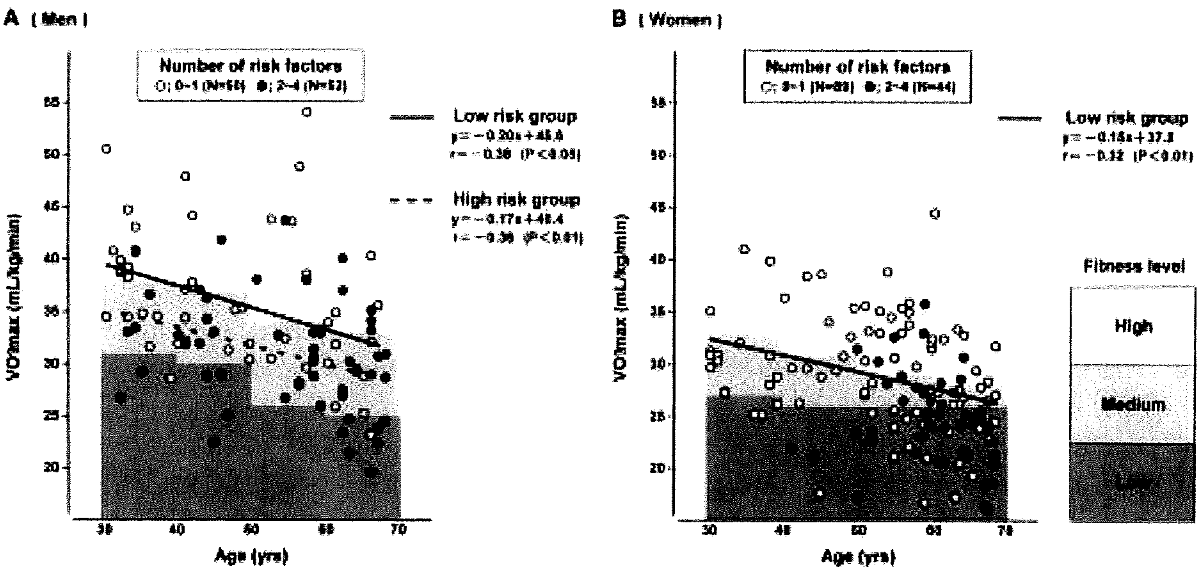

Fig. 2.　Maximal oxygen uptake ($\dot{V}O_2max$), age, and the number of risk factors for metabolic syndrome in men (A) and women (B).

Ⅳ. 考　　察

本研究では，235名の中高年男女を対象に，心肺体力及びMS危険因子を横断的に評価し，“EPAR2006”の“健康づくりのための最大酸素摂取量”の「基準値」および「範囲」と，MSリスク保有数との関係を検討した．その結果，男女とも心肺体力が低い群（L群）は，高い群（H群）に対して2倍以上高いMSリスク保有数を示した．男性では心肺体力が“健康づくりのための最大酸素摂取量”の「基準値」より低い群（M，L群に相当）では，上回っている群（H群に相当）よりMSリスク保有数が有意に高いこと，女性では「範囲」を下回っている群（L群に相当）では，上回っている群（M，H群に相当）よりMSリスク保有数が有意に高いことが示された．心肺体力と個々のMS危険因子との関係を検討した結果，男性では腹囲，HDL-C及びDBP，女性では腹囲，TG，HDL-C，SBP，DBPおよびBGにおいて，心肺体力レベルの異なる3群間で有意な差が認められた．

2007年に行われた国民健康・栄養調査[19]によると，30～69歳でMS（腹囲＋項目2つ以上該当）に該当する者は，男性では約22%，女性では約7％とされている．本研究で対象とした被験者においては，男性の22%（22名），女性の8％（11名）がMSと判定され，最近の国民健康・栄養調査の結果とほぼ同程度のMS発現頻度であった．また，本研究の被験者には，喫煙習慣のある男性が13%（13名），女性が8％（11名）含まれていた．同調査[19]によると，30～69歳における喫煙者の割合は，男性では45%，女性では13%とされている．本研究の喫煙者の割合が特に男性において少なかったことがわかる．

MSリスク保有数についてみると（Table 1），男性は平均では1.63であるのに対し，女性は1.03と男性の方が高い値を示しており，現在用いられているMS判定基準では，男性のMSリスクが女性よりも著しく高かった．そのため，心肺体力レベルが同じ男性と女性をそれぞれ比較すると，男性の方が高いリスク保有数を示したものと考えられる（Fig. 1AおよびFig. 1B）．特に，心肺体力が「基準値」を下回る男性（MおよびL群）で，MSリスクが著しく高いことが示された．

加齢に伴いMS発現頻度が高くなることが知られている[20]．本研究では，被験者を心肺体力レベルによって3群に分類したとき，女性では心肺体力が低いL群の年齢が他の2群より高かった（$P < 0.001$）．“健康づくりのための最大酸素摂取量”（Ref. 1）の「範囲」の下限値についてみると，男性では年齢とともに低下しているが，女性においては20歳代に比べて30歳代では低く，さらに40歳代ではより低くなっているものの，40歳代以降では一定

である．したがって，$\dot{V}O_2max$は，加齢による低下が原因で，中年以降の女性では年齢が高くなるほど基準とする「範囲」を下回る割合が高くなったものと考えられる．そのため，女性においてのみ，3群間の年齢に有意な差が認められたと考えられる．この結果は，女性の“健康づくりのための最大酸素摂取量”の「範囲」について再検討する必要性を示唆しているかもしれない．“EPAR2006”において，心肺体力の基準値を策定する際に参考とされた文献で，女性を対象としたものは，文献数が男性の1/4～1/5程度と非常に少なかったことから，今後，特に中高年女性の心肺体力と生活習慣病・MS予防に関するデータを蓄積する必要があると思われる．また，肥満の判定基準であるBMIが高くなることで，MS発現頻度も高くなることが報告されている[20,21]．本研究では，男女とも心肺体力が低い群のBMIが高かった．そのため，心肺体力が低い群のMSリスク保有数に，BMI高値が影響している可能性が考えられた．そこで，BMIを共変量として心肺体力とMSリスクとの関係を共分散分析によって検討した．しかし，男女ともBMIの影響を取り除いても，MSリスク保有数に有意な差が認められた．したがって，本研究の結果は，高い心肺体力がBMIとは独立してMSリスクを軽減する可能性を示唆している．さらに，女性では，L群の年齢が高かったため，年齢を共変量として，心肺体力とMSリスクとの関係を共分散分析によって検討したが，年齢の影響を取り除いても，MSリスク保有数の有意な差は認められた．この結果は，女性においてもやはり，高い心肺体力が年齢とは独立してMSリスクを軽減している可能性を示唆している．

本研究において，男女とも心肺体力が低い人では腹囲が有意に大きいことが明らかとなった（Table 3)．この結果は，心肺体力が低い人では，腹囲が大きく[9,11]，内臓脂肪の蓄積量が多い[22]と報告されている先行研究と一致していた．腹囲は内臓脂肪の蓄積をよく反映することが報告されている[23]．本研究において，心肺体力の低い男性（L群）では，平均値でみると腹囲はMS判定基準とされる85cmより約9cm大きく，一方，心肺体力の低い女性（L群）では，他の2群と比べて腹囲が大きい値を示したものの，平均値でみる限りMS判定基準（≧90cm）に該当しなかった．これらの結果は，特に心肺体力が「基準値」を下回る男性では，腹囲がMS判定基準に該当しやすく，内臓脂肪の蓄積が多い可能性を示唆している．

血中脂質異常の判定に用いられるTGおよびHDL-Cについて，本研究は，心肺体力が低いと，女性ではTGが有意に高く，男女ともHDL-Cが有意に低いことを明らかにした．この結果は，心肺体力の低い人では，男女ともTGが高く，HDL-Cが低いと報告されている先行研究の結果とほぼ一致していた[9,11]．本研究では心肺体力の低い男性では，高い男性に比べてTGは高い傾向にあったが，その差は有意ではなかった．本研究では，少なくともHDL-Cには男女とも心肺体力と関係が認められたため，高い心肺体力を保持することで，血中脂質異常が一部軽減される可能性を示唆している．

