



Universidad
del País Vasco

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HEZKUNTZA
ETA KIROL
FAKULTATEA
FACULTAD
DE EDUCACIÓN
Y DEPORTE

CEiMD

DE LAS RECOMENDACIONES GENERALES A LOS PLANES INDIVIDUALIZADOS

Dosis de actividad física para la prevención y
tratamiento de enfermedades crónicas

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1. RELACIÓN ENTRE ACTIVIDAD FÍSICA Y MORTALIDAD

2. EFECTOS DEL EJERCICIO FÍSICO EN LA SALUD

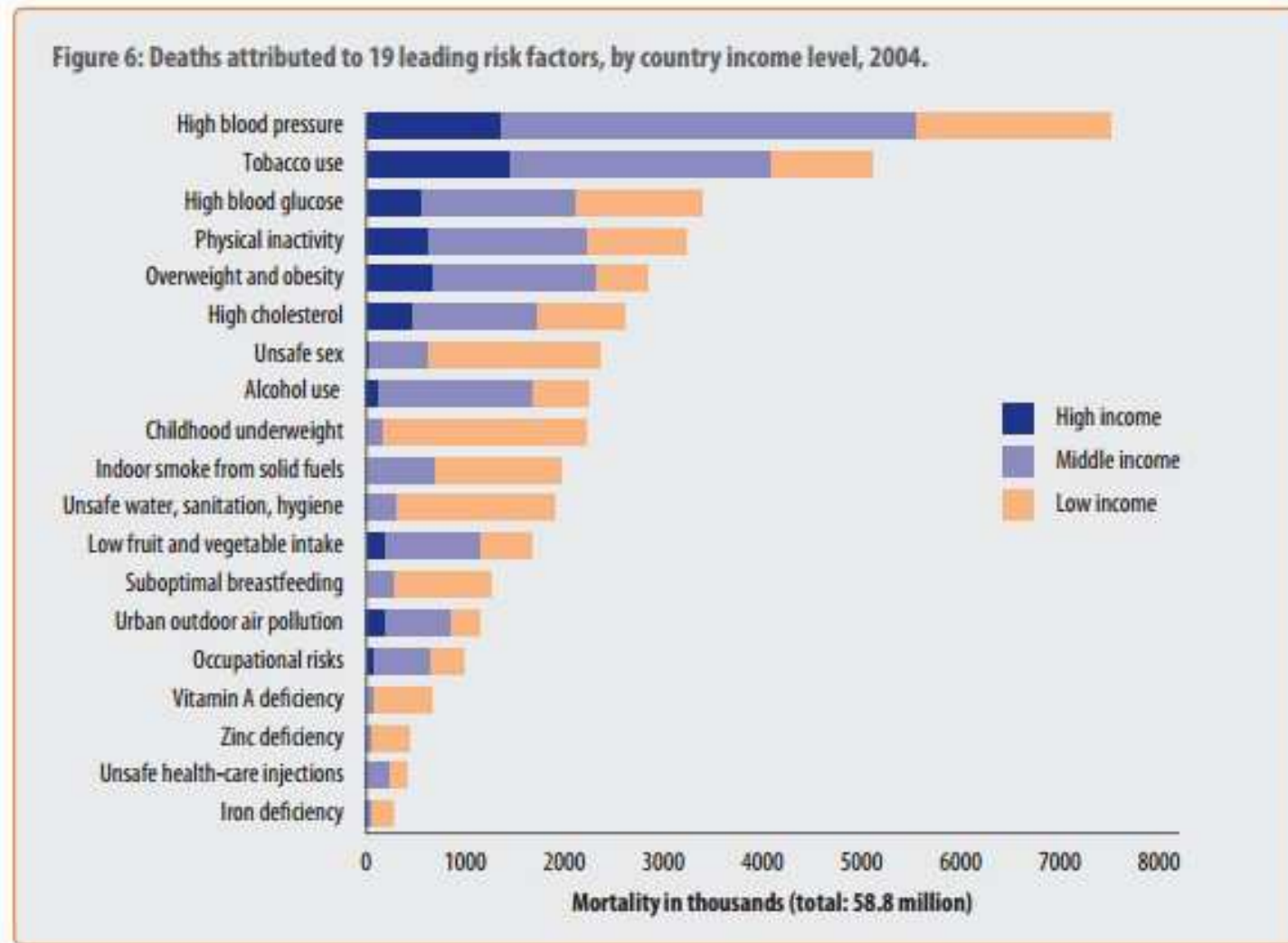
3. RECOMENDACIONES Y GUÍAS DE AF INTERNACIONALES

4. INDIVIDUALIZACIÓN DE LA INTENSIDAD

5 MEDICIÓN OBJETIVA DE LA AF - ACELERÓMETROS

1. Relación entre AF y mortalidad

El mundo se muere por inactividad



Organización Mundial de la Salud, 2004 (OMS)

Los inicios de la epidemiología y la actividad física

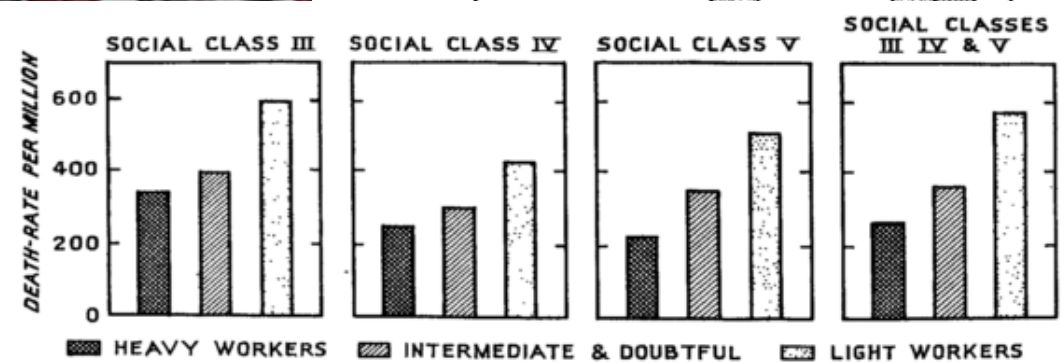
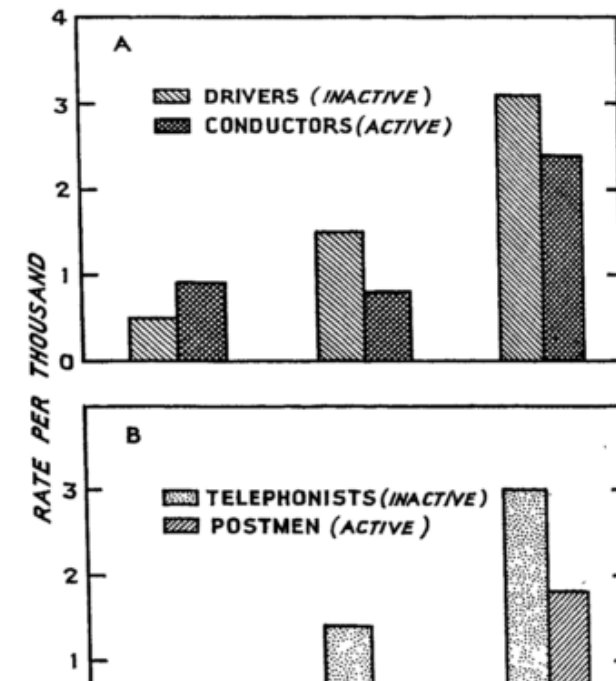
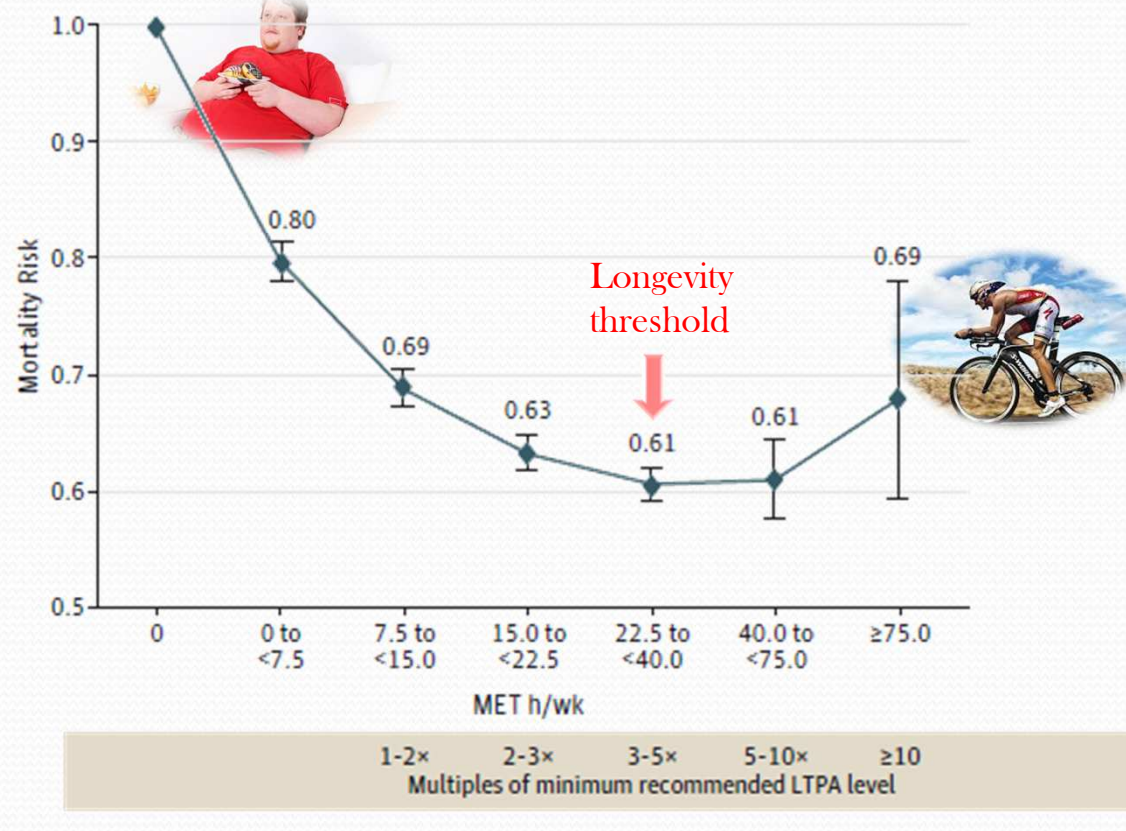


Fig. 3—Mortality from coronary heart-disease in heavy and light workers, men aged 45–64, in England and Wales in 1930–32.

Morris et al. *The Lancet* 1953; 265: 1053-1057

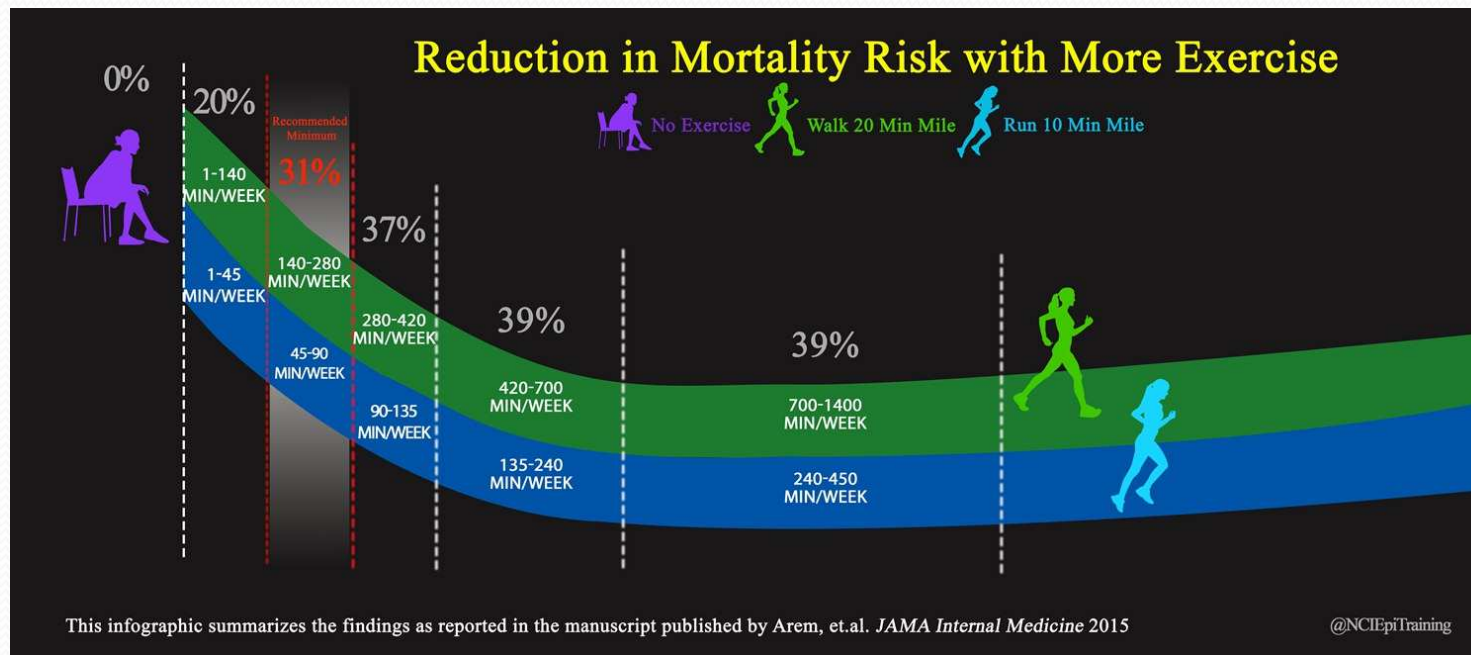
¿Cual es la mínima dosis de AF para reducir la mortalidad?

Figure. Hazard Ratios (HRs) and 95% CIs for Leisure Time Moderate- to Vigorous-Intensity Physical Activity and Mortality



Arem et al. *JAMA Int Med* 2015; 175 (6): 959-967

1. Relación entre AF y mortalidad



eTable 6. Approximate amounts of example activities to meet stated goals^a

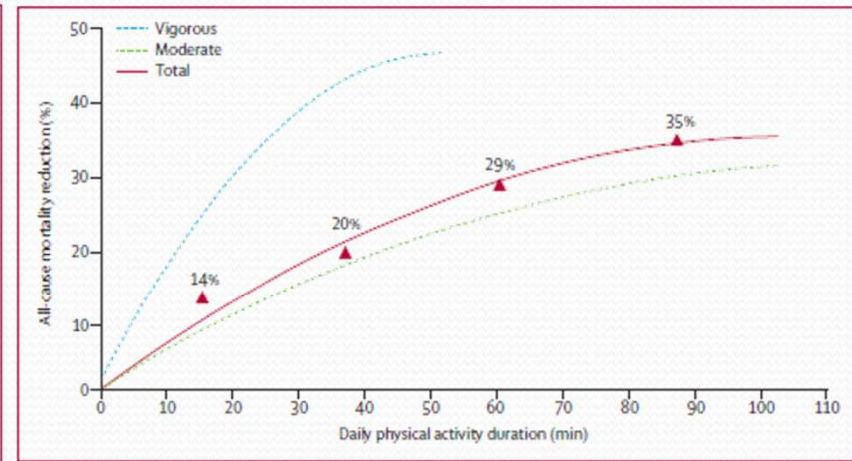
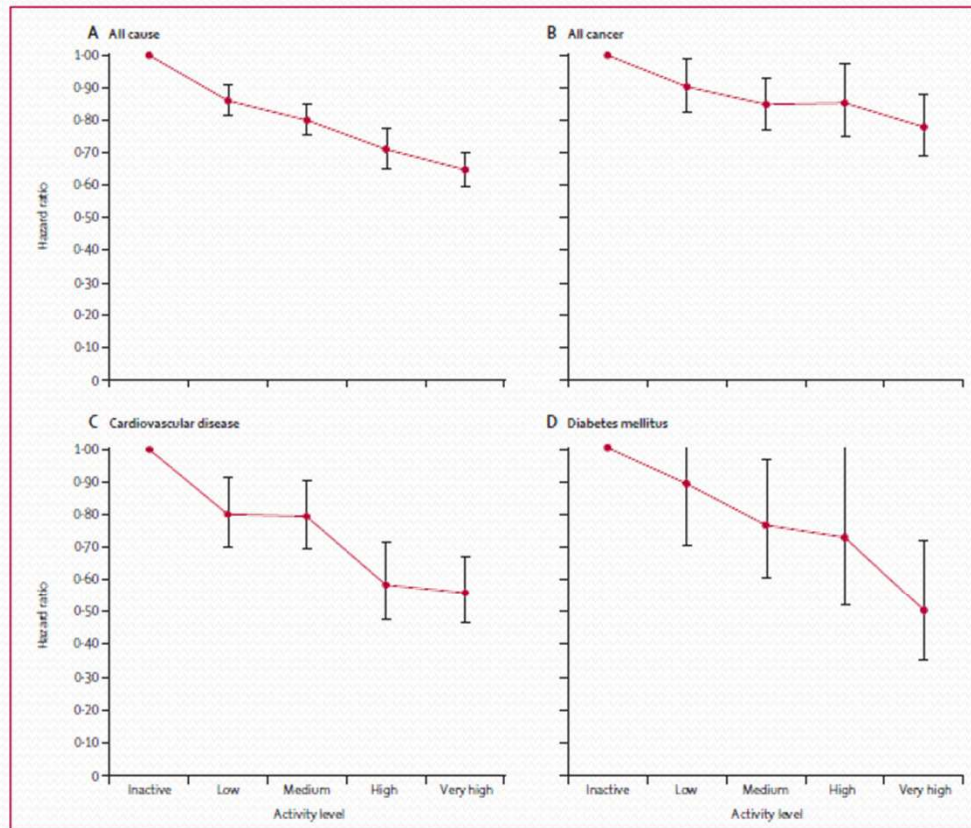
Comparison with Physical Activity Guidelines	Energy expended (MET h/wk)	Example 1: <i>Walking</i> (20 min mile or 3 mph)	Example 2: <i>Biking</i> (leisurely effort)	Example 3: <i>Swimming</i> (moderate effort)	Example 4: <i>Running</i> (10 min mile or 6 mph)
Recommended minimum	7.5	20 minutes per day	45 minutes, 2 days per week	35 minutes, 2 days per week	45 minutes per week
3x minimum	22.5	60 minutes per day	60 minutes, 5 days per week	60 minutes, 3 days per week	45 minutes, 3 days per week
5x minimum	37.5	90 minutes per day	75 minutes, 7 days per week	45 minutes, 7 days per week	60 minutes, 4 days per week
10x minimum	75	180 minutes per day	150 minutes, 7 days per week	90 minutes, 7 days per week	60 minutes, 7 days per week

^aEach example activity column alone meets the corresponding defined metabolic equivalent (MET) h/wk, but either moderate or vigorous activities can be combined to reach stated physical activity goals.

