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Association between the caregiver's burden and physical activity in community-dwelling caregivers of dementia patients

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ABSTRACT

Physical activity in the elderly has a significant influence on their health status. Studies have shown that elderly caregivers have fewer physical activities relative to non-caregivers. The present study aimed to identify factors associated with lower physical activity in elderly caregivers of demented patients. A cross-sectional survey of 50 elderly caregivers living with patients diagnosed with Alzheimer's-type dementia showed that the Zarit caregiver burden interview (ZBI) scores were significant predictors of physical activity measured by the questionnaire score (QS) of physical activities. Among the three subscales of the QS, it was only leisure time activity scores (LS) that the ZBI scores significantly predicted. The numbers of chronic diseases were associated with lower household activity scores (HS) and sport activities scores (SS). Physical activities, in particular leisure activities, were found to be inversely associated with care burden assessed by the ZBI. Interventions to increase the physical activity levels of older caregivers may improve their health status and quality of life.

1. Introduction

It has been reported that lower levels of physical activity increase the risk of cardiovascular events (Blair et al., 1989) and higher mortality (Lee et al., 1995; Barengo et al., 2004) and that increased physical activity levels can help to maintain physical functions (Chu et al., 2004), contribute to the prevention of the cardiovascular disease (Dubbert, 2002), and decrease mortality (Davis et al., 2001). In addition, habitual physical exercise has been reported to be beneficial in terms of maintaining psychological health in the elderly (Bowen et al., 2006; Gautam et al., 2007).

In Japan aging of the population is occurring at an unprecedented rate, and the ratio of older adults aged 65 and above is estimated to reach 25% in 2015 (Health and Welfare Statistics Association, 2003). Under the urgent pressure of expected increases in the social burden related to care of the older population, Japanese government commenced an initiative to promote health called Healthy Japan 21 (Japan Health Promotion and Fitness Foundation, 2000). In this program, regular physical activities with an intensity of moderate degree (such as doing simple gymnastics and walking) is recommended for health promotion of older adults.

Despite such encouragement to exercise regularly for physical fitness, in general it had been shown that elderly caregivers have few physical activities (Burton et al., 1997; Wilcox et al., 2000; Fredman et al., 2006). As such, the physical health of elderly caregivers of demented patients might be at risk due to their reduced opportunities for regular exercise. The psychological burden of care in caregivers of demented patients has been suggested to be greater than that in caregivers of non-demented patients, presumably due to the psychological and behavioral symptoms present in demented patients (Onishi et al., 2005). Moreover, a possibility that the physical health of those caring for patients with dementia might also be at stake has been suggested by previous findings, showing a higher prevalence of hypertension (Shaw et al., 1999), a higher mortality rate in these individuals (Schulz and Beach, 1999), and reduced lymphocyte sensitivity (Bauer et al., 2000).

As mentioned above, caregivers have smaller amount of physical activities and higher care burden, and both conditions are associated with deteriorated health and higher mortality. Indeed, several studies reported that psychological distress is a factor associated with lower physical activity (Kaplan et al., 2001; Lim and Taylor, 2005). However, there has been a dearth of study thus far to investigate the association of reduced physical activities and care burden in this "high-risk" population.

In the current study we tried to find the associated factors with reduced physical activities in the caregivers of the demented, in

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particular focused on the association between the types of physical activities and the care burden.

2. Methods

2.1. Sample and study design

The study participants were 50 caregivers aged 65 and older who were living with elderly patients diagnosed with Alzheimer's-type dementia according to DSM-IV (American Psychiatric Association, 1994) diagnostic criteria. Diagnoses were made by a group of experienced geriatricians.

The study was approved by the ethics committee of the Nagoya University Graduate School of Medicine, and all participants gave written consent after being given a detailed description of the study.

2.2. Assessment of caregivers

Caregivers were assessed using three assessment tools. Firstly, the Japanese version of the ZBI (Zarit et al., 1980) is a questionnaire that includes 22 items. The caregiver's burden, assessed based on physical, psychological, and economical factors, was scored (0–88). Higher score indicated increased burden. Secondly, physical activity was assessed by the physical activity QS for the elderly (Voorrips et al., 1991). The QS comprises three subscales: household activity scores (HS), sport activity scores (SS), and leisure time activity scores (LS). Items related to the household activity scores were questions with 4–5 possible ratings, ranging from very active to inactive. The SS is an assessment of activity in all types of sports (e.g., walking, golf, gymnastics, and so on). The LS assesses leisure activity (e.g., gardening, ceramic art, and so on). The SS and LS are assessed by the hours per week spent on each type of activity, and by the period of the year during which the activity is normally performed. All activities are graded their intensity, hours and period of the year. Thirdly, the visual analogue scale (VAS) (Carlsson, 1983), a simple and commonly used self-rating scale originally developed for the subjective assessment of pain (0–100), was used to assess the mood of caregivers.

2.3. Assessment of care recipients

Care recipients were assessed using two assessment tools. Firstly, the Japanese version of the neuropsychiatric inventory (NPI; Hirono et al., 1997) was used to evaluate the psychobehavioral symptoms of care recipients. Secondly, the cognitive function and severity of dementia were assessed using the mini-mental state examination (MMSE; Folstein et al., 1975) (0–30).

2.4. Statistical analysis

Quantitative data analyses were carried out using SPSS (version 17.0) statistical software. Results were considered statistically significant at the level of $p < 0.05$. Multiple linear regression was used to estimate unique variance in QS or inferior scores (HS, SS, LS). The independent variables were ZBI, age, gender, VAS for depression, number of chronic diseases, and number of persons living together. Additionally, Pearson's correlation coefficient was computed to estimate the association between the time spent for caregiving and the QS.

3. Results

Table 1 shows demographic data and various health parameters of the participating caregivers and their care recipients. Hypertension was the most prevalent condition of caregivers (56%), followed by hypercholesterolemia (34%) and diabetes (24%). More than half of the participants lived with other family members (56%). Care recipients showed various degrees of psychobehavioral symptoms assessed by NPI (14.0 ± 11.03).

Table 1
Health factors for caregivers and care recipients, mean ± S.D. or *n* (%).

Caregiver	
Male/female	18/32
Age (years)	73.3 ± 4.2
Systolic blood pressure (mmHg)	128.3 ± 22.4
Diastolic pressure (mmHg)	77.5 ± 9.5
HbA_1C (%)	5.6 ± 0.8
HDL-C (mg/dl)	59.6 ± 16.5
LDL-C (mg/dl)	112.6 ± 32.0
Triglyceride (mg/dl)	144.0 ± 66.2
Body mass index (kg/m^2)	22.6 ± 3.3
Having no other family members	28 (56)
Comorbidity of chronic disease	45 (90)
Hypertension	28 (56)
Diabetes	12 (24)
Hypercholesterolemia	17 (34)
Cancer	2 (4)
Others	4 (8)
Care recipient	
Male/female	31/19
Age (years)	76.6 ± 6.4
MMSE score	18.0 ± 7.5
NPI	14.0 ± 11.3

The average ZBI score was 32.1 ± 19.8, with female caregivers having higher scores (36.0 ± 21.6) than male caregivers (25.3 ± 14.4). The HS and VAS for depression in female caregivers were significantly higher than those for male caregivers. Meanwhile, the QS (4.1 ± 2.9), SS (1.3 ± 2.7) and LS (1.0 ± 2.0) were higher in male caregivers, none of these trends reached statistical significance (Table 2).

To compute the unique variance in the QS, the variables (ZBI scores, gender, age, VAS for depression) were forced into the regression equation as the first step, followed by the number of chronic diseases and the number of persons living together as second and third steps, respectively (model 1, 2). The analysis showed that the ZBI scores were significant predictors of the QS and LS (model 1, 2), but they did not predict the HS and SS (Table 3).

In order to compute the unique variance in each inferior score of the QS (HS, SS, LS), the variables for the ZBI, gender, age, the VAS for depression, and the number of chronic diseases were forced into the regression equation as the fourth and fifth steps. The number of chronic diseases emerged as a significant predictor of the HS and SS, while only the ZBI scores were significant predictors of the LS.