また，本研究では，男女とも心肺体力が低いと血圧が有意に高いことが明らかとなった．心肺体力の低い人では，SBPおよびDBPともに高いことが報告されている[9,11]．本研究では，心肺体力が低い男性ではDBPが高くなっていたが，SBPに3群間で有意な差は認められなかった．男性を対象としたStewartら[24]の研究では，6ヶ月の運動介入の結果，$\dot{V}O_2max$は向上し，DBPは改善したが，SBPは変化しなかった．また，Kiyonagaら[25]は，10週間の運動介入によってSBPおよびDBPはどちらも低下したが，さらに10週間の運動を行ってもSBPは変化せず，DBPのみがより低下したと報告している．これらの先行研究の結果より，SBPはDBPに比べて運動による改善効果が小さいことが示唆され，心肺体力が高い人でSBPが低いという関係性は，DBPに比べると弱いと考えられる．一方，心肺体力が低い女性では，SBPおよびDBPはともに高かった．本研究では，少なくともDBPは男女とも心肺体力と関係が認められたため，高い心肺体力を保持することで，高血圧のリスクが一部軽減される可能性が示唆される．

さらに本研究は，心肺体力が低い女性では，BGが有意に高いことを明らかにした．心肺体力の低い人では，男女ともBGが高いことがこれまでにも報告されている[9,11]．本研究において，男性ではBGについては3群間で有意差が認められなかったが，本研究の結果は，少なくとも女性においては，高い心肺体力を保持することで高血糖のリスクを軽減で

きる可能性を示唆している．男性を対象にしたいくつかの研究では，心肺体力が高いからといって必ずしも血糖や血圧が低いわけではないことが報告されている[8,22,26]．これらの値には，いずれも身体活動などの生活習慣に加え，食生活や遺伝的素因が関連する諸因子が大きく影響することが知られている．

以上述べてきたように，心肺体力の低い男性では，腹囲，血中脂質および血圧の項目が，心肺体力の低い女性では腹囲，血中脂質，血圧に加え血糖の項目が，高いMSリスクに関与していたと考えられ，その結果，男女とも心肺体力が高い群では低い群に比べてMSリスクが低かったと考えられる．そこで，MSリスクが異なる集団において心肺体力に差があるか否かを検証することとした．被験者を低リスク群（リスク保有数0または1）と高リスク群（リスク保有数2以上）に分類し，年齢に対する$\dot{V}O_2max$の差を検討したところ，男性では両群の回帰直線の傾きには有意な差が認められなかった（Fig. 2A）．したがって，MSリスクの異なる男性において，加齢による$\dot{V}O_2max$低下は同程度であったと考えられる．また，男性においては低リスク群は高リスク群よりy切片が有意に高い値を示したため，MSリスクの低い男性は，高い男性に比べて$\dot{V}O_2max$が有意に高いことが示唆される．一方，女性では，MSリスクの高い群においては，年齢と$\dot{V}O_2max$の間に相関関係がみられなかった（Fig. 2B）．閉経後女性では，若年女性に比べて体脂肪率が高い一方で除脂肪量が少なく，心肺体力も低いと報告されている[27]．また，内臓脂肪蓄積が閉経後の期間によく相関することが指摘されている[28]．本研究においても，女性では，これらの指標についての閉経というライフイベントによる身体的変化が，年齢より強くMSリスクに影響しているのかもしれない．

最後に，MSリスクの低い群の$\dot{V}O_2max$と“EPAR 2006”で基準とされた心肺体力との関係を検討するために，“健康づくりのための最大酸素摂取量”の「基準値」および「範囲」の下限値をFig. 2AおよびFig. 2Bに示した．男女ともMSリスクの低い群の$\dot{V}O_2max$の加齢変化を示す回帰直線は，「基準値」とほぼ一致していたことより，MSリスクの低い人は，“健康づくりのための最大酸素摂取量”の「基準値」程度の心肺体力を保持していることが示唆される．

$\dot{V}O_2max$は，身体活動量を比較的よく反映すると報告されている[29]．また，$\dot{V}O_2max$を向上させるためには，一定の強度以上で身体活動を行うことが重要であるとの指摘もある[30]．Simmonsら[31]は，コホート研究によって身体活動量および心肺体力の変化とMSリスクとの関係を明らかにしており，我が国においても今後，$\dot{V}O_2max$などの体力指標だけでなく，日常生活の身体活動量やその強度がMSリスクに及ぼす影響を調査・検討し，MS予防のための身体活動の量さらにはその強度を示す必要があるだろう．

Ⅵ．ま と め

日本人中高年者を対象とした本研究では，男性では心肺体力が“健康づくりのための最大酸素摂取量”の「基準値」より低いとMSリスクが高く，女性では「範囲」を下回っているとMSリスクが高いことが示された．特に，心肺体力の低い男性において，MSリスクが高いことが示唆された．心肺体力が高い中高年者では，MSを発現しにくいことが示唆される．これらの結果は，心肺体力が“健康づくりのための最大酸素摂取量”の「基準値」および「範囲」より低い場合，$\dot{V}O_2max$を高めるような身体活動を推奨する根拠の一部を提示しているといえるだろう．

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原　著

全身持久力の向上とメタボリックシンドローム改善効果

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要旨：全身持久力の代表的な指標で、安全に測定できる換気性閾値を用いて、全身持久力の向上とメタボリックシンドローム改善との関係を日本人男性で検討した。対象は当施設において、1年間隔で2度呼気ガス分析法による換気閾値の測定、空腹時採血を受け、薬物治療を受けていない男性70名(45.9±7.7歳)であった。測定項目は、換気性閾値に加え、身長、体重、腹囲、ヒップ囲、安静時血圧、中性脂肪、HDLコレステロール、空腹時血糖であった。メタボリックシンドロームの診断はわが国の診断基準を用いた。2回目の受診では、体重、腹囲、血圧、中性脂肪の有意な改善が認められた。換気性閾値の増加した群(I群)と増加しなかった群(D群)の2群で比較すると、I群ではメタボリックシンドロームが改善した頻度が高く、腹囲、HDLコレステロールが有意に改善した。換気性閾値時酸素摂取量の向上とメタボリックシンドロームの改善との間には有意な関連が認められ、運動習慣の獲得等をとおして全身持久力の向上をはかることが、メタボリックシンドローム予防、改善に必要と思われた。

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—キーワード—

メタボリックシンドローム, 換気性閾値, 酸素摂取量

Introduction

Metabolic syndrome is a common disorder and has become a public health challenge in Japan [1]. For example, 30.7% of men and 3.6% of women have been diagnosed as having metabolic syndrome using the new criterion developed in Japan [2]. Metabolic syndrome has been associated with an increased risk of cardiovascular disease [3], proteinuria [4], and elevation of hepatic enzymes [5]. Lifestyle modifications, especially exercise, are important for preventing and improving metabolic syndrome.

Although maximum oxygen uptake is generally considered an accurate and reliable parameter, it is not fully applicable to the population in clinical practice. Ventilatory threshold (VT) is closely linked to maximum oxygen uptake. It is defined as the upper limit of aerobic exercise and is also thought to serve as an accurate and reliable standard for exercise prescription [6]. Since exercise intensity at VT is not harmful to cardiovascular function, it can be safely applied to patients with myocardial infarction as exercise prescription [7]. We have previously reported in a cross-sectional study that lower levels of oxygen uptake at VT were characteristic in subjects with metabolic syndrome [8]. However, whether an increase in oxygen uptake at VT is beneficial for improving metabolic syndrome, and what effects this will have on metabolic syndrome remain to be investigated in a longitudinal study.

In this study, we evaluate the link between increases in oxygen uptake at VT and metabolic syndrome in Japanese men with a 1-year follow up.

