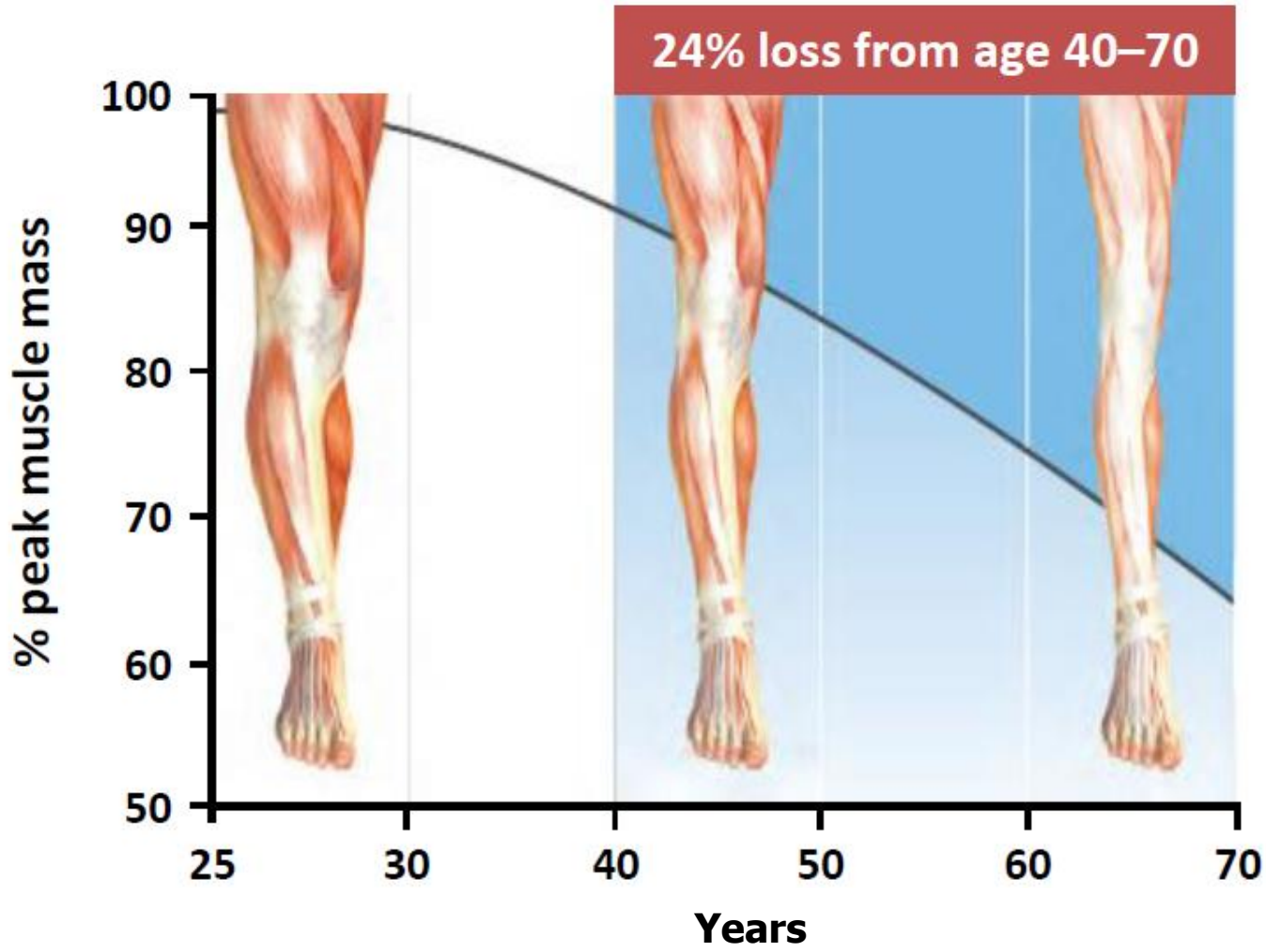
# Una corretta nutrizione per la salute muscolare

Stefano Volpato

**Dipartimento di Scienze Mediche – UNIFE &**
**Dipartimento Medico ad Attività Integrata – OSPFE**

Università degli Studi di Ferrara
Dipartimento di Scienze Mediche

# Age-related anthropometric changes

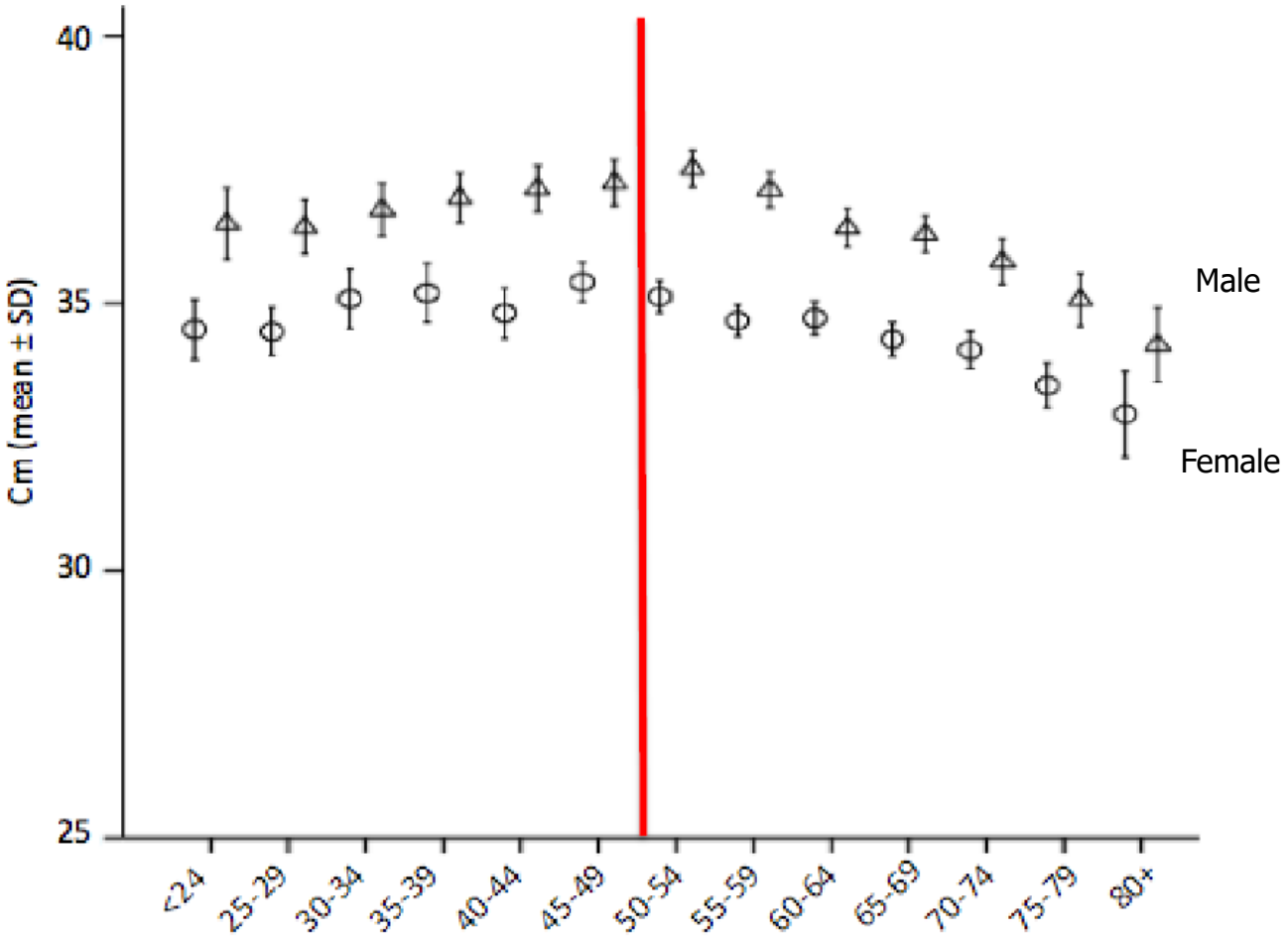



**15% loss each decade after age 70**

Flakoll P et al , Nutrition 2004

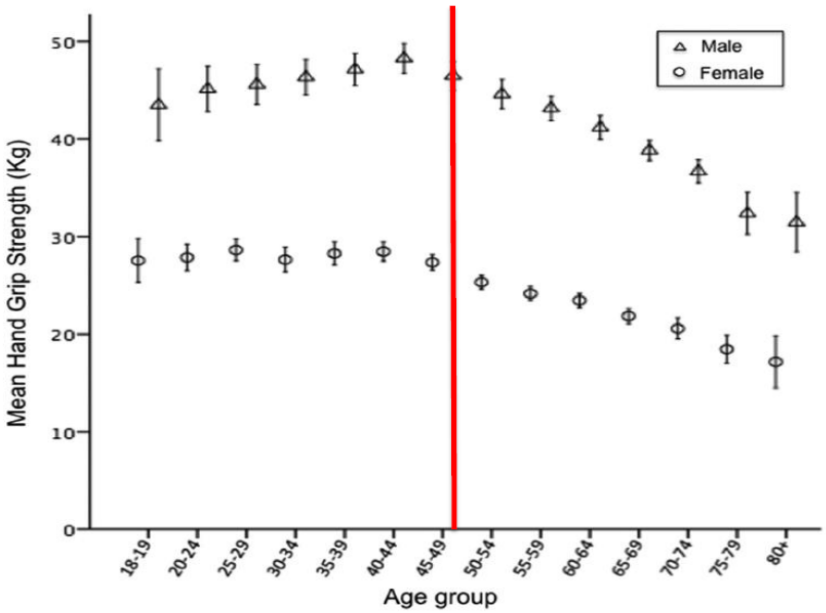
Bajers S et al, JPEN 2009

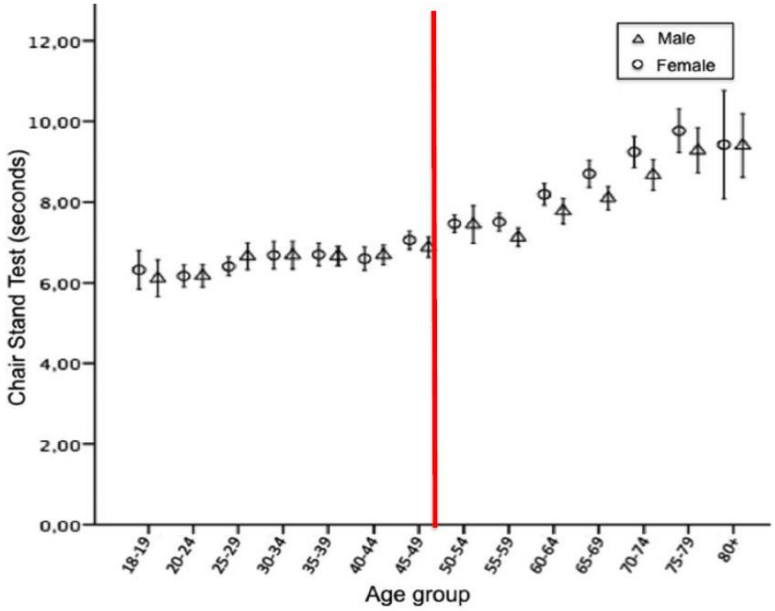
# **Aging, muscle and function:**
1,853 visitors of the Milan EPXO




