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特集 高齢者における健康増進

Seminar

8．サルコペニア予防と健康増進

金　憲経

KEY WORD
- サルコペニア
- 筋力強化運動
- アミノ酸補充
- 健康増進

SUMMARY

■加齢に伴う骨格筋量の減少は筋の質を表す筋力の衰えや身体機能の低下をもたらし，特に下肢筋力の衰えは歩行機能を低下させ，転倒・骨折の危険因子となるなど，高齢者の活動的余命を考える上で，大変重要な問題である．

■加齢に伴う骨格筋量の減少や身体機能低下予防のためには，多様な要因の中で可変因子の改善に焦点を当てる支援が有効である．主な可変因子は骨格筋の不使用と栄養である．これらの背景を踏まえて，サルコペニア高齢者に対する運動，栄養補充の効果を調べたところ，運動指導に必須アミノ酸を含んだ栄養を補充する包括的指導がサルコペニア予防により効果的であることが実証されている．

はじめに

European Working Group on Sarcopenia in Older People 報告では，「筋量」，「筋力」，「身体機能」に着目し，筋量減少のみは Presarcopenia，筋量減少に伴う筋力低下あるいは身体機能低下は Sarcopenia，筋量減少，筋力低下，身体機能低下は Severe sarcoprnia と分類している[1]．特に，下肢筋量の減少や筋力の衰えは歩行機能を著しく低下させ，ひいては転倒・骨折の危険因子となるなど，高齢者の活動的余命を考える上で，大変重要な問題であることから，サルコペニア予防のための健康増進の有効性について最近の研究に基づき解説する．

サルコペニア高齢者の特徴

都市部在住後期高齢者 1,399 人を調査，サルコペニア高齢者 304 人を選定し，その特徴を調べた研究によれば，サルコペニア群は正常群に比べて年齢が高く，下腿三頭筋周囲，骨密度，BMI，筋肉量は有意に低く，また健康度自己評価，定期的な運動習慣者の割合は低いが，外出頻度低下者の割合は高い．既往歴においては，高血圧症，高脂血症は正常群より低いが，骨粗鬆症の既往はサルコペニア群 38.2%，正常群 30.7%，60 歳以降の骨折歴はサルコペニア群 28.6%，正常群 22.9%とサルコペニア群で多くみられる．一方，過去 1 年間の転倒率はサルコペニア群 26.5%，正常群 16.4%とサルコペニア群が有意に高い．以上の結果よりサルコペニア高齢者は，骨密度の低下による骨粗鬆症の既往が多く，さらに転倒が多いことから要介護状態の主な原因である骨折の危険に曝され，サルコペニア予防のための健康増進は，介護予防の観点から大変重要であることが強く示唆される．

サルコペニア予防のための健康増進のポイント

骨格筋量の減少に影響する要因は加齢，慢性

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表1　高齢者における高強度レジスタンストレーニングによる下肢筋力増加（文献5より一部抜粋）

文献	研究タイプ・対象者	性別	年齢	頻度/週，強度	期間（週）	効果
Charette et al, 1991	RCT，地域在住健常者	女性	平均69歳	3回，65～75% 1-RM	12	1-RM足筋力28～115%↑
Fiatarone et al，1994	RCT，ナーシングホーム入所者	男女	平均87歳	3回，80% 1-RM	10	1-RM足筋力37～178%↑
Lexell et al，1995	RCT，地域在住健常者	男女	70～77歳	3回，85% 1-RM	11	1-RM足筋力163%↑
Vincent et al, 2002	RCT，地域在住健常者，不活動者	男女	平均68歳 平均67歳	3回，50% 1-RM 3回，80% 1-RM	24 24	1-RM足筋力16%↑ 1-RM足筋力20%↑
Bamman et al, 2003	RCT，健常者	男女	男性：平均69歳 女性：平均66歳	3回，80% 1-RM 3回，80% 1-RM	25 25	1-RM足筋力82%↑ 1-RM足筋力58%↑
Brose et al，2003	RCT，地域在住健常者	男女	男性：平均69歳 女性：平均70歳	3回，80% 1-RM 3回，80% 1-RM	14 14	1-RM足筋力36%↑ 1-RM足筋力66%↑
Frontera et al, 2003	RCT，地域在住不活動者	女性	平均74歳	3回，85% 1-RM	12	1-RM足筋力39%↑ 等速性足筋力9%↑

疾患，内分泌環境の変化，骨格筋の不使用，栄養不良など様々である．骨格筋量の減少を予防するためには，様々な要因の中で可変因子の改善に焦点を当てる支援が有効である．可変因子として注目されているのは，骨格筋の不使用と栄養不良である．

骨格筋の不使用を解消するためには運動が有効である．Progressive resistance strength trainingは，高齢者の筋肉量や筋力向上に有効であると多くの研究で指摘している[2,3]．栄養不良の対策としては必須アミノ酸が注目され，必須アミノ酸の補充によって筋タンパク質合成が促進されることが多く検証されている[4]．

1．サルコペニア予防のための健康増進―①運動―

高齢者に対するレジスタンス運動が筋肉に及ぼす影響について，49介入研究のmeta-analysis結果によれば，介入後に1.1 kg（95% CI＝0.9～1.2 kg，$p<0.001$）増大効果を認めている[3]．高齢者の下肢筋力向上について調べた主な研究をみると，運動期間は10～25週，頻度は週3回，強度は1-RMの80%以上の高強度が多く，効果は9～178%と広範囲である（**表1**）[5]．先行研究で運動介入は筋肉量や筋力増大に効果的であると報告しているが，ここで注目すべきことは，先行研究で採用している運動はhigher intensity training, higher-volume interventionであり，低強度負荷の運動では筋量の上昇，筋力の向上効果は見込めないことを指摘している．確かに，筋肉量の上昇や筋力向上という結果のみを求めるには，先行研究の見解である高強度，高頻度，長時間の運動が有効であろう．しかし，骨格筋量の減少に伴う筋力の衰え，歩行機能の低下といった状態のサルコペニア高齢者に高強度，高頻度，長時間の運動を指導し，筋肉量や筋力の上昇効果を検証しようとした場合，「adverse effect」についての論議も必要と考える．Taaffe[6]は，サルコペニア改善のためにはmoderate intensity運動でも十分効果が期待できると提案しているが，その効果検証はほとんど報告されず，一層の研究が必要といえる．

2．サルコペニア予防のための健康増進―②栄養―

筋肉の構成成分である筋タンパク質は合成と分解を常に繰り返し，合成と分解のバランスによって筋量は一定に保たれている．高齢になる

と様々な要因によって筋タンパク質の量が徐々に減少する．つまり，筋タンパク質の分解量が合成量を上回るか，合成速度が低下するかによって筋量は徐々に減少していく．しかし，筋タンパク質の合成を促進するか分解を抑制することができれば，筋量の減少を抑え，有効な対策と考えられる．高齢者でも必須アミノ酸の摂取は，筋タンパク質の合成を促進する効果があり，必須アミノ酸の中でもロイシン高含量の必須アミノ酸の摂取が，より効果的であることが認められている．

アミノ酸補充効果について検討した先行研究によれば，Borsheim ら[7]は，アミノ酸を12週間補充すると，筋肉量のみならず下肢筋力，通常歩行速度などの体力が有意に改善する効果を検証しているが，Dillon らの試験によれば，アミノ酸補充によって筋肉量は有意に増加するが，筋力の変化は有意ではないと報告している[8]．これらの先行研究を総合すると，筋肉量の上昇効果はおおむね認められているが，筋力の向上効果については必ずしも一致せず，研究者によって異なる結果を報告している．今後，一層の検証が必要であろう．

3．サルコペニア予防のための健康増進―③運動＋栄養―

70歳以上の施設長期入所者100人を対象に運動，栄養補充の効果を検証した Fiatarone ら[9]の結果によれば，炭水化物中心の栄養補充のみでは虚弱高齢者の筋力や歩行機能の低下抑制は不十分であり，運動中心の指導が有効であると指摘している．