Subjects and Methods

Subjects. We used data for 70 (0.5%) Japanese men, aged 45.9±7.7 years, retrospectively from a database of 14,345 subjects who met the following criteria: (1) received an annual health check-up at baseline from June 1997 to March 2006, (2) received an annual health check-up every year with a follow up duration of 1-year, (3) received anthropometric and oxygen uptake at VT measurements, fasting blood examination and blood pressure measurements as part of the annual health check-up, (4) received no medications for diabetes, hypertension, and/or dyslipidemia, and (5) provided written informed consent (Table 1).

Table 1: Clinical profiles and changes in parameters with 1-year follow up

	Baseline	Follow up	p
Number of subjects	70		
Height (cm)	169.4 ± 4.5		
Body weight (kg)	81.9 ± 9.4	79.7 ± 9.0	<0.0001
Abdominal circumference (cm)	93.9 ± 6.0	90.9 ± 8.5	<0.0001
Oxygen uptake at ventilatory threshold (ml/kg/min)	14.5 ± 2.6	14.8 ± 2.6	0.8037
Work rate at ventilatory threshold (W)	85.1 ± 15.0	85.9 ± 16.7	0.2709
Heart rate at ventilatory threshold (beats/min)	103.1 ± 10.4	100.1 ± 10.6	0.0050
Systolic blood pressure (mmHg)	133.9 ± 14.8	124.4 ± 12.2	<0.0001
Diastolic blood pressure (mmHg)	83.0 ± 12.4	76.2 ± 8.5	<0.0001
Triglyceride (mg/dl)	169.7 ± 102.4	128.5 ± 73.9	0.0010
HDL cholesterol (mg/dl)	52.1 ± 14.3	53.5 ± 13.8	0.1362
Blood sugar (mg/dl)	106.4 ± 23.2	110.9 ± 35.1	0.3474

Mean ± SD

At the first annual health check-up, all subjects were given instructions by well-trained medical staff on how to change their lifestyle *i.e.* not to eat too much, consider balance when they eat and increase their daily steps.

Ethical approval for the study was obtained from the Ethical Committee of Okayama Health Foundation.

Anthropometric and body composition measurements. Anthropometric and body compositions were evaluated based on the following parameters: height, body weight and abdominal circumference. Body mass index (BMI) was calculated by weight / [height] ^{2} (kg/m^2). Abdominal circumference was measured at the umbilical level in standing subjects after normal expiration [1].

Blood pressure measurements at rest. Resting systolic and diastolic blood pressure were measured indirectly using a mercury sphygmomanometer placed on the right arm of the seated participant after at least 15 minutes of rest.

Blood sampling and assays. Overnight fasting serum levels of high density lipoprotein (HDL) cholesterol, triglycerides (L Type Wako Triglyceride・H, Wako Chemical, Osaka) and plasma glucose were measured.

Definition of metabolic syndrome. Men with a waist circumference in excess of 85 cm were defined as having metabolic syndrome if they also had two or more of the following components: 1) Dyslipidemia: triglycerides≧150 mg/dl and/or HDL cholesterol<40 mg/dl, 2) High blood pressure: blood pressure≧130/85 mmHg, 3) Impaired glucose tolerance: fasting plasma glucose≧110 mg/dl [1].

Exercise testing. A graded ergometer exercise protocol [9] was performed. Two hours after breakfast, a resting ECG was recorded and blood pressure was measured. Then, all participants were given graded exercise after 3 min of pedaling on an unloaded bicycle ergometer (Excalibur V2.0, Lode BV, Groningen, Netherlands). The profile of incremental workloads was automatically defined by the methods of Jones [9], in which the workloads reach the predicted $\dot{V}O_2$max in 10 min. A pedaling cycle rate of 60 rpm was maintained. Loading was terminated when the appearance of symptoms forced the subject to stop. During the test, ECG was monitored continuously together with the recording of heart rate (HR). Expired gas was collected and rates of oxygen consumption ($\dot{V}O_2$) and carbon dioxide production ($\dot{V}CO_2$) were measured breath-by-breath using a cardiopulmonary gas exchange system (Oxycon Alpha, Mijnhrdt b.v., Netherlands). VT was determined by the standard of Wasserman et al [6], Davis et al [10], and the V-slope method of Beaver [11] from $\dot{V}O_2$, $\dot{V}CO_2$ and minute ventilation ($\dot{V}E$). At VT, $\dot{V}O_2$ (ml/kg/min), work rate (W), and heart rate (beats / min) were measured and recorded.

Statistical analysis. All data are expressed as mean ± standard deviation (SD) values. A statistical analysis was performed using a paired *t* test, an unpaired *t* test and χ^2 test: $p<0.05$ was considered to be statistically significant. Pearson's correlation coefficients were calculated and used to test the significance of the linear relationship among continuous variables.

Results

The clinical parameters at the baseline and the 1-year follow up are summarized in Table 1. Anthropometric and body composition parameters such as body weight and abdominal circumference were significantly reduced after one year. Systolic blood pressure, diastolic blood pressure, triglyceride levels and heart rate at VT were significantly reduced. The prevalence of metabolic syndrome was also significantly reduced (Baseline: 31 men, Follow up: 24 men) (Table 2).

Table 2: Changes in the prevalence of metabolic syndrome

Metabolic syndrome (Baseline)	Metabolic syndrome (Follow up) (−)	(+)	p
(−)	34	5	<0.0001
(+)	12	19	

Thirty five men unexpectedly increased their oxygen uptake at VT by the time of the 1-year follow up. We investigated the changes in the prevalence of metabolic syndrome amongst men who had different levels of increased oxygen uptake at VT [Group I: Delta (delta represents positive changes in parameters) oxygen uptake at VT ≧ 0 ml/kg/min, Group D: Delta oxygen uptake at VT < 0 ml/kg/min] (Table 3). The prevalence of subjects with metabolic syndrome at baseline and without metabolic syndrome at follow up was higher (8 men, 22.9%) in Group I than those in Group D (4 men, 11.4%).

Table 3: Relationship between changes in oxygen uptake at ventilatory threhold and metabolic syndrome

Metabolic syndrome Baseline	Metabolic syndrome Follow up	Oxygen uptake at ventilatory threshold: Group I (n)	Group I %	Group D (n)	Group D %	p
(−)	(−)	11	31.4	23	65.7	
(−)	(+)	3	8.6	2	5.7	
(+)	(−)	8	22.9	4	11.4	0.0393
(+)	(+)	13	37.1	6	17.1	
Total		35	100.0	35	100.0	

Group I: Delta oxygen uptake at VT ≧ 0 ml/kg/min
Group D: Delta oxygen uptake at VT < 0 ml/kg/min

We further compared parameters at baseline and changes in each parameter at baseline and follow up between Group I and Group D (Table 4). At baseline, significant differences were noted in abdominal circumference, oxygen uptake at VT, work rate at VT, heart rate at VT and diastolic blood pressure. After 1-year follow up, there were also significant differences in delta oxygen uptake at VT (Group I: 1.6±1.2 ml/kg/min vs Group D: -1.5±0.8 ml/kg/min), delta work rate at VT, delta heart rate at VT, delta abdominal circumference, delta HDL cholesterol and delta blood sugar between the two groups. However, delta systolic blood pressure, delta diastolic blood pressure and delta triglyceride in Group I were similar to those in Group D.

