表2　男女別要介護者の背景ならびに併存症

	男性	女性	p
基本的 ADL（range：0～20，mean（SD））*	12.6（6.3）	12.8（6.8）	0.496
GDS-15（range：0～15，mean（SD））*，†	6.8（3.7）	6.4（3.6）	0.064
Charlson index（mean（SD））*	2.4（1.6）	1.8（1.5）	＜0.001
定期的受診（%）	61.7	58.4	0.164
服薬薬剤数（%）			
0～2種類	16.5	24.7	
3～5種類	43.8	40.9	＜0.001
6種類以上	39.7	34.4	
慢性疾患の有無（%）			
冠動脈疾患	12.3	12.1	0.888
慢性心不全	7.5	9.0	0.278
脳血管障害	46.6	28.3	＜0.001
慢性閉塞性肺疾患	9.9	5.9	0.003
糖尿病	13.2	11.4	0.280
認知症	31.7	37.0	0.031
高血圧	21.8	25.5	0.080
悪性腫瘍	12.9	7.3	＜0.001
転倒歴（過去半年間）（%）	32.3	32.2	0.965
骨折歴（過去5年間）（%）	14.7	27.4	＜0.001

*：student t-test，それ以外はカイ二乗検定
†：n＝1,409

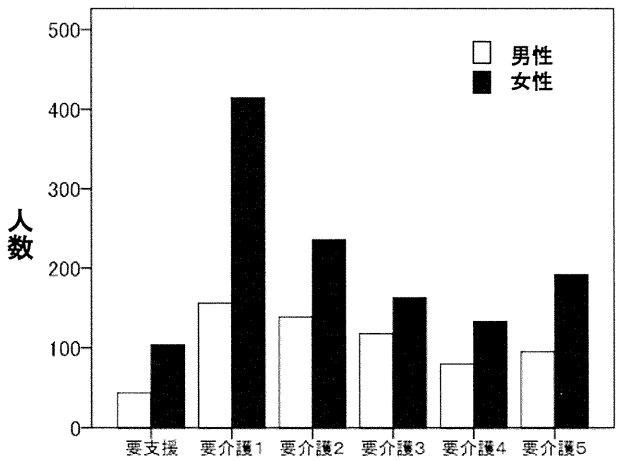

図1　男女別登録者の要介護度分布

解析では1.19（0.73～1.93）と男性要介護者との有意な差は消失した（表4）．なお性差に要介護者年齢のみを調整因子として投入したモデルでも女性の入所リスクは1.30（0.87～1.93），p＝0.195と有意差は消失していた．

考　察

高齢社会白書にあるように本コホートにおいても登録された要介護者は女性が男性のほぼ2倍を占めた．障害を持ちながらも居宅サービスを使用し，独居を継続している集団が存在したが，この集団は明らかに女性が多く，男性に比較し要介護認定を受けていながらでも自立した生活が女性では可能である場合が多い．このことは女性が元々身の回りのことを自分で長年こなしてきたという反面，男性は配偶者（妻）に若い時より依存して生活をしてきたため，独居での生活が困難であるケースが多い，ということを表している可能性がある．厚生労働省「国民生活基礎調査」（平成19年）でも男性高齢者の独居率は10%前後である一方，女性高齢者では20～25%と高率である[9]．

男性要介護者は主介護者が配偶者（妻）であるケースは73.6%と高率であった半面，女性要介護者で主介護者が夫であるケースは22.1%と低かった．これは男性の方が短命であり，女性が要介護状態になった時点で，すでに夫が他界，または夫も要介護状態である場合が多いこと，さらには男性配偶者（夫）は妻の介護をすることが困難である（しない），ということを表しているのかもしれない．実際，総務省「国勢調査」では，男性高齢者は配偶者と生活しているものは平成17年の調査で81.8%，女性では47.1%と女性高齢者の約二人に一人は「配偶者なし」と報告されている[9]．すなわち要介護状態になる以前より高齢者女性は配偶者と生活をしている数が男性高齢者より少ないことを意味している．これらの独居率さらには主介護者が配偶者である割合の性差は日本固有のものではなく，他の国でも同様との報告がなされているため[10]，世界的に共通の事象なのかもしれない．

表3　男女別3年間に観察された各種イベントの発症率

各種イベント	男性		女性		
	人数	%	人数	%	p
全死亡	198	31.3	256	20.6	＜0.001
在宅死亡	36	5.7	71	5.7	0.989
入院	307	48.6	496	39.9	＜0.001
介護施設への入所	33	5.2	105	8.4	0.011

全てカイ二乗検定

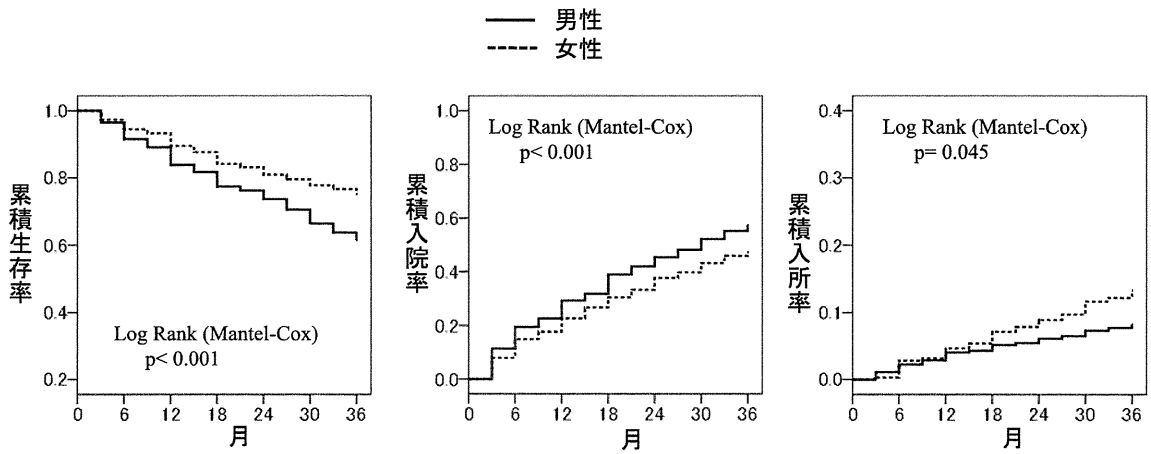

図2　男女別，累積生存率，累積入院率，累積入所率（Kaplan-Meier のプロット）

表4　女性の種々のイベントに関するリスク（Cox 比例ハザード・モデル）

	univariate			multivariate		
	HR	95%CI	p	HR	95%CI	p
生命予後						
女性（vs 男性）	0.61	0.51 ～ 0.74	＜0.001	0.51	0.39 ～ 0.66 *	＜0.001
入院						
女性（vs 男性）	0.76	0.66 ～ 0.88	＜0.001	0.83	0.69 ～ 0.99 *	0.042
入所						
女性（vs 男性）	1.48	1.00 ～ 2.19	0.048	1.19	0.73 ～ 1.93 **	0.485

HR：Hazard ratio；95%CI：95% confidence interval
*：性，年齢，基本的 ADL score，GDS-15 score，Charlson index をモデルに投入
**：性，年齢，基本的 ADL score，介護者年齢，主介護者 ZBI をモデルに投入

全米調査では女性の要介護者の独居率は男性に比較し有意に高く（女性：45.4%，男性 16.8%），本調査と同様に配偶者と生活している率は男性で高い（男性：73.6%，女性：27.8%）ことが報告されている[10]．

居宅介護サービスの使用に関しては，本調査時期と比較的近い平成 14 年の厚生労働省の報告によると，全国の居宅サービス利用者総数あたり，訪問介護利用率が最も多く 41.5%，通所介護（デイサービス）が 38.7%，通所リハビリテーション（デイケア）が 20.8%，訪問看護サービス 13.3%，短期入所（ショートステイ）8.6% とある[11]．本コホートでは訪問看護サービス使用が男性 56.2%，女性 48.0% と明らかに利用率が高い．これは本研究対象者が訪問看護ステーションを基盤に登録をされたためである．本調査では訪問介護サービス使用率が男性より，女性要介護高齢者に多かった．このことは一見矛盾するように思えるが，男性要介護者の主介護者の多くは配偶者（妻）であるため，家事援助などの訪問介護サービスの使用が不必要である．一方女性要介護者では配偶者（夫）はすでに存在していないか，または主介護者として存在しているにも関わらず，充分な家事が実行

されていないため，訪問介護サービスの使用が多いと思われる．基本的ADLは両群で差を認めず，男女間で身体機能障害の大きな差はなかった．同様に平均GDS-15得点は男女差を認めなかったが，Charlson comorbidity indexは男性で高得点であり，より生命予後に係る併存症の集積が男性に認められた．実際悪性腫瘍，慢性閉塞性肺疾患，脳血管障害の有病率は男性でより高かった．認知症の有病率は女性で高かったが，女性のほうがより高齢であることが関与しているものと推測された．一方過去半年間の転倒歴に関しては男女差を認めなかったが，過去5年間の骨折の既往に関しては，他の報告と一致し[12]，女性で多かった．これらの結果は厚生労働省「国民生活基礎調査」(平成19年)の男女別の要介護にいたった原因疾患の結果を反映している．すなわち男性では脳血管障害が要介護の原因疾患として最も多く（35.9%），女性は脳血管障害（16.8%），関節疾患（15.9%），認知症（15.0%），骨折（11.1%）と原因が分散している[9]．

