IV CONGRESSO NAZIONALE

SOCIETÀ ITALIANA G.U.I.D.A.
PER LA GESTIONE UNIFICATA E INTERDISCIPLINARE DEL DOLORE MUSCOLO-SCHELETRICO E DELL'ALGODISTROFIA

Ruolo dell'esercizio fisico e terapeutico sulla Bone Health

Centro Congressi Unione Industriali
TORINO 11-13 MAGGIO 2023

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Approccio riabilitativo

- **Attività fisica**: qualsiasi movimento corporeo prodotto dai muscoli scheletrici che si traduce in un dispendio energetico superiore al livello basale

- **Esercizio fisico**: sotto-categoria di attività fisica pianificata, strutturata in maniera ripetitiva e mirata, con l'obiettivo di migliorare o mantenere uno o più aspetti della forma fisica

- **Esercizio terapeutico**: prescrizione di contrazioni muscolari e di movimenti corporei al fine di migliorare la funzionalità generale e specifica di un individuo per aiutarlo a rispondere al meglio alle esigenze della vita quotidiana

Effetti dell'esercizio sull'osso

L'esercizio determina presumibilmente effetti diretti sul turnover osseo aumentando la **formazione ossea** attraverso stimoli meccanici, migliorando o mantenendo la BMD femorale e della vertebrale

Ostir GV et al. Clinical Epidemiology 2002

Effetti dell'esercizio sull'osso

REVIEWS

NATURE REVIEWS | ENDOCRINOLOGY

Combating osteoporosis and obesity with exercise: leveraging cell mechanosensitivity

*Gabriel M. Pagnotti[1], Maya Styner[2], Gunes Uzer[3], Vihitaben S. Patel[4], Laura E. Wright[1], Kirsten K. Ness[5], Theresa A. Guise[1], Janet Rubin[2] and Clinton T. Rubin[4]**

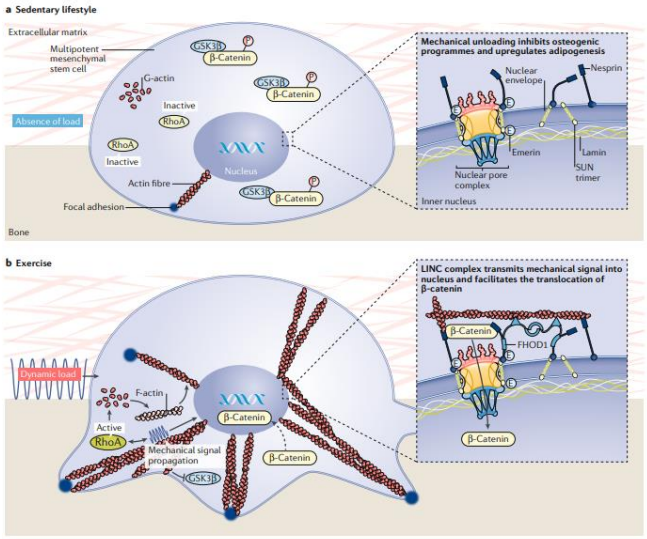


Fig. 3 | **Mechanotransductive responses of mesenchymal stem cells to dynamic mechanical stimuli are achieved through the internal stiffening of the cell via cytoplasmic-bound actin proteins. a** | The absence of mechanical forces prevents the polymerization of actin fibres, preventing the dephosphorylation of β-catenin, which remains bound to GSK3β. As such, β-catenin does not translocate to the nucleus, resulting in the expression of PPARγ-driven adipogenic pathways. **b** | By contrast, mechanical stimuli recruit actin fibres to the interface of the cell membrane and the substrate surface. These focal adhesions become stronger and denser in response to dynamic mechanical stimuli, permitting the movement of β-catenin into the nucleus and an ensuing osteogenic response. FHOD1, FH1/FH2 domain-containing protein 1; LINC, linker of nucleoskeleton and cytoskeleton.

Key points

- Ageing and inactivity each contribute towards a local and systemic environment conducive to poor bone quality, increased systemic adiposity, marrow adipogenesis and inflammation.
- Mesenchymal stem cells and their lineage-differentiated progeny (for example, osteoblasts) are mechanosensitive, such that increased mechanical signals (such as exercise) stimulate muscle and bone anabolism.
- Mechanical signals suppress obesity end points, including fat gain, adipocyte lipid acquisition, chronic inflammation and indices associated with type 2 diabetes mellitus.
- Transduction of mechanical signals across the plasma membrane of stem cells into the nucleus activates signalling cascades and cytoskeletal adaptations to initiate osteogenic, chondrogenic and myogenic differentiation and inhibit adipocyte differentiation.
- Mechanical signals, such as those induced through low-intensity vibration, need not be large in magnitude, or long in duration, to influence bone or fat phenotypes.

Effetti dell'esercizio sull'osso

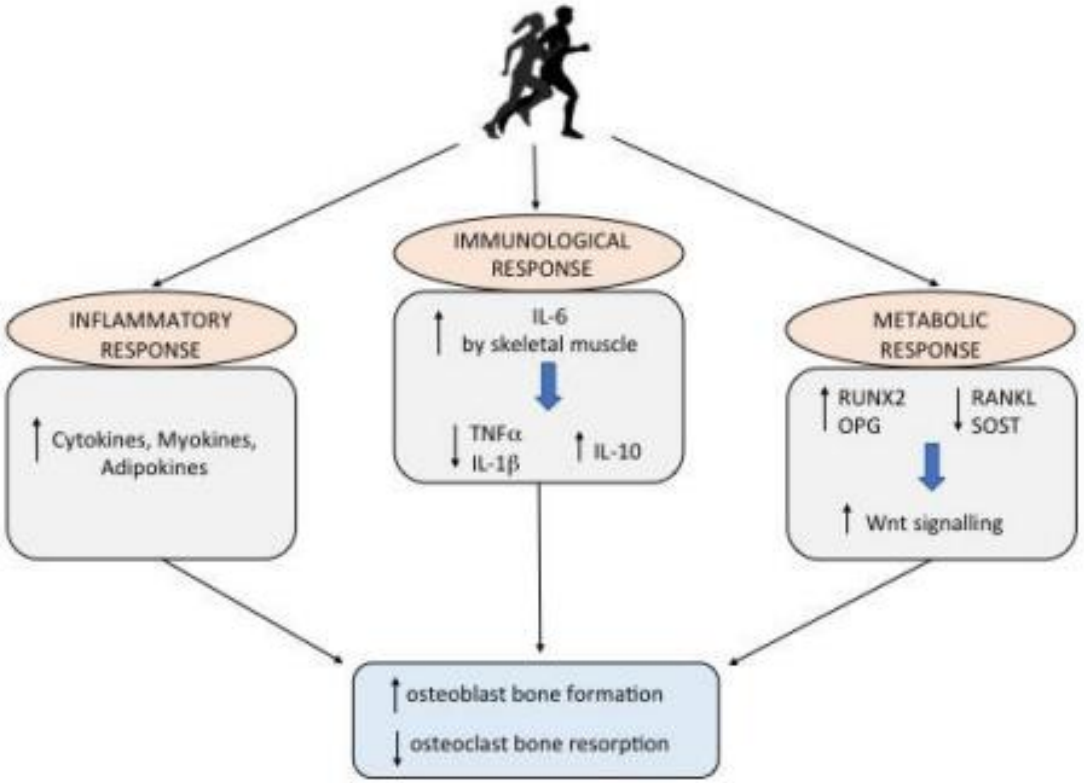
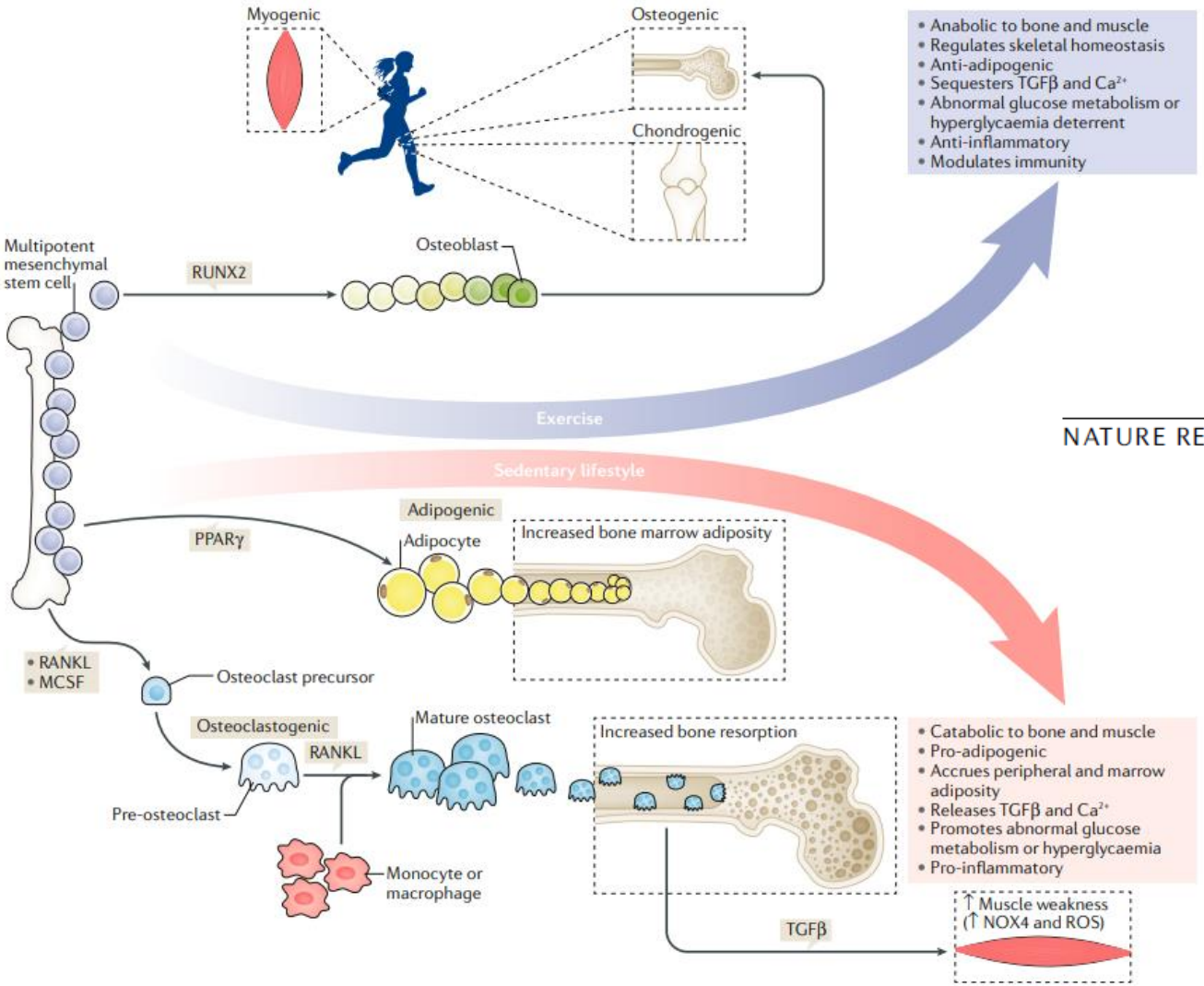


