

Table 1
Tokyo Metropolitan Institute of Gerontology Index of Competence

1	Can you use public transportation (bus or train) by yourself?
2	Are you able to shop for daily necessities?
3	Are you able to prepare meals by yourself?
4	Are you able to pay bills?
5	Can you handle your own banking?
6	Are you able to fill out forms for your pension?
7	Do you read newspapers?
8	Do you read books or magazines?
9	Are you interested in news stories or programs dealing with health?
10	Do you visit the homes of friends?
11	Are you sometimes called on for advice?
12	Are you able to visit sick friends?
13	Do you sometimes initiate conversations with young people?

used for “information processing speed.” Verbal fluency was used for “executive function.” Time and place orientation from the MMSE was used for “orientation,” and delayed recall, also from the MMSE, was used for “episodic memory.”

Digit symbol substitution is comprised of a paper-and-pencil task. The participants receive a test sheet paper and are asked to do a timed translation of numbers to symbols using a cue given at the top of the test page and write as many symbols as possible into the empty boxes below each digit. The test is scored as the number of correct translations completed within 90 s, with a potential range of 0–93. The task evaluates the domain of “information processing speed,” which refers to the cognitive ability to quickly and accurately process newly input information from outside and retrieve materials held in memory storage (Barberger-Gateau et al., 1999).

Verbal fluency requires participants to generate aloud as many words as possible that belong to particular categories semantically and phonologically during a certain period of time. In this study, two tasks were administered as verbal fluency tasks. The participants were given 60 s to say as many words as possible belonging to the category of animals and beginning with the Japanese *kana* syllabary letter of “ka”. The task score was the number of acceptable words produced in the two tasks. For the domain of “executive function,” this test reflects a set of cognitive abilities involved in the planning, initiation, sequencing, and monitoring of goal-directed activities (Chaves et al., 2006).

Time and place orientation is comprised of summing up the number of correct answers to the 10 items of the “orientation to time and place” subscale of the MMSE. It thus has a score range of 0–10. The task assesses the domain of “orientation,” which reflects the mental ability to grasp basic circumstances and understand fundamental information like time and place in order to live independently.

Delayed recall is a subscale of the MMSE with a score range of 0–3 that records the number of objects correctly recalled. The task assesses the domain of “episodic memory,” which reflects the long-term memory storage system that deals with everyday experiences encoded in a particular time and place. It enables the conscious recollection of personal events and episodes from one’s personal past (Tulving, 1983).

2.4. Other measurements

Data for age, gender, the number of years of education, self-rated health, living alone, presence of chronic diseases, and depressive status (Sheehan et al., 1998), were used to describe the characteristics of the study participants. Self-rated health was scored from responses to the question, "Would you say your health in general is excellent, good, poor, or very poor?" Moreover, in the analysis these responses were dichotomized into two categories: "Excellent/Good" and "Poor/Very Poor." The presence of chronic diseases was defined as having at least one disease from among stroke, heart disease, and diabetes mellitus. Data for age, gender, the number of years of education, presence of chronic diseases, and depressive status were used as covariates in analyzing for independent associations between cognitive performance and functional decline.

2.5. Procedure

The participants took part in a face-to-face interview in a comprehensive health examination (*Otasha-Kenshin*) (Iwasa et al., 2007) at baseline and in a door-to-door interview in the follow-up period. Trained research assistants administered the instruments to obtain the data described above. The study was approved by the Ethics Committee of the Tokyo Metropolitan Institute of Gerontology. We were given access to the municipal resident registration files by the Itabashi ward authorities. The study was explained to all participants, and all were advised that: (1) their participation would be entirely voluntary; (2) they could withdraw from the study at any time; and (3) if they chose not to participate or to withdraw, then they would not be disadvantaged in any way.

2.6. Statistical analysis

To examine the relationships between cognitive function and functional decline, only subjects who had no functional dependency at baseline in each subscale of functional capacity (BADL and higher-level competence) were followed-up. "Functional decline" was defined as the new onset of functional dependency during the 4-year follow-up period.

Logistic regression analyses were performed to test the associations by each cognitive performance test. Crude odds ratio [OR] estimates and the confidence intervals [CI] corresponding to the four cognitive performance domains were initially computed, and then adjusted OR estimates controlling for age, gender, number of years of education, presence of chronic diseases, and depressive status were calculated. One OR unit in the cognitive tests corresponded to a 1S.D. decrease (9.9, 6.6, 0.8, and 0.9 points for information processing speed, executive function, orientation, and episodic memory in BADL decline model, respectively; 9.7, 6.7, 0.6, and 0.8 points for information processing speed, executive function, orientation, and episodic memory in higher-level competence decline model, respectively). All statistical procedures were performed using SAS Version 9.1 software (SAS Institute Inc., Cary, NC, USA).

Table 2
 Characteristics of participants at baseline ($N = 313$)

Age (mean \pm S.D.)	74.7 \pm 3.7
Gender (% women)	62.0
Number of years of education (mean \pm S.D.)	10.6 \pm 2.7
Living alone (%)	18.5
Self-rated health (% poor/very poor)	19.8
Presence of chronic diseases ^a (%)	19.2
Depression (%)	3.2
Information processing speed (mean \pm S.D.) ^b	37.6 \pm 9.9
Executive function (mean \pm S.D.) ^b	23.5 \pm 6.6
Orientation (mean \pm S.D.) ^b	9.6 \pm 0.8
Episodic memory (mean \pm S.D.) ^b	2.2 \pm 0.9
BADL dependent (%)	0
Higher-level competence dependent (%)	13.1

^a Presence of chronic diseases was defined as having at least one disease from among stroke, heart disease, and diabetes mellitus.

^b Actual range for information processing speed (6–70), for executive function (8–42), for orientation (6–10), and for episodic memory (0–3).

3. Results

Table 2 gives the characteristics of the members of the follow-up cohort (e.g., age, proportion of women, number of years of education, proportion of living alone, self-rated health, presence of chronic diseases, and proportion of depression), cognitive performance (information processing speed, executive function, orientation, and episodic memory) and functional capacity (BADL and higher-level competence) at baseline.

During the follow-up period, the number of participants who were classified as newly BADL decline was 19 (6.1%), and the number who were classified as newly higher-level competence decline was 83 (30.5%).

Table 3 shows the associations between cognitive performance and functional decline. Multiple logistic regression analyses, adjusted for the potential confounders cited above, showed that information processing speed (OR (for a 1S.D. decrease) = 2.22, 95% CI: 1.26–4.12) and orientation (OR = 1.59, 95% CI: 1.13–2.22) were associated significantly, independently, and inversely with BADL decline, and that information processing speed (OR = 1.45, 95% CI: 1.08–1.96) and executive function (OR = 1.38, 95% CI: 1.04–1.83) were related significantly, independently, and inversely to higher-level competence decline. Episodic memory was neither associated with BADL decline nor higher-level competence decline.

