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Evaluation of Cardiorespiratory Function by a Graded Cycling Exercise Test in Obese and Non-obese Stroke Hemiparetic Patients

Akimitsu Tsutou¹, Junichi Katoh², Yasuhisa Hara², Masanori Iwahashi², Yasuo Nagata², Kunihiko Oda², Tsutomu Kazumi² and Hiroshi Taniguchi¹

Using a graded cycling exercise test, the cardiorespiratory responses were examined in 43 stroke hemiparetic inpatients with or without obesity. These responses were also examined in 17 simple obese subjects. The following results were obtained: 1) Peak oxygen uptake (VO₂ peak) and peak heart rate (HR peak) were not significantly different in these three groups. 2) Peak oxygen uptake per body weight (VO₂ peak/W) in obese hemiparetic patients was significantly lower than that in the others. 3) Peak metabolic equivalent (METS peak) in obese hemiparetic patients was significantly lower than that in simple obese subjects. 4) Percentage of maximum oxygen uptake (% VO₂ max.) and peak load per body weight (Load peak/W) in hemiparetic patients were significantly lower than that in simple obese subjects. 5) Other indices such as percentage of maximum heart rate (% HR max.), peak minute ventilation (VE peak), % vital capacity (% VC) and forced expiratory volume at one second (FEV 1.0 sec.) were not significantly different in these three groups. And also, oxygen uptake (VO₂), heart rate (HR) and oxygen uptake per body weight (VO₂/W) at the anaerobic threshold were not significantly different.

These results suggest that the physical fitness in hemiparetic patients is relatively lower than that in simple obese subjects, and VO₂ peak/W in obese hemiparetic patients is particularly lower than that in non-obese ones. Thus, attempts to improve the low fitness by both exercise and diet therapy might be particularly necessary for the better recovery of obese hemiparetic patients in the rehabilitation program.

Key Words
Obesity,
Stroke hemiparetic patient,
Cardiorespiratory fitness,
Exercise testing,
Rehabilitation.

INTRODUCTION
The obesity is considered to be one of primary risk factors of chronic diseases such as cardiovascular diseases ¹, hypertension²) and non-insulin dependent diabetes mellitus.³)

It is well known that physical exercise is of benefit in the treatment of obesity, though many investigators have argued about the intensity of physical training.⁴) ⁵)

By the way, though it depends on the degree of impairment, each stroke

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inpatient usually has low endurance
to daily admission life itself and exercise. The low endurance may com­
ound the increased energy cost of movement and contribute to poor re­
habilitation outcomes.6) In addition, physically inactive behavior has been
extensively linked with increased risk for disuse syndrome in post-stroke
hemiplegic subjects.7) And also, the lower level of physical fitness is
associated with a higher risk of death from coronary heart disease and car­
diovascular disease even in clinically healthy men, independent of conven­
tional coronary risk factors.8,9) Previously, we reported that weight re­
duction as a result of exercise improved cardiorespiratory function in middle-aged women with obesity.10) We also reported that the cardiores­
piratory functions of disabled subjects were relatively diminished than those
of healthy ones.11) So, it is very im­
portant to evaluate the physical fit­
ess of hemiparetic stroke patients,
especially obese patients.

The purpose of this investigation is
to describe the cardiorespiratory fit­
ness of stroke hemiparetic patients
with obesity evaluated by the exercise
testing system.

MATERIALS AND METHODS

Subjects were twenty-one stroke
hemiparetic patients with obesity (14
males and 7 females), twenty-two
non-obese stroke ones (17 males and
5 females), and seventeen simple
obese persons (6 males and 11
females) (Table 1.). Each patient,
who had had a hemispheric stroke
about 3.5 months before this study,
was medically stable, and was treated
by a formal medical rehabilitation
program at Hyogo Rehabilitation Cen­
ter Hospital as an inpatient. The
Brunnstrom stage12) of lower extrem­
ity of hemiparetic patients were from
IV to V. Each patient was inde­
pendent in indoor gait by a prosthesis

<table>
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<th>Table 1. Characteristics of all subjects.</th>
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<tr>
<td>Age (years)</td>
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<tr>
<td>Height (cm)</td>
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<tr>
<td>Body weight (Kg)</td>
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<tr>
<td>Body mass index (Kg/m²)</td>
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<tr>
<td>%Fat (%)</td>
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★ P<0.01 vs. obese hemiparetic patients

Mean ± SD
and/or indoor wheelchair handling.