Landi F. et al JAMDA 2017

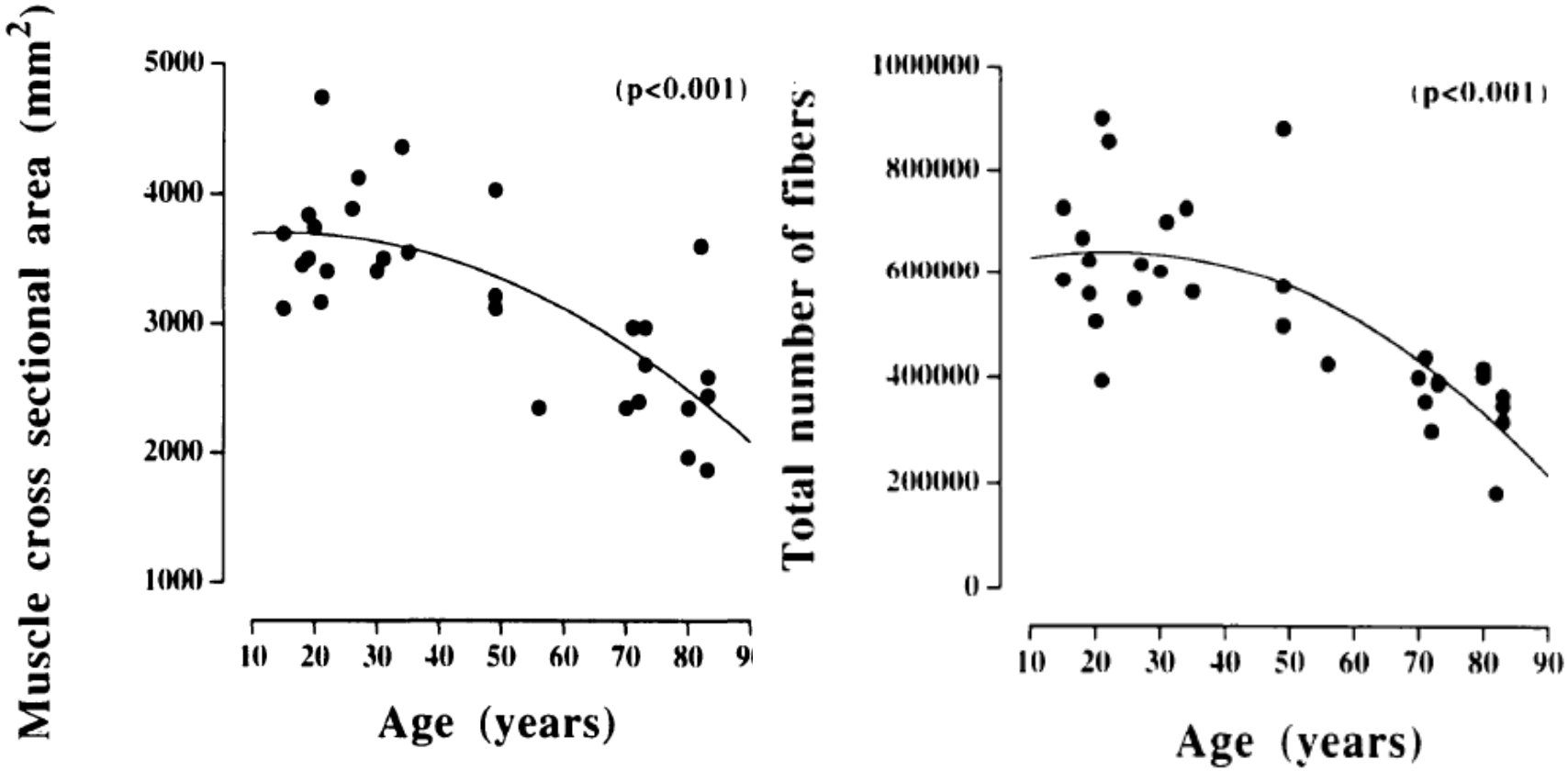
# **Aging, muscle and function:**
# 1,853 visitors of the Milan EPXO



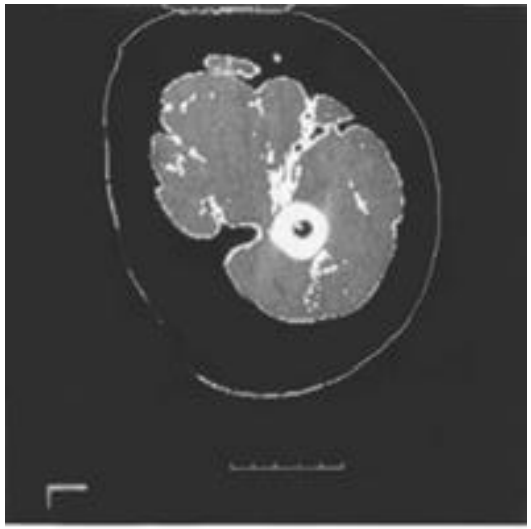

Landi F. et al JAMDA 2017

# Relationship between age, muscle cross-sectional area, and total numbers of fibers

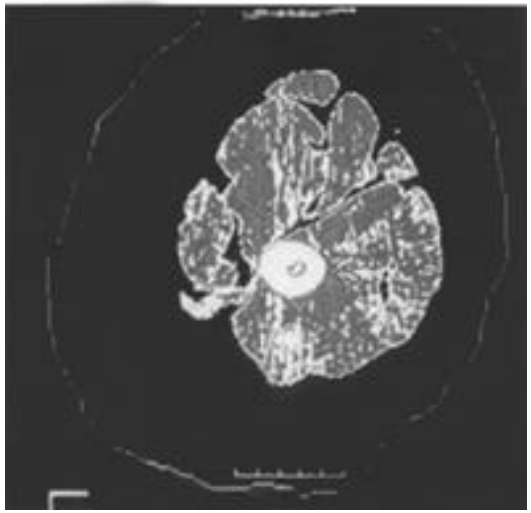



Lexell J. JGMS 50A, 11-16, 1995

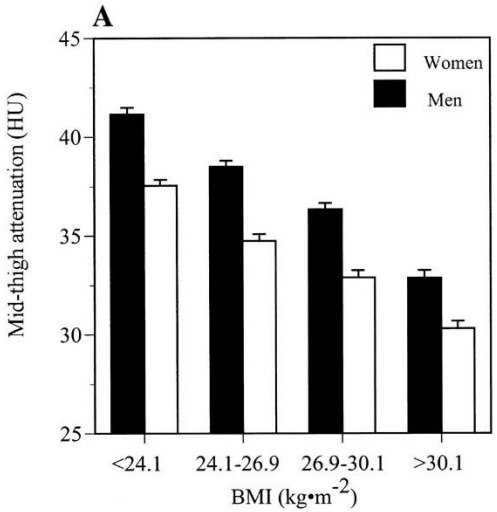
# Association between age, BMI and skeletal muscle adipose tissue infiltration