The significant negative association was estimated between the time spent for caregiving and the QS ($r = -0.312$, $p < 0.05$).

Table 2
Gender comparison of psychosocial and physical activity scales, mean ± S.D.

	All	Male	Female	*p*
Number	50	18	32	
ZBI	32.1 ± 19.8	25.3 ± 14.4	36.0 ± 21.6	0.067
QS	3.9 ± 2.7	4.1 ± 2.9	3.8 ± 2.7	0.671
HS**	2.1 ± 0.5	1.8 ± 0.4	2.2 ± 0.4	0.009
SS	1.2 ± 2.4	1.3 ± 2.7	1.2 ± 2.3	0.882
LS	0.6 ± 1.6	1.0 ± 2.0	0.4 ± 1.2	0.199
Depression*	29.4 ± 25.7	18.6 ± 22.2	35.5 ± 25.9	0.024
No. of chronic diseases	1.5 ± 0.9	1.6 ± 0.9	1.4 ± 0.8	0.562
No. of family members	3.0 ± 1.7	2.9 ± 1.5	3.1 ± 1.7	0.633

* $p < 0.05$.
** $p < 0.01$.

Table 3
Multiple linear regression model for physical activity and ZBI.

	Variables	β	T	p
QS	(Model 1)			
	ZBI*	−0.340	−2.177	0.035
	Gender	0.109	0.777	0.441
	Age	−0.081	−0.602	0.550
	Depression	−0.194	−1.246	0.219
	No. of chronic diseases	0.150	1.131	0.264
QS	(Model 2)			
	ZBI*	−0.340	−2.102	0.041
	Gender	0.088	0.617	0.540
	Age	−0.066	−0.484	0.631
	Depression	−0.186	−1.178	0.245
	No. of family members	0.063	0.463	0.646
HS	ZBI	−0.039	−0.249	0.804
	Gender **	0.419	3.023	0.004
	Age	−0.035	−0.264	0.793
	Depression	−0.198	−1.284	0.206
	No. of chronic diseases*	−0.272	−2.067	0.045
SS	ZBI	−0.070	−0.447	0.657
	Gender	0.129	0.913	0.366
	Age	−0.103	−0.756	0.454
	Depression	−0.293	−1.863	0.069
	No. of chronic diseases*	0.354	2.644	0.011
LS	ZBI**	−0.479	−3.046	0.004
	Gender	−0.135	−0.957	0.344
	Age	0.028	0.207	0.837
	Depression	0.175	1.114	0.271
	No. of chronic diseases	−0.209	−1.557	0.127

* $p < 0.05$.
** $p < 0.01$.

4. Discussion

In the current study we examined factors associated with low physical activities of the caregivers who were taking care of older patients with dementia. Physical activities, especially leisure activities were inversely associated with care burden measured by the ZBI, and the observed association was independent of depressive mood.

Several reasons may be considered to explain the association between low physical activities and higher care burden. As supported by an inverse correlations observed between the time spent for caregiving and the QS, providing care has been described as a stressful experience that may erode psychological well-being and physical health of caregivers (Pinquart and Sorensen, 2003). Accordingly, caregivers with high care burden may have less temporal or psychological capacity to spare time for physical activities. Caregivers may also be prone to feel physically fatigued by a sense of burden. Care burden was reportedly associated with depressive mood (Adams, 2008), and depressive mood generally lowers the level of physical activity (Wise et al., 2006). The association between physical activity and ZBI scores observed in the current study, however, was independent of depressive mood measured by VAS. In other words, the care burden itself was associated with lower activity levels, but depressive mood did not intervene between these two factors. A more detailed analysis of depressive mood may be necessary to confirm these findings.

On the other hand, the ZBI scores had no significant relationship with the HS and the SS. Housekeeping works are the necessities of life in most households, thus routinely operated, and also some sport-related activities, such as playing golf, can be long-standing habit hard to give up. Therefore such activities may not easily be affected by a sense of burden.

The current investigation also revealed that many caregivers have chronic medical conditions. Subjects with chronic disease generally have low levels of physical activity (Arne et al., 2009), and the impact of the disease was negatively correlated with the mental health status (Forbes et al., 2007). In the current study, the number of chronic diseases was associated with lower HS and SS, but not with QS and LS.

Higher mortality in caregivers has been reported (Schulz and Beach, 1999; Fredman et al., 2008), however, the underlying mechanism of higher mortality remains unknown. Many literatures indicated that low physical activities including leisure are closely associated with higher mortality (Lee et al., 1995; Barengo et al., 2004), and the effectiveness of exercise in maintaining physical health in the elderly has been demonstrated (Struck and Ross, 2006). Recently, Byberg et al. (2009) reported that increased leisure activities reduced the mortality. The current study suggested that care burden reduces the overall physical activities in the caregivers, and it particularly affects the time spent for leisure activities. Taken all these findings together, one can easily conceive that the reduced physical activities due to care burden may have some deteriorating effects on caregivers' health. To prevent caregivers from having their own health status at stake by caregiving, it may be appropriate to seek for external sources of care provision in view of reducing substantial burden by sharing it with professional care providers. In Japan the public long-term care insurance system was launched in 2000, aiming to provide sufficient support for disabled older adults and their caregivers. Various types of supports that the insured can benefit from the insurance policy include home aides, day care, and short-term stay in the facilities. However, it has been suggested that the care burden of caregivers has not necessarily decreased since the introduction of the insurance scheme (Okamoto and Harasawa, 2009), and several reports suggested that the health-related quality of life of caregivers (Morimoto et al., 2003; Takai et al., 2009) had in fact deteriorated. Improvement of service provisions would be warranted in order to meet substantial needs of informal caregivers as well as care recipients.

On the other hand, increasing physical activities of the caregivers may help to reduce care burden. It may be difficult for older adults to maintain or begin the habit of regular exercise (Conn et al., 2003), however, given the results of the current study that leisure score was most strongly associated with care burden, interventions attempting to increase leisure activities may reduce care burden.

Limitations of the current study are as follows. Firstly, assessments of the physical activity levels of caregivers relied on self-reported scoring of the three domains. Therefore the variances inherent in subjective assessments may have affected the results. Secondly, the sample size was relatively small and study design was cross-sectional. A longitudinal intervention involving more participants would be warranted to investigate the effects of increased physical activities on care burden.

In conclusion, we observed an association between lower physical activity levels in the caregivers of demented patients and a higher care burden. This association was particularly strong with regard to leisure activities.

Conflict of interest statement

None.

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加齢と精神心理的変化

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KEY WORD
知的機能，人格，心理状態，ビタミン，亜鉛

ライフステージと精神心理的変化

精神心理的変化という言葉は，理解しやすいようでいささか漠とした響きがあるのも事実である．感覚や知覚など比較的「低次」な機能を意味する場合や，記憶や言語など比較的「高次」といわれる機能をもって精神心理機能を評価する場合もある．本稿では栄養との関連性という観点から論をすすめるが，精神心理機能がおもに脳における精神活動を基礎とするかぎりにおいて，栄養が精神心理機能に影響を与えていることは間違いのないところであろう．しかしながらそれをいかに証明するのかという点においては困難が存在する．精神心理機能は日常の活動性，生活の質に影響を与えるのは想像に難くないが，脳機能にのみ依存しているわけではなく，社会的機能，身体的機能と相互依存的な関連性をもっている．

幼少期から，青年期の発達段階，壮年期の成熟段階などそれぞれのライフステージにおいて精神心理機能は環境や身体状況によってつねに変化し続ける．とくに高齢期においては，心理的ストレスに対する生体反応や恒常性の維持機能の低下が身体症状に影響を与え，それが逆に精神心理機能に反映されるという双方向性の関係が示唆される．栄養との関連という視点からは，長期的な食習慣や栄養環境による影響の蓄積が高齢期の精神心理機能に反映される可能性はおおいに考えられる．

