の指標として多数の先行研究で利用されており，測定が比較的簡便で短時間で試行可能であるという利点を有している。

符号検査は，WAIS-R 日本語版[16]の下位検査である。1から9まで9つの数字に対応する符号を例に倣って可及的速やかに書き入れてゆくことを求める。制限時間内（90秒間）に正しく書き入れることができた符号の個数を得点とする。最大得点は93点である。

語想起検査は，カテゴリー想起と頭文字想起に分かれる。カテゴリー想起では，制限時間内（1分間）に，特定のカテゴリー（例えば，「植物」，「スーパーマーケットで購入可能な物品」）に所属する言葉をできるだけ多く口頭で報告することを求める。本研究では，「動物」カテゴリーに所属する言葉の想起を求めた。頭文字想起は，制限時間内（1分間）に，特定のかな文字（例えば「あ」，「た」）から始まる言葉をできるだけ多く口頭で報告することを求める。本研究では，「か」から始まる言葉の想起を求めた。カテゴリー想起と頭文字想起における産出語数を合計し，語想起検査得点とした。

数唱検査は，WAIS-R 日本語版[16]の下位検査である。順唱と逆唱に分かれる。順唱では，検査者が口頭で提示した数系列（例えば，1-6-3）を，提示された順序で唱えさせる。試行が進むにつれて唱えるべき数系列の桁数が増加する。逆唱では，検査者が口頭提示した数系列を，それとは逆の順序で唱えさせる。例えば，検査者が，「1-6-3」と提示したならば，対象者は，「3-6-1」と順序を逆にして唱えなければならない。順唱と同様に，試行が進むにつれて唱えるべき数系列の桁数が増加する。本研究では，順唱と逆唱の得点を合計し，数唱検査得点とした（28点満点）。

2）老研式活動能力指標

老研式活動能力指標は，身体的自立よりも高次の生活機能（以下，高次生活機能と表記する）を評価することが可能な尺度である。この尺度は，「手段的自立（Instrumental Self-Maintenance）」（5項目），「知的能動性（Intellectual Activity）」（4項目），「社会的役割（Social Role）」（4項目）の3つの下位尺度，計13項目から構成される。全項目の合計得点から高次生活機能を総合的に評価することが可能であるが，下位尺度ごとの評価を行うこともできる（表1）。この尺度の信頼性および妥当性はすでに確認されている[22,23]。また，老研式活動能力指標を用いた地域在宅高齢者における高次生活機能の検討は，生命予後との関連[22]，飲酒状況の推移との関連[24]，運動機能との関連[25,26]，地域在宅要介護者における高次生活機能の実態[27]，というように多岐にわたりさまざまな見地から行われている。表1にある計13項目について，「はい」もしくは「いいえ」で回答を求め，「はい」に対しては1点を，「いいえ」に対しては0点を与えた。手段的自立，知的能動性，社会的役割の3つの下位尺度得点を算出し分析に用いた。

3．手続き

認知機能検査は，健診の一部で行った。血圧測定，疾病の既往状況の聴取，身体測定，骨密度測定，心電図検査，血液の採取，歯科検診，運動機能検査，生活習慣に関する聞き取り調査の後，MMSE および認知機能検査（符号検査，語想起検査，数唱検査）を行った（詳細は，鈴木ら[2]を参照のこと）。健診全体の所要時間は約1時間半から2時間であった。MMSE および認知機能検

表1　老研式活動能力指標

No.	項　　目
	手段的自立
1	バスや電車を使って1人で外出できますか
2	日用品の買い物ができますか
3	自分で食事の用意ができますか
4	請求書の支払いができますか
5	銀行預金・郵便貯金の出し入れが自分でできますか
	知的能動性
6	年金などの書類が書けますか
7	新聞を読んでいますか
8	本や雑誌を読んでいますか
9	健康についての記事や番組に関心がありますか
	社会的役割
10	友達の家を訪ねることがありますか
11	家族や友達の相談にのることがありますか
12	病人を見舞うことができますか
13	若い人に自分からはなしかけることがありますか

注1）各項目については，「はい」，もしくは「いいえ」で回答を求め，「はい」には1点を，「いいえ」には0点を与えて得点化する。

表2　対象者基本属性

	年齢群1 70-74歳	年齢2 75-79歳	年齢3 80-84歳
人数	215	160	62
年齢	71.8(1.3)	77.0(1.4)	81.8(1.4)
女性率（%）	60.4	65.6	56.4
教育年数	10.9(2.6)	10.1(2.6)	9.7(2.4)
健康度自己評価	2.0(0.7)	2.0(0.7)	2.2(0.8)
MMSE	28.4(1.7)	27.9(1.9)	26.4(3.5)

