노인당뇨병에서의 Sarcopenia

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자료: 통계청
Projections of Diabetes Burden Through 2050

Sarcopenia

• Age related loss of muscle mass
  – “Sarco” = Muscle, “-penia” = reduced
  – Is distinguished from:
    • Cachexia
    • Wasting
    • Muscle Disease

• Direct consequences
  – Lower strength
  – Lower resting metabolic rate
  – Lower volume of distribution for drugs
In general,

- Loss of muscle mass
- Loss of muscle strength
- Loss of physical function
- Loss of mobility
- Loss of independence
- Institutionalization

Frailty

- Low muscle mass
- Low muscle strength
- High risk of disability
- High risk of death
노화에 따른 생리적 기능 감퇴

노화자체의 영향

환경적인 영향

손상 (from disuse & abuse)

임상전단계 (Subclinical diseases)

각종 질병 (Disease Processes)

Frailty (노쇠)

기능 저하 (Functional Decline)

회복가능

스트레스

장애

입원

요양시설 입소

사망

Fig. The Frailty Cascade
노쇠(老衰, Frailty)

- 동의어: 연약(軟弱), 허약(虛弱)
- Frailty: frailness, infirmity, weakness, liableness, imperfection, failing, vulnerability…
- 물건으로 비교하면 깨지기 쉬운 상태

- 노쇠(Frailty)란 노화와 연관되어 나타나는 연약하고 스트레스에 취약한 상태로 쉽게 장애 및 사망에 이룰 수 있다.
노쇠의 유병률 (춘천지역)

Unpublished data (2009 추계노인병학회)
Working Definition of Frailty

- Weight loss: > 5% in previous year
- Poor endurance: exhaustion, self report
- Low activity: Kcal/wk, lowest 20%
- Weakness: grip strength, lowest 20%
- Slowness: walking speed, lowest 20%

- Frailty: ≥ 3 criteria present
- Prefrail: 1 or 2 criteria present

Linda P. Fried, 2001
Relative Risk of Poor Health Outcomes

<table>
<thead>
<tr>
<th>Frailty Level</th>
<th>Fall</th>
<th>Mobility Limitation</th>
<th>ADL Disability</th>
<th>Hospitalization</th>
</tr>
</thead>
<tbody>
<tr>
<td>No frail</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Prefrail</td>
<td>1.5</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Frailty</td>
<td>5</td>
<td>3</td>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>

J Gerontology (2001; 56A:M146-156)
Frailty and Mortality

J Gerontology (2001; 56A:M146-156)
Place of Sarcopenia in the Cycle of Frailty
Causes of sarcopenia in aging

- **Loss of neuromuscular function** (loss of α-motor neuron)
- **Alterations in the endocrine milieu**
  (decrease in anabolic hormones: Insulin, GH, IGF-1, E2, Testosterone, and increased catabolic hormones: cortisol, Vitamin D and PTH)
- **Proinflammatory cytokines** (IL-6, TNF-α)
- **Change in protein metabolism** (negative muscle protein turnover)
- **Nutritional deficiency** (protein malnutrition, RDA for protein ↑)
- **Insulin resistance** (impaired muscle protein synthesis)
- **Free radicals, alterations in mitochondrial function**
- **Genetics / altered gene expression**
- **Apoptosis**
Underlying facts for hypothesis development

With aging,

1) we lost muscle mass and strength.

2) insulin sensitivity decreases, worsening of glucose tolerance, increasing prevalence of diabetes

Impaired insulin action in diabetes (especially when poorly controlled status) is associated with negative nitrogen balance; muscle breakdown and loss of lean mass.

Older subjects with diabetes,

→ More accelerated loss of lean mass and strength?
Changes in muscle mass and strength with aging

Sarcopenia, loss of muscle mass
 poorer muscle quality

Loss of muscle strength

Deterioration of glucose metabolism, diabetes mellitus

Functional limitations, disability
Hypothesis:

Diabetes mellitus would show detrimental impact on muscle mass and strength in older adults.
내장지방/골격근 증후군의 개념

내장 지방 증가

1. Overnutrition
2. Imbalance of sex hormone
3. Lack of exercise

Visceral Fat ↑
- High lipolytic activity
- Portal FFA ↑
- Hepatic TG synthesis
- Hyperlipidemia

Insulin Resistance
- Hypertension

VMR ↑

Skeletal Muscle ↓
- Glucose utilization ↓
- \(\beta\)-cell dysfunction
- Glucose intolerance

Aging

Health ABC Study

- 3075 men and women, aged 70-79 at baseline
- No disability or functional limitation at baseline.
- Annual examinations for weight, body composition, muscle strength, and health outcomes

<table>
<thead>
<tr>
<th>Year</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
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<td>X</td>
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<td>X</td>
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<tr>
<td>HbA1c</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>DXA, whole body</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>CT, abdomen, thigh</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Muscle strength</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
Leg Strength by Age (Health ABC Study)

Research questions

• Does the metabolic derangements in diabetes affect muscle mass, strength, or muscle quality?