3年間のイベント調査では，予測されたとおり男性で死亡，入院というイベントが女性に比較し高率であり，明らかにそれらのリスクは女性で低かった．女性の方がより高齢集団であることを考えると興味深いことであるが，男性の方がより重度な併存症を背景に所有していることが関連している可能性がある．しかし，Cox比例ハザードモデルではCharlson index，年齢，ADL，GDS-15などを組み込んだモデルでもなお女性のリスクが有意に低かったことより，併存症などの背景の相違だけでは説明が困難である．なお，在宅での死亡（看取り），病院死を別々に解析してもリスクの性差は全死亡と同様な傾向を示した．一方介護施設への入所は女性で高かったが，その理由としては女性の方がより高齢であることが関与している可能性がある．実際，年齢を組み込んでCox比例ハザード解析を行うと，要介護者の性別は介護施設入所との関連を認めなかった．

本研究の限界としては，本研究で使用した登録者は方法にあるように，訪問看護サービス使用者ならびに看護サービス未使用者としてリクルートしているため，介護保険サービス使用率に関しては偏りがある可能性がある．また1,875名のうち3年間で脱落（訪問看護サービス（ケアプラン作成）の使用中止）が男性で90名，女性で168名存在しており，さらに介護施設入所した対象者はその時点で追跡を中止しており，死亡の数自体が低く見積もられている可能性がある．

本研究において，性別による疾病背景，介護環境，介護保険サービスの使用状況，健康障害（生命予後，入院などのイベント），介護施設入所リスクなどに相違があることが明らかになった．今後医療関係者，福祉関係者は性別による様々な相違を考えながら，医療，介護保険サービスなどの使用を実施すべきである．

謝辞：本調査は名古屋市高齢者療養サービス事業団の多大な協力の下行われたものである．名古屋市高齢者療養サービス事業団の関係者ならびに各訪問看護ステーションの看護師，介護支援専門員のみなさんの多大なご協力に対し深謝いたします．またご協力いただいた患者さまならびにご家族の方々にも深謝いたします．また本解析を行うきっかけをいただいた国立長寿医療センター研究所疫学研究部下方浩史先生に感謝いたします．なお本研究の一部は平成21年厚生労働省科学研究費補助金（循環器疾患等生活習慣対策総合研究事業）「ライフステージに応じた女性の健康状態に関する疫学研究～10代から90代までの女性を対象とした長期縦断研究」（班長：下方浩史）より助成を受けた．

文　献

1) http://www8.cao.go.jp/kourei/whitepaper/w-2009/zenbun/21pdf_index.html
2) 榎　裕美，葛谷雅文，益田雄一郎，平川仁尚，岩田充永，井澤幸子ほか：訪問看護サービス利用者の身体計測指標と生命予後について　the Nagoya Longitudinal Study of Frail Elderly（NLS-FE）より．日老医誌　2007; 44: 212–218.
3) 葛谷雅文，益田雄一郎，平川仁尚，岩田充永，榎　裕美，長谷川潤ほか：在宅要介護高齢者の「うつ」発症頻度ならびにその関連因子．日老医誌　2006; 43: 512–517.
4) Kuzuya M, Masuda Y, Hirakawa Y, Iwata M, Enoki H, Hasegawa J, et al.: Underuse of medications for chronic diseases among the oldest of community-dwelling Japanese frail elderly. J Am Geriatr Soc 2006; 54: 598–605.
5) Kuzuya M, Masuda Y, Hirakawa Y, Iwata M, Enoki H, Hasegawa J, et al.: Day-care service use is associated with lower mortality among community-dwelling frail elderly. J Am Geriatr Soc 2006; 54: 1364–1371.
6) Mahoney F, Barthel DW: Functional evaluation: The Barthel Index. Md State Med J 1965; 14: 61–65.
7) Yesavage JA: Geriatric Depression Scale. Psychopharmacol Bull 1988; 24: 709–711.
8) Charlson ME, Pompei P, Ales KL, MacKenzie CR: A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. J Chronic Dis 1987; 40: 373–383.
9) http://www8.cao.go.jp/kourei/whitepaper/w-2009/zenbun/pdf/1s2s_1.pdf
10) Katz SJ, Kabeto M, Langa KM: Gender disparities in the receipt of home care for elderly people with disability in the United States. JAMA 2000; 284: 3022–3027.
11) http://www.mhlw.go.jp/topics/kaigo/kaigi/020604/1-1.html
12) Pietschmann P, Rauner M, Sipos W, Kerschan-Schindl K: Osteoporosis: an age-related and gender-specific dis-

ease—a mini-review. Gerontology 2009; 55: 3–12.

Gender difference characteristics in the sociodemographic background of care recipients

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Abstract

Aim: We compared gender differences in the sociodemographic characteristics of community-dwelling dependent elderly who use various community-based services under long-term care insurance programs, as well as in mortality, hospitalization, and institutionalization during a 3-year follow-up period.

Methods: We conducted a cross-sectional study using the baseline data of 1,875 care recipients from the Nagoya Longitudinal Study for Frail Elderly (NLS-FE), and a prospective study using their 3-year follow-up data. The data, which were collected at the patients' homes or from care-managing center records, included the clients' and caregivers' demographic characteristics, living arrangements, community-based services used, depression as assessed by the Geriatric Depression Scale (GDS-15), a rating for basic activities of daily living (ADL), and comorbidities. The data included, at 3-year follow-up, all-cause mortality, hospitalization, and institutionalization.

Results: Among 1,875 care recipients 66.3% were women. They had a higher rate of living alone (26.2% vs 14.6% in men), and a lower rate of receiving care by a spouse (22.1% vs. 73.6% of men). Although there were no differences in ADL levels or GDS-15 scores between genders, a higher Charlson comorbidity index, higher prevalence of cerebrovascular disease, chronic obstructive pulmonary disease (COPD), and cancer were observed in the male care recipients. Kaplan-Meier analysis demonstrated that during the 3-year follow-up, higher mortality, hospitalization, and lower institutionalization rates were observed in men.

Conclusion: We observed that two thirds of care recipients were women. Compared with male recipients, female recipients were more likely to live alone, and to be cared for by non-spouse caregivers. Lower mortality and hospitalization, but higher institutionalization, were observed in female recipients.

Key words: Long-term care insurance, Care recipient, Community-dwelling dependent elderly, Formal service, Gender difference
(Nippon Ronen Igakkai Zasshi 2010; 47: 461–467)

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British Journal of Nutrition (2010), **103**, 289–294
doi:10.1017/S0007114509991723

The longitudinal change in anthropometric measurements and the association with physical function decline in Japanese community-dwelling frail elderly

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(Received 3 December 2008 – Revised 4 June 2009 – Accepted 21 July 2009 – First published online 14 September 2009)

Although anthropometric parameters have been extensively studied regarding their relationship to physical function status, the association between these parameters and the activity of daily living (ADL) function remains controversial. We investigated whether BMI or mid-upper arm circumference (AC) is an indication of variation in the physical functioning of the frail elderly. The present study was a prospective cohort analysis of 543 community-dwelling frail elderly. Data included the participants' demographic characteristics, basic ADL, comorbidity and anthropometric measurements at baseline and at 2-year follow-up. Logistic regression models were used to investigate the association between ADL status and anthropometric measurements during the study period. Among the 543 participants, 418 maintained or improved their ADL status, while 125 showed an ADL decline during the study period. Multivariate logistic regression analysis showed that BMI and AC levels or ADL status at baseline were not independent predictors of the loss of ADL function or the decline in these anthropometric measurements during the study period, respectively. However, the decline in BMI and AC levels and the loss of ADL function were associated with each other during the study period. There is an association between the negative changes in anthropometric measurements during the follow-up period and the decline in ADL function during a 2-year follow-up in community-dwelling frail elderly.

Activities of daily living: Declining anthropometric measurement: Declining activity of daily living score: Elderly

The decline in physical performance is directly linked to the negative consequences of the reduced health and quality of life of elderly people. A number of studies have demonstrated relationships between physical disability and nutritional status, including anthropometric measurements, in the elderly[1,2]. Among anthropometric parameters, weight and BMI have been extensively studied in terms of their relationship with physical function status. In cross-sectional analysis, community-dwelling older people with BMI 30 kg/m^2 or higher than 30 kg/m^2 were associated with a greater probability of functional limitation[3–6]. In contrast, severe disability in institutionalised elderly subjects was associated with low waist/hip ratio[7]. Longitudinal studies have demonstrated that weight loss is associated with an increase in the risk of becoming disability compared with weight stability in community-dwelling elderly[8–11]. In contrast, it has been reported that obesity (BMI: 35 kg/m^2 or greater) and weight gain are risk factors for functional decline between 3 and 4 years later in mean aged 71 years participants[12]. Thus, the causal relationships between anthropometric measurements and physical functional ability remain controversial.

Most prior studies utilise body weight or BMI as an anthropometric parameter to examine the relationships between nutritional status and functional ability. We recently reported that the height and weight of older people with activity of daily living (ADL)[13,14] impairment are not likely to be measured at home or to be regularly measured in the community[15]. In fact, approximately one-third of disabled elderly living at home lack recent height or weight measurements[15]. We proposed that anthropometric measurements of the mid-arm may be a more practical and suitable index not only for nutritional assessment but also for capturing the vulnerable subset of older people living in the community[16]. However, no data were available concerning the relationships between mid-arm measurements and ADL status.

In the present study, we investigated whether anthropometric measurements such as the BMI and mid-arm circumference (AC) of frail elderly individuals are an accurate indication of variation in their physical functioning using a prospective cohort study of community-dwelling frail elderly.

Methods

Subjects

The present study employed baseline data for the subgroup of participants in the Nagoya Longitudinal Study for Frail Elderly and data on the mortality and hospitalisation of these participants during the 2-year follow-up period. Details

Abbreviations: AC, arm circumference; ADL, activity of daily living; AMA, arm area; TSF, triceps skin fold.