4. Discussion

The present study was conducted in order to examine the relationships among specific domains of cognitive function and longitudinal change in functional capacity among non-disabled, community dwelling older people. Our findings indicated that information processing speed and orientation inversely predicted BADL decline, and that information

Table 3
Crude and adjusted [OR] of I.S.D. decrease in cognitive performance to functional decline during a 4-year follow-up^{a,b,c}

	BADL (N = 313)						Higher-level competence (N = 272)					
	Crude model			Adjusted model ^a			Crude model			Adjusted model ^d		
	OR	95% CI	p	OR	95% CI	p	OR	95% CI	p	OR	95% CI	p
Information processing speed	2.56	1.51–4.55	<0.001	2.22	1.26–4.12	0.008	1.45	1.11–1.93	0.008	1.45	1.08–1.96	0.015
Executive function	1.39	0.86–2.35	0.192	1.34	0.82–2.31	0.263	1.36	1.04–1.79	0.028	1.38	1.04–1.83	0.026
Orientation	1.72	1.26–2.33	<0.001	1.59	1.13–2.22	0.007	1.23	0.96–1.59	0.095	1.22	0.95–1.58	0.123
Episodic memory	1.14	0.71–1.75	0.577	0.99	0.61–1.54	0.954	1.12	0.73–1.23	0.692	0.93	0.71–1.21	0.593

^a During the follow-up period, the number of participants who were classified as newly BADL decline was 19 (6.1%), and the number who were classified as newly higher-level competence decline was 83 (30.5%).

^b One OR unit in cognitive performance corresponds to a I.S.D. decrease (9.9, 6.6, 0.8, and 0.9 points for information processing speed, executive function, orientation, and episodic memory in BADL decline model, respectively; 9.7, 6.7, 0.6, and 0.8 points for information processing speed, executive function, orientation, and episodic memory in higher-level competence decline model, respectively).

^c Logistic regression analyses were performed by each cognitive performance test.

^d Adjustments for age, gender, number of years of education, presence of chronic diseases (stroke, heart disease, and diabetes mellitus), and depressive status were calculated.

processing speed and executive function also inversely predicted higher-level competence decline, when adjusted for potential confounders.

Information processing speed predicted both BADL decline and higher-level competence decline in this study, suggesting that information processing speed is a comprehensive predictor of longitudinal change in both high and essential levels of functional capacity in daily life. Owsley et al. (2002) examined cross-sectionally the relationship between three domains of cognitive measures (information processing speed, episodic memory, and reasoning) and functional capacity and found that only information processing speed was associated with the instrumental activities of daily living (IADL), which are comprised of higher-level competence activities, indicating that information processing speed is integral to the rapid and efficient performance of especially higher-level daily activities among the elderly. In addition, we also confirmed the relationship of information processing speed with BADL. It is well-known that information processing speed is also a good predictor of mortality (Swan et al., 1995) and is also associated closely with physical function performance (Owsley and McGwin, 2004), indicating that information processing speed might also maintain basic levels of daily activity. For these reasons, information processing speed is a comprehensive predictor of longitudinal change in both high and essential levels of functional capacity in daily life.

Executive function predicted only higher-level competence decline in this study, suggesting that executive function is a more important predictor of higher-level competence decline compared to BADL decline. Carlson et al. (1999) found in a cross-sectional study among the community elderly that executive function had a much closer correlation to IADL than to BADL. Additionally, Cahn et al. (1998) discovered in a cross-sectional study among patients with Parkinson's disease that there was only a relationship between executive function and IADL and not simple motor functioning like finger movements and finger tapping, in contrast, simple motor function, but not executive function, was found to be associated with BADL.

Orientation predicted only BADL decline in this study, suggesting that orientation may be more of a predictor of BADL decline than higher-level competence decline. Our finding is similar to the results of previous studies (Weiler et al., 1994; Gill et al., 1997). Orientation is a sign of the early stage of cognitive impairment (Solomon et al., 1998). Older people with cognitive impairment are likely to experience BADL decline (Aguero-Torres et al., 1998). Consequently, a low level of orientation is an indicator of the incidence of cognitive impairment and can predict BADL decline. On the other hand, a relationship between orientation and higher-level competence was not found in this study. These therefore indicate that orientation may be more of a predictor of BADL decline than higher-level competence decline.

Episodic memory predicted neither BADL decline nor higher-level competence decline in this study, suggesting that there is a possibility that episodic memory itself could be unimportant and employed not so much for daily life among the community elderly because of following three reasons. First, there are a few cross-sectional studies that did not find a significant relationship between episodic memory and functional capacity (Carlson et al., 1999; Cahn-Weiner et al., 2000; Owsley et al., 2002). Second, older people are likely to take notes to memorize information, and read recordings on

books and newspapers to recollect detailed information about past events in everyday life. Third, it is guessed that "prospective memory", which is concerned with memory function for future intentions, may be more reliable predictor of functional decline in daily life, compared to episodic memory. Ability to remember to do at the right time has important implications for older people's everyday functioning, because, for instance, failing to take medication or attend a medical appointment could potentially have very serious consequences (Crawford et al., 2006). On the other hand, there are previous studies that discovered a significant relationship between episodic memory and functional decline (Gill et al., 1997; Dodge et al., 2006). Thus, further detailed examinations of the relationship are needed.

The mechanism related to the association between the components of cognitive performance and functional decline was unable to be clarified in this study. Nonetheless, we can suggest two possible types of association between cognitive function and functional decline. First, cognitive functioning may be an indicator of the influence of the other critical risk factors for functional decline, such as physical and mental health status, socio-economic status, and social integration, etc. (Stuck et al., 1999). However, this possibility should be noted as being relatively weak as the present study managed to adjust for possible confounding factors in the association. Second, cognitive function may also have a direct effect on functional decline, namely, aging-related cognitive decline and the incidence of cognitive impairment may directly determine functional decline in old age. Regardless of the type of mechanism, however, in this study we could confirm that cognitive performance is a crucial predictor for functional decline, and, moreover, our findings are useful for the prevention of functional decline in health promotion settings of the community elderly.

Generalization from our findings is limited in one major way. There is the possibility that the representativeness of the data set may have been restricted because out of the 438 individuals who participated in the baseline survey, 116 (26.5%) did not take part in the follow-up survey due to reasons including death, loss of follow-up contact information, and declining to participate, etc.

5. Conclusion

This study longitudinally examined associations between specific domains of cognitive performance and functional decline among the community elderly. We found that information processing speed and orientation are reliable and inverse predictors of BADL decline, and that information processing speed and executive function are reliable and inverse predictors for higher-level competence decline. Further research is needed to better understand the mechanism involved in the relationships reported herein.