地域在住サルコペニア高齢者に対する運動，栄養補充の3カ月間の複合介入が有効であるとの先行研究を簡単に紹介する[10]．

1）運動指導

週2回，1回当たり60分間の椅子体操，レジスタンス運動（ゴムバンド：黄色，赤色使用，Ankle-weight：錘 0.50 kg，0.75 kg，1.00 kg，1.50 kg 使用），歩行・バランス運動である．

2）栄養補充

ロイシン 42.0%，リジン 14.0%，バリン 10.5%，イソロイシン 10.5%，トレオニン 10.5%，フェニルアラニン 7.0%，ほか 5.5%組成のアミノ酸3gを1日2回補充する．

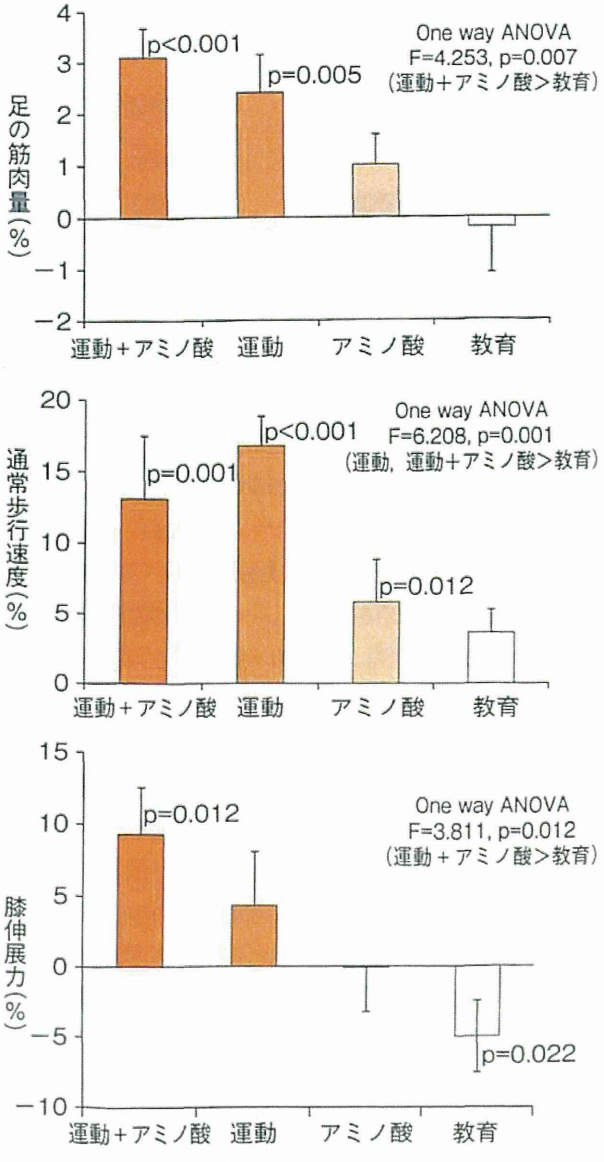

図1　3カ月間の指導による足の筋肉量，通常歩行速度，膝伸展力の変化率（文献10より引用）

3）運動＋栄養介入の効果

介入前後における足の骨格筋量は運動群，運動＋栄養群の2群で，通常歩行速度は運動群，栄養群，運動＋栄養群の3群で有意な増加が観察され，サルコペニア高齢者の歩行速度は運動のみならず，栄養補充によって増える可能性を示唆している．下肢筋力は運動＋栄養群のみで有意な向上が認められる（図1）．

表2　介入後の骨格筋量および身体機能の改善に対する介入群間の調整済オッズ比の比較(文献10より引用)

		介入					
	健康教育群	アミノ酸群		運動群		運動＋アミノ酸群	
従属変数*	基準	OR#	95% CI	OR#	95% CI	OR#	95% CI
四肢の筋肉量＋膝伸展力	1.00	1.99	0.72～5.65	2.61	0.88～8.05	4.89	1.89～11.27
四肢の筋肉量＋通常歩行速度	1.00	1.35	0.45～4.08	2.41	0.79～7.58	4.11	1.33～13.68

*従属変数：筋肉量と身体機能の変化：1＝向上，0＝無変化あるいは低下
#OR＝調整済オッズ比，95% CI＝95%信頼区間

このような単一変数の変化検討も重要であるが，ここで注目したいのはサルコペニアの定義である．つまり，サルコペニアとは「筋量減少＋筋力低下」あるいは「筋量減少＋歩行速度低下」という概念である．よって，健康増進効果を検証するときも，これらの概念に基づいた分析が必要である．表2に示したように，「下肢筋量＋膝伸展力」改善のためには，アミノ酸補充あるいは運動単独による指導効果は不十分であり，「運動＋アミノ酸補充」の複合指導によって効果が上昇(OR＝4.89，95% CI＝1.89～11.27)し，「下肢筋量＋通常歩行速度」の改善にも「運動＋アミノ酸補充」の複合指導で効果(OR＝4.11，95% CI＝1.33～13.68)が高まることを検証している．

おわりに

骨格筋量の減少に伴う筋力の衰え，あるいは身体機能の低下を意味するサルコペニアを効果的に予防するためには，運動指導に栄養補充を加える包括的指導がより有効であることが多く実証されている．今後，運動と必須アミノ酸のみならず，ほかの栄養素との組み合わせによる効果検証の成果を期待する．

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Q.10

診断のための臨床症候について教えてください

金 憲経

A

- **下腿三頭筋周囲萎縮，下肢筋量減少，下肢筋力低下，健康度自己評価が低い**
- **IADL障害，転倒，60歳以降の骨折歴などの症候が多く，骨密度は低い**
- **高脂血症・高血圧・変形性膝関節症の既往歴は少なく，骨粗鬆症や貧血の既往歴は多く，肺活量は少ない**

われわれは大都市部在住75歳以上の後期高齢女性1,399人の中から，サルコペニア高齢者304名（21.7％）を抽出し，以下のようなサルコペニア高齢者の臨床症候を見出した。

1. 臨床症候1：下腿三頭筋周囲萎縮，下肢筋量減少，下肢筋力低下

サルコペニア群は正常群に比べて，年齢が高く，下腿三頭筋周囲径，BMI，全身筋量および下肢筋量，下肢筋力は有意に低い値を示す。下腿三頭筋周囲径は筋肉量の指標となり，高齢者の身体機能や障害を評価する有効な項目として広く採用され，31cm以下になると歩行困難，着替え困難，入浴困難，階段昇降困難の危険性が増えると指摘する[1]。今回の対象者304人の平均下腿三頭筋周囲径は30.17±2.03cm，70.4％（214人）は31.0cm未満で，サルコペニア高齢者の多くで下腿三頭筋周囲萎縮が確認される。筋量の減少，なかでも下肢筋量は，サルコペニア群9.84±1.01kgと正常群（11.79±1.31kg）に比べて有意（t-値27.78，$p < 0.001$）に少ない。一方，下肢筋力はサルコペニア群155.84±38.82 N，正常群209.24±47.83 Nとサルコペニア群が正常群より顕著に弱い（表1）。サルコペニア群で下肢筋量のみな

◎表1　サルコペニア群と正常群の連続変数の比較

項　目	サルコペニア群	正常群	p値
年齢（歳）	79.49±2.93	78.51±2.77	<0.001
身長（cm）	146.17±5.77	148.21±5.41	<0.001
体重（kg）	40.51±4.44	52.13±6.75	<0.001
BMI（kg/m²）	18.98±2.01	23.74±2.84	<0.001
下腿三頭筋周囲径（cm）	30.17±2.03	33.92±2.60	<0.001
BMD（g/cm²）	0.248±0.053	0.296±0.061	<0.001
収縮期血圧（mmHg）	129.13±20.45	135.00±18.38	<0.001
拡張期血圧（mmHg）	70.53±11.53	74.41±10.35	<0.001
脈拍数（拍）	78.29±11.68	75.38±11.62	<0.001
肺活量（L）	1.90±0.41	2.05±0.42	<0.001
筋肉量（kg）	26.92±2.61	31.73±3.16	<0.001
下肢筋肉量（kg）	9.84±1.01	11.79±1.31	<0.001
膝伸展力（N）	155.84±38.82	209.24±47.83	<0.001

