Main Symposium 7: “Diabetes and exercise”

Diabetes and exercise: from clinical view point

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Diabetes is a world pandemic, especially in Asia

2000 to 2030

World Diabetes Day

(Tokyo Tower: Nov. 14, 2007)
Diabetes Mellitus

1. Type 1 (IDDM)
   insulin deficiency

2. Type 2 (NIDDM)
   decreased insulin secretion
   insulin resistance
Pathogenesis of Type 2 Diabetes

Genetic Factors

Environmental Factors

- Obesity
- Overeating (High Fat Diet)
- Sedentary Life
- Stressor (Aging)

Genetic Resistance

- Insulin Resistance
- Decreased Insulin Secretion
- Decreased Insulin Action

Glucose Toxicity

- Hyperglycemia

Type 2 Diabetes

(Iwamoto Y, 2000)
Effects of exercise

1. Immediate effects of exercise include increased utilization of glucose and fatty acids and lowered blood glucose.
2. One of the most important long-term effects of exercise is the improvement of insulin resistance.
3. Improved balance between energy intake and expenditure is effective for the reduction of body weight.
4. Muscular atrophy and osteoporosis caused by aging and sedentariness can be prevented.
5. Exercise can improve hypertension and hyperlipidemia.
6. Cardiopulmonary function is enhanced.
7. Exercise capacity increases.
8. Improvement in the QOL is accompanied by a feelings of exhilaration and increased energy.

(Treatment Guide for Diabetes, 2009)
Changes in glycerol concentrations in the blood, mesenteric adipose tissue, and abdominal subcutaneous adipose tissue during the microdialysis study

(Iwao N, Oshida Y, Sato Y, 1997)
Arterial glucose concentration and leg uptake of glucose at rest and during exercise

(Wahren J: Diabetologia, 1978)
Comparison of GIR (insulin sensitivity index) (mg/kg/min)

- Athletes
- Controls
- Obese diabetics
- Simple obesity

White Fat Cell Acts as an Endocrine Cell

Immunoactivating Factors
- Adipsin (factor D)
- C3
- B
- PAI-1 (Thrombus formation)

Cholesterol Ester Transporting Protein

Leptin (Obese Gene Product)

apM1 (Adiponectin)

Lipoprotein Lipase (LPL)

PAGF (Adipose Cell Growth Factor)

Androgen Estrogen

Retinoid Binding Protein

Angiotensinogen

Angiotensin II (Hypertension)

Adrenal Steroid Precursor (Kawada, 1997)

Androgen

Estrogen

TNF-α (Insulin Resistance)
白色成熟脂肪組織

21歳  男性  普通体重者  皮下

(Prof. H.Sugihara: Saga Univ.)
70〜90ミクロン

普通体重者の脂肪細胞・内臓

(Prof. H. Sugihara: Saga Univ.)
メタボリック・シンドロームの
代表的な脂肪細胞像

内臓

140μm

過度の
肥大

脂肪細胞の
過度の肥大と
增殖の不十分さ

(Prof. H. Sugihara: Saga Univ.)
MCR before and after diet or diet & exercise intervention

MCR (ml/kg/min)

- Before Diet (D) Group
- After Diet (D) Group
- Before Diet & Exercise (DE) Group
- After Diet & Exercise (DE) Group

p < 0.01

NS

(Yamanouchi K et al.: Diabetes Care 18:775, 1995)
Changes in the ratio of glucose infusion rate (GIR) to steady-state insulin levels (I) during the euglycemic clamp, before and after long-term regular jogging

M/I: GIR/mean insulin concentrations during the euglycemic clamp

Glucose metabolism during the regular-dose euglycemic clamp study expressed as mg/kg BW/min (A) or mg/kg LBM/min (B)

* p < 0.05 vs controls

Correlation between GIR and Age

$\text{GIR} = -0.665$

$p < 0.001$

(Fink RI et al.: J Clin Invest 71:1523, 1983)
Older diabetic patients and Tai Chi

The amount of aerobic and resistance exercise necessary to achieve metabolic benefits in clinical trials has sometimes led to poor compliance. Older diabetic patients, often characterized by long-term sedentariness and overweight/obesity, may demonstrate better adherence to a low-intensity, low-impact exercise such as Tai Chi.
Tai Chi Exercise (4 Mets)

1. Slow and steady exercise with controlled respiration.
2. Continuous and slow-moving aerobic exercise that uses muscles of the whole body.
3. Simple exercise that can be performed anytime and anywhere.