To evaluate physical strength, a graded cycling exercise test was performed in a humidity- and temperature-controlled laboratory according to modified standard criteria of the American college of Sports Medicine. Subjects were fully acclimated to the testing procedures by thorough explanations and were tested on a cycle ergometer (Lode Corival WLP-400, Germany) with a load of 10 Watts/min. (ramp test). The dynamic exercise was continued until maximal effort was achieved. The electrocardiogram was monitored continuously with an electrocardiography (Fukuda ML-600, Japan), and blood pressure was measured with an autoelectrocardiometer (Colin STPB-780, Japan). The AT point was measured, and ventilator gas change was monitored with a respiromonitor (Minato RM-300 system, Japan). Respiratory functions were measured with an autospiror (Chest DISCOM-21, Japan).

The values of exercise metabolic parameters such as oxygen uptake ($VO_2$), heart rate (HR), and load were continuously determined during a graded exercise test using breath-by-breath respiration gas analysis assembly. Each maximal value for exercise parameters was the maximum of average at every 30 seconds. Percentage of each body fat was measured with an impedance fat meter (Selco SIF-891, Japan).

Data are expressed as mean ± SD. Unpaired Student's t-test was used for statistical analyses of the data. Statistical significance was accepted where $P<0.05$.

RESULTS

Characteristics of all subjects were shown in Table 1. The mean ± SD of body mass index (BMI) in obese and non-obese patients with hemiplegia was 28.2 ± 4.4 and 22.0 ± 2.6 kg/m², respectively. Meanwhile, that in simple obese subjects was 30.3 ± 2.1 kg/m². Percent fat was 30.3 ± 7.8, 18.0 ± 4.0 and 34.8 ± 5.8 %, respectively. There were significant differences in the BMI and % fat between non-obese hemiparetic patients' group and the other two groups ($P<0.01$).

The physiological responses with exercise were shown in Fig. 1, Fig. 2, Table 2 and Table 3. None of the subjects reported symptoms of dizziness, fainting, or chest pain during the exercise testing. With regard to the maximal response of blood pressure (BP) to exercise, the systolic BP increased to be below 230, whereas the diastolic BP rose only slightly during exercise in these three groups. Peak $VO_2$ ($VO_2$ peak: ml/min.) and peak HR (HR peak: beats/min.) were not significantly different among these three groups, (Fig.1 Left column). The each value of $VO_2$ peak in these three groups was 1240.8 ± 331.2, 1213.0 ± 409.0 and 1441.1 ± 442.6, respectively. And also, the each value of HR peak was 138.5 ± 26.3, 151.5 ± 20.3 and 139.9 ± 26.9, respectively. Percent $VO_2$ max. (% $VO_2$ max.: %) in hemiparetic patients was significantly lower than that in simple obese subjects ($P <0.05$) (Fig.1 Right column). The each value of % $VO_2$ max in these three groups was 65.9 ± 14.1, 65.9 ± 11.4 and 93.8 ± 13.5, respectively.
Hereupon, we calculated the degrees of functional aerobic impairment (FAI). To be brief, %FAI = (predicted \( \dot{V}O_2 \) max. − peak \( \dot{V}O_2 \))/predicted \( \dot{V}O_2 \) max. × 100. The normal value of FAI is 0 %. For the sake of convenience, values are classified as mild, moderate, marked and...
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extreme impairment. Namely, these values are divided into four groups which consist of $27\sim 40\%$, $41\sim 54\%$, $55\sim 68\%$ and more than $68\%$. According to the calculation, mean %FAI of obese hemiparetic patients, non-obese ones and simple obese subjects was $34.1$, $34.1$ and $6.2\%$, respectively.

As to %HRmax. (%), it was not significantly different among these three groups. (Fig.1 Right column). The each value of %HR in these three groups was $82.9 \pm 15.9$, $88.9 \pm 9.9$ and $84.0 \pm 13.0$, respectively.

Peak oxygen uptake per body weight ($\dot{V}O_2$ peak /W : ml/min./Kg) in obese hemiparetic patients was significantly lower than that in the others (P<0.05) (Fig.2). The each value of $\dot{V}O_2$ peak /W in these three groups was $16.5 \pm 4.1$, $20.1 \pm 5.6$ and $19.2 \pm 4.5$, respectively.

Peak metabolic equivalent (METs peak : Kcal/min.) in obese hemiparetic patients was significantly lower than that in simple obese subjects (P<0.05) (Fig.2). The each value of METs peak in obese hemiparetic patients, non-obese hemiparetic ones and simple obese subjects was $4.8 \pm 1.1$, $5.7 \pm 1.5$ and $5.9 \pm 1.2$, respectively.

Peak load per body weight (Load peak /W : watts/Kg) in hemiparetic patients was significantly lower than that in simple obese subjects (P<0.05) (Fig.2). The each value of Load peak /W in these three groups was $1.2 \pm 0.2$, $1.3 \pm 0.3$ and $1.7 \pm 0.3$, respectively.