Figure 1. The impact of physical activity on bone health. Physical activity positively affects bone metabolism via different mechanisms: 1. activation of an inflammatory cascade involving cells of the innate and adaptive immunity and mediators of inflammation; 2. triggering an immunological response due to the increase of IL-6 by skeletal muscle; 3. stimulation of the Wnt signaling pathway.

Effetti dell'esercizio sull'osso



Biomarcatori ossei ed esercizio

- In una recente SR, comprendente 13 studi e 275 pazienti sono stati indagati
  - Esercizi di resistenza
  - Esercizio aerobico

- Ed il loro effetto in acuto sui biomarcatori ossei, CTX, CTP, sclerostina, ALP, P1NP, osteocalcina e PICP

Bone 143 (2021) 115766

Contents lists available at ScienceDirect

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journal homepage: www.elsevier.com/locate/bone

Review Article

The effects of acute exercise on bone turnover markers in middle-aged and older adults: A systematic review

Cassandra Smith [a,b], Alexander Tacey [a,b], Jakub Mesinovic [c], David Scott [b,c,d], Xuzhu Lin [e], Tara C. Brennan-Speranza [f,g], Joshua R. Lewis [h,i,j], Gustavo Duque [b,k], Itamar Levinger [a,b,*]

Table 1
Markers of bone turnover that have been used in the exercise literature.

Markers of bone resorption	
C-terminal crosslinked telopeptide of type I collagen	CTX, Crosslaps
Cross-linked carboxyterminal telopeptide of type I collagen	ICTP
Sclerostin	SCL
Markers of bone formation	
Alkaline phosphatase (total)	ALP
Alkaline phosphatase (bone specific)	B-ALP
Procollagen I carboxyterminal propeptide	*PICP*
Procollagen type 1 N propeptide	*P1NP*
Osteocalcin	OC

Biomarcatori ossei ed esercizio

- E' stato evidenziato come l'**esercizio aerobico** abbia aumentato significativamente il CTX, ALP e l'isoforma ossea in pazienti adulti e anziani.
- Aumentata anche l'osteocalcina in pazienti adulti ed il CTX ed il PICP nelle donne anziane
- L'**esercizio di resistenza** ha ridotto i valori di ALP ossea nella popolazione anziana e ridotto i valori di CTX nella popolazione adulta
- Gli autori concludono che l'esercizio può **modificare i biomarcatori ossei**, in modo dipendente dall'intensità e dalla modalità di esercizio, e sembra essere **specifico** per età e sesso

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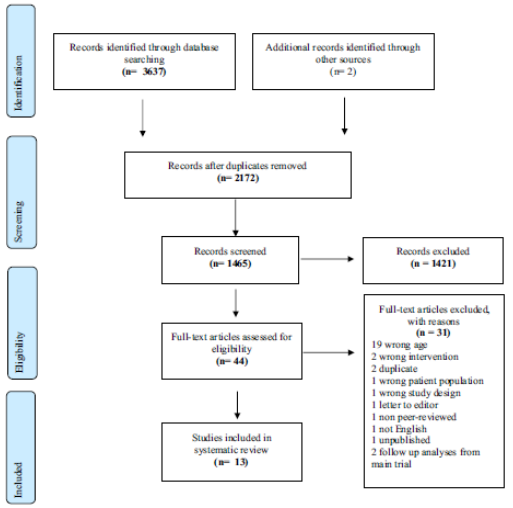

Fig. 1. Identification screening and selection of studies (PRISMA Flow Diagram).

Table 2
Quality rating scale (MINORs).

MINORs Scale (detailed below and scored as: 0, not reported; 1, reported but inadequate; 2, reported and adequate)
Field 9 to 10 only relevant for comparative studies

Author, year	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	Score
1. Kim, et al. (2014)	1	1	0	1	0	2	2	0	n/a	n/a	n/a	n/a	43.8%
2. Levinger, et al. (2011)	2	2	2	2	0	2	2	0	1	2	2	2	79.2%
3. Levinger, et al. (2014)	2	2	2	2	0	2	2	2	n/a	n/a	n/a	n/a	87.5%
4. Maimoun, et al. (2005)	1	2	2	2	0	2	2	0	1	1	2	2	70.8%
5. Rudberg, et al. (2000)	2	1	0	2	0	2	2	0	n/a	n/a	n/a	n/a	50.3%
6. Thorsen, et al. (1995)	2	1	1	2	0	2	2	0	n/a	n/a	n/a	n/a	62.5%
7. Thorsen, et al. (1996)	2	1	1	2	0	2	2	0	n/a	n/a	n/a	n/a	62.5%
8. Aly, et al. (2017)	1	1	2	2	0	2	2	0	n/a	n/a	n/a	n/a	62.5%
9. Wherry, et al. (2019)	2	2	2	2	0	2	2	2	1	2	2	1	83.3%
10. Zeuth, et al. (1997)	2	1	2	2	0	2	2	0	n/a	n/a	n/a	n/a	68.8%

MINORs Scale assessed as per; 1. A clearly stated aim; 2. Inclusion of consecutive patients; 3. Prospective data collection; 4. Endpoints appropriate to study aim; 5. unbiased assessment of study endpoint; 6. follow up period appropriate to the aim; 7. loss to follow up <5%; 8. Prospective calculation of study size; 9. adequate control group; 10. contemporary groups; 11. Baseline equivalence of groups and 12. Adequate statistical analysis.

