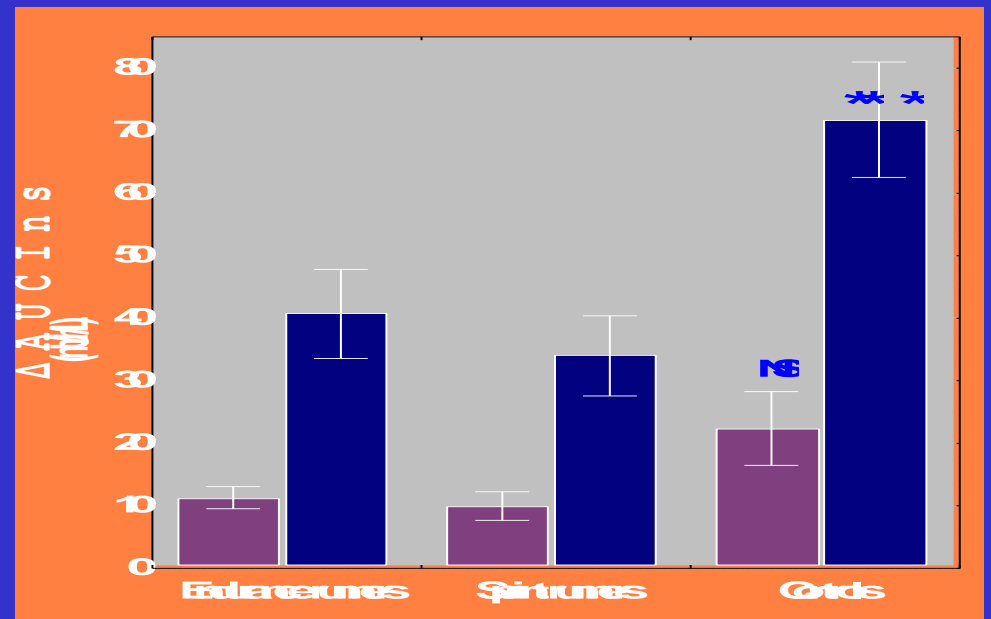
Insulin ■



Delay of  
Insulin Release:

0'-30' ■

30'-120' ■

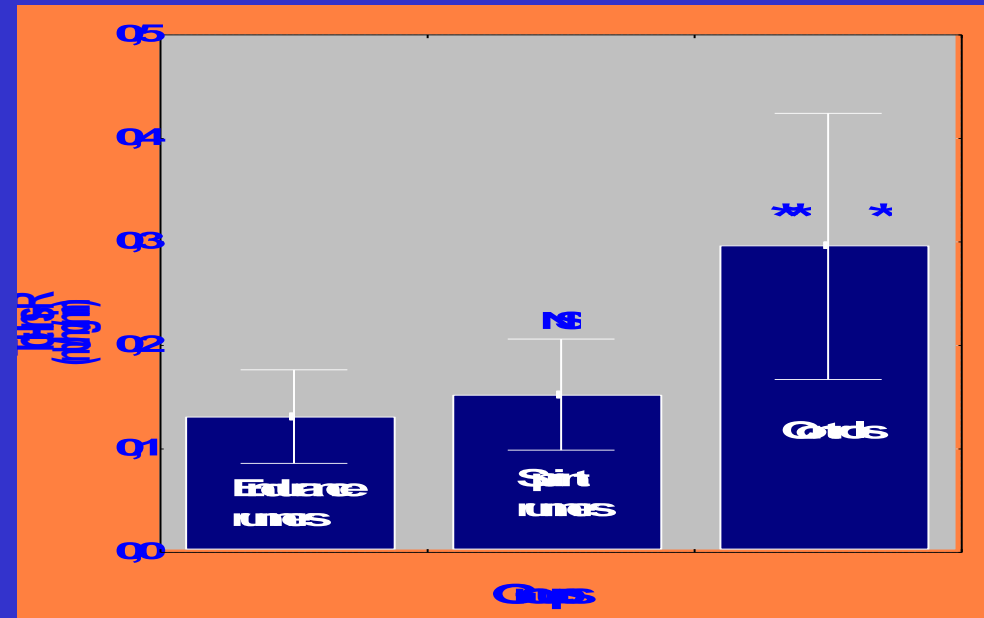




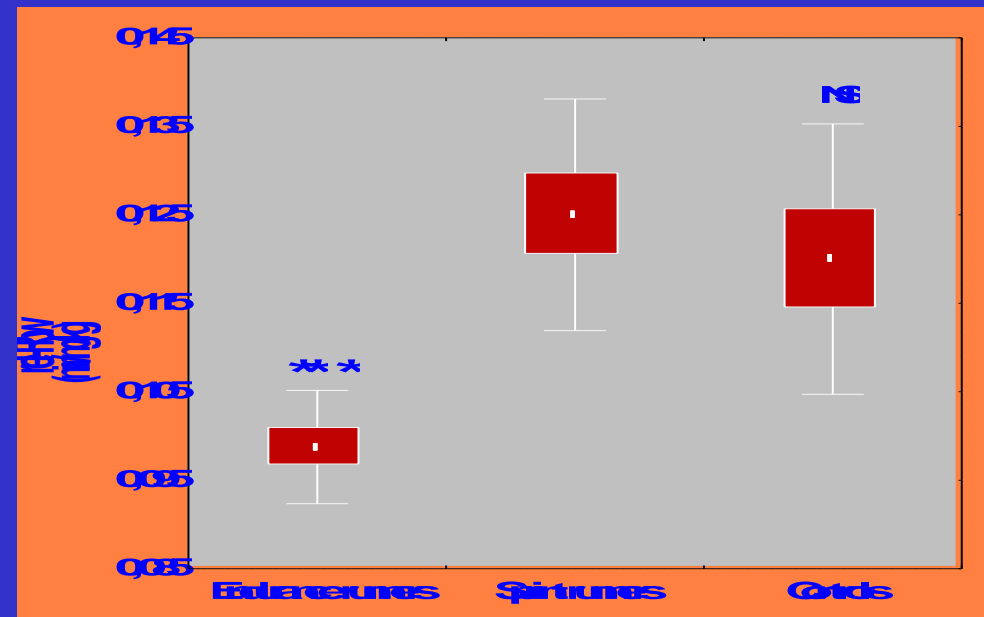
**...The higher insulin release  
the greater target-tissues (muscle, fat, liver)  
resistance to insulin action.**

# Peripheral Resistance...

**Total Insulin  
Resistance**



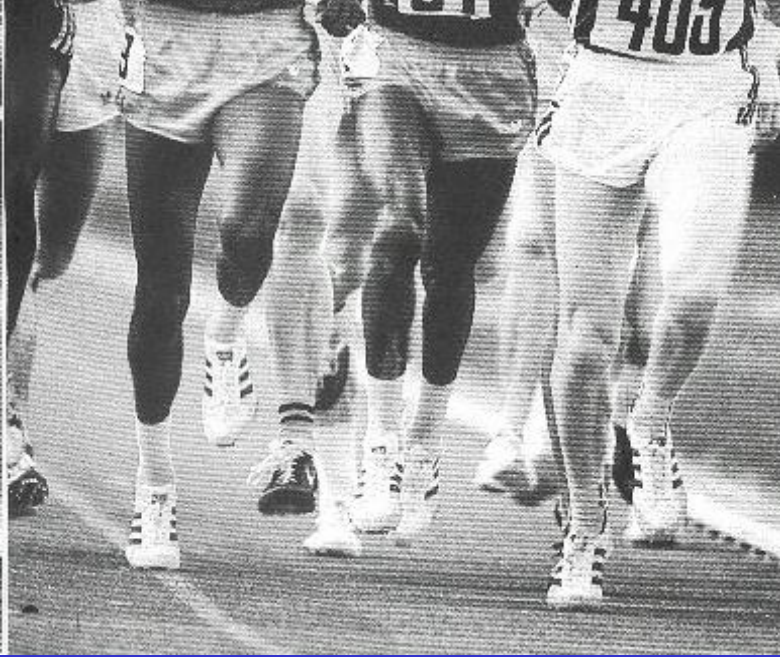
**Relative Peripheral  
Resistance (1 / M)\*  
(kg BW)**



\* Cederholm, & Wibell, 1985



Thesis 1...