Arem et al. *JAMA Int Med* 2015; 175 (6): 959-967

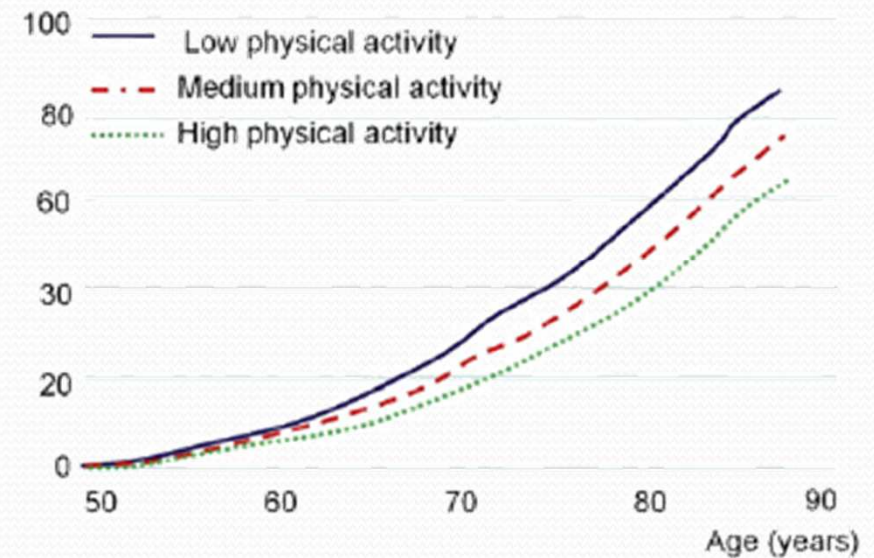
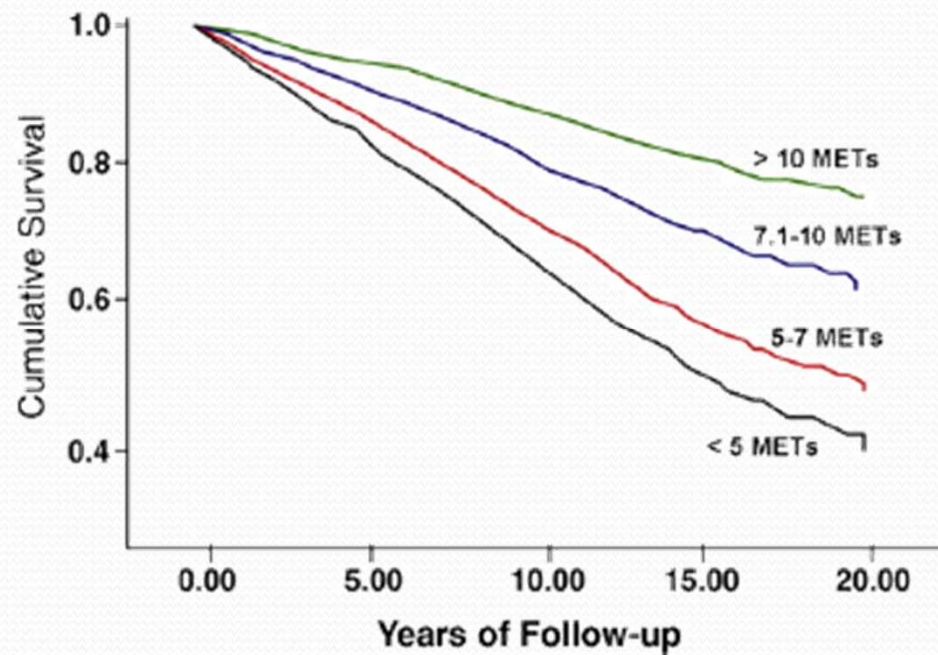
I. Relación entre AF y mortalidad

¿Cual es la mínima dosis de AF para reducir la mortalidad?



15 min /día de LTPA (92min/sem) ↓14% el RM por cualquier causa y ↓10% el RM por cáncer (+2.5 - 3.1 años de vida). Cada 15min+/día hasta 100min/d ↓4% la M y ↓1% M por cáncer

Physical fitness vs Physical activity



Cada aumento en 1 MET supone
↑12-17% de la esperanza de vida
(O'Keefe et al., 2011; Castillo
Garzón et al. 2006)

O'Keefe et al. *Prog Card Dis* 2011; 53: 471-479

Physical fitness and activity as separate heart disease risk factors: a meta-analysis

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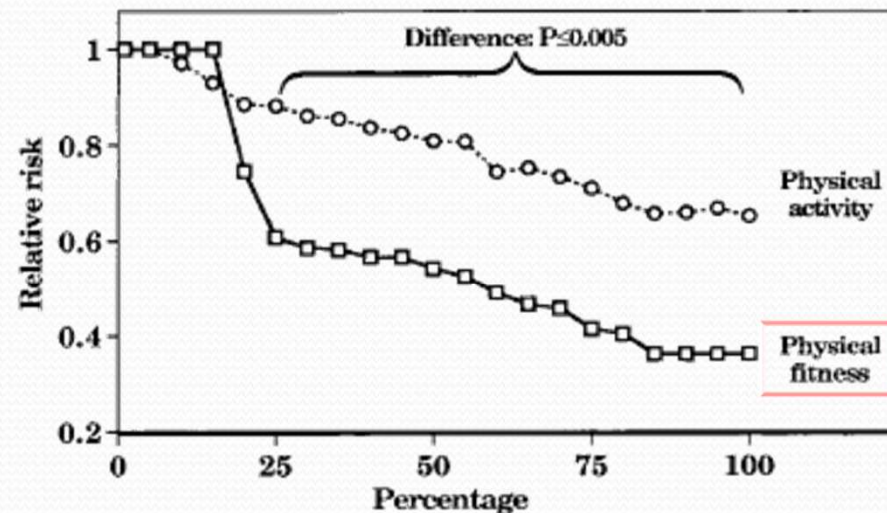
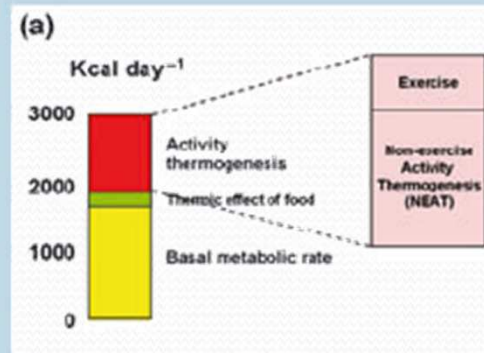


FIGURE 4—Relative risk for CHD or CVD in 8 physical fitness (317,908 person-yr of follow-up) and 30 physical activity cohorts (2,286,806 person-years of follow-up) for studies cited in, and subsequent to, the Report of the Surgeon General (57).

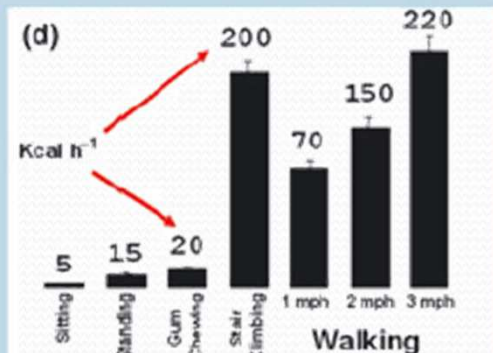
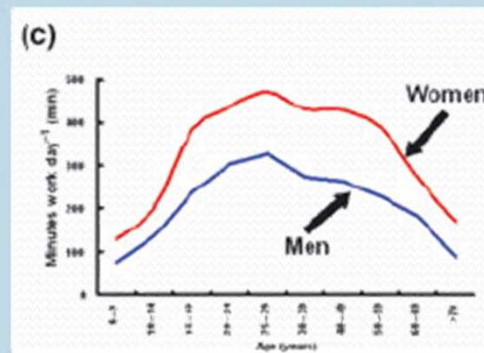
Gasto energético y NEAT: Non-Exercise activity thermogenesis



(b)

Occupation-type	NEAT (kcal day ⁻¹)
Chair-bound	300
Seated work: no option of moving	700
Seated work: discretion & requirement to move	1000
Standing work, e.g. homemaker, shop assistant	1400
Strenuous work, e.g. agriculture	2300

Data assuming BMR = 1600 kcal day⁻¹



- BMR ~60% del GE (~80% masa magra)
- **NEAT** el componente más variable (15-50% del GE o en 2000kcal/d)
- TEF (~10% GE)



El trabajo/ ocio
son los
mayores
determinantes

De la Paleovida a la Industrialización: Experiencia del antropólogo Kim Hill durante 30 años viviendo con tribus

“ Los Ache cazaban a diario, excepto los días muy lluviosos, recorriendo unos 10km diarios a baja intensidad y otros 1-2 a intensidades vigorosas para cazar (recogido por GPS). Los Hiwi cazaban 2-3 días a la semana y el resto de días los dedicaban a preparar herramientas y trabajo de casa. Básicamente realizan actividad física moderada todos los días y de vez en cuando días de actividad física muy intensa seguidos por días de descanso. Caminan por terrenos difíciles a diario, trepando por árboles, arrastrándose por hierbajos y bajo ramas, moviendo cargas pesadas etc. Las cazas de monos eran realmente fatigantes, ya que consistían en sprints repetidos cada 20-30 segundos durante periodos de 1 hora sin descansar. El periodo de caza supone largos periodos de actividad aeróbica para buscar la presa y trabajo de fuerza intenso para arrastrar lo cazado hasta el campamento, sobre terreno irregular. Los sprints, saltos, escalada, cargar animales y objetos pesados estaban a la orden del día.

La mayoría de estas personas entre 30-50 años presentaban mayor capacidad aeróbica que los Americanos modernos de su edad.

Las mujeres normalmente recogían frutos, vegetales, animales pequeños como reptiles, huevos, agua y otro tipo de alimentos cada 3 días para posteriormente transportarlos hasta el campamento. Esto suponía recorrer largas distancias en grupo, caminando durante horas y con los niños encima. Muchas veces requerían esfuerzos de escavar, trepar, llevar cargas pesadas etc. Además hasta que el niño cumplía 4 años lo llevaban en brazos o en la espalda, recorriendo distancias de hasta 5 km. Otras responsabilidades eran la construcción de la cabaña y herramientas, preparar la comida y socialización mediante danzas y cuentos.



De la Paleovida a la Industrialización: Experiencia del antropólogo Kim Hill durante 30 años viviendo con tribus

Energy expenditure on physical activity: hunter-gatherers vs modern Humans²³

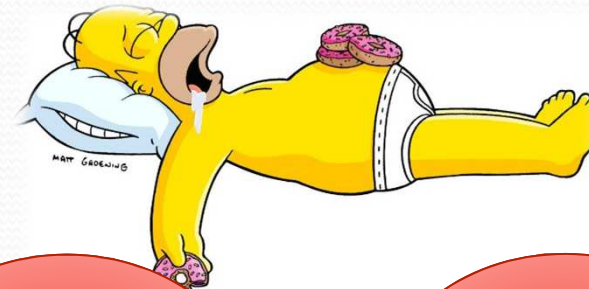
Species	Sex	Total daily energy expenditure*	Energies for PA*	Daily distances covered (km)
Fossil hominids				
<i>Homo habilis</i>		2,387	983	
<i>Homo erectus</i>		2,731	1,214	
<i>Homo sapiens</i> (early)		2,880	1,284	
Hunters-gatherers				
Kung	M	2,178	903	10
	F	1,770	600	8
Ache	M	3,327	1,778	16
Sedentary modern humans				
	M	2,000	306	2.4
	F	1,679	231	2.4

Abbreviations: M indicates male; F, female.

* Values are displayed in kCal.

8-16km/d
vs 2-3
actuales

Las personas
obesas déficit
de 2h30´/d
deambular &
de pie



50,2% de
inactividad
en España

58,2%
sobrepeso/
obesidad en
España

O'Keefe et al. *Prog Card Dis* 2011; 53: 471-479

En países desarrollados caminar no es una necesidad



O'Keefe et al. *Prog Card Dis* 2011; 53: 471-479

Consecuencias de la inactividad



Consecuencias de la inactividad

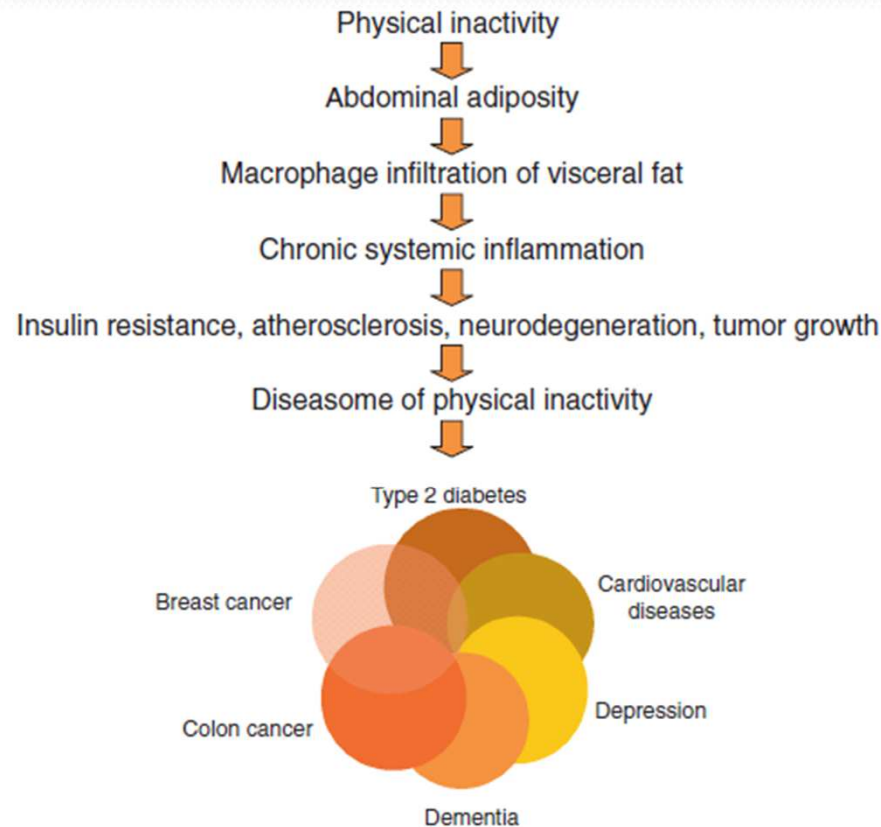


Figure 10 Hypothesis: physical inactivity leads to accumulation of visceral fat and consequently to the activation of a network of inflammatory pathways, which promotes development of insulin resistance, atherosclerosis, neurodegeneration, and tumor growth, leading to the development of "the diseasome of physical inactivity." Adapted, with permission, from [155].

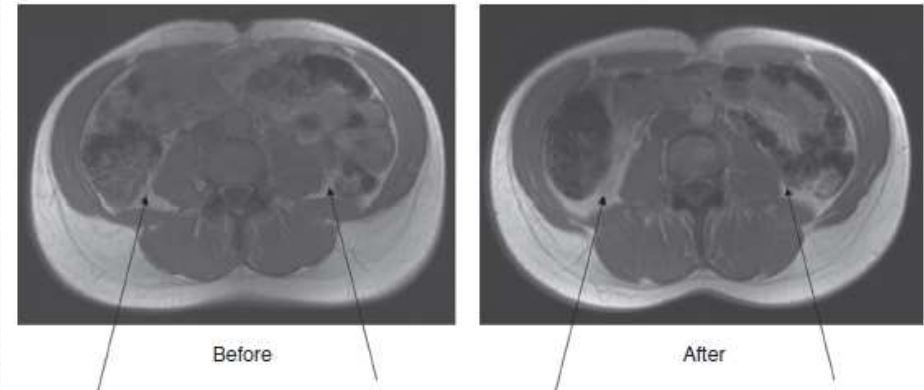


Figure 11 MR-scanning demonstrating visceral fat mass before and after 14 days of reduced daily stepping as described in [155].

↑ 7% grasa intra-abdominal, ↓ 7% VO_{2max} , ↓ sensibilidad a la insulina y metabolismo lipídico tras 14 días de inactividad

- Acumulación de grasa visceral previa a segregación de $TNF-\alpha$ por el tejido adiposo (resistencia a la insulina, diabetes, síndrome metabólico)

2. Efectos del ejercicio físico en la salud

Exercise is the real pollypill

Table 1

Physiological mechanisms underlying the positive effects of exercise training on the aging process.

	Protective mechanisms of exercise training		
1	Improved endothelial function and passivation of atherosclerotic plaques	8	Improvement in skeletal muscle function (resistance training) • Improved muscle mass and strength developed by muscle groups • Improved muscle power (force generation at high contraction speed) • Improved muscle quality, muscle recruitment and connective tissue • Reduction of functional deficits and disease co-morbidity • Improved QoL and IADL performance
2	Reduction in systemic inflammation	9	Improvements in bone mineral density and ultrastructure
3	Beneficial effects on the autonomic regulation of cardiovascular function	10	Improvement of chromosomal function • Improved telomerase enzyme activity • Less reduction in telomerase length
4	Improvement in cardiovascular risk factor control • Increase in HDL-cholesterol concentrations • Reduction in triglyceride and LDL-cholesterol • Reduction in blood pressure • Reduction in body fat mass • Reduction in insulin resistance and improvement in glucose metabolism	11	Improvement in cognitive function (aerobic and resistance training)
5	Potential anti-thrombotic and anti-platelet effects		
6	Heart intrinsic mechanisms • Ischemic preconditioning with reduced myocardial damage during prolonged ischemia • Prevention of reperfusion-induced ventricular arrhythmias		
7	Improvement in maximal oxygen uptake ($\text{VO}_{2\text{max}}$) • Reduced all-cause and cardiovascular mortality • Improved functional capacity, QoL and ADL performance • Improved pulmonary function • Improved central hemodynamics (cardiac output/stroke volume) • Improved skeletal muscle metabolism (muscle blood flow, O_2 utilization, mitochondrial function)		

QoL indicates quality of life; ADL: activities of daily living; IADL: independent activities of daily living.