らず下肢筋力の低下が検証されたことに注目すべきである。

健康度自己評価をみると，不健康だと回答した者の割合はサルコペニア群24.3％，正常群14.2％と有意に高く，定期的な運動習慣を持っている者の割合はサルコペニア群27.3％，正常群33.5％と有意に低い（表2）。

以上のように，サルコペニア高齢者は下腿三頭筋周囲が細く，下肢筋量の減少にともなう筋力低下，健康に対する自信感の喪失という症候を示す。

2．臨床症候2：ADL障害や転倒・骨折上昇，低骨密度

サルコペニアとactivities of daily living（ADL）や手段的ADL（instrumental ADL: IADL）障害，転倒，骨折との関連性については，多くの先行研究で検証されている。ADLは，一人の人間が独立して生活するために行う基本的な，しかも各人ともに共通に毎日繰り返す食事，排泄，移乗，更衣，入浴など身の回りの動作を指し，IADLは外出，買い物，食事の支度，金銭管理，家事など，個人が社会環境に適応し，自立生活を維持するために不可欠な能力である。サルコペニア高齢者のIADLの障害について調べた研究報告によれば，サルコペニア高齢者は正常者に比べてIADL障害の危険性は5倍以上〔odd ratio（OR）＝5.04，95％ confidence interval（CI）＝1.95-13.02〕と高い[2]。今回の対象者の場合，IADL障害はサルコペニア群7.9％，

◎表2　サルコペニア群と正常群のカテゴリー変数の比較

項　目	サルコペニア群	正常群	p値
健康度自己評価：不健康(%)	24.3	14.2	<0.001
外出頻度：少ない(%)	4.6	2.5	0.051
運動習慣：有(%)	27.3	33.5	0.039
IADL 障害：有(%)	7.9	4.6	0.022
転倒：有(%)	26.5	16.4	<0.001
痛み：有(%)	58.9	65.4	0.037
既往歴：有(%)			
脳卒中	6.9	7.1	0.897
心臓病	17.1	21.6	0.090
糖尿病	8.2	10.6	0.223
慢性閉塞性肺疾患	0.7	0.9	0.669
変形性股関節症	1.7	2.4	0.445
高血圧	51.0	58.0	0.029
高脂血症	32.2	40.5	0.009
変形性膝関節症	14.5	25.5	<0.001
貧血症	4.6	2.2	0.022
骨粗鬆症	38.2	30.7	0.014
60 歳以降骨折	28.6	22.9	0.038

正常群4.6％と先行研究の指摘と同様にサルコペニア群で有意に高いことから，サルコペニア高齢者に対するIADL自立支援は緊急の課題であるといえる。

次に転倒問題についてみると，サルコペニア高齢者に転倒率の上昇が観察され，正常者に比べて転倒の危険性が3倍以上あることがわかった（hazard ratio＝3.23，95％CI＝1.25-8.29）[3]。今回のデータでも，過去1年間の転倒率はサルコペニア群26.5％，正常群16.4％とサルコペニア高齢者の転倒率は有意に高い（表2）。サルコペニア高齢者における転倒率上昇の背景には前述の下肢筋量の減少にともなう下肢筋力の低下が大きく関与していると推測する。また，筋力低下が転倒の危険因子であることはよく知られているところである。

転倒の影響として最も深刻なのは骨折である。高齢者に起こりやすい骨折として，脊椎，橈骨末端部，上腕骨近位部，大腿骨近位部が挙げられるが，大腿骨頸部あるいは転子部骨折は起立，歩行に最も関連し対応が適切でなければ要介護状態あるいは寝たきりに結びつきやすい。大腿骨近位部骨折

の増加は，年齢とともに骨が脆弱性を増すと同時に，転倒頻度が上昇するためである。もう一つ注目したいのは骨密度である。DTX-200より計測した橈骨の骨密度は，サルコペニア群0.248±0.053g/cm^2，正常群0.296±0.061g/cm^{2}と有意に低い。

サルコペニア高齢者に多発する骨折は，サルコペニア高齢者の条件，つまり下肢筋量の減少，下肢筋力の低下，低骨密度，易転倒が骨折増加と強く関わると推測する。60歳以降の骨折歴はサルコペニア群28.6％，正常群22.9％とサルコペニア群が有意に高い。一方，サルコペニア高齢者の骨折部位をみると，大腿骨頸部8.0％（正常群4.4％）と腰部10.3％（正常群6.4％）が多い。

もう一つの特徴は痛みである。痛みの有症率はサルコペニア群58.9％，正常群65.4％とサルコペニア群の方が低い（p＝0.037）。サルコペニア高齢者は正常者より痛みの有症率は低いが，痛みを有するサルコペニア高齢者の各種健康指標は顕著に悪いことが深刻な問題である。また，痛みを有するサルコペニア高齢者は痛みがないサルコペニア高齢者に比べて，不健康32.4％，運動習慣無78.8％，転倒恐怖感81.0％，尿漏れ39.1％，60歳以降骨折歴34.6％と高くなっている。

以上のように，サルコペニア高齢者は，正常者に比べてIADLの障害率が高く，転倒や骨折歴が多いという特徴を示す。さらに，サルコペニア群内で痛みを持っているサルコペニア高齢者は，より深刻な健康問題を多く抱えていることが示唆される。

3. 臨床症候3：骨粗鬆症多発，小肺活量

サルコペニアと疾病との関連性については，おもに骨粗鬆症に焦点を当てた検討が散見される。骨粗鬆症は低骨量で，かつ骨組織の微細構造が変化し，骨の脆弱化とその結果として起こる骨折の危険が増大した病態と定義される。骨粗鬆症の発症には複数の生活習慣に関連する要因と遺伝的素因が関わるが，サルコペニアが骨粗鬆症と密接に関連するとの指摘も多い。サルコペニア高齢者は正常者に比べて骨粗鬆症の危険が2倍くらい（odds ratio＝1.80，95％CI＝1.07-3.02）高い[4]。骨粗鬆症のみならず，サルコペニア高齢者の既往歴を総合的にみると，高血圧症51.0％（正常群58.0％），

高脂血症32.2％（正常群40.5％），変形性膝関節症14.5％（正常群25.5％）は正常群より低い割合を示すが，先行研究と同様に骨粗鬆症38.2％（正常群30.7％）と高く，さらに貧血も4.6％（正常群2.2％）と有意に高い割合を示す。一方，脳卒中，心臓病，糖尿病，慢性閉塞性肺疾患，変形性股関節症は両者間で有意差は見られない（表2）。しかし，狭心症はサルコペニア高齢者35.3％（正常群24.8％）と高い傾向を示す。一方，収縮期血圧（サルコペニア群＝129.13±20.45mmHg，正常群＝135.00±18.38mmHg，$p < 0.001$），拡張期血圧（サルコペニア群＝70.53±11.53mmHg，正常群＝74.41±10.35mmHg，$p < 0.001$）はサルコペニア群が正常群より低い値を示すが，脈拍数（サルコペニア群＝78.29±11.68拍，正常群＝75.38±11.62拍，$p < 0.001$）はサルコペニア群で高い。しかし，肺活量はサルコペニア群1.90±0.41L，正常群2.05±0.42Lとサルコペニア群で顕著に減っている（表1）。

以上のことから，サルコペニア高齢者は，下肢筋力の低下に起因する転倒増加，骨密度の低下や骨粗鬆症にともなう骨折の危険性が高く，診断にあたってはこれらの臨床症候の把握が必要であることが示唆される。