加齢にともなう精神心理的変化

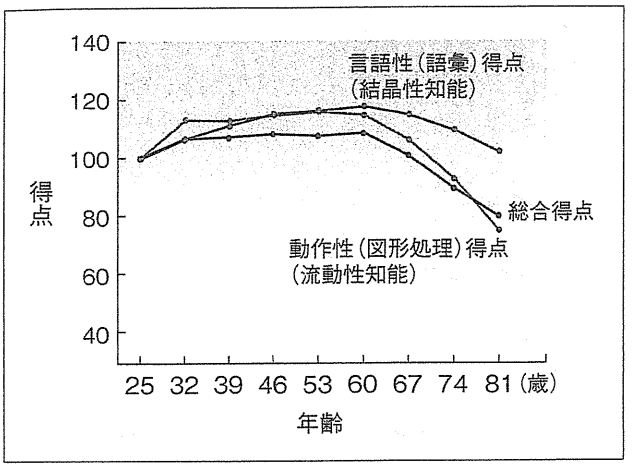
精神心理機能は非常に幅広い概念領域をもつものであり，総体としてはつかみどころのない機能である．したがって，本稿ではあえて「知的機能」「人格機能」「心理機能」に絞って述べることとする．これら人間の精神心理機能を構成する重大な機能に栄養がどのようにかかわっているのかを，後に概説を試みる．

知的機能

知的機能とは，与えられた課題に含まれている関連因子を分析し，その課題を行動的または概念的に解決する能力と定義できる．つまり生活のあらゆる場面において思考し，判断し，行動するために人間がもっとも行使する機能といってよい．

従来から経験に基づく「結晶性知能」と経験によらない「流動性知能」に分類されてきた．一般的には応用力や思考の柔軟性，情報の処理能力やその効率によって規定される流動性知能は，認知症など知的能力に重大な障害をもたらす病態に罹患しない場合でも，年齢とともに緩徐に低下すると考えられている．その低下幅は同年齢の個人差ほど大きくはないと考えられており，個々の栄養を含む生活史とも関連している．それに対して経験に基づいた知識の蓄積によって規定される結晶性知能は，中高年になっても簡単に低下するものではなく，認知症などで過去の経験の記憶が失われない限りは加齢で簡単に低下するものではない（図1）．

図1　知能の加齢による変化（系列法）



井上勝也，木村周，編．新版老人心理学：朝倉書店；1993．p51．

人格の加齢による変化

加齢にともなう人格の変化は拡大型，反動型，円熟型に大別することができる（**表1**）．これらの変化は社会的引退にともなう生活感の変容あるいは身体的変化および変化への適応によってさらに分類することができる（**表2**）．円満，活動，孤独の3タイプはある程度加齢を運命として受容し，抗う態度を示さないのに対して，依存，支配，過剰活動の3タイプは加齢にともない喪失するものを容易に受容しない態度を示す傾向にある．一般的な性格変化の特徴としては，保守化，心気的，猜疑心，偏執的，吝嗇，自己中心傾向などが観察される．これらの傾向の有無や程度は社会環境や現在の境遇に対する自己評価のみでなく，脳内の器質的，機能的環境の変化の結果として表出するものであり，一概にすべての高齢者にあてはめられるものではない．認知症に罹患した高齢者の場合は脳内で特定の部位（おもに前頭葉と考えられているが）に病理的変化が現れることにより，個人が従来もっていたものとまったく正反対の性格変化が現れることもある．たとえば認知症性疾患のなかでも，比較的まれな疾患である前頭側頭型認知症（その典型例は病理所見を報告した医師の名にちなんでピック病とよばれる）の場合，おもに前頭葉の障害により，もともときれい好きだったのに不潔にしていても一向に構わなくなったり，食の嗜好がまったく変わって同じ食べ物に異常なまでの執着をみせたりすることもある．

表1　加齢にともなう人格の変化

拡大型	生来の性格がより顕著になる（性格の先鋭化）
反動型	生来の性格と反対の方向に変化する
円熟型	調和がとれて穏やかで円満になる

表2　加齢による身体的，社会的変化による性格変化

円満型	自らの老いを受け入れ，社会，家族との軋轢を避け，分別をもって穏やかに余生を送る
活動型	社会的引退を肯定的にとらえ，余暇を楽しむことにより活動性を維持する．社会的責任からの解放感がある
孤独型	生来社交性がないのが顕在化する．周囲との交流を拒絶し，孤独に生活する
依存型	若年期に満たされなかった愛情を求めて，周囲に対して依存的態度をとる
支配型	過去の社会的地位に固執し，頑固で傲慢，命令的な態度を維持する． 社会的地位の高かった高齢者に多い
過剰活動型	満たされなかった願望の実現のために極端な方向で活動的になる． 宗教や健康への異常な執着を示す

心理状態の加齢変化

高齢者の心理状態は内因性の素因の強い若年者と比較して，心理社会的要因と身体的要因が背景に存在し，高齢期にみられるうつ状態および病的な心理状態としてのうつ病はさまざまな喪失体験に対する心理的不適応が起因となる場合が多い．高齢者の心理状態は身体症状として表出することが多く，逆に身体症状の悪化がうつの起因となることもまれではない．うつによる身体症状としては，口渇，めまい，血圧の上昇，食思不振，便秘，下痢など自律神経系の症状をともなうことが多い．詳細は次項の「うつと低栄養」の項に譲るが，それらのうつに起因する身体の変調が高齢者の栄養状態に与える影響は大きいと考えられる．高齢者の病的な心理状態としてのうつは**表3**のように分類できる．心気症は高齢者によく観察される症状であるが，その他の型の場合には認知症

表3　高齢者のうつの分類

心気症型	体の不調を訴えることが多い
意欲低下型	何もする気が起こらずに，そのことを悩む
不安焦燥型	不安感が強く落ち着きがない
妄想型	体や自己の状況に関する妄想をともなう

や脳血管障害などの器質性疾患が背景にある場合が多いので，意欲低下，焦燥感，妄想などの症状を認める場合にはなるべく早く医療機関で原因疾患の検索を行い対処することが望まれる．詳細は認知症と栄養の項に譲るが，認知症によくみられる症状に「無関心」があり，症状としては難治性である．通常，アルツハイマーを代表とする認知症の初期から中等症にかけては比較的食欲が亢進することが多くみられるが，食に対する無関心がある場合には低栄養の重大な危険因子となりうる．

高齢期の栄養素と知的機能，心理状態との関連

●ビタミンと知的機能の関連

ビタミンDは従来，骨代謝との関連においてその重要性が認識されてきたのは周知の事実である．しかしながら近年の研究においてはその抗がん作用，抗炎症作用，心血管系，精神神経系の保護作用など多面的な機能維持に寄与している可能性が示唆されるようになった．実験系においてもビタミンD受容体および終末ビタミンD活性酵素が，胎児および成人脳に広く分布しており，神経保護機能やカルシウム結合蛋白，アセチルコリンなど神経伝達物質の合成に関与していることが報告されている[1]．高齢在宅女性（平均年齢80.5歳）5,596名を対象にした大規模な横断調査においては，不十分な食事からのビタミンD摂取は認知機能の障害と有意な関連を認めている[2]．施設入所高齢者において1週間の食事内容を検討（各栄養成分の正確な重量測定法による）したところ，簡易の知能検査で誤答のなかった群では，シリアル，卵，油，脂肪の消費が有意に多く，総エネルギー消費および教育歴で調整すると食事内容としては魚および野菜の消費，成分内容としては食物繊維，ビタミンB_6，葉酸の摂取と知的機能との間に有意な関連がみられた[3]．近年の健康ブームの影響も手伝って，ふだんの食事に加えてマルチビタミンやミネラルのサプリメントを服用する高齢者もみられるようになったが，その精神心理機能への効果は十分に検証されているとはいい難い．成人女性を対象とした二重盲検試験に結果によるとサプリメント服用群においては課題遂行における気分／疲労度の減少効果および課題遂行の正確性，計算課題，前頭前野機能を反映するとされるStroop課題において非服用群と比較して改善がみられた[4]．一方で，ビタミンB_{12}，B_6，葉酸による介入試験では知的機能に対する効果は認められなかったとする報告がある．75歳以上の地域在住高齢者を対象とした長期間のフォローアップ（二重盲検）によると，ビタミン付加は2年後の認知機能の改善および8年間のフォロー期間の認知症の発症になんら期待された効果を認めなかった[5]．また，認知症の発症リスクを高めるとされるApoE4遺伝子保有者に対するビタミンB群投与による認知機能低下のリスクの軽減は観察されなかった[6]．