2. Efectos del ejercicio físico en la salud

Exercise is the real polypill

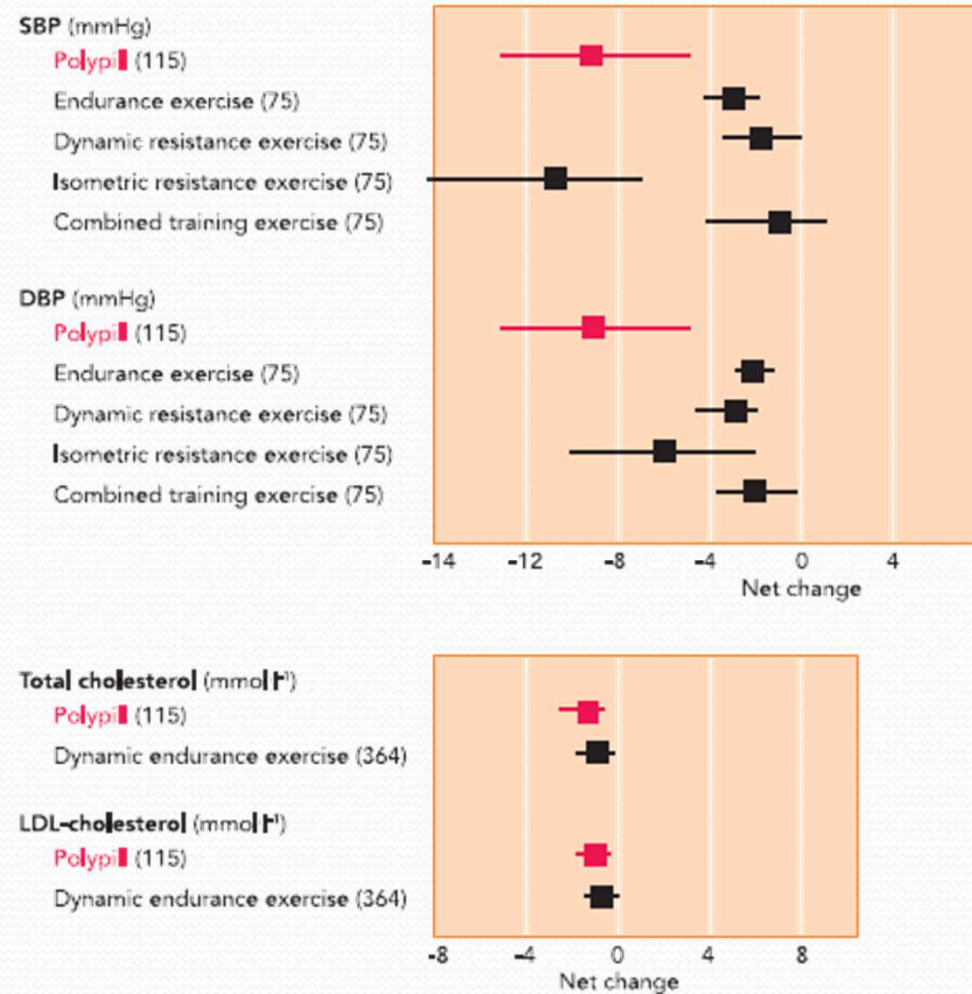


FIGURE 1. Comparison on the effects of the polypill vs. exercise interventions on outcomes related to CVD risk using data from meta-analyses (see text for more details)

Data of mean change in the outcomes are expressed in mean and 95% confidence intervals.

2. Efectos del ejercicio físico en la salud

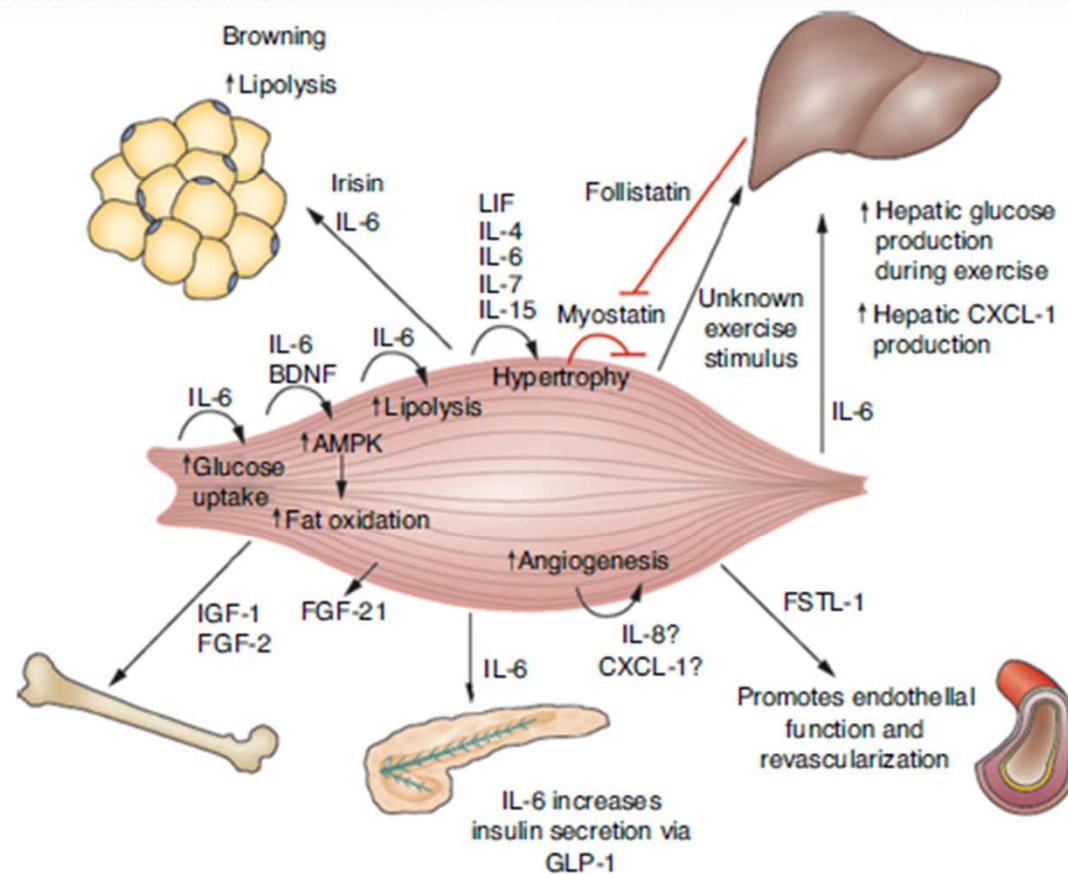


Figure 1 Skeletal muscle is a secretory organ. Leukemia inhibitory factor (LIF), interleukin (IL)-4, IL-6, IL-7, and IL-15 promote muscle hypertrophy. Myostatin inhibits muscle hypertrophy and exercise provokes the release of a myostatin inhibitor, follistatin, from the liver. Brain-derived neurotrophic factor (BDNF) and IL-6 are involved in AMP-activated protein kinase (AMPK)-mediated fat oxidation and IL-6 enhances insulin-stimulated glucose uptake. IL-6 appears to have systemic effects on the liver and adipose tissue and increases insulin secretion via upregulation of GLP-1. Insulin-like growth factor-1 (IGF-1) and FGF-2 are involved in bone formation, and follistatin-related protein 1 improves endothelial function and revascularization of ischemic vessels. Irisin has a role in "browning" of white adipose tissue. Adapted, with permission, from (172).

Pedersen. *Compr Physiol* 3: 1337-1362, 2013

Yin-Yang Tejido Adiposo vs Tejido Muscular

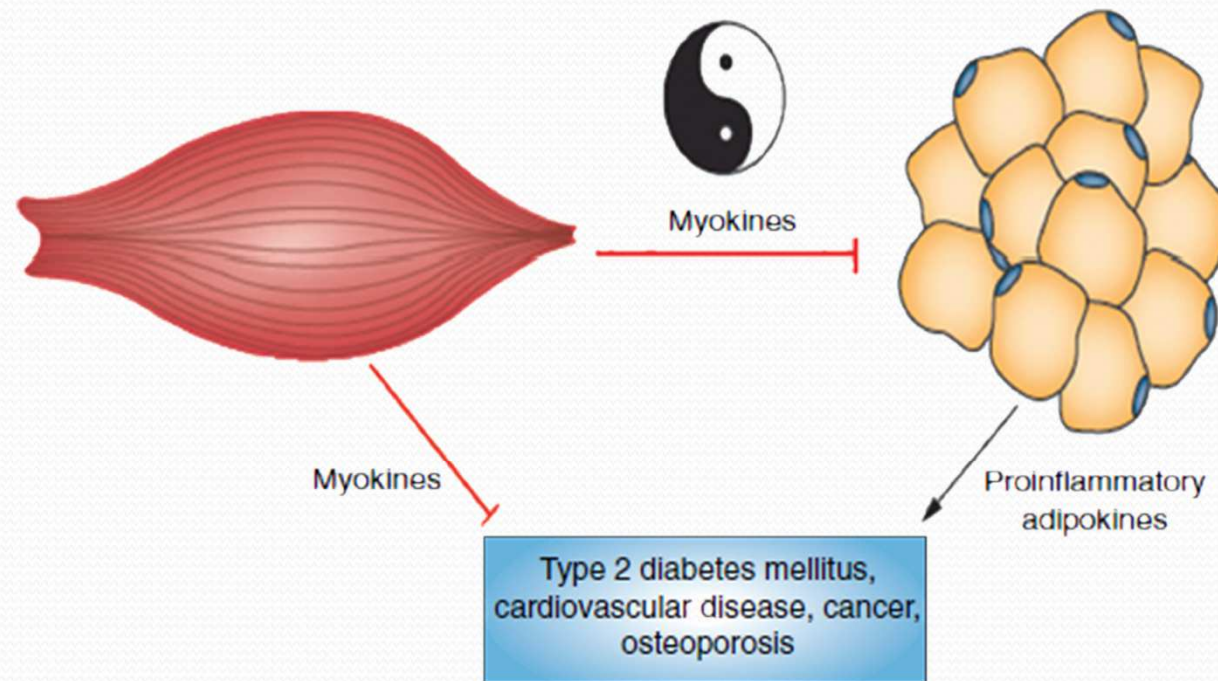


Figure 2 The interplay between adipokines and myokines represents a Yin Yang balance. Especially under conditions of obesity, adipose tissue secretes adipokines that contribute to establish a chronic inflammatory environment, promoting pathological processes such as atherosclerosis and insulin resistance. Skeletal muscles are capable of producing myokines that confer some of the health benefits of exercise. Such myokines might counteract the harmful effects of proinflammatory adipokines. Adapted, with permission, from (1/2).

2. Efectos del ejercicio físico en la salud

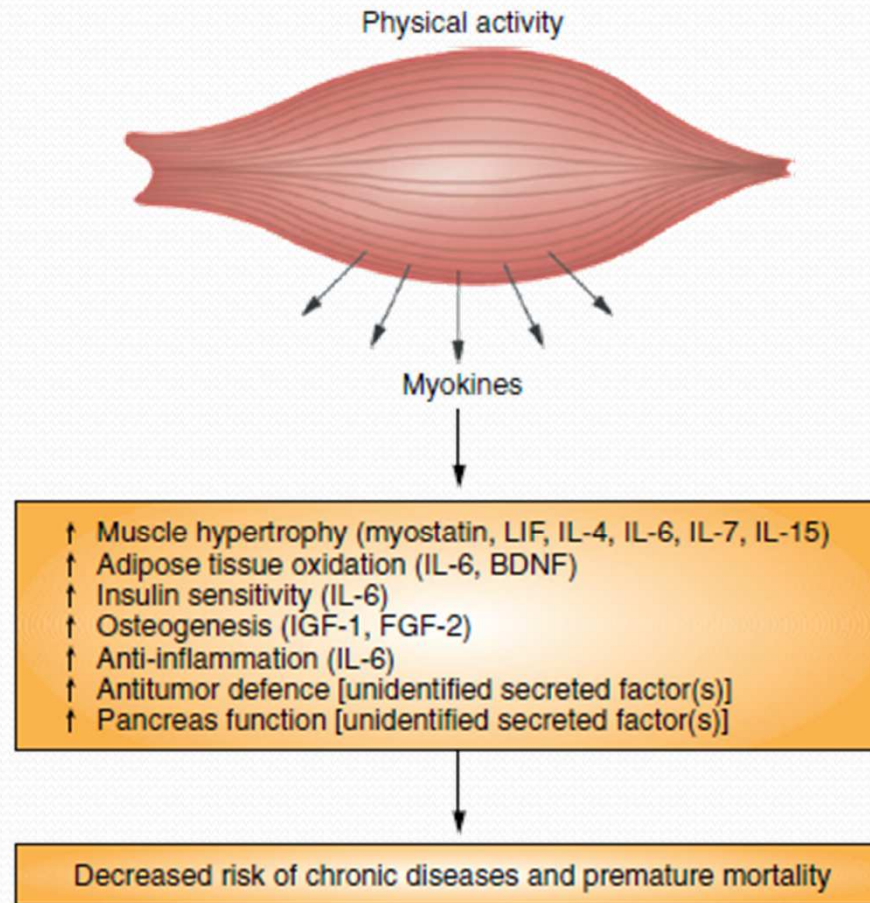


Figure 13 The finding that muscle produces and releases myokines provides a conceptual basis for understanding some of the molecular mechanisms that link physical activity to protection against premature mortality (172).

El rol de la Interleuquina-6

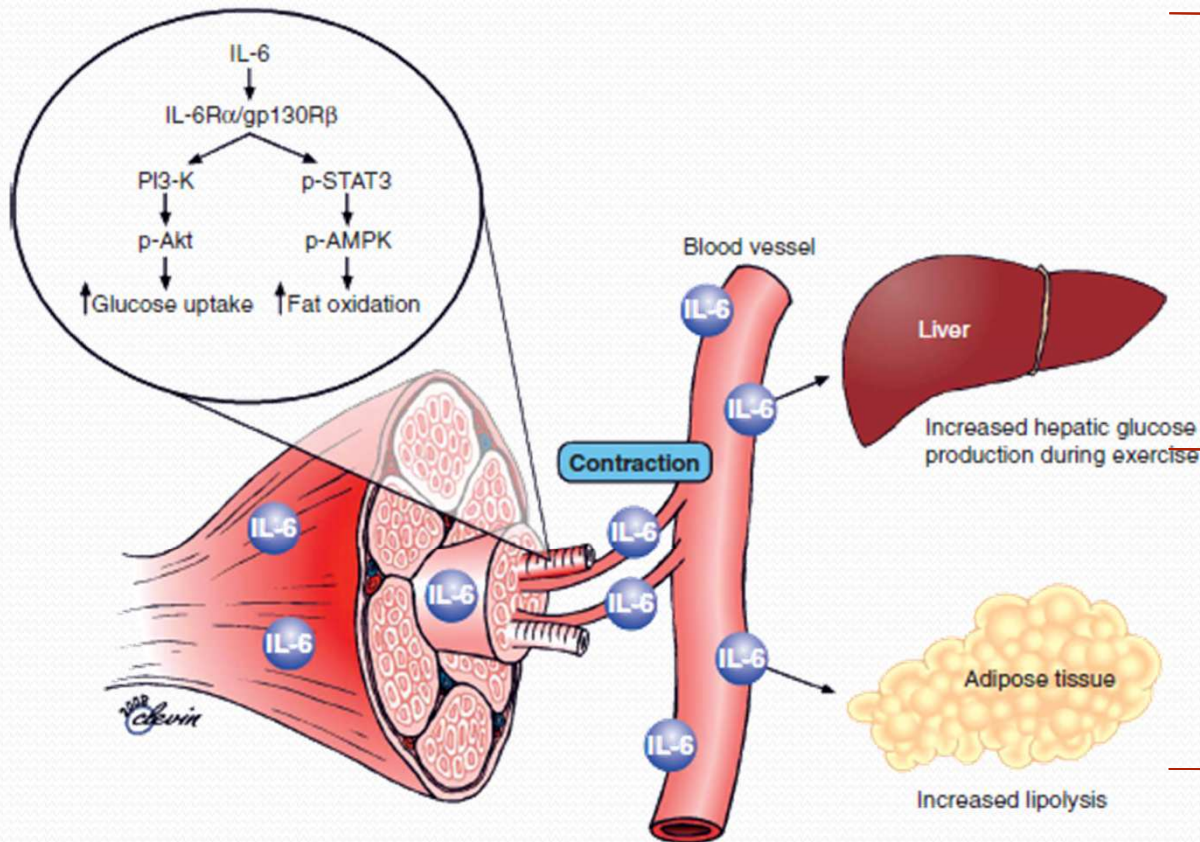


Figure 7 Biological role of contraction-induced interleukin-6 (IL-6). Skeletal muscle expresses and releases myokines into the circulation. In response to muscle contractions, both type I and type II muscle fibers express the myokine IL-6, which subsequently exerts its effects both locally within the muscle (e.g., through activation of AMPK) and—when released into the circulation—peripherally in several organs in a hormone-like fashion. Specifically in skeletal muscle, IL-6 acts in an autocrine or paracrine manner to signal through a gp130R β /IL-6R α homodimer resulting in activation of AMP-kinase and/or PI3-kinase to increase glucose uptake and fat oxidation. IL-6 is also known to increase hepatic glucose production during exercise or lipolysis in adipose tissue. Modified, with permission, from [173].