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NS British Journal of Nutrition

of the participants and the Nagoya Longitudinal Study for Frail Elderly have been published elsewhere[17,18]. The study population consisted of 952 community-dwelling frail elderly (men: 355, mean age 78·5 years (range: 65–101); women: 597, mean age 81·6 years (range: 65–102)) with physical or mental disability in some degree. They were eligible for long-term care insurance[19,20], lived in Nagoya City, and were provided visiting nurse services by the Nagoya City Health Care Service Foundation for Older People, which has seventeen visiting nursing stations associated with care-managing centres. Eligibility of long-term care insurance is strictly a matter of age, physical and mental status, and whether or not the individual has undergone medical procedures. These Nagoya Longitudinal Study for Frail Elderly participants, who were enrolled between 1 December 2003 and 31 January 2004, were scheduled to undergo comprehensive in-home assessments by trained nurses at the baseline, and at 6, 12 and 24 months. At 3-month intervals, data were collected about any important events in the lives of the participants, including admission to the hospital, long-term care facilities placement and mortality. In the present study, a fall was defined as a sudden, unexpected descent from a standing, sitting or horizontal position, and slipping from a chair or wheelchair. Participants found down on the floor were also included in falls. After 1 year, the participants or family member caregivers were asked the fall experience by trained nurses. Written informed consent for participation, according to procedures approved by the institutional review board of Nagoya University Graduate School of Medicine, was obtained from the patients or, for those with physician-diagnosed substantial cognitive impairment, from a surrogate (usually the closest relative or legal guardian), and from family member caregivers.

Data collection

The data were collected at the clients' homes using structured interviews with patients or surrogates and caregivers, and from care-managing centre records taken by trained nurses. The data included clients' demographic characteristics, depressive symptoms as assessed by the short version of the Geriatric Depression Scale[21], and ADL was assessed by the 20-point Barthel Index with some modification (feeding, mobility on bed, bathing, grooming, dressing, using the toilet, walking inside and outside, transferring and using stairs) using summary scores ranging from 0 (total disability) to 20 (no disability). For each ADL task, nurses rated participants as independent (a score of 2, able to perform the activity without help), partially dependent (a score of 1, requiring some assistance) or completely dependent (a score of 0, needing help for the entire activity). Nurse ratings were based on direct observation, questioning of patients and speaking with family members and caregivers. Information obtained from care-managing centre records included data on the following physician-diagnosed chronic conditions: IHD; congestive heart failure; cerebrovascular disease; diabetes mellitus; dementia; cancer; neurodegenerative disorders including Parkinson's disease; other diseases comprising the Charlson comorbidity index[22], which represents the sum of weighted indices taking into account the number and seriousness of pre-existing comorbid conditions.

Anthropometry

Height and weight data were generally measured at home and collected by trained nurses using the methods described by the World Health Organization[23]. The visiting nurses were asked to measure the height or weight of participants at home as much as possible. If body weight measurements could not be taken at home for some reason, recorded or self-reported weight data obtained sometime within the last month were used. If the participants have some cognitive impairment, weight data were obtained form a surrogate or family member caregivers. Weight was measured in light clothing without shoes using a portable weight scale at home. Height was generally measured in an upright position using a tape measure attached to the wall. However, when participants could not maintain an upright position, height measurements were obtained in a prone position. Although there are surrogate methods for obtaining height using estimation equations based on body segment lengths, these methods have not been validated in the Japanese elderly. Height measurements were unavailable for subjects (n 342, 35·9 %) with severe kyphosis (defined as any subject whose kyphosis made it impossible for the visiting nurse to make a convenient or reliable height measurement) or severe muscle and arterial contracture.

Measurement[23] of the triceps skin fold (TSF) thickness (to the nearest 0·1 mm) was made using skinfold callipers and AC (to the nearest 0·1 cm) using a flexible measuring tape on the right side of the participant's body, unless affected by disability or disease. Arm area (AMA) was calculated using the standard formula[24]: $\text{AMA} = (\text{AC (cm)} - 0{\cdot}3142 \times \text{TSF (mm)})^2/4\pi$. These measurements were taken at least twice by each trained nurse according to the instruction sheet, and the reported values were the means of the repeated measurements.

Among the 952 participants, 207 (21·7 %) subjects died, 41 (4·3 %) were admitted to hospitals, 78 (8·2 %) had long-term care placement and 83 (8·7 %) declined to participate at some point during the 2-year follow-up.

Therefore, the ADL levels of a total of 543 participants (men: 201; women: 342) were assessed after the 2-year period and were used for the analysis in the present study. The subjects who died during the 2-year follow-up were older (mean age: 82·1 years *v.* 79·8 years, $P=0{\cdot}001$), and mean scores of BMI, AC, TSF, AMA and basic ADL at baseline were significantly lower than those of 543 participants analysed in the present study (BMI: 18·8 *v.* 21·2, $p < 0{\cdot}001$; AC: 21·8 *v.* 24·0, $P<0{\cdot}001$; TSF: 1·3 *v.* 1·6, $P<0{\cdot}001$; AMA: 26·6 *v.* 30·3, $P<0{\cdot}001$; basic ADL: 7·7 *v.* 10·7, $P<0{\cdot}001$). The 50th percentile of ADL scores at baseline (range: 0–20) was 12. There were seventy-five participants who had an ADL score of 0 at baseline, and 291 participants who had ADL scores of 12 or more at baseline among all participants (n 543). Out of 543 participants, 280 (51·6 %) and 471 (86·7 %) were available for their BMI and mid-arm measurements at both baseline and at 2 years, respectively.

Statistical analysis

The Student's t test and χ^2 test were used to compare differences between participants with ADL decline and those without decline (improved or stable ADL function).

The main dependent variable was a change in the ability to perform ADL tasks over the 2-year follow-up period. We distinguished two levels of categorical change: (i) participants with no change or improved ADL score at the 2-year endpoint compared with baseline; (ii) participants with a decline in ADL score from baseline to the 2-year endpoint.

Univariate and multivariate logistic regression models were used to assess the following two questions: (1) Do the anthropometric measurements (BMI or AC) at baseline predict ADL status change during the 2-year follow-up? (2) Does baseline ADL status predict the loss of these anthropometric parameters during the study period? To avoid the floor effect of ADL score, the analysis was also conducted with participants with ADL scores of 12 (the 50th percentile of basic ADL at baseline) or higher at baseline. The following baseline data were used in univariate analysis: the sex; age; ADL score; Charlson comorbidity index; living arrangement; the presence or absence of chronic diseases; BMI; AC; TSF; AMA; Geriatric Depression Scale score; the fall and hospitalisation experience during the 2-year period. The covariates included in the multivariate analysis were variables associated with dependent variables with $P<0{\cdot}05$ in univariate analysis. The risk of a variable was expressed as an OR with a corresponding 95 % CI.

We also examined the association between ADL score decline and the change in anthropometric measurements change during the study period using logistic regression analysis. The ADL score changes were categorised into three groups: improved/stable; 1 point change; ≥2 points change. The changes in BMI or AC were categorised into three or four groups: BMI, increase/stable, <1·0 and ≥1·0 kg/m^2; AC, increase/stable, ≤0·5, 0·6–1·5 and ≥1·6 cm. Again the covariates included in the multivariate analysis were variables associated with dependent variables in univariate analysis.

To evaluate the relationship between the decline in BMI and AC levels and the decline in ADL scores during the study period, Spearman's rank correlation coefficient was used. Partial rank correlation coefficients adjusted for age and sex were also used to measure the relationships between the decline in BMI and AC levels and the decline in ADL scores during the study period.

All analyses were performed using the Statistical Package for the Social Sciences (SPSS, Inc., Chicago, IL, USA) Version 15.0. A probability value of 0·05 or less was considered significant.

Results

At the baseline, total dependent participants (basic ADL score of 0) were 143 (15·0 %) and total independent participants (basic ADL score of 20) were 61 (6·4 %), among the 952 participants. Among the 543 participants, 418 (77·0 %) participants maintained (*n* 390) or improved (*n* 28) their ADL status, while 125 (23 %) showed an ADL decline during the study period.

Table 1 shows the comparisons of baseline characteristics of participants with or without ADL decline during the 2-year period. No differences were observed in baseline BMI, AC, TSF and AMA between participants in the two groups. A higher prevalence of hypertension and neurodegenerative disease and a higher ADL score at baseline were observed in participants with ADL decline. The prevalence rates of hospitalisation and falls during the 2-year period were significantly higher for those with ADL decline

Table 1. Baseline characteristics of the 543 care recipients
(Mean values and standard deviations)

	Change in basic ADL scores during 2-year follow-up				
	Improved/stable (*n* 418)		Declined (*n* 125)		
	Mean	SD	Mean	SD	*P*
Men/women, *n* (% of men/total)	150/268 (35·9)		51/74 (40·8)		0·318
Age (years)*	79·6	7·8	80·5	9·5	0·285
BMI (kg/m^2)*	21·2	4·0	21·2	3·6	0·973
Mid-arm circumference (cm)*	24·0	4·3	24·0	4·1	0·854
Triceps skin fold (cm)*	1·6	0·9	1·5	0·9	0·168
Arm muscle area (cm^2)*	30·0	11·8	31·0	12·2	0·399
Basic ADL (range 0–20)*	10·1	7·2	12·8	4·7	<0·001
GDS-15 (range, 0–15)*	6·7	3·6	7·3	3·6	0·138
Charlson comorbidity index*	2·2	1·6	2·1	1·6	0·602
Living alone (% of total)	19·1		16·9		0·590
Chronic diseases (% of total)†					
IHD	11·6		10·5		0·757
Congestive heart failure	11·0		10·5		0·884
Cerebrovascular disease	43·5		43·9		0·947
Diabetes mellitus	11·9		13·2		0·713
Dementia	33·3		31·6		0·729
Cancer	6·8		9·6		0·311
Hypertension	23·2		32·8		0·031
Pressure sore	11·7		6·4		0·089
Neurodegenerative disorders	9·8		19·2		0·005

ADL, activity of daily living; GDS-15, geriatric depression scale.
* Student's *t* test, others were analysed by χ^2 test (changeless improvement *v.* decline).
† Chronic diseases: physician-diagnosed chronic conditions.