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都市部在住の高齢女性肥満者における老年症候群の有症状況および関連要因
—介護予防のための包括的健診—

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都市部在住の高齢女性肥満者における老年症候群の有症状況および関連要因 —介護予防のための包括的健診—

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要 約 目的：地域在住の高齢女性肥満者における老年症候群の有症状況を把握したうえで、体力、健康度自己評価、生活機能、既往歴の特徴および肥満関連要因を分析する。方法：平成18年11月に行ったお達者健診に参加した70歳以上の地域在住高齢者957名の中で、Body Composition Analyzer (InBody720)による身体組成の計測ができた925名のデータを分析した。身体組成のデータに基づいて体脂肪率30%未満を正常群、30~35%未満を軽度肥満群、35%以上を肥満群と定義した。3群間で聞き取り調査項目(転倒、尿失禁、高次生活機能など)および体力(筋力、バランス、歩行速度)を比較した。多重ロジスティック回帰分析法により肥満関連要因を抽出した。成績：3群間で有意差が見られた項目は、尿失禁の有症率(正常群35.4%、軽度肥満群41.1%、肥満群51.0%、 $P < 0.001$)であった。しかし、排尿回数(昼間、夜間)、尿失禁期間、過去1年間の転倒率、転倒恐怖感に有意差はなかった。高次生活機能の下位尺度の中で、手段的自立($P = 0.046$)、知的能動性($P = 0.009$)に3群間で有意差が見られ、肥満群で障害率は高かったが、社会的役割の障害には有意差が見られなかった。また、高血圧の既往、3種類以上の服薬、体の痛み割合および体脂肪量、腹囲、臀囲、下腿三頭筋周径の値は肥満群で高く、歩行速度(通常、最大)、開眼片足立ちの成績は肥満群で低かった。肥満は、高血圧の既往(オッズ比(OR) = 1.70, 95%信頼区間(CI) = 1.25~2.32)、体の痛み(OR = 1.46, 95%CI = 1.07~2.01)、尿失禁(OR = 1.44, 95%CI = 1.08~1.92)、SBP(OR = 1.02, 95%CI = 1.01~1.03)、通常歩行速度(OR = 0.43, 95%CI = 0.24~0.75)に関連していた。結論：高齢女性の肥満群に多くみられる尿失禁の有症、歩行機能やバランスの能力の低下、生活機能障害を改善するためには、日常生活における身体活動量の増大に結び付く生活習慣の形成が重要であることが示唆された。

Key words：高齢女性肥満、体脂肪率、老年症候群、体力

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緒 言

少子高齢化が着実に進む社会構造のなかで、元気な高齢者をいかに増やせるのかは大きな課題である。元気な高齢者を増やせるには、高齢者の生活機能の自立を阻害する要因を明らかにし、その改善策を立てることが重要な要素であろう。高齢者の生活機能障害に関連する要因は様々であるが、身体組成が深く関わっている^{1)~4)}ことに注目したい。加齢に伴う身体組成の重要な変化は、筋肉量の減少と脂肪量の相対的な増加である⁵⁾⁶⁾。これらの変化は高齢者の生活機能の自立と障害に強く関わっていることが多くの研究で指摘されている^{7)~9)}。とくに、筋肉量や除脂肪体重(fat-free mass, 以下FFM)が低下

する虚弱¹⁾は要介護状態になる主たる要因であることから⁸⁾、本邦では虚弱に関心が高まり、改善策が多く講じられている。高齢者の生活機能の障害に影響する要因は虚弱のみではなく、肥満も強く関わっているが、高齢期の肥満には関心が薄れている⁹⁾のが現状である。BMI、体脂肪率の増加は生活機能の障害¹⁰⁾および死亡率の増加¹⁰⁾のみではなく、歩行速度などの身体機能の低下¹¹⁾、尿失禁の危険因子¹²⁾¹³⁾であることが多数の研究で強調されているにも関わらず、本邦では高齢肥満についての検討は極めて限られている。

これらの背景を踏まえて、本研究では、地域在住高齢女性肥満者における老年症候群の有症状況を把握したうえで、体力、健康度自己評価、生活機能、既往歴の特徴および肥満関連要因を分析することを目的とした。

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方 法

1. 対象者の選定

平成18年9月に、研究の趣旨、目的、調査方法、参加への自由、資料の活用方法などについて詳細に記述した案内文を東京都I区の住民基本台帳より無作為で抽出した70歳以上の女性5,935名に郵送し、研究協力者を募集した。初回調査に1,119名が参加を希望、957名(85.5%)が受診、うち身体組成の計測ができた925名が本研究の対象者である。生活機能低下、転倒、尿失禁などの老年症候群の有症率は男性より女性で高く、介護が必要になった原因は男女で異なり、男性は脳卒中41.3%と最も多く、女性は虚弱18.5%、転倒・骨折13.4%と女性の方が老年症候群の影響を受けやすいことから⁸⁾、本研究では高齢女性に焦点を当てた。本研究は東京都老人総合研究所の倫理委員会の承諾を得て、参加者には個別的に研究の趣旨、目的、参加への自由、個人データの活用方法などについて詳細に説明したうえで、自筆の同意を得た後に、聞き取り調査、身体組成および体力測定を行った。参加者から調査拒否やデータ使用に同意しなかった者はいなかった。

2. 初回データの収集

1) 質問紙調査

個別面接法により過去1年間の転倒の有無、転倒の回数、骨折、転倒恐怖感、高次生活機能¹⁰⁾、外出頻度、尿失禁の有無、健康度自己評価¹¹⁾、体の痛み、服薬、既往歴、運動習慣、喫煙、飲酒などについて調査した。

2) 身体組成測定

多くの研究で採用されているBMIは正確な体脂肪を表すことができていない間接的な指標であると指摘され²⁾、本研究では多周波数(1 kHz, 5 kHz, 50 kHz, 250 kHz, 500 kHz, 1 MHz)の8電極法により左腕、右腕、胴体、左脚、右脚の抵抗値を基に体脂肪率、体脂肪量、FFMを求めるBody Composition Analyzer (InBody 720, Biospace)を用いて身体組成を計測した。詳細な原理および測定方法については他の論文に委ねる¹⁰⁾¹⁷⁾。体脂肪率30%未満を正常群、30~35%未満を軽度肥満群、35%以上を肥満群と定義した¹⁰⁾。

3) 形態および体力測定

(1) 形態

①身長：正面から見て、身長計の計測部が頭頂からずれていないことを確認し、対象者には踵、臀部、背中、頭を尺柱につけるように指示し、頭・腰・膝が良く伸びているかを確認したうえで、目盛りを真横から読み取って、0.1 cm単位で計測した。

②体重：対象者は体重計の中央部に描かれた足形の上に静かに乗り安定した値を0.1 kg単位で計測した。

(2) 周囲

- 腹囲：足を軽く開いて自然に立った状態で、肋骨下弓から腸骨稜の間時点点を計測した。メジャーが水平になるようにし、きつく絞めすぎないように注意した。
- 臀部：足を軽く開いて自然に立った状態で、臀部の最後方突出部を通る水平面の周径を計測した。
- 下腿三頭筋囲：椅子に両足を軽く開いて座り、下腿を正面から見て最も幅の広い部位を水平に計測した。

(2) 体力

①握力：人差し指の第2関節が直角になるように握力計の握り幅を調整し、示針は外側に、手は身体に触れないように腕を自然に伸ばした状態で、スمدレー式握力計(hand dynamo meter)を用いて利き手で2回測定し、良い記録を採用した(0.5 kg単位)。

②内転筋力(座位)：膝の角度が90°になるように椅子の高さを調整して座り、両膝を骨盤の幅に開いて、測定器のセンサ(μ TasMF-01, ANIMA, Japan)を両膝の内側に当て、両股で締める最大の力を2回計測し、高い値を採用した。