注1）（ ）内はSD。
注2）健康度自己評価：1＝「とても健康」，2＝「まあ健康」，3＝「あまり健康でない」，4＝「健康でない」。
注3）MMSE(Mini-Mental State Examination）の最大得点は30点。MMSEの分析対象者は，年齢群1が211人，年齢群2が154人，年齢群3が60人であった。

表3　認知機能検査得点の年齢群間における比較

	年齢群1 70-74歳	年齢群2 75-79歳	年齢群3 80-84歳
符号検査	38.7(9.6)	36.1(10.5)	29.1(8.8)
	215	157	57
語想起検査	23.4(6.5)	22.6(7.0)	21.1(6.4)
	215	158	62
数唱検査	12.3(3.6)	11.7(3.2)	10.2(3.1)
	215	158	60

注1）表中上段には平均値，（ ）内はSD，下段には分析に使用した人数を示した。
注2）符号検査はWAIS-R日本語版下位検査。最大得点は93点。
注3）語想起検査は，カテゴリ想起と頭文字想起の合計得点。
注4）数唱はWAIS-R日本語版下位検査。順唱と逆唱の合計点を得点に用いた。最大得点は28点。

査は，事前に十分な訓練を受けた心理学を専攻する大学院生が試行し，約20分間を要した。

4.　分析方法

認知機能の年齢差については，教育年数を共変量とした共分散分析により検討した。教育年数を共変量とした理由は，認知機能は教育年数による影響を強く受けるので[20]，真の年齢差を検討するためには，教育年数が認知機能に及ぼす効果を排除する必要があるためである。

認知機能と高次生活機能の関連については，測定時の年齢および教育年数を統制変数とした偏相関分析および重回帰分析により検討を行った。

すべての統計解析は，統計パッケージSAS (Version 6.12) を用いて行った。

Ⅲ　研究結果

認知機能検査を一部実施できなかった対象者がいたため，従属変数により分析人数は異なる。符号検査における分析人数は429人（年齢群1が215人，年齢群2が157人，年齢群3が57人）であった。語想起検査における分析人数は435人（年齢群1が215人，年齢群2が158人，年齢群3が62人）であった。数唱検査における分析人数は433人（年齢群1が215人，年齢群2が158人，年齢群3が60人であった)。

1.　認知機能検査得点の年齢群間における比較

表3は，各認知機能検査得点を年齢群間で比較したものである。

認知機能検査得点における年齢差を検討するため，3つの認知機能検査を従属変数，教育年数を共変量とした共分散分析を行った。符号検査は，年齢群の効果，教育年数の効果ともに有意であった（$F(2, 425)=18.46$, $P<0.01$; $F(1, 425)=59.83$, $P<0.01$)。最小二乗平均による推定値を算出し群間差を検討したところ，年齢群1と年齢群3，および年齢群2と年齢群3における差が有意であった（$P<0.01$)。語想起検査は，年齢群の効果，教育年数の効果ともに有意であった（$F(2, 431)=3.19$, $P<0.05$; $F(1, 431)=20.60$, $P<0.01$)。最小二乗平均による推定値を算出し群間差を検討したところ，年齢群1と年齢群3（$P<0.01$)，および年齢群2と年齢群3における差が有意であった（$P<0.05$)。数唱検査は，年齢群の効果，教育年数の効果ともに有意であった（$F(2, 429)=7.21$, $P<0.01$; $F(1, 429)=35.47$, $P<0.01$)。最小二乗平均による推定値を算出し群間差を検討したところ，年齢群1と年齢群3，および年齢群2と年齢群3における差が有意であった（$P<0.01$)。

2.　認知機能検査と老研式活動能力指標間における関連性の検討

表4は，年齢と教育年数を統制変数として各認知機能検査得点と老研式活動能力指標下位尺度得点間における偏相関係数を算出しまとめたものである。手段的自立は符号検査（$r=0.15$, $P<0.01$)

表4　認知機能検査および老研式活動能力指標下位尺度間における Pearson の積率偏相関係数

	符号検査	語想起検査	数唱検査
手段的自立	0.15**	0.18**	0.06
知的能動性	0.18**	0.18**	0.11*
社会的役割	0.06	0.13**	0.05

注1)　* $P<0.05$, ** $P<0.01$.
注2)　年齢および教育年数を統制変数とした。
注3)　符号検査，語想起検査，数唱検査における分析人数はそれぞれ429人，435人，433人であった。