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Review

Sarcopenia in Asia: Consensus Report of the Asian Working Group for Sarcopenia

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A B S T R A C T

Sarcopenia, a newly recognized geriatric syndrome, is characterized by age-related decline of skeletal muscle plus low muscle strength and/or physical performance. Previous studies have confirmed the association of sarcopenia and adverse health outcomes, such as falls, disability, hospital admission, long term care placement, poorer quality of life, and mortality, which denotes the importance of sarcopenia in the health care for older people. Despite the clinical significance of sarcopenia, the operational definition of sarcopenia and standardized intervention programs are still lacking. It is generally agreed by the different working groups for sarcopenia in the world that sarcopenia should be defined through a combined approach of muscle mass and muscle quality, however, selecting appropriate diagnostic cutoff values for all the measurements in Asian populations is challenging. Asia is a rapidly aging region with a huge population, so the impact of sarcopenia to this region is estimated to be huge as well. Asian Working Group for Sarcopenia (AWGS) aimed to promote sarcopenia research in Asia, and we collected the best available evidences of sarcopenia researches from Asian countries to establish the consensus for sarcopenia diagnosis. AWGS has agreed with the previous reports that sarcopenia should be described as

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low muscle mass plus low muscle strength and/or low physical performance, and we also recommend outcome indicators for further researches, as well as the conditions that sarcopenia should be assessed. In addition to sarcopenia screening for community-dwelling older people, AWGS recommends sarcopenia assessment in certain clinical conditions and healthcare settings to facilitate implementing sarcopenia in clinical practice. Moreover, we also recommend cutoff values for muscle mass measurements (7.0 kg/m^2 for men and 5.4 kg/m^2 for women by using dual X-ray absorptiometry, and 7.0 kg/m^2 for men and 5.7 kg/m^2 for women by using bioimpedance analysis), handgrip strength (<26 kg for men and <18 kg for women), and usual gait speed (<0.8 m/s). However, a number of challenges remained to be solved in the future. Asia is made up of a great number of ethnicities. The majority of currently available studies have been published from eastern Asia, therefore, more studies of sarcopenia in south, southeastern, and western Asia should be promoted. On the other hand, most Asian studies have been conducted in a cross-sectional design and few longitudinal studies have not necessarily collected the commonly used outcome indicators as other reports from Western countries. Nevertheless, the AWGS consensus report is believed to promote more Asian sarcopenia research, and most important of all, to focus on sarcopenia intervention studies and the implementation of sarcopenia in clinical practice to improve health care outcomes of older people in the communities and the healthcare settings in Asia.

Sarcopenia has been accepted as a new geriatric syndrome,[1] and the knowledge related to sarcopenia is growing rapidly worldwide. Over the past 20 years of sarcopenia research after the first introduction by Rosenberg et al,[2] the etiology, pathophysiology, risk factors, and consequences of sarcopenia have gradually become clearer.[3] Moreover, a number of therapeutic approaches and clinical trials have been developed and are still evolving.[4–7] Most importantly, the association of sarcopenia with poorer health status and adverse outcomes had triggered a new approach for health promotion and health care of older people. The escalation of elderly population worldwide further strengthened the clinical importance of sarcopenia, which is even more significant in Asia because of the rapid demographic transition in this highly populated continent.[8–10]

Sarcopenia has been described as an age-related decline in skeletal muscle mass as well as muscle function (defined by muscle strength or physical performance),[11] which may result in reduced physical capability,[12–14] poorer quality of life, impaired cardiopulmonary performance,[15,16] unfavorable metabolic effects,[17] falls,[18] disability, and mortality in older people,[19,20] as well as high health care expenditure.[21] Furthermore, sarcopenia is also associated with multimorbidity,[22,23] cigarette smoking,[22,24] low body mass index,[25] underweight,[26] physical inactivity,[12] and low serum levels of testosterone in men.[27,28] In general, the association between sarcopenia and functional decline is more significant in men than in women,[29,30] which deserves further research for therapeutic consideration. Since Asia is the most populated and fastest aging region in the world, sarcopenia will pose great impacts to Asian populations in the near future.[31,32] Therefore, experts and researchers of sarcopenia from China, Hong Kong, Japan, South Korea, Malaysia, Taiwan, and Thailand organized the Asian Working Group for Sarcopenia (AWGS) and had several meetings in Taipei, Seoul, and Kyoto to promote further research development of sarcopenia in Asia since March 2013. This article will focus on the epidemiology of sarcopenia in Asian countries and to propose a diagnostic algorithm based on currently available evidence in Asia.

Diagnosis of Sarcopenia and Its Impact to Asia

Asia is a huge and densely populated continent with a wide range of ethnicities, cultural, social, religious backgrounds, and lifestyles. Because of the rapid population aging and the population size, the impact of sarcopenia in Asia may be stronger than in other continents. However, the status of population aging and economic development varies extensively in different Asian countries. Therefore, developing a consensus for sarcopenia diagnosis and clinical approaches based on available evidence is of great importance for sarcopenia research in the future.

In 2010, European Working Group on Sarcopenia in Older People (EWGSOP) proposed an operational definition and diagnostic strategy for sarcopenia that had become the most widely used in the world.[33] The EWGSOP definition required measurements of muscle mass, muscle strength, and physical performance for the diagnosis of sarcopenia, which is compatible with current understanding about sarcopenia. Based on the discussion of the AWGS meetings, we decided to take similar approaches for sarcopenia diagnosis, but unlike EWGSOP, we recommended measuring both muscle strength (handgrip strength) and physical performance (usual gait speed) as the screening test (Figure 1). Although the recommended approaches for measurements of muscle mass, muscle strength, and physical performance by AWGS were similar to the EWGSOP definition, the cutoff values of these measurements in Asian populations may differ from those in Caucasians because of ethnicities, body size, lifestyles, and cultural backgrounds. Therefore, developing an Asian consensus in sarcopenia diagnosis based on the evidence derived from Asian populations is essential for research and therapeutic approaches to sarcopenia in Asia.

Strategy for Sarcopenia Screening and Assessment

In principle, AWGS followed the diagnostic approach of EWGSOP, and we added some Asian perspectives in sarcopenia diagnosis and research. In the previous studies from Western countries, the prevalence of sarcopenia in older people was around 20% among people aged 65 years and older and may reach 50%–60% in octogenarians.[34] EWGSOP recommends routine screening for sarcopenia among community-dwelling people aged 65 years and older. On the other hand, the International Working Group on Sarcopenia (IWGS) specifies certain conditions for sarcopenia assessment, including (1) noted decline in function, strength, "health" status, (2) self-reported mobility-related difficulty, (3) history of recurrent falls, (4) recent unintentional weight loss (>5%), (5) post-hospitalization, and (6) other chronic conditions (eg, type 2 diabetes, chronic heart failure, chronic obstructive pulmonary disease, chronic kidney disease, rheumatoid arthritis, and cancer).[35] Moreover, IWGS recommends assessing patients with reduced physical functioning (or weakness) or patients with habitual gait speed <1.0 m/s (by 4-m course) to assess body composition by dual x-ray absorptiometry (DXA). Nonambulatory patients or those who cannot rise from a chair unassisted should be considered to be sarcopenic without DXA measurements. Since sarcopenia is defined as an age-related condition, assessment of sarcopenia is limited to people aged 65 years and older only in the