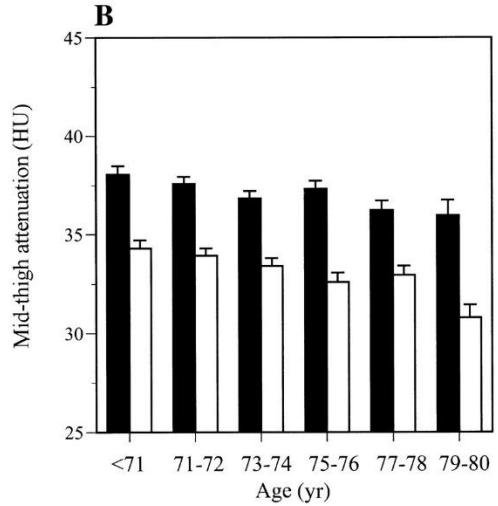


Lean volunteer



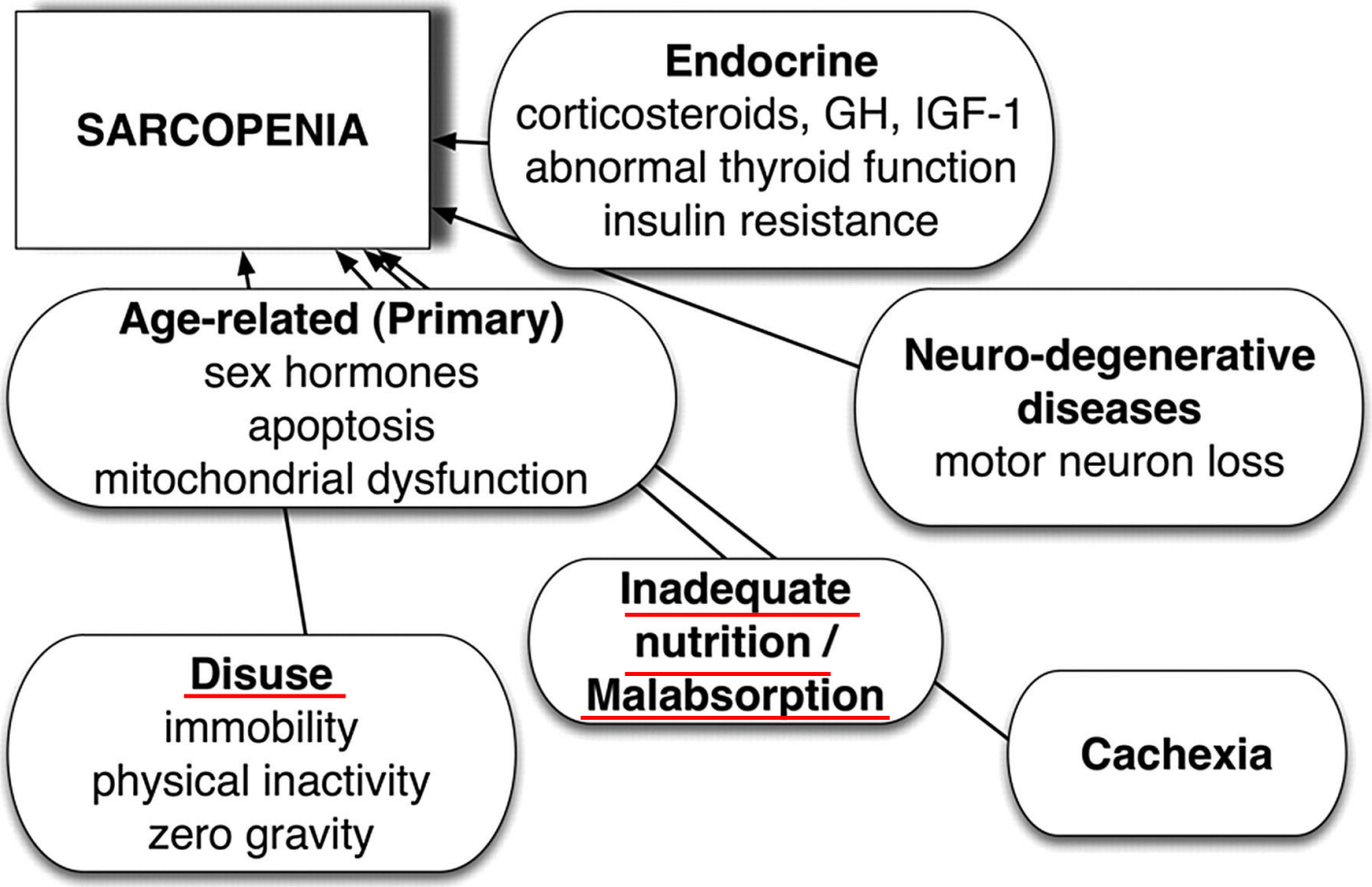
Obese volunteer




Goodpaster B et al, PNAS; 2000:904:18-24; JAP; 2001;90:2157-2165

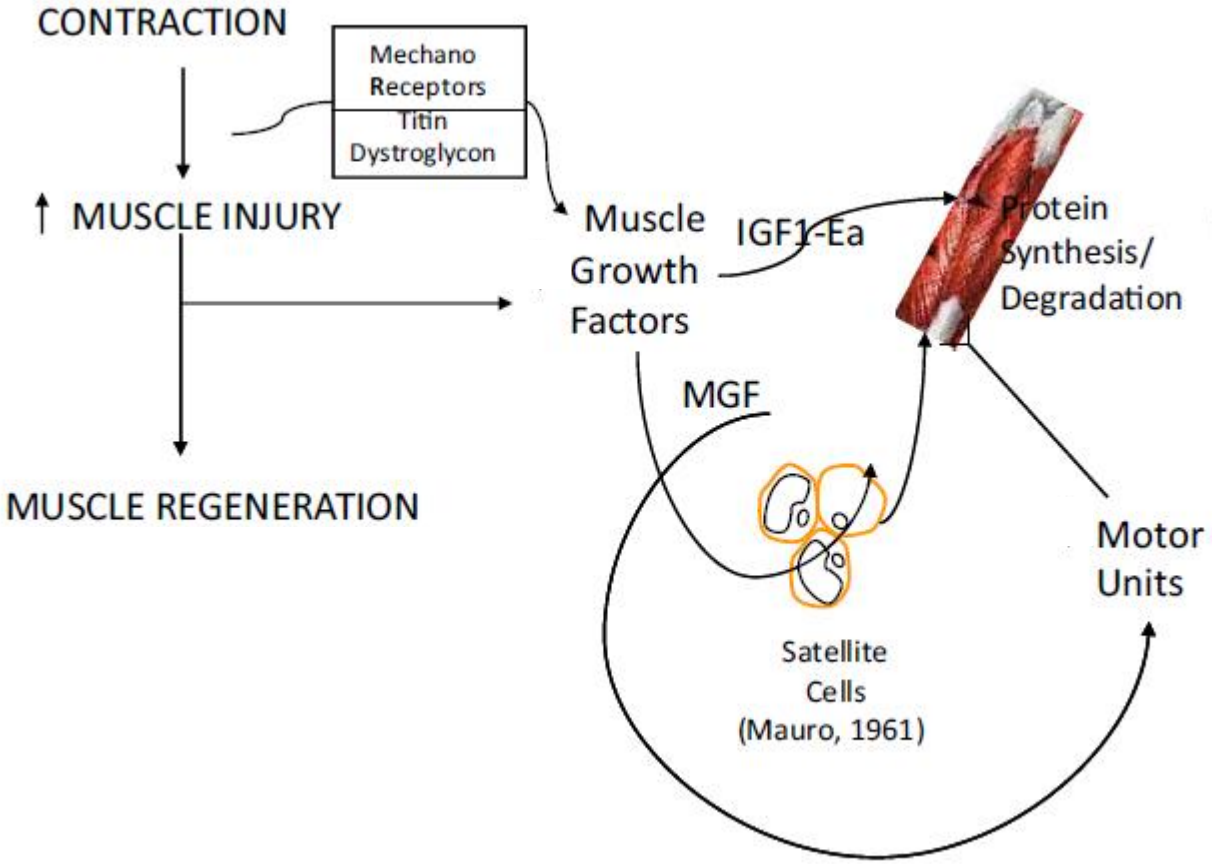
# Mechanisms of sarcopenia




Cruz-Jentoft A J et al. Age Ageing 2010;39:412-423

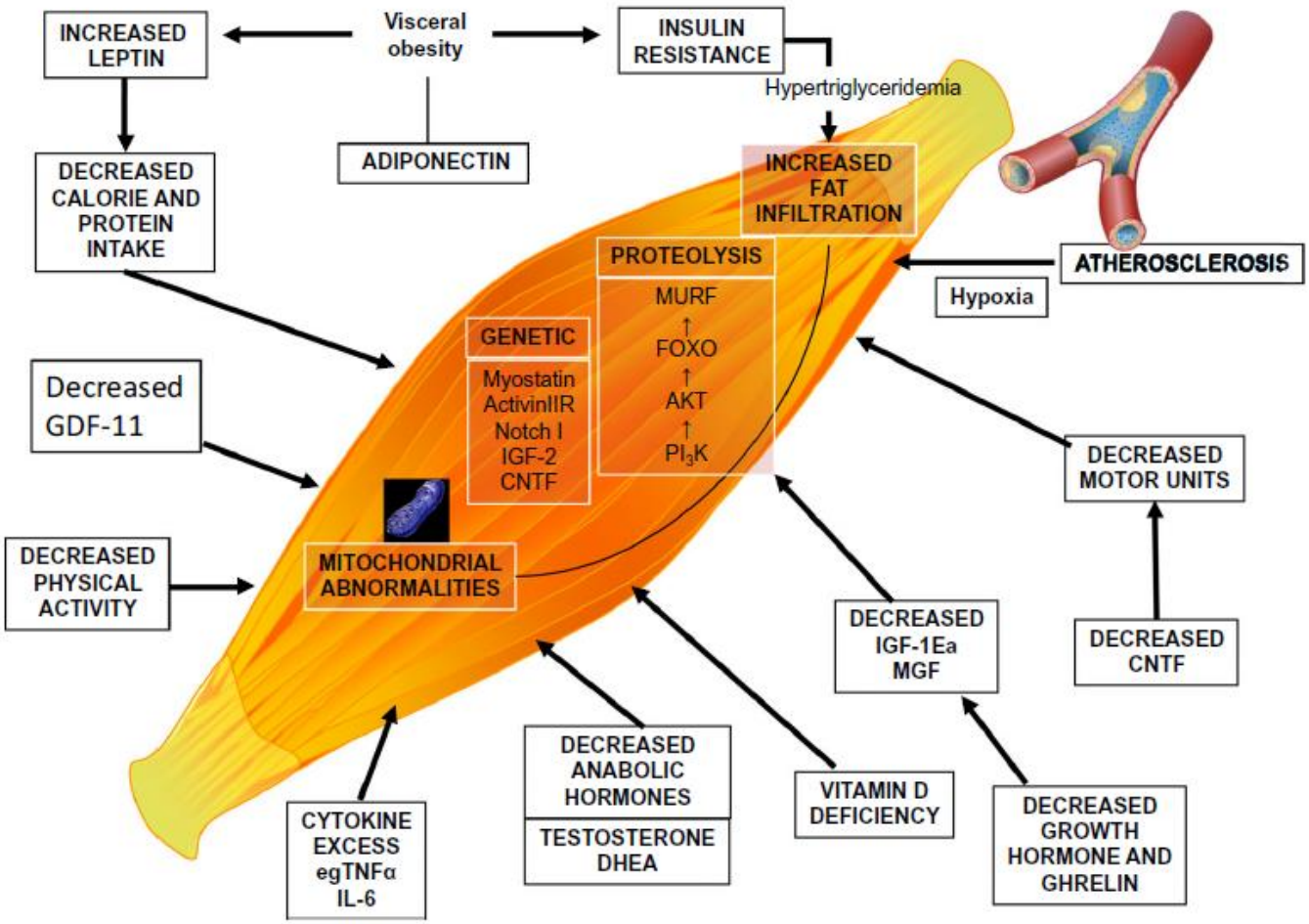
# The Pathophysiology of Sarcopenia

Age-realted increased muscle injury with a decrease in muscle regeneration and function



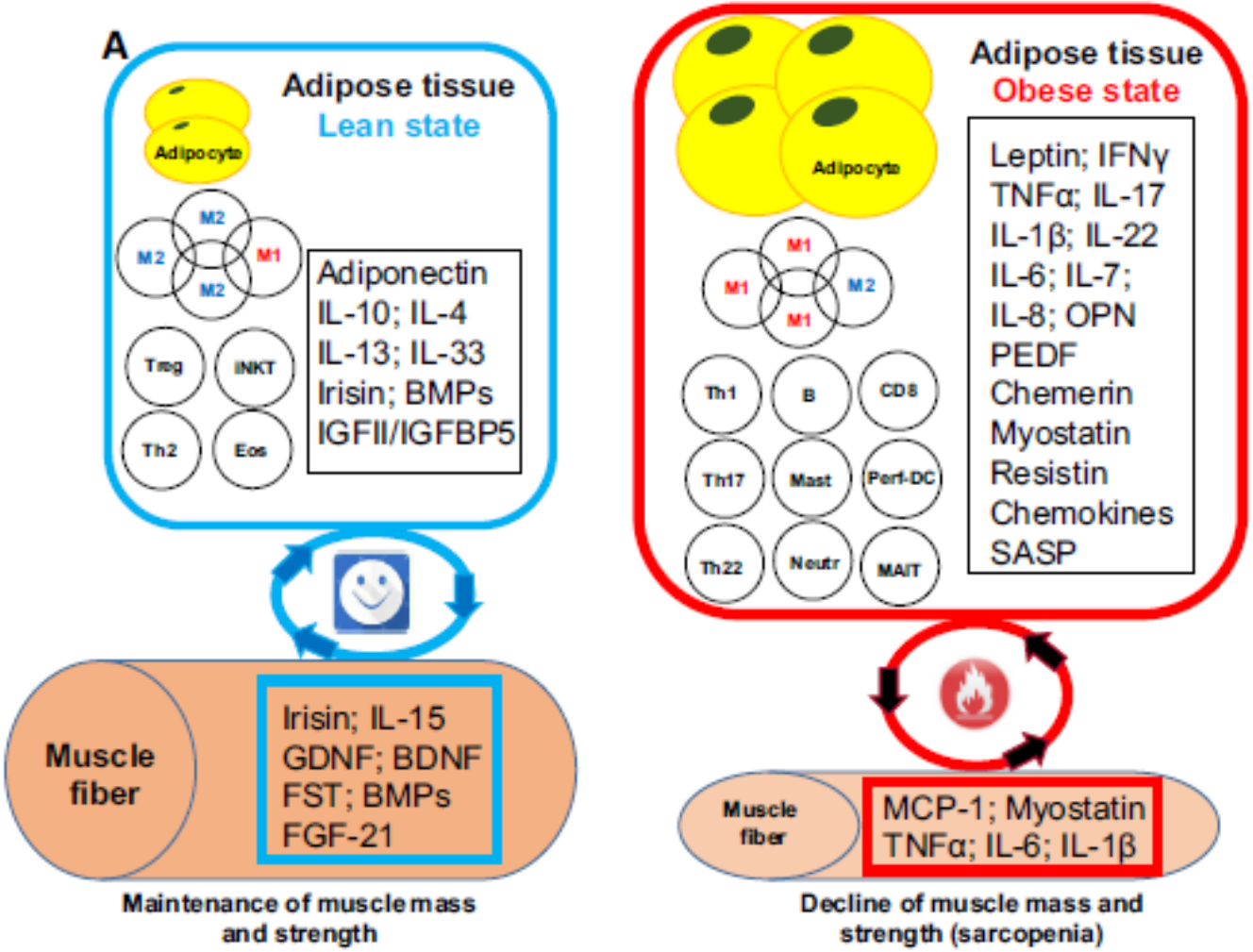

Morley JE. Calcif Tissue Int. 2016; 98:319–333

# The Pathophysiology of Sarcopenia




Morley JE. Calcif Tissue Int. 2016; 98:319–333

# Cross talk between adipose tissue and skeletal muscle in lean and obese conditions




Source: Kalinkovich A. Ageing Research Review, 2016

# Major epidemiologic studies investigating skeletal muscle strenght according to diabetes

| Study | N Follow-Up | Gender | Skeletal Muscle Groups | Significant Association | Statistical Adjustment |
|---|---|---|---|---|---|
| **Cross-sectional studies** | | | | | |
| HEALTH ABC[63] | 2618 | Men/Women | Knee: extension<br>Hand: grip strength | Yes<br>Yes in men; No in women | Age, race, education, smoking, drinking, body mass index, physical activity, comorbidity |
| InCHIANTI[21] | 835 | Men/Women | Hip: abduction or adduction<br>Hip: flexion or extension<br>Knee: extension or flexion<br>Ankle: dorsoplantar flexion | Yes | Age, gender |
| NHANES1999–02[19] | 2573 | Men/Women | Knee: extension | Yes | Demographics, weight, height physical activity, CRP |
| Hertfordshire Cohort Study[64] | 1391 | Men/Women | Hand: grip strength | Yes | Body weight |
| SOF[65] | 2864 | Women | Hand: grip strength | No | None |
| **Prospective studies** | | | | | |
| HEALTH ABC[62] | 1840, 3 y | Men/Women | Knee: extension | Yes | Age, gender, race, education, smoking, drinking, body mass index, physical activity, comorbidity |
| SOF[65] | 2864, 4.9 y | Women | Grip strength | No | Age, race, clinic site, baseline physical performance measure, body mass index, self-rated health, hypertension, and estrogen use |