●ビタミンと心理状態との関連

以前よりビタミンBと抑うつ気分の関連は指摘されてきたが，高齢者を対象とした平均7年余りにわたる縦断的検討によれば，余分にビタミンB_6とB_{12}を摂取すると抑うつ発生を12年間まで抑えられる可能性があると報告された[7]．脳卒中に罹患した高齢者を対象とした二重盲検試験によると，ビタミンB投与群と非投与群を平均7年間観察したところ抑うつの発症が有意に押さえられたことがわかった[8]．これらのビタミンBによる気分への影響が，ビタミンそのものの直接作用によるものか，あるいはホモシステインの抑制を介しての血管障害の進展予防による間接的なものなのかをはっきりと区別することは困難である．

◉亜鉛と心理機能の関連

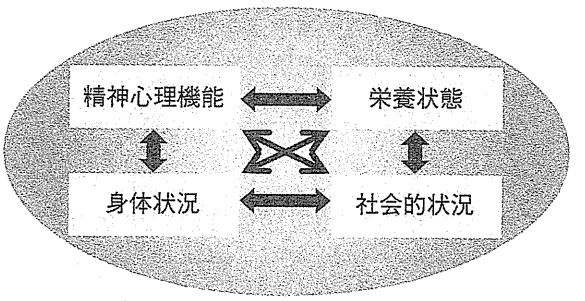
栄養成分と心理機能との関連についてはさまざまな報告がある．そのなかでも亜鉛については高齢期の心理状態との密接な関連が指摘されている．亜鉛の人体における機能は多彩である．代謝，細胞情報の伝達，遺伝情報の制御から染色体や細胞膜の構造維持にいたるまでさまざまな機能に関与している．長期にわたる亜鉛摂取の不足や吸収不良は身体に重大な影響を与える．亜鉛欠乏は高齢者により多く観察されると考えられている[9]．

一般に亜鉛欠乏は味覚や免疫機能に影響を与えるとされているが，心理機能への影響も指摘されている[10]．脳内の亜鉛は大脳皮質，記憶に関与する海馬や感情機能をコントロールする扁桃体にも集積が認められる．神経細胞内ではグルタミン酸系ニューロンのシナプス前小胞に局在し，グルタミン酸の貯蔵，放出や再取り込みに関与しているとされるが詳細な機能は明らかにされていない[11]．血清亜鉛濃度は高齢者の認知機能との関連が報告されており[12]，うつ病患者において亜鉛を含む微量栄養素の欠乏は数多く報告されている．食品およびそのなかに含まれる栄養素は国や地方によって異なる．北欧と南欧の5カ国を対象に普段の食品に含まれる推定亜鉛含量と認知機能，抑うつの頻度，主観的ストレスなど精神心理機能の指標との関連を検討した結果，亜鉛に乏しい食品の消費の多い国ではこれらいずれの機能とも低い傾向にあることが確認されている[13]．

おわりに

加齢による精神心理機能の変化と栄養との関連について概観してみた．いうまでもなく栄養は生命活動の源であり，脳がその中枢と考えられる精神心理機能とて例外ではない．しかしながら**図2**に示すように，その関係は原因と結果のような単純な因果関係で結ばれるものではなく．高齢期においても人間が社会的存在であり続ける以上，その身体機能，社会とのかかわりと相互依存的に関連するものであると考えられる．

図2　高齢期の精神心理機能―栄養の関連



各要素は原因と結果ではなく相互に関連しあっている

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各論

1. フットケアの理解に必要な高齢者の身体機能
—転倒など含む—

鈴木 裕介

KEY WORD
- 歩行機能
- 転倒
- 転倒リスク評価

SUMMARY

フットケアは通常，糖尿病合併症や閉塞性動脈硬化症などによる下腿潰瘍のケアが主な目的とされるが，不適切なフットケアが高齢者の機能予後に最も重大な影響を及ぼす転倒の危険性を高めていることは，まだ十分認知されていない．高齢糖尿病患者の転倒リスクが高いのは足底の知覚，触覚の障害による歩行機能，バランスの障害が原因として推察されている．また，足背筋膜炎，外反母趾，胼胝，中足骨痛や不適切な靴の使用など，足の痛みの原因となる症候と転倒の関連性が近年の研究により明らかにされるようになった．今後，転倒リスク評価および予防において足病変に対するフットケア，靴や足関節機能への介入も含めた転倒予防効果に関する論拠の構築が期待される．

高齢者におけるフットケアの意義

日本においてフットケアが一般的な用語として普及してからまだ日が浅いが，他稿でも紹介されると思われるが，日本フットケア学会も設立され(http://footcare.main.jp/)，医療者のみでなく様々な職種の方々のフットケアに関する関心は，近年とみに高まっているといえる．海外においては，既に医療においてpodiatryとして専門性をもった臨床領域として認識されており，podiatryの専門医のための教育プログラムおよび専門資格も存在する．一部の英語圏ではchiropodistという旧来の呼称を用いられる国もあるが，近年はpodiatryという用語が一般的になっている．Podiatryは足，踵，下腿に関する障害の研究，診断，治療に関する学問と定義できる．その目的や意義は国によって異なる．全くの余談ではあるが，podiatryの専門家としてのpodiatristは，かつて雑誌『Forbes』において世界で14番目に所得の高い専門職にランクされたこともあるらしい．かように海外において“足の臨床”の専門性が高く認識され，先行して発達したのは，何も医学の先進性にその要因を求める類いのものではなく，下肢の主に血管疾患の有病率の高さと，その医療経済学的な意義によるものではないかと考える．したがって近年，日本においてフットケアが重要視されるようになったのも，生活習慣の欧米化に伴う疾病分布の変化と無関係ではないと考えられる．少し前になるが，米国における高齢者用の医療保険(Medicare)の対象者の糖尿病性下腿潰瘍の医療費負担およびフットケアによる費用

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軽減効果に関する報告があった[1]．それによると，下腿潰瘍を有するMedicare利用者の医療費は有しない利用者の約3倍（$15,309 vs $5,226）であり，下腿潰瘍を有する高齢者の医療費の約1/4が下腿潰瘍のケアに費やされ，その大部分（73.7%）は入院治療に伴うコストであることがわかっている．また，20週間の治療により治癒率を約10%改善すると，患者1人当たり$189の費用削減効果に相当することもわかった．実際の臨床の枠組みにおいて，podiatryの関与する領域は老年医学に限らず，血管外科，スポーツ医学からプライマリーケアまで多岐にわたるが，本稿においては主に老年医学領域におけるフットケアが関与する病態を転倒という視点から論ずることとする．

高齢者の足の問題と歩行機能の関連

60～80歳までの健常高齢者213名の調査によると，全体の14%に何らかの足の痛みの訴えがみられ（男女比：1対4），その原因は足背筋膜炎，外反母趾，胼胝，中足骨痛，不適切な靴の使用など多岐にわたっていた．また当然のことではあるが，足の痛みの訴えは高齢者の歩行速度に影響することも確認されている．転倒歴との関連に関する足の問題については多変量解析の結果，足の痛み，特に足背の筋膜炎によるものと転倒に有意な関連が観察された．また男性においては，足の触覚の障害にも転倒との関連が指摘された[2]．これらは，従来より指摘されていた転倒のリスクとしての変形性関節症など下肢の問題に加えて，立位における唯一の接地面である足の問題が転倒のリスクを高めている可能性を示唆するものである．前述のごとく，足に関する訴えは通常女性に多くみられるが，長年の靴の使用状況と無関係ではない[3]．