• If yes, is there a cumulative effect by the duration of diabetes and by severity (level of glycemic control)?
Cross-sectional study

Muscle Strength, Mass, and Quality in Men

<table>
<thead>
<tr>
<th></th>
<th>No Diabetes (n, 1004)</th>
<th>Diabetes (n, 273)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leg strength (Nm)</td>
<td>133.0 ± 32.4</td>
<td>128.5 ± 34.6</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Leg lean mass (kg)</td>
<td>8.7 ± 1.3</td>
<td>9.1 ± 1.4</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Leg muscle quality (Nm/kg)</td>
<td>15.3 ± 3.2</td>
<td>14.2 ± 3.3</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Grip Strength (kg)</td>
<td>40.0 ± 8.9</td>
<td>38.7 ± 8.8</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Arm lean mass (kg)</td>
<td>3.4 ± 0.6</td>
<td>3.6 ± 0.6</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Arm muscle quality (kg/kg)</td>
<td>11.7 ± 2.4</td>
<td>10.8 ± 2.3</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>BMI</td>
<td>26.7</td>
<td>28.3</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

# Muscle Strength, Mass, and Quality in Women

<table>
<thead>
<tr>
<th></th>
<th>No Diabetes (n, 1129)</th>
<th>Diabetes (n, 212)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Leg strength (Nm)</strong></td>
<td>81.1 ± 22.0</td>
<td>83.8 ± 21.4</td>
<td>0.096</td>
</tr>
<tr>
<td><strong>Leg lean mass (kg)</strong></td>
<td>6.3 ± 1.2</td>
<td>7.0 ± 1.2</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>Leg muscle quality (Nm/kg)</strong></td>
<td>13.0 ± 3.1</td>
<td>12.2 ± 3.2</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>Grip Strength (kg)</strong></td>
<td>24.4 ± 6.4</td>
<td>25.1 ± 5.9</td>
<td>0.098</td>
</tr>
<tr>
<td><strong>Arm lean mass (kg)</strong></td>
<td>2.1 ± 0.4</td>
<td>2.3 ± 0.4</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>Arm muscle quality (kg/kg)</strong></td>
<td>12.0 ± 2.9</td>
<td>11.0 ± 2.9</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>BMI</strong></td>
<td>27.1</td>
<td>30.2</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Muscle Quality by duration of diabetes

- **Leg muscle quality (Nm/kg)**
  - **Men**
    - No diabetes, duration ≤ 6 yrs: *<0.001*
    - duration > 6 yrs: 0.001
  - **Women**
    - No diabetes, duration ≤ 6 yrs: *<0.001*
    - duration > 6 yrs: 0.001

- **Arm muscle quality (kg/kg)**
  - **Men**
    - No diabetes, duration ≤ 6 yrs: *<0.001*
    - duration > 6 yrs: 0.001
  - **Women**
    - No diabetes, duration ≤ 6 yrs: *<0.001*
    - duration > 6 yrs: 0.001

*P: p value for linearity,*

* * p <0.05 compared to subjects without diabetes,*

† * p <0.05 compared to duration ≤ 6 yrs.

Muscle Quality by Glycemic Control (HbA$_1$c)

- **Leg muscle quality (Nm/kg)**
  - Men: *†
  - Women: *†

- **Arm muscle quality (kg/kg)**
  - Men: *
  - Women: *

No diabetes, HbA1c ≤ 8.0 %, HbA1c > 8.0 %,
P: p value for linearity,
* p <0.05 compared to subjects without diabetes,
† p <0.05 compared to HbA1c ≤ 8.0 %.

Results from cross-sectional study

• Absolute muscle strength was *surprisingly* lower in men with diabetes than non-diabetic men.

• Muscle quality (strength/mass) was decreased in both men and women with diabetes.

• Longer duration and poor glycemic control (HbA1c level) were associated with even lower muscle quality *suggesting causal relationship*. 
Is this association causal?