Table4: Comparison of clinical parameters at baseline and changes in parameters with 1-year follow up

	Group I	Group D	p
Number of subjects	35	35	
Age	48.2 ± 7.0	45.6 ± 8.4	0.7455
Abdominal circumference (cm)	95.6 ± 7.6	91.1 ± 7.5	0.0037
Oxygen uptake at ventilatory threshold (ml/kg/min)	13.5 ± 1.7	15.6 ± 3.0	0.0005
Work rate at ventilatory threshold (W)	81.4 ± 14.1	88.7 ± 15.1	0.0409
Heart rate at ventilatory threshold (beats/min)	101.8 ± 5.6	104.5 ± 11.1	0.2760
Systolic blood pressure (mmHg)	134.2 ± 15.3	133.6 ± 14.5	0.8567
Diastolic blood pressure (mmHg)	86.5 ± 10.9	79.6 ± 13.1	0.0185
Triglyceride (mg/dl)	165.9 ± 76.5	163.4 ± 129.0	0.7981
HDL cholesterol (mg/dl)	50.3 ± 12.2	53.9 ± 16.1	0.3033
Blood sugar (mg/dl)	110.3 ± 25.0	106.5 ± 21.5	0.5135
Delta oxygen uptake at ventilatory threshold (ml/kg/min)	1.6 ± 1.2	−1.5 ± 0.8	<0.0001
Delta work rate at ventilatory threshold (W)	9.0 ± 10	−5.4 ± 12.4	<0.0001
Delta heart rate at ventilatory threshold (beats/min)	−0.7 ± 7.3	−5.3 ± 9.3	0.0226
Delta abdominal circumference (cm)	−4.1 ± 5.2	−1.5 ± 3.7	0.0304
Delta systolic blood pressure (mmHg)	−7.7 ± 11.2	−11.5 ± 14.5	0.2806
Delta diastolic blood pressure (mmHg)	−7.4 ± 10.9	−0.2 ± 12.9	0.0502
Delta triglyceride (mg/dl)	37.2 ± 68.7	39.[illegible] ± 112.5	0.9320
Delta HDL cholesterol (mg/dl)	4.3 ± 6.0	−1.3 ± 9.3	0.0038
Delta blood sugar (mg/dl)	7.8 ± 18.2	−2.6 ± 12.2	0.0447

Mean±SD
Group I: Delta oxygen uptake at VT ≧ 0 ml/kg/min
Group D: Delta oxygen uptake at VT < 0 ml/kg/min

Finally, we evaluated the relationship between delta oxygen uptake at VT and each delta parameter of metabolic syndrome by a simple correlation analysis. Oxygen uptake at VT was weakly correlated with delta abdominal circumference ($r=-0.308$, $p=0.0094$) and delta HDL cholesterol ($r=0.312$, $p=0.0085$). Although a significant difference in delta blood sugar was noted between Group I and Group D, the correlation between delta oxygen uptake at VT and delta blood sugar was not at a significant level ($r=0.172$, $p=0.1556$).

Table5: Simple correlation analysis between changes in (delta) oxygen uptake at ventilatory threshold and clinical parameters

	r	p
Delta abdominal circumference (cm)	−0.308	0.0094
Delta systolic blood pressure (mmHg)	0.086	0.4794
Delta diastolic blood pressure (mmHg)	−0.129	0.2872
Delta triglyceride (mg/dl)	−0.089	0.4634
Delta HDL cholesterol (mg/dl)	0.312	0.0085
Delta blood sugar (mg/dl)	0.172	0.1556

Discussion

We explored, using the Japanese criterion, whether an increase in oxygen uptake at VT can improve metabolic syndrome and its components in Japanese men.

Regular physical activity has been shown to increase HDL and reduce resting blood pressure, triglycerides, abdominal fat, fasting blood sugar, and insulin responses to oral glucose challenge test [12-16]. Some cross sectional studies show that metabolic syndrome is significantly correlated with physical fitness [17-19]. We also previously showed that lower oxygen uptake at VT was characteristic in Japanese men with metabolic syndrome [8]. In addition, lower exercise habits were noted in subjects with metabolic syndrome compared to those without [8]. It seems reasonable to suggest that simply moving from the lower oxygen uptake at VT to a higher oxygen uptake at VT might result in the amelioration of metabolic syndrome in some Japanese men. However, these were cross sectional studies and the hypothesis that metabolic syndrome may be caused by lower oxygen uptake at VT cannot be accurately proven.

In turn, few longitudinal studies have been carried out to prove a link between metabolic syndrome and exercise. Katzmarzyk *et al* reported on the effects of 20 weeks supervised aerobic training program on the prevalence of metabolic syndrome in 621 men and women who were enrolled in the HERITAGE Study. 30.5% of the participants with metabolic syndrome at baseline were classified as not having the syndrome after the intervention [20]. The Kuopio Ischemic Heart Disease Risk Factor Study [21] followed several hundred men without the syndrome at baseline. After four years, subjects in the upper one-third of VO_2max at baseline were 75% less likely than unfit men to develop metabolic syndrome. Ekelund *et al* reported that the energy expenditure of physical activity predicts progression to metabolic syndrome independent of aerobic fitness, obesity, and other confounding factors followed by 5.6 years [22]. By using the criterion developed in Japan, Okura *et al* recently reported that 67 women with metabolic syndrome were treated with a 14-week weight loss program, which included a low-calorie diet and aerobic exercise. The adjusted odds ratios for metabolic syndrome improvement in the two interventions with diet alone and diet plus exercise were 1.0 and 3.68. In addition, $\dot{V}O_2max$ in subjects on the low-calorie diet and aerobic exercise treatment was 22.9±3.2 ml/kg/min at baseline and 27.0±3.8 ml/kg/min after intervention ($p<0.001$) [23].

In the present study, using the criterion developed in Japan, increasing oxygen uptake at VT was associated with improvement of metabolic syndrome in Japanese men with a 1-year follow up. In addition, clinical impacts of abdominal circumference and HDL-cholesterol improvement were also noted. Compared to Okura *et al*, the observation period was longer and oxygen uptake at VT as a parameter of aerobic exercise was used. Our results suggest the clinical significance of increasing aerobic exercise level.

Potential limitations still remain in this study. First, the 14,345 subjects in our study voluntarily underwent the annual health check-up; they were, therefore, probably more health-conscious than the average person. The selected 70 subjects (0.5%) underwent an annual health check-up every year with a follow-up duration of 1-year and received no medication; they were, therefore, probably even more health-conscious than most of the subjects in the database, and the small sample size makes it difficult to infer causality between increasing oxygen uptake at VT and metabolic syndrome. Second, the parameters of VT were significantly lower and diastolic blood pressure was significantly higher in subjects in Group I than those subjects in Group D at baseline. Third, although delta blood sugar was significantly higher in Group I than in Group D by unpaired *t* test, delta oxygen uptake at VT was not correlated with delta blood sugar. Blood sugar might be more changeable compared to other parameters.

In conclusion, it seems reasonable to suggest that simply moving from the lower oxygen uptake at VT to higher oxygen uptake at VT might result in the amelioration of the metabolic syndrome in some Japanese men. In addition, exercise habit was closely linked to oxygen uptake at VT [8]. Therefore, we need promote exercise habits for preventing and improving metabolic syndrome. Further prospective investigation studies are needed in Japanese using the new criterion of Japan.

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Increasing Oxygen Uptake at Ventilatory Threshold is Associated with Improving Metabolic Syndrome in Japanese Men

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The link between changes in oxygen uptake at ventilatory threshold (VT) and metabolic syndrome was evaluated in Japanese men with a 1-year follow up. We used data for 70 Japanese men (45.9±7.7 years) with a 1-year follow up. Metabolic syndrome has been defined by a new criterion in Japan. Changes in oxygen uptake at VT on metabolic syndrome were also evaluated. Body weight, abdominal circumference, systolic blood pressure, diastolic blood pressure and triglyceride were significantly reduced and the prevalence of metabolic syndrome was also significantly reduced with a 1-year follow up. The prevalence of metabolic syndrome was reduced in subjects with an increase in oxygen uptake at VT (Group I) compared to subjects without such an increase (Group D). In addition, there were remarkable differences in delta abdominal circumference (delta represents positive changes in parameters) and delta HDL cholesterol between Group I and Group D. An increase in oxygen uptake at VT may be associated with improving metabolic syndrome and its components in Japanese men.

Key words: Metabolic syndrome, Ventilatory threshold, , Oxygen uptake

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Original Article

Leg Strength per Body Weight is Associated with Ventilatory Threshold in Japanese Women

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Abstract

Objective: The link between leg strength per body weight and oxygen uptake at ventilatory threshold (VT) was evaluated in Japanese women with a 1-year follow up.

Subjects and Methods: We used data for 60 Japanese women (46.1 ± 10.6 years) with a 1-year follow up. Changes in leg strength per body weight on oxygen uptake at VT were also evaluated.