および語想起検査（r＝0.18, $P<0.01$）と，知的能動性は符号検査（r＝0.18, $P<0.01$），語想起検査（r＝0.18, $P<0.01$），数唱検査（r＝0.11, $P<0.05$）と，社会的役割は語想起検査（r＝0.13, $P<0.01$）とそれぞれ有意な正の相関関係が認められた。

次に，高次生活機能が認知機能によって規定される程度を明らかにするため重回帰分析を行った。いずれかの認知機能検査を試行できなかった対象者10人を除外し，427人のデータを分析に使用した。手段的自立得点，知的能動性得点，社会的役割得点をそれぞれ目的変数，符号検査，語想起検査，数唱検査，年齢，教育年数を説明変数とする重回帰分析を行った。手段的自立では，モデル全体の決定係数（R^2）は0.04（$P<0.01$）であり，符号検査（$\beta=0.11$, $P<0.1$）における寄与が有意傾向を示した。知的能動性では，モデル全体の決定係数（R^2）は0.09（$P<0.01$）であり，符号検査（$\beta=0.14$, $P<0.05$）における寄与が有意，語想起検査（$\beta=0.09$, $P<0.1$）における寄与が有意傾向を示した。また，年齢（$\beta=-0.09$, $P<0.05$）における寄与が有意であった。社会的役割では，モデル全体の決定係数（R^2）は0.04（$P<0.01$）であり，語想起検査（$\beta=0.09$, $P<0.1$）における寄与が有意傾向を示した。また，年齢（$\beta=-0.16$, $P<0.01$）における寄与が有意であった。

Ⅳ　考　　察

本研究は，地域在宅高齢者を対象として認知機能の年齢差，および認知機能と高次生活機能間の関連性について検討し，地域高齢者を対象とした要介護予防活動に対して有用な基礎資料を提供することを目的とした。

1.　認知機能における年齢差について

認知機能が加齢によって受ける影響について検討した最近の研究では，従来のように高齢期以前の若年者と高齢者間の比較に加え，高齢期以降での認知機能に対する加齢の影響について関心が高まっている[29]。本研究では，認知機能検査得点を年齢群間で比較することにより，高齢期以降での認知機能（情報処理速度，遂行機能，一次記憶）に対する加齢の影響について検討を行った。

符号検査，語想起検査，数唱検査において顕著な年齢差が認められ，年齢群3（80–84歳）の成績が年齢群1（70–74歳）および年齢群2（75–79歳）のそれよりも低かった。この結果は，情報処理速度，遂行機能，一次記憶に関して80歳以上の高齢者は80歳未満の高齢者よりも能力が劣っていることを示す結果である。これらのことから，情報処理速度，遂行機能，一次記憶について高齢期以降で加齢の影響が認められることが明らかになった。これらの結果は，高齢期以降において情報処理速度[29]，遂行機能[30]，一次記憶[31]に対して加齢の影響を認めた先行研究結果と一致する。さらに，年齢群1（70–74歳）と年齢群2（75–79歳）の間では成績に差が認められなかったことから，情報処理速度，遂行機能，一次記憶における機能低下は，後期高齢期以降により顕著に生じる可能性が示唆された。前期高齢期と後期高齢期における認知機能の3年間にわたる変化について縦断的調査により検討した Hultsch ら[32]は，前期高齢期と比較して後期高齢期では認知機能に対する加齢の影響がより大きくなるとしている。ただし，本研究は断面調査の結果を用いているため，縦断的調査結果との直接的な比較は困難である。今後は，後期高齢期以降においてより顕著な認知機能低下が生じるか否かについて明らかにするために，断面調査結果と縦断的調査結果とを組み合わせ検討してゆく必要があると思われる。

2.　高次生活機能を規定する認知機能について

高齢者における生活機能と認知機能間の関連について調べた多くの研究では，生活機能を身体的自立もしくは手段的自立状況に限定して検討が行われている。そこで本研究では，Lawton の階層モデルにおける身体的自立よりも高次の生活機能

である手段的自立，知的能動性，社会的役割と認知機能（情報処理速度，遂行機能，一次記憶）がどのように関連するかについて検討を行った。

偏相関分析結果について考察する。手段的自立は，符号検査および語想起検査と正の相関関係を有することが認められた。すなわち，情報処理速度や遂行機能における能力が高い者のほうが手段的自立の能力が高いことが示唆された。これらの結果は，手段的自立と情報処理速度間に相関関係を認めたOwsleyら[9]，手段的自立と遂行機能間に相関関係を認めたCahn-Weinerら[4]，Grigsbyら[33]と一致する。知的能動性は，符号検査，語想起検査，数唱検査と正の相関関係を有することが認められた。すなわち，情報処理速度，遂行機能，一次記憶における能力が高い者のほうが知的能動性の能力が高いことが示唆された。社会的役割は，語想起検査と正の相関関係を有することが認められた。すなわち，遂行機能の能力が高い者のほうが社会的役割の能力が高いことが示唆された。上記より，高次生活機能は認知機能と正の関連性を有することが確認された。