1. Temporal relationship (never tested before)
2. Strength of association (relatively weak)
3. Dose-response relationship (yes)
4. Replication of findings (the first)
5. Biologic plausibility (yes)
6. Consideration of alternative explanations (?)
7. Cessation of exposure (almost impossible)
8. .....
Longitudinal study

3 year follow-up examination of muscle mass and strength
Percent loss of leg strength and leg lean mass

* Annualized rates of lean mass decline =~ 1%

J Gerontology 61(10): 91-96, 2006
Figure 1. Mean (± SE) relative 3-yr changes in skeletal muscle strength, mass, and muscle quality in older adults with type 2 diabetes (■) and without diabetes (□). NS, not significant, * P < 0.05, ** P < 0.01

Adjustments

Model 1: age, sex, race, and clinic site
Model 2: + BMI, baseline strength/quality, changes in muscle mass
Model 3: + CHD, stroke, CHF, PAD, knee OA, cancer, depression, impaired vision, renal insufficiency, subclinical PAD (ankle arm index <0.9)
Model 4: + interleukin-6, tumor necrosis factor-α
Table. Adjusted 3-year changes in knee extensor strength and muscle quality by diabetes status in the Health ABC Study

<table>
<thead>
<tr>
<th></th>
<th>Without diabetes n, 1535</th>
<th>With diabetes n, 305</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Muscle strength (Nm)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model 1</td>
<td>-12.4 ± 0.5</td>
<td>-16.5 ± 1.2</td>
<td>0.001</td>
</tr>
<tr>
<td>Model 2</td>
<td>-12.5 ± 0.5</td>
<td>-16.2 ± 1.1</td>
<td>0.001</td>
</tr>
<tr>
<td>Model 3</td>
<td>-12.5 ± 0.5</td>
<td>-15.8 ± 1.1</td>
<td>0.008</td>
</tr>
<tr>
<td>Model 4</td>
<td>-12.7 ± 0.5</td>
<td>-15.6 ± 1.2</td>
<td>0.027</td>
</tr>
<tr>
<td><strong>Muscle quality (Nm/kg)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model 1</td>
<td>-1.22 ± 0.07</td>
<td>-1.57 ± 0.15</td>
<td>0.034</td>
</tr>
<tr>
<td>Model 2</td>
<td>-1.20 ± 0.06</td>
<td>-1.69 ± 0.14</td>
<td>0.001</td>
</tr>
<tr>
<td>Model 3</td>
<td>-1.21 ± 0.06</td>
<td>-1.64 ± 0.14</td>
<td>0.006</td>
</tr>
<tr>
<td>Model 4</td>
<td>-1.24 ± 0.06</td>
<td>-1.63 ± 0.15</td>
<td>0.019</td>
</tr>
</tbody>
</table>

Data are adjusted means ± standard error
Model 1: adjusted for sex, race, age, and clinic site
Model 2: additionally adjusted for body mass index, baseline strength or quality, and changes in leg lean mass
Model 3: additionally adjusted for coronary heart disease, stroke, congestive heart failure, peripheral artery disease, knee osteoarthritis, cancer, depression, impaired vision, renal insufficiency, and subclinical PAD (AAI <0.9)
Model 4: additionally adjusted for cytokines (log transformed IL-6 and TNF-α)

Summary of follow-up study

• Older adults with diabetes showed rapid loss of leg strength compared to those without diabetes.

• Loss of muscle mass, comorbid conditions, and cytokines (IL-6, TNF-α) explained only a small part of rapid declines of leg muscle strength in older adults with diabetes.

• Changes in muscle quality may play an important role on strength decline in diabetes.
Current Concepts

Nutritional, Hormonal, Metabolic, Immunologic Factors

↓ Muscle mass

↓ Strength

Weakness

Disability, Morbidity, Mortality

Alternative Hypothesis

↓ Muscle function

Decreased activity and immobility

Secondary atrophy

↓ Muscle mass

SW Park, 02/17/04
Replication of findings through extended (6 years) follow-up examinations in different ethnic group (Koreans)
# Measurements of body composition in the Health ABC Study

<table>
<thead>
<tr>
<th></th>
<th>Yr 1</th>
<th>Yr 2</th>
<th>Yr 3</th>
<th>Yr 4</th>
<th>Yr 5</th>
<th>Yr 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height, Weight</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>DXA, whole body</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>CT, Mid-thigh</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

- Y1 and at least one more follow-up measurements \( n=2,675 \)
- Y1 and Y6 measurements \( n=1,629 \)
Definition of diabetes (DM)

- **Diagnosed DM**
  - n=402, (15.0%)
  - self report of physician diagnosed diabetes
  - or, use of insulin or oral hypoglycemic agents

- **Undiagnosed DM**
  - n=226, (8.5%)
  - fasting plasma glucose $\geq 126$ mg/dl
  - or, 2hr after 75g OGGT $\geq 200$ mg/dl
Statistics

- Longitudinal analyses for repeated measures (up to 6 measurements).