**ENDURANCE RUNNERS**

**have the lowest target-tissues  
resistance to insulin...**



**...best Insulin Sensitivity!**



## **SPRINT RUNNERS**

**have lower target-tissues  
resistance to insulin**

**compare with untrained subjects...**



**...better Insulin Sensitivity!**



# The Strongest Predictor...

## rel-Rbw

	<i>r</i>	<i>P</i>
<b>Lean mass</b>	<b>0.69*</b>	<b>&lt;0.001</b>
<b>Fat mass</b>	<b>0.61*</b>	<b>&lt;0.003</b>
<b>PVO2</b>	<b>-0.75*</b>	<b>&lt;0.001</b>
<b>AVT</b>	<b>-0.43*</b>	<b>&lt;0.044</b>
<b>Lact</b>	<b>0.55*</b>	<b>&lt;0.007</b>

## Tot-Ins-R

	<i>r</i>	<i>P</i>
<b>Fat mass</b>	<b>0.69*</b>	<b>&lt;0.001</b>
<b>PVO2</b>	<b>-0.52*</b>	<b>&lt;0.013</b>
<b>AVT</b>	<b>-0.47*</b>	<b>&lt;0.024</b>
<b>MP</b>	<b>-0.57*</b>	<b>&lt;0.005</b>



## **LOW BODY FAT**

**has the most positive effect  
to Insulin Sensitivity..**



**...better Lipid Metabolism!**

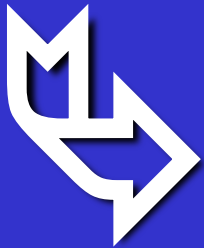




**LARGE MUSCLE MASS**

**has not any positive effect**

**to Insulin Sensitivity..**



**...no change in Muscle Metabolism?**

## TYPE OF TRAINING...

- **Aerobic Power**

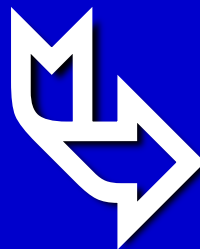


- **Anaerobic Threshold**

- **Muscles Endurance**



- **Body Fat**



**...ISULIN ACTION  
IMPROVEMENT**

## CONCLUSION...

**The chronic adaptations of both  
Aerobic and Anaerobic  
track and field training  
have positive effect to Insulin Action,  
but those induced by  
the Aerobic type of training  
have the most pronounced effect.**