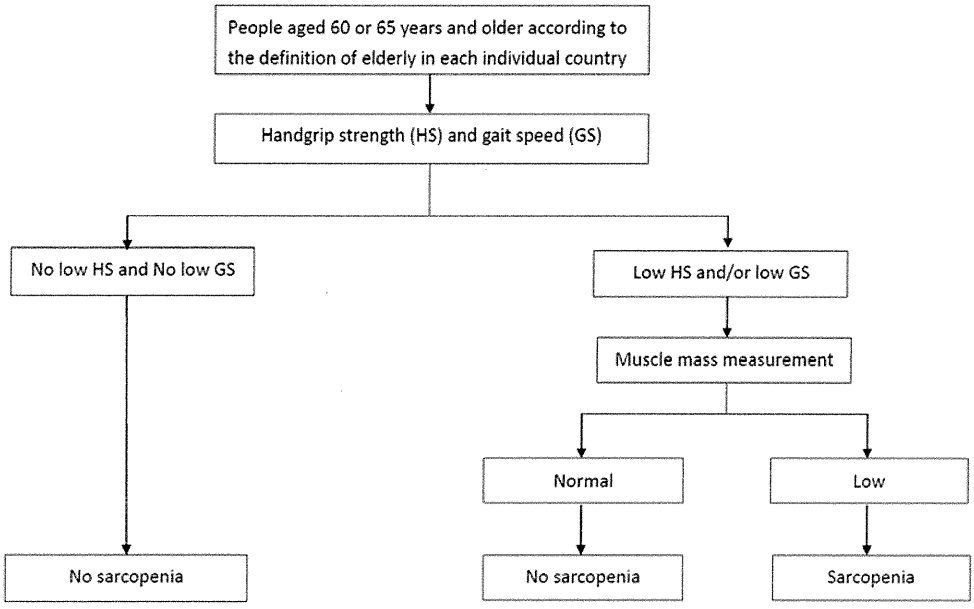

Fig. 1. Recommended diagnostic algorithm of Asian Working Group for Sarcopenia.

EWGSOP criteria, but IWGS does not specify the age for sarcopenia diagnosis.

In Asia, because of the different states of aging, not all countries use the same age cutoff to define elderly populations. Therefore, AWGS recommends using 60 or 65 years as the age for sarcopenia diagnosis according to the definitions of elderly in each country. Although muscle aging is a continuous process, most previous studies supported the idea that loss of muscle mass and muscle strength becomes pronounced around the age of 50,[36] progresses faster after the age of 60,[37] and accelerates even faster after the age of 75.[38] The overall benefits of sarcopenia screening or assessment programs are dependent on the outcomes of effective intervention programs. AWGS emphasizes the benefits of intervention programs in addition to sarcopenia screening and assessment; therefore, we recommend screening for sarcopenia among community-dwelling older people as well as older people with certain clinical conditions in all healthcare settings. Table 1 summarized the recommended strategy for sarcopenia screening and assessment of AWGS by dividing cases into 2 categories (ie, community settings and specific chronic conditions in all healthcare settings). From the perspective of public health, sarcopenia screening for community-dwelling older people would facilitate health promotion and disability prevention in their communities, and the assessment of sarcopenia in clinical settings would facilitate strategies for the intervention in clinical practice. AWGS would like to emphasize the prognostic significance of sarcopenia in clinical practice through assessment under certain clinical conditions. However, the benefits of identification of and interventions for sarcopenia remain to be determined.

Table 1
Strategy of Sarcopenia Screening and Assessment for Older People (60 or 65 Years of Age and Older) in Asia

Community Settings
People aged 60 or 65 years and older (according to the definitions of elderly in each individual country) living in communities
Specific Clinical Conditions in All Healthcare Settings
Presence of recent functional decline or functional impairment
Unintentional body weight loss for over 5% in a month
Depressive mood or cognitive impairment
Repeated falls
Undernutrition
Chronic conditions (eg, chronic heart failure, chronic obstructive pulmonary disease, diabetes mellitus, chronic kidney disease, connective tissue disease, tuberculosis infection, and other chronic wasting conditions)

Suggested Outcome Indicators in Sarcopenia Research

The EWGSOP definition suggests using physical performance, muscle strength, and muscle mass as the primary treatment outcome indicators for sarcopenia intervention trials, whereas activities of daily living, quality of life, metabolic and biochemical markers, inflammatory markers, global impression of change by subject or physician, falls, admission to nursing home or hospital, social support, and mortality as secondary outcome indicators.[33] While most epidemiologic studies in sarcopenia research to date have taken a static approach, the state of sarcopenia may change over time and this dynamic approach may provide different considerations in developing sarcopenia intervention programs. Therefore, AWGS also recommends a dynamic approach for sarcopenia research by measuring changes in (1) muscle mass, strength, and function, (2) physical performance, (3) frailty status, (4) instrumental activities of daily living, and (5) basic activities of daily living over a given period of time as outcome indicators for sarcopenia research. In addition to the above-mentioned outcome indicators, AWGS also recommends using fear of falling and incontinence as outcome indicators for sarcopenia research (Table 2).

Assessment Techniques and Suggested Cutoff Values

Assessment of sarcopenia in Asian populations presents a great challenge because of the lack of outcome-based studies. However, determining appropriate cutoff values for sarcopenia diagnosis in Asia is critical to promote further sarcopenia research and treatment in Asia. Consequently, AWGS focused on the best available evidence to determine cutoff values for the diagnosis of sarcopenia in Asia. If, however, no outcome-based data are available, AWGS would recommend standardized approaches for cutoff value determination.

Table 2
Outcome Indicators for Sarcopenia Research Recommended by AWGS

Static Approach
Activities of daily living
Quality of life
Inflammatory markers
Falls
Frailty status
Mobility disorders
Admission to hospitals
Admission to long term care facilities
Mortality
Dynamic Approach
Changes in muscle mass
Changes in muscle strength
Changes in physical performance
Changes in frailty status
Changes in instrumental activities of daily living
Changes in activities of daily living

AWGS, Asian Working Group for Sarcopenia.

Muscle Mass

EWGSOP recommends DXA, computed tomography (CT), magnetic resonance imaging (MRI), and bioimpedance analysis (BIA) for sarcopenia research. Currently, the precision of DXA, CT, and MRI has been well recognized, but the precision of BIA in measuring muscle mass is controversial. BIA was developed to estimate the volume of body fat and lean body mass, but not appendicular muscle mass. Although the accuracy of BIA in sarcopenia diagnosis has been validated,[39–41] it is heavily dependent on the accuracy of the equation of the equipment and the conditions of assessments, eg, temperature, humidity, skin condition, etc.[42] Nevertheless, the high cost, CT-generated radiation exposure, and inconvenience for community screening have limited the applications of CT and MRI despite both CT and MRI have both been considered gold standards for evaluation of body composition. On the other hand, DXA is also considered an appropriate alternative approach to distinguish between fat, bone mineral, and lean tissues. Currently, DXA may be the most widely used method for muscle mass measurement in sarcopenia research. Despite the minimal radiation exposure from DXA, using DXA in community screening of sarcopenia is still difficult. Newly developed models of BIA equipment may obtain measurements of appendicular muscle mass with precision.[43,44] Portability, reasonable cost, fast processing, noninvasiveness, radiation-free functions, and convenience of use made BIA suitable for community sarcopenia assessment. Results of multiple segment fat-free mass estimation using BIA are highly associated with that measured using DXA among elderly Taiwanese.[45] Although using BIA equipment with validated equations is recommended for sarcopenia research in EWGSOP criteria, the equations of BIA equipment in Western countries are not derived from Asian populations. Strasser et al[46] proposed measurement of muscle thickness, especially of musculus vastus medialis, by musculoskeletal ultrasound to be a reliable method for the estimation of sarcopenia, which deserves further research for applications in Asian studies. In current Asian studies, the most commonly used BIA machines were manufactured by only 2 companies, and the results were quite consistent. Because of its portability and reasonable cost, BIA may be considered the main approach in sarcopenia assessment in community-based screening programs. Therefore, AWGS supports using BIA for sarcopenia diagnosis and evaluation of the effect of intervention programs, but AWGS suggests researchers to provide coefficient of variance, inter- and intra-examiner reliability whenever possible to facilitate subsequent international comparisons.