- **Generalized estimating equations (GEE)** adjusting for age, sex, race, clinic site, baseline body composition and weight loss intention.

- GEE models: additional adjustment for changes in body weight.

- Linear models to compare changes in thigh composition.
<table>
<thead>
<tr>
<th>Baseline characteristics of participants</th>
<th>Without DM (n, 2047)</th>
<th>Diagnosed DM (n, 402)</th>
<th>Undiagnosed DM (n, 226)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age (years)</strong></td>
<td>73.6 ± 2.9</td>
<td>73.6 ± 2.7</td>
<td>73.7 ± 2.8</td>
<td>NS</td>
</tr>
<tr>
<td><strong>Men (%)</strong></td>
<td>47.6</td>
<td>55.5</td>
<td>55.8</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>Black (%)</strong></td>
<td>36.7</td>
<td>57.7</td>
<td>42.0</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>BMI (kg/m²)</strong></td>
<td>26.8</td>
<td>29.1</td>
<td>28.5</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>Total body mass (kg)</strong></td>
<td>74.2</td>
<td>81.2</td>
<td>79.9</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>Total lean mass (kg)</strong></td>
<td>45.9</td>
<td>50.4</td>
<td>49.1</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>Trunk lean (kg)</strong></td>
<td>23.1</td>
<td>25.3</td>
<td>24.8</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>Appendicular lean (kg)</strong></td>
<td>19.8</td>
<td>21.9</td>
<td>21.1</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>Total fat mass (kg)</strong></td>
<td>26.0</td>
<td>28.5</td>
<td>28.4</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>Trunk fat (kg)</strong></td>
<td>12.9</td>
<td>15.0</td>
<td>14.9</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>Appendicular fat (kg)</strong></td>
<td>12.6</td>
<td>12.8</td>
<td>13.0</td>
<td>NS</td>
</tr>
</tbody>
</table>

NS: Not significant

Changes in total body mass (body weight)

<table>
<thead>
<tr>
<th>Year</th>
<th>Diagnosed DM</th>
<th>Undiagnosed DM</th>
<th>Non-DM</th>
<th>% of baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>79%</td>
<td>79%</td>
<td>76%</td>
<td>100%</td>
</tr>
<tr>
<td>2</td>
<td>78%</td>
<td>79%</td>
<td>77%</td>
<td>99%</td>
</tr>
<tr>
<td>3</td>
<td>77%</td>
<td>79%</td>
<td>78%</td>
<td>98%</td>
</tr>
<tr>
<td>4</td>
<td>76%</td>
<td>79%</td>
<td>79%</td>
<td>97%</td>
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<tr>
<td>5</td>
<td>75%</td>
<td>79%</td>
<td>80%</td>
<td>*</td>
</tr>
<tr>
<td>6</td>
<td>74%</td>
<td>79%</td>
<td>81%</td>
<td>*</td>
</tr>
</tbody>
</table>

* * p<0.05 vs non-DM, adjusted for age, gender, race, and clinic site
## Annual changes in body composition

<table>
<thead>
<tr>
<th></th>
<th>Non-DM</th>
<th>Diagnosed DM</th>
<th>Undiagnosed DM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total body mass (g/yr)</td>
<td>-189 (23)</td>
<td>-279 (72)</td>
<td>-441 (80)**</td>
</tr>
<tr>
<td>Total lean mass (g/yr)</td>
<td>-196 (10)</td>
<td>-216 (29)</td>
<td>-340 (37)**</td>
</tr>
<tr>
<td>Appendicular lean (g/yr)</td>
<td>-149 (5)</td>
<td>-184 (16)*</td>
<td>-225 (20)**</td>
</tr>
<tr>
<td>Trunk lean (g/yr)</td>
<td>-42 (6)</td>
<td>-27 (16)</td>
<td>-105 (22)**</td>
</tr>
<tr>
<td>Total fat mass (g/yr)</td>
<td>27 (16)</td>
<td>-61 (53)</td>
<td>-93 (53)*</td>
</tr>
<tr>
<td>Appendicular fat (g/yr)</td>
<td>-15 (7)</td>
<td>-27 (24)</td>
<td>-49 (24)</td>
</tr>
<tr>
<td>Trunk fat (g/yr)</td>
<td>46 (10)</td>
<td>-32 (32)*</td>
<td>-41 (35)*</td>
</tr>
</tbody>
</table>

β-coefficients (SE) estimated by GEE model adjusting for age, sex, race, clinic site, baseline body composition, and weight loss intention.