高齢者の足の病態と転倒，骨折の関連

不適切なフットケアが転倒のリスクを高めていることと逆に，転倒が足の問題の要因となる可能性も考えられる．糖尿病性の神経障害により足底の痛覚，触覚が鈍麻することはよく知られている事実である．また，下腿，足の潰瘍形成が歩行機能に与える影響は看過できない問題である．55歳以上の糖尿病患者60名を対象にした調査によると，過去1年間に転倒した群と非転倒群を比較した場合，転倒群と非転倒群の末梢神経障害の有病率はそれぞれ86% vs 56%であった．ロジスティック回帰分析では，歩行速度，足関節の背屈力，末梢神経障害スコアが転倒の75%を予測するという結果を得ている[4]．さらに小規模ではあるが，2型糖尿病患者14名と同数の年齢，性別，BMIを調整した対照群との歩行パターンを比較したところ，糖尿病群においては末梢神経障害がないにもかかわらず踵の上がりが低く，つまづきやすい歩行パターンを示すことが報告されている[5]．健常高齢者を対象にした研究では，つま先の屈伸力が弱いこと，足の変形（外反母趾なし）が歩行不安定性，転倒のリスクを有意に高めていることが示されている[6,7]．足の病変を客観的に評価し，その程度と可動性障害，転倒の関連を検討した報告がある．それによると，Foot problem score（足の痛み，外反母趾の程度，そのほか足の変形，骨の突出，胼胝などの過角化）とバランス機能，転倒の有無を検討したところ，多変量解析によりFoot problem scoreとバランス，階段昇降などの歩行機能に有意な関連性があり，過去の複数回の転倒を有意に予測することがわかった[8]．176名の高齢者（平均年齢80.1歳）を対象にした足の機能と歩行バランスとの関連性を検討した報告によると，足関節の柔軟性，足底の痛覚，足底の屈曲筋力が，歩行バランス機能の独立した予測因子であるという結果を得ている[9]．また，同じ対象群を1年間追跡したところ，転倒群においては有意に上記の歩行バランス機能の規定要因以外に，外反母趾による足の変形と足痛が有意に関連していることが確認された．さらに判別分析により，ほかの転倒に関連する生理的な機能や年齢を除外した後でも，足底の屈曲力と足痛は独立した転倒の予測因子であった[10]．同様の研究デザインで312名の高齢者を1年間追跡したところ，転倒群においては有意

表1　転倒ハイリスク者の発見のための問診票

1）過去1年間転んだことがありますか(はい，いいえ)
　はいの場合転倒の回数(　　回/年)
2）つまづくことがありますか(はい，いいえ)*
3）手摺につかまらず，階段の昇り降りをできますか(はい，いいえ)
4）歩く速度が遅くなってきましたか(はい，いいえ)
5）横断歩道を青のうちに渡りきれますか(はい，いいえ)*
6）1kmくらい続けて歩けますか(はい，いいえ)
7）片足で5秒くらい立っていられますか(はい，いいえ)
8）杖を使っていますか(はい，いいえ)*
9）タオルを固くしぼれますか(はい，いいえ)*
10）めまい，ふらつきがありますか(はい，いいえ)*
11）背中が丸くなってきましたか(はい，いいえ)
12）膝が痛みますか(はい，いいえ)*
13）目が見にくいですか(はい，いいえ)
14）耳が聞こえにくいですか(はい，いいえ)
15）物忘れが気になりますか(はい，いいえ)
16）転ばないかと不安になりますか(はい，いいえ)
17）毎日薬を5種類以上飲んでいますか(はい，いいえ)
18）家の中で歩くとき暗く感じますか(はい，いいえ)
19）廊下，居間，玄関によけて通る物が置いてありますか(はい，いいえ)*
20）家の中に段差がありますか(はい，いいえ)
21）階段を使わなくてはなりませんか(はい，いいえ)
22）生活上家の近くの急な坂道を歩きますか(はい，いいえ)

文献18より一部改変引用　　*：独立した転倒の危険因子として抽出された項目

に足痛の訴えがあり，足底にかかる最大圧および圧時間積分値が有意に高いことが報告されている[11]．因果関係に関する考察には慎重を要するが，足底への過度な圧が足痛を引き起こし，結果として歩行の不安定性につながっている可能性が示唆される．ちなみに足の痛みを客観的に評価する指標としては，歩行や生活動作における痛みを考慮したManchester Foot Pain and Disability Indexがある[12]．

靴と足の病変，転倒の関連

足の病変(変形，潰瘍形成)などは，糖尿病などの身体疾患によってのみ引き起こされるものではなく，不適切な靴の選択も原因となることが過去の報告により確認されている．不適切な長さの靴を履いている高齢者においては足痛，足の潰瘍の発生が有意に高いことが観察されている[13]．サイズ以外にも，靴の形状が高齢者のバランス機能に与える影響に関する報告もある．それによれば，靴底が柔らかい材質の靴や踵の底面が高い靴は高齢者には推奨されない[14]．また，高齢者の歩行特性として急に立ち止まるのに時間がかかる傾向にあり，靴底が柔らかいものは不適切だが，踵周りの高い靴は止まる動作には適しているとの報告がある[15]．不適切な靴の着用の危険性は在宅高齢者のみに限ったものではなく，亜急性期病棟における転倒の危険性を高めることも指摘されている[16]．

フットケアを考慮した転倒リスク評価，転倒予防について

高齢者の機能予後における転倒の重要性は疑いの余地のないところであり，転倒リスク評価および介入に関する指針も多く存在する[17]．高齢者の転倒の要因は内因，外因ともに複合的なものであることから，必然的に予防においても複合的なアプローチが必要であることはいうまでもない．予防に有効とされる介入方法に関しては，これまでに様々な試みがなされ，その有

効性が報告されてきた．予防的介入の効果を高めるという視点から，転倒リスクの適切な評価は最も重要なプロセスであるといえる．日本においても，転倒リスクの評価を目的とした過去の転倒歴と21の下位項目からなる転倒問診票（**表1**）が考案され，地域在住高齢者において転倒予測における有用性が確認されている[18]．海外においても，多因子的なアプローチで転倒予測因子を同定する試みがなされてはいるが，高齢者の個々の転倒要因を評価する上でフットケアによる介入を意識した転倒予防プログラムは，いまだ一般的であるとはいえないのが現状である[19,20]．今後，転倒リスク評価および予防において足病変に対するフットケア，靴や足関節機能への介入も含めた転倒予防効果に関する論拠[21]の蓄積に期待したい．

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ORIGINAL ARTICLE

Physical and functional factors in activities of daily living that predict falls in community-dwelling older women

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Aim: In order to propose rehabilitation strategies for the reduction of falls risk, thereby preventing falls in older women, the present study was designed to explore the physical and functional factors related to actual incidence of falls.

Methods: Fifty-eight female patients aged 65 years and older (mean age ± standard deviation, 80.5 ± 5.7), who were attending a geriatric outpatient clinic participated. All the participants were assessed with their activities of daily living, gait and balance using various scales. Their handgrip strength and muscle strength of lower extremities were also measured using dynamometers. Falls of the participants during the 6 months follow-up period were recorded.

Results: Correlation analysis investigating associations between the scores of assessment scales and actual measurement of muscle strength and balance showed that there were significant correlations between handgrip strength and Falls Efficacy Scale, Functional Reach test, Timed Up and Go test, Berg Balance Scale, Motor Fitness Scale, motor Functional Independence Measure in fallers and non-fallers. A binary logistic stepwise regression analysis incorporating all the possible variables into the model revealed that only inability to "being able to go up and down the staircase" in the Motor Fitness Scale remained a significant variable to predict falls during the period of observation.

Conclusion: The results confirmed that the sub-item in the Motor Fitness Scale has a possibility of being a significant predictor of falls in older women, and therefore might prove useful in considering specific rehabilitation program on falls prevention as well as screening this population at risk of falls. **Geriatr Gerontol Int 2011; 11: ••–••.**

Keywords: activities of daily living, incidence of falls, physical performances, preventing falls, risk assessment of falls.

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Introduction

According to an estimate by the Ministry of Health, Welfare and Labor, there are approximately 1.7 million bedridden older adults in Japan in 2010 and it will increase to 2.3 million in 2025.[1] Also, the survey showed that 12% of older adults in a bedridden state occurred as a consequence of falls and related injuries, which are the second greatest cause after stroke. While the incidence of stroke almost remained unchanged for the last 10 years, fractures are reported to have increased by 1.5 times during this decade.[2] In Japan, bedridden older persons remain a major medical and social problem. Greater attention should be directed to falling, because it is one of the direct causes of older persons becoming bedridden.