重回帰分析を用いて高次生活機能が認知機能によって規定される程度について検討したところ，手段的自立では4%，知的能動性では9%，社会的役割では4%の分散がそれぞれ説明されることが明らかになった。上記より，高次生活機能の中では，知的能動性が認知機能と最も明瞭な関連性を有することが示唆された。これは，知的能動性測定項目には，「年金などの書類が書けますか」，「新聞を読んでいますか」，「本や雑誌を読んでいますか」というように，認知機能を主として使用する活動の実施状況を問う項目が多く含まれているためであると推察される。

また，偏相関分析結果より，遂行機能は3つの高次生活機能すべてと関連性を有していることが明らかになった。遂行機能とは，目的をもった一連の行動を有効に行うために必要な機能であり，目標の設定（goal formation），計画の立案（planning），目標に向かって計画を実際に行うこと（carrying out goal-directed plans），効果的に行動を行うこと（effective performance）の4つの要素が含まれるとしている。この機能は，人が，社会的，自立的，創造的な活動を行うために重要とされている[19]。上記より，地域在宅高齢者における高次生活機能の維持には，遂行機能の維持が重要となることが推測される。今後は，縦断的調査結果を用い，高次生活機能低下の予測因子としての遂行機能の性質について詳細に検討してゆくことが課題となる。

3. 本研究における知見の限界と今後の展開

最後に，本研究で得られた知見の限界について述べる。第1に，サンプルの代表性に関する事柄である。先述のとおり，本研究における対象者は，東京都老人総合研究所が平成3年度から平成12年度まで行った10年間にわたる特別研究プロジェクト「中年からの老化予防総合的長期追跡研究心理班」における最終年調査参加者である。調査初年度（平成3年）に等間隔抽出法によるサンプリングを行い代表性を確保したが，その後10年間の追跡期間中に虚弱者の選択的脱落が生じた可能性が考えられる。また，本研究では会場招聘型健診によってデータを収集した。それゆえ，独力もしくは介助者の助けを借りて，会場まで足を運ぶことができる程度に健康度が高い者が健診に参加した。こうした手続き上の問題から，受診者と非受診者の間に特性の差が生じた可能性が考えられる。この点については，先行研究において既に論じた[2]。上記より，認知機能および身体機能ともに比較的健康で，健診参加に対する動機づけの強い者が分析対象者となった可能性は否定できない。第2に，試行した認知機能検査バッテリーの内容に関する事柄である。本研究では，包括的健診という手続き上の制約から，「長期記憶（long-term memory）」を測定する記憶検査を試行することができなかった。長期記憶は，いったん記銘した情報を遅延時間後に思い出す能力であり，日常生活において重要な役割を担う認知機能である。例えば，「物を置いた場所を憶えておいて後で思い出す」，「他人との約束を忘れずに実行する」といった行為の遂行には，長期記憶が必要不可欠であり，高齢者の高次生活機能の維持にも大きく関わっていることが予想される。今後は，長期記憶を測定する記憶検査を加えた認知機能検査バッテリーを組み，より詳細な形で，地域在宅高齢者における高次生活機能を規定する認知機能について検討することが課題である。

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ORIGINAL ARTICLE

Walking speed as a good predictor for maintenance of I-ADL among the rural community elderly in Japan: A 5-year follow-up study from TMIG-LISA

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Background A population-based prospective cohort study was undertaken to examine the predictors of functional decline in instrumental activities of daily living (I-ADL) among non-disabled older Japanese subjects living in a rural community during a five-year interval from 1992 to 1997.

Methods The subjects consisted of 624 men and women aged from 65–89 years and independent in I-ADL at baseline, who could be completely followed for five years. Independent variables were various physical factors potentially associated with higher level of functional capacity obtained from an interview survey and medical examinations at baseline. Dependent variables were functional status in I-ADL obtained at the time of the 5-year follow-up.

Results Significant predictors of functional decline in I-ADL during a 5-year follow-up period included: (1) older age; (2) higher blood pressure; and (3) lower maximum walking speed at baseline. Among these predictor, the maximum walking speed is likely to the strongest predictor for the decline in I-ADL.

Conclusion The ability to walk faster in the old age is strongly associated with independence in the other I-ADL, and walking speed should be modified by the lifestyle to strengthen muscles of the lower extremities in daily life.