In terms of cutoff value determination, most current Asian studies have adopted the classical approach for muscle mass measurement (ie, below 2 standard deviations of the mean muscle mass of young adults). However, Asian studies reported an extremely low prevalence of sarcopenia through this approach, especially in older women.[26,47,48] Lau et al[26] also found that the relative total skeletal muscle of Hong Kong Chinese (total skeletal muscle /height^2) was 17% lower among young Chinese men than that of Caucasian men.[26] A potential cohort effect may exist in this approach since younger people in Asia today leading a westernized or more urbanized lifestyle while older Asian people have carried out a traditional lifestyle since adulthood. This cohort effect may be derived from the economic development, urbanization, and development of public transportation in Asia in recent decades. Older Asian people today may have walked and performed more physical activities because of the underdevelopment of public transportation and living conditions since their early adulthood, so their muscle mass may be maintained better than that of the younger generation. On the other hand, because of the relatively higher adiposity of Asian people in comparison with Caucasians, appendicular muscle mass may be overestimated by DXA. Overall, AWGS recommends using 2 standard deviations below the mean muscle mass of young reference group or the lower quintile as the cutoff value determination. Moreover, AWGS recommends using height-adjusted skeletal muscle mass instead of weight-adjusted skeletal muscle mass, and the suggested cutoff values were 7.0 kg/m^2 in men and 5.4 kg/m^2 in women by using DXA. By using BIA, the suggested cutoff values were 7.0 kg/m^2 in men and 5.7 kg/m^2 in women, defined by appendicular skeletal muscle mass/height^2.

Muscle Strength

Measuring handgrip strength is considered a feasible and convenient measure of muscle strength because of cost, availability, ease of use, and its association with leg strength. Wu et al[49] presented the norm of handgrip strength in Taiwan, which disclosed that the mean grip strength of the study sample in Taiwan was significantly lower (male 25%, female 27%) than consolidated norms derived from largely Caucasian populations. Although some papers published in Taiwan using this adjusted cutoff value based on EWGSOP definition for sarcopenia research,[50] some unpublished papers from Japan, Hong Kong, and China recommended using 25 kg for men and 18 or 16 kg for women as the cutoff values for handgrip strength. Currently, handgrip strength is the most widely used measure for muscle strength in Asian sarcopenia research (Table 3), and AWGS also recommends using it for the measurement of muscle strength. Although knee flexion/extension and peak expiratory flow are also recommended for sarcopenia research in EWGSOP criteria, they are less commonly used. In Thailand, the cutoff points of quadriceps strength had been defined based on the outcome of mobility decline. The cutoff points of <18 kg in men and <16 kg in women can discriminate those had normal and abnormal various sarcopenia-related variables. Because of the lack of outcome-based cutoff values, AWGS recommends using the lower 20th percentile of handgrip strength of the study population as the cutoff value for low muscle strength before outcome-based data is available. Low handgrip strength is suggested to be defined as <26 kg for men and <18kg for women by AWGS.

Physical Performance

A wide range of tests for physical performance are recommended in EWGSOP criteria, including the Short Physical Performance Battery (SPPB), usual gait speed, the 6-minute walk test, the stair climb power test, and the timed-up-and-go test (TUG).[51] Timed usual gait is highly predictive for the onset of disability,[52] and other adverse health

Table 3
Measurable Variables and Cutoff Points in Asian Populations

Criterion	Measurement Method	Cutoff Points by Sex	Reference Group Definition	Prevalence of Sarcopenia	Country/ Ethnicity	Reference
Muscle mass	DXA	ASM/height^2 Class 1 and class 2 sarcopenia Men: 7.77 and 6.87 kg/m^2 Women: 6.12 and 5.46 kg/m^2	Based on values 1 and 2 SD below the sex-specific means of the study reference data (n = 529)	Class 1 and class 2 sarcopenia in subjects 70–85 years of age: Men: 6.7%, 56.7% Women: 6.3%, 33.6%	Japan	69
		ASM/height^2 Men <5.72 kg/m^2 Women <4.82 kg/m^2	Based on 2 SD below the mean of young Asians in study (n = 111)	In older Chinese ≥70 years of age Men: 12.3% Women: 7.6%	Chinese	26
		ASM/height^2 Men: 7.40 kg/m^2 Women: 5.14 kg/m^2	Based on 2 SD below the sex-specific mean of a younger population (n = 145)	In older subjects ≥ 60 years of age Men: 6.3% Women: 4.1%	Korea	70
		SMI (%)[†] Men: 35.71% Women: 30.70%	Based on 2 SD below the sex-specific mean of a younger population (n = 145)	Men: 5.1% Women: 14.2%		
		Using the residuals method		Men: 15.4% Women: 22.3%		
		ASM/height^2 Class I and class II sarcopenia Men: 7.50 and 6.58 kg/m^2 Women: 5.38 and 4.59 kg/m^2	Based on 1 and 2 SD below the mean of young adults in study (n = 2513)	Class I and class II sarcopenia Men: 30.8% and 12.4% Women: 10.2% and 0.1%	Korea	48
		ASM/body weight (%) Class I and class II sarcopenia Men: 32.2% and 29.1% Women: 25.6% and 23.0%	Based on 1 and 2 SD below the mean of young adults in study	Men: 29.5% and 9.7% Women: 30.3% and 11.8%	Korea	48
		ASM/body weight (%)[‡] Men: 29.53% Women: 23.20%	Based on 2 SD of sex-specific young normal people		Korea	71
		Use SMI (% of skeletal muscle index) but not mentioned the cutoff points in the manuscript	Based on 2 SD of sex-specific young normal people	Sarcopenia class I, II, overall Men: 32.5%, 15.7%, 35.33 % Women: 30.5%, 10%, 34.74 %	Thailand	72
		RASM index Men: 7.27 kg/m^2 Women: 5.44 kg/m^2	Based on the lower 20% of study group	Men: 10.8% Women: 3.7%	Taiwan	47
		SMI (% of skeletal muscle index) Men: 37.4% Women: 28.0%	Based on the lower 20% of study group	Men: 14.9% Women: 19%		
	BIA	SMI Men <8.87 kg/m^2 Women <6.42 kg/m^2	Based on 2 SD below the normal sex-specific mean for young people	18.6% in elderly women and 23.6% in elderly men age 65 and older	Taiwan	10
		ASM/height^2 Men <7.0 kg/m^2 Women <5.8 kg/m^2	Based on 2 SD below young adult values	Men: 11.3% Women: 10.7% using EWGSOP criteria	Japan	13
		ASM/height^2 Women ≤ 6.42 kg/m^2		Women: 22.1%	Japan	6
		ASM/height^2 Men <6.75 kg/m^2 Women <5.07 kg/m^2	Based on 2 SD below young adult values	Men: 21.8% Women: 22.1% using EWGSOP criteria	Korea/Health ABC data	15
Muscle strength	Handgrip strength	Men: 30.3 kg Women: 19.3 kg	Based on lowest quartile of study group		Japan	13
		Men <22.4 kg Women <14.3 kg	Based on EWGSOP recommendation and adjusted according to Asian data[49]		Taiwan	50
	Knee extension	Women ≤1.01 Nm/kg			Japan	6,73
Physical performance	Gait speed	Gait speed Men <1.27 m/s Women <1.19 m/s	Based on the lowest quartile of study group, gait speed obtained from the middle 5 m of a total of 11 m walking	Men: 11.3% Women: 10.7% using EWGSOP criteria	Japan	13
		Gait speed ≤ 1 m/s			Taiwan	50
		Gait speed ≤ 1.22 m/s		Women: 22.1%	Japan	6,73
	SPPB	SPPB scores <9			Korea	74

ASM, appendicular skeletal muscle mass; BIA, bioimpedance analysis; DXA, dual x-ray absorptiometry; EWGSOP, European Working Group on Sarcopenia in Older People; Health ABC, The Health Aging and Body Composition Study; RASM, relative appendicular skeletal muscle; SD, standard deviation; SPPB, Short Physical Performance Battery; SMI, skeletal muscle mass index.