Results: Oxygen uptake at VT (per body weight) was significantly correlated with body weight, body mass index (BMI), abdominal circumference, hip circumference, body fat percentage, leg strength and leg strength per body weight ($r=0.520$, $p<0.001$). Body weight, BMI, abdominal circumference and body fat percentage were significantly reduced; work rate and right grip strength were significantly increased with a 1-year follow up. In addition, changes in oxygen uptake at VT (per body weight) were also significantly correlated with leg strength and leg strength per body weight ($r=0.317$, $p=0.0137$).

Conclusion: An increase in leg strength per body weight may be associated with increasing oxygen uptake at VT in Japanese women.

KEY WORDS: leg strength, oxygen uptake, ventilatory threshold

Introduction

Aerobic exercise has been shown to increase HDL and reduce resting blood pressure, triglycerides, abdominal fat, fasting blood sugar, and insulin responses to oral glucose challenge test [1-5]. Some cross sectional studies show that metabolic syndrome is significantly correlated with physical fitness [6-8].

Although maximum oxygen uptake is generally considered an accurate and reliable parameter of aerobic exercise level, it is not fully applicable to the population in clinical practice. Ventilatory threshold (VT) is defined as the upper limit of aerobic exercise and is also thought to serve as an accurate and reliable standard for exercise prescription [9]. Since exercise intensity at VT is not harmful to cardiovascular function, it can be safely applied to patients with myocardial infarction as exercise prescription [10]. It is also well known that low and declining muscle strength is associated with increased mortality, independent of physical activity and muscle mass [11] and well reported that there is significant loss in muscle strength with aging [12,13]. We have solely reported in a cross sectional study that oxygen uptake at VT was significantly correlated with leg strength per body weight in Japanese women [14]. However, whether an increase in leg strength per body weight is beneficial for increasing oxygen uptake at VT, and what effects this will have on oxygen uptake at VT remain to be investigated in a longitudinal analysis.

In this study, we evaluate the link between increases in leg strength per body weight and oxygen uptake at VT in Japanese women with a 1-year follow up.

Subjects and Methods

Subjects

We used data for 60 Japanese women, aged 46.1 ± 10.6 years who met the following criteria: (1) received an annual health check-up every year with a follow up duration of 1-year, (2) received no medications for diabetes, hypertension, and/or dyslipidemia, and (3) provided written informed consent (***Table 1***).

At the first annual health check-up, all subjects were given instructions by well-trained medical staff on how to change their lifestyle i.e. not to eat too much, consider balance when they eat and increase their daily steps.

Ethical approval for the study was obtained from the Ethical Committee of Okayama Health Foundation.

Anthropometric and body composition measurements

Anthropometric and body compositions were evaluated based on the following parameters: height, body weight, abdominal circumference, hip circumference and body fat percentage. Body mass index (BMI) was calculated by weight / $[\text{height}]^2$ (kg/m^2). Abdominal circumference was measured at the umbilical level and hip circumference was measured at the widest circumferences over the trochanter in standing subjects after normal expiration [15]. Body fat percentage was measured by an air displacement plethysmograph called the BOD POD Body Composition System (Life Measurement Instruments, Concord, CA, USA) [16,17]. Lean body mass was calculated as follows: Body weight(kg) − [body weight(kg) × body fat percentage (%)/100].

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Table 1 Clinical characteristics and changes in parameters with 1-year follow up

	Baseline	Follow up	p
Number of Subjects	60		
Age	46.1 ± 10.6		
Height (cm)	155.8 ± 4.4		
Body weight (kg)	62.0 ± 8.0	60.9 ± 8.4	**0.0159**
Body mass index (kg/m2)	25.5 ± 3.2	25.1 ± 3.5	**0.0133**
Abdominal circumference (cm)	78.3 ± 7.4	76.9 ± 8.2	**0.0184**
Hip circumference (cm)	95.4 ± 6.0	94.6 ± 6.5	0.0797
Lean body mass (kg)	39.5 ± 3.9	39.6 ± 3.9	0.9933
Body fat percentage (%)	35.8 ± 4.9	34.8 ± 5.2	**0.0027**
Systolic blood pressre (mmHg)	122.8 ± 14.0	121.9 ± 15.9	0.5259
Diastolic blood pressure (mmHg)	77.2 ± 9.6	75.2 ± 10.6	0.1142
Triglyceride (mg/dl)	98.0 ± 63.1	95.4 ± 60.4	0.6653
HDL cholesterol (mg/dl)	65.1 ± 14.6	64.9 ± 15.3	0.8599
Blood sugar (mg/dl)	94.3 ± 9.1	93.6 ± 8.7	0.4523
Oxygen uptake at ventilatory threshold (ml/body weight (kg)/min)	12.9 ± 2.1	13.0 ± 1.9	0.6742
Oxygen uptake at ventilatory threshold (ml/lean body mass (kg)/min)	20.1 ± 2.9	19.9 ± 2.3	0.5943
Oxygen uptake at ventilatory threshold (ml/min)	792.7 ± 133.1	784.9 ± 120.0	0.6231
Work rate at ventilatory threshold (watt)	50.7 ± 11.5	55.0 ± 14.5	**0.0131**
Heart rate at ventilatory threshold (beat/min)	102.4 ± 11.7	100.4 ± 10.5	0.1095
Right grip strength (kg)	25.9 ± 5.4	27.0 ± 4.3	**0.0237**
Left grip strength (kg)	25.2 ± 5.1	25.6 ± 4.5	0.1908
Leg strength (kg)	44.2 ± 10.5	45.3 ± 10.3	0.2673
Leg strength per body weight	0.72 ± 0.16	0.75 ± 0.15	0.0645
Leg strength per lean body mass	1.12 ± 0.25	1.15 ± 0.23	0.3901
Flexibility (cm)	8.0 ± 8.8	8.8 ± 8.2	0.1641

Mean ± SD

Blood pressure measurements at rest

Resting systolic and diastolic blood pressure was measured indirectly using a mercury sphygmomanometer placed on the right arm of the seated participant after at least 15 minutes of rest.

Blood sampling assays

Overnight fasting serum levels of high density lipoprotein (HDL) cholesterol, triglycerides (L Type Wako Triglyceride·H, Wako Chemical, Osaka) and serum glucose were measured.

Exercise testing

A graded ergometer exercise protocol [18] was performed. Two hours after breakfast, a resting ECG was recorded and blood pressure was measured. Then, all participants were given graded exercise after 3 min of pedaling on an unloaded bicycle ergometer (Excalibur V2.0, Lode BV, Groningen, Netherlands). The profile of incremental workloads was automatically defined by the methods of Jones [18], in which the workloads reach the predicted VO_2 max in 10 min. A pedaling cycle rate of 60 rpm was maintained. Loading was terminated when the appearance of symptoms forced the subject to stop. During the test, ECG was monitored continuously together with the recording of heart rate (HR). Expired gas was collected and rates of oxygen consumption (VO_2) and carbon dioxide production (VCO_2) were measured breath-by-breath using a cardiopulmonary gas exchange system (Oxycon Alpha, Mijnhrdt b.v., Netherlands). VT was determined by the standard of Wasserman et al [9], Davis et al [19], and the V-slope method of Beaver [20] from VO_2, VCO_2 and minute ventilation (VE). At VT, VO_2 (ml/kg/min), work rate (W), and heart rate (beats / min) were measured and recorded.

Measurement of muscle strength

To assess muscle strength, grip and leg strength had been measured. Grip strength was measured using THP-10 (SAKAI, Tokyo, Japan), while leg strength was measured by COMBIT CB-1 (MINATO, Osaka, Japan). Isometric leg strength was measured as follows: the subject sat in a chair, grasping the armrest in order to fix the body position. The dynamometer was then attached to the subject's ankle joint by a strap. Next, the subject extended the leg to 60 degrees [21]. To standardize the influence of the total body weight, we calculated the leg strength (kg) per body weight (kg) [22], the level of which "over 1.0" is recommended for daily activity [21].