(Wada M, 2001)
Effects of Exercise on Foot Impact and Heart Rate

Impact

Jump

Jogging

Walking

Tai Chi

Heart Rate

(Wada M, 2001)
Balance Index and Maximal Gait Speed before and after Tai Chi Intervention

Balance Index

- Before: 110
- After: 120
- p = 0.03

Maximal Gait Speed (m/s)

- Before: 1.0
- After: 2.0
- p = 0.005

(Orr R et al.: Diabetes Care, 2006)
Summary

1. Tai Chi has demonstrated to improve balance, gait speed, muscle strength, cardio-respiratory fitness, and QOL in elder adults.

2. The intermittent style of Tai Chi may be safely performed by sedentary and older people.

3. The continuous style of Tai Chi can be sometimes dangerous to sedentary and aged people.
Materials and Methods

An innovative exercise equipment
Joba®, Panasonic Co., Japan

Joba®

Swing
front and rear

Slide
front and rear

Swing
right and left
The euglycemic hyperinsulinemic glucose clamp was performed at an insulin infusion rate of 40 mU/m²/min in the post-absorptive state (DeFronzo, 1970). After confirming a stabilized glucose infusion rate (GIR) from 60 min to 90 min after starting the glucose clamp, a 30-min Joba® exercise was performed. During the Joba® exercise, blood glucose was maintained at the fasting level by adjusting the infusion rate of a 20% glucose solution. The glucose clamp procedure was continued for 90 min after the end of the exercise. GIRs, averaged for each 5-min period, were calculated in three periods: the last 30 min before starting exercise, during exercise, and the last 30 min of the clamp procedure.
Results

Insulin sensitivity

Acute effects

Values are means ± SE for 9 subjects.

*K * p < 0.01

(Kubota et al.: DRCP, 2006)
PET計測（Positron Emission Tomography）

目的：ブドウ糖取り込み部位の特定

方法

対象：6名（20代：5名、30代：1名）
24.5 ± 4.7歳

0分 30分 70分

安静 (ベッド上) → ショーブにて
座位で安静 → PET計測

(2週間後)

安静 (ベッド上) → ショーブ運動 → PET計測

注射

PET計測
ブドウ糖に陽電子放出物質を組込んだ薬剤を静脈注射し、画像化する計測法

結果

安定期
大腿部にブドウ糖取り込みを確認
(6名中5名で取り込み量が増加)

運動後
約25%増加

（ブドウ糖濃度を濃淡で表示）

第43回日本核医学会で発表
愛知県一宮市大雄会病院 放射線科 伊藤哲先生
Results

Insulin sensitivity

Chronic effects

Values are means ± SE for 6 subjects.
* p < 0.05

(Kubota et al.: DRCP, 2006)
Summary

1) In the acute study, GIR increased immediately after starting JOBA® exercise.

2) The 12-week training program resulted in a significant increase in the steady state GIR.

We conclude that, in elder diabetic patients, passive exercise training significantly enhances the lower level of insulin-induced glucose uptake. The Joba® apparatus may be useful as a therapeutic equipment.
A clinical survey on the present condition of physical exercise therapy in Japan (1): Joint study with the Japan Medical Association

Research Committee for the Establishment of Exercise Therapy for Diabetic Patients of the Japan Diabetes Society
Yuzo Sato*, Hirohito Sone, Masashi Kobayashi, Ryuzo Kawamori (Yoshito Tamura), Yoshihito Atsumi, Yoshiharu Oshida, Shiro Tanaka, Susumu Suzuki, Shigeru Makita, Isao Osawa

Japan Medical Association
Satoshi Imamura
Aichi Gakuin University
Tomoyuki Watanabe

* Chairman
Background

Regular physical exercise has long been known to be beneficial in the prevention and the treatment of diabetes mellitus. However, clinical surveys on the present state of exercise therapy among diabetic patients have not been performed in Japan.