[†]SMI (%) = total skeletal muscle mass (kg)/weight (kg) × 100.

[‡]The author also named it modified skeletal muscle mass index (SMI).

events like severe mobility limitation and mortality.[53] TUG is an assessment of ambulation and dynamic balance. Poorer TUG has been demonstrated to be associated with poorer physical and mental function and mood status, as well as low fat-free mass by BIA measurements.[54] Although TUG has been proposed as a suitable measurement for physical performance in EWGSOP, abnormal TUG may result from a great variety of underlying conditions. AWGS is more conservative in the use of TUG as a measurement for physical

performance, and we recommend using 6-meter usual gait speed for measurement of physical performance.

Ideally, determination of the cutoff values of these measurements should be based on longitudinal outcome-based studies instead of a simply statistical approach.[55] Although the association between sarcopenia and functional decline or even mortality has been established,[56] selection of universal outcome indicators in subsequent research may facilitate international comparisons. Table 3 summarized the epidemiology and proposed cut-off points in different cases of Asian sarcopenia research. EWGSOP has developed a suggested algorithm based on gait speed measurement with a cutoff point of <0.8 m/s.[33] The association of slow usual gait speed in the elderly with adverse clinical outcomes has been reported extensively, but the application was also dependent on the determination of appropriate cutoff points. Meanwhile, the prevalence of low muscle mass in the Asian population as determined using the classical approach is very low, which is confusing. The potential cohort effect may partially explain the phenomenon of older people today engaging in more physical activities than younger people, which made the prevalence of sarcopenia lower than expected. Specific consideration of this potential cohort effect deserves further attention in the diagnosis of sarcopenia in Asia. Although there is a potential gender difference in the cutoff value of usual gait speed and a wide range of walking speed (from 0.6 to 1.2 m/s) being reported in this special issue, AWGS suggested using ≤0.8 m/s as the cutoff for low physical performance after extensive consideration of data available in Asian studies.

Therapeutic Implications

Physical activities, including aerobics, endurance exercise,[57] and resistance exercise training[58,59] have been demonstrated to significantly increase muscle mass and strength in sarcopenic older people. Although the recommended frequency of exercise training to improve muscle strength and functional performance has been shown,[60] a consensus has not yet been reached concerning the content of the prescribed exercise and the most optimal frequency and intensity. Inappropriate exercise training in the elderly may result in unfavorable adverse outcomes such as musculoskeletal complaints,[61] which is not uncommon. Further research should be focused on the development of suitable exercise prescription, especially for older people at risk of functional decline or sarcopenia. The Society for Sarcopenia, Cachexia, and Wasting Disease developed nutritional recommendations for the prevention and management of sarcopenia, which combined exercise with adequate protein and energy intake.[62] A leucine-enriched balanced essential amino acid or balanced amino acid supplementation is suggested for sarcopenia. Recently, Kim et al[6] demonstrated that exercise and amino acid supplementation (3 g of a leucine-rich essential amino acid mixture twice a day) together may actually be effective in enhancing muscle strength, variables of muscle mass, and walking speed in sarcopenic women. Aside from exercise and nutritional supplementation, the pharmaceutical approach to sarcopenia is still under development. Growth hormone replacement was not successful because the effect of increased muscle mass by growth hormone replacement was not associated with the improvement of muscle performance,[63–65] unless it is used for growth hormone deficiency patients for a period longer than 12 months.[66–68] In addition, the effects of antimyostatin antibodies on sarcopenia have been demonstrated and may be marketed in a few years. Therefore, sarcopenia should be treated through a multilevel approach employing combined physical activities and nutritional supplementation. Currently, there is no well-established evidence for pharmaceutical approach for sarcopenia intervention, but a few agents may be available in future.

Future Challenge and Conclusion

Sarcopenia significantly impacts daily activities, functional status, disability, and quality of life in older populations. Although Asian populations are rapidly ageing, from the clinical practice or public health points of view, the understanding of and preparation for sarcopenia remain inadequate. Hence, this consensus collected as many Asian studies as possible and offers a working diagnosis of sarcopenia for Asian people. The main aims of AWGS were to promote sarcopenia research in Asian countries through providing recommended diagnostic strategies and cutoff values based on Asian studies, and to foster the importance of implementing sarcopenia in clinical practice and in community health promotion programs.

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ORIGINAL ARTICLE

Prevalence of knee pain, lumbar pain and its coexistence in Japanese men and women: The Longitudinal Cohorts of Motor System Organ (LOCOMO) study

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Abstract The Longitudinal Cohorts of Motor System Organ (LOCOMO) study was initiated in 2008 through a grant from the Ministry of Health, Labour, and Welfare of Japan to integrate information from several cohorts established for the prevention of musculoskeletal diseases. We integrated the information of 12,019 participants (3,959 men and 8,060 women) in the cohorts comprising nine communities located in Tokyo (two regions: Tokyo-1 and Tokyo-2), Wakayama [two regions: Wakayama-1 (mountainous region) and Wakayama-2 (seaside region)], Hiroshima, Niigata, Mie, Akita, and Gunma prefectures. The baseline examination of the LOCOMO study consisted of an interviewer-administered questionnaire, anthropometric measurements, medical information recording, X-ray radiography, and bone mineral density measurement. The prevalence of knee pain was 32.7 % (men 27.9 %; women 35.1 %) and that of lumbar pain was 37.7 % (men 34.2 %; women 39.4 %). Among the 9,046 individuals who were surveyed on both knee pain and lumbar pain at the baseline examination in each cohort, we noted that the prevalence of both knee pain and lumbar pain was 12.2 % (men 10.9 %; women 12.8 %). Logistic regression analysis showed that higher age, female sex, higher body mass index (BMI), living in a rural area, and the presence of lumbar pain significantly influenced the presence of knee pain. Similarly, higher age, female sex, higher BMI, living in a rural area, and the presence of knee pain significantly influenced the presence of lumbar pain. Thus, by using the data of the

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LOCOMO study, we clarified the prevalence of knee pain and lumbar pain, their coexistence, and their associated factors.

Keywords Nation-wide population-based cohort study · Epidemiology · Prevalence · Knee pain · Lumbar pain

Introduction

Musculoskeletal diseases, including osteoarthritis (OA) and osteoporosis (OP), are major public health problems among the elderly; these diseases can affect activities of daily living (ADL) and quality of life (QOL), and can lead to increased morbidity and mortality. According to the recent National Livelihood Survey by the Ministry of Health, Labour, and Welfare in Japan, OA is ranked fourth among diseases that cause disabilities and subsequently require support for ADL, whereas falls and osteoporotic fractures are ranked fifth [1]. Studies have reported increased mortality after osteoporotic fractures at the hip and other sites [2]. An estimated 47,000,000 individuals (21,000,000 men and 26,000,000 women) aged ≥40 years will eventually be affected by either OA or OP [3].

Considering that the population of Japan is aging rapidly, a comprehensive and evidence-based prevention strategy for musculoskeletal diseases is urgently needed. However, only a few prospective, longitudinal studies designed to develop such a strategy have been conducted. Therefore, little information is available regarding the incidence of disability and the prevalence and incidence of musculoskeletal disorders, including knee pain, and lumbar pain, and their associated factors in Japan. The absence of such epidemiological data hampers the rational design of clinical and public health approaches for the diagnosis, evaluation, and prevention of musculoskeletal diseases.

Several cohorts have focused on the prevention of OP, knee OA (KOA), lumbar spondylosis (LS) or disability caused by musculoskeletal diseases. However, since the prevalence of the musculoskeletal diseases has been reported to be high [3], the extent of the population at risk after excluding those who had the target disease at the baseline seems to be small. To identify epidemiological indices, especially the incidence of musculoskeletal diseases and/or disability, a large number of subjects is required. In addition, to determine the regional differences in epidemiological indices, we need a survey of cohorts across Japan.