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(40·0 %, $P<0·012$ and 46·6 %, $P<0·002$, respectively) than for those who were stable or showed improvement in ADL (28·2 and 31·3 %, respectively).

Table 2 shows the average changes in ADL scores and the average changes in the BMI and AC levels of participants with or without ADL score decline during the 2-year period. Significant decreases in BMI and AC during the 2-year period were observed in participants with loss of ADL function compared with those with a stable or improved ADL score, although there was no difference in TSF or AMA change during the 2-year period between two groups (data not shown).

To examine whether the anthropometric measurements (BMI or AC) at baseline may predict ADL status change during the 2-year follow-up, logistic regression analysis was conducted. As shown in Table 3, BMI or AC levels at baseline were not an independent predictor of the loss of ADL function during the study period not only in univariate analysis but also in multivariate analysis. When the analysis was conducted for participants with ADL scores of 12 or higher at baseline, again there was no association between the decline in ADL status and BMI and AC at baseline.

During the 2-year period, 94 among 280 participants (33·6 %) and 165 among 471 participants (35·0 %) experienced a decline in their BMI or AC levels, respectively. The multivariate logistic analysis demonstrated that baseline ADL status was not associated with the loss of these anthropometric parameters during the study period (BMI: OR, 1·02; 95 % CI, 0·97, 1·08 and AC: OR, 0·981; 95 % CI, 0·95, 1·01).

There were correlations between the levels of decline in BMI and AC and changes in ADL score during the study period in all participants, as well as those excluded for having an ADL score 0 or with an ADL score of 12 or higher at baseline. These correlations persisted after adjusting for the age and sex of the participants (Table 4).

We next examined the association between the decline in ADL performance and BMI or AC change during the study period using logistic regression analysis (Table 5). Univariate as well as multivariate analysis showed that a larger decline in BMI ($\geq 1·0\,kg/m^2$) and the highest level of AC decline ($\geq 1·6\,cm$) compared with stable or increasing BMI and AC measurements were associated with the loss of ADL performance during the 2-year period. Conversely, a decline in ADL score during the 2-year period of ≥ 2 points was associated with a loss of BMI or AC scores in univariate analysis. These associations persisted after adjustments for potential confounders were made in multivariate models (Table 5). When multivariate analysis was conducted among participants with an ADL score of 12 or higher, similar associations were detected between the decline in BMI and AC levels and the loss of ADL function (model 2 in Table 5).

Table 2. Change in anthropometric measurements and basic activity of daily living (ADL) scores during the 2-year period
(Mean values and standard deviations)

	A change in basic ADL scores				
	Improved/ stable (*n* 418)		Declined (*n* 125)		
	Mean	SD	Mean	SD	*P*
Basic ADL score (range 0–20)*					
Change during 2 years	0·1	0·5	−3·5	3·43	<0·001
BMI (kg/m²)*					
Baseline	21·2	4·0	21·3	3·5	0·788
After the 2-year period	21·2	4·1	20·7	3·5	0·399
Change during 2 years	−0·005	1·2	−0·60	1·8	0·010
Mid-arm circumference (cm)*					
Baseline	24·1	4·2	24·1	4·0	0·916
After the 2-year period	23·6	4·5	23·1	3·9	0·327
Change during 2 years	−0·3	1·9	−1·0	2·7	0·015

* Student's *t* test.

Discussion

The present study examined the association between anthropometric measurements at baseline or longitudinal changes in those measurements and the degree of disability or longitudinal physical function decline during a 2-year follow-up in community-dwelling frail Japanese elderly. Although, as far as we know, there has been no report demonstrating that AC acts as a predictor of physical functional impairment, a previous report has demonstrated that greater BMI (BMI: 35 kg/m² or greater) at baseline was associated with physical function decline in community-dwelling frail elderly[12]. In contrast, in the present study, we clearly showed that baseline BMI or AC was not a predictor for the decline in ADL performance. These differences may be due to the different ethnicity of the participants or the presence of participants with lower BMI (mean BMI: 21·2 kg/m²) and lower physical function in the present study compared with those in previous studies. However, it showed be noted that the means of BMI and AC levels at baseline in the participants of the present cohort study were similar to those of the standard Japanese older population as previously reported[16,25]. It is possible that poor nutritional status, which reflects anthropometric parameters, contributes to the development of functional disability; likewise, it is also plausible that disability at baseline may lead to lifestyle changes, which in turn result in the decline in anthropometric parameters. However, we also demonstrated that lower ADL function at baseline was not a risk for the loss of BMI or AC levels during the follow-up period. These results suggested that there are neither causal relationships between basal lower anthropometric

Table 3. Logistic regression analysis to identify independent predictors of declining basic activity of daily living (ADL) score
(OR values with 95 % CI)

	OR	95 % CI	*P*
BMI (kg/m²)			
Unadjusted	1·00	0·94, 1·07	0·972
Adjusted*	0·98	0·91, 1·06	0·625
Adjusted†	0·97	0·89, 1·06	0·558
Mid-arm circumference (cm)			
Unadjusted	1·00	0·95, 1·04	0·853
Adjusted*	0·98	0·93, 1·04	0·467
Adjusted†	0·96	0·90, 1·04	0·327

The 50th percentile of basic ADL scores at baseline was 12 in the present study.
* Adjusted includes sex, age, presence or absence of hypertension and neurodegenerative disease, hospitalisation and fall experience during the 2-year study period and the score of basic ADL at baseline.
† Analysis was conducted for participants with basic ADL score of 12 or higher at baseline.

Table 4. Correlations between changes in basic activity of daily living (ADL) score during 2-year study period and anthropometric measurements during 2-year study period

	Change of ADL score during 2-year follow-up		
Changes in levels during 2-year period	All participants (*n* 543)	Excluded basic ADL score of 0 at baseline (*n* 468)	Basic ADL score of 12 or higher† at baseline (*n* 291)
BMI (kg/m^2)			
Crude	0·123*	0·117	0·134
Adjusted‡	0·149*	0·137*	0·191**
Mid-arm circumference (cm)			
Crude	0·157**	0·169**	0·099
Adjusted‡	0·152**	0·158**	0·169**

Mean values were significantly different: *$P<0·05$, **$P<0·01$.
† The 50th percentile of basic ADL scores at baseline was 12 in the present study.
‡ Adjusted for age and sex.

measurements and ADL function decline nor between basal poor ADL performance and a decrease in anthropometric parameters.

Previous prospective cohort studies emphasised that weight loss is a risk factor for the functional decline[8–12]. However, no studies allow the evaluation of causal relationships between weight loss and the functional decline. In the present study, we showed that physical functional change was well correlated with change in anthropometric parameters. In addition, logistic regression models demonstrated that the decline in anthropometric parameters was a predictor of the decline in ADL performance, and that, conversely, the decline in ADL performance was also a predictor of anthropometrics decline. These results may indicate that these factors, anthropometric parameters and ADL status, influence each other and decline simultaneously. BMI and AC are parameters of nutritional status in older adults[26,27]. Therefore, the results may indicate that nutritional status and ADL performance were well correlated and changed simultaneously through causal and consequential relationships. Theoretically, inadequate intake of nutrients, one of the manifestations of undernutrition, which can lead to loss of muscle protein as well as body mass, may explain the association between weight loss and decline in physical function. In contrast, physical functional decline may be a cause of weight loss through difficulties in eating, provisioning and cooking, which can be reflected by a decline in the food-related items of the ADL.

It is possible that there are third factors that might produce the association between the loss of anthropometric parameters and the decline in ADL performance during the follow-up period. The occurrence of new diseases or poor control of chronic disease during the follow-up period might be a candidate for the third factor. However, the association persisted even after adjusting for hospitalisation for acute illness during the study period, which suggests that poor health outcomes leading to hospitalisation did not contribute to these relationships.