UNCORRECTED PROOF

Source: De Rekeneire & Volpato, Clinics in Geriatric Medicine, 2014

# Major population-based studies investigating skeletal muscle mass distribution according to diabetes status

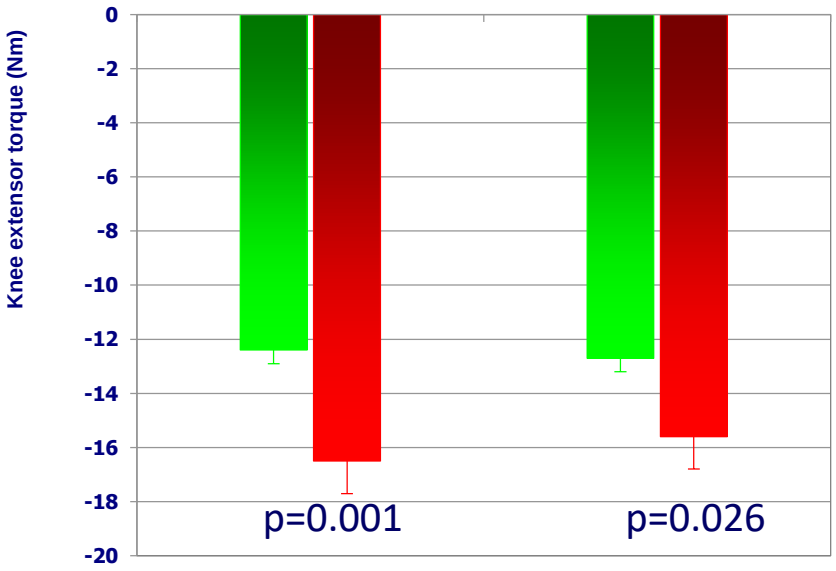
| Study reference | Population (*n* diabetics) follow-up | Skeletal muscle groups (and methods) | Results |
|---|---|---|---|
| *Prospective studies* | | | |
| Community-dwelling chinese cohort<br>Lee et al. [14] | 3153<br>(442)<br>4 years | Total lean mass (DEXA)<br>Appendicular lean mass (DEXA) | Significant loss in diabetic participants<br>Significant loss (adjusted for diabetes-related conditions) in diabetic participants |
| Health ABC<br>Park et al. [15] | 2675<br>(632)<br>6 years | Midthigh muscle cross-sectional area (CT)<br>Total lean mass (DEXA)<br>Trunk lean mass (DEXA)<br>Appendicular lean mass (DEXA) | Significant loss in diabetic female<br>Significant loss in undiagnosed diabetic participants<br>No difference<br>Significant loss in undiagnosed diabetic participants |
| MrOS<br>Lee et al. [16] | 3752<br>(1403 IFG, 496 diabetics)<br>3.5 ± 0.7 years | Total lean mass and appendicular lean mass (DEXA) | Significant loss in participants with untreated diabetes, diabetes treated without insulin sensitizers, or IFG<br>Significant lower loss for diabetic participants treated with insulin sensitizer |

*DEXA* dual-energy X-ray absorptiometry, *CT* computed tomography, *Health ABC* Health, Aging, and Body Composition Study, *InCHIANTI* Invecchiare in Chianti, *KSOS* Korean Sarcopenic Obesity Study, *MrOS* Osteoporotic Fractures in Men Study, *IFG* impaired fasting glucose