No requiere daño muscular (ejercicio excéntrico) para su segregación

Mayor segregación con $\downarrow$ glucógeno. *Training low, ayunas!!!*

Estimula el crecimiento muscular y la angiogénesis

El rol de la Interleuquina-6

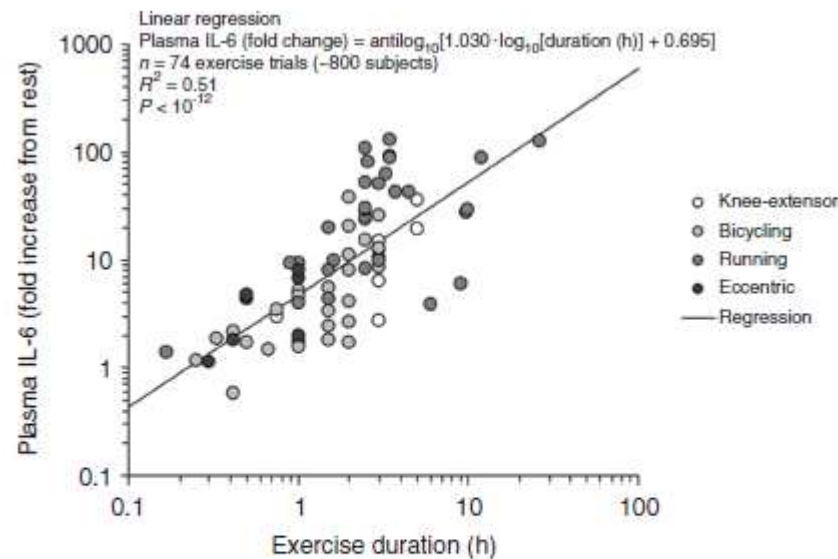


Figure 5 The overall log₁₀-log₁₀ linear relation (straight solid line) between exercise duration and increase in plasma interleukin-6 (IL-6) (fold change from preexercise level) indicates that 51% of the variation in fold plasma IL-6 increase may be explained by the duration of exercise. Modified, with permission, from (58).

La producción de IL-6 aumenta de forma exponencial con el la duración del ejercicio y la masa muscular activa (Running)

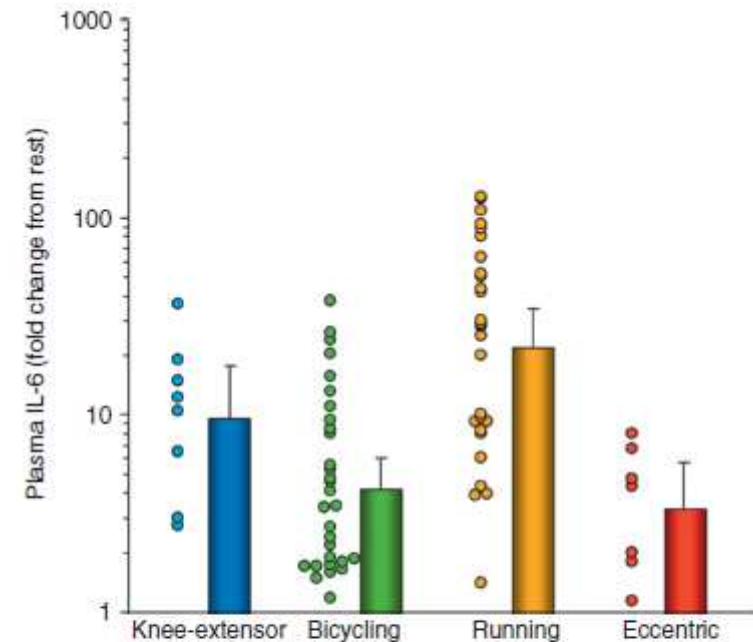


Figure 4 Different modes of exercise and the corresponding increase in plasma interleukin-6 (IL-6) levels. Graph is based on 73 exercise trials and represents ~800 subjects. Each dot indicates one exercise trial; the corresponding bars represent geometric means with 95% confidence intervals. Although different modes of exercise are associated with different levels of muscle damage, the increase in plasma IL-6 levels postexercise is a consistent finding. Modified, with permission, from (58, 173).

2. Efectos del ejercicio físico en la salud

Efectos agudos vs Crónicos del ejercicio físico. Cáncer de mama



- **Body & Cancer program:** 6 semanas de EF como parte del tratamiento junto a quimioterapia (3d/s, 2h fuerza+HIIT Spinning)
- **PA after cancer treatment:** 6 meses ejercicio ≥ 3 d/s (1 sesión supervisada 90´ Aeróbico HIIT spinning + Fuerza)

Dethlefsen et al. *Breast Cancer Res Treat* 159: 469-479, 2016



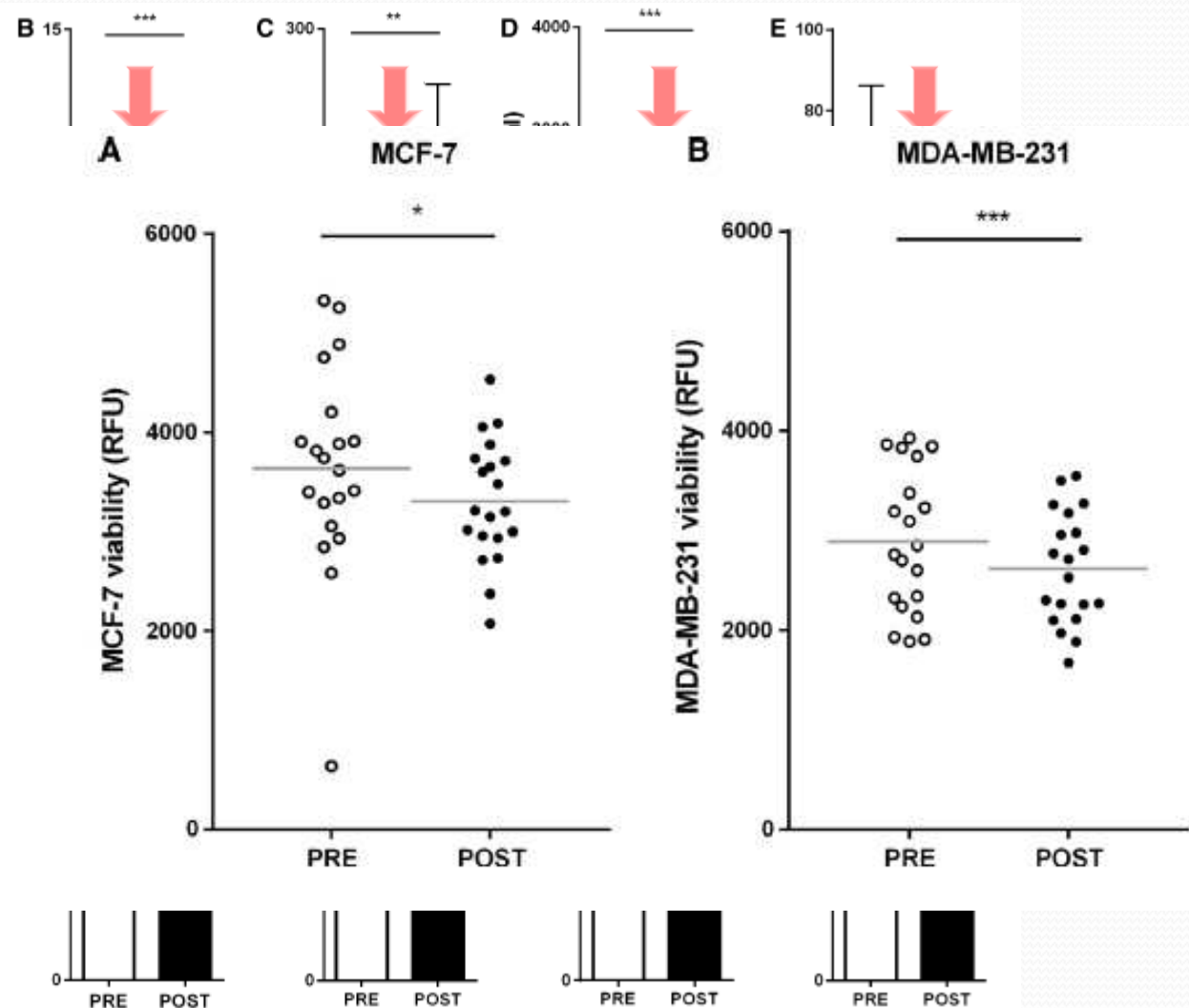
The Danish National Research Foundation's

Centre of Inflammation and Metabolism



Efectos agudos del ejercicio. Cáncer de mama

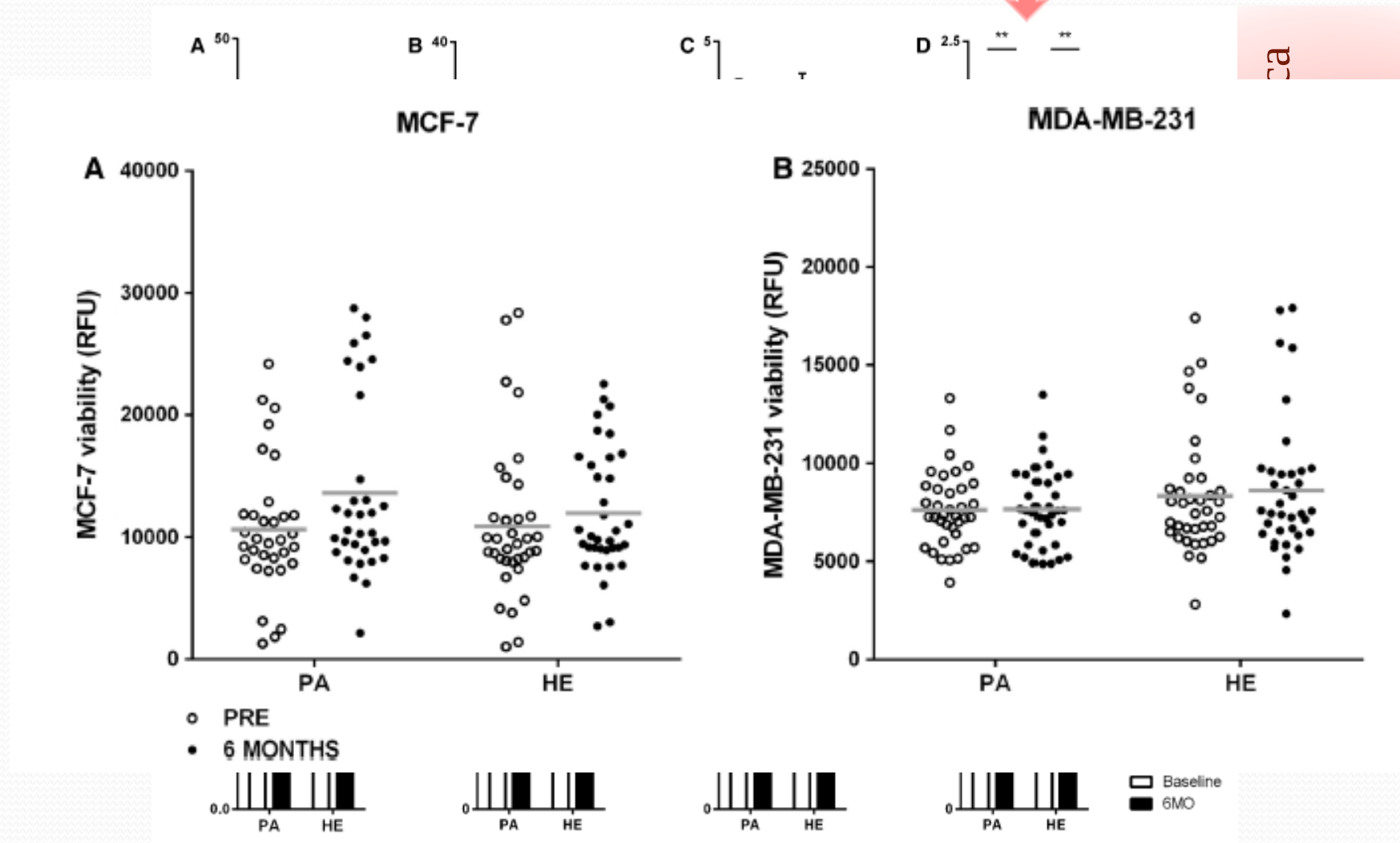
Fig. 4 Viability of MCF-7 (a) and MDA-MB-231 (b) breast cancer cells measured as a fluorescence signal, RFU, generated by live-cell protease activity after 48 h of stimulation with media containing 10 % human serum obtained after (POST) the acute exercise bout compared to serum obtained at rest (PRE). Statistical significance was tested by paired *t*-test. **p* < 0.05, ****p* < 0.001



Dethlefsen et al. *Breast Cancer Res Treat* 159: 469-479, 2016

2. Efectos del ejercicio físico en la salud

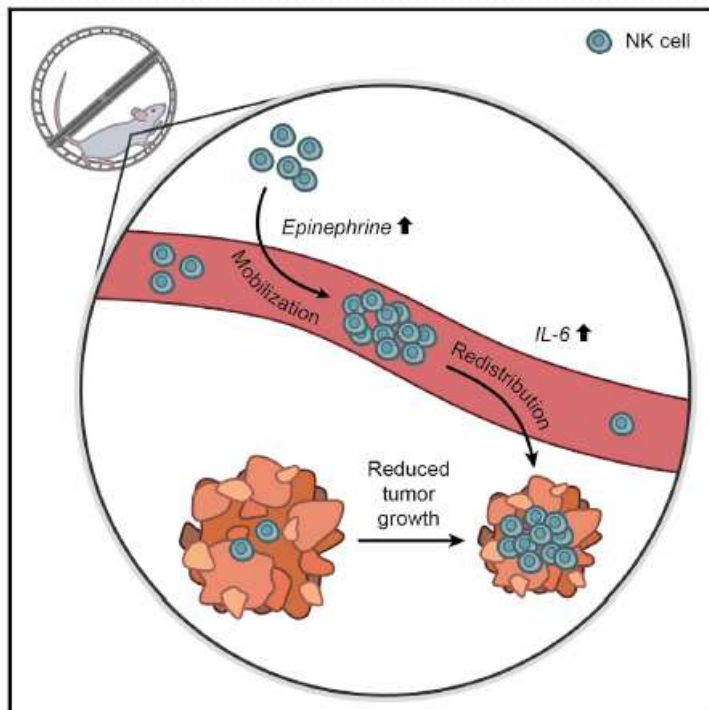
Efectos crónicos del ejercicio. Cáncer de mama



Dethlefsen et al. *Breast Cancer Res Treat* 159: 469-479, 2016

2. Efectos del ejercicio físico en la salud

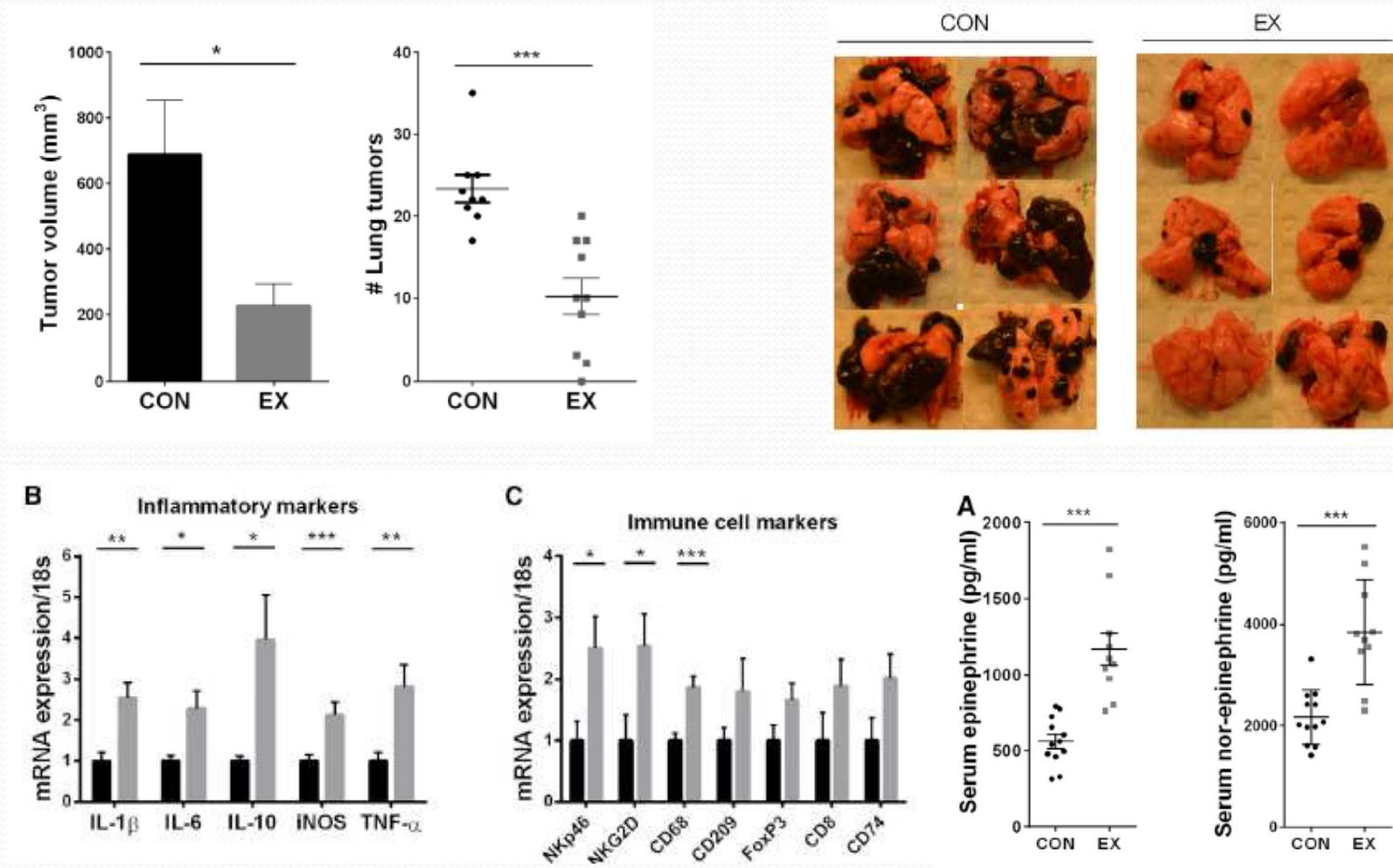
Correr reduce el tamaño del tumor por la segregación de epinefrina y la movilización de células NK dependientes de IL-6



- ↓60% incidencia y el crecimiento del tumor en ratones que corren 4.1 – 6.8km/día (Pedersen et al., 2016)
- Los ratones que corrían prevenían la pérdida de peso o caquexia
- **↑ Epinefrina + IL-6** → Movilización, redistribución e infiltración de **células NK** reduciendo el tamaño del tumor

Pedersen et al. *Cell Metabolism* 23: 1-9, 2016

Correr reduce el tamaño del tumor por la segregación de epinefrina y la movilización de células NK dependientes de IL-6

Pedersen et al. *Cell Metabolism* 23: 1-9, 2016

3. Guías internacionales de AF

¿Una misma intensidad para todos?