Measurements of flexibility

To evaluate the flexibility of all the participants, they were measured as follows: Sit-and-reach measurements were obtained to assess the overall flexibility in the forward flexion, with the measurements recorded as the distance (in centimeters) between the fingertips and toes. The subject's knees were kept straight throughout the test and ankles were maintained at 90 degrees by having the soles of the feet pressed against a board perpendicular to the sitting surface [23].

Statistical analysis

All data are expressed as mean ± standard deviation (SD) values. A statistical analysis was performed using a paired t test: $p<0.05$ was considered to be statistically significant. Pearson's correlation coefficients were calculated and used to test the significance of the linear relationship among continuous variables.

Results

The clinical parameters at the baseline and the 1-year follow up are summarized in Table 1. Anthropometric and body composition parameters such as body weight, BMI, abdominal circumference and body fat percentage were significantly reduced after one year. Work rate at VT and right grip strength were significantly increased.

Relationship between oxygen uptake at VT and clinical parameters at baseline was evaluated. Oxygen uptake at VT (per body weight) was negatively correlated with body weight, BMI, abdominal circumference, hip circumference and body fat percentage; and it was positively correlated with leg strength (r=0.295, p=0.0220), leg strength per body weight (r=0.520, p<0.0001) and leg strength per lean body mass (r=0.385, p=0.0024) (*Table 2, Figure 1*). Oxygen uptake at VT (per lean body mass) was also correlated with leg strength, leg strength per body weight and leg strength per lean body mass (*Table 2*). However, there was no significant relationship between oxygen uptake at VT (per body mass and per lean body mass) and other clinical parameters.

Simple correlation analysis between oxygen uptake at VT and age (*Figure 2*), and between leg strength per body weight, leg strength and age (*Figure 3*) were also evaluated. Leg strength per body weight and leg strength were negatively correlated with age. Leg strength per lean body mass was also weakly correlated with age (r=-0.281, p=0.0297). Oxygen uptake at VT (ml/min) was weakly correlated with age (*Figure 2: B*). However, oxygen uptake at VT (per body weight: ml/kg/min) (*Figure 2: A*) and oxygen uptake at VT (per lean body mass: ml/kg/min) were not correlated with age at a significant level (per body weight: r=-0.187, p=0.1529, per lean body mass: r=-0.106, p=0.4185).

Table 2 Simple correlation analysis between oxygen uptake at ventilatory threhold and clinical parameters at baseline

	Per body weight		Per lean body mass	
	r	p	r	p
Body weight (kg)	-0.344	**0.0072**	-0.058	0.6602
Body mass index (kg/m²)	-0.361	**0.0046**	-0.043	0.7414
Abdominal circumference (cm)	-0.373	**0.0034**	-0.027	0.8361
Hip circumference (cm)	-0.321	**0.0125**	-0.070	0.5977
Body fat percentage (%)	-0.395	**0.0018**	0.085	0.5191
Systolic blood pressre (mmHg)	0.088	0.5031	0.231	0.0758
Diastolic blood pressure (mmHg)	0.077	0.5598	0.181	0.1675
Triglyceride (mg/dl)	-0.185	0.1571	-0.172	0.1890
HDL cholesterol (mg/dl)	0.198	0.1303	0.114	0.3843
Blood sugar (mg/dl)	-0.136	0.2990	-0.004	0.9759
Right grip strength (kg)	0.229	0.0789	0.246	0.0579
Left grip strength (kg)	0.183	0.1607	0.161	0.2191
Leg strength (kg)	0.295	**0.0220**	0.422	**0.0008**
Leg strength per body weight	0.520	**<0.0001**	0.487	**<0.0001**
Leg strength per lean body mass	0.385	**0.0024**	0.522	**<0.0001**
Flexibility (cm)	-0.035	0.7881	-0.046	0.7247

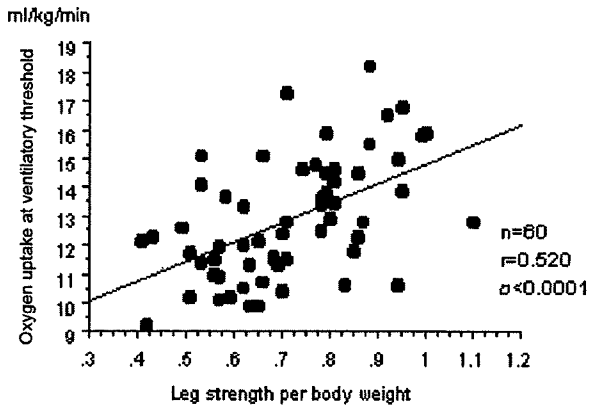

Fig. 1. Simple correlation analysis between oxygen uptake at ventilatory threshold (per body weight) and leg strength per body weight in Japanese women at baseline.

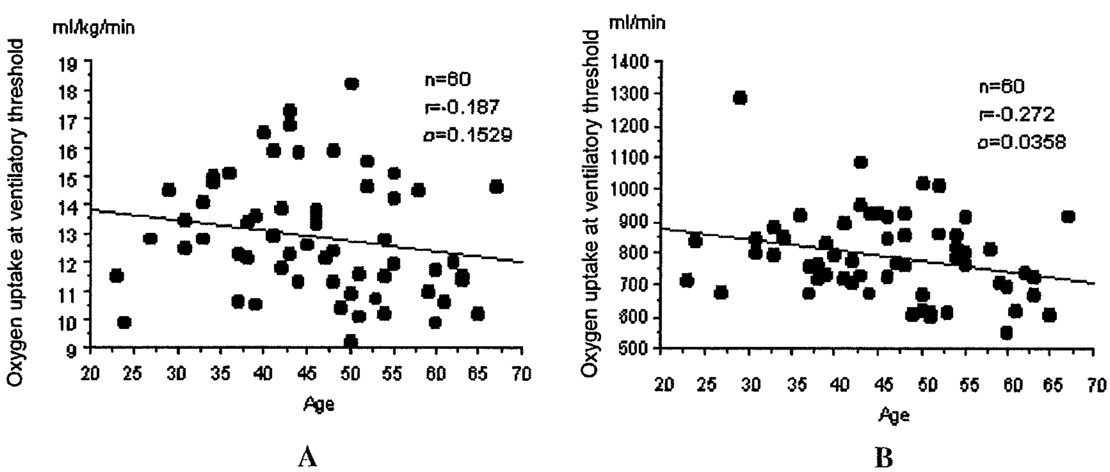

Fig. 2. Simple correlation analysis between oxygen uptake at ventilatory threshold (A: ml/body weight (kg)/min, B: ml/min) and age.

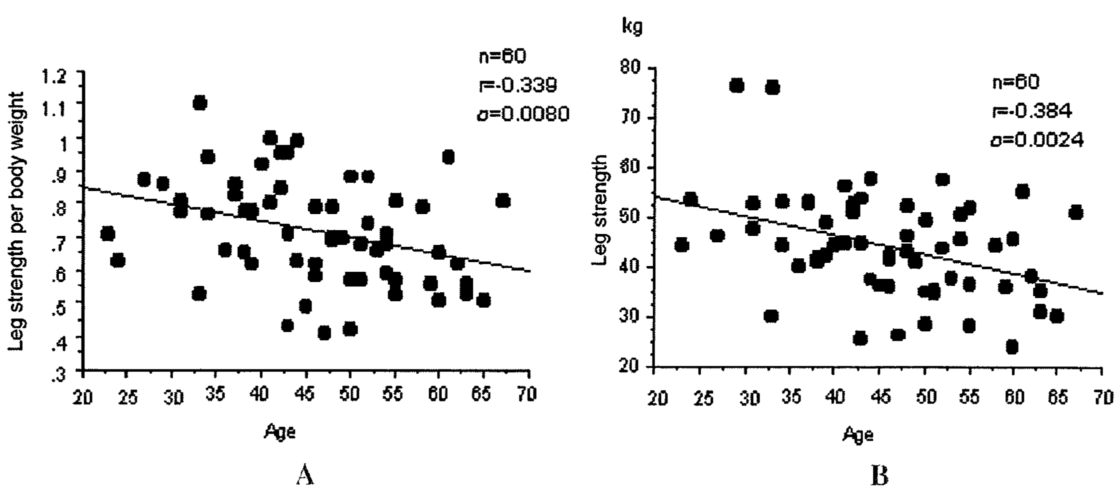

Fig. 3. Simple correlation analysis between leg strength per body weight (A), Leg strength (B) and age.