Esercizi raccomandati per pazienti con osteoporosi

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Online version at http://www.minervamedica.it

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SYSTEMATIC REVIEW

Osteoporosis guidelines from a rehabilitation perspective: systematic analysis and quality appraisal using AGREE II

Giovanni IOLASCON [1], Alessandro de SIRE [2] *, Claudio CURCI [3], Marco PAOLETTA [1], Sara LIGUORI [1], Dario CALAFIORE [3], Francesca GIMIGLIANO [4], Antimo MORETTI [1]

[1]Department of Medical and Surgical Specialties and Dentistry, Luigi Vanvitelli University of Campania, Naples, Italy; [2]Department of Medical and Surgical Sciences, University of Catanzaro "Magna Grecia", Catanzaro, Italy; [3]Section of Neuromotor Rehabilitation, Department of Neuroscience, ASST Carlo Poma, Mantova, Italy; [4]Department of Mental and Physical Health and Preventive Medicine, Luigi Vanvitelli University of Campania, Naples, Italy

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Esercizi raccomandati per pazienti con osteoporosi

Summary of exercise of physical activity recommendations for individuals with osteoporosis[1]

Type	How often per week?	Osteoporosis	Osteoporosis and history of vertebral fracture	Examples and comments
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Aerobic Exercise	≥5 days per week, ≥30 min/day	Moderate- to vigorous-intensity	Moderate intensity	Do bouts of 10 min or more – accumulate 30 min/day. On a 0–10 scale where 0=rest, and 10=maximum effort, aim for intensity of 5–8. Moderate: You are breathing heavier than usual. You can have a conversation, but you couldn't sing. Vigorous: You are breathing much heavier than usual. You would not be able to converse or sing.
Spine Sparing	During daily activities	Spine loads supine < standing < seated. Alignment more important than intensity.		Modify activities that flex (bending forward) or twist the spine; most risky when rapid, repetitive, weighted, bending all the way forward, or twisting to the side. Avoid lifting to or lowering from the floor.
Spinal Extensor Training	Daily for 5–10 min	Emphasis on endurance for back extensors. Perform "holds" 3–5 seconds.		Lie face up on firm surface, knees bent, feet flat. Use pillow only if head doesn't reach floor. Gently press shoulders into floor, as if they are becoming "heavy" into the ground - hold. Repeat 3–5 times
Activity Recommendations	Apply to ADLs, activities of leisure and exercise	May be able to continue most activities with attention to activity considerations. Avoid high fall risk or contact sports.	The risks of exercise machines, many classes and some ADLs may outweigh benefits. Consult with physical/occupational therapist on safe ADL and activity performance.	Activity considerations: Modify or avoid activities that require repeated, rapid, repetitive, weighted or end-range twisting or flexion of the spine, avoid high fall risk or contact sports. Use hip hinge instead of spinal flexion to bend, and step-to-turn instead of twisting.

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Esercizi raccomandati per pazienti con osteoporosi

1. In posizione eretta, addominali e glutei contratti, sguardo davanti a sé, braccia piegate e mani sul punto vita.
2. Sollevare la gamba destra fino a che la caviglia destra arriva all'altezza del ginocchio sinistro.
3. Mantenere la posizione per circa 10 secondi (3 in caso di precedente frattura vertebrale) , tenendo le mani poggiate sui fianchi per migliorare la stabilità. Abbassare la gamba destra e ripetere il movimento con l'altra gamba.

1. In posizione eretta, addominali e glutei contratti, sguardo davanti a sé, braccia lungo i fianchi.
2. Portare il piede destro avanti in modo che il tacco si posizioni davanti alla punta del piede sinistro.
3. Tenere la posizione per circa 10 secondi (3 in caso di precedente frattura vertebrale) evitando, se possibile, di allargare le braccia. Quindi avanzare analogamente con l'arto sinistro e ripetere l'esercizio.

1. In posizione eretta, addominali e glutei contratti, schiena dritta e gambe estese, sguardo davanti a sé, appoggiare le mani sullo schienale della sedia, tenendo le braccia distese. Mettersi in posizione in equilibrio su un solo piede, tenendosi alla sedia.
2. Allungare la gamba destra dietro di sé, tenendola distesa il più possibile, tenendo il piede a martello.
3. Mantenere la posizione per circa 3 secondi e riportare in posizione, senza appoggiarla al terreno. Ripetere tre volte e poi procedere con l'altra gamba.

1. In posizione eretta, gambe unite, addominali e glutei contratti, sguardo davanti a sé, braccia stese lungo i fianchi. Muovere la gamba destra verso destra e fare un passo laterale.
2. La gamba sinistra seguirà per ricongiungere gli arti inferiori e ritornare a piedi uniti.
3. Fare tre passi verso destra, poi ripetere analoga sequenza con tre passi verso sinistra. Per accrescere la complessità si possono incrociare le gambe.

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1. Mettersi in posizione eretta, schiena dritta, gambe divaricate ed estese e mani sui fianchi. Piedi con la punta rivolta leggermente verso l'esterno.

2. Tenendo la schiena dritta, glutei e addominali contratti, piegarsi sulle ginocchia quanto possibile, senza sbilanciarsi, come se si volesse assumere la posizione seduta effettuando una profonda inspirazione.

3. Mantenere questa posizione per qualche secondo e poi lentamente ritornare in posizione di partenza, espirando.

1. Mettersi seduti poggiati sullo schienale, cosce e gambe flesse e, se possibile, braccia incrociate con le mani sulla spalla opposta.

2. Alzarsi dalla sedia, mantenendo i muscoli addominali e dei glutei contratti, spostando il peso in avanti, all'occorrenza aiutandosi con le mani.

3. Tornare lentamente a sedersi sulla sedia se possibile senza l'aiuto degli arti superiori, mantenendo i muscoli addominali e dei glutei contratti e la schiena dritta.

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1. **Camminata lenta**. Adatto anche per chi ha già avuto una frattura. Tenendo il busto eretto e lo sguardo fisso davanti a sé camminare lentamente per la stanza. Non partire con una camminata a elevato ritmo, ma eseguire un esercizio costante e corretto per poi eventualmente nel tempo aumentare a poco a poco la velocità, con una camminata più veloce.

2. **Camminata veloce**. Tenendo il busto eretto e lo sguardo fisso davanti a sé camminare velocemente in linea retta.

3. Questi esercizi possono essere sostituiti, compatibilmente con le forze e l'allenamento, con altre attività aerobiche. Andare in **bicicletta** è un esercizio a basso impatto con ridotto stress sulle articolazioni e sulla colonna vertebrale. Pedalare stimola non solo i muscoli dell'arto inferiore, glutei, cosce e polpacci, ma anche i muscoli della schiena migliorando il controllo del tronco. Il **pilates** consiste nell'esecuzione di esercizi di tonificazione e allungamento dei muscoli. Il beneficio si riflette soprattutto sui muscoli addominali e della schiena migliorando il controllo posturale e l'equilibrio. Inoltre l'attività di gruppo stimola la socializzazione e ha un effetto positivo anche sul benessere psichico.

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Activity Recommendations	Apply to ADLs, activities of leisure and exercise	May be able to continue most activities with attention to activity considerations. Avoid high fall risk or contact sports.	The risks of exercise machines, many classes and some ADLs may outweigh benefits. Consult with physical/occupational therapist on safe ADL and activity performance.	Activity considerations: Modify or avoid activities that require repeated, rapid, repetitive, weighted or end-range twisting or flexion of the spine, avoid high fall risk or contact sports. Use hip hinge instead of spinal flexion to bend, and step-to-turn instead of twisting.

Esercizi raccomandati per pazienti con osteoporosi

1. Sdraiarsi a terra in posizione prona su un tappetino, con le braccia lungo i fianchi, le gambe estese e i palmi verso l'alto. Piedi a punta. Collo dritto e mento sul pavimento.
2. Cercare di sollevare il tronco dal suolo il più possibile, allontanando le spalle dal tappetino, mantenendo a contatto con il suolo la pancia e le gambe.
3. Mantenere la posizione per 3 secondi prima di ritornare nella posizione di riposo. Ricominciare poi l'esercizio.

1. Sdraiarsi a terra supini, su un tappeto, con la schiena ben aderente al pavimento, le braccia lungo il corpo, le gambe flesse e i palmi verso il basso. Arti inferiori leggermente divaricati e semipiegati per limitare l'intervento dei muscoli flessori della coscia. Piedi paralleli, in appoggio sul pavimento. Collo dritto e sguardo al soffitto.
2. Usando gli addominali sollevare le spalle o semplicemente la testa espirando, e mantenere questa posizione per circa 3 secondi
3. Tornare lentamente in posizione di riposo e inspirare; espirare ricominciando a salire.