Gasto energético de las actividades laborales y de ocio

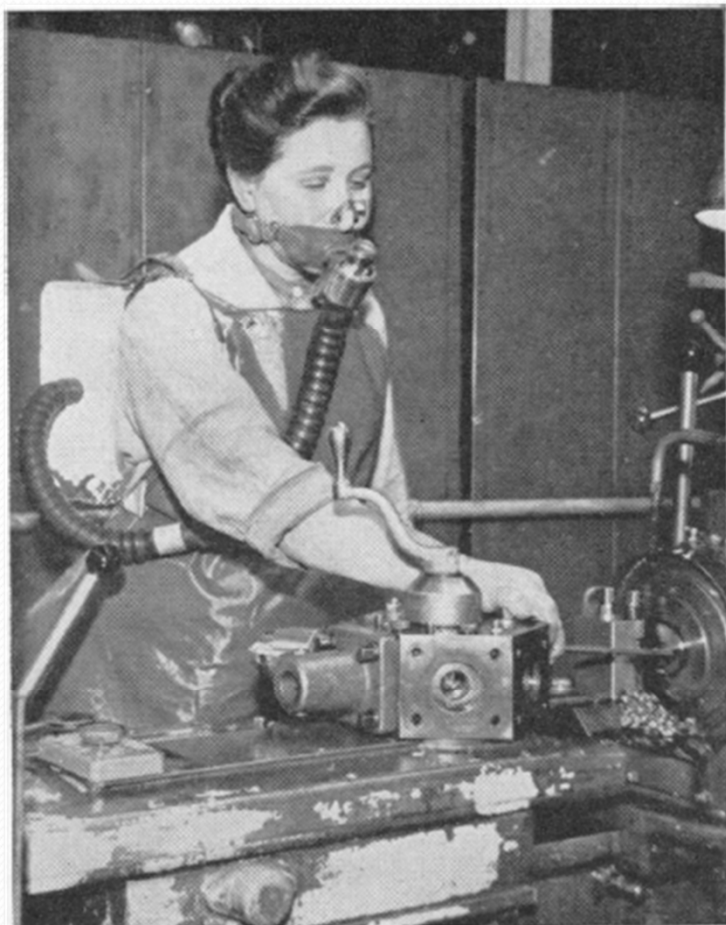


FIG. 1.—Capstan lathe operative with portable respirometer fitted and adjusted so that it does not impede normal work performance.

RANGES AND MEAN RATES OF ENERGY EXPENDITURE OF 381 SUBJECTS, 242 MEN AND 139 WOMEN, IN 54 OCCUPATIONS, AND "SLOUGH SCALE" RANGES

Work Grade	Occupation	Subjects		Energy Expenditure (kcal./m ² ./hr.)		
		M	F	Range	Mean	Slough Scale
Sedentary	Mechanical A/c	—	17	37.0-80.7	59.0	40-70
	Hollerith	2	2	46.1-74.6	62.1	
	Typist	—	5	57.0-76.0	68.0	
	Tailor	9	—	49.0-67.0	55.0	
	Draughtsman	5	—	51.0-75.0	61.0	
	Inspector	—	4	56.0-62.0	59.0	
	Watch repairer	8	—	46.0-60.0	53.0	
	Clerk	9	—	40.2-65.9	54.4	
Sedentary-to-light	Tally clerk	10	—	43.0-91.3	64.6	40-110
	Gasket inspector	—	4	57.7-89.2	73.1	
Light	Machine minding	6	—	56.6-123.3	90.2	70-110
	Frame cutting	2	—	77.8-104.8	90.5	
	Gasket packing	—	6	71.5-115.9	96.6	
	Canteen work	—	5	74.1-126.2	92.7	
	Light turning	8	6	50.6-98.0	72.8	
	Finishing	1	17	50.0-114.0	81.0	
	Boot and shoe repair	5	—	76.0-117.0	97.0	
Light-to-moderate	Tapping and drilling	2	—	109.1-173.3	140.9	70-180
	Tool making	5	—	47.4-155.0	106.7	
	Capstan lathe	—	1	88.5-115.3	106.1	
	Gasket roller	—	1	102.1-112.9	107.9	
	Router machine	1	—	124.0-129.8	126.9	
	Medium press	10	—	70.8-137.2	104.5	
	Small press	—	15	65.8-116.9	82.9	
	Eyelet (foot) press	—	9	55.1-114.1	81.2	
	Printing press	5	—	72.3-140.6	97.6	
	Plastic moulding	12	1	84.0-148.0	111.0	
	Ebonite moulding	7	—	96.0-146.0	112.0	
	Plate punching (battery)	5	—	92.0-135.0	110.6	
	Plate cutting (battery)	14	—	82.0-168.0	113.0	
	Machinist	12	—	74.0-144.0	104.0	
	Roller mill	3	—	101.0-146.0	129.0	
	Sheet metal work	8	—	50.0-144.0	102.0	
	Metal turning (shell cases)	—	8	58.8-165.6	96.0	
	Turning and finishing (shell cases)	—	8	42.6-186.6	112.0	
	Tool setting	—	5	69.0-201.6	124.0	
	Forging	—	4	81.0-160.8	114.0	
Moderate	Hand press	6	—	73.0-165.4	121.3	110-180
	Annealing	2	—	88.7-147.9	119.0	
	Gasket supply	—	4	147.5-195.9	170.2	
Moderate-to-heavy	Labourers	4	5	68.7-206.4	147.4	110-300
	Power truck driver	5	—	83.9-218.4	164.3	
	Copper and card cutter	3	—	62.6-177.7	115.5	
	Carboy washer	4	—	83.4-237.8	158.8	
	Walking and carrying (shell cases)	—	3	112.2-207.6	161.3	
	Cleaning and drying (shell cases)	—	5	109.8-298.2	182.3	
	Gauging shell cases	—	4	78.0-235.2	154.0	
Heavy	Filling and stacking 1-cwt. bags	4	—	150.9-248.6	200.4	180-300
	Hopper loader	3	—	203.2-282.9	241.9	
	Loading and unloading carboys and 1-cwt. bags	4	—	131.8-256.5	187.6	
Heavy-to-very heavy	Furnace cleaning	2	—	161.5-351.7	267.5	180-300 +
	Hewing coal	18	—	181.8-364.2	241.8	
	Girding and timbering	18	—	143.0-267.3	195.2	
	Loading coal	20	—	168.6-325.8	243.1	

Brown & Crowden. *Br J Industr* 20: 277-283, 1963

3. Guías internacionales de AF



8. Guías internacionales de AF



Compendium of Physical Activities

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3.0	walking the dog
3.0	walking, 2.5 mph, level, firm surface
3.3	walking, 2.5 mph, downhill
3.5	walking, 2.8 to 3.2 mph, level, moderate pace, firm surface
4.3	walking, 3.5 mph, level, brisk, firm surface, walking for exercise
5.3	walking, 2.9 to 3.5 mph, uphill, 1 to 5% grade
8.0	walking, 2.9 to 3.5 mph, uphill, 6% to 15% grade
5.0	walking, 4.0 mph, level, firm surface, very brisk pace
7.0	walking, 4.5 mph, level, firm surface, very, very brisk
8.3	walking, 5.0 mph, level, firm surface

2.3	cleaning, sweeping, slow, light effort
3.8	cleaning, sweeping, slow, moderate effort
3.5	cleaning, heavy or major (e.g. wash car, wash windows, clean garage), moderate effort
3.5	cleaning, mopping, standing, moderate effort
3.2	cleaning windows, washing windows, general
2.5	mopping, standing, light effort
4.5	polishing floors, standing, walking slowly, using electric polishing machine
2.8	multiple household tasks all at once, light effort
3.5	multiple household tasks all at once, moderate effort

7.0	bicycling, stationary, general
3.5	bicycling, stationary, 30-50 watts, very light to light effort
6.8	bicycling, stationary, 90-100 watts, moderate to vigorous effort
8.8	bicycling, stationary, 101-160 watts, vigorous effort
11.0	bicycling, stationary, 161-200 watts, vigorous effort
14.0	bicycling, stationary, 201-270 watts, very vigorous effort
4.8	bicycling, stationary, 51-89 watts, light-to-moderate effort
8.5	bicycling, stationary, RPM/Spin bike class
8.0	calisthenics (e.g., push ups, sit ups, pull-ups, jumping jacks), vigorous effort

Clasificación de la intensidad de la actividad física: METs

TABLE 2. MET equivalents of common physical activities classified as light, moderate or vigorous intensity.

Light <3.0 METs	Moderate 3.0 – 6.0 METs	Vigorous >6.0 METs
Walking Walking slowly around home, store or office = 2.0*	Walking Walking 3.0 mph = 3.3* Walking at very brisk pace (4 mph) = 5.0*	Walking, jogging & running Walking at very very brisk pace (4.5 mph) = 6.3* Walking/hiking at moderate pace and grade with no or light pack (<10 lb) = 7.0 Hiking at steep grades and pack 10–42 lb = 7.5–9.0 Jogging at 5 mph = 8.0* Jogging at 6 mph = 10.0* Running at 7 mph = 11.5*
Household & occupation Sitting — using computer work at desk using light hand tools = 1.5 Standing performing light work such as making bed, washing dishes, ironing, preparing food or store clerk = 2.0–2.5	Cleaning — heavy: washing windows, car, clean garage = 3.0 Sweeping floors or carpet, vacuuming, mopping = 3.0–3.5 Carpentry — general = 3.6 Carrying & stacking wood = 5.5 Mowing lawn — walk power mower = 5.5	Shoveling sand, coal, etc. = 7.0 Carrying heavy loads such as bricks = 7.5 Heavy farming such as bailing hay = 8.0 Shoveling, digging ditches = 8.5
Leisure time & sports Arts & crafts, playing cards = 1.5 Billiards = 2.5 Boating — power = 2.5 Croquet = 2.5 Darts = 2.5 Fishing — sitting = 2.5 Playing most musical instruments = 2.0–2.5	Badminton — recreational = 4.5 Basketball — shooting around = 4.5 Bicycling — on flat: light effort (10–12 mph) = 6.0 Dancing — ballroom slow = 3.0; ballroom fast = 4.5 Fishing from river bank & walking = 4.0 Golf — walking pulling clubs = 4.3 Sailing boat, wind surfing = 3.0 Swimming leisurely = 6.0† Table tennis = 4.0 Tennis doubles = 5.0 Volleyball — noncompetitive = 3.0–4.0	Basketball game = 8.0 Bicycling — on flat: moderate effort (12–14 mph) = 8.0; fast (14–16 mph) = 10 Skiing cross country — slow (2.5 mph) = 7.0; fast (5.0–7.9 mph) = 9.0 Soccer — casual = 7.0; competitive = 10.0 Swimming — moderate/hard = 8–11† Tennis singles = 8.0 Volleyball — competitive at gym or beach = 8.0

Haskell et al. *Med Sci Sports Exer* 49: 1432-1434, 2007

Quantity and quality of exercise for Adults: ACSM Position Stand

TABLE 2. Evidence statements and summary of recommendations for the individualized exercise prescription.

	Evidence-Based Recommendation	Evidence Category
Cardiorespiratory ("aerobic") exercise		
Frequency	≥ 5 d·wk ⁻¹ of moderate exercise, or ≥ 3 d·wk ⁻¹ of vigorous exercise, or a combination of moderate and vigorous exercise on ≥ 3 –5 d·wk ⁻¹ is recommended.	A
Intensity	Moderate and/or vigorous intensity is recommended for most adults.	A
	Light- to moderate-intensity exercise may be beneficial in deconditioned persons.	B
Time	30–60 min·d ⁻¹ (150 min·wk ⁻¹) of purposeful moderate exercise, or 20–60 min·d ⁻¹ (75 min·wk ⁻¹) of vigorous exercise, or a combination of moderate and vigorous exercise per day is recommended for most adults.	A
	<20 min·d ⁻¹ (<150 min·wk ⁻¹) of exercise can be beneficial, especially in previously sedentary persons.	B
Type	Regular, purposeful exercise that involves major muscle groups and is continuous and rhythmic in nature is recommended.	A
Volume	A target volume of ≥ 500 –1000 MET·min·wk ⁻¹ is recommended.	C
	Increasing pedometer step counts by ≥ 2000 steps per day to reach a daily step count ≥ 7000 steps per day is beneficial.	B
	Exercising below these volumes may still be beneficial for persons unable or unwilling to reach this amount of exercise.	C
Pattern	Exercise may be performed in one (continuous) session per day or in multiple sessions of ≥ 10 min to accumulate the desired duration and volume of exercise per day.	A
	Exercise bouts of <10 min may yield favorable adaptations in very deconditioned individuals.	B
	Interval training can be effective in adults.	B
Progression	A gradual progression of exercise volume by adjusting exercise duration, frequency, and/or intensity is reasonable until the desired exercise goal (maintenance) is attained.	B
	This approach may enhance adherence and reduce risks of musculoskeletal injury and adverse CHD events.	D

Garber et al. *Med Sci Sports Exer* 43(7): 1334-1359, 2011

Quantity and quality of exercise for Adults: ACSM Position Stand

Resistance exercise		
Frequency	Each major muscle group should be trained on 2–3 d·wk ⁻¹ .	A
Intensity	60%–70% of the 1RM (moderate to hard intensity) for novice to intermediate exercisers to improve strength.	A
	≥80% of the 1RM (hard to very hard intensity) for experienced strength trainers to improve strength.	A
	40%–50% of the 1RM (very light to light intensity) for older persons beginning exercise to improve strength.	A
	40%–50% of the 1RM (very light to light intensity) may be beneficial for improving strength in sedentary persons beginning a resistance training program.	D
	<50% of the 1RM (light to moderate intensity) to improve muscular endurance.	A
	20%–50% of the 1RM in older adults to improve power.	B
Time	No specific duration of training has been identified for effectiveness.	
Type	Resistance exercises involving each major muscle group are recommended.	A
	A variety of exercise equipment and/or body weight can be used to perform these exercises.	A
Repetitions	8–12 repetitions is recommended to improve strength and power in most adults.	A
	10–15 repetitions is effective in improving strength in middle aged and older persons starting exercise	A
	15–20 repetitions are recommended to improve muscular endurance	A
Sets	Two to four sets are the recommended for most adults to improve strength and power.	A
	A single set of resistance exercise can be effective especially among older and novice exercisers.	A
	≤2 sets are effective in improving muscular endurance.	A
Pattern	Rest intervals of 2–3 min between each set of repetitions are effective.	B
	A rest of ≥48 h between sessions for any single muscle group is recommended.	A
Progression	A gradual progression of greater resistance, and/or more repetitions per set, and/or increasing frequency is recommended.	A

Garber et al. *Med Sci Sports Exer* 43(7): 1334-1359, 2011

Quantity and quality of exercise for Adults: ACSM Position Stand

Flexibility exercise		
Frequency	$\geq 2-3 \text{ d} \cdot \text{wk}^{-1}$ is effective in improving joint range of motion, with the greatest gains occurring with daily exercise.	B
Intensity	Stretch to the point of feeling tightness or slight discomfort.	C
Time	Holding a static stretch for 10–30 s is recommended for most adults. In older persons, holding a stretch for 30–60 s may confer greater benefit. For PNF stretching, a 3- to 6-s contraction at 20%–75% maximum voluntary contraction followed by a 10- to 30-s assisted stretch is desirable.	C C B
Type	A series of flexibility exercises for each of the major muscle–tendon units is recommended. Static flexibility (active or passive), dynamic flexibility, ballistic flexibility, and PNF are each effective.	B B
Volume	A reasonable target is to perform 60 s of total stretching time for each flexibility exercise.	B
Pattern	Repetition of each flexibility exercise two to four times is recommended. Flexibility exercise is most effective when the muscle is warmed through light to moderate aerobic activity or passively through external methods such as moist heat packs or hot baths.	B A
Progression	Methods for optimal progression are unknown.	
Neuromotor exercise training		
Frequency	$\geq 2-3 \text{ d} \cdot \text{wk}^{-1}$ is recommended.	B
Intensity	An effective intensity of neuromotor exercise has not been determined.	
Time	$\geq 20-30 \text{ min} \cdot \text{d}^{-1}$ may be needed.	B
Type	Exercises involving motor skills (e.g., balance, agility, coordination, and gait), proprioceptive exercise training, and multifaceted activities (e.g., tai ji and yoga) are recommended for older persons to improve and maintain physical function and reduce falls in those at risk for falling. The effectiveness of neuromuscular exercise training in younger and middle-aged persons has not been established, but there is probable benefit.	B D
Volume	The optimal volume (e.g., number of repetitions, intensity) is not known.	
Pattern	The optimal pattern of performing neuromotor exercise is not known.	
Progression	Methods for optimal progression are not known.	

Table evidence categories: A, randomized controlled trials (rich body of data); B, randomized controlled trials (limited body of data); C, nonrandomized trials, observational studies; D, panel consensus judgment. From the National Heart Lung and Blood Institute (263).

Garber et al. *Med Sci Sports Exer* 43(7): 1334-1359, 2011

Quantity and quality of exercise for Adults: ACSM Position Stand

TABLE 5. Classification of exercise intensity: relative and absolute exercise intensity for cardiorespiratory endurance and resistance exercise.