Table 3 Simple correlation analysis between changes in oxygen uptake at ventilatory threhold and changes in clinical parameters with 1-year follow up

	Per body weight		Per lean body mass	
	r	p	r	p
Body weight (kg)	-0.181	0.1670	0.009	0.9456
Body mass index (kg/m²)	-0.165	0.2087	0.024	0.8596
Abdominal circumference (cm)	-0.162	0.2157	-0.014	0.9132
Hip circumference (cm)	-0.156	0.2354	0.046	0.7268
Body fat percentage (%)	-0.216	0.1005	0.056	0.6751
Systolic blood pressre (mmHg)	0.138	0.2922	0.169	0.2006
Diastolic blood pressure (mmHg)	0.091	0.4911	0.130	0.3249
Triglyceride (mg/dl)	-0.079	0.5501	-0.073	0.5840
HDL cholesterol (mg/dl)	0.015	0.9066	-0.038	0.7777
Blood sugar (mg/dl)	0.220	0.0909	0.258	**0.0487**
Right grip strength (kg)	-0.050	0.7087	0.026	0.8440
Left grip strength (kg)	0.027	0.8403	-0.005	0.9706
Leg strength (kg)	0.260	**0.0440**	0.309	**0.0172**
Leg strength per body weight	0.317	**0.0137**	0.305	**0.0188**
Leg strength per lean body mass	0.264	**0.0430**	0.307	**0.0179**
Flexibility (cm)	0.159	0.2260	0.091	0.4952

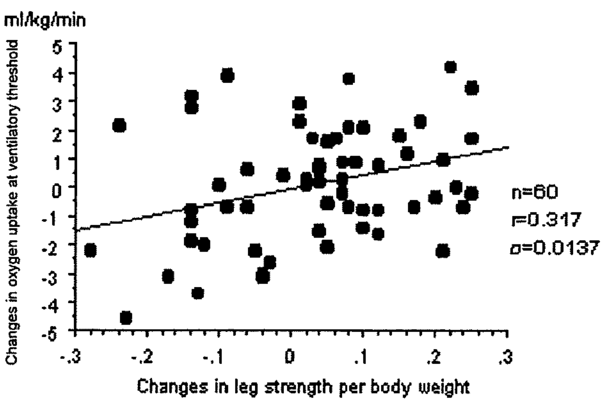

Fig. 4. Simple correlation analysis between changes in oxygen uptake at ventilatory threshold (per body weight) and changes in leg strength per body weight in Japanese women with 1-year follow up.

We further evaluated the relationship between changes in oxygen uptake at VT and changes in clinical parameters. Changes in oxygen uptake at VT (per body weight) were weakly correlated with changes in leg strength (r=0.260, p=0.0440), leg strength per body weight (r=0.317, p=0.0137) and leg strength per lean body mass (r=0.264, p=0.0430) (*Table 3*, Figure 4). Changes in oxygen uptake at VT (per lean body mass) were also correlated with leg strength parameters (Table 3).

Discussion

The main findings of this study were explored the link between changes in oxygen uptake at VT (per body weight) and changes in leg strength per body weight in Japanese women with a 1-year follow up.

Some cross sectional studies show that aerobic exercise level is significantly correlated with body composition and physical fitness parameters [24-26]. Wong et al reported that high cardiorespiratory fitness group had significantly lower abdominal circumference and less visceral adipose tissue [24]. Thigh skeletal muscle was closely associated with VO2peak and/or VT in both in men and women, and the decrease in VT with age was predominantly due to an age-related decline of skeletal muscle mass [25]. Neder et al also reported that maximal oxygen uptake was related to leg muscle mass and leg strength [26]. We also previously showed oxygen uptake at VT was significantly correlated with abdominal circumference [23] and leg strength per body weight [14] in Japanese. It seems reasonable to suggest that simply improving body composition and increasing leg strength per body weight might result in the amelioration of oxygen uptake at VT in some Japanese. However, these were cross sectional studies and the hypothesis that oxygen uptake at VT is closely linked to leg strength per body weight cannot be accurately proven.

In turn, no longitudinal studies have been carried out to prove a link between oxygen uptake at VT and leg strength per body weight in Japanese. In the present study, in a cross sectional analysis, oxygen uptake at VT was significantly correlated with body composition and leg strength per body weight as previous studies [24-26]. However, in a longitudinal analysis, changes in oxygen uptake at VT were not correlated with changes in body composition parameters such as body weight, BMI, abdominal circumference, hip circumference and body fat percentage. In addition, changes in oxygen uptake at VT (per body weight) were weakly correlated with changes in leg strength per body weight in Japanese women with a 1-year follow up. Our results solely suggest the clinical significance of increasing leg strength per body weight level for increasing oxygen uptake at VT. It is difficult for subjects with lower leg strength per body weight to support the entire body's weight; and also difficult for subjects with lower leg strength per body weight to carry out aerobic exercise i.e. walking and jogging. In addition, changes in oxygen uptake at VT (per lean body mass) were also correlated with changes in leg strength per lean body mass (r=0.307). Although aerobic exercise has been advocated as most suitable for reducing fat mass and increasing aerobic exercise level, it is important for subjects with lower leg strength per body weight to maintain or maximize the muscle strength of their lower limbs as well as to carry out aerobic exercise for reducing fat mass and increasing aerobic exercise level.

Potential limitations remain in our study. First, small sample size in our study makes it difficult to infer causality between oxygen uptake at VT and leg strength per body weight. Second, we could not accurately prove the mechanism of linkage between oxygen uptake at VT and leg strength per body weight. Third, we also could not investigate the relationship between free-living daily physical activity i.e. steps per day and oxygen uptake at VT. It is well known that a reduction in free-living daily physical activity was associated with a decrease in ambulatory ability [27]. Cao et al reported that maximal oxygen uptake was significantly correlated with physical activity determined pedometer-determined step counts [28]. Further prospective studies are needed in Japanese.

In conclusion, an increase in leg strength per body weight may be associated with increasing oxygen uptake at VT and both aerobic exercise and resistance training are necessary for prevention and improvement of age-related change in Japanese women.

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フィールド・レポート

岡山県南部健康づくりセンターにおける運動施設利用の実態とその問題点

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岡山県南部健康づくりセンターは，岡山市内から南西部郊外約10kmに位置し，平成9年の事業開始以来，運動，食事，休養を健康づくりの3つの柱として，岡山県民の健康づくりにかかわってきた[1]．特に，肥満，メタボリックシンドロームの予防，改善と高齢者，障害者の健康づくりを事業の中心としている[2,3]．当センターには，岡山県民が健康づくりを運動面から実践できるように，健康度測定（体力測定など）を行なうヘルスチェック室，ジム，プール，スタジオなどがあり，日々多くの県民が利用している．

今回，平成9年以来の当センター利用者の実態を明らかにし，運動施設の利用実態とその問題点を検討した．

1．対象と方法

当センターで，平成9年6月から平成19年3月までに，メディカルチェック（血液，尿検査），ヘルスチェック（健康度測定）を受診した男性4,651名（43.6±14.3歳），女性9,927名（42.9±14.3歳），計14,578名であった．ヘルスチェックは，当センター会員として安全に効果的に健康づくりに取り組んでもらうために必須となっており，データの解析は，データ欠損者を除きかつデータ利用についての同意が得られた男性4,410名（43.6±14.1歳），女性9,553名（42.5±14.1歳），計13,963名で，前述の期間のうちヘルスチェックを複数回受診の場合は1回目のデータを用いて平成19年4月1日の時点で行なった（表1）．