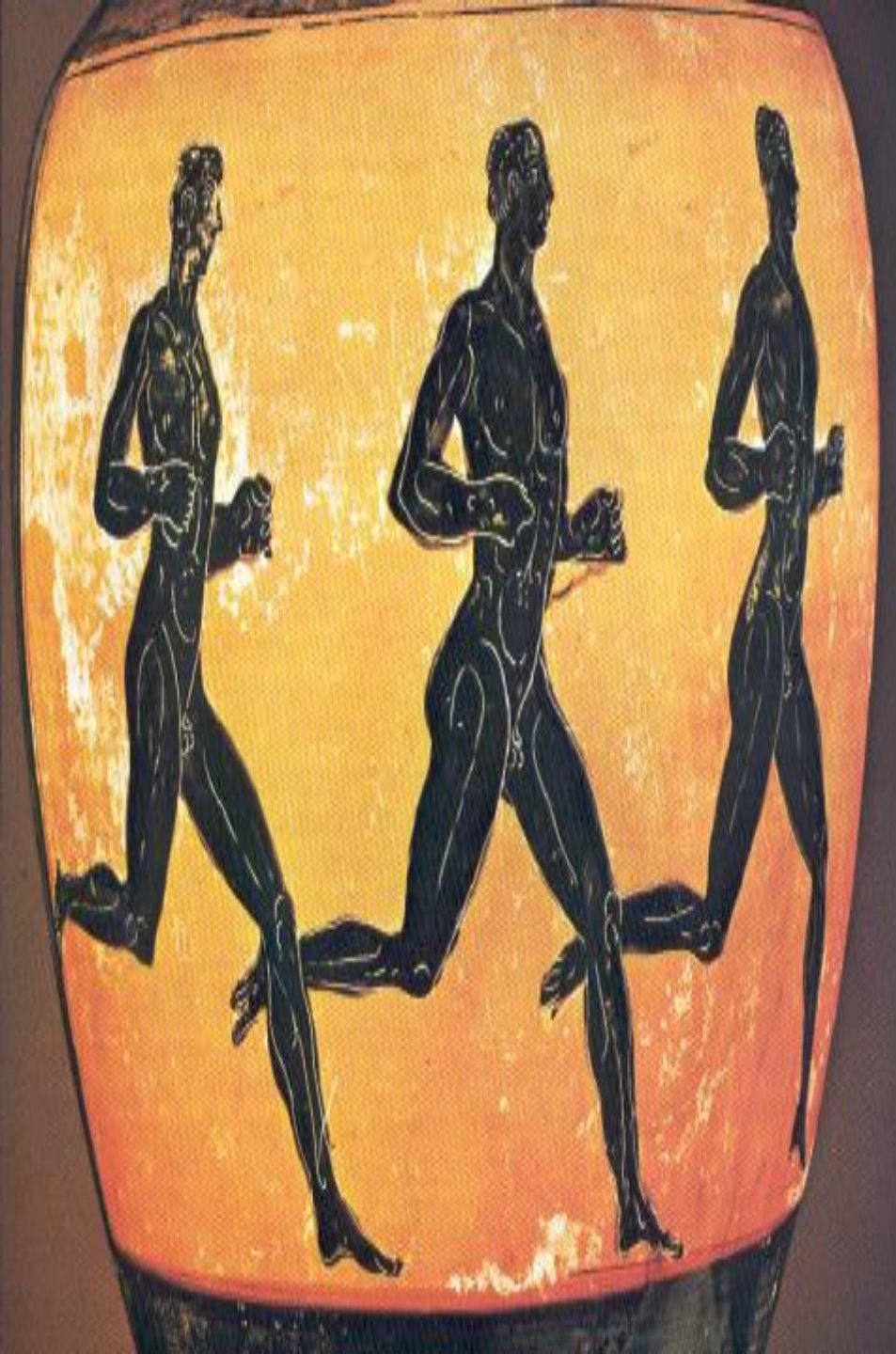




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**I thank you**

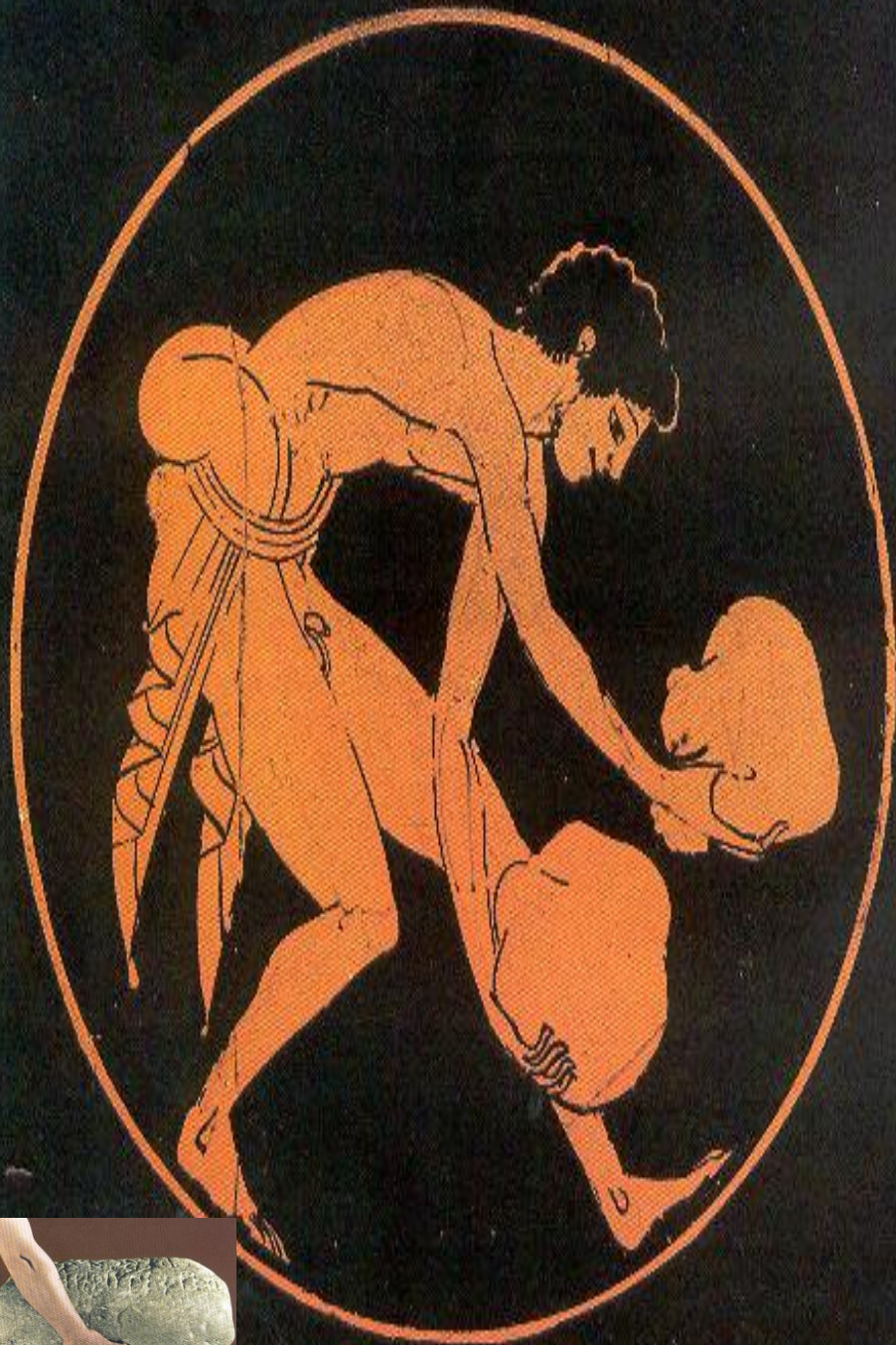




- **Glucose Transport and Metabolism**
- **Body Composition and Lipid Metabolism**
- **Hepatic Glucose output**
- **Insulin Signaling**







- **Glucose Transport and Metabolism**
- **Body Composition and Lipid Metabolism**

?

- **Insulin Signaling**
- **Hepatic Glucose output**



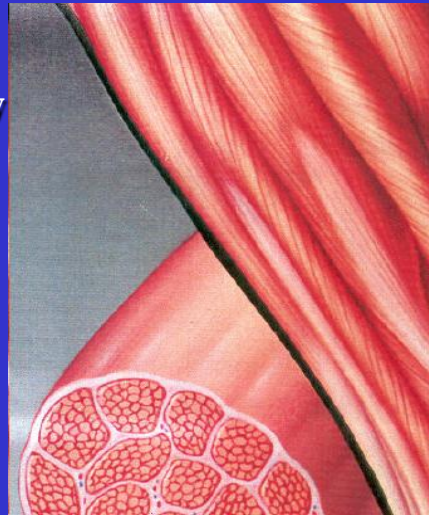
*...Blood Glucose Control*



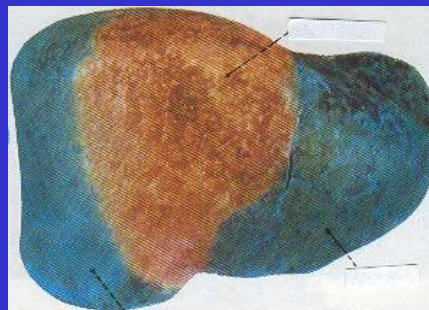