Source: Bianchi & Volpato, Acta Diabetol, 2016

# 3-year changes in knee extensor strength and muscle quality by diabetes in the Health ABC Study

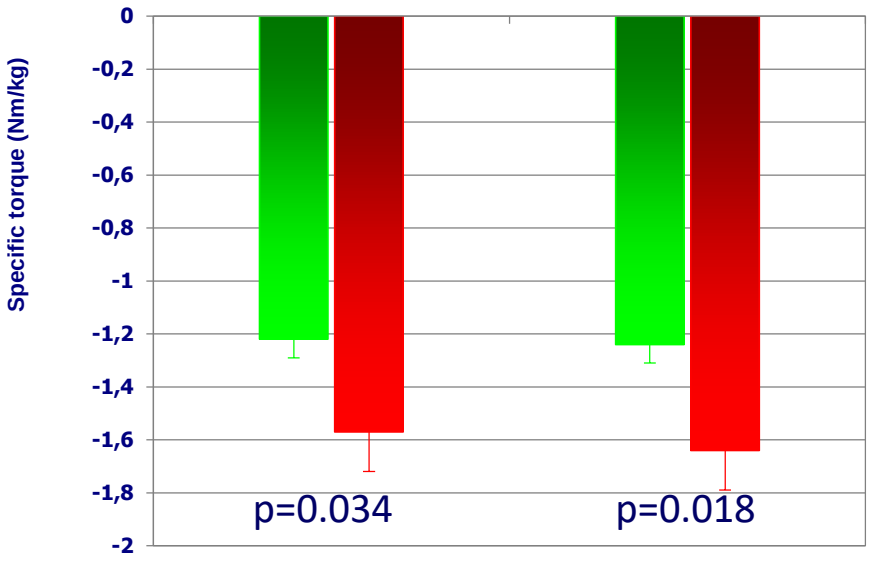
## Muscle strength




Adjusted for age sex, and race

Fully adjusted

## Muscle quality



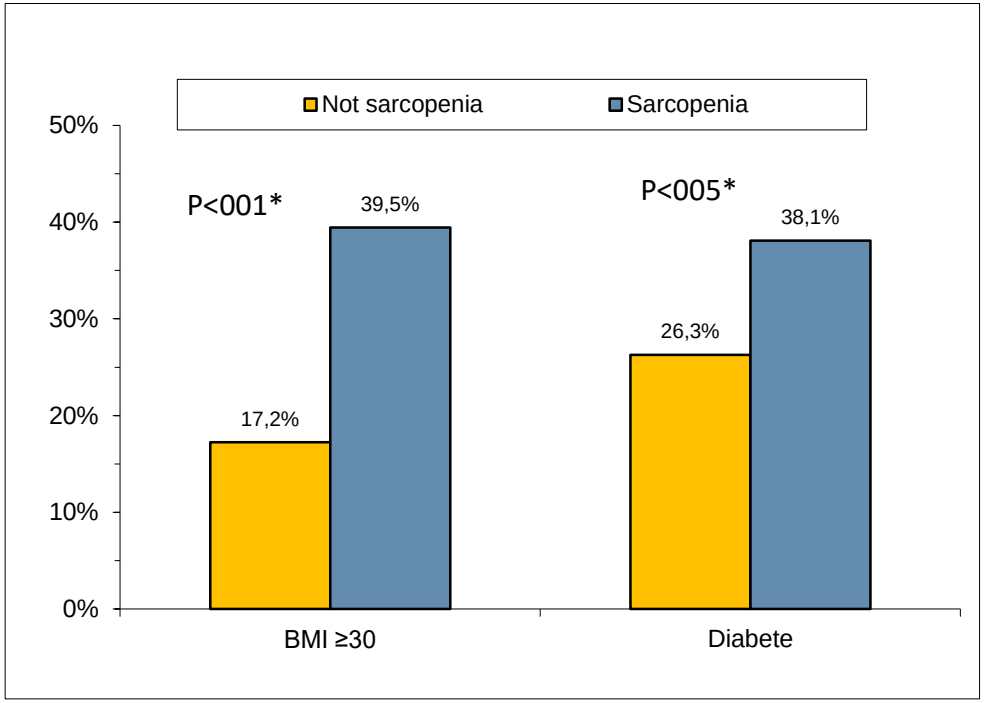

Adjusted for age sex, and race

Fully adjusted

Source: Park et al, Diabetes Care; 2007

# Relationship of Diabetes with BMI and Sarcopenia: The Glisten Study

**FNIH**

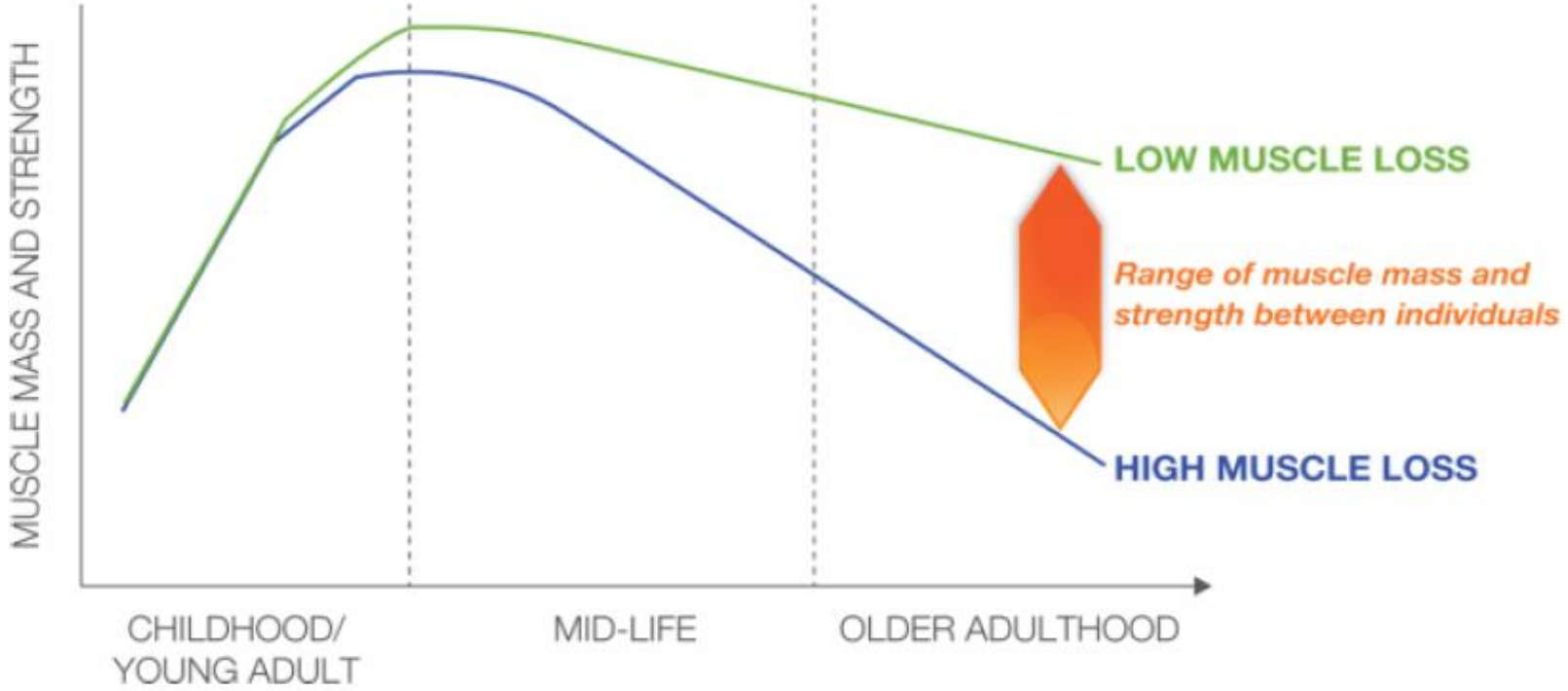



SMI: Appendicular skeletal muscle mass/BMI

*age and gender adjusted

Volpato et al, unpublished

# Aging and muscle



BMJ

RESEARCH

# Adherence to Mediterranean diet and risk of developing diabetes: prospective cohort study

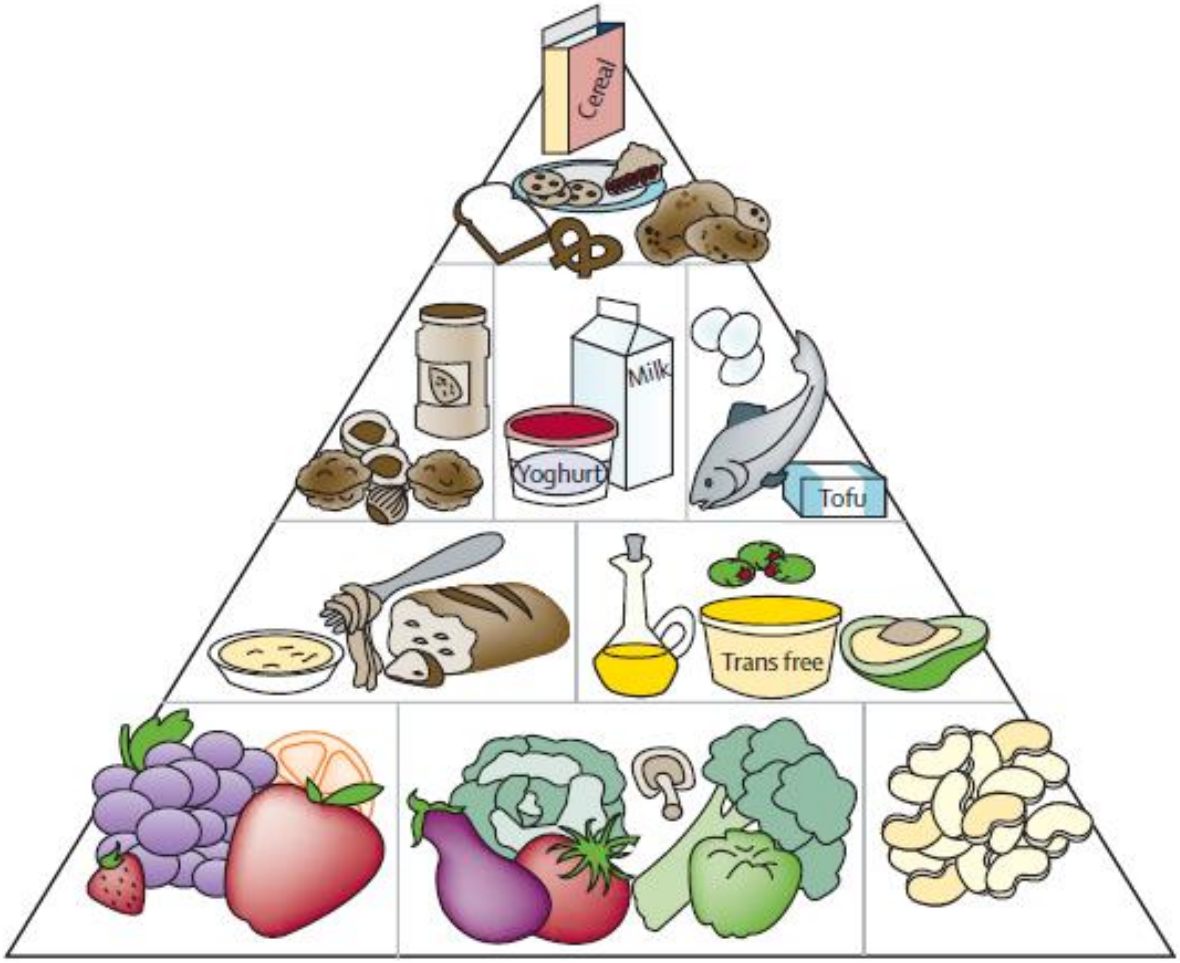
M Á Martínez-González, professor of epidemiology and chair,[1] C de la Fuente-Arrillaga, research assistant,[1] J M Nunez-Cordoba, research fellow,[1,2] F J Basterra-Gortari, research fellow,[1,3] J J Beunza, assistant professor,[1] Z Vazquez, research assistant,[1] S Benito, research assistant,[1] A Tortosa, research fellow,[1] M Bes-Rastrollo, assistant professor[1]

| | No in group | Unadjusted cumulative incidence of type 2 diabetes (%) | Incidence rate ratio* adjusted for age and sex (95% CI) | Multivariate adjusted incidence rate ratio (95% CI)† |
|---|---|---|---|---|
| Low (score 0-2) | 2253 | 0.40 | 1 (reference) | 1 (reference) |
| Moderate (score 3-6) | 9604 | 0.23 | 0.41 (0.19 to 0.87) | 0.40 (0.18 to 0.90) |
| High (score 7-9) | 1523 | 0.13 | 0.17 (0.04 to 0.75) | 0.17 (0.04 to 0.72) |

*Poisson regression model with robust standard errors.

BMJ 2008; 336: 1348–1351

# The Low-glycaemic load pyramid




Ludwig DS. The Lancet 2007

# Low glycaemic index, or low glycaemic load, diets for diabetes mellitus (Review) Thomas D, Elliott EJ

THE COCHRANE COLLABORATION®

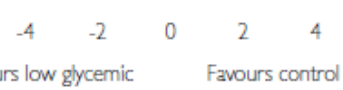
## Low glycaemic index or low glycaemic load diet versus other diet
## Glycated haemoglobin

| Study or subgroup | Favours low glycemic N | Mean(SD) | Favours control N | Mean(SD) | Mean Difference IV,Fixed,95% CI | Weight | Mean Difference IV,Fixed,95% CI |
|---|---|---|---|---|---|---|---|
| Brand 1991 | 16 | 7 (0.6) | 16 | 7.9 (2) | | 8.9 % | -0.90 [ -1.92, 0.12 ] |
| Giacco 2000 | 29 | 8.8 (1) | 25 | 9.1 (1.3) | | 23.7 % | -0.30 [ -0.93, 0.33 ] |
| Gilbertson 2001 | 51 | 8 (1) | 38 | 8.6 (1.4) | | 34.0 % | -0.60 [ -1.12, -0.08 ] |
| Jimenez-Cruz 2003 | 14 | 8.1 (0.9) | 14 | 8.6 (0.9) | | 20.9 % | -0.50 [ -1.17, 0.17 ] |
| Komindr 2001 | 10 | 10.97 (1.55) | 10 | 11.15 (2.02) | | 3.7 % | -0.18 [ -1.76, 1.40 ] |
| Rizkalla 2004 | 12 | 7.17 (1.35) | 12 | 7.57 (1.21) | | 8.8 % | -0.40 [ -1.43, 0.63 ] |
| **Total (95% CI)** | **132** | | **115** | | | **100.0 %** | **-0.50 [ -0.81, -0.20 ]** |

Heterogeneity: $Chi^2 = 1.31$, df = 5 (P = 0.93); $I^2 = 0.0\%$

Test for overall effect: Z = 3.22 (P = 0.0013)

Test for subgroup differences: Not applicable



# Mediterranean Diet and Type 2 Diabetes Risk in the European Prospective Investigation Into Cancer and Nutrition (EPIC Study)

Risk (HR) of Type 2 Diabetes according to level of adherence to MDP

| | Categories of rMED† | | | | | | |
|---|---|---|---|---|---|---|---|
| Number of case subjects/number of subcohort* | Low (3,879/3,902) | | Medium (5,103/6,767) | | High (4,380/7,392) | | |
| | HR§ | 95% CI | HR§ | 95% CI | HR§ | 95% CI | *P* (trend) |
| Crude model | 1.00 | Referent | 0.74 | 0.70–0.79 | 0.65 | 0.60–0.71 | <0.001 |
| Sex- and BMI-adjusted model | 1.00 | Referent | 0.87 | 0.81–0.94 | 0.80 | 0.72–0.89 | <0.001 |
| Multiple adjusted model | 1.00 | Referent | 0.93 | 0.86–1.01 | 0.88 | 0.79–0.97 | 0.013 |

*Numbers in the subcohort exclude type 2 diabetic case subjects. †rMED categories: low adherence to the MDP (rMED 0–6); medium adherence to the MDP (rMED 7–10); high adherence to the MDP (rMED 11–18). ‡rMED included as a continuous variable (range 0–18). §Modified Cox proportional hazards regression models stratified by center. Multiple adjusted models were adjusted for sex, BMI (as continuous variable), educational level (no formal education, primary school, technical/professional school, secondary school, and longer education including university degree), physical activity (inactive, moderately inactive, moderately active, and active), smoking status (never, former, and three categories of current smoker: 1–10 cigarettes day$^{-1}$, 11–20 cigarettes day$^{-1}$, and >20 cigarettes day$^{-1}$), and total calorie intake (as a continuous variable).