The present study has several limitations. The results of the present study cannot be transferred to non-frail-independent

Table 5. Logistic regression analysis to identify independent predictors of declining basic activity of daily living (ADL) score, declining BMI and arm circumference
(OR values with 95 % CI)

	Unadjusted			Multivariate					
				Model 1			Model 2		
	OR	95 % CI	*P*	OR	95 % CI	*P*	OR	95 % CI	*P*
Basic ADL decline *v.* improve/stable*									
Change in BMI levels during 2-year period									
Increase or stable	1·00	Reference		1·00	Reference		1·00	Reference	
Decline (<1·0 kg/m^2)	1·09	0·50, 2·39	0·833	0·90	0·31, 2·09	0·810	0·89	0·30, 2·58	0·822
Decline (≥ 1·0 kg/m^2)	3·86	1·96, 7·59	<0·001	3·64	1·73, 7·65	0·001	4·69	1·89, 11·67	0·001
Change in AC levels during 2-year period									
Increase or stable	1·00	Reference		1·00	Reference		1·00	Reference	
Decline (≤ 0·5 cm)	1·55	0·66, 3·65	0·319	1·52	0·60, 3·83	0·373	1·00	0·31, 3·25	0·998
Decline (0·6–1·5 cm)	1·77	0·91, 3·45	0·092	2·54	1·20, 5·38	0·015	2·80	1·02, 7·69	0·045
Decline (≥ 1·6 cm)	2·75	1·63, 4·64	<0·001	3·45	1·88, 6·35	<0·001	3·18	1·40, 7·20	0·006
Loss of BMI levels *v.* increase/stable†									
Change in basic ADL score during 2-year period									
Improved or stable	1·00	Reference		1·00	Reference		1·00	Reference	
Decline (1 point)	1·95	0·87, 4·42	0·107	1·94	0·77, 4·84	0·158	2·67	0·93, 7·70	0·069
Decline (≥ 2 points)	2·33	1·20, 4·55	0·013	3·28	1·50, 7·17	0·003	3·28	1·32, 8·16	0·011
Loss of AC levels *v.* increase/stable‡									
Change in basic ADL score during 2-year period									
Improved or stable	1·00	Reference		1·00	Reference		1·00	Reference	
Decline (1 point)	1·40	0·74, 2·66	0·307	1·17	0·55, 2·49	0·678	1·01	0·40, 2·58	0·981
Decline (> 2 points)	2·90	1·72, 4·89	<0·001	3·62	1·95, 6·73	<0·001	2·94	1·35, 6·38	0·007

The 50th percentile of basic ADL scores at baseline was 12 in the present study.
* Multivariate analysis includes sex, age, presence or absence of hypertension and neurodegenerative disease, hospitalisation and fall experience during the 2-year period and the score of basic ADL at baseline. BMI: *n* 135. mid-arm circumference (AC): *n* 416. Model 2 participants that had a basic ADL score of 12 or higher at baseline. BMI: *n* 182. AC: *n* 245.
† Multivariate analysis includes sex, age, living alone, regular medical checkups, cerebrovascular disease, hospitalisation during the 2-year period and the score of BMI at baseline. Participants had a basic ADL score of 2 or higher at baseline (*n* 225). Model 2 participants that had a basic ADL score of 12 or higher at baseline. *n* 172.
‡ Multivariate analysis includes sex, age, living alone, regular medical checkups, cerebrovascular disease, hospitalisation during the 2-year period and the score of AC at baseline. Participants had a basic ADL score of 2 or higher at baseline. *n* 342. Model 2 participants that had a basic ADL score of 12 or higher at baseline (*n* 228).

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older individuals, since there are many differences between the participants in Nagoya Longitudinal Study for Frail Elderly and standard non-frail older people, including differences in ADL levels and comorbidity. There was a possibility that the presence of lower BMI levels and fewer obese individuals in our cohort may have affected the present results. In addition, these findings may not be generalisable to other populations, given that they may have been influenced by cultural differences, health practices and a variety of social and economic factors. The mechanisms underlying the association between the decline in BMI/AC levels and declining ADL score during the 2-year follow-up period are unclear in the present study. Future study is needed to examine whether the ADL scores and anthropometric measurements of these frail elderly with functional limitations in the community decrease concurrently.

The present study showed that anthropometric measurements at baseline were not a predictor of physical function decline during a 2-year follow-up in community-dwelling elderly. An association was found between negative changes in anthropometric measurements during the follow-up period and the decline in ADL function.

Acknowledgements

The authors wish to thank all the patients, caregivers and the many nurses participating in the study, and the Nagoya City Health Care Service Foundation for Older People for their vigorous cooperation. The present study was supported by a Grant-in-Aid for the Comprehensive Research on Aging and Health from the Ministry of Health, Labor and Welfare of Japan, and a grant from Mitsui Sumitomo Insurance Welfare Foundation. The authors have no conflicts of interest with the manufactures of any drug evaluated in the present paper. S. I. contributed to the analysis of data and the writing of the manuscript. H. E. contributed to the analysis and interpretation data. Y. H. contributed to conduct of study and interpretation of data. M. I. contributed to analysis and interpretation of data. J. H. contributed to acquisition of data. A. I. contributed to the providing of significant advice. M. K. contributed to the study concept and design, the interpretation of data, and was performing quality control of the present study.

References

1. Stuck AE, Walthert JM, Nikolaus T, *et al.* (1999) Risk factors for functional status decline in community-living elderly people: a systematic literature review. *Soc Sci Med* **48**, 445–469.
2. Topinková E (2008) Aging, disability and frailty. *Ann Nutr Metab* **52**, Suppl. 1, 6–11.
3. Zoico E, Di Francesco V, Guralink JM, *et al.* (2004) Physical disability and muscular strength in relation to obesity and different body composition indexes in a sample of healthy elderly women. *Int J Obes Relat Metab Disord* **28**, 234–241.
4. Larrieu S, Pérès K, Letenneur L, *et al.* (2004) Relationship between body mass index and different domains of disability in older persons: the 3C study. *Int J Obes Relat Metab Disord* **28**, 1555–1560.
5. Friedmann JM, Elasy T & Jensen GL (2001) The relationship between body mass index and self-reported functional limitation among older adults: a gender difference. *J Am Geriatr Soc* **49**, 398–403.
6. Chen H & Guo X (2008) Obesity and functional disability in elderly Americans. *J Am Geriatr Soc* **56**, 689–694.
7. Romagnoni F, Zuliani G, Bollini C, *et al.* (1999) Disability is associated with malnutrition in institutionalized elderly people. The I.R.A. Study. Istituto di Riposo per Anziani. *Aging (Milano)* **11**, 194–199.
8. Launer LJ, Harris T, Rumpel C, *et al.* (1994) Body mass index, weight change, and risk of mobility disability in middle-aged and older women. The epidemiologic follow-up study of NHANES I. *JAMA* **271**, 1093–1098.
9. Tully CL & Snowdon DA (1995) Weight change and physical function in older women: findings from the Nun Study. *J Am Geriatr Soc* **43**, 1394–1397.
10. Al Snih S, Raji MA, Markides KS, *et al.* (2005) Weight change and lower body disability in older Mexican Americans. *J Am Geriatr Soc* **53**, 1730–1737.
11. Ritchie CS, Locher JL, Roth DL, *et al.* (2008) Unintentional weight loss predicts decline in activities of daily living function and life-space mobility over 4 years among community-dwelling older adults. *J Gerontol A Biol Sci Med Sci* **63**, 67–75.
12. Jensen GL & Friedmann JM (2002) Obesity is associated with functional decline in community-dwelling rural older persons. *J Am Geriatr Soc* **50**, 918–923.
13. Mahoney F & Barthel DW (1965) Functional evaluation: The Barthel Index. *Md State Med J* **14**, 61–65.
14. Collin C, Wade DT, Davies S, *et al.* (1998) The Barthel ADL Index: a reliability study. *Int Disabil Stud* **10**, 61–63.
15. Izawa S, Enoki H, Hirakawa Y, *et al.* (2007) Lack of body weight measurement is associated with mortality and hospitalization in community-dwelling frail elderly. *Clin Nutr* **26**, 764–770.
16. Enoki H, Kuzuya M, Masuda Y, *et al.* (2007) Anthropometric measurements of mid-upper arm as a mortality predictor for community-dwelling Japanese elderly: the Nagoya Longitudinal Study of Frail Elderly (NLS-FE). *Clin Nutr* **26**, 597–604.
17. Kuzuya M, Masuda Y, Hirakawa Y, *et al.* (2006) Underuse of medications for chronic diseases in the oldest of community-dwelling older frail Japanese. *J Am Geriatr Soc* **54**, 598–605.
18. Kuzuya M, Masuda Y, Hirakawa Y, *et al.* (2006) Day care service use is associated with lower mortality in community-dwelling frail older people. *J Am Geriatr Soc* **9**, 1364–1371.
19. Campbell JC & Ikegami N (2000) Long-term care insurance comes to Japan. *Health Aff (Millwood)* **19**, 26–39.
20. Tsutsui T & Muramatsu N (2005) Care-needs cerfication in the long-term care insurance system of Japan. *J Am Geriatr Soc* **53**, 522–527.
21. Arai Y, Kudo K, Hosokawa T, *et al.* (1997) Reliability and validity of the Japanese version of the Zarit Caregiver Burden interview. *Psychiatry Clin Neurosci* **51**, 281–287.
22. Charlson ME, Pompei P, Ales KL, *et al.* (1987) A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chronic Dis* **40**, 373–383.
23. World Health Organization (1986) Use and interpretation of anthropometric indicators of nutritional status: report of a WHO working group. *Bull World Health Organ* **64**, 929–941.
24. Heymsfield SB, McManus C, Smith J, *et al.* (1982) Anthropometric measurement of muscle mass: revised equations for calculating bone-free arm muscle area. *Am J Clin Nutr* **36**, 680–690.
25. Japanese Anthropometric Reference Data (2002) JARD 2001, Japanese Anthropometric Reference Data (in Japanese). *Jpn J Nutr Assess* **19**, Suppl., 45–81.
26. Gariballa S & Forster S (2007) Malnutrition is an independent predictor of 1-year mortality following acute illness. *Br J Nutr* **98**, 332–336.
27. Izawa S, Kuzuya M, Okada K, *et al.* (2006) The nutritional status of frail elderly with care needs according to the mini-nutritional assessment. *Clin Nutr* **25**, 962–967.

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6. Avorn J, Soumerai SB, Everitt DE et al. A randomized trial of a program to reduce the use of psychoactive drugs in nursing homes. N Engl J Med 1992;327:168–173.
7. Ray WA, Taylor JA, Meador KG et al. Reducing antipsychotic drug use in nursing homes. A controlled trial of provider education. Arch Intern Med 1993;153:713–721.
8. Bates DW, Kuperman GJ, Wang S et al. Ten commandments for effective clinical decision support: Making the practice of evidence-based medicine a reality. J Am Med Inform Assoc 2003;10:523–530.
9. Kuperman GJ, Bobb A, Payne TH et al. Medication-related clinical decision support in computerized provider order entry systems: A review. J Am Med Inform Assoc 2007;14:29–40.
10. Gill SS, Bronskill SE, Normand S-LT et al. Antipsychotic drug use and mortality in older adults with dementia. Ann Intern Med 2007;146:775–786.