③開眼片足立ち：対象者は一辺40 cmの四角の範囲内で、視線の高さで前方1 mに設定された指標点を注視しながら腰に手を当て挙げやすい側の足を挙上し、片足立ちを保持するように指示し、挙上した足が床面に接した時、あるいは立脚した足が移動した時を片足立ちの終了とした。最大60秒までの時間を2回測定し、良い記録を採用した。

④歩行速度(通常、最大)：3 mと8 m地点にテープで印を付けた11 mの歩行路上で直線歩行を行い、体幹の一部(腰または肩)が3 m地点を越える時点から8 mを越える時点までの時間を計測した。通常歩行は「いつも歩いている速さで歩いて下さい」、最大歩行は「出来るだけ速く歩いて下さい」と被験者に指示した。試行は通常で1回、最大で2回行い、最大は2回中速いほうを採用した。

4) 血清アルブミン濃度

肘静脈から採血し血清を分離し、BCG法より求めた。

3. 解析方法

連続変数については、各項目別の平均値と標準偏差を求め、正常群、軽度肥満群、肥満群の平均値を比較するために一元配置分散分析を行い、有意差が見られた項目の多重比較はScheffe法を用いた。カテゴリ変数については、 χ^2 検定を行った。肥満に関連する要因を抽出するために、群間で有意差が認められた項目を独立変数に

表1 対象者における選択項目の特徴

変数	カテゴリー	% (n)
転倒	有	20.6 (191/925)
複数回転倒	有	28.8 (55/191)
転倒恐怖感	有	72.4 (670/925)
高次生活機能		
手段的自立の障害	有	5.6 (52/925)
知的能動性の障害	有	29.7 (275/925)
社会的役割の障害	有	40.5 (375/925)
外出頻度	1日1回以上	81.7 (756/925)
	2~3日に1回	16.7 (154/925)
	1週間に1回	1.2 (11/925)
	ほとんど外出しない	0.4 (4/925)
尿失禁の有無	有	43.0 (398/925)
健康度自己評価	不健康	20.5 (190/925)
体の痛み	有	66.2 (612/925)
入院歴	有	11.0 (102/925)
3種類以上の服薬	有	53.2 (492/925)
既往歴		
高血圧	有	50.8 (470/925)
脳卒中	有	5.0 (46/925)
心臓病	有	20.0 (185/925)
糖尿病	有	9.6 (89/925)
高脂血症	有	37.1 (343/925)
定期的な運動	していない	31.2 (289/925)

多重ロジスティック回帰分析を行った。解析は、統計パッケージ SPSS 15.0 for Windows および SAS 9.1.3 for Windows で行った。統計学的な有意水準は $P < 0.05$ に設定した。

成 績

参加者の諸特性を調べたところ (表1)、過去1年間で1回以上の転倒経験者 20.6%、尿失禁者 43.0%、手段的自立の障害者 5.6%、外出頻度が2~3日に1回以下者の割合 18.3%、健康度自己評価で不健康者 20.5%に見られた。既往歴では高血圧 50.8%、高脂血症 37.1%、心臓病 20.0%であった。

肥満群は正常群、軽度肥満群に比べて、体重、BMI、腹囲、臀囲、下腿三頭筋囲、血圧 (収縮期、拡張期)、体脂肪量の値は有意 ($P < 0.001$) に高く、歩行速度 (通常、最大)、開眼片足立ちの成績は有意 ($P < 0.001$) に低かった (表2)。

肥満群、軽度肥満群、正常群で有意差が見られた項目は、尿失禁、外出頻度、高血圧歴、3種類以上の服薬、体の痛み、手段的自立、知的能動性であった。肥満群では、尿失禁者、外出頻度が少ない者、高血圧既往者、3種類以上の服薬者、体の痛みを有する者、手段的自立の障害者、知的能動性の障害者の割合が高かった。

肥満に関連する要因を抽出するために多重ロジスティック回帰分析を施した (表4)。肥満には、高血圧既往 (オッズ比 (OR) = 1.70, 95% 信頼区間 (CI) = 1.25~2.32)、体の痛み (OR = 1.46, 95% CI = 1.07~2.01)、尿失禁 (OR = 1.44, 95% CI = 1.08~1.92)、SBP (OR = 1.02, 95% CI = 1.01~1.03)、通常歩行速度 (OR = 0.43, 95% CI = 0.24~0.75) が有意に関連していた。

考 察

多くの疫学調査結果によれば、高齢者における高い BMI あるいは高脂血症率は生活機能障害や移動障害との関連性¹¹⁻¹³⁾、死亡率の予知因子¹⁰⁾、活動量¹⁴⁾や体力の低下¹⁵⁾に影響することが報告されている。

まず、体力要素である。筋力の絶対量は肥満群が非肥満群より高値を示すが、筋の質 (筋量を調整した筋力) には差がないと指摘されている¹⁶⁾。本研究の結果では (表2)、上肢の静的筋力を推測する握力に3群間で有意差はなく、軽度肥満群の内転筋は正常群より高い値を示した。先行研究では肥満群で筋力の絶対値が高いと報告されているが、本研究ではこの傾向が観察されなかった。FFM 1 kg 当たりの筋力を求めて、筋の質を比較したところ、上肢の筋質 (握力) に正常群、軽度肥満群、肥満群で有意差は見られなかったが、下肢の筋質 (内転筋) は軽度肥満群 (0.64 ± 0.14 kg/kg) が正常群 (0.60 ± 0.14 kg/kg)、肥満群 (0.61 ± 0.14 kg/kg) より有意 ($P = 0.004$) に高い値を示し、本研究では軽度肥満群の筋質が優れていることが観察された。

次は、老年症候群の有症である。高齢期の生活機能の自立を阻害する要因として、老年症候群に関心が高まっているが、肥満と老年症候群との関連性についての情報は極めて限られている。肥満が尿失禁の危険因子であることは多くの研究で指摘されている^{10,12)}。肥満が尿失禁の危険因子になる理論的背景は、腹部の脂肪が増えることによって腹腔内圧が増え、腹壁重や腹腔内圧の増加は骨盤底筋群の負荷として働き、ひいては骨盤底筋の収縮力の低下につながる可能性が高まることである¹²⁾。肥満は尿失禁の予知因子であるが、肥満の解消は尿失禁の改善に有効であることが指摘されている¹²⁾。本研究でも肥満群に尿失禁の割合が高いことが観察され、先行研究の結果と類似した傾向が観察された。

最後に、生活機能障害である。男女高齢者における生活機能障害の予知因子を明らかにするために、横断データと縦断データを分析した報告によれば⁹⁾、横断データで脂肪と移動障害の関連性は男性 OR = 2.77 (95% CI: 1.82~2.85)、女性 OR = 3.04 (95% CI: 2.18~4.25)、縦