The Research Committee for the Establishment of Exercise Therapy for Diabetic Patients of the Japan Diabetes Society (Chairman: Prof. Yuzo Sato) was founded in 2007.
Aims

In order to assess the current state of exercise therapy among diabetic patients in Japan and to establish appropriate exercise therapy guidelines for individual diabetic patients, a clinical survey was conducted in connection with the Japan Medical Association.

Comparison of physical exercise and dietary guidance for diabetic patients between diabetes specialists and non-specialist physicians was performed.
Subjects and Methods

Subjects: Paper questionnaires were mailed to randomly selected 600 diabetes specialists and 600 non-specialist physicians introduced by Japan Medical Association.

Methods: Responses from 275 diabetes specialists (50 ± 11 yrs) and 128 non-specialist physicians (52 ± 10 yrs) were analyzed. Questionnaires were prepared by members of the Research Committee for the Establishment of Exercise Therapy for Diabetic Patients.
Survey Items

- Practice of special clinic for diabetic patients and admission systems for the education of diabetic patients.
- Diabetes therapeutic method.
- Diet education systems.
- Exercise therapy education systems.
- Problems of exercise therapy education.
Diet Education (first visit)

Almost all patients* (90%≦)
- Diabetes specialists: 78%
- Non-specialists: 67%

70%≦ >90%
- Diabetes specialists: 12%
- Non-specialists: 8%

50%≦ >70%
- Diabetes specialists: 7%
- Non-specialists: 7%

30%≦ >50%
- Diabetes specialists: 1%
- Non-specialists: 1%

10%≦ >30%
- Diabetes specialists: 1%
- Non-specialists: 8%

No education*
- Diabetes specialists: 0%
- Non-specialists: 3%

*p < 0.05, **p < 0.01
χ² test, Fisher’s Exact test
Diet Education Systems (multiple answers)

- Diet education based on diet prescription: 67%
- No diet prescription but individual education: 29%
- Group education: 28%
- No special education systems: 5%
- Others: 3%

**p < 0.01
χ² test, Fisher’s Exact test
Exercise Therapy Education (first visit)

Almost all patients (90% ≤)

- Diabetes specialists: 36%
- Non-specialists: 45%

70% ≤ >90%

- Diabetes specialists: 15%
- Non-specialists: 12%

50% ≤ >70%

- Diabetes specialists: 18%
- Non-specialists: 7%

30% ≤ >50%

- Diabetes specialists: 7%
- Non-specialists: 9%

10% ≤ >30%

- Diabetes specialists: 14%
- Non-specialists: 10%

No education (10% >)

- Diabetes specialists: 9%
- Non-specialists: 17%

*p < 0.05, **p < 0.01
χ² test, Fisher’s Exact test
Exercise Therapy Education Systems (multiple answers)

- **No special education systems**: 44% diabetes specialists, 65% non-specialists
- **No exercise prescription but individual education**: 45% diabetes specialists, 30% non-specialists
- **Group education**: 15% diabetes specialists, 2% non-specialists
- **Exercise education based on exercise prescription**: 9% diabetes specialists, 2% non-specialists
- **Others**: 2% diabetes specialists, 3% non-specialists

*p < 0.05, **p < 0.01
χ² test, Fisher’s Exact test
**Physical Exercise Educator**

- **Presence***
  - Diabetes specialists: 17%
  - Non-specialists: 8%

- **No***
  - Diabetes specialists: 83%
  - Non-specialists: 92%

*\( \chi^2 \) test, Fisher’s Exact test

\( *p < 0.05 \)
Exercise Education Systems without Specialized Educator

- Nurse or dietician properly (no specialized staff): 12% (Nurse or dietician) vs. 26% (diabetes education specialists)
- Physician: 6% (Nurse or dietician) vs. 71% (diabetes education specialists)
- No exercise education: 1% (Nurse or dietician) vs. 1% (diabetes education specialists)
- Other: 1% (Nurse or dietician) vs. 1% (diabetes education specialists)