FACTORS ASSOCIATED WITH NONADHERENCE TO MEDICATION IN COMMUNITY-DWELLING DISABLED OLDER ADULTS IN JAPAN

To the Editor: Nonadherence to drug therapy is a serious problem for older people, because adherence to medication is essential for obtaining the optimal therapeutic effects of medication.[1–4] Although numerous studies have identified the factors related to nonadherence to drug therapy, only limited studies have taken a wider perspective, focusing on adherence in older community-dwelling disabled adults and on factors affecting adherence.[5,6] The aim of this study was to identify the factors associated with nonadherence to drug therapy in older community-dwelling disabled adults.

The present study used baseline data on participants in the Nagoya Longitudinal Study for Frail Elderly.[4,7,8] The study population consisted of 1,722 older community-dwelling disabled adults (611 men, 1,161 women; mean age 80.3 ± 7.6, range 65–104) and 1,502 caregivers (375 men, 1127 women; mean age 64.1 ± 12.6, range 31–93). The baseline data included the recipients' demographic characteristics, activities of daily living (ADLs), depressive symptoms as assessed using the short version of the Geriatric Depression Scale (GDS-15), physician-diagnosed chronic conditions, living arrangement, number of prescribed medications, and self-reported difficulty with self-medication management, which was assessed as previously described.[4] The participants or family were also asked whether they were receiving any assistance for taking medication or medication management from others. The participants were divided into two groups: no difficulty with self-medication management, and difficulty with self-medication management. Data were also obtained from caregivers concerning their own personal demographic characteristics, their subjective health status, and burden as assessed according to the Zarit Burden Interview. The adherence rate to the prescribed medication was defined as the total number of pills taken divided by the total number of prescribed pills as assessed by the self-reported average medication adherence during 1 month. It was decided to use self-reporting rather than other forms of adherence measurements because they are prohibitively expensive and cumbersome, and there is little evidence that they are superior to self-report instruments.[1,9] Nonadherence was defined as less than 80% of the adherence rate. Univariate and multivariate logistic regression were used to determine which characteristics of the disabled older adult or caregiver predicted nonadherence to prescribed medication.

Of 1,772 participants, 223 (12.6%) were categorized as nonadherent. Univariate logistic analysis demonstrated that participants living alone (vs living with someone, odds ratio (OR) = 1.43, 95% confidence interval (CI) = 1.04–1.96), with depression (GDS-15 $\geq$ 11 vs $<$5, OR = 1.61, 95% CI = 1.03–2.53), and with dementia (vs its absence, OR = 1.47, 95% CI = 1.10–1.96) and participants who had difficulty with self-medication management (vs no difficulty with self-medication, OR = 1.69, 95% CI = 1.24–2.30) were more likely to be nonadherent. Multivariate analysis (Table 1, Model 1) showed that medication nonadherence was associated with participants living alone, having depression, and having difficulty with self-medication. When participants who had difficulty with self-medication were divided as to the absence or presence of assistance (Model 2), nonadherence was associated with participants living alone, participants with depression, the presence of dementia, participants who had difficulty with self-medication but had no assistance, and participants with assistance. For participants who had difficulty with self-medication and had assistance, none of the variables of care recipients were associated with nonadherence in univariate analysis. Multivariate analysis revealed that a male caregiver and poor subjective health status of the caregiver were likely to result in nonadherence in participants having assistance.

In the present study, it was observed that participants who had difficulty with self-medication management had a high risk of nonadherence to medication. In particular, participants needing support but who did not have any, had a OR of nonadherence 3.2 times as high as those who had no difficulty with self-medication management, suggesting that medication management assessment is needed to determine which older people are at risk of medication management problems and to minimize adverse events attributable to poor medication adherence. Participants receiving medication management assistance had an OR of medication nonadherence 1.64 times as high as participants who had no difficulty with self-medication management. These results may imply that families or relatives living with disabled older patients may not always give appropriate assistance for medication management. A male caregiver and subjective poor health status of the caregiver were associated with recipient nonadherence to prescribed medication, suggesting that caregivers with those characteristics may tend to provide inadequate levels of assistance for medication or that neglectful behavior by caregivers may be involved in this association.

In conclusion, the results suggest that, in older community-dwelling disabled adults, the lack of medication assistance for those needing medication support was associated with a higher risk of nonadherence, although even those receiving assistance had a higher risk of nonadherence than those with no difficulty with self-medication management.

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Table 1. Logistic Regression Analysis for Nonadherence

Characteristic	Odds Ratio (95% Confidence Interval)		
	Multivariate*		
	Model 1†	Model 2‡	Multivariate for Those Having Assistance§
Care recipient characteristics			
Men (vs women)	0.86 (0.61–1.23)	0.89 (0.62–1.28)	—
Age (continuous variable)	0.99 (0.97–1.02)	0.99 (0.97–1.02)	—
Living alone (vs living with someone)	2.00 (1.35–2.95)	1.94 (1.31–2.86)	1.38 (0.59–3.25)
GDS-15 (range 0–15) (vs score 0–5)			
6–10	1.22 (0.85–1.77)	1.25 (0.86–1.81)	—
≥ 11	1.61 (1.02–2.53)	1.68 (1.06–2.66)	—
Presence of dementia (vs absence)	1.34 (0.91–1.97)	1.56 (1.04–2.36)	—
Medication management (vs self medication)			
Difficulty with self-medication	2.04 (1.37–3.05)	—	—
Absence of assistance	—	3.20 (1.92–5.34)	—
Presence of assistance	—	1.64 (1.05–2.54)	—
Caregiver characteristics			
Men (vs women)	—	—	1.90 (1.18–3.06)
Age (continuous variable)	—	—	1.00 (0.98–1.02)
Subjective health status (vs good to excellent)			
Fair	—	—	0.90 (0.54–1.49)
Poor	—	—	2.09 (1.11–3.94)

*The covariates included in the multivariate analysis were variables associated with nonadherence with $P<.05$ in univariate analysis. Activity of daily living score, presence of comorbid diseases (ischemic heart disease, congestive heart failure, cerebrovascular disease, diabetes mellitus, cancer, or hypertension), number of medication, and regular medical examination were not associated with nonadherence in univariate analysis. All analyses were performed using SPSS version 17.0 (SPSS, Inc., Chicago, IL).

†Model 1 includes sex, age, living alone (vs living with someone), 15-item Geriatric Depression Scale (GDS-15) categories, presence of dementia (vs absence), and difficulty with self-medication (vs no difficulty).

‡Model 2 includes sex, age, living alone (vs living with someone), GDS-15 categories, presence of dementia (vs absence), and absence or presence of medication assistance (vs no difficulty).

§Logistic regression analysis was conducted to identify the predictor of the risk of nonadherence in 929 participants who had difficulty with self-medication and had assistance. The covariates included in the multivariate analysis were variables associated with nonadherence with $P<.05$ in univariate analysis. None of the variables of care recipients, including sex, age, comorbidity, depressive status, and number of prescribed medications, were associated with nonadherence in univariate analysis. The relationship to care recipient (spouse vs nonspouse) and the Zarit Burden Interview score were not associated with nonadherence in univariate analysis.

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ACKNOWLEDGMENTS

The authors wish to thank all the patients and caregivers and the many nurses participating in the study and the Nagoya City Health Care Service Foundation for Older People for their vigorous cooperation.

Conflict of Interest: Kuzuya M has received financial support from a Grant-in-Aid for the Comprehensive Research on Aging and Health from the Ministry of Health, Labor, and Welfare of Japan. This study was supported by a Grant-in-Aid for the Comprehensive Research on Aging and Health from the Ministry of Health, Labor, and Welfare of Japan, and a grant from Mitsui Sumitomo Insurance Welfare Foundation. The authors have no conflicts of interest with the manufacturers of any drug evaluated in this letter.

Author Contributions: Masafumi Kuzuya: study concept, design, conduct of study, interpretation of data, study supervision, and preparation of manuscript. Hiromi Enok: and Sachiko Izawa: analysis and interpretation of data. Jun Hasegawa and Yusuke Suzuki: conduct of study and interpretation of data. Akihisa Iguchi: study supervision.

Sponsor's Role: The sponsor had no role in the design, methods, subject recruitment, data collection, analysis, or letter preparation.

REFERENCES

1. Osterberg L, Blaschke T. Adherence to medication. N Engl J Med 2005;353:487–497.

2. Vik SA, Hogan DB, Patten SB et al. Medication nonadherence and subsequent risk of hospitalisation and mortality among older adults. Drugs Aging 2006; 23:345–356.
3. Navaratnam P, Jayawant SS, Pedersen CA et al. Asthma pharmacotherapy prescribing in the ambulatory population of the United States: Evidence of nonadherence to national guidelines and implications for elderly people. J Am Geriatr Soc 2008;56:1312–1317.
4. Kuzuya M, Hirakawa Y, Suzuki Y et al. Association between unmet needs for medication support and all-cause hospitalization in community-dwelling disabled elderly people. J Am Geriatr Soc 2008;56:881–886.
5. Bull SA, Hu XH, Hunkeler EM et al. Discontinuation of use and switching of antidepressants: Influence of patient-physician communication. JAMA 2002; 288:1403–1409.
6. Lin EH, Katon W, Von Korff M et al. Relationship of depression and diabetes self-care, medication adherence, and preventive care. Diabetes Care 2004;27: 2154–2160.
7. Kuzuya M, Masuda Y, Hirakawa Y et al. Underuse of medications for chronic diseases in the oldest of community-dwelling older frail Japanese. J Am Geriatr Soc 2006;54:598–605.
8. Kuzuya M, Masuda Y, Hirakawa Y et al. Day care service use is associated with lower mortality in community-dwelling frail older people. J Am Geriatr Soc 2006;54:1364–1371.
9. Hutchison LC, Jones SK, West DS et al. Assessment of medication management by community-living elderly persons with two standardized assessment tools: A cross-sectional study. Am J Geriatr Pharmacother 2006;4: 144–153.