1. Sdraiarsi a terra in posizione prona su un tappetino, con le gambe estese, le braccia lungo i fianchi e i palmi verso l'alto. Piedi a punta. Collo dritto e mento sul pavimento.
2. Alzare la gamba destra verso l'alto e mantenere la posizione per circa tre secondi.
3. Abbassare la gamba destra e ripetere l'esercizio con la sinistra.

1. Mettersi a terra carponi su un tappetino poggiando mani e ginocchia, mantenendo la schiena dritta. Portare le mani in avanti appoggiandole sul pavimento all'altezza delle spalle.
2. Si muovano lentamente avanti le mani una per volta fino a dove ci si sente sicuri senza sbilanciarsi.
3. Mantenere questa posizione per tre secondi circa, poi ritornare lentamente alla posizione di partenza.

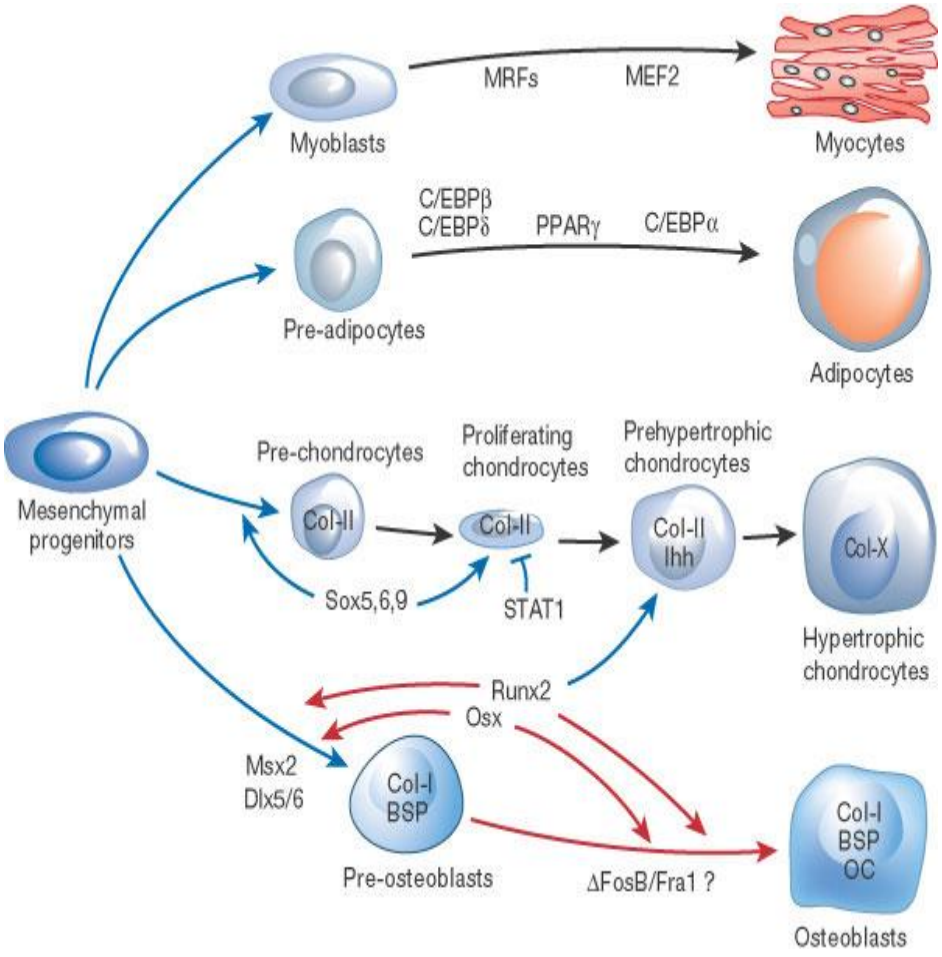
Esercizi raccomandati per pazienti con osteoporosi

Summary of exercise of physical activity recommendations for individuals with osteoporosis[1]

Type	How often per week?	Osteoporosis	Osteoporosis and history of vertebral fracture	Examples and comments
Balance training	Daily for ≥15–20 min	Progress from "standing still" exercises" to dynamic Fig. 1.		Can do during daily walks or activities: Standing still: ↓ base of support e.g., Semi-tandem stance, one-leg stand; shift weight between heels & toes while standing Dynamic movements: Tai Chi; tandem walk, dancing
Strength Training	≥2 days a week	8–12 repetitions per exercise. Intensity at 8–12 repetitions maximum[2]	8–12 repetitions per exercise. Aim for 8–12 repetitions maximum[2], but form and alignment more important than intensity	Min. 1 exercise each for: legs; arms; chest; shoulders; back. Use: exercise bands; weights, or body weight against gravity. 1–3 sets/exercise. *Train at↓ intensity initially if:* sedentary; conditions affecting activity; high fracture risk; strength training novice
Aerobic Exercise	≥5 days per week, ≥30 min/day	Moderate- to vigorous-intensity	Moderate intensity	Do bouts of 10 min or more – accumulate 30 min/day. On a 0–10 scale where 0=rest, and 10=maximum effort, aim for intensity of 5–8. Moderate: You are breathing heavier than usual. You can have a conversation, but you couldn't sing. Vigorous: You are breathing much heavier than usual. You would not be able to converse or sing.
Spine Sparing	During daily activities	Spine loads supine < standing < seated. Alignment more important than intensity.		Modify activities that flex (bending forward) or twist the spine; most risky when rapid, repetitive, weighted, bending all the way forward, or twisting to the side. Avoid lifting to or lowering from the floor.
Spinal Extensor Training	Daily for 5–10 min	Emphasis on endurance for back extensors. Perform "holds" 3–5 seconds.		Lie face up on firm surface, knees bent, feet flat. Use pillow only if head doesn't reach floor. Gently press shoulders into floor, as if they are becoming "heavy" into the ground - hold. Repeat 3–5 times
Activity Recommendations	Apply to ADLs, activities of leisure and exercise	May be able to continue most activities with attention to activity considerations. Avoid high fall risk or contact sports.	The risks of exercise machines, many classes and some ADLs may outweigh benefits. Consult with physical/occupational therapist on safe ADL and activity performance.	Activity considerations: Modify or avoid activities that require repeated, rapid, repetitive, weighted or end-range twisting or flexion of the spine, avoid high fall risk or contact sports. Use hip hinge instead of spinal flexion to bend, and step-to-turn instead of twisting.

Ed il muscolo?

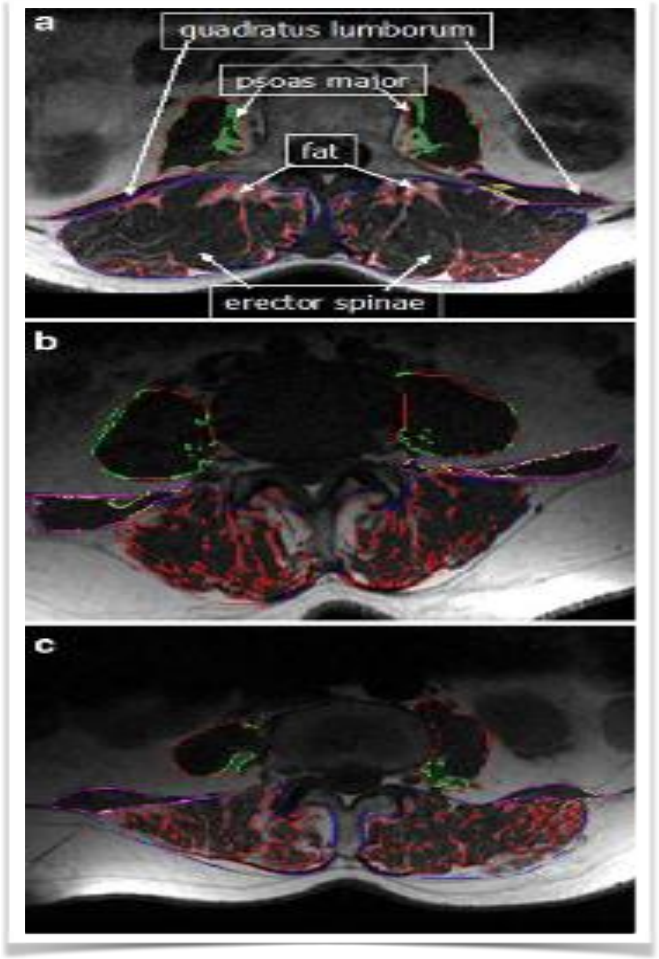
- Muscoli e ossa sono strettamente collegati, a partire dall'organogenesi (precursori mesodermici comuni)
- Diversi fattori (invecchiamento, esercizio fisico/disuso) sono in grado di indurre variazioni a carico della struttura di entrambi i tessuti