Falls are frequent and recurrent problems among older people and one of the major incidences that affect the activities of daily living (ADL) and quality of life (QOL). One in three persons over 65 years of age and almost half of those who were over 80 years of age reportedly fell at least once a year.[3] The chance of recurrent falls increases with advancing age and it was reported that 8–17% of those who were 75 years or older[3] sustained multiple falls.[3–6] The consequences of falls include hip fractures, soft tissue injuries,[7–10] fear of falling,[10] hospitalization, increased immobility and greater disability.[9] Furthermore, falls can lead to loss of self-confidence in one's ability to perform routine daily tasks, eventually relating to the occurrence of social withdrawal (sometimes termed "post-fall syndrome").[11]

Various risk factors of falls have been raised based on the results of both retrospective and prospective studies. These factors include age, number of chronic diseases, body composition, muscle strength, functional mobility and performance measures related to balance function.[12–14] Previous studies have shown that decreased muscle strength of lower extremities and the balance instability lead to the fall.[15] Most previous findings related to falls risk have been based on both clinical evaluation methods[16] and self-reported confidence to accomplish ADL, but not many of which were gained from the results of actual physical performance tests.[17]

Activities of daily living is a term commonly used in a wide spectrum of disciplines, and there are many factors that may contribute to ADL such as age, functional ability and balance in old age, but its definitions and conceptualization vary from health status to life satisfaction. Conventionally, various instruments such as the Barthel Index (BI)[18] and Functional Independence Measure (FIM)[19] had been used for the assessment of ADL.

Because falls and their consequences have a major impact on functional prognosis in the older population, rehabilitation programs, which aim to reduce the risk of falling by augmenting all contributing factors such as muscle strength, flexibility and balance, have the potential to both decrease the risk of falling and improve ADL of older adults.

It was confirmed that women had a higher risk of falling than men.[20] It has been speculated that there are various intrinsic factors that make women more prone to falls than men, such as history of osteoporotic fracture after menopause, self-confidence on falling, lower muscle strength and worse physical performances. Differences in muscle strength and body composition are known to exist between men and women, and from early adulthood on, women have, on average, 30–40% less muscle strength than men.[21]

In order to propose rehabilitation strategies for the reduction of falls risk, thereby preventing falls in older women, the present study was designed to explore physical and functional factors related to actual incidence of falls during a 6-month follow-up period.

Methods

Subjects

Female patients aged 65 years and older, who were attending the Geriatric Outpatient Clinic of Nagoya University Hospital, participated in this study. The study was performed according to the principles of the Declaration of Helsinki and approved by the Ethics Committee of Nagoya University School of Medicine, Japan, in December 2007.

Exclusion criteria were: (i) hospital admission within 6 months; (ii) uncontrolled hypertension; (iii) dementia (Mini-Mental State Examination [MMSE][22] ≤15); (iv) ischemic heart disease or heart failure; (v) chronic obstructive pulmonary disease; and (vi) acute orthopedic pain and presence of neurological impairments.

Prior to the data collection, a written informed consent was obtained from each patient participating. After having obtained informed consent, all subjects were instructed to complete a questionnaire. It was designed to assess the risk of falls by scoring, and had 22 questions[23] including one asking about history of falls in the previous year (full score, 22). Those who scored 6 and above were regarded as subjects at risk of falls,[24] and were included in the present study. Eventually, 58 female patients (mean age ± standard deviation, 80.5 ± 5.7 years) were subjected to analyses. (Fig. 1)

All the participants had their medical background obtained by asking existing or previous history of illness, type of drugs used, existing physical complaints and geriatric syndromes. All the participants were then subjected to assessments of ADL, gait and balance, and muscle strength. Detailed descriptions of the assessments are provided below.

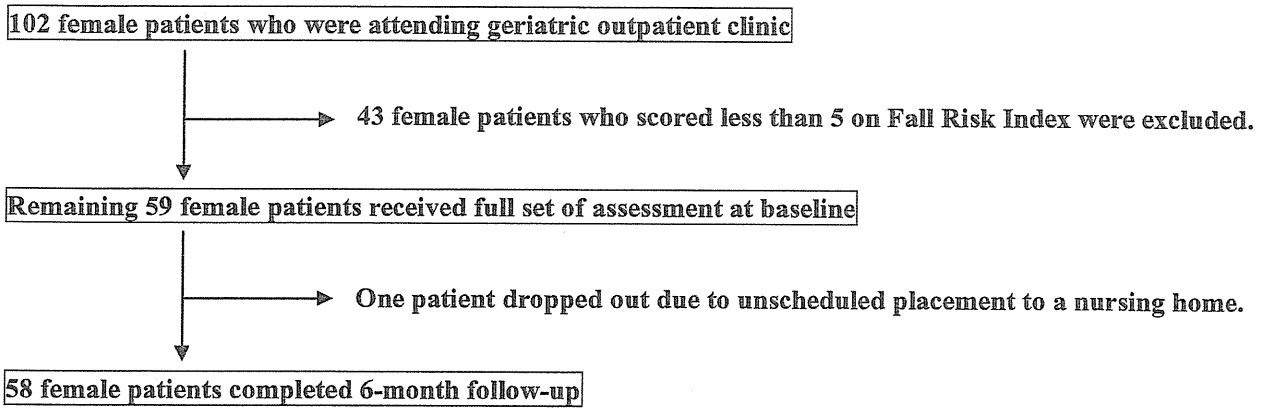

Figure 1 Flowchart showing the selection procedure of participants.

Assessment of ADL

The BI and FIM were used to assess ADL. Specific items in both scales are described elsewhere. In brief, BI is the most commonly used scale to assess one's basic ADL, and it consists of 10 items and scores range 0–100 points, with a higher score indicating greater ability. FIM is an 18-item, seven-level scale of independent performance in self-care, sphincter control, transfers, locomotion, communication and social cognition. The possible total score range from 18 (lowest) to 126 (highest level of independence).

Assessment of gait and balance

The Timed Up and Go test (TUG),[25] Functional Reach test (FR),[26] Berg Balance Scale (BBS)[27] and the Motor Fitness Scale (MFS)[28] were used to evaluate stability, balance and mobility of the participants. We adopted the BBS in the present study rather than the well-acknowledged Tinetti Balance and Gait Evaluation (Performance-Oriented Mobility Assessment [POMA])[29] because POMA is not suitable for analysis of slight differences, given the narrow range of scores in each item as previously suggested.[30]

The TUG test was designed as a quick measure of basic balance and mobility skill in elderly people. The time taken for subjects to rise from a chair, walk 3 m and return to the chair is measured in s, with a shorter time taken indicating better balance ability. Each subject was asked to perform two test trials. The mean score was recorded. The FR was designed to measure the limits of stability in an anterior direction. The score was determined by measuring the maximal distance that subjects can reach forward horizontally while maintaining a fixed base of support, with a greater distance indicating better balance ability. Two trials were performed and the mean score was recorded. The BBS was developed to measure balance impairments in elderly persons and people with neurological disorders. The scale consists of 14 common functional activities which are scored 0–4 (maximum score, 56). The MFS was created by totaling the scores for each item on the questionnaire, consisting of 14 items on motor fitness. This scale has a unidimensional structure with three subscales: mobility, strength and balance. In addition, all subjects were assessed on their postural sway, which was performed on a vertical force platform (Gravicorder GS-10 type C; ANIMA, Tokyo, Japan), fitted with three pressure gauges located in the corners. The subject was required to remain as stable as possible but relaxed, bipedal standing barefoot on the platform with the hands held hanging downwards in a neutral position, arms along the body and breathing normally, staring at a mark placed 2 m away, in a quiet room with artificial lightning. This test lasted 60 s and was performed with eyes open.