日本未病システム学会雑誌　別刷

Vol.16　No.2　2010

研究論文●4

歩行速度(無次元速度)の性差と年代差に関する考察

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研究論文●4

歩行速度(無次元速度)の性差と年代差に関する考察

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1 緒言

直立二足歩行は地球上でヒトだけが行うことのできる移動動作である。二足歩行が優れた移動手段であるかないかを同程度の大きさの四足動物と比較することで，ヒト特有の歩行のメカニズムが探求できる。歩行中のヒトの質量重心は四足動物と比べ高く不安定であり，移動速度もほとんどの動物より遅い。この相違は，形態的な骨格形成や筋の力発揮メカニズムの違いによると考えられる。

一方，ヒトの体を形成する神経筋骨格系の構造(骨格，筋，腱，靭帯など)は，人種によって大きさが異なるが[1)]その形や筋の機能的力発揮メカニズムは同一である。そのため，歩行の基本パターンの習得においては人種を問わず，長期にわたる本能と学習の組合せによって発達していくことが考えられる。

二足歩行の基本パターンは，身体各部または質量重心の「時間因子・距離因子・運動学および運動力学因子」の相互作用によって決定される。また，これらの因子は神経系のフィードバックによって総括され，その許容と制御が行われている。一方，これらの因子は加齢とともに低下することが指摘されており[2-6)]，とりわけ歩行速度には，性差および年代差が認められてきた[7,8)]。そのため，歩行速度は近年の中高齢者の運動機能を評価する際，重要なパラメータとして注目され，医学やリハビリテーションなど分野で広く応用されてきた。しかし，これまで歩行速度は身長や体重の影響を考慮しない「絶対速度」で評価されてきたため，加齢変化と歩行速度の関係について必ずしも明快な結論が導き出されたとは限らない。

Alexander[9)]は，ヒトを含む動物の歩行メカニズムについて「体の大きさは異っていても筋肉の動きを最小限に，できるだけ経済的に動くのであるならば，動力学的に同一の運動をするはずである」と述べ，歩行速度には相対歩幅(相対歩幅＝歩幅/下肢長)が密接に関係していることを示唆した。

本研究は，Alexander[9)]の理論に基づく歩行モデルにヒントを得て，大きさや体重に影響されない無次元速度($Fr=[v/(g*h)^{0.5}]$：v＝速度，g＝重力加速度，h＝下肢長)の概念を用い[9,10)]，大規模な中高年地域住民のコホートで歩行速度を定量化し，歩行速度の性差・年代差を明らかにすることを目的とした。

2 対象および方法

対象は「国立長寿医療研究センター・老化に関する長期縦断疫学調査(NILS-LSA)[11)]」の第5次調査(2006年6月～2008年6月)に参加した地域住民男女2,419人(40～88歳，男性1,200人，女性1,219人)である。

本研究では，10 mの歩行路上を対象者に通常歩行および速歩行させ，解剖学的指標上に貼り付けた10個の反射マーカーの3次元座標データを6台の赤外線カメラ(Vicon370，Oxford Metrix Inc Oxford UK)で記録した。このデータから身体重心位置を推定し，時間微分するこ

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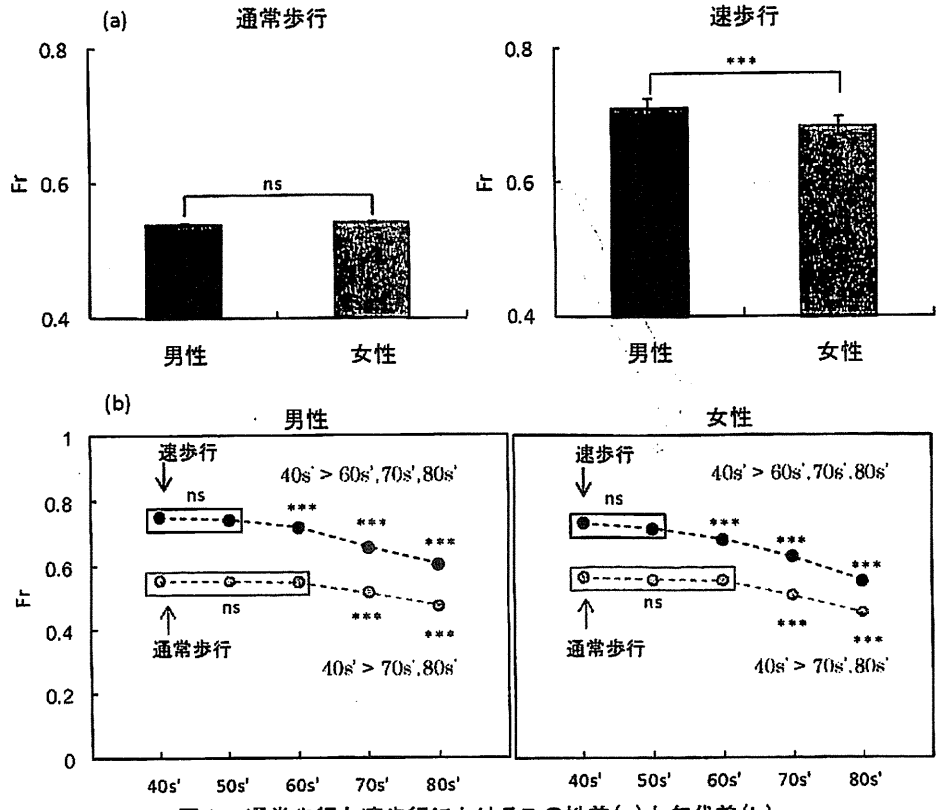

図1 通常歩行と速歩行におけるFrの性差(a)と年代差(b)

ns：not significant, ***p<0.001

とにより身体重心速度を算出した。空腹時の体重と下肢長[静止位での床面から転子点(大転子の最外側点)までの高さ]を計測し，これらから無次元速度(Fr＝[v/(g*h)$^{0.5}$]：v＝速度，g＝重力加速度，h＝下肢長)を求めた。

Fr(通常・速歩行)の性差について，一般線形モデルを用い年齢で調整し解析した。Fr(通常・速歩行)の年代差は，性別に5グループ(40代，50代，60代，70代，80代)に分け一元配置分散分析を用いて年代の影響を検討した。要因に有意性が認められたときは，Tukeyの多重比較を行った。統計処理はSAS統計パッケージ9.1.3.を用い，有意水準は5％未満とした。

3 結果

対象者の身体計測値は男女それぞれ，身長：165.9±6.6 cm，152.5±6.3 cm，体重：64.0±9.3 kg，52.4±8.5 kg，BMI：23.2±2.7 kg/m^2，22.5±3.3 kg/m^2，下肢長：79.2±3.9 cm，74.0±3.5 cmであった。

通常歩行におけるFrは，男性で0.54±0.07，女性で0.54±0.07であり，性差は認められなかった(図1a左)。一方，速歩行でのFrは，男性で0.71±0.09，女性で0.68±0.09であり，男性の方が有意に大きかった($p<0.001$；図1a右)。Frの年代差に関しては，通常歩行では男女ともに40～60代まで有意な差は認められず，70～80代では40代に比べ有意に低下していた($p<0.001$；図1b通常歩行)。一方，速歩行におけるFrは，通常歩行より早い60代から低下が始まり，70代，80代を含め40代に比べ有意に低下していた($p<0.001$；図1b速歩行)。

4 考察・結論

無次元速度に関するVaughanら[12]の研究(通常歩行時のFr)では，生後50カ月から成人までの間，Frの変化はほとんどみられなかった。本研究でも，通常歩行においては男女ともに40～60代までFrが一定に保たれており，人種差，年齢差があるにもかかわらず，Vaughanらの結果と近似の値であった。現在，30代の無次元速度の報告がないため明確な結論を出すことは困難であるが，この年代でも同様にFrが一定である可能性が高い。歩行の基本パターンを決定する因子が4歳児以降からほぼ完成され