Other indices such as peak minute ventilation (VE peak), % vital capacity (% VC) and forced expiratory volume at one second (FEV 1.0 sec) were not significantly different in these three groups (Table 2). And also, $\dot{V}O_2$, HR and oxygen uptake per body weight ($\dot{V}O_2$ /W) at the anaerobic threshold (AT) were not sig-

Figure 2. Peak oxygen uptake per body weight ($\dot{V}O_2$peak/W), peak metabolic equivalent (METs peak) and peak load per body weight (Load peak/W) by a graded cycling exercise test.
Table 2. Peak minute ventilation (VE peak), % vital capacity (% VC), forced expiratory volume at one second (FEV 1.0 sec) by a graded cycling exercise test.

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<th>Obese hemiparetic</th>
<th>Non-obese hemiparetic</th>
<th>Simple obese</th>
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<tr>
<td><strong>VE peak</strong> (L/min)</td>
<td>55.3 ± 18.9</td>
<td>51.8 ± 11.7</td>
<td>53.9 ± 17.0</td>
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<tr>
<td><strong>% VC (%)</strong></td>
<td>92.3 ± 18.8</td>
<td>96.2 ± 13.5</td>
<td>97.6 ± 13.4</td>
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<tr>
<td><strong>FEV 1.0 sec (%)</strong></td>
<td>83.2 ± 8.1</td>
<td>84.1 ± 8.2</td>
<td>85.9 ± 4.7</td>
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Mean ± SD, n.s.

Table 3. Cardiorespiratory responses at the anaerobic threshold by a graded cycling exercise test.

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<th>Non-obese hemiparetic</th>
<th>Simple obese</th>
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<tbody>
<tr>
<td><strong>VO₂ (m/min)</strong></td>
<td>836.4 ± 114.1</td>
<td>759.9 ± 181.7</td>
<td>852.3 ± 123.1</td>
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<tr>
<td><strong>HR (beats/min)</strong></td>
<td>108.4 ± 11.2</td>
<td>118.9 ± 10.6</td>
<td>107.8 ± 13.9</td>
</tr>
<tr>
<td><strong>VO₂/W (m/min/Kg)</strong></td>
<td>11.6 ± 1.6</td>
<td>12.8 ± 3.0</td>
<td>11.6 ± 1.7</td>
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Mean ± SD, n.s.

significantly different (Table 3).

**DISCUSSION**

Hemiparetic patients investigated were moderately impaired ones those were medically stable and relatively well into the rehabilitation term after stroke.

It was demonstrated for the first time in this investigation that the %VO₂ max. and Load peak /W in obese hemiparetic patients and non-obese ones were significantly lower than that in simple obese subjects (Fig.1 and 2). And also, VO₂ peak /W in obese hemiparetic patients was significantly lower than that in non-obese hemiparetic patients and simple obese subjects (Fig.2). In addition, the METS peak in obese hemiparetic patients was significantly lower than that in simple obese subjects (Fig.2). Although no significant difference (P = 0.07) was found, the METS peak in obese hemiparetic patients might become statistically lower than that in non-obese ones in case of the large scale study (Fig.2).

The VO₂ peak is well known to be changeable by the factors such as body weight, quantity of body muscles, age, sex, degree of daily life.
activity and promotion of physical strength. As for the VO2 peak /W, it means individual peak oxygen uptake per body weight. So, low values of VO2 peak /W in obese hemiparetic patients were suggested to be due to, at least, two combined factors of obesity and hemiparesis (Fig.2). On the other hand, the %VO2 max. (VO2 peak/predicted VO2 max.) is an index which indicates the individual relative intensity of exercise in point of respiratory function. The results of not only %VO2 max. but also % FAI suggest that hemiparetic patients with or without obesity are mildly impaired in functional aerobic ability and obese subjects are not normal, too. These results in hemiparetic patients might be due to the low activity of daily life caused by hemiparesis (Fig.1 and paragraph of RESULTS).

Although it has been reported that VO2 and VO2 /W of stroke hemiparetic patients at the AT point were significantly lower than those of healthy subjects19, it was also suggested from the present investigation that such indices of simple obese subjects at the AT point were lower than those of healthy subjects (Table 3).

Anyhow, these results suggest that the physical fitness of obese hemiparetic patients is relatively diminished compared with that of non-obese hemiparetic ones. These findings in stroke hemiparetic patients, especially obese hemiparetic ones, are likely related to low endurance, the reduction in number of motor units capable of being recruited during dynamic exercise. Low levels of fitness due to deconditioning, associated with physical inactivity, have commonly been reported in the general population of individuals with physical disabilities20-22. These studies have suggested that the low level of fitness may contribute to poor ability of exercise and poor rehabilitation outcomes. Though the role of aerobic exercise training in the functional recovery of patients after stroke has not been well documented, it has been reported that improvement in sensorimotor function is significantly related to the improvement in aerobic capacity.23 Hence attempts to improve the low fitness by both exercise and diet therapy might be particularly necessary for the better recovery of obese hemiparetic patients in the rehabilitation program.

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