表1　本調査の対象

	男性	女性
人数	4,410	9,553
年齢（歳）	43.6±14.1	42.5±14.1
身長（cm）	169.0±6.2	156.3±5.6
体重（kg）	70.3±11.7	55.1±9.0
BMI（kg/m²）	24.6±3.7	22.6±3.6
腹囲（cm）	84.3±10.2	72.2±9.7
経過月数（月）	70.5±33.9	72.7±31.6

平均値±標準偏差

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表2　男女別利用回数，月当たり利用回数の比較

	男性	女性	p	年齢補正後p	年齢，経過月数補正後p
利用回数（回）	49.3 ± 142.2	36.9 ± 115.1	<0.0001	<0.0001	<0.0001
月当たり利用回数（回/月）	1.0 ± 2.6	0.6 ± 1.7	<0.0001	<0.0001	<0.0001

平均値±標準偏差

調査，評価を行なった項目は，年齢，身長，体重，BMI，腹囲，1回目ヘルスチェック受診からの経過月数，当センター運動施設利用回数，運動習慣の有無（1回30分，週2回，3カ月以上継続）であった．

結果は平均値±標準偏差で表し，有意差検定は対応のないt検定，ロジスティック回帰分析を用い，有意水準5%未満を有意とした．

なお，本調査の内容については岡山県健康づくり財団倫理委員会の承認を得た．

2. 結　果

男女別に利用回数，月当たり利用回数を比較すると（表2），平均利用回数は男性49.3回で女性の36.9回に比較して有意に高値で，ロジスティック回帰分析で年齢，年齢と経過月数でそれぞれ補正しても有意であった．なお，男性の最も多い利用回数は1,711回，女性は2,160回であった．平均月当たり利用回数は男性1.0回，女性0.6回で，男性が女性に比較して月当たり利用回数が有意に高値であった．また，ロジスティック回帰分析で年齢，年齢と経過月数でそれぞれ補正しても有意であった．

男女別，年代別に月当たり利用回数を比較した結果を表3に示す．男性では60歳代，女性は50歳代が最も月当たりの利用回数が多かった．男性では20，30歳代に比較して50，60，70歳代が有意に高値を示し，60歳代は40，50歳代に比較しても有意に高値を示した．女性では20歳代に比較して40，50，60歳代が，30，40，60，70歳代に比較して50歳代が有意に高値であった．

男女別，月当たり利用回数別に人数（%）を比較すると，男女とも圧倒的に月当たり利用回数1回未満が多く，男性3,576名（81.1%），女性8,210名（85.9%）であった（表4）．なお，男性で最も多い月当たり利用回数は25.5回，女性22.1回であった．

表3　年代別月当たり利用回数の比較

	人数	月当たり利用回数
男性		
20〜29	891	0.6 ± 1.6
30〜39	1,063	0.7 ± 1.9
40〜49	925	1.0 ± 2.4
50〜59	808	1.2 ± 2.8 [ab]
60〜69	570	1.8 ± 4.0 [abcd]
70〜79	153	1.5 ± 4.3 [ab]
女性		
20〜29	2,363	0.4 ± 1.0
30〜39	2,021	0.5 ± 1.4
40〜49	1,910	0.7 ± 1.9 [a]
50〜59	1,894	1.0 ± 2.4 [abc]
60〜69	1,148	0.7 ± 1.9 [ad]
70〜79	217	0.4 ± 1.1 [d]

a：p<0.05 vs 20〜29，b：p<0.05 vs 30〜39，c：p<0.05 vs 40〜49，d：p<0.05 vs 50〜59

1回目ヘルスチェック受診時の運動習慣の有無によるその後の利用回数，月当たり利用回数を比較したものを表5に示す．運動習慣ありと回答したのは男性1,540名（35.0%），女性2,529名（26.5%）であった．男女とも運動習慣ありの群が，なしの群に比較して有意に高値を示し，ロジスティック回帰分析を用いて年齢，年齢と経過月数でそれぞれ補正しても有意であった．

3. 考　察

今回，当センター利用者の運動施設利用実態を調査したところ，男性が女性に比較して月当たり利用回数が多く，男性では60歳代，女性では50歳代の月当たり利用回数が最も多かった．

表4 月当たり利用回数別人数

	男性 人数 (%)	女性 人数 (%)
0≦ <1	3,576 (81.1)	8,210 (85.9)
1≦ <2	292 (6.6)	621 (6.5)
2≦ <3	151 (3.4)	255 (2.7)
3≦ <4	95 (2.2)	134 (1.4)
4≦ <5	44 (1.0)	78 (0.8)
5≦ <6	59 (1.3)	54 (0.6)
6≦ <7	39 (0.9)	31 (0.3)
7≦ <8	18 (0.4)	29 (0.3)
8≦ <9	18 (0.4)	20 (0.2)
9≦ <10	16 (0.4)	21 (0.2)
10≦	102 (2.3)	100 (1.0)

表5 運動習慣別利用回数，月当たり利用回数の比較

	運動習慣あり	運動習慣なし	p	年齢補正後p	年齢，経過月数補正後p
男性					
人数	1,540	2,870			
利用回数（回）	69.8±181.5	38.3±114 2	<0.0001	<0.0001	<0.0001
月当たり利用回数（回/月）	1.3±3.2	0.8±2.2	<0.0001	<0.0001	<0.0001
女性					
人数	2,529	7,024			
利用回数（回）	53.7±156.8	30.9±95.0	<0.0001	<0.0001	<0.0001
月当たり利用回数（回/月）	0.8±2.2	0.6±1.6	<0.0001	0.0002	<0.0001

平均値±標準偏差

平成9年の国民栄養調査によると運動習慣者（1回30分以上の運動を週2回以上実施し，1年以上継続している人）は，男性28.6％，女性24.5％であった[4]．岡山県の平成11年県民健康調査によると，運動習慣者は男性27.1％，女性27.9％であった[5]．今回平成9年6月から平成19年3月までの間に当センターを利用した人を対象とした結果では，運動習慣者は男性35.0％，女性26.5％であった．男性は全国調査，岡山県の調査に比較して運動習慣者の割合は高く，女性ではほぼ同じ結果となった．当センター利用者は，自ら当施設に健康づくりに取り組もうとして来た人で，健康意識の高いことが予想されること，一般地域住民との関連が明らかでないこと，運動習慣の継続期間が全国調査に比較すると3カ月と短いことなどが影響していたと思われた．

運動療法，行動療法などを用いた生活習慣改善の意図的介入の報告では，継続率が比較的高い報告が多い[6〜8]．われわれも以前，肥満男性を対象とした週1回90分，1年間，運動施設を利用した運動プログラムの成果を報告したが，継続率は67％であった[9]．これらの報告は，比較的強い介入を行ない，調査期間は長くても1年間である．今回のわれわれの調査対象者は自らの意思で健康づくりに取り組もうと施設利用に来所し，メディカルチェック，ヘルスチェックの結果をもとに運動指導員からアドバイスを受けた人というバイアスのある集団であるが，調査期間は長い人で約10年と長期にわたっていたことは特筆すべき点と思われた．日本における民間運動施設の会員参加率は2005年が3.02％で（http://www.fitnessclub.jp/industry/budget/industry.htm，URLは2009年4月20日現在）運動習慣者の割合に比較するとかなり少ない状況である．また，当施設での調

査からも，利用者の月当たりの利用回数は1回未満が男女とも8割を超えており，継続した施設利用がなされていなかった．特に男女とも20，30歳代の比較的若い年代の方が月当たり利用回数が低かった．これらのことから，施設を利用した運動習慣の獲得および継続の難しさがうかがわれた．一方で，今回の調査から，月当たり利用回数の多かったのは，女性よりも男性，年代別では男性60歳代，女性50歳代と中年期の人，また，最初に運動習慣ありと回答した人であった．運動施設の立地，料金，営業時間，プログラム内容などさまざまな要因はあるものの，今後，運動施設を運動習慣獲得，継続のひとつの場，手段として活用するためには，特に若い人に対する継続のためのアプローチの方法の改善，施設利用初期におけるアプローチ方法の改善などが必要と思われた．

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