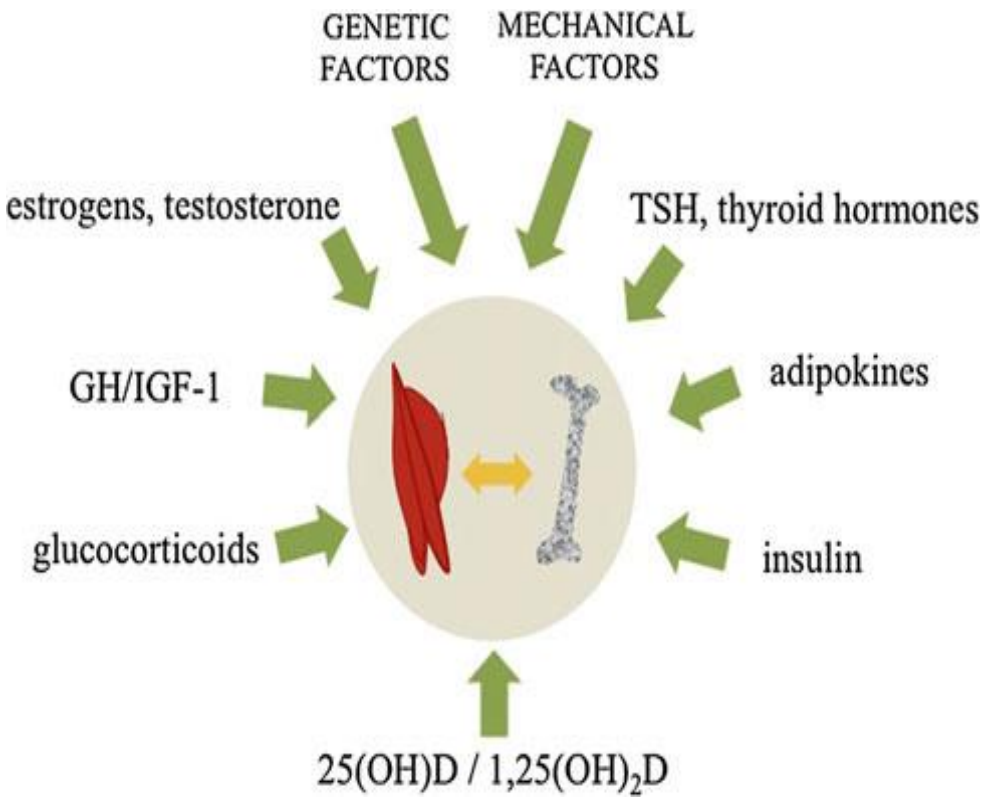
Hamrick MW et al. J Musculoskelet Neuronal Interact. 2010
Pitsillides AA J Anat. 2006
Harada S et al. Nature. 2003

Sarcopenia e osteoporosi

- Incremento della massa magra precede quello della massa ossea: adattamento del tessuto osseo allo stress indotto dalle forze muscolari
- Attività fisica: effetti anabolici sullo scheletro diretti (azione muscolare) e indiretti (↑GH e IGF-1)
- Microgravità: perdita di massa ossea (2% al mese) e muscolare (1%)
- Aging: stress ossidativo, diminuzione cellule satellite, incremento tessuto adiposo/inflamm-aging



Sarcopenia e osteoporosi



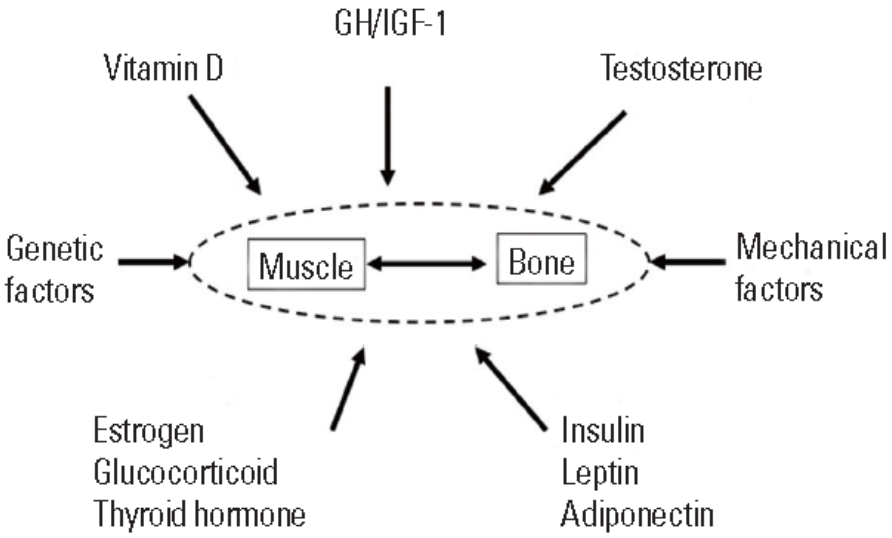
Numerosi fattori biochimici/endocrini e meccanici possono agire sia sui muscoli che sul tessuto osseo:

- IGF-1 Ea, IGF-1,BMPs, Wnt, FGFs, PG, VEGF, IL-6
- Inserzione tendinea
- Interfaccia epimisio/periostio
- Fibre di Sharpey

Tarantino U et al. J Bone Joint Surg Am. 2015
Cianferotti L et al. Endocrine. 2014

Sarcopenia e osteoporosi

- Fattori patogenetici comuni
  - Ridotti livelli di attività fisica
  - Apporto proteico inadeguato
  - Flogosi cronica
  - Disturbi endocrino-metabolici

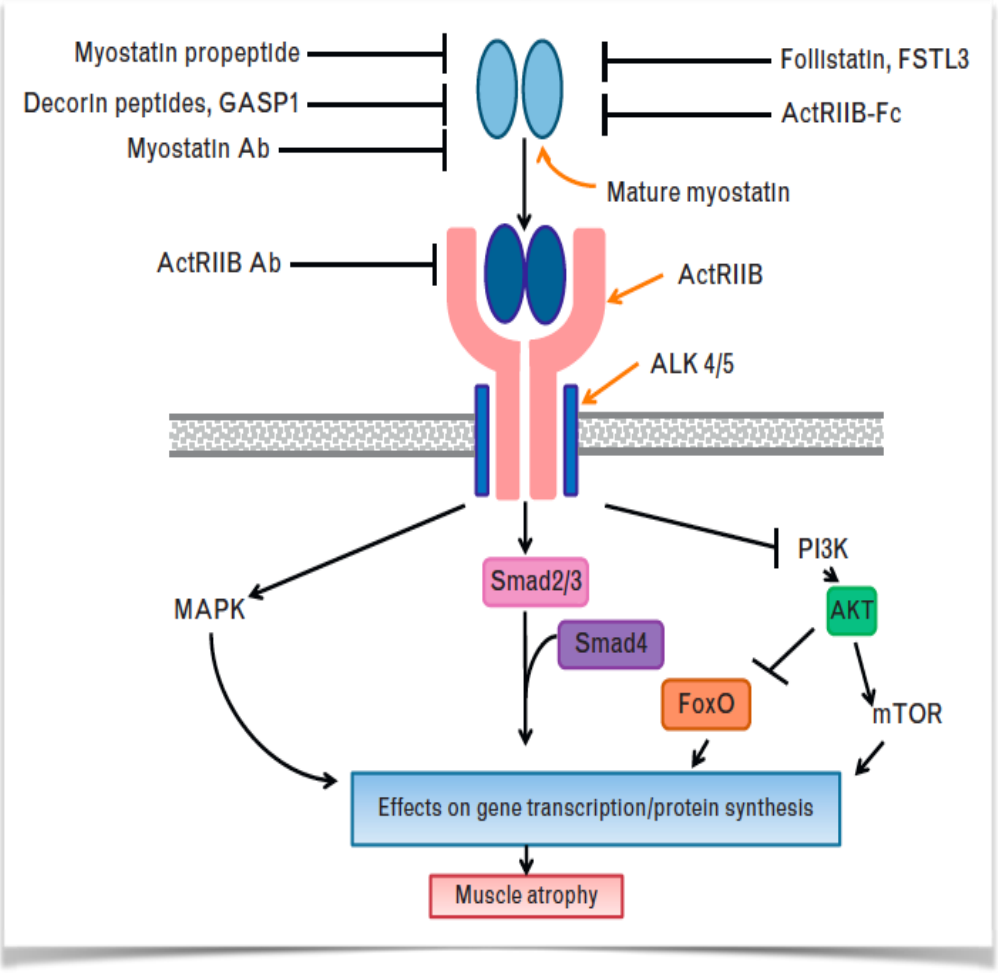


Constitutional	Lifestyle
Female gender	**Low body weight**
Age	**Cigarette smoking**
Asian or Caucasian race	**Excessive alcohol consumption**
Sex hormone deficiency	**Prolonged immobilisation**
Early environment	*Low dietary calcium intake*
	Low protein intake
Co-morbidity	**Vitamin D deficiency**
Genetic Factors	Use of ACE inhibitors
Previous fragility fracture	**Use of steroids**
Family history of fragility fracture	Low growth hormone level