表2 正常群, 軽度肥満群, 肥満群の選択項目の比較

領域	項目	正常群 n = 315	軽度肥満群 n = 275	肥満群 n = 335	P値*	多重比較†
形態	年齢 (歳)	75.5 ± 4.0	75.4 ± 3.8	75.7 ± 4.1	0.618	
	身長 (cm)	149.7 ± 5.9	149.3 ± 5.3	148.3 ± 5.5	0.004	正 > 肥
	体重 (kg)	45.0 ± 6.2	51.1 ± 5.6	57.5 ± 7.2	< 0.001	正 < 軽度 < 肥
	BMI (kg/m ²)	20.1 ± 2.2	22.9 ± 1.8	26.1 ± 2.7	< 0.001	正 < 軽度 < 肥
	腹囲 (cm)	77.5 ± 5.7	84.7 ± 4.7	93.8 ± 7.3	< 0.001	正 < 軽度 < 肥
	臀囲 (cm)	86.1 ± 3.5	90.0 ± 2.9	94.2 ± 3.8	< 0.001	正 < 軽度 < 肥
	下腿三頭筋囲 (cm)	31.6 ± 2.4	33.3 ± 2.3	34.7 ± 2.7	< 0.001	正 < 軽度 < 肥
血圧	収縮期 (mmHg)	129.3 ± 20.3	134.5 ± 18.9	140.4 ± 19.4	< 0.001	正 < 軽度 < 肥
	拡張期 (mmHg)	71.2 ± 11.1	73.8 ± 9.8	76.7 ± 10.2	< 0.001	正 < 軽度 < 肥
身体組成	脈拍 (回/分)	75.1 ± 12.1	75.2 ± 10.7	77.4 ± 11.5	0.015	正 < 肥
	体脂肪率 (%)	24.6 ± 4.4	32.6 ± 1.5	39.5 ± 3.5	< 0.001	正 < 軽度 < 肥
	脂肪量 (kg)	11.2 ± 3.0	16.6 ± 2.1	22.9 ± 4.3	< 0.001	正 < 軽度 < 肥
体力	FFM (kg)	33.8 ± 4.0	34.4 ± 3.7	34.7 ± 3.7	0.015	正 < 肥
	握力 (kg)	18.8 ± 4.8	19.2 ± 4.1	18.5 ± 4.6	0.219	
	内転筋力 (kg)	20.6 ± 5.5	21.8 ± 5.0	21.0 ± 5.0	0.013	正 < 軽度
	通常歩行速度 (m/sec)	1.2 ± 0.3	1.2 ± 0.3	1.1 ± 0.3	< 0.001	正, 軽度 > 肥
	最大歩行速度 (m/sec)	1.8 ± 0.4	1.8 ± 0.4	1.7 ± 0.4	< 0.001	正, 軽度 > 肥
排尿	開眼片足立ち (秒)	41.4 ± 22.0	38.8 ± 22.7	29.1 ± 23.4	< 0.001	正, 軽度 > 肥
	昼間排尿回数 (回)	6.7 ± 2.2	6.8 ± 2.5	6.7 ± 2.2	0.770	
	夜間排尿回数 (回)	1.3 ± 1.1	1.3 ± 1.1	1.5 ± 1.2	0.110	
	尿失禁期間 (年)	4.2 ± 6.6	4.1 ± 5.9	4.7 ± 7.3	0.711	
血液	血清アルブミン (g/dl)	4.2 ± 0.2	4.3 ± 0.2	4.3 ± 0.2	0.002	正 < 軽度

* 一元配置分散分析

† 正 = 正常群, 軽度 = 軽度肥満群, 肥 = 肥満群

表3 正常群, 軽度肥満群, 肥満群の老年症候群有症率

項目		正常群	軽度肥満群	肥満群	P値
転倒 (%)	有	18.7	23.6	20.0	0.318
転倒恐怖感 (%)	有	71.9	71.6	74.0	0.758
尿失禁 (%)	有	34.9	42.5	51.0	< 0.001
尿失禁頻度 (%)	高	45.5	42.7	50.3	0.429
1回尿失禁量 (%)	多量	11.8	14.5	20.5	0.131
外出頻度 (%)	少ない	18.4	13.1	22.4	0.013
既往歴 (%)					
高血圧	有	36.8	53.1	62.1	< 0.001
脳卒中	有	2.9	7.6	4.8	0.028
心臓病	有	19.4	20.0	20.6	0.926
糖尿病	有	7.6	9.5	11.6	0.219
高脂血症	有	31.7	41.8	38.2	0.036
入院歴 (%)	有	10.8	8.7	13.1	0.221
3種類以上の服薬 (%)	有	47.9	53.8	57.6	0.046
体の痛み (%)	有	63.5	60.4	73.4	0.001
高次生活機能の障害 (%)					
手段的自立	有	3.5	5.1	8.1	0.037
知的能動性	有	26.0	26.5	35.8	0.009
社会的役割	有	39.4	40.4	41.8	0.818

断データで脂肪と3年後の移動障害の関連性は男性 OR = 1.72 (95% CI: 1.03~2.85), 女性 OR = 2.83 (95% CI: 1.80~4.46) と有意であったが, FFM と移動障害と

の関連性は見られなかったことから, 高齢者の移動障害の危険性を減らすためには脂肪量の増加を避けるべきであると強調している。一方, 身体活動量を増やせると

表4 高齢女性肥満に関連する要因

独立変数	オッズ比	95%信頼区間	P値
高血圧既往 (1:有, 0:無)	1.70	1.25 ~ 2.32	0.001
入院歴 (1:有, 0:無)	1.29	0.82 ~ 2.02	0.259
3種類以上の服薬 (1:有, 0:無)	0.92	0.66 ~ 1.26	0.587
体の痛み (1:有, 0:無)	1.46	1.07 ~ 2.01	0.018
尿失禁 (1:有, 0:無)	1.44	1.08 ~ 1.92	0.013
外出頻度 (1:少ない, 0:普通)	1.17	0.80 ~ 1.71	0.416
IADL 障害 (1:有, 0:無)	1.28	0.67 ~ 2.44	0.456
SBP (mmHg) (1単位毎に)	1.02	1.01 ~ 1.03	0.001
通常歩行速度(m/sec) (1単位毎に)	0.43	0.24 ~ 0.75	0.003

従属変数 (1 = 肥満, 0 = 非肥満)

IADL 障害リスクが低下することも報告されていることに注目したい²⁰。本研究では、IADL および知的能動性の障害率が肥満群で高い割合を示し (表3)、先行研究で指摘された結果と同様であった。肥満者の筋力、歩行機能、IADL 障害を改善するためには活動量の増加が必要不可欠であると強調されているが²¹、活動量には様々な要因が関わっていることから²⁰、体力レベルが低く、活動量が少ない²²肥満者の活動量を増やすのは容易なことではないと推測できる。

本研究で抽出された高齢女性の肥満に関連する要因は、体の痛み、高血圧の既往、収縮期血圧、尿失禁、歩行速度である。これらの要因の中には、身体活動を抑制する働きを持っている属性が多く含まれていることに着目し、その関連性についての考察を加えたい。

体脂肪率は体の痛みと密接に関わり、肥満群に痛みが多いこと²³や痛みを有する肥満者は心肺機能や歩行能力が有意に劣っていることが報告され²⁴、肥満者の痛みは身体活動を抑制する可能性が示唆された。

身体活動およびBMIの高低と高血圧発症との関連性について11年間追跡した調査結果によれば²⁵、身体活動量が増えるほど高血圧の危険率が下がり、BMIが高くなるほど高血圧の危険率が上昇するが、BMIの高低に関らず身体活動の予防効果が観察されたと報告している。以上のことから、肥満は高血圧の危険因子と挙げられるが、身体活動を活発に行うことによって、血圧が下がる可能性が示唆され、肥満者に身体活動の重要性が再度強調されたといえる。