# Body Fat apart (bibliography accordance)...

## Aerobic training

- Capillary density-muscle blood flow
- Oxidative enzyme activity
- Number/activity of Glut-4
- Nonoxidative glucose metabolism-glycogen synthesis



- Hepatic glucose production



## Anaerobic training (resistance training)

- Capillary-to-muscle-fiber ratio-muscle blood flow
- Nonoxidative glucose metabolism-glycogen synthesis
- ? • Number/activity of Glut-4



- ? • Hepatic glucose production



**I thank you**

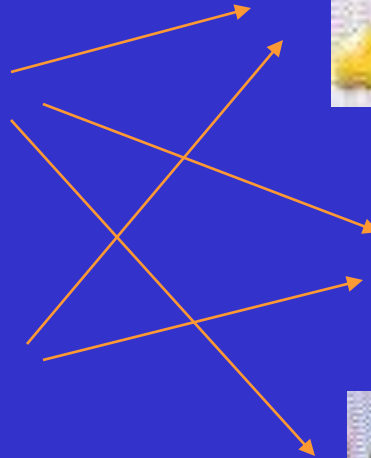
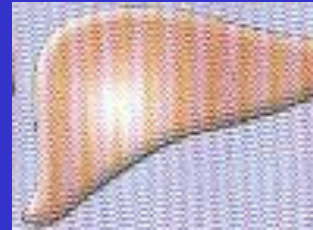