Intensity	Cardiorespiratory Endurance Exercise										
	Relative Intensity				Intensity (% $\dot{V}O_{2max}$) Relative to Maximal Exercise Capacity in METs			Absolute Intensity	Absolute Intensity (MET) by Age		
	%HRR or % $\dot{V}O_{2R}$	%HR _{max}	% $\dot{V}O_{2max}$	Perceived Exertion (Rating on 6–20 RPE Scale)	20 METs % $\dot{V}O_{2max}$	10 METs % $\dot{V}O_{2max}$	5 METs % $\dot{V}O_{2max}$	METs	Young (20–39 yr)	Middle-aged (40–64 yr)	Older (≥65 yr)
Very light	<30	<57	<37	<Very light (RPE < 9)	<34	<37	<44	<2	<2.4	<2.0	<1.6
Light	30–39	57–63	37–45	Very light–fairly light (RPE 9–11)	34–42	37–45	44–51	2.0–2.9	2.4–4.7	2.0–3.9	1.6–3.1
Moderate	40–59	64–76	46–63	Fairly light to somewhat hard (RPE 12–13)	43–61	46–63	52–67	3.0 to 5.9	4.8–7.1	4.0–5.9	3.2–4.7
Vigorous	60–89	77–95	64–90	Somewhat hard to very hard (RPE 14–17)	62–90	64–90	68–91	6.0–8.7	7.2–10.1	6.0–8.4	4.8–6.7
Near-maximal to maximal	≥90	≥96	≥91	≥Very hard (RPE ≥ 18)	≥91	≥91	≥92	≥8.8	≥10.2	≥8.5	≥6.8

Table adapted from the American College of Sports Medicine (14), Howley (173), Swain and Franklin (344), Swain and Leutholtz (346), Swain et al. (347), and the US Department of Health and Human Services (370). HR_{max}, maximal HR; %HR_{max}, percent of maximal HR; HRR, HR reserve; $\dot{V}O_{2max}$, maximal oxygen uptake; % $\dot{V}O_{2max}$, percent of maximal oxygen uptake; $\dot{V}O_{2R}$, oxygen uptake reserve; RPE, ratings of perceived exertion.

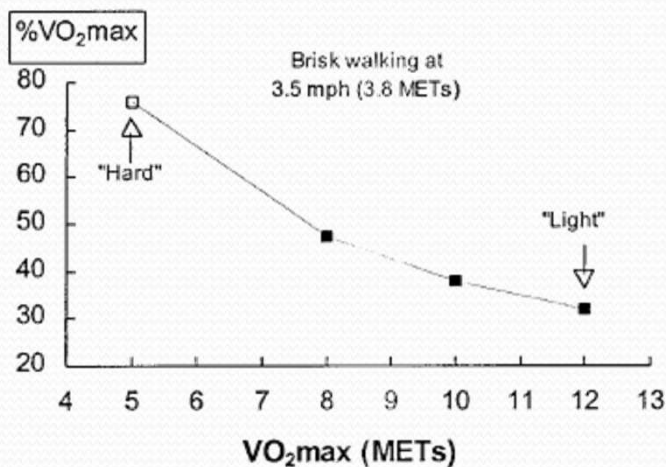


FIGURE 1—Changes in the relative intensity of exercise (% $\dot{V}O_{2max}$) when the same absolute intensity of exercise is performed by groups differing in $\dot{V}O_{2max}$. Figure adapted from Haskell (16).

¿Caminar a 5.6km/h?
Ni loco...



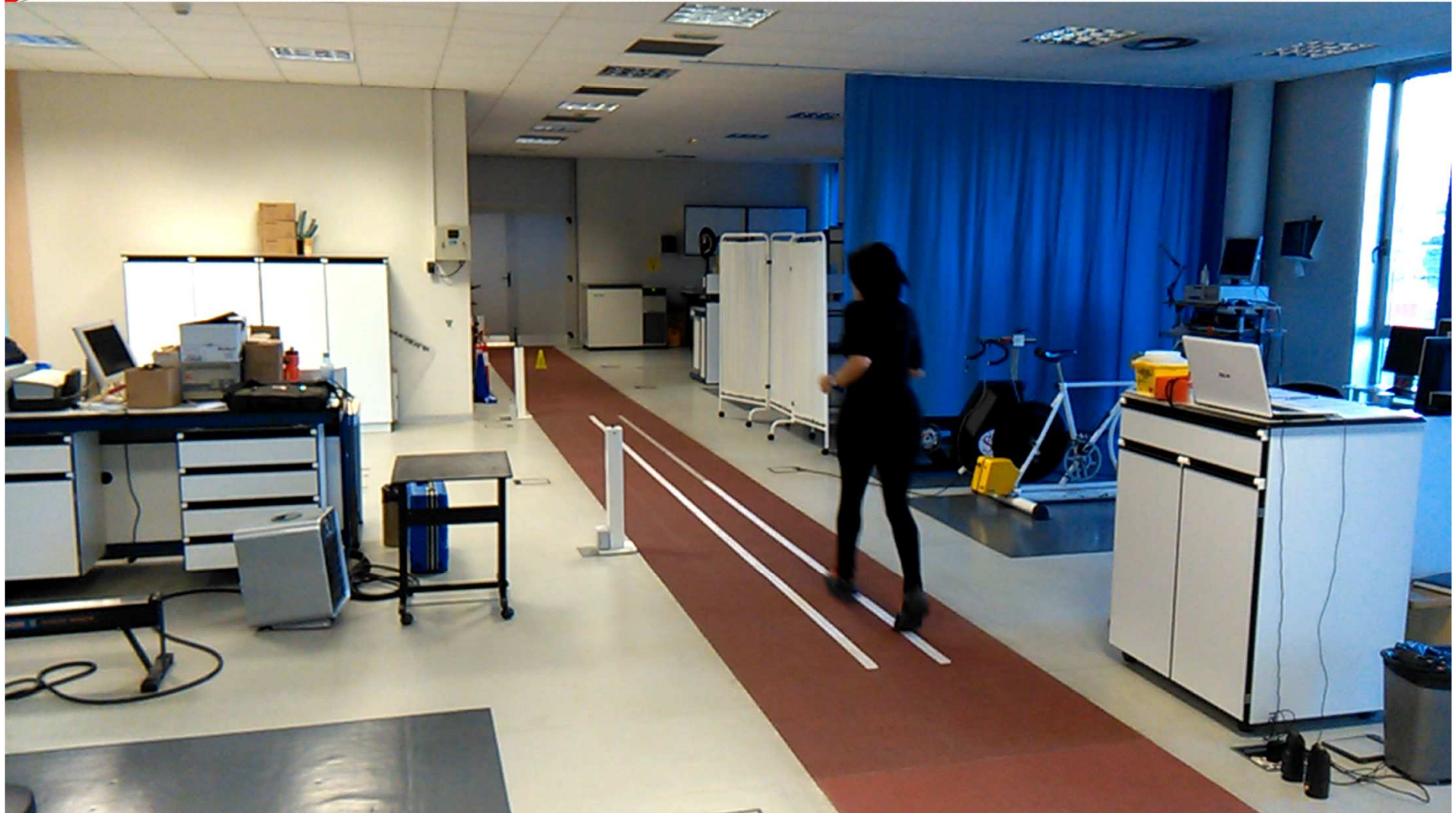
Garber et al. *Med Sci Sports Exer* 43(7): 1334-1359, 2011

4. Individualización de la intensidad

¿Qué tipo de esfuerzo es este?



4. Individualización de la intensidad



4. Individualización de la intensidad

La utilización de los substratos energéticos depende de la **demanda energética**

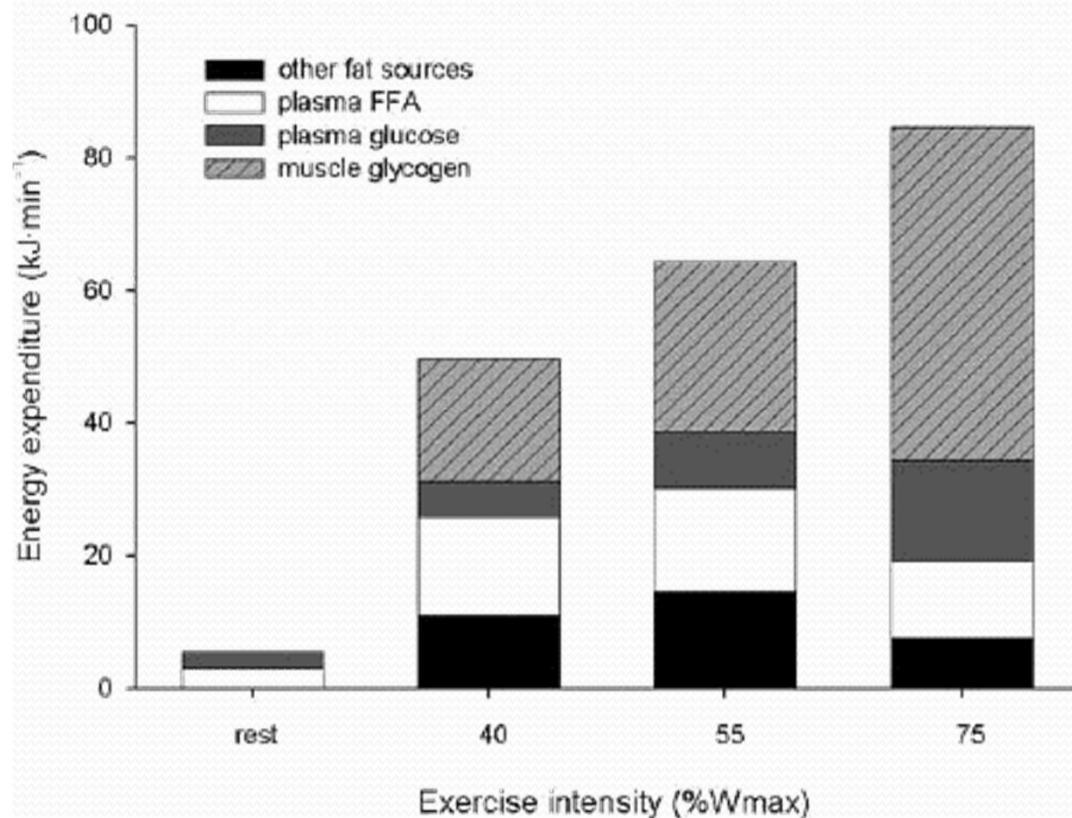


TABLE 2.1 Body Stores of Fuels and Associated Energy Availability

Location	g	kcal
CARBOHYDRATES		
Liver glycogen	110	451
Muscle glycogen	500	2,050
Glucose in body fluids	15	62
FAT		
Subcutaneous and visceral	7,800	73,320
Intramuscular	161	1,513
Total	7,961	74,833

Note. These estimates are based on a body weight of 65 kg (143 lb) with 12% body fat.



- En una maratón (80-90VO_{2max}) ~96% depende de los CHO como fuente energética.

4. Individualización de la intensidad

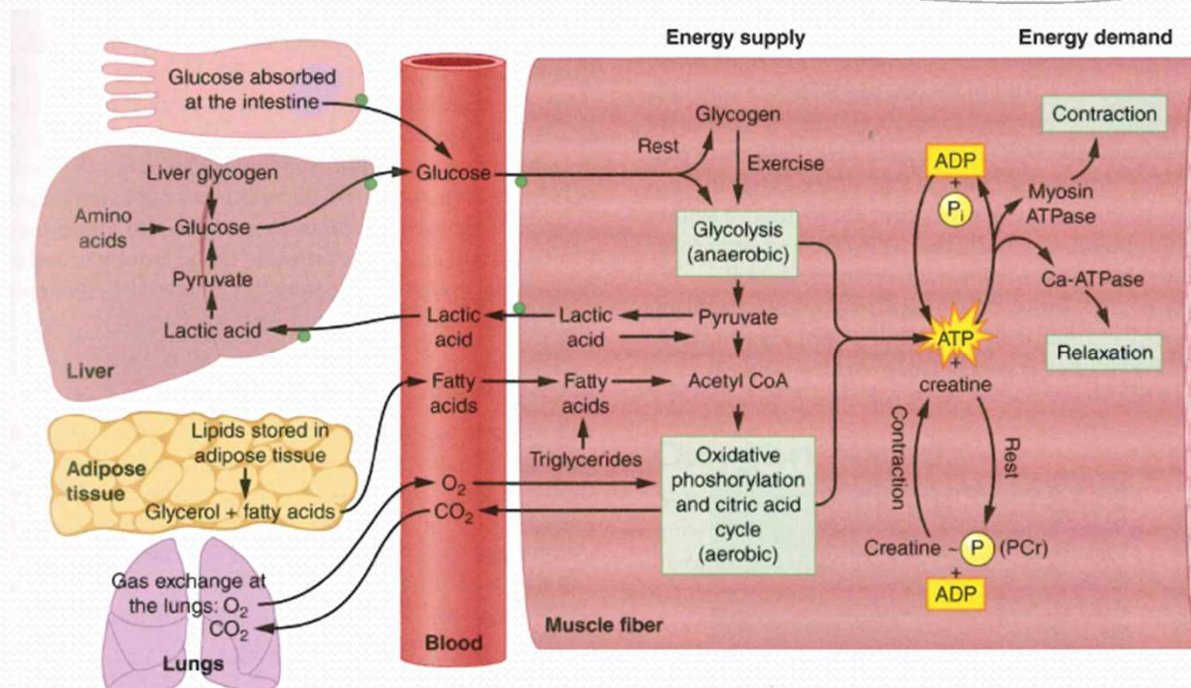


TABLE 2.3 Characteristics of the Various Energy Supply Systems

Energy system	Oxygen necessary?	Overall chemical reaction	Relative rate of ATP formed per second	ATP formed per molecule of substrate	Available capacity
ATP-PCr	No	PCr to Cr	10	1	<15 s
Glycolysis	No	Glucose or glycogen to lactate	5	2-3	~1 min
Oxidative (from carbohydrate)	Yes	Glucose or glycogen to CO_2 and H_2O	2.5	36-39*	~90 min
Oxidative (from fat)	Yes	FFA or triglycerides to CO_2 and H_2O	1.5	>100	days

*Production of 36-39 ATP per molecule of carbohydrate excludes energy cost of transport through membranes. The net production is slightly lower (see text).

Courtesy of Dr. Martin Gibala, McMaster University, Hamilton, Ontario, Canada.

4. Individualización de la intensidad

Entrenamiento a la carta: Individualización por Umbrales metabólicos

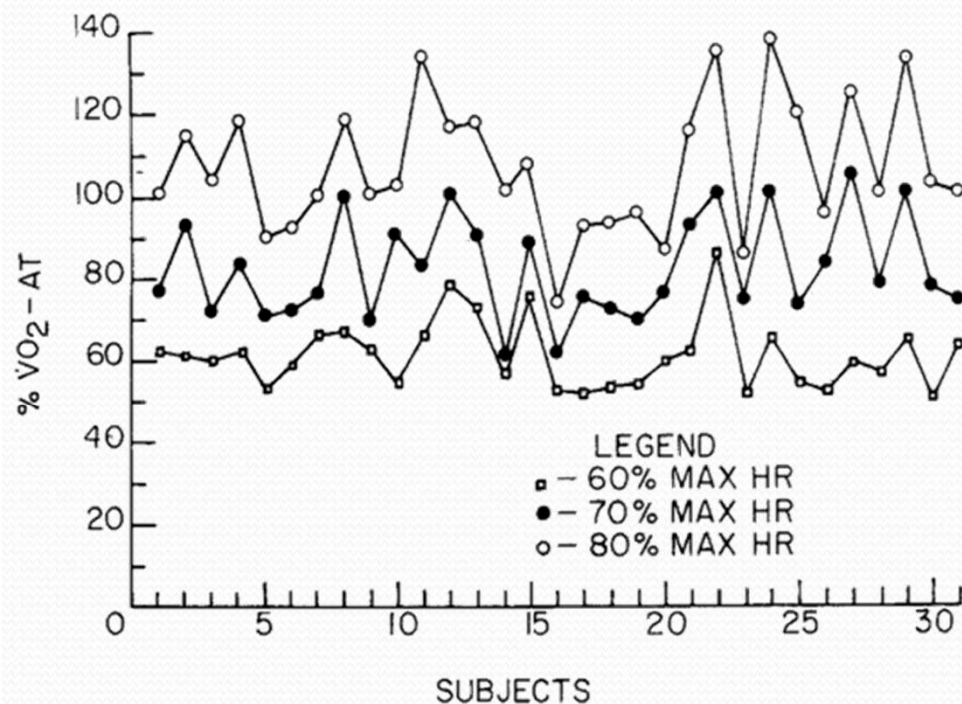


Fig. 2. Plot of individual subject's percent of anaerobic threshold (AT) at the different percent max HR. On the right axis is labeled the corresponding oxygen uptake for the respective percent AT

¿Qué ocurre cuando un grupo de personas entrenan a la misma intensidad relativa, digamos a un 80% de la FC_{max}?
¿Tienen el mismo estímulo metabólico?



4. Individualización de la intensidad

Ácido láctico: ¿Ángel o demonio? Respuesta durante el ejercicio progresivo

Tab. 2 Epinephrine, norepinephrine, lactate, heart rate, and oxygen intake in trained and untrained volunteers during graduated exercise.