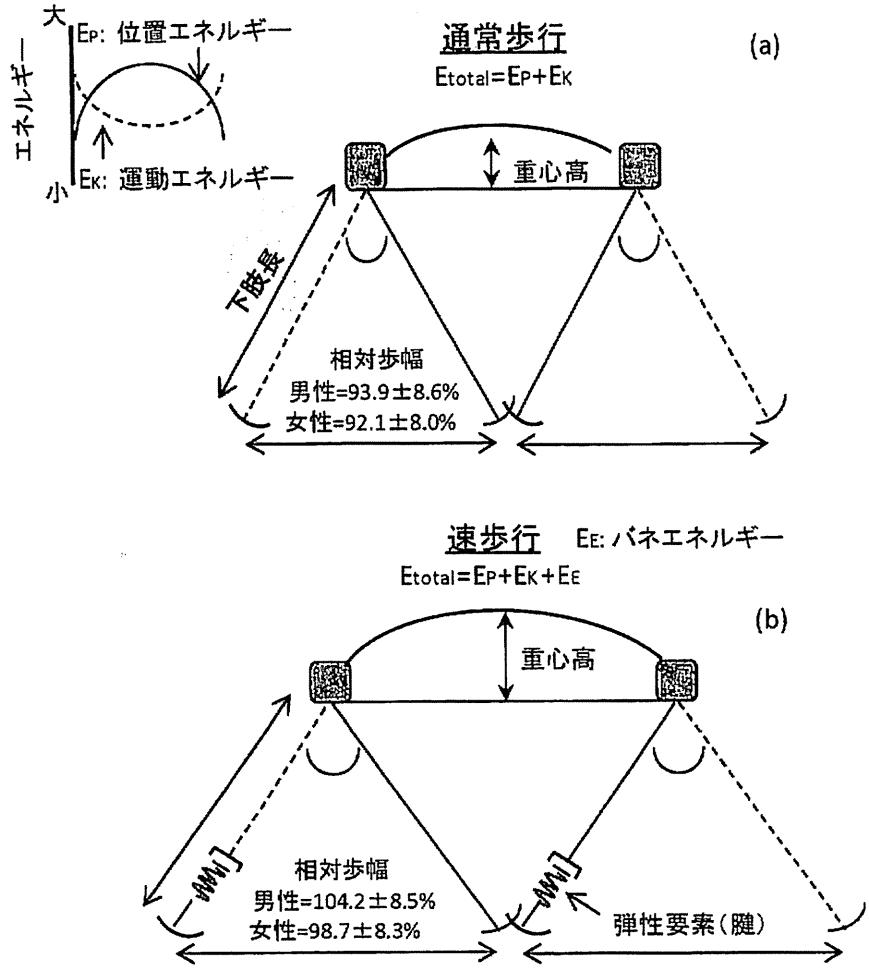

図2 逆振り子歩行モデル

(a)通常歩行における歩行モデル。相対歩幅(歩幅/下肢長)は男性で93.9±8.6%，女性で92.1±8.0%である。単純な下肢の振り子運動を活かすため重心高は低い。(b)速歩行における歩行モデル。相対歩幅は男性で104.2±8.5%，女性で98.7±8.3%である。下肢の振り子運動によるエネルギーの交換のみならず，収縮要素(筋)と弾性要素(腱)の協調が重要となる。通常歩行に比べよりパワーフルな筋骨格系の挙動が要求され，重心高は高くなる。

るとしたら，成長期から高齢期の初期までの間，Frはほとんど変化しないこととなる。これは，Alexanderが主張した「最小限の努力で行う歩行は動力学的に同一である」という理論が本研究で改めて証明されたといえよう。

本研究の通常歩行において性差が認められなかったことも，サイズや性別を問わず筋肉の動きを最小限ですむように，経済的歩行が選択されていることによるかもしれない。図2aに示すように通常歩行の際，人々は自分の下肢長に合った相対歩幅をとることで位置エネルギーと運動エネルギーの交換を効率的に活かしている可能性がある。つまり，脚の長い人は歩幅を，脚の短い人は歩調を活かす歩行を選択している可能性が考えられる。一方，速歩行は通常歩行からランニングに移行する中間の動作であるため，より大きなエネルギーが要求される。しかし，図2aのような振り子運動(位置エネルギーと運動エネルギーの交換)のみでは，前方に早く進むことが困難になる。すなわち，身体重心を上昇させるためのよりパワーフルな筋骨格系の収縮要素(筋)と弾性要素(腱)間の協調が同時に要求される。しかし，筋骨格系を取り巻く環境には，性差と年代差が存在することは多くの研究で認められている(図2b)。60代からFrに顕著な低下が認められたのもこのような理由が伺える。つまり，加齢に伴う関節変性による動作制限，下肢筋力や神経系のフィードバックの低下が結果的に相対歩幅や歩行速度に

影響することが考えられる。

今日までの報告によれば，高齢者の歩行速度(絶対速度)は，若年者に比較し遅い[5,6,13]とされているが，本研究により，高齢者の通常歩行においては比較的高い年齢までFrを保つことが可能であることが示唆された。一方，速歩行ではより早い時期から無次元速度は低下した。無次元速度(Fr)の中高年者の歩行解析への応用は，大きさや体重の相違による歩様変化を除外できるため，今後の歩行の加齢変化の本質的な関連因子を調べる際，有効であると思われる。

文　献

1) Jessica, R. and James, G. G.: Human Walking, Lippincott Williams & Wilkins, Philadelphia, 2006.
2) Furuna,T., Nagasaki, H., Nishizawa, S. et al.: Longitudinal change in the physical performance of older adults in the community. J. Jpn. Phys. Ther. Assoc. **1**: 1-5, 1998.
3) DeVita, P. and Hortobagyi, T.: Age causes a redistribution of joint torques and powers during gait. J. Appl. Physiol. **88**: 1804-1811, 2000.
4) Elble, R. J., Thomas, S. S., Higgins, C. et al.: Stride-dependent changes in gait of older people. J. Neurol. **238**: 1-5, 1991.
5) Finley, F. R., Cody, K. A., Finizie, R. V.: Locomotion patterns in elderly woman. Arch. Phys. Med. Rehabil. **50**: 140-146, 1969.
6) Gabel, R. H., Johnston, R. C., Crownishield, R. D.: A gait analysis/trainer instrumentation system. J. Biomechanics. **12**: 543-549, 1979.
7) Brunner, E., Shiply, M., Spencer, V. et al.: Social inequality in walking speed in early old age in the Whitehall II study. J. Gerontology **64**(10): 1082-1089, 2009.
8) 伊東　元，長崎　浩，丸山仁司ほか：健康男子の最大歩行時における歩行周期の加齢変化．日本老年医学雑誌 **26**(4): 347-351, 1989.
9) Alexander, R. M.: Dynamics of dinosaurs & other extinct giants, pp. 27-43, Columbia University Press, New York, 1989.
10) Alexander, R. M.: Estimates of speeds of dinosaurs. Nature **261**: 129-130, 1976.
11) Simokata, H., Ando, F. and Niino, N.: A new comprehensive study on aging-the National Institute for Longevity Sciences, Longitudinal Study of Aging (NILS-LSA). J. Epidemiol. **10**(Suppl. 1): S1-S9, 2000.
12) Vaughan, C. L., Langerak, N. G. and O'Malley, M. J.: Neuromaturation of human locomotion revealed by non-dimensional scaling. Exp. Brain Res. **153**: 123-127, 2003.
13) Himann, J. E., Cunningham, D. A., Rechnitzer, P. A. et al.: Age-related changes in speed of walking. Med. Sci. Sports Exerc. **20**(2): 161-166, 1988.

日本未病システム学会雑誌　別刷

Vol.16　No.2　2010

研究論文●2

地域在住中高年者の下肢筋力と重心動揺の関連に関する横断的検討

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研究論文●2

地域在住中高年者の下肢筋力と重心動揺の関連に関する横断的検討

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1 背景・目的

平衡機能は，起立，歩行，跳躍など，どのような運動の場合にも姿勢を支えるための基本的なADLにかかわる重要な機能である[1)]。加齢に伴って体力の各要素は衰えるが，そのなかでも平衡機能の低下は著しい[2)]。特に高齢者において平衡機能の低下は転倒の大きな要因ともいわれており，平衡機能の維持が重要と考えられる[3)]。

平衡機能を正確に評価する指標として重心動揺がある。重心動揺は直立時における足圧重心の動揺から姿勢維持機能を評価する指標であり，閉眼と開眼での重心動揺の形，長さ，面積など，多方面からの検討が可能であるため重心動揺の総合的評価ができる[4)]。平衡機能の低下を防ぐためには，身体の重心を支える下肢筋力を維持することが重要であると考えられる。これまでの平衡機能と下肢筋力の関連に関する研究では，高齢者の静止立位時の重心動揺に影響を及ぼす体性感覚・視覚・下肢筋力・反応時間の4つの要因との関係を一次構造方程式モデルにて検討し，下肢筋力の影響がほかの要因よりも大きかったと報告している[5)]。藤原らは20～79歳までの健常成人を対象に，最前傾位での重心動揺と下肢筋力との関連性について検討し，筋活動量の多い立位姿勢では安定性の規定要因として筋力の重要性が増大すると報告している[6)]。しかし，これらの研究は少数のボランティアを対象とした研究がほとんどであり，地域代表性のある中高年者を対象とした大規模な研究ではない。また，平衡機能の指標として片足立ち[3)]や機能的バランス評価法の中でもFunctional Reach Test[7)]項目を用いた検討もされてきた[8)]が，このような方法は再現性に問題があることや一方向の平衡機能のみ評価しているため加齢などによる平衡機能変化の評価には十分ではない[4)]。

本研究では重心動揺計を用いて測定した平衡機能と，日常生活活動動作と密接に関係している大腿四頭筋力の評価指標である膝伸展筋力[1)]との関連を，無作為抽出された地域在住の中高年者で明らかにし，平衡機能障害の予防に役立てることを目的として検討を行った。

2 方法

1．対象

対象者は，「国立長寿医療研究センター・老化に関する長期縦断疫学研究(NILS-LSA：National Institute for Longevity Sciences-Longitudinal Study of Aging)」の第5次調査(2006～2008)に参加した中高年男女である。NILS-LSAは愛知県大府市(人口約70,000名)および知多郡東浦町(人口約40,000名)の地域住民を対象とした老化と老年病に関する縦断的コホート調査である。本調査の参加者は，年齢別・性別に層化無作為抽出されている。この調査は国立長寿医療研究センターにおける倫理委員会の了承のもとに参加者に対して事前に調査・検査内容とその意義を十分に説明し調査への参加の文書による同意(informed consent)の得られた者を対象として行われている。本研究は第5次調査に参加した2,419名の中で膝

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