Diabete Care 2011; 34: 1913–18

The New England
Journal of Medicine

Copyright © 2001 by the Massachusetts Medical Society

VOLUME 344 MAY 3, 2001 NUMBER 18

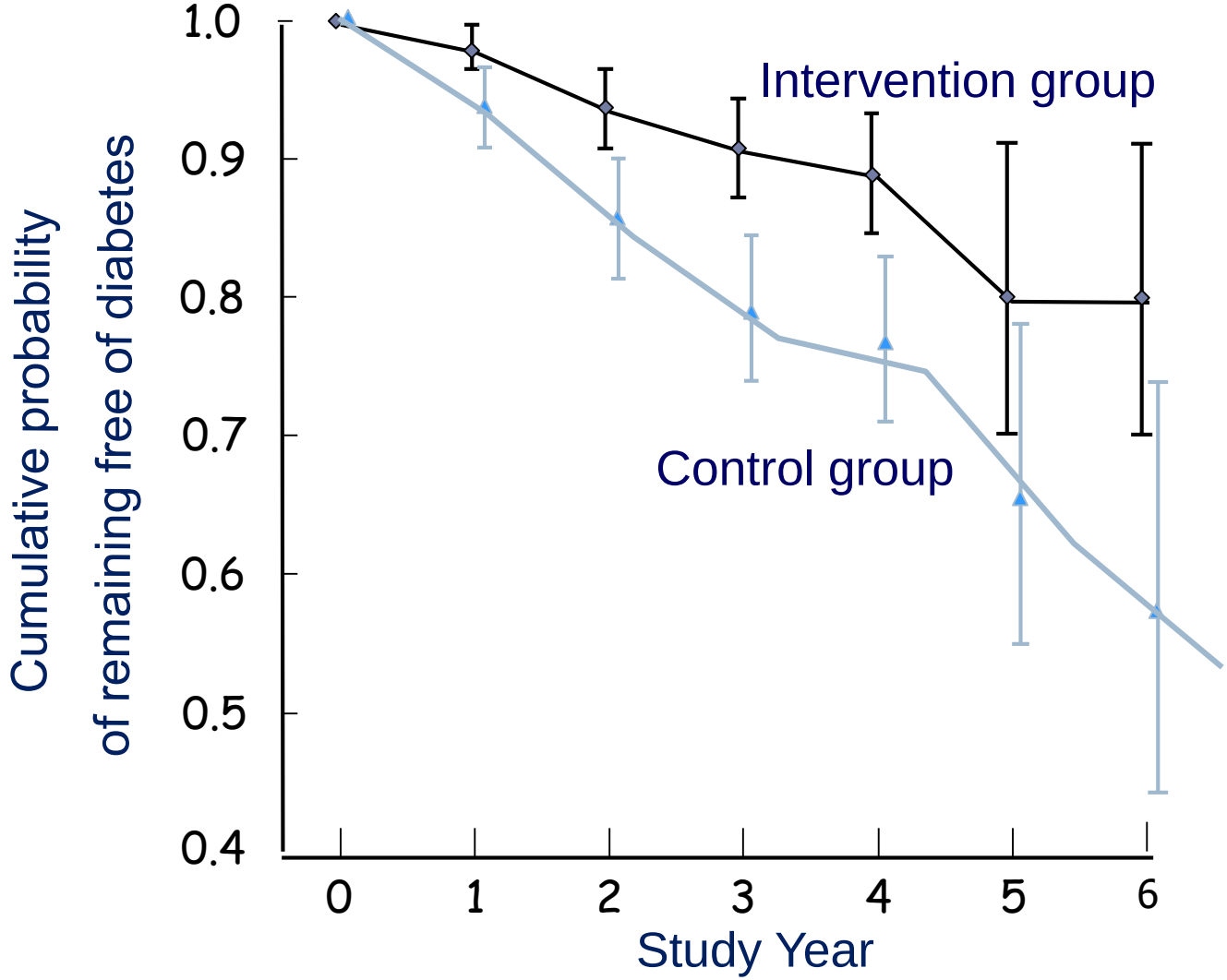
# PREVENTION OF TYPE 2 DIABETES MELLITUS BY CHANGES IN LIFESTYLE AMONG SUBJECTS WITH IMPAIRED GLUCOSE TOLERANCE

JAAKKO TUOMILEHTO, M.D., PH.D., JAANA LINDSTRÖM, M.S., JOHAN G. ERIKSSON, M.D., PH.D., TIMO T. VALLE, M.D., HELENA HÄMÄLÄINEN, M.D., PH.D., PIRJO ILANNE-PARIKKA, M.D., SIRKKA KEINÄNEN-KIUKAANNIEMI, M.D., PH.D., MAURI LAAKSO, M.D., ANNE LOUHERANTA, M.S., MERJA RASTAS, M.S., VIRPI SALMINEN, M.S., AND MATTI UUSITUPA, M.D., PH.D., FOR THE FINNISH DIABETES PREVENTION STUDY GROUP

# Finnish Diabetes Prevention Study. Success in achieving intervention goals by one year

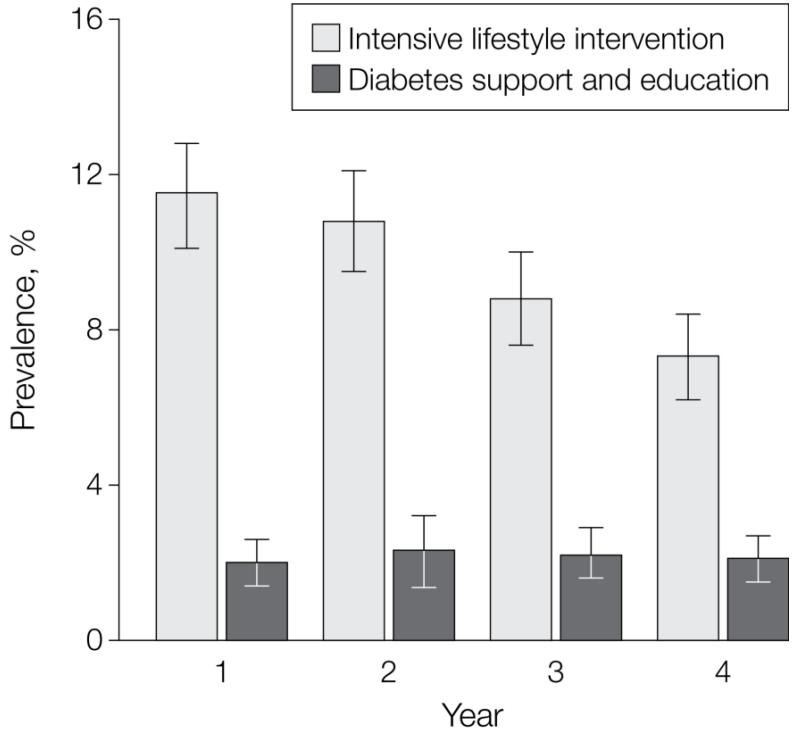
| Goals | Intervention group | Control group | P value |
|---|---|---|---|
| | *% of subjects* | | |
| Weight reduction>5% | **43** | **13** | **0.001** |
| Fat intake <30% of energy intake | **47** | **26** | **0.001** |
| Saturated fat intake <10% of energy intake | **26** | **11** | **0.001** |
| Fiber intake ≥ 15g/1000 Kcal | **25** | **12** | **0.001** |
| Exercise >4 hr/week | **86** | **71** | **0.001** |