* p < 0.05, ** p < 0.01 vs Non-DM

Annual changes in lean body mass (g/yr)

No DM | Known DM | New DM

<table>
<thead>
<tr>
<th>Total mass</th>
<th>Lean mass</th>
<th>Appendicular</th>
<th>Trunk</th>
</tr>
</thead>
<tbody>
<tr>
<td>-100</td>
<td>-200</td>
<td>-300</td>
<td>-500</td>
</tr>
<tr>
<td>-200</td>
<td>-300</td>
<td>-400</td>
<td></td>
</tr>
<tr>
<td>-300</td>
<td>-400</td>
<td>-500</td>
<td></td>
</tr>
<tr>
<td>-400</td>
<td>-500</td>
<td></td>
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<tr>
<td>-500</td>
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</tbody>
</table>
Loss of appendicular lean mass after adjusting for weight changes

<table>
<thead>
<tr>
<th></th>
<th>Non-DM</th>
<th>Diagnosed DM</th>
<th>Undiagnosed DM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total lean mass (g/yr)</td>
<td>-125 (7)</td>
<td>-106 (20)</td>
<td>-186 (25)*</td>
</tr>
<tr>
<td>Appendicular lean (g/yr)</td>
<td>-113 (4)</td>
<td>-130 (11)</td>
<td>-149 (14)*</td>
</tr>
</tbody>
</table>

$\beta$-coefficients (SE) estimated by GEE adjusting for age, sex, race, clinic site, baseline body composition, weight loss intention, and changes in body weight.

* $p < 0.05$ vs Non-DM

Relative changes in thigh muscle area over 5 years

Men                      Women

ND M

No DM
Diagnosed DM
Undiagnosed DM

% of baseline

0

-1

-2

-3

-4

-5

-6

P=0.012

P=0.008

Linear models adjusted for age, race, clinic site, and body weight changes.
There is a significant sex and diabetes status interaction (P < 0.05).

Summary

- In this older cohort, both diagnosed and undiagnosed DM were associated with *accelerated loss of appendicular lean mass*.

- Those with *undiagnosed DM* were particularly at high risk for loss of appendicular lean mass, *independent of weight loss*.

- In older women, both diagnosed and undiagnosed DM were associated with about two fold excess loss of thigh muscle area after adjustment for weight change.
Diabetes and Muscle Mass (in Koreans)

- Older Adults aged above 65 years old
- Diabetic patients (n, 128)
  - Patients who visited diabetes clinic at Bundang CHA hospital
- Older adults without diabetes (n, 241)
  - Subjects who underwent routine medical check-up at Bundang CHA hospital

Data showed decreased appendicular skeletal muscle mass (ASM) and ASM/height$^2$ in older men with diabetes (gender difference).

Lee, et al. (KDA2009-Oral)
Prevalence of Sarcopenia by diabetes status

<table>
<thead>
<tr>
<th></th>
<th>Men</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No diabetes</td>
<td>Diabetes</td>
</tr>
<tr>
<td>ASM/h²</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>42 %</td>
<td>67.9 %</td>
</tr>
<tr>
<td>SMI(%)</td>
<td>34.9 %</td>
<td>67.9 %</td>
</tr>
</tbody>
</table>

ASM/h²: appendicular skeletal muscle mass divided by height square,
SMI(skeletal muscle mass index): calculated by total skeletal muscle mass X 100

Lee, et al. (KDA2009-Oral)
Unifying hypothesis explaining the association of diabetes and physical disability in older adults

Diabetes Mellitus

- Uncontrolled hyperglycemia
  - Insulin deficiency
  - Catabolic milieu
  - Inflammatory cytokines

- Peripheral neuropathy
  - Axonal loss
  - Incomplete reinnervation

- Combined Obesity
  - Higher fat mass
  - Increased burden

- Loss of muscle mass
  - Changes in muscle composition

- Loss of muscle strength

- Physical limitations

Disability

SW Park, 06/15/06
Future directions

• Find factors related with loss of muscle in diabetes (eg, glycemic control, neuropathy, etc)

• Clinical outcomes of sarcopenia in diabetes

• How to prevent rapid loss of muscle mass/function in diabetes.

• Include muscle phenotypes in clinical trials in diabetic subjects.

Application to Public Health

- Three epidemiological trends in our modern society: aging of the population, epidemics of obesity and diabetes

- Be aware that older adults with diabetes are at high risk for loss of lean mass, muscle strength and quality thus, sarcopenic.

- These changes may give rise to physical disability and high mortality in older adults with diabetes.

- Should recommend adequate diet rich in protein and regular resistance exercise.
Acknowledgement

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- Tamara Harris, MD. NIA, NIH
- Study participants