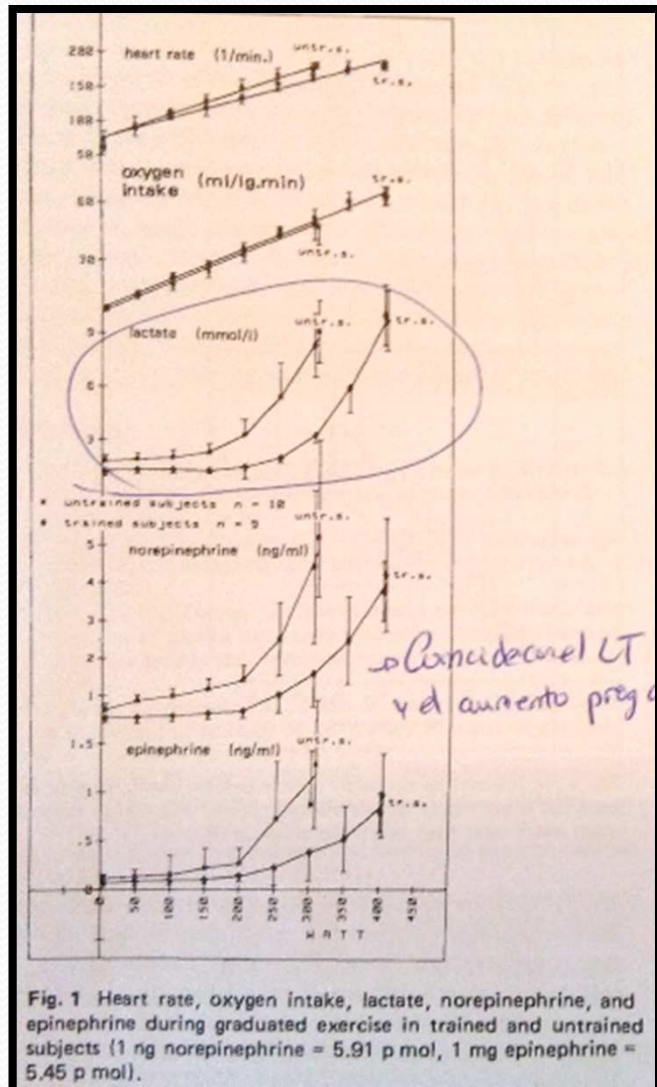
		Epinephrine* (ng/ml)		Norepinephrine* (ng/ml)		Lactate (ng/ml)		Heart rate (mmol/l)		Oxygen intake						
		Untrained subjects (I)	Trained subjects (II)	I	II	I	II	I	II	I	II					
W	$\bar{x}$	0.114	0.075	—	0.629	0.420	+	1.82	1.30	+	72	62	—	4.21	4.99	—
	s	0.043	0.044		0.162	0.122		0.07	0.30		13	0		0.82	0.65	
	n	10	9		10	9		10	9		10	9		10	9	
50	$\bar{x}$	0.135	0.085	+	0.861	0.423	+++	1.93	1.40	+	95	90	—	11.93	12.18	—
	s	0.069	0.052		0.153	0.157		0.44	0.21		12	11		2.25	2.11	
	n	10	9		10	9		10	9		10	9		10	9	
100	$\bar{x}$	0.154	0.092	+	0.978	0.456	+++	2.04	1.42	++	109	115	—	17.87	21.20	—
	s	0.052	0.046		0.201	0.165		0.51	0.21		7	11		3.49	2.33	
	n	10	9		10	9		10	9		10	9		10	9	
150	$\bar{x}$	0.218	0.102	+	1.167	0.516	+++	2.33	1.36	+++	133	123	+	25.10	27.99	—
	s	0.129	0.046		0.270	0.157		0.64	0.15		8	12		4.06	2.24	
	n	10	9		10	9		10	9		10	9		10	9	
200	$\bar{x}$	0.262	0.137	+	1.402	0.578	+++	3.34	1.59	++	153	140	+	33.33	36.70	—
	s	0.158	0.058		0.388	0.197		1.34	0.71		12	10		4.51	3.31	
	n	10	9		10	9		10	9		10	9		10	9	
250	$\bar{x}$	0.713	0.222	+	2.479	0.999	++	5.52	2.16	+++	173	161	+	47.04	44.90	—
	s	0.591	0.182		0.973	0.484		2.32	0.27		11	11		2.00	3.66	
	n	10	9		10	9		10	9		10	9		10	9	
300	$\bar{x}$	0.859	0.376	+	4.410	1.561	+++	8.49	3.52	+++	183	175	—	50.16	53.50	—
	s	0.555	0.286		2.057	0.888		2.34	0.46		9	9		8.09	4.64	
	n	7	9		7	9		7	9		7	9		7	9	
350	$\bar{x}$		0.510			2.431			6.40		187				62.72	
	s		0.332			1.167			1.48		8				4.90	
	n		9			9			9		9				9	
400	$\bar{x}$		0.780			3.750			10.78		192				65.97	
	s		0.204			0.803			1.81		5				5.05	
	n		7			7			7		7				7	
max**	$\bar{x}$	1.275	0.957	—	5.207	4.190	—	9.26	10.46	—	187	192	—	49.22	65.86	++
	s	0.661	0.427		2.615	1.533		2.33	1.81		7	6		9.81	4.69	
	n	10	9		10	9		10	9		10	9		10	9	

* 1 ng/ml norepinephrine = 5.91 pmol/ml; 1 ng/ml epinephrine = 5.45 pmol/ml.
 ** Maximum bicycle exercise: untrained subjects 306 ± 40 W, trained subjects 403 ± 20 W.
 — = NS; + = P < 0.05; ++ = P < 0.01; +++ = P < 0.001.

Lehmann et al. *Int J Sport Med* 2: 143-147, 1981

4. Individualización de la intensidad

Ácido láctico: ¿Ángel o demonio?



- Relación lineal directa entre el lactato y las catecolaminas, que presentan una evolución entrenamiento-dependiente. El punto de inflexión (LT) es la dosis mínima para mejorar la salud y la capacidad aeróbica
- El ácido pirúvico producido en la glucólisis puede incorporarse por vías oxidativas vía el ciclo de Krebs o ser convertido en ácido láctico, necesario para la oxidación de NADH en el citoplasma que permite un continuo suministro de energía
- La acumulación de ácido láctico representa una situación por la cual la producción de ácido pirúvico/láctico excede la tasa de incorporación de estas moléculas en el ciclo de Krebs

4. Individualización de la intensidad

LT es el mínimo estímulo para mejorar la capacidad aeróbica y la salud

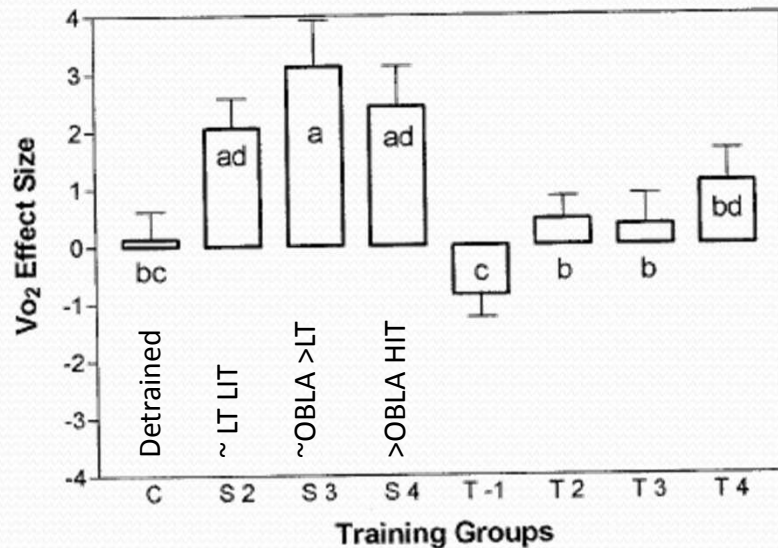


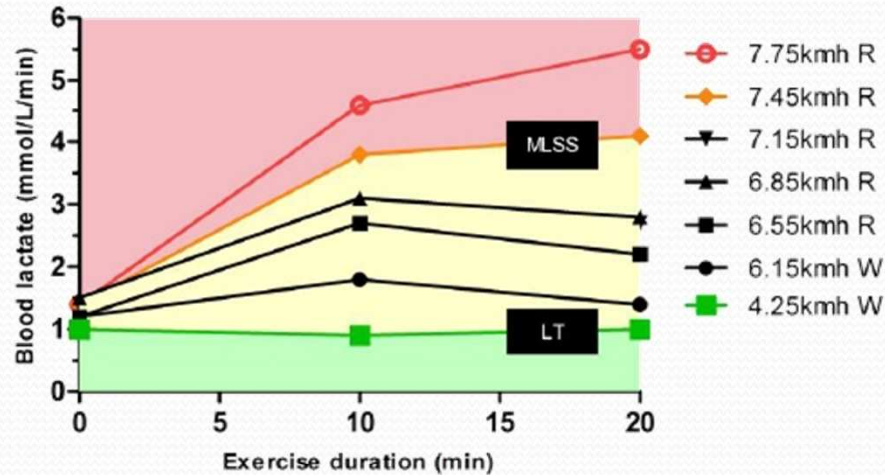
Figure 2—Weighted $\dot{V}O_2$ effect sizes for each training group for the lactate threshold data (Mean $\pm$ SD). Bars with the same letter are not significantly different. C, control; S, sedentary; T, trained.

- Las personas sedentarias con entrenar $\sim$ LT les es un estímulo suficiente para mejorar el $\dot{V}O_{2max}$.
- Las mayores mejoras ocurren en las primeras 8-12 semanas
- Los deportistas necesitan un estímulo mayor para producir mejoras metabólicas

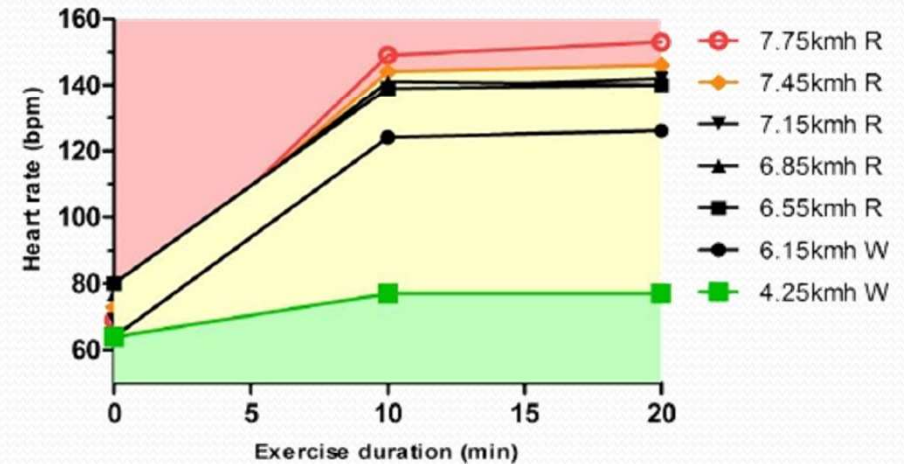


4. Individualización de la intensidad

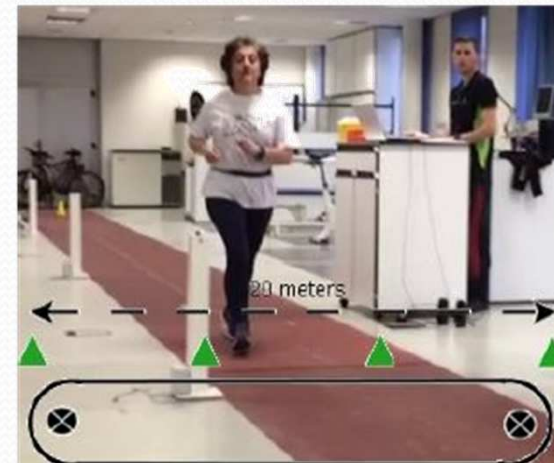
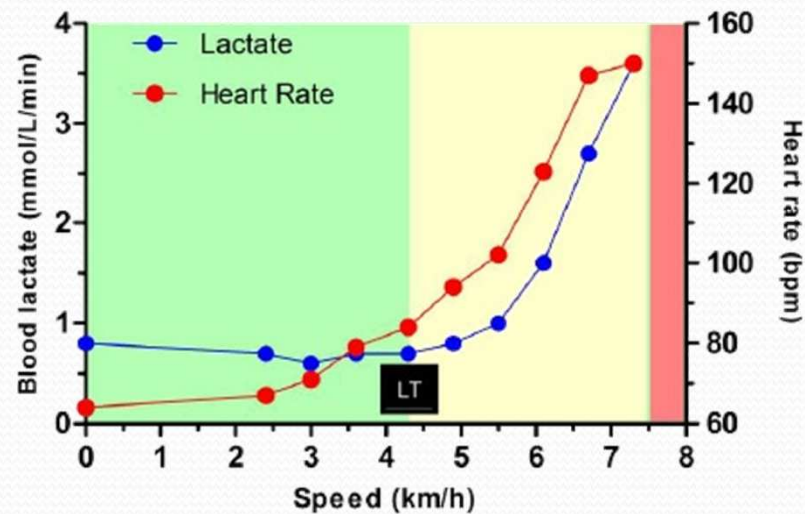
Lactate response to constant speed tests



Heart rate response to constant speed tests

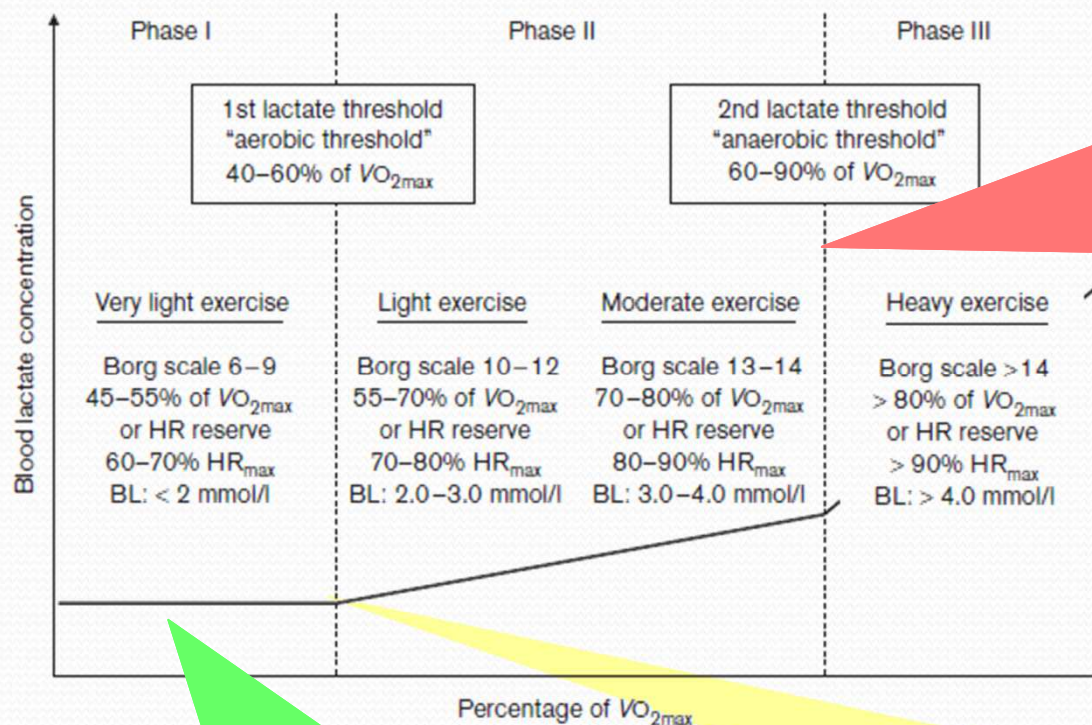


Progressive shuttle walk-running test



4. Individualización de la intensidad

Ácido láctico: ¿Ángel o demonio?



Aumenta la extracción de O_2 por los músculos y se produce más CO_2 y VE de forma lineal. No aumentos de [L]

Aumento exponencial de [L] y H^+ que son tamponados por HCO_3^- . Como consecuencia aumenta la producción de CO_2 y la VE con aumento lineal de VO_2 ($\uparrow VE/VO_2$). La capacidad oxidativa del organismo (músculos inactivos, hígado, riñones, corazón) es suficiente para mantener el [L] en equilibrio (gluconeogénesis)

UAn o **MLSS** es la máxima intensidad en la que se mantiene un equilibrio entre la tasa de producción y eliminación de [L] en ejercicio constante (20–30min) ($< 0.05 \text{ mM/min}$).

Inadecuado suministro de O_2 para satisfacer la demanda. $\uparrow$ exponencial de [L] por encima del MLSS, $\uparrow VE/VCO_2$

MOD vs HIIT - Lack of time? A Little Pain for a Lot of Gain

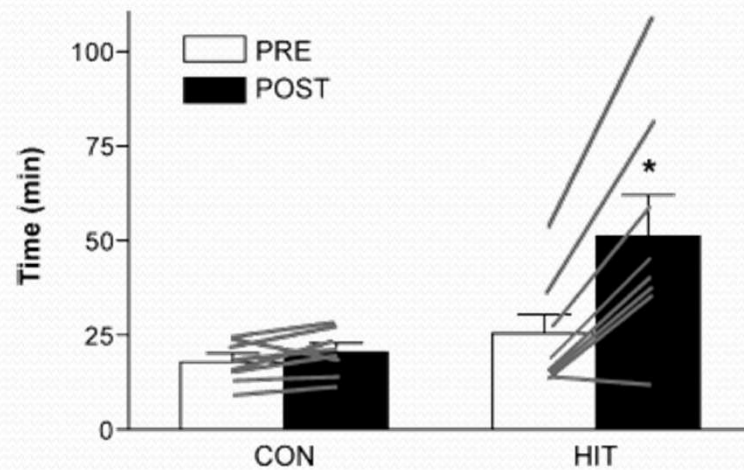


Figure 1. Cycle time to exhaustion at 80% of pretraining peak oxygen uptake before (PRE) and after (POST) six sessions of high-intensity interval training (HIT) over 2 wk or equivalent period without training (control; CON). Individual and mean ($\pm$ SE) data are plotted for eight subjects in each group. * $P < 0.05$ versus PRE within same condition. [Adapted from Burgomaster, K.A., S.C. Hughes, G.J.F. Heigenhauser, S.N. Bradwell, and M.J. Gibala. Six sessions of sprint interval training increases muscle oxidative potential and cycle endurance capacity. *J. Appl. Physiol.* 98:1895–1990, 2005. Copyright © 2005 The American Physiological Society. Used with permission.]