Key: Risk factor for both muscle and bone aging
Risk factor for muscle aging only
Risk factor bone aging only

Miostatina come potenziale target

- Regolatore negativo della massa muscolare
- Agisce legandosi ai recettori dell'activina di tipo I (Alk4/5) e di tipo II
- Topi knock-out per il gene della miostatina mostrano:
  - Riduzione del grasso corporeo
  - Incremento del 25-30% della massa muscolare (ipertrofia/iperplasia)
  - Incremento BMD e resistenza ossea
  - Callo osseo più resistente



Elkasrawy M et al. J Histochem Cytochem 2012
Lee SJ et al. Ann Rev Cell Dev Biol 2004
McPherron AC et al. Nature 1997

Miostatina come potenziale target

Aging Clinical and Experimental Research
https://doi.org/10.1007/s40520-019-01436-8

SHORT COMMUNICATION

Check for updates

Myostatin as a potential biomarker to monitor sarcopenia in hip fracture patients undergoing a multidisciplinary rehabilitation and nutritional treatment: a preliminary study

Alessandro de Sire[1,2] · Alessio Baricich[1,3] · Filippo Renò[4] · Carlo Cisari[1,3] · Nicola Fusco[5] · Marco Invernizzi[1]

de Sire A et al. Aging Clin Exp Res 2020

Miostatina come potenziale target

Table 1 Baseline characteristics of study population

	Group A ($n=10$)	Group B ($n=10$)	p value
Age (years)	80.33 ± 6.72	77.65 ± 8.40	NS
Sex (male/female)	1/9	2/8	NS
Myostatin levels (ng/mL)	1.3 ± 0.3	1.2 ± 0.6	NS
Sarcopenic patients	7 (70.0)	8 (80.0)	NS

Continuous variables are expressed as means ± standard deviations; categorical variables are expressed as counts (percentages); rates are expressed as *x*/*y*

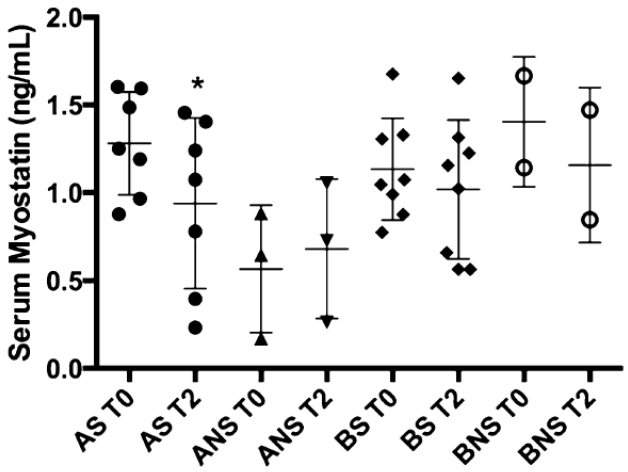


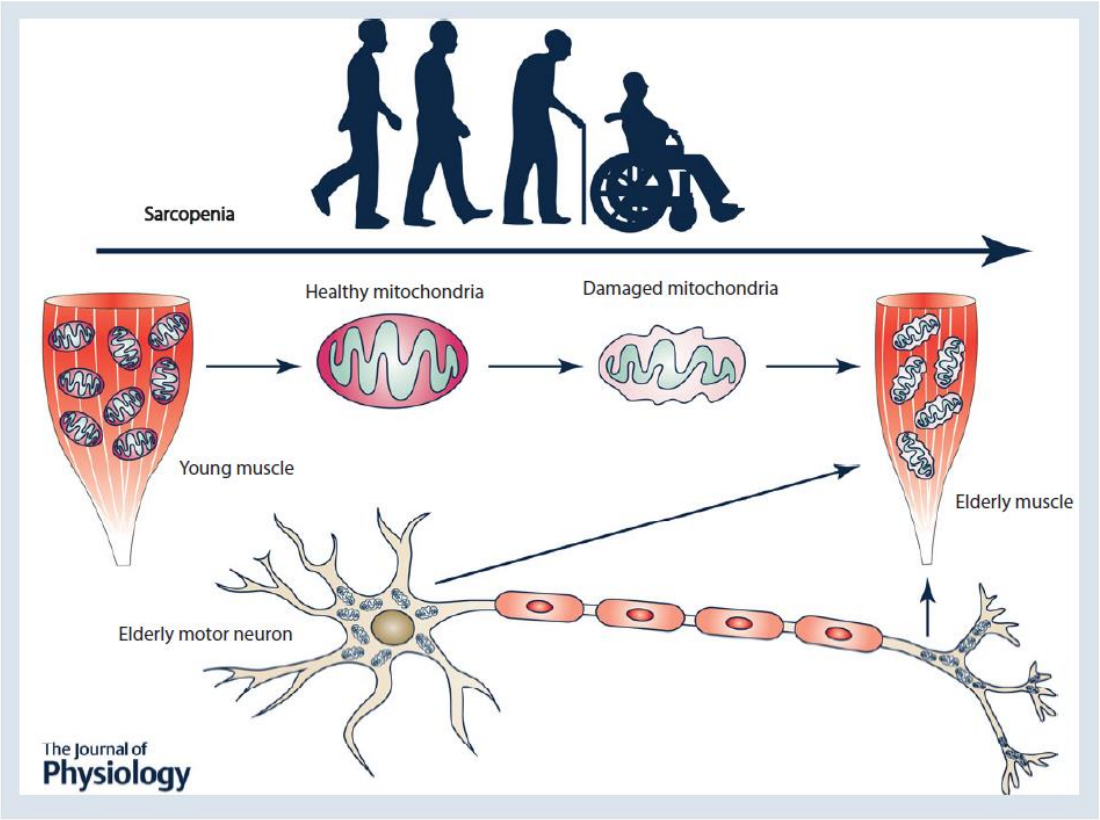
Fig. 2 Serum myostatin modifications in group A and group B patients. *AS* group A sarcopenic, *ANS* group A non-sarcopenic, *BS* group B sarcopenic, *BNS* group B non-sarcopenic. *$p < 0.05$

a significant reduction of serum myostatin levels was observed in the sarcopenic patients of group A (1.3 ± 0.3 vs 0.9 ± 0.5 ng/mL; $p = 0.04$), but not in those in group B (1.2 ± 0.6 vs 1.0 ± 0.7 ng/mL; $p = 0.12$). There were no statistically significant differences between groups in terms of serum myostatin levels. Data have been graphically resumed in Fig. 2.

de Sire A et al. Aging Clin Exp Res 2020

Mitocondri e sarcopenia

- Modificazioni mitocondriali sono state osservate nel muscolo in dipendenza dell'invecchiamento cellulare e della sarcopenia