# Adaptations...

**Aerobic training**

**Anaerobic training**

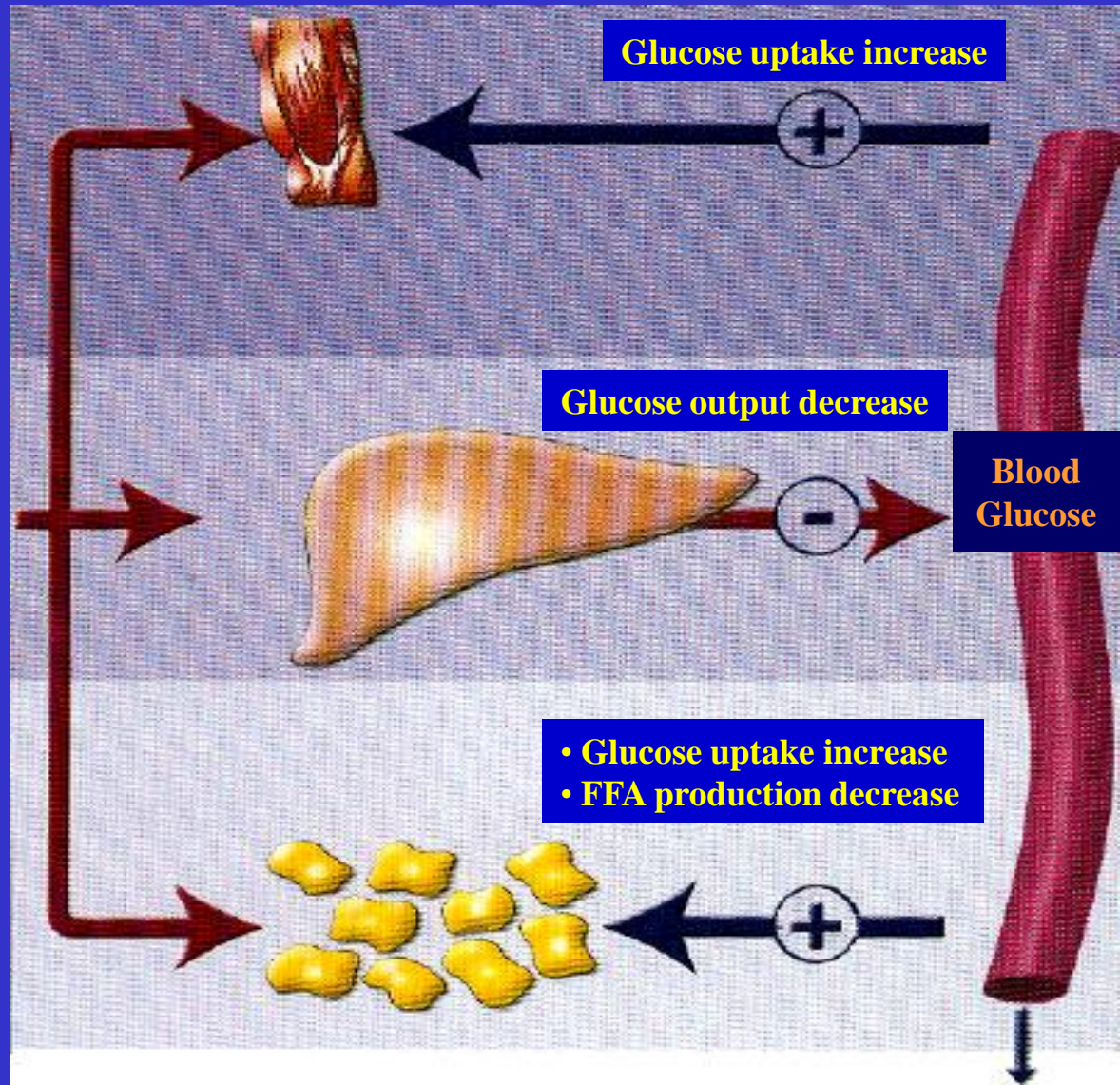




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**BLOOD GLUCOSE CONTROL**