尿失禁を有すると仕事、社会活動やスポーツ活動が制限されるとともに知人や友人との交流が減っていくことが指摘されている²⁶。これらの様々な活動の制限はエネルギー消費量の低下につながり肥満の主因になると考えられる。骨盤底筋運動を中心とする指導によって尿失禁が完治されると尿失禁者の活動制限や付き合いの支障が

顕著に改善されることが確認されている²⁷。尿失禁が完治されることによって社会活動およびスポーツ活動の再開、知人や友人との付き合い機会の増加などの活動量が増えることによって、エネルギー消費量が増大し、肥満の改善および生活機能障害の解消に結びつく可能性も推測できる。また、BMIの改善群に尿失禁の完治者の割合が高かったことから²⁸、BMIの増加抑制は尿失禁予防に有効であると推察される。

脂肪量は歩行機能と密接に関わり、脂肪量が多くなると歩行速度は低下し、移動障害は増える²⁹と指摘されている³⁰。本研究においても、肥満者の歩行速度 (通常、最大) は正常群および軽度肥満群より有意に遅いことが確認され、先行研究の主張と同様の結果が得られた。筋力とバランス能力は歩行機能の決定的な要素³¹であることから、肥満者の筋の質が非肥満者より劣っていることに加えてバランス能力が悪い状態の中で、肥満者の過剰脂肪が負荷として作用し、歩行速度の低下に深く関わっていると推測できる。人間の活動の基本である移動能力が低下すると日常生活の活動量が減り、活動量が減ると余剰のエネルギーが脂肪細胞内に蓄積しやすく、体重の過剰増加を誘発する可能性が考えられる。

以上のように、肥満に関連するこれらの要因の働きによって起こりうる身体活動量の減少は脂肪量の増加と筋肉量の低下を招き、筋肉量の低下は筋力や歩行機能の低下に結びつき、ひいては尿失禁の有症あるいは生活機能の障害が高くなることによって、さらに身体活動量が減っていく悪循環の構図が形成されていると推測できる。これらの問題点を解決するために、高齢肥満者の活動量を増やせる支援システムを構築するのが今後の課題といえよう。

本研究は幾つかの限界点がある。まず、尿失禁の有無、外出頻度、体の痛み、服薬状況は自己申告に基づく面接調査のデータを利用したものであり、客観的かつ臨床的な手法による十分な証拠の確保が出来なかったことである。2番目は、肥満に関連する要因の分析は、横断データを利用した結果であり、因果関係の分析が出来なかったことである。3番目は、高齢女性肥満に限った分析であり、高齢男性肥満に関する情報提供が出来なかったことである。

本研究の結果を解釈したところ、幾つかの課題が浮上してきた。まず、「軽度肥満」という用語が適切か否かである。軽度でも肥満という用語を使用した場合、健康状態や体力、健康関連意識とネガティブの関連性が浮かび上がることは事実である。本研究では「境界群」、「肥り気味群」を意味する用語として採用した。しかし、「痛み」、

「高次生活機能」, 「筋力」に正常群と有意差が観察されなかったことから, 「軽度肥満群」を正常群に含めて分析する方法も考えられ, 体脂肪率25.0%未満を「いそ群」, 25.0~35.0%未満を「正常群」, 35.0%以上を「肥満群」と定義するのも可能であるが, 科学的根拠を伴わないとの欠点がある。

次は, BMIと%Fatとの間に乖離する傾向が観察されたことである(表2)。この乖離は, 加齢とともに筋肉の量は減り, 脂肪量が増えていく高齢者の身体組成の特徴をBMIによっては正しく評価できなくなっている可能性が示唆されたと考えられる。最後に, 肥満者に限って老年症候群の有症状況を分析したことである。先行研究で, BMIと各種病態はU, 又はJ字型を示すことが指摘されている²⁰。本研究でも, 体脂肪率の分布と老年症候群の有症率との関連性を検討したところ, 「外出頻度が少ない者の割合」, 「IADLの障害」などの一部の症状でU字又はJ字型の分布が観察されたことから, 体脂肪の分布と老年症候群の有症率との関連性について, 今後詳細な検討が必要であろう。

これらの限界および課題を解決するための一層のデータ収集や追跡研究が必要といえる。

まとめ

都市部在住70歳以上の高齢女性925名のデータを分析した結果, 体脂肪率35%以上の肥満者は36.2%と高かった。肥満者は歩行機能やバランス能力は低く, 尿失禁の有症, 体の痛み, IADLおよび知的能動性の障害者の割合は高かった。高齢女性の肥満には, 高血圧の既往, 体の痛み, 尿失禁, SBP, 通常歩行速が有意に関連していた。これらの結果より, 肥満の予防および肥満者に多くみられる尿失禁, 生活機能障害を改善するためには, 日常生活における身体活動量の増大に結び付く生活習慣の形成が重要であることが示唆された。

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Prevalence of geriatric syndrome and risk factors associated with obesity in community-dwelling elderly women

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Abstract

Aim: To evaluate the prevalence of geriatric syndrome and risk factors associated with obesity in community-dwelling elderly women.

Methods: The baseline survey was conducted in November 2006. Subjects were 925 women aged 70 years and older who participated in a comprehensive health examination which included a face-to-face interview, body composition, and physical fitness tests. The participants were classified, based on percentage of body fat, as normal (<30.0), mild obesity (30.0 to 34.9), and obesity (≥ 35.0) groups. To evaluate the differences among the groups with regard to the physical fitness and the interview data, one-way analysis of variance performed for continuous variables and the chi-square test for categorical variables. Multivariate logistic regression models were used to assess the factors associated with obesity in elderly women.

Results: Although obese women had a higher prevalence of urinary incontinence than the normal and mild obese women, there were no significant differences in history of falls during the last year, or fear of falling. A high percentage of body fat was significantly associated with a higher level of instrumental activities of daily living (IADL) and intellectual activity disability, use of 3 or more medications, pain, and circumference (abdominal, hip, calf), and was associated with a lower level of balance and walking ability. According to the logistic model, history of hypertension (odds ratio (OR) = 1.70, 95% confidence intervals (CI) = 1.25-2.32), pain (OR = 1.46, 95% CI = 1.07-2.01), urinary incontinence (OR = 1.44, 95% CI = 1.08-1.92), SBP (OR = 1.02, 95% CI = 1.01-1.03), and usual walking speed (OR = 0.43, 95% CI = 0.24-0.75) were independent variables significantly associated with obesity.

Conclusions: These cross-sectional data show that a higher percentage of body fat is associated with high prevalence of urinary incontinence, IADL and intellectual activity disability, and is related to lower level of walking ability and balance. The present study suggests that regular physical activity and weight control may contribute to the prevention of IADL disability and improvement of physical fitness in obese elderly women.