# Proportion of subjects without diabetes during the trial

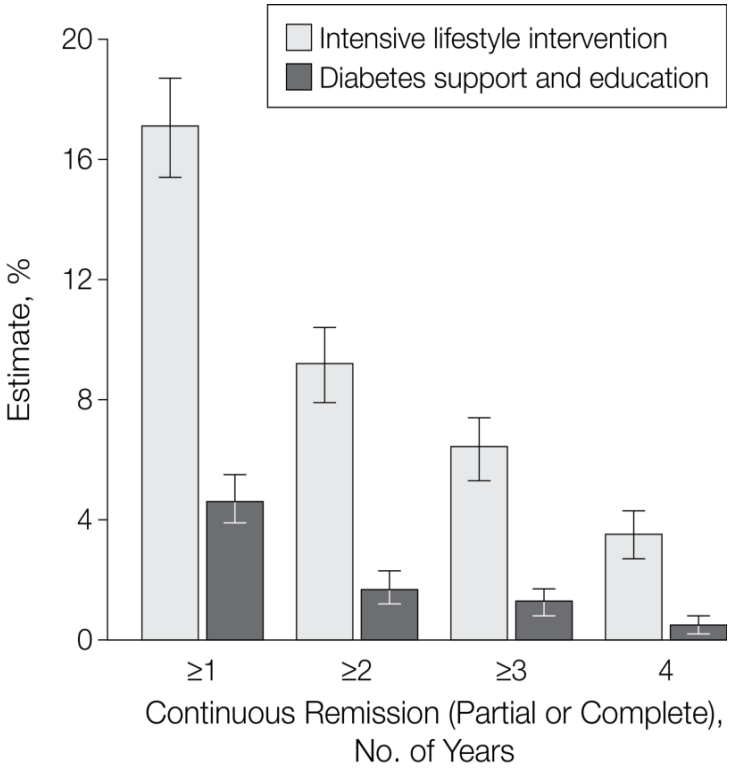


# Association of an Intensive Lifestyle Intervention With Remission of Type 2 Diabetes

Prevalence of Any Remission



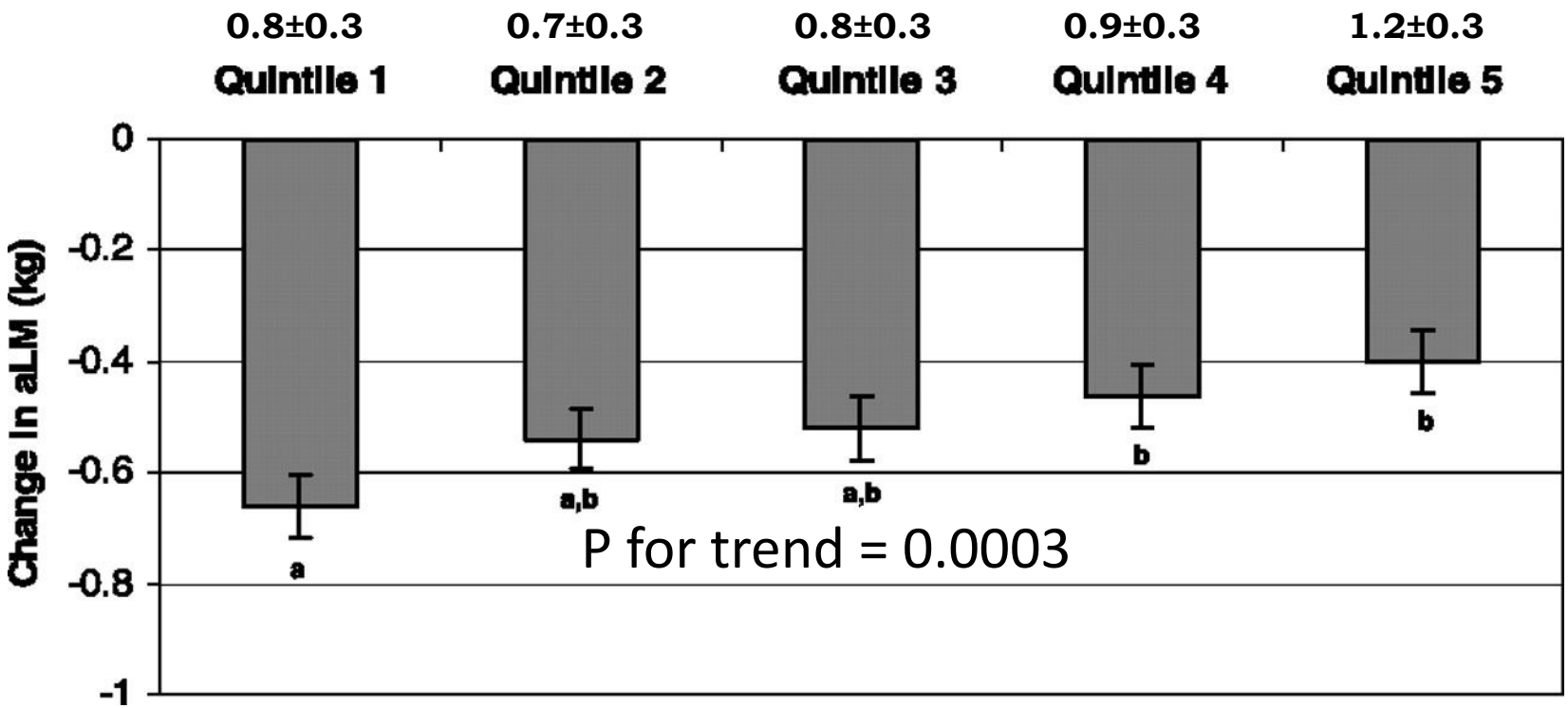

Duration of Any Remission




Gregg Ed. Et al JAMA. 2012;308:2489-2496

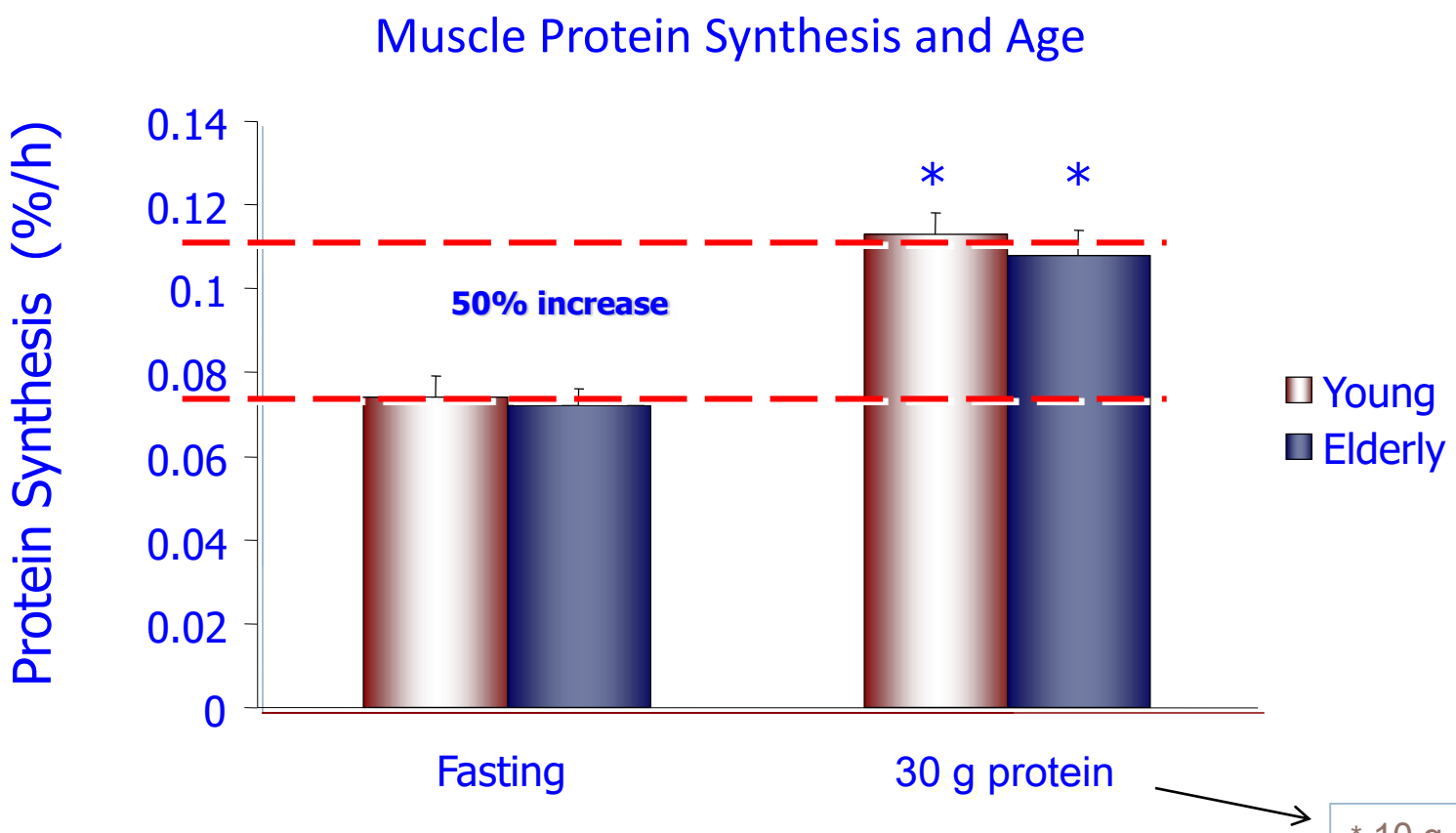
# Riduzione della massa muscolare appendicolare in rapporto all'introito proteico (HABC Study)

Introito Proteico totale aggiustato per KCal




Houston D K et al. Am J Clin Nutr 2008;87:150-155

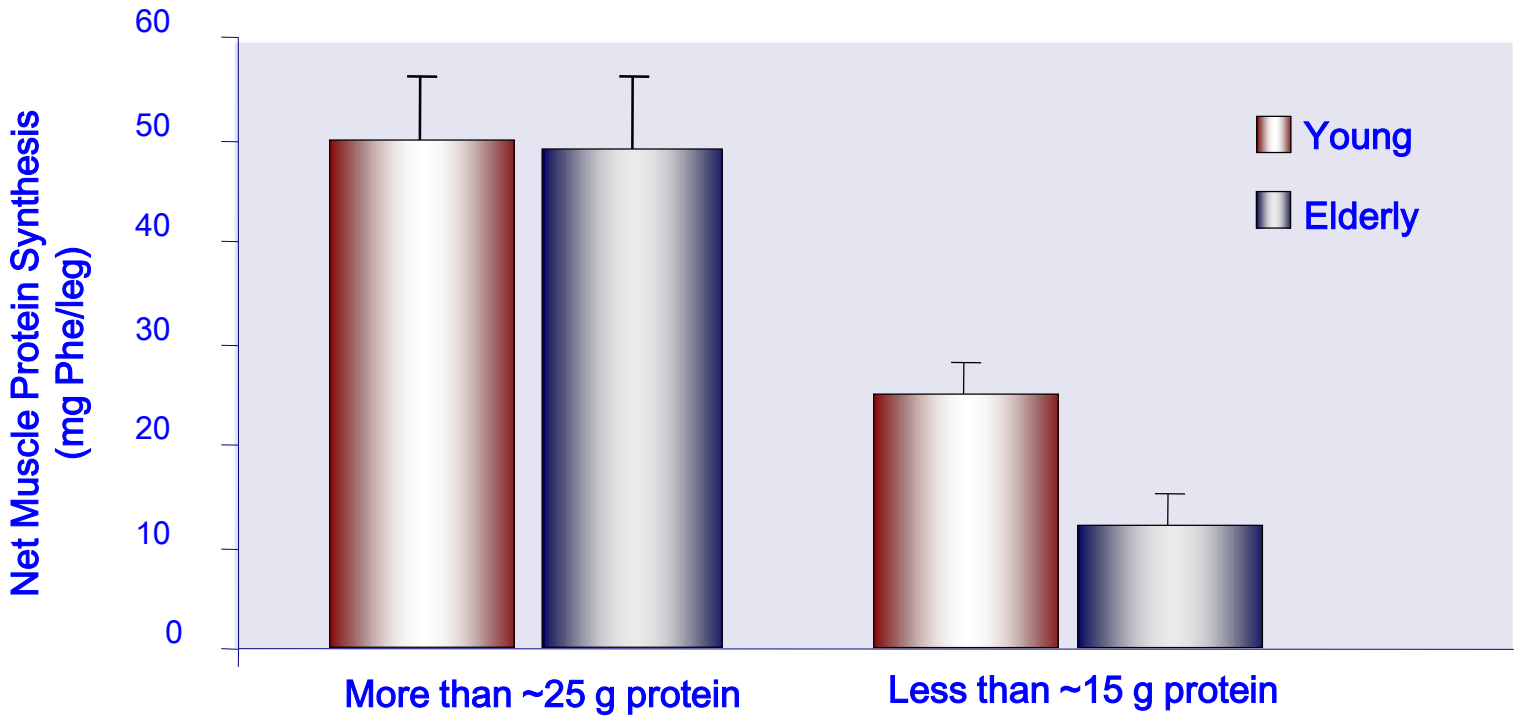
# Protein synthesis according to protein intake and age