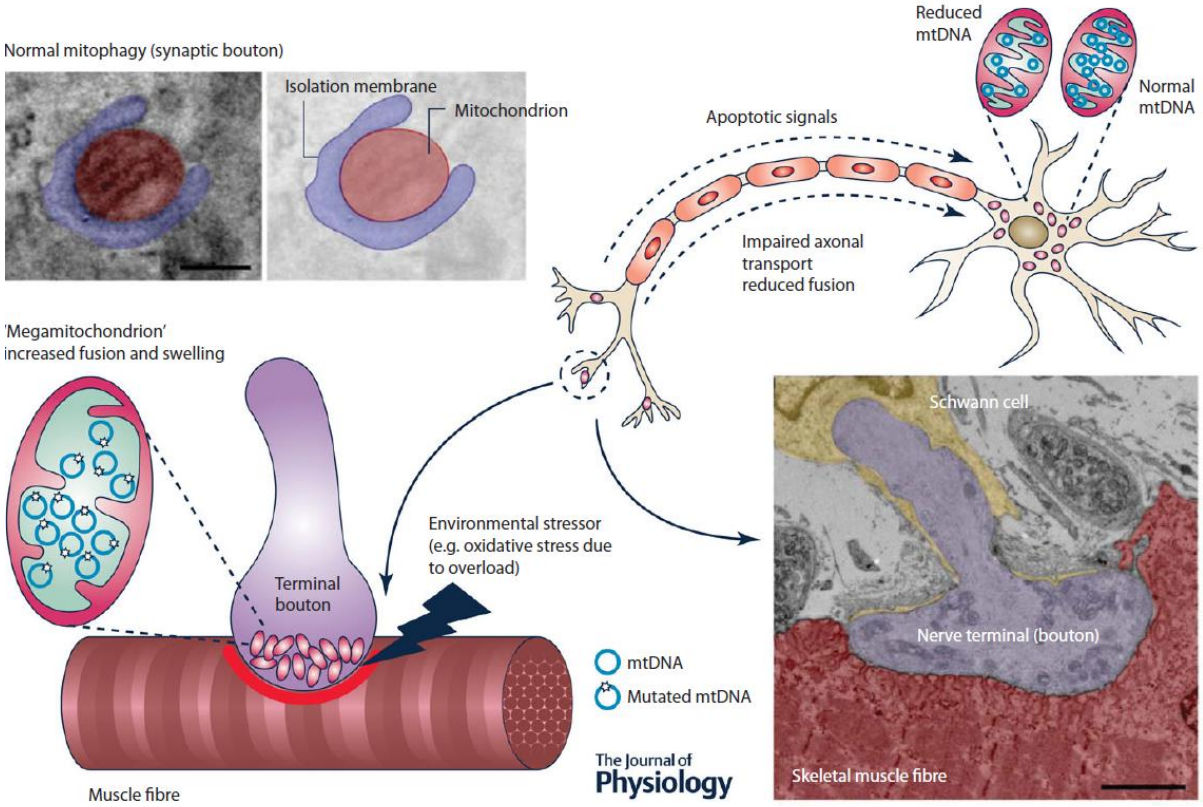


Rygiel J et al. J Physiol 2016

Mitocondri e sarcopenia

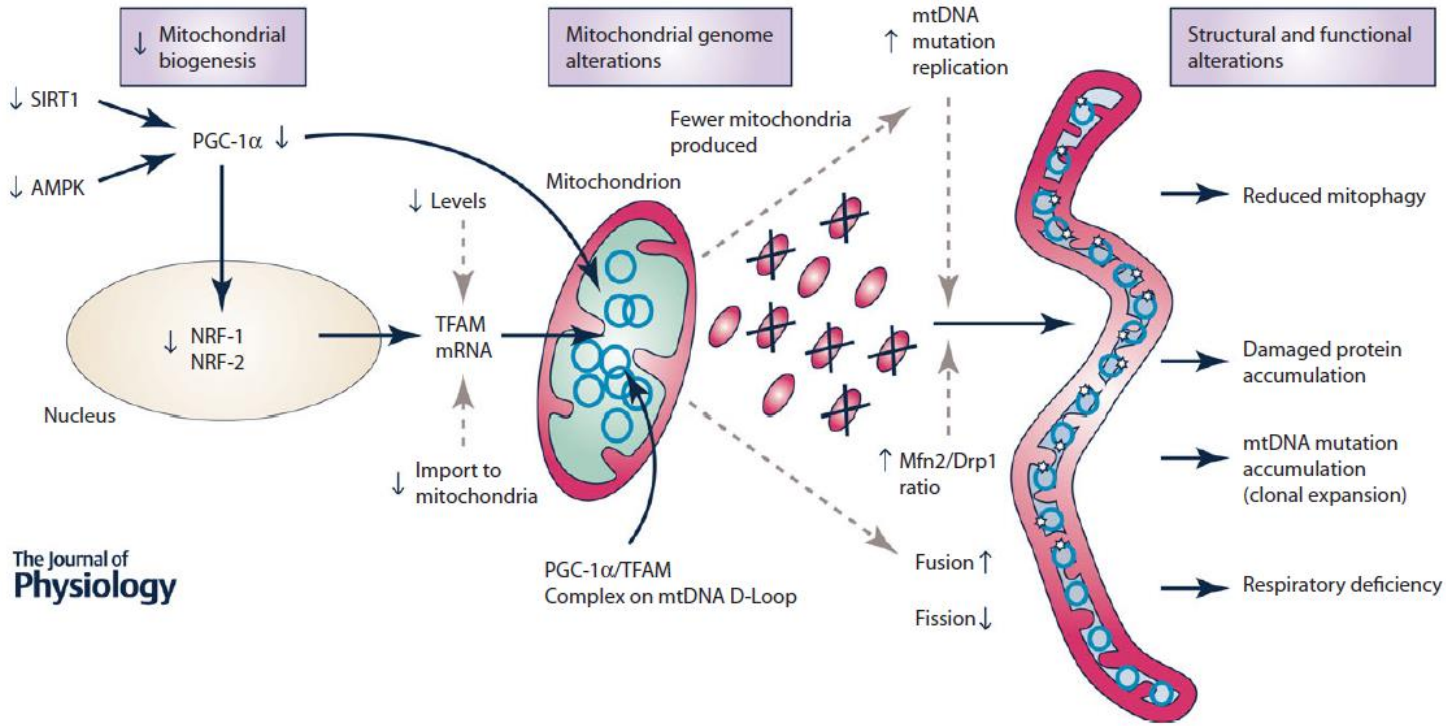
- Il meccanismo comprende danni ossidativi localizzati prevalentemente alla giunzione neuromuscolare

- Il risultato sarebbe una ridotta fissione, con mitocondri fusi e accumulo di danno al mtDNA, con conseguente accumulo di proteine non funzionali



Rygiel J et al. J Physiol 2016

Mitocondri e sarcopenia



• Questo porterebbe ad una trasmissione neuromuscolare deficitaria, ridotto potenziale di membrana, alterata respirazione cellulare e conseguente innesco dell'apoptosi

Rygiel J et al. J Physiol 2016

Mitocondri e sarcopenia

- La domanda è, può l'esercizio rendere reversibile il danno mitocondriale? E come agisce?
- In una recente SR di RCT sono stati presi in considerazione **pazienti anziani** sottoposti ad **esercizio fisico** valutando
  - **Densità mitocondriale**
  - **Fusione/fissione tramite proteine specifiche (Mfn/Drp)**
  - **Capacità ossidativa, come attività della citrato sintasi**
  - **Proteine implicate nella conservazione della funzione mitocondriale come SIRT e COX**
  - **Complessi ossidativi e recovery rate della fosfocreatina**
  - **Funzione antiossidante mediante studio di SOD2 e CAT**

Aging Clinical and Experimental Research
https://doi.org/10.1007/s40520-021-02073-w

REVIEW ARTICLE

Check for updates

Impact of exercise training on muscle mitochondria modifications in older adults: a systematic review of randomized controlled trials

Lorenzo Lippi[1] · Alessandro de Sire[2,10] · Kamal Mezian[3] · Claudio Curci[4] · Luca Perrero[5] · Alessio Turco[5] · Silvia Andaloro[6,7] · Antonio Ammendolia[2] · Nicola Fusco[6,8] · Marco Invernizzi[1,9]

Mitocondri e sarcopenia

- 6 studi selezionati per un totale di 164 soggetti
- Effetti positivi in termini di qualità mitocondriale, densità dinamica, capacità ossidative
- Diversa efficacia dei vari protocolli di esercizio, con il **training di resistenza** che porta i maggiori effetti, ma che è anche il maggiormente studiato in letteratura

Lippi et al. Aging Clin Exp Res 2021

Table 3 Exercise characteristics of included studies

Study	Exercise modality	Type of activity	Protocol duration	Frequency	Volume (session)	Intensity	Supervised/ home based	Control group activity
Estebanez et al. (2019)	RT	Weight machines and free weights activity	8 weeks	2 days/week	3 sets of 8–12 reps for each exercise	The lower body exercises: 40% of 1RM, progression of 5% 1 RM each week Upper body exercise: progressive RPE (5—8)	Information not provided	No specific exercise intervention
Frank et al. [32]	RT	Weight machines	8 weeks	3 days/week	3 sets of 12 reps for each exercise	75–80% 1RM	Supervised	No specific exercise intervention
Irving et al. [33]	ET RT CT	ET = cycling RT = information not provided CT = ET + RT protocol	8 weeks	ET = 5 days/week RT = 4 days/week CT = ET (5 days/week) + RT (4 days/week)	ET = 60 min RT = 4 sets of 8 to 10 repetitions targeting multiple muscle groups CT = 30 min of ET and two thirds the RT volume	ET = 65% $VO_{2\ peak}$ RT = information not provided CT = ET: 65% $VO_{2\ peak}$ RT: information not provided	Supervised	No specific exercise intervention
Johnson et al. [34]	ET	Cycling	8 weeks	3–5 days/week	60 min	65% $VO_{2\ peak}$	Supervised	No specific exercise intervention
Short et al. [35]	ET	Cycling	16 weeks	3–4 days/week	20–40 min	70–80% HR_{max}	Supervised	Flexibility exercises
Jubrias et al. [36]	ET RT	ET = one-legged press exercise and kayaking-type exercise RT = weight machines	24 weeks	3 days/week	ET = 5–20 min for each exercise RT = 3–5 sets of 4–15 reps	ET = 60–85% HRR RT = 60–85% 1RM	Information not provided	No specific exercise intervention