Key words: *Obese elderly women, Percent body fat, Geriatric syndrome, Physical fitness*
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Low Serum 25-Hydroxyvitamin D Levels Associated With Falls Among Japanese Community-Dwelling Elderly

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Low Serum 25-Hydroxyvitamin D Levels Associated With Falls Among Japanese Community-Dwelling Elderly

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ABSTRACT: Previous studies have shown that low serum 25-hydroxyvitamin D [25(OH)D] level is a risk factor for falls among the elderly in European and North American populations. We used a cross-sectional community-based survey to study the association of serum 25(OH)D level and falls among Japanese community-dwelling elderly. A total of 2957 elderly persons (950 men and 2007 women) 65–92 yr of age who participated in mass health examinations for the prevention of geriatric syndrome for the elderly underwent an interview, blood analysis, and physical performance testing. Experience of falls over the previous year was assessed in an interview. Physical performance tests of handgrip strength, stork standing time with the eyes open, and normal waking speed as risk factors for falls among the elderly were conducted. Serum albumin and 25(OH)D concentrations were analyzed. Mean 25(OH)D concentration was significantly lower in women than in men ($p < 0.001$). Women showed a significant decline of 25(OH)D level with increased age ($p < 0.001$). There was also a significant difference in the prevalence of 25(OH)D insufficiency [25(OH)D level < 20 ng/ml] between the sexes ($p < 0.001$). The rate of falls was significantly higher in the lowest quartile of 25(OH)D level in women ($p = 0.02$) and in women with 25(OH)D insufficiency ($p = 0.001$). Women also showed significant declines in all three fall-related physical performance tests. Multiple logistic regression analysis showed significant and independent associations between 25(OH)D level and experience of falls in women only ($p = 0.01$). Low 25(OH)D level was significantly associated with a high prevalence of falls in Japanese elderly women because of their inferior physical performance. Low serum 25(OH)D levels appear preventable and easily treated; there is an evident need for greater awareness to screen and thus prevent this condition.

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Key words: 25-hydroxyvitamin D, fall, physical performance, community elderly

INTRODUCTION

THE IMPORTANCE of vitamin D for skeletal health is well known.^(1,2) Through the regulation of calcium and phosphorus levels in the blood by promoting their absorption from food in the intestines, vitamin D promotes bone formation and mineralization for the development of a strong skeleton. Vitamin D deficiency, which can result from inadequate intake coupled with inadequate sunlight exposure, plays an important role in the development of osteoporosis because of the induction of a secondary hyperparathyroidism that mobilizes calcium from the bone.

Vitamin D deficiency results not only in impaired bone mineralization, but also in myopathy in the elderly.^(3,4) It has also been shown recently to be associated with a decline of muscle strength,^(5–8) sarcopenia,⁽⁷⁾ and functional limitations and disability,^(5,8) and probably because of these phenomena, with falls in the elderly.^(9–11) We have studied and reported that concomitant low serum 25-hydroxyvitamin D [25(OH)D] and albumin were associated with decreased objective physical performance among Japanese

community-dwelling elderly from a nutritional point of view.⁽¹²⁾ However, falls were not taken into account in the previous study.

The aim of this study was to investigate the association between serum 25(OH)D levels and falls, and the associated physical performance among community-dwelling Japanese elderly who in some previous studies have been reported to have stronger muscle strength and lower fall rates than whites.^(13,14) We hypothesized that low 25(OH)D levels (1) correlate with poor muscle strength, balance, and walking capability and (2) are consequently associated with the occurrences of falls among community-dwelling Japanese elderly.

MATERIALS AND METHODS

Subjects

The participants were 2957 residents (950 men and 2007 women) ≥ 65 yr of age living in Itabashi ward in Tokyo, Japan, who had participated in mass health checkups for the community elderly (Otasha-Kenshin) conducted in October/November 2004 and 2005. Otasha-Kenshin, which means "health checkups for successful aging" in Japanese, is a comprehensive mass health examination for commu-

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nity-dwelling elderly that aims to prevent "geriatric syndrome" including falls and fractures, incontinence, poor oral health, mild cognitive impairment, depression, and undernutrition. The overall aim is to prevent the loss of independence and the need for long-term care in later life. Details of Otasha-Kenshin, including participant details, investigation methods, and its contents, have been described in our earlier papers.⁽¹⁵⁻¹⁷⁾ None of the subjects analyzed in this study had a history of malignant diseases, current treatment of vitamin D, chronic renal failure, or other serious diseases affecting vitamin D regulation. All participants were essentially ambulatory, lived independently in their homes, and had sound functional capacity. Participants provided written informed consent to participate in the study, which was approved by the Institutional Review Board and Ethic Committee of the TMIG (Accepted No. 5, July 1, 2004).

Data collection

Interviews were conducted to assess the age, physical activity, and chronic disease conditions of subjects. History of chronic diseases was self-reported and included hypertension, stroke, heart disease, diabetes, and renal failure. Heart disease included angina pectoris, acute myocardial infarction, congestive heart failure, and various arrhythmias. Renal failure was defined as chronic renal failure under treatment including hemodialysis, which can affect the regulation and metabolism of serum vitamin D levels.

We also assessed fall experience over the previous year. A fall was defined as an unintentional change in position resulting in coming to rest at a lower level or on the ground. The subjects were asked about their falls in the same manner as in our previous study.⁽¹⁸⁾ That is, they were asked the question, "Have you experienced any falls during the previous 12 months?" Those who reported one or more falls were asked about the circumstances and consequences of each fall (i.e., the time, reason and place of the fall, the presence or absence of injury, and whether they visited a doctor).

Previous population-based studies have confirmed that physical performance characteristics, including those based on handgrip strength, stork standing time with the eyes open, and normal walking speed, are risk factors for falls among the community elderly in Japan.⁽¹⁸⁻²⁰⁾ Moreover, these three variables have also been confirmed by a covariance structure model as the essential factors underlying physical performance measures for Japanese elderly living in a community.⁽²¹⁾

Handgrip strength

The peak handgrip force (kg) of each hand was measured by Smedley's hand dynamometer (Yagami, Tokyo, Japan). The test was performed twice, and the higher of the two measurements made on the dominant hand was recorded.

Stork standing

While standing on a square (0.4 × 0.4 m), each subject stood on one foot while watching a point set at eye level 1 m away and tried to maintain this posture. A stopwatch

measured the duration in seconds, up to a maximum of 1 min, and the longer of two attempts was recorded.

Normal walking speed

A flat walking path of 11 m was marked with tape at the 3- and 8-m points. A stopwatch measured the time taken to walk 5m, from the time when a foot first touched the ground after the 3-m line to when a foot touched the ground after the 8-m line. The participants were asked to take the test by walking at their normal or preferable speed. The test was repeated and the faster speed recorded.

Because of the possibility of a high correlation among the three physical performance tests, after confirmation by Pearson's correlation coefficient (*r*), normal walking speed was selected as the representative independent variable for the multiple logistic regression model.