*p < 0.05
χ² test, Fisher’s Exact test

※ Clinics without specialized staff
The Reason why Exercise Education was not Practiced (from physicians)

- Lack of time to do: 73% (diabetes specialists), 61% (non-specialists)
- Lack of mind to do: 58% (diabetes specialists), 67% (non-specialists)
- Patients don’t like exercise: 45% (diabetes specialists), 39% (non-specialists)
- Lack of exercise educator: 32% (diabetes specialists), 37% (non-specialists)
- Lack of understanding beneficial effects of exercise: 30% (diabetes specialists), 37% (non-specialists)
- Lack of understanding diabetes: 16% (diabetes specialists), 26% (non-specialists)

*p < 0.05
χ² test, Fisher’s Exact test
Problems Related to the Practice of Exercise Therapy for Diabetic Patients (multiple answers)

- Lack of time to teach: 68% diabetes specialists, 64% non-specialists
- No additional consultation fee: 58% diabetes specialists, 43% non-specialists
- Lack of exercise educator: 51% diabetes specialists, 50% non-specialists
- Lack of guide book for exercise therapy: 46% diabetes specialists, 40% non-specialists
- Patients don't practice exercise even after instruction: 37% diabetes specialists, 47% non-specialists
- Lack of facilities: 27% diabetes specialists, 21% non-specialists
- Possibilities of accidents during exercise: 18% diabetes specialists, 13% non-specialists

*p < 0.05, **p < 0.01
χ² test, Fisher’s Exact test
Summary of this survey

- Compared with non-specialists, diabetes specialists accomplish rather completely diet and physical exercise education to diabetic patients, especially in the aspects of teaching staff and education systems.
- Even diabetes specialists don’t have specialized teaching staff (less than 20%) and the percentages of systematical education form and preparation of exercise prescription are not high at all.
- Many diabetic patients don’t want to continue physical exercise, don’t have exercise educators, and don’t understand the beneficial effects of exercise.
- Problems related to the practice of exercise therapy for diabetic patients are as follows: lack of time to teach, no additional consultation fee, lack of exercise educators, and lack of a guidebook on exercise therapy.
Conclusions of this survey

- Even among diabetes specialists, the practice of exercise therapy education is lower than that of diet education, and there are few (less than 20%) specialized teaching staffs for exercise education. Further studies should be performed to deepen our knowledge on the present condition of exercise education for diabetic patients and to establish appropriate exercise therapy guidelines.
- Our committee would like to publish a guidebook on exercise therapy for diabetic patients.
<table>
<thead>
<tr>
<th>Type</th>
<th>Aerobic</th>
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<tbody>
<tr>
<td></td>
<td>walking, jogging</td>
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<tr>
<td></td>
<td>swimming, bicycling</td>
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<tr>
<td>Intensity</td>
<td>50% VO₂max (LT levels)</td>
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<tr>
<td></td>
<td>(30-50 yrs 120/min)</td>
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<tr>
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<td>(60-70 yrs 100/min)</td>
</tr>
<tr>
<td>Duration</td>
<td>10 - 30 (60) min</td>
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<tr>
<td></td>
<td>(after meals, 2 times / day)</td>
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<tr>
<td>Frequency</td>
<td>3 - 5 times / wk</td>
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<tr>
<td>Compliance</td>
<td>Make exercise enjoyable</td>
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<tr>
<td></td>
<td>Active life-style education</td>
</tr>
</tbody>
</table>
Conclusions

1. Mild jogging increases insulin action despite of having no influence on BMI or VO$_2$max.

2. Traditional exercise such as Tai Chi improves balance, leg muscle strength, gait speed, cardiorespiratory fitness, and QOL in older adults.

3. Passive exercise training using the Joba® apparatus may be useful as an exercise therapy for aged diabetic patients.

4. The relative practice of exercise therapy education is lower than that of diet education.

5. Problems related to the practice of exercise therapy for diabetic patients are as follows: lack of time to teach, no additional consultation fee, lack of exercise educators, and lack of a guidebook on exercise therapy.
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