* 10 g essential amino acids

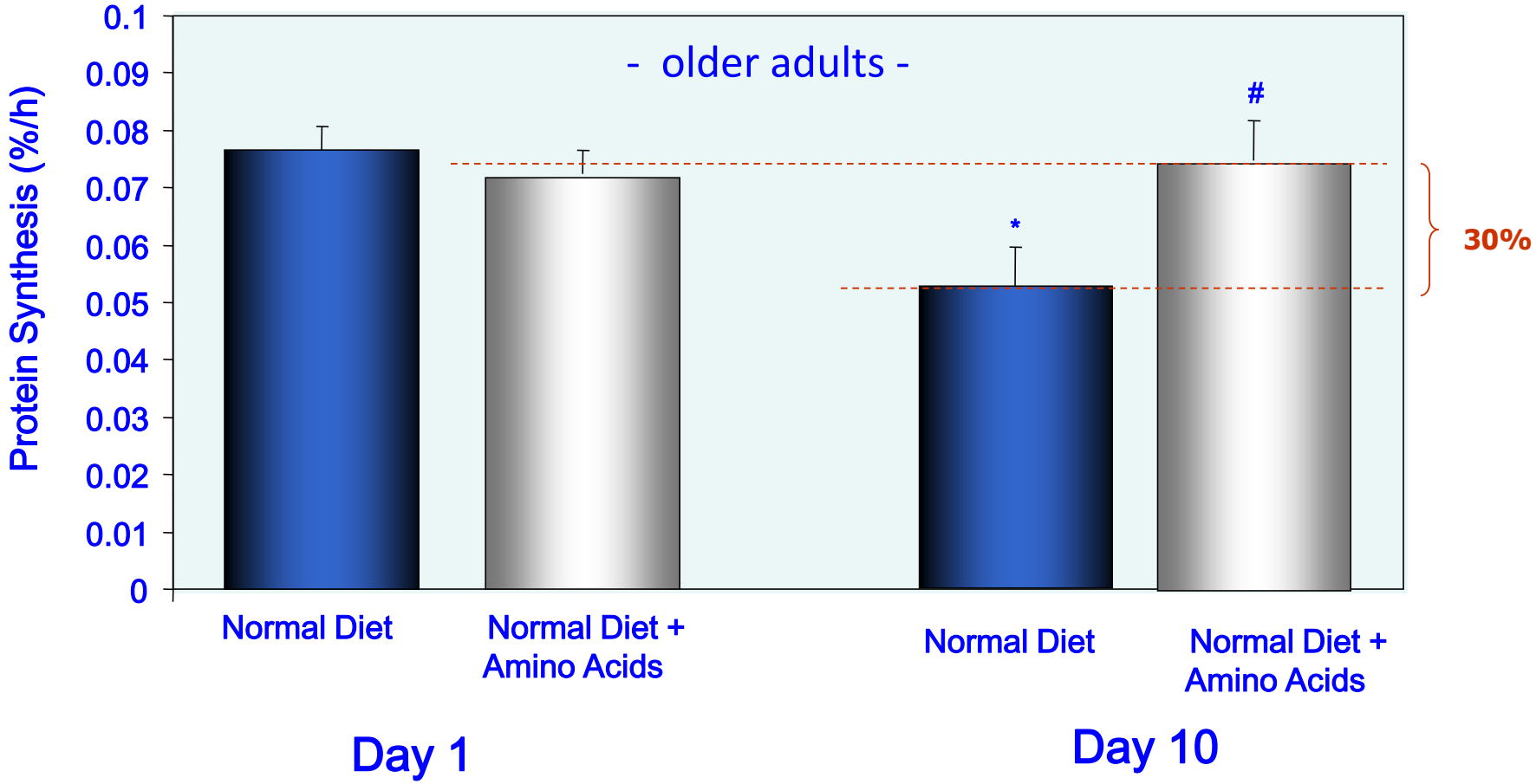
Symons et. al. AJCN, 2007

# Protein synthesis according to protein intake and age



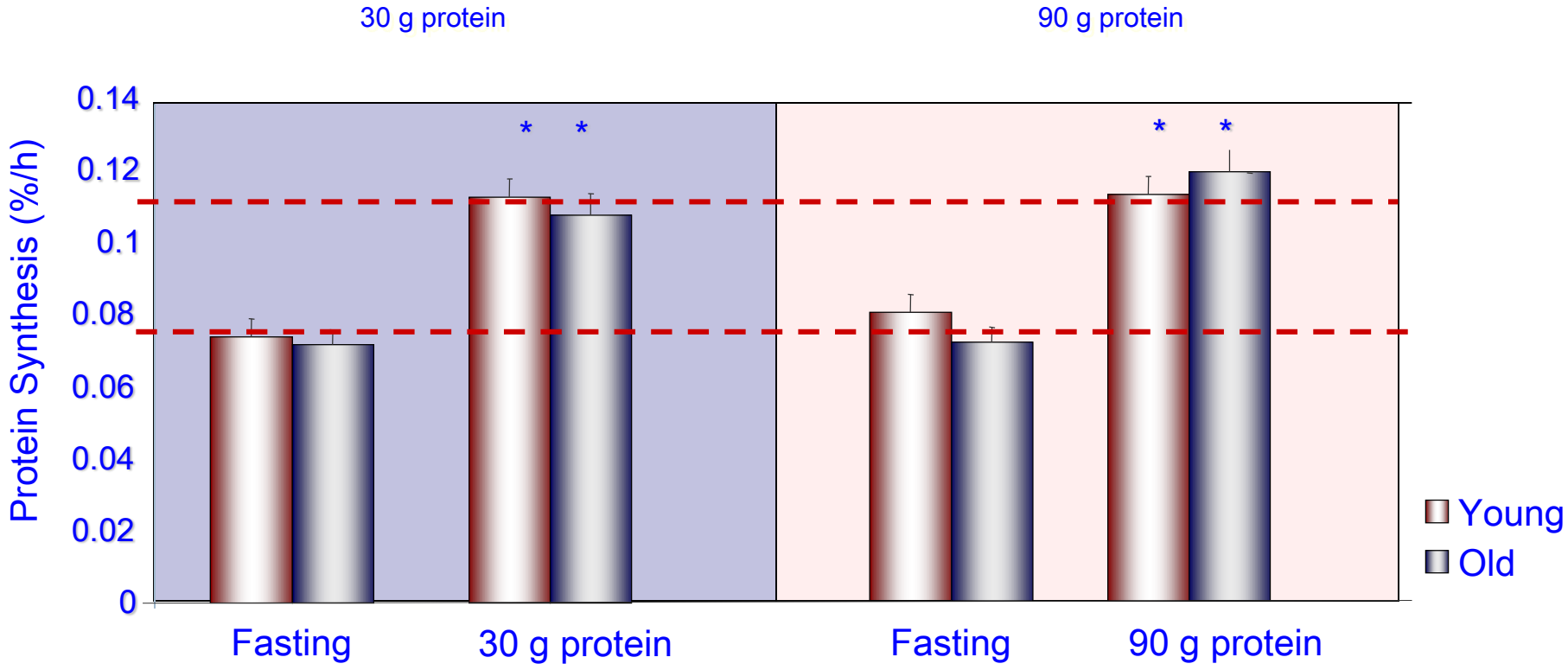

Katsanos et. al. AJCN, 2005

# Proteins intake counteracts reduction in protein synthesis secondary to inactivity




Ferrando & Paddon-Jones et. al. 2009

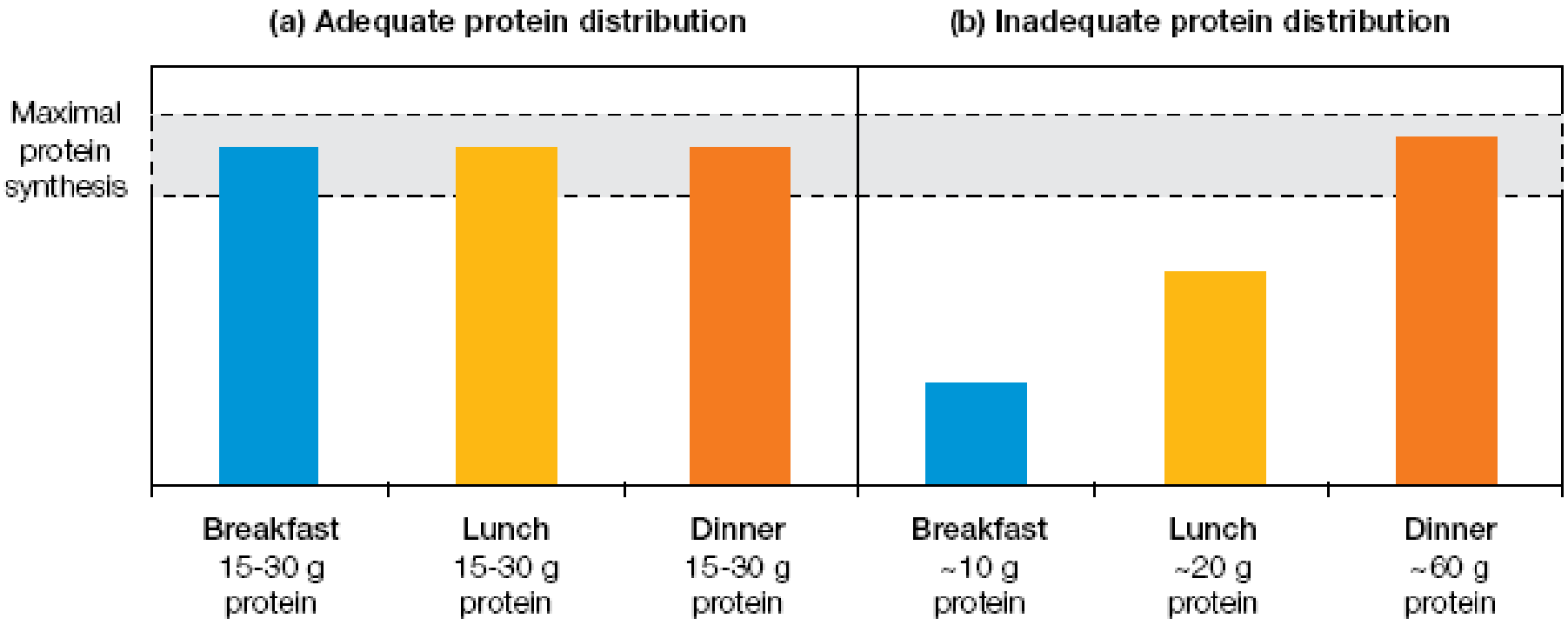
# Effect of protein intake amount on protein synthesis response




*~1.2 g/kg/day for 180 lb individual*

Symons et. al. AJCN, 2007 JADA. 2009

# Distribution of protein intake and protein synthesis response

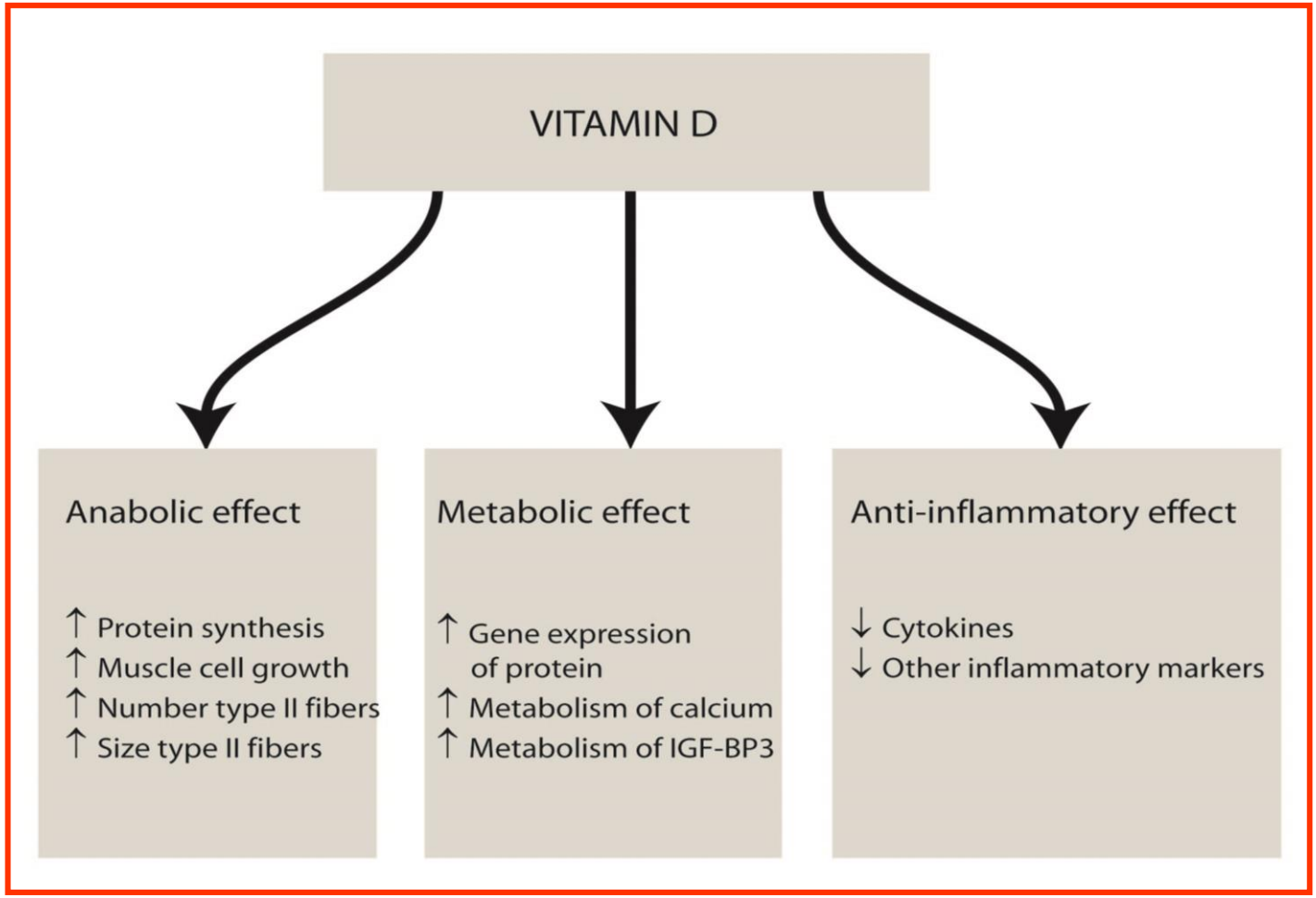



Adapted from Paddon-Jones, 2009

# Options to optimize post-prandial anabolic action of dietary proteins

- Increase protein intake
  - Age-specific RDAs
- Increase amino acid bioavailability
  - Distribution of protein intake
  - Digestion rate
- Use specific substrates
  - Leucine
  - ß-hydroxy-ß-methylbutyrate (HMB)
  - Vitamin D

# Role of Vitamin D on muscle function



IL CASTELLO
DI FERRARA