Measurement of serum levels of albumin and 25(OH)D

Blood samples were collected in a nonfasting state and in a sitting position. Analyses were carried out centrally in one laboratory (Special Reference Laboratories, Tokyo, Japan). Serum 25(OH)D levels are commonly used as a measure of vitamin D status,⁽²²⁻²⁴⁾ and these were measured with an RIT 2 kit (Dia Sorin, Stillwater, MN, USA). The RIT 2 method is based on an antibody specific to 25(OH)D; using this method, the CV was <1%. We summarized the serum 25(OH)D levels of these subjects into quartiles, and used the 25 percentile cut-off to compare groups of subjects with higher and lower 25(OH)D. Lower serum 25(OH)D was defined as 25.0 ng/ml (62.5 nM) or below for men and 21.0 ng/ml (52.5 nM) or below for women. For a definition of vitamin D insufficiency, based on studies performed in the United States and Australia^(25,26) showing that a serum 25(OH)D level of at least 15–20 ng/ml is needed to achieve optimum PTH levels, we defined a 25(OH)D level of <20 ng/ml as insufficiency.

Statistical analysis

All data were analyzed with SPSS software for Windows, version 13.0 (SPSS, Chicago, IL, USA); the level of significance was set at 5%.

Means and SDs (for continuous variables) along with proportions (for categorical variables) were calculated for all participants. Differences between men and women were assessed using *t*-tests for continuous variables and χ^2 tests for categorical data. Differences in serum 25(OH)D levels were analyzed among the four age groups by one-way ANOVA in both sexes. Furthermore, comparisons of fall-related variables by 25(OH)D level were performed using analysis of covariance (ANCOVA) controlled for age in continuous variables, and Mantel-Haenszel χ^2 tests were used to adjust for age in categorical variables in both sexes.

To analyze the association of serum albumin and 25(OH)D level with physical performance (i.e., handgrip strength, stork standing time with the eyes open, and normal walking speed), multiple regression analysis was conducted with age adjustment. To study the association of falls and 25(OH)D levels, logistic regression analysis was

TABLE 1. CHARACTERISTICS OF STUDY PARTICIPANTS

Characteristics	Male (n = 950)	[Min-Max]	Female (n = 2007)	[Min-Max]	p
Age (yr, mean \pm SD)	74.5 \pm 5.1	[65-89]	75.4 \pm 4.7	[65-92]	<0.001*
Fall experience over the previous year (yes, %)	103 (10.8)		372 (18.5)		<0.001†
Hand grip strength (kg, mean \pm SD)	31.4 \pm 6.6	[10-52]	18.8 \pm 4.6	[1-38]	<0.001*
Stork standing time with eyes open (s, mean \pm SD)	37.1 \pm 22.5	[1-95]	35.8 \pm 23.3	[1-88]	0.152*
Normal walking speed (m/s, mean \pm SD)	1.23 \pm 0.26	[0.40-2.08]	1.18 \pm 0.29	[0.15-2.00]	<0.001*
Serum albumin (g/dl, mean \pm SD)	4.35 \pm 0.23	[3.4-5.0]	4.31 \pm 0.21	[3.3-5.0]	<0.001*
Serum 25(OH)D level (ng/ml, mean \pm SD)	28.5 \pm 5.0	[8-42]	24.2 \pm 4.9	[9-38]	<0.001*
Age group	(n)		(n)		
65-69	(173) 28.4 \pm 4.5		(163) 26.8 \pm 3.8		
70-74	(314) 28.5 \pm 5.3		(763) 24.2 \pm 4.6		
75-79	(320) 28.6 \pm 4.9		(675) 24.0 \pm 5.1		
80+	(143) 28.4 \pm 5.5	<i>p</i> = 0.97‡	(406) 23.6 \pm 5.3	<i>p</i> < 0.001†	
Quartile [cut-off value of 25(OH)D for each percentile]	(ng/ml)		(ng/ml)		
25 percentile	25.0		21.0		
50 percentile	29.0		24.0		
75 percentile	32.0		28.0		
Insufficient (<20 ng/ml, %)	4.8		17.7		<0.001†

* Student's *t*-test for continuous variables between males and females.

† χ^2 test for categorical variables between males and females.

‡ ANOVA in both males and females.

conducted using "fall experience over the previous year" as a dependent variable and other variables [age, physical performance test, serum albumin, and 25(OH)D levels] as independent variables.

RESULTS

The basic characteristics of the subjects, including age, handgrip strength, stork standing with the eyes open, normal walking speed, serum albumin level, and 25(OH)D level, are shown in Table 1. Mean ages were 74.5 \pm 5.1 yr in men and 75.4 \pm 4.7 yr in women (*p* < 0.001). Concerning fall experience, the numbers (percentage) of individuals who experienced a fall over the previous year were 103 (10.8%) in men and 372 (18.5%) in women. The prevalence of falls was significantly higher in women than men ($\chi^2 = 28.30$, *p* < 0.0001). The number of falls varied from one to five. Sixty-one men (59.2%) and 259 women (69.8%) had experienced only one fall, whereas 42 men and 113 women had recurrent falls of two or more times. The predominant cause of falling was "tripping" in both sexes, followed by "slipping" and "missing a step." The consequences of falling, that is, the conditions of injury, were clearly different between men and women. Although "bruise" (38.7%) and "scratch" (26.1%) were frequent among women, "no injury" accounted for nearly one half (44.7%) of men.

The mean 25(OH)D concentrations were 28.5 \pm 5.0 ng/ml in men and 24.2 \pm 4.9 ng/ml in women (*p* < 0.001). Only in women was there a significant decline of 25(OH)D concentration with increasing age by ANOVA (*p* < 0.001). Forty-six (4.8%) men and 356 (17.7%) women had a 25(OH)D level of <20 ng/ml (50 nM; *p* < 0.001).

Comparisons of the rate of fall experience over the previous year, average number of falls, physical performance tests, and serum albumin levels are shown in Table 2. Subjects who were judged as not appropriate for the tests be-

cause of high blood pressure, heart failure, lumbago, knee pain, etc., were excluded from the physical performance tests. Thus, the total number of subjects who underwent the physical performance tests was 2837 (917 men and 1921 women) in the handgrip strength test, 2519 (792 men and 1727 women) in the stork standing test, and 2044 (455 men and 1589 women) in the normal walking speed test. First, comparisons were conducted between the lowest quartile group (≤ 25.0 ng/ml in men and ≤ 21.0 ng/ml in women) and the higher groups. Both hand grip strength and stork standing time were significantly different in men, and all of the measurements were significantly different in women. Furthermore, for women only, the rate of fall experience and average number of falls were significantly higher in the lowest quartile group compared with the other groups (*p* = 0.02 for the rate and *p* = 0.021 for the number). Second, comparisons were conducted between the 25(OH)D insufficiency group (<20 ng/ml) and the normal group (≥ 20 ng/ml). Hand grip strength and serum albumin level in men, and all measurements except hand grip strength in women, were significantly different between these two groups. Stork standing time, normal walking speed, and serum albumin level were significantly lower in the 25(OH)D insufficiency group. As for rate of fall experience and average number of falls, only women showed that the 25(OH)D insufficiency group had a significantly higher rate (*p* = 0.001) and average number (*p* = 0.006) of falls than the normal group.

Table 3 shows the associations of serum concentrations of albumin and 25(OH)D with physical performance tests by multiple regression models adjusted for age. Serum 25(OH)D level showed significant association with all three variables in the physical performances of both men and women. However, serum albumin level showed significant association only with handgrip strength in both sexes.

Calculations of Pearson's correlation coefficient (*r*) were