Evaluation of self-efficacy

Self-efficacy was evaluated using the Falls Efficacy Scale (FES).[31] The FES was designed to evaluate an individual's confidence in the ability to avoid a fall during each of 10 relatively non-hazardous ADL. The FES consists of questions related to the individual's concern about the possibility of falling when completing 10 specific daily living activities. Respondents are asked to identify, on a 10-point scale, how confident they feel of not falling when performing each activity, with 1 indicating extreme confidence and 10 indicating no confidence at all. The FES score was the sum of scores on each of the 10 activities. Possible scores range 10–100.

Measurement of muscle strength

The muscle strength in hip flexor, knee extensor, ankle extensor and flexor were measured using a hand-held dynamometer (EG-220; SAKAI, Tokyo, Japan) as the strength expressed in Newtons (N). No practice was

allowed before measurements except that oral instruction was given prior to the trials. Only one attempt providing verbal encouragement was made for both sides, and the mean of both sides was used for analysis in order to dilute the influence of the dominant side. None of the participants had history of medical conditions that may affect muscle strength such as overt osteoarthritis or stroke.

The maximum grip strength of the dominant hand was recorded with a Smedley's dynamometer (Matsuyoshi, Nagoya, Japan), expressed in kg. Participants were allowed to rest between the tests as necessary. Time to complete the interview and testing procedures ranged 40–60 min.

Falls record

Based on a definition of falls as "an unintentional change in body position resulting in contact with the ground or with another lower level, however, not as a result of a major intrinsic event (e.g. stroke, syncope) or an overwhelming hazard (e.g. car accident)",[32] history of incident falls and their frequency in a previous year was obtained from all participants. Also, they were given a "falls diary" and were asked to record fall events at the time they occurred during the 6-month follow-up period. The diary was collected at the end of the follow-up period for counting the number of falls subjected for analysis. All falls were recorded by the participants or their informants.

Statistics

Statistical analyses were performed using PASW (ver. 18.0) to investigate the association between the parameters examined and actual incidence of falls. Continuous variables between fallers and non-fallers were compared using the Mann–Whitney *U*-test.

Bivariate correlations on the cross-sectional data in both groups (fallers and non-fallers) were assessed using Spearman's rank of order correlation analysis to investigate the association between the functional scales and muscle strength.

Bivariate odds ratios (OR) with their 95% confidence intervals (CI) of the physiological variables at baseline were calculated for fallers who were defined as those who fell at least once or more during the 6-month observation period versus non-fallers who were defined as those who did not fall during the 6-month observation period.

Before constructing a multivariable model for the prediction of falls, univariate analysis was performed across all the variables. They were combined in a binary logistic stepwise regression analysis in which fallers and non-fallers formed a group criterion.

All the medical and pharmaceutical information were supplied by participants' attending geriatricians, and all the assessments were carried out by the same physiotherapist.

Results

The characteristics of the participants at baseline and the results of group comparison for continuous variables and of logistic univariate analysis are presented in Table 1. There were no statistically significant differences in all the continuous variables examined between fallers and non-fallers by Mann–Whitney *U*-test (Table 1).

Correlation analysis investigating associations between the scores of assessment scales and actual measurement of muscle strength and balance showed that there were significant correlations between handgrip strength and FES, FR, TUG, BBS, MFS and motor FIM in fallers and non-fallers. On the other hand, while significant correlations were found between muscle strength of hip flexor, knee extensor and cognitive FIM in non-fallers, it was muscle strength of the ankle dorsiflexor and plantar flexor that were significantly correlated with cognitive FIM in fallers (Table 2).

Because we only had a limited number of variables that gained *P*-values less than generally acceptable for the entrance to multiple logistic models, variables that met the increased threshold *P*-values ($P < 0.3$) in the univariate analysis, which were FES, mean of anteroposterior sway, BBS and handgrip strength, and those of our interest, which were age, muscle strength (hip flexor, knee extensor, ankle dorsiflexor and plantar flexor), functional measures (FR, TUG), ADL scales (motor FIM, cognitive FIM, BI) and sub-items of MFS, were forced into a binary logistic regression analysis (Table 3). A binary logistic stepwise regression analysis incorporating all the possible variables into the model revealed that only inability to "to go up and down the staircase" in MFS remained a significant variable to predict falls during the period of observation (Table 4).

Discussion

In the current study, we explored the factors of physical performances and self-claimed assessment scales related to actual incidence of falls in older female patients who were attending a geriatric outpatient clinic. Because all the participants of the present study were attending the clinic due to chronic medical conditions, which may have increased the risk of falls, the results obtained cannot necessarily be generalized to healthy community-dwelling older adults.

The analysis showed that the sub-item in MFS "being able to go up and down the staircase" has a possibility of

Table 1 Descriptive characteristics at baseline and logistic regression univariate analysis between fallers (F: $n = 25$) and non-fallers (NF: $n = 33$)

Category	Variable	All ($n = 58$) proportion (%) or mean ± SD	F ($n = 25$) proportion (%) or mean ± SD	NF ($n = 33$) proportion (%) or mean ± SD	*P*-value*	OR	95% CI	*P*-value
General	Previous falls (%)	65.5%	72.0%	60.6%	0.370 n.s.	1.67	0.55–5.11	0.37
	Falls (follow up) (%)	43.1%	100.0%	0.0%		–	–	–
	Age (years)	80.5 ± 5.7	80.5 ± 4.9	80.6 ± 6.3	0.795 n.s.	0.98	0.90–1.08	0.77
	Body mass index (BMI) (kg/m^2)	22.8 ± 4.0	22.5 ± 4.3	23.1 ± 3.8	0.451 n.s.	0.96	0.84–1.10	0.55
Medical	Polypharmacy (%)†	6.7 ± 3.5	6.8 ± 3.9	6.5 ± 3.2	0.906 n.s.	1.03	0.88–1.19	0.75
Psychological	Falls Efficacy Scale (FES) (range 1–100)	30.5 ± 20.7	35.1 ± 24.6	26.9 ± 16.7	0.303 n.s.	1.02	0.99–1.05	0.14
	Cognitive FIM	32.7 ± 3.0	32.3 ± 3.5	32.9 ± 2.6	0.604 n.s.	0.93	0.78–1.12	0.46
Postural	Length (cm)	133.3 ± 54.0	138.7 ± 69.9	129.4 ± 39.5	0.974 n.s.	1.00	0.99–1.01	0.52
	Mean of mediolateral direction sway (cm)	0.08 ± 1.5	0.27 ± 0.9	-0.06 ± 1.8	0.265 n.s.	1.17	0.81–1.70	0.41
	Mean of anteroposterior direction sway (cm)	−1.94 ± 3.1	−1.0 ± 3.9	−2.6 ± 2.2	0.078 n.s.	1.26	0.98–1.63	0.07
	Functional Reach test (FR) (cm)	18.5 ± 8.2	17.9 ± 8.2	19.0 ± 8.2	0.741 n.s.	0.98	0.92–1.04	0.60
	Berg Balance Scale (BBS) (score)	39.4 ± 9.2	37.9 ± 10.5	40.5 ± 8.1	0.566 n.s.	0.97	0.92–1.03	0.29
Physical	Handgrip strength (kg)	13.9 ± 4.9	13.0 ± 4.9	14.6 ± 4.9	0.278 n.s.	0.93	0.84–1.04	0.22
	Hip flexion strength (N)	17.4 ± 6.8	17.6 ± 6.4	17.3 ± 7.1	0.783 n.s.	1.01	0.93–1.09	0.84
	Knee extension strength (N)	9.6 ± 4.5	9.8 ± 4.1	9.5 ± 4.8	0.671 n.s.	1.02	0.90–1.14	0.79
	Ankle dorsiflexion strength (N)	19.6 ± 5.4	19.4 ± 4.5	19.7 ± 6.1	0.994 n.s.	0.99	0.90–1.09	0.84
	Ankle plantar flexion strength (N)	22.9 ± 14.7	21.7 ± 11.8	23.9 ± 16.7	0.962 n.s.	0.99	0.95–1.03	0.57
	Timed Up and Go test (TUG) (s)	15.3 ± 8.4	16.0 ± 7.1	14.7 ± 9.4	0.227 n.s.	1.02	0.96–1.08	0.58
	Motor Fitness Scale (MFS) (range 1–14)	5.8 ± 3.6	5.2 ± 3.8	6.2 ± 3.4	0.347 n.s.	0.93	0.80–1.08	0.32
ADL	Barthel Index (BI) (score 0–100)	93.9 ± 9.1	92.8 ± 10.7	94.8 ± 7.7	0.404 n.s.	0.98	0.92–1.03	0.41
	Motor FIM	84.3 ± 8.6	83.0 ± 9.7	85.4 ± 7.7	0.267 n.s.	0.97	0.91–1.03	0.33

*Difference of continuous variables between fallers (F) and non-fallers (NF) by Mann–Whitney *U*-test. †Polypharmacy is defined as a state of patients who were taking more than five medications. CI, confidence interval; n.s., non-significant; OR, odds ratio; SD, standard deviation.