The Longitudinal Cohorts of Motor System Organ (LOCOMO) study was initiated in 2008 by the members of the committee for 'the prevention of knee and back pain and bone fractures in a large cohort of regionally representative residents from across Japan,' through a grant from the Ministry of Health, Labour, and Welfare of Japan (Director, Noriko Yoshimura). This study aimed to integrate the information of several cohorts established for the prevention of musculoskeletal diseases from 2000 onwards, and to initiate a follow-up examination using the unified questionnaire from 2006 onwards in Japan.

In the present paper, by using the integrated information at the baseline of the LOCOMO study, we tried to confirm the prevalence of clinical symptoms of musculoskeletal diseases, such as knee pain and lumbar pain and their characteristics.

Materials and methods

Participants

Participants in the cohorts were residents of nine communities located in Tokyo (two regions: Tokyo-1, principle investigators (PIs): Shigeyuki Muraki, Toru Akune, Noriko Yoshimura, Kozo Nakamura; Tokyo-2, PIs: Yoko Shimizu, Hideyo Yoshida, Takao Suzuki), Wakayama [two regions: Wakayama-1 (mountainous region) and Wakayama-2 (seaside region); PIs: Noriko Yoshimura, Munehito Yoshida], Hiroshima (PI: Saeko Fujiwara), Niigata (PI: Go Omori), Mie (PI: Akihiro Sudo), Akita (PI: Hideyo Yoshida), and Gunma (PI: Yuji Nishiwaki) prefectures [4]. Figure 1 shows the location of each cohort in Japan, and Fig. 2 provides the timeline of the LOCOMO study. Residents of the nine regions were recruited from resident registration lists in the relevant region. Data for the 12,019 participants were collected and registered as an integrated cohort. Numbers of participants in the LOCOMO study classified by regions of each cohort are shown in Table 1. The smallest cohort consisted of 826 individuals in Wakayama-2, and the largest consisted of 2,613 individuals in Hiroshima.

All participants provided written informed consent, and the study was conducted with the approval of the ethics committees of the University of Tokyo (nos. 1264 and 1326), the Tokyo Metropolitan Institute of Gerontology (no. 5), Wakayama (no. 373), The Radiation Effects Research Foundation (RP03-89), Niigata University (no. 446), Mie University (no. 837 and no. 139), Keio University (no. 16–20), and National Center for Geriatrics and Gerontology (no. 249). Safety of the participants was ensured during the examination and during all other study procedures.

Data collection

The baseline examination of the LOCOMO study consisted of the following: an interviewer-administered questionnaire,

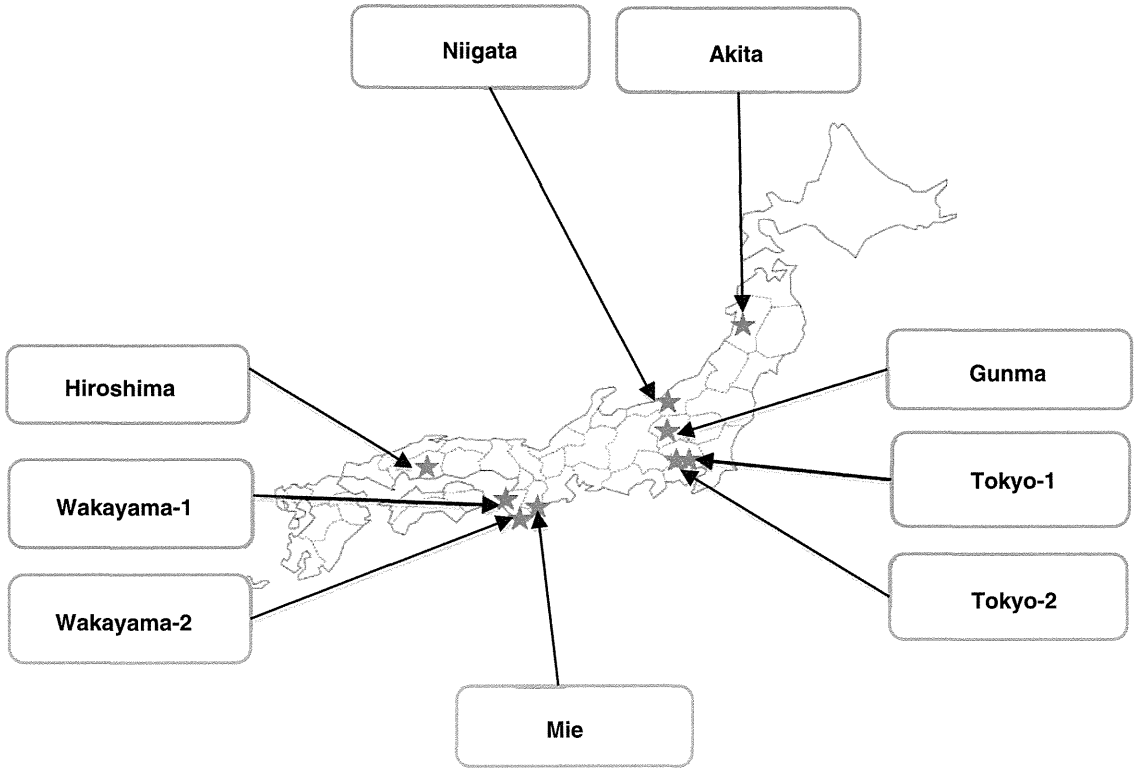

Fig. 1 Locations of the nine different regions from which the study cohorts were derived

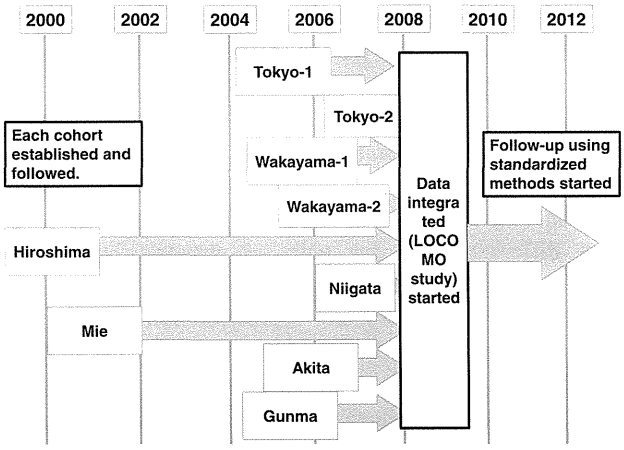

Fig. 2 Timeline of the LOCOMO study

Table 1 Numbers of participants in the LOCOMO study classified by regions of each cohort

Regions of each cohort	Start year	Total	Men	Women
Tokyo-1	2005	1,350	465	885
Tokyo-2	2008	1,453	59	1,394
Wakayama-1 (mountainous)	2005	864	319	545
Wakayama-2 (seaside)	2006	826	277	549
Hiroshima	2000	2,613	794	1,819
Niigata	2007	1,474	628	846
Mie	2001	1,175	423	752
Akita	2006	852	366	486
Gunma	2005	1,412	628	784
Total		12,019	3,959	8,060

anthropometric measurements, medical information recording, radiography, and bone mineral density (BMD) measurement.

Interviewer-administered questionnaire

A questionnaire was prepared by modifying the questionnaire used in the Osteoporotic Fractures in Men Study (MrOS) [5], and some new items were added to the modified questionnaire. Knee symptoms were evaluated using the Western Ontario and McMaster University Osteoarthritis Index (WOMAC) [6]. Health-related QOL was evaluated using the European QOL-5 dimensions instrument (EuroQOL EQ5D) [7] and the Medical Outcomes Study 8-item Short Form (SF-8) [8]. The study staff recorded all the medications administered and their doses.

Anthropometric measurements

Anthropometric factors were measured by well-trained medical nurses. Body mass index [BMI; weight in