Mejoras en la capacidad oxidativa del 15-35% y $\uparrow$ contenido de glucógeno muscular

Mejoras en el tiempo de agotamiento de 26 a 51min en 2 semanas de entrenamiento SIT (4-6 x 30s all-out (wingate) reps/4' rec (2-3min por sesión) 3' d/sem

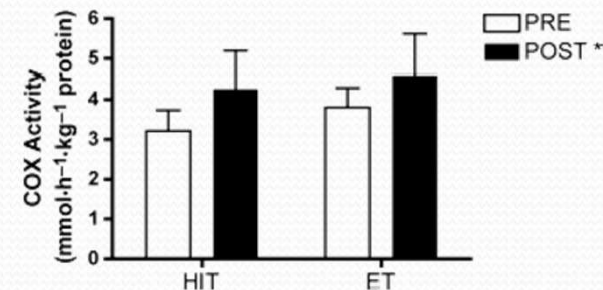
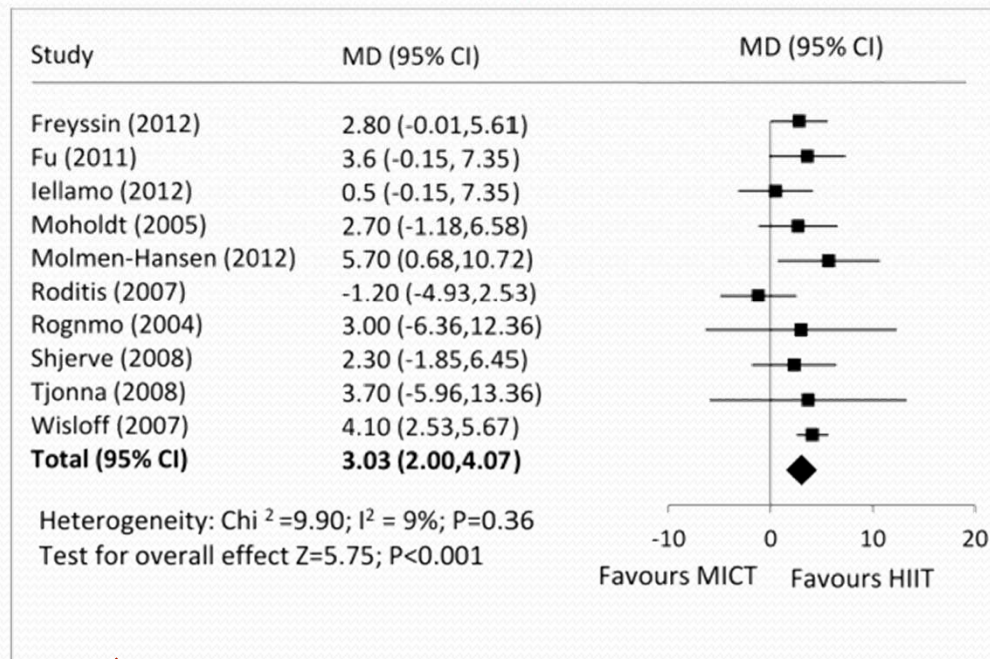


Figure 2. Maximal activity of cytochrome c oxidase (COX) measured in resting human skeletal muscle biopsy samples obtained before (PRE) and after (POST) six sessions of high-intensity interval training (HIT) or continuous moderate-intensity training (ET) over 2 wk. Total training time commitment was approximately 2.5 and 10.5 h for the sprint and endurance groups, respectively, and total exercise volume was approximately 90% lower for the HIT group. Values are means $\pm$ SE for eight subjects in each group. * $P < 0.05$ versus PRE (main effect for time). [Adapted from Gibala, M.J., J.P. Little, M. van Essen, G.P. Wilkin, K.A. Burgomaster, A. Safdar, S. Raha, and M.A. Tarnopolsky. Short-term sprint interval versus traditional endurance training: similar initial adaptations in human skeletal muscle and exercise performance. *J. Physiol.* 575(Pt 3):901–911, 2006. Copyright © 2006 Blackwell Publishing. Used with permission.]

4. Individualización de la intensidad

High-intensity interval training in patients with lifestyle-induced cardiometabolic disease: a systematic review and meta-analysis

Kassia S Weston,¹ Ulrik Wisløff,² Jeff S Coombes¹



Cambio en VO_{2peak} (4-16 semanas entren.)
 HIIT: De 22.5 a 27.9ml/kg/min ($\uparrow 19.4\%$)
 MIT: De 22.6 a 25.2ml/kg/min ($\uparrow 10.3\%$)

Table 2 Protocol recommendations for HIIT

Frequency	3x/Week
Duration	40 min
Modality	Treadmill/hill, cycle ergometer. Increasing speed or incline
Intensity	Interval=85–95% PHR Rest=passive=70% PHR
Interval times	4×4 min intervals 3×3 min recovery
Warm-up	10 min at 60% PHR
Cool-down	5 min at 50% PHR

HIIT, homeostasis model assessment-insulin resistance; PHR, peak heart rate.

Box 2 Suggested contraindications to high-intensity interval training (HIIT)

- ▶ Unstable angina pectoris
- ▶ Uncompensated heart failure
- ▶ Recent myocardial infarction (<4 weeks)
- ▶ Recent coronary artery bypass graft or percutaneous coronary intervention (<12 months)
- ▶ Heart disease that limits exercise (valvular, congenital, ischaemic and hypertrophic cardiomyopathy)
- ▶ Complex ventricular arrhythmias or heart block
- ▶ Severe chronic obstructive pulmonary, cerebrovascular disease or uncontrolled peripheral vascular disease
- ▶ Uncontrolled diabetes mellitus
- ▶ Hypertensive patients with blood pressure >180/110 (or uncontrolled)
- ▶ Severe neuropathy

4. Individualización de la intensidad

Efectos del tiempo de rec. en protocolos HIIT: Chronic stroke patients

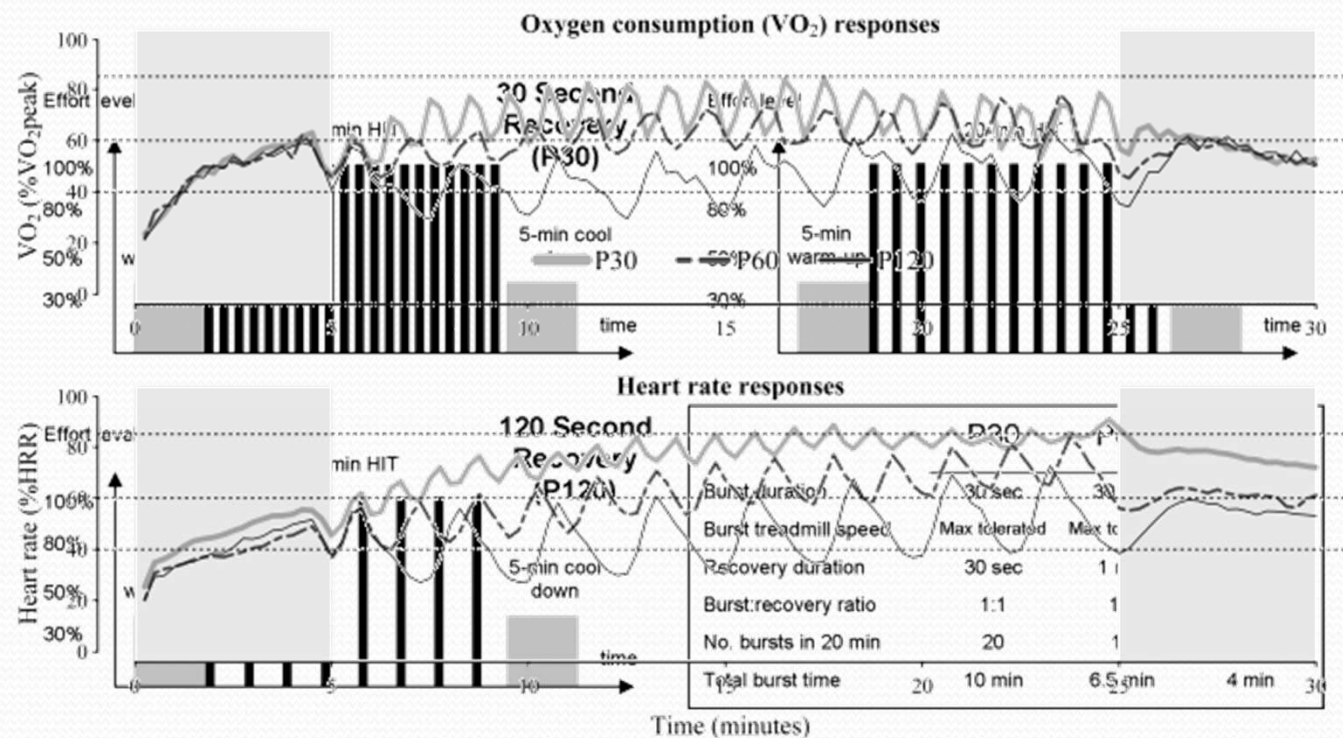


FIGURE 2—Mean time course of exercise responses by protocol ($n = 18$). Shaded regions represent warm-up and cooldown. Dotted lines represent 40%, 60%, and 85% aerobic intensity thresholds.

5. Medición de la actividad física

Diarios de actividad

INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE

PARTE 4: ACTIVIDADES FÍSICAS DE RECREACIÓN, DEPORTE Y TIEMPO LIBRE

Esta sección se refiere a todas aquellas actividades físicas que usted hizo en los últimos 7 días únicamente por recreación, deporte, ejercicio o placer. Por favor no incluya ninguna de las actividades que ya haya mencionado.

20. Sin contar cualquier caminata que ya haya usted mencionado, durante los últimos 7 días, ¿Cuántos días caminó usted por lo menos 10 minutos continuos en su tiempo libre?

_____ días por semana

☐

Ninguna caminata en tiempo libre



Pase a la pregunta 22

21. Usualmente, ¿Cuánto tiempo gastó usted en uno de esos días caminando en su tiempo libre?

_____ horas por día
_____ minutos por día

☐

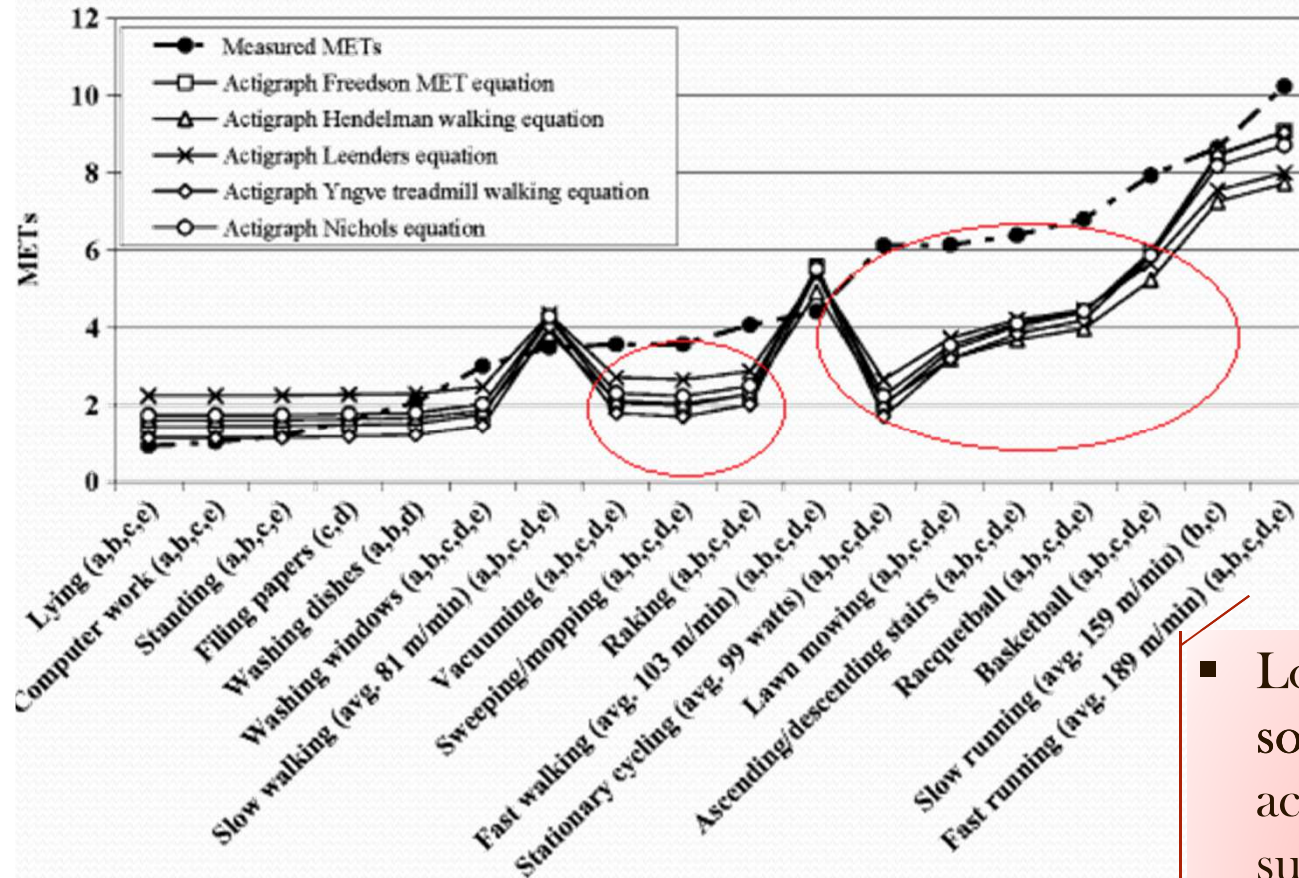
No sabe/No está seguro(a)

- PRÁCTICA I. Cuantificación de la AF mediante diarios de actividad

<https://sites.google.com/site/compediumofphysicalactivities/>

DÍA 1	Fecha	09/09/2015	Día	Miércoles
		Hora	Min	
	Hora a la que se levantó de la cama	0	7	4
	Hora a la que se acostó en la cama	2	3	5
	¿Hubo alguna razón especial por la que no pudo realizar su actividad diaria normal?	☒	no	
	En caso afirmativo, ¿cuál fue el motivo?	☐ 1 Enfermedad	☐ 2 Lesión	☐ 3 Condiciones atmosféricas
		☒ 4	Otra (por favor indique el motivo debajo)	
	Viaje en tren de 4 horas			
	Breve descripción de la actividad diaria (incluya las horas)			
	Trabajo: Sentado en la oficina con breves periodos caminando (08:30-15:30)			
	Desplazamientos: caminando al trabajo y a la vuelta (08:15-08:25 / 15:30-15:35)			
	Trabajo de casa: Limpieza general (18:00-19:30), cuidado de mi madre (20:00-21:00)			
	Ocio/Recreación: Caminar por el monte (16:30-17:30) y lectura (21:15-21:45)			
	Indique numéricamente el grado de dolor/rigidez que haya tenido durante el día			
Articular		0	1	2
Muscular		0	1	2

Acelerómetros



- Los acelerómetros sobreestiman el GE de actividades sedentarias-suaves y subestiman la GE de actividades complejas y vigorosas (Crouter et al., 2006)

<https://movementsciencems.wordpress.com/2016/11/07/camina-y-deja-tu-huella-medicion-individualizada-de-la-actividad-fisica-con-acelerometros-hacemos-lo-suficiente/>

5. Medición de la actividad física

Cuantificación objetiva e individualizada de la actividad física

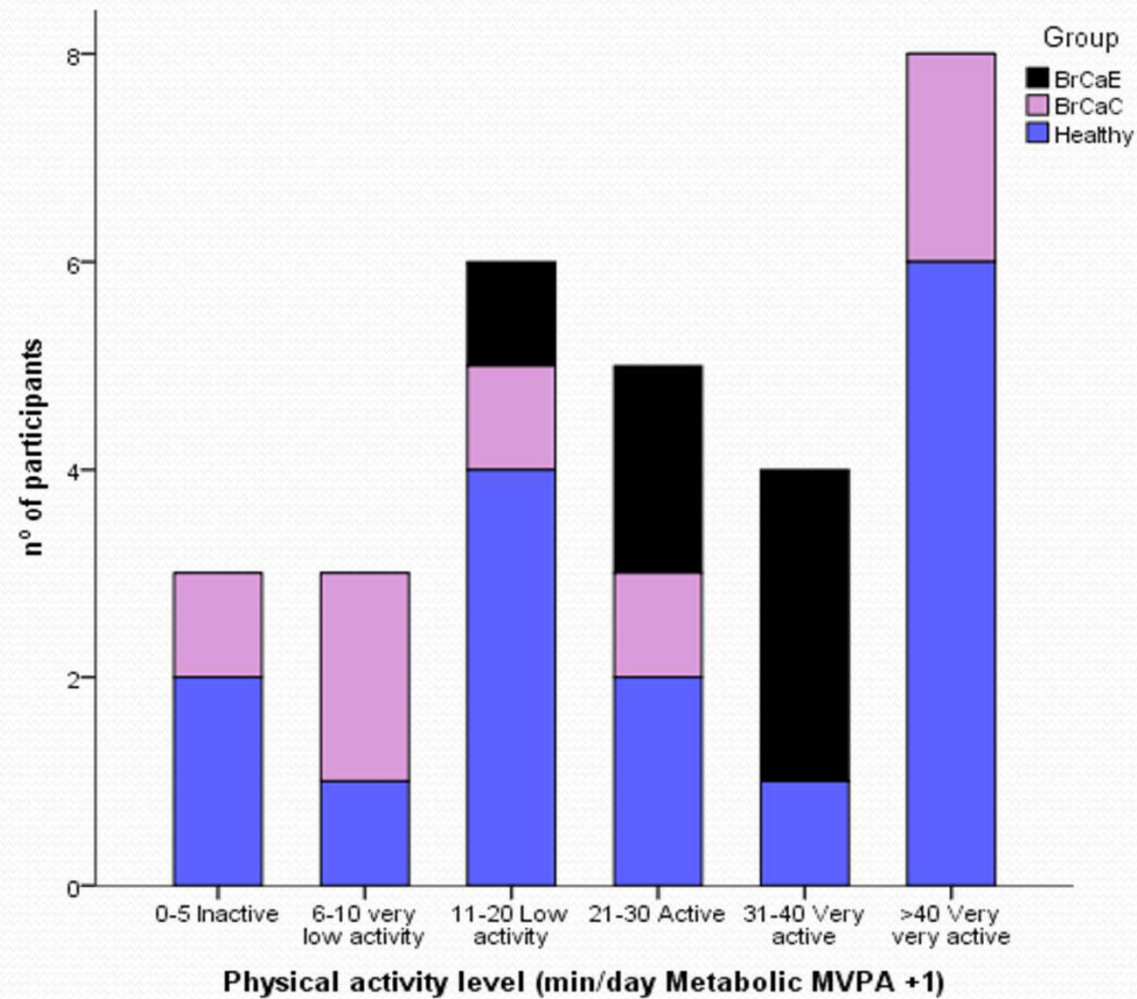


Figure 3. Distribution of Metabolic MVPA+1 physical activity levels among post-menopausal women

5. Medición de la actividad física

Cuantificación objetiva e individualizada de la actividad física