Abbreviations: ET endurance training, *RT* resistance training, *CT* combined training (resistance + endurance), *VO_2peak* Peak oxygen uptake, *1RM* 1 repetition maximum, *4RM* 4 repetition maximum, *HRR* Hart rate reserve, *HRmax* Maximal hart rate

Sarcopenia ed esercizio terapeutico

Experimental Gerontology 151 (2021) 111420

Contents lists available at ScienceDirect

Experimental Gerontology

journal homepage: www.elsevier.com/locate/expgero

Effects of exercise on muscle mass, strength, and physical performance in older adults with sarcopenia: A systematic review and meta-analysis according to the EWGSOP criteria

Adrian Escriche-Escuder [a, b], Iván J. Fuentes-Abolafio [a, b, *], Cristina Roldán-Jiménez [a, b], Antonio I. Cuesta-Vargas [a, b, c]

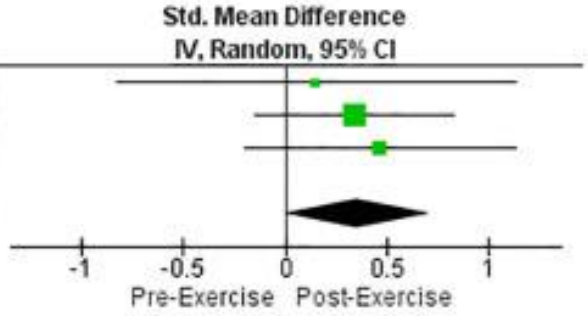
- Quattro RCT e tre non RCT con un totale di 235 pazienti affetti da sarcopenia
- L'esercizio mostra un largo effetto sulla performance fisica (d = 1.21, 95%CI [0.79 to 1.62]; P < 0.001), un medio effetto sulla forza muscolare (d = 0.51,95%CI [0.25 to 0.76]; P < 0.001), e nessun effetto significativo sulla massa sebbene,
- La durata dei protocolli non è stata valutata

Sarcopenia ed esercizio terapeutico

A

Study or Subgroup	Post-Exercise Mean	SD	Total	Pre-Exercise Mean	SD	Total	Weight	Std. Mean Difference IV, Random, 95% CI
Balachandran, 2014	6.6	0.59	8	6.5	0.66	8	13.8%	0.15 [-0.83, 1.13]
Piastra, 2018	7.36	2.31	33	6.48	2.75	33	56.1%	0.34 [-0.14, 0.83]
Tsekoura, 2018	5.94	0.51	18	5.7	0.49	18	30.1%	0.47 [-0.19, 1.13]
Total (95% CI)			**59**			**59**	**100.0%**	**0.35 [-0.01, 0.72]**

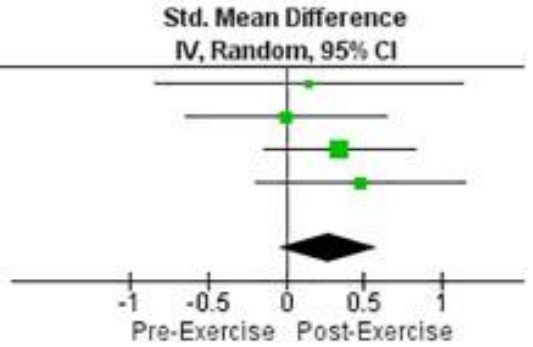
Heterogeneity: Tau² = 0.00; Chi² = 0.28, df = 2 (P = 0.87); I² = 0%
Test for overall effect: Z = 1.91 (P = 0.06)



B

Study or Subgroup	Post-Exercise Mean	SD	Total	Pre-Exercise Mean	SD	Total	Weight	Std. Mean Difference IV, Random, 95% CI
Balachandran, 2014	6.6	0.59	8	6.5	0.66	8	10.4%	0.15 [-0.83, 1.13]
Del Campo-Cervantes, 2019	7.1	1.2	19	7.1	1.3	19	24.7%	0.00 [-0.64, 0.64]
Piastra, 2018	7.36	2.31	33	6.48	2.75	33	42.2%	0.34 [-0.14, 0.83]
Tsekoura, 2018	5.94	0.5	18	5.7	0.49	18	22.7%	0.47 [-0.19, 1.14]
Total (95% CI)			**78**			**78**	**100.0%**	**0.27 [-0.05, 0.58]**

Heterogeneity: Tau² = 0.00; Chi² = 1.20, df = 3 (P = 0.75); I² = 0%
Test for overall effect: Z = 1.66 (P = 0.10)



- A) Effects sizes of exercise on Muscle Mass (SMI) in RCTs
- B) Effects sizes of exercise on Muscle Mass (SMI)in RCTs and non-randomised interventional studies.

Modalità di esercizio efficace

Table 1
General recommendations on exercise-based interventions to treat age-associated sarcopenia and frailty.

Exercise modality	Duration	Volume	Intensity	Frequency	Indication
RESISTANCE	Variable (10–60 min) 3 months (range 2–12 months)	8–10 exercises involving major muscle groups. Progressive (1–3 sets, 6–12 repetitions)	Progressive (until 80% 1RM)	2–3 times/week (range 1–6)	SARCOPENIA (+++) FRAILTY (++)
ENDURANCE	20–60 min 3 months (range 2–12 months)	Progressive	Progressive (moderate to high; 6–8 points on a RPE scale)	3–5 days/week	SARCOPENIA (++) FRAILTY (++)
MULTICOMPONENT: RESITANCE (R) + ENDURANCE (E) + BALANCE (B) + FLEXIBILITY (F)	45–60 min *Pre-frail:* 20 min R + 10 min E + 20 min B + 10 min F *Frail:* 10 min R + 20 min E + 8 min B + 7 min F 3 months (range 1–18 months)	Progressive	Progressive (moderate to high; 6–8 points on a RPE scale)	2–3 times/week (range 1–7)	SARCOPENIA (+++) FRAILTY (+++)

- Le raccomandazioni per i pazienti sarcopenici suggeriscono programmi di endurance e rinforzo
- Gli esercizi di endurance dovrebbero essere effettuati per 30-60 min al giorno, ad intensitò moderata, 5 giorni alla settimana, accompagnati da 20-30 minuti ad alta intensità per 3 giorni alla settimana, con non più di due giorni di riposo
- Gli esercizi di rinforzo dovrebbero essere eseguiti per due giorni alla settimana non consecutive, con set di 8-10 esercizi, ed intensità che consentano 8-12 ripetizioni

Conclusioni

- L'esercizio terapeutico ha un ruolo fondamentale per la salute dell'osso e del muscolo, soprattutto in condizioni di osteosarcopenia

- L'esercizio esercita la sua funzione anabolica sull'osso non solo in temini di BMD, ma agendo anche tramite effetti endocrini

- Diversi marcatori sono stati studiati e molti sono in via di sperimentazione (miostatina, CTX, CTP, sclerostina, ALP, P1NP, osteocalcina e PICP)

IV CONGRESSO NAZIONALE

SOCIETÀ ITALIANA G.U.I.D.A.
PER LA GESTIONE UNIFICATA E INTERDISCIPLINARE DEL DOLORE MUSCOLO-SCHELETRICO E DELL'ALGODISTROFIA

Ruolo dell'esercizio fisico e terapeutico sulla Bone Health

Centro Congressi Unione Industriali
TORINO 11-13 MAGGIO 2023

Prof. Alessandro de Sire

Professore Associato di Medicina Fisica e Riabilitativa
Consigliere di Presidenza della Società Italiana di Medicina Fisica e Riabilitativa (SIMFER)
Coordinatore Regionale Società Italiana G.U.I.D.A. per Calabria e Basilicata
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