Table 2 Correlation analysis between fallers ($n = 25$) vs non-fallers ($n = 33$)

	Fallers ($n = 25$)/Non-fallers ($n = 33$)				
	Handgrip strength	Hip flexor	Knee extensor	Ankle dorsiflexor	Ankle plantar flexor
Falls Efficacy Scale	−0.600**/−0.437*	−0.165/−0.169	−0.201/−0.054	−0.319/−0.091	−0.278/−0.107
Functional Reach test	0.596**/0.526**	−0.134/0.258	−0.070/0.191	0.049/0.132	0.255/0.234
Timed Up and Go test	−0.466*/−0.689**	−0.204/−0.136	−0.011/−0.085	−0.300/−0.095	−0.371/−0.202
Berg Balance Scale	0.398*/0.650**	0.147/0.326	0.105/0.228	0.192/0.272	0.248/0.323
Motor Fitness Scale	0.619**/0.690**	0.052/0.057	0.034/0.008	0.099/−0.033	0.186/0.015
Cognitive FIM	0.273/0.356	0.175/0.481**	−0.132/0.370*	0.443*/0.238	0.677**/0.360
Motor FIM	0.622**/0.416*	−0.013/0.304	0.090/0.113	0.199/0.153	0.290/0.232
Barthel Index	0.095/0.289	−0.077/0.100	0.135/0.088	0.108/−0.156	0.291/0.019

*$P < 0.05$ **$P < 0.01$. Correlations between muscle strength of lower extremities and assessment scales were examined using Spearman's coefficient of correlation. FIM, Functional Independence Measure.

being a significant ADL predictor of falls. This finding has clinical relevance, given that many older women with poor physical performance have difficulties in going up and down the staircase, and many falls in fact occur during such movement. It also has important implications for clinicians in view of planning effective rehabilitation for the prevention of falls. In usual clinical settings, on the other hand, clinicians can be advised that asking the simple question of whether the patient has any difficulty in using the staircase or observation of actual movement using a step under careful supervision may both be considered for the initial risk assessment of falls.

From our results, MFS can be recommended as the functional assessment of choice for physiotherapists working with older women. The scale is easy to administer, requires no special equipment and is equally applicable to any older adults. Appropriate falls risk assessment could also have important implications for secondary prevention strategies, where the role of professional guidance of a physiotherapist may be crucial. First, this can be used as a screening tool for the identification of older women at risk of falling. Second, it also provides the necessary information to construct an individualized physical intervention program as it examines general muscle strength, balance, mobility and coordination. We believe in the importance of an individualized rehabilitation program based on the assessment of various domains of physical function in order to identify individual risk of falls for effective interventions.

Training for independence in bathing and climbing stairs was reported to be the most difficult during rehabilitation of the elderly with apoplexy.[33] Nonetheless, the present findings suggest the importance of offering rehabilitation aimed at maintaining the ability of actual daily movement for preventing falls or deterioration in physical function.

As shown by our results concerning the postural sway control, inadequate anteroposterior stability may be an important predictor of falls, which is in agreement with the findings of Shumway-Cook *et al.*[34] Diminished muscle strength and low physical performance may enforce the impairment of postural reflexes and increase the risk of falls. The ability to perform ADL is related to balance and potential falls in older people.[35,36]

The postural sway control research by Nashner and colleagues explored muscle patterns that underlie movement strategies for balance.[37]

The ankle strategy is the first pattern for controlling upright sway to be identified.[37] Muscle activity begins in the distal muscle, the tibialis anterior, followed by activation of the quadriceps femoris and abdominal muscles. Use of the ankle strategy requires muscle strength in the ankles.

Table 3 Binary logistic regression analysis to predict risk model of fallers ($n = 25$) vs non-fallers ($n = 33$)

	B	SE	*P*-value	OR	95% CI
Age	0.098	0.103	0.341	1.103	0.902–1.349
FES	0.046	0.040	0.249	1.047	0.969–1.131
Handgrip strength	−0.172	0.178	0.334	0.842	0.594–1.193
Hip flexion strength	0.095	0.165	0.563	1.100	0.797–1.518
Knee extension strength	−0.200	0.244	0.413	0.819	0.507–1.321
Ankle dorsiflexion strength	0.045	0.163	0.783	1.046	0.760–1.440
Ankle plantar flexion strength	−0.050	0.047	0.283	0.951	0.868–1.042
FR	0.059	0.110	0.593	1.061	0.854–1.317
TUG	−0.063	0.082	0.440	0.939	0.800–1.102
Motor FIM	0.022	0.125	0.861	1.022	0.801–1.305
Cognitive FIM	−0.001	0.235	0.996	0.999	0.630–1.538
BBS	−0.171	0.136	0.209	0.843	0.646–1.101
BI	0.076	0.096	0.430	1.079	0.893–1.303
MFS: Being able to go up and down the staircase	3.169	1.746	0.069	23.795	0.777–728.628
No breathlessness when taking staircase	1.399	1.016	0.168	4.053	0.553–29.691
Being able to jump	0.381	1.548	0.805	1.464	0.070–30.435
Being able to run	−3.149	1.703	0.064	0.043	0.002–1.208
Being able to overtake others while walking	2.183	1.383	0.115	8.869	0.589–133.490
Being able to walk for more than 30 min without break	−1.086	1.045	0.299	0.337	0.044–2.617
Being able to carry a bucket filled with water	0.703	1.355	0.604	2.019	0.142–28.745
Being able to lift a 10 kg bag of rice	−3.459	1.723	0.045	0.031	0.001–0.921
Being able to stand a fallen bicycle up	1.371	1.164	0.239	3.941	0.402–38.603
Being able to open the lid of a jar	−0.875	1.099	0.426	0.417	0.048–3.591
Being able to touch the floor without bending the knees	−0.495	1.013	0.625	0.610	0.084–4.443
Being able to wear trousers, socks or skirts without support while standing	−3.115	1.586	0.050	0.044	0.002–0.994
Being able to rise from a chair without support of hands	0.814	1.246	0.514	2.257	0.196–25.949
Being able to stand on toes without support	−1.406	1.278	0.271	0.245	0.020–3.000
Constant	−0.910	16.988	0.957	0.402	

Sub-items of Motor Fitness Scale entered as dichotomous variable "yes" or "no". B, regression coefficient; BBS, Berg Balance Scale; BI, Barthel Index; CI, confidence interval; FES, Falls Efficacy Scale; FR, Functional Reach test; MFS, Motor Fitness Scale; OR, odds ratio; SE, standard error; TUG, Timed Up and Go test.

Table 4 Risk model for the prediction of fallers versus non-fallers obtained by binary logistic stepwise regression ($n = 58$)

	B	SE	*P*-value	OR	95% CI
Being able to go up and down the staircase	1.715	0.859	0.046	5.559	1.031–29.963
Constant	−2.178	1.013	0.032	0.113	

B, regression coefficient; CI, confidence interval; OR, odds ratio; SE, standard error.

The study has also identified another in-place strategy for controlling body sway, the hip movement strategy. This strategy controls motion at the hip joints with anti-phase of the ankles.[37]

Cognition is defined as the ability to process, sort, retrieve and manipulate information.[38] A normally functioning cognitive system is critical to successful interaction with the environment. Thus, impairments in this system affect the patient's ability to move effectively and efficiently.

In this study, there were significant correlations between cognitive FIM and muscle strength of the hip