Keywords: community elderly; instrumental ADL (I-ADL); Japanese, longitudinal study (TMIG-LISA); walking speed.

Introduction

The World Health Organization (WHO) proposed autonomy as a reasonable proxy for health in the elderly. Further, WHO emphasized that mortality and morbidity are no longer useful for evaluating the health status of the elderly or the aged society.[1]

Autonomy or maintenance of functional capacity in later life is a basic goal shared by geriatricians and their patients, and is an integral part of good quality of life for

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older adults.[2] The maintenance of an acceptable level of functional capacity in community-living elderly currently has a high priority both with medical researchers and policy makers. In other words, decline in functioning has to be prevented if possible, or otherwise reduced to a minimum.

The conceptual framework and measures of functional capacity adopted in this study are based on a hierarchical model of competence proposed by Lawton (1972),[3] which comprises seven sublevels starting from life maintenance as the first sublevel to social role performance as the seventh sublevel. Scales for activities of daily living such as Katz's Index of ADL[4] and basic activities of daily living (B-ADL) seem to correspond to the fourth sublevel of Lawton's model; 'Physical self-maintenance'. The index of instrumental activities of daily living (I-ADL) developed by Fillenbaum[5] represents the fifth level; 'Instrumental health-maintenance'. According to Lawton's model, we developed a multidimensional 13-item index of competence, the so-called Tokyo Metropolitan Institute of Gerontology (TMIG) Index of Competence (Table 1), which was devised to assess competence corresponding to higher (5th to 7th) sublevels of Lawton's model.[6,7] This multidimensional 13-item index of competence comprises three subscales; 'instrumental self-maintenance', 'intellectual activity', and 'social roles'; and has already been verified to have high reliability and validity. The TMIG-Index of Competence has been widely accepted and used in Japan. The possible range of competence score in this index is from 0 to 13 points, and a high score indicates high functional capacity.

Table 1 Item of the TMIG Index of Competence

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

The response to each item is 'yes' (= able to do) or 'no' (= unable).
The total score is the number of items answered with 'yes'. Therefore, a higher score indicates higher functional capacity.
The items I to 5 are indicators of the first-order factor *Instrumental Self-Maintenance*. items 6–9 are those of *Intellectual Activity*.
and items 10 to I3 are indicators of Social Role.

The most important point to maintain functional capacity, in a sense, is to prevent functional disability that limits independence in tasks including hygienic and personal care (B-ADL) and the most relevant capacities to live in a community (I-ADL). Many previous studies[8–13] have shown that performance-based measurements of physical function in non-disabled older people predict future incidence of disability or dependence in B-ADL. Objective measurements of lower extremity functions, such as walking speed, standing balance, and repeated rising from a chair, are highly predictive of subsequent disability in older populations of various ethnicities.[9–11,13] In addition, hand-grip strength is an important predictor of disability and mortality of older people.[12–14] Also, many population-based longitudinal studies also examined the factors associated with functional decline in I-ADL with special reference to physical performance of the elderly.[14–18] Among these studies, two population-based prospective studies confirmed that hand-grip strength could predict incident disability in both B-ADL and I-ADL.[14,18]

In 1991, we launched a longitudinal interdisciplinary study on aging, in which we assessed the functional capacity by TMIG Index of Competence in representative samples of older community residents of rural areas in Japan.[19] The participants were followed up for 5 years. Using these data, we investigated the association between baseline physical performance including walking speed, muscle strength, balance as well as manual skill and decline of I-ADL over 5 years in elderly residents living in the community.

Subjects and methods

Study area and subjects

The data in this study were obtained from the Longitudinal Interdisciplinary Study on Aging conducted by the Tokyo Metropolitan Institute of Gerontology (TMIG-LISA), which is a long-term project aiming to verify predictors of longevity and outcome, and to identify factors accelerating or retarding the aging process. The TMIG-LISA comprises three major disciplines: medical, psychological, and social science. Sampling methods of subjects have been described elsewhere.[19] One of the cohorts in the medical science discipline of TMIG-LISA is from Nangai Village, a rural area in Akita Prefecture and a typical agricultural area in the northern part of Honshu Island, Japan. The total population in 1992 was 5136 people and the proportion of residents aged 65 years and older to the total population was approx-

imately 20%. The criteria for including in the cohort were ambulatory residents aged 65 and over. A preliminary survey identified 852 people as ambulatory residents; they were then asked to participate in the baseline survey.

Baseline and follow-up surveys

A baseline survey including face-to-face interview and medical examinations was carried out in the summer of 1992, and a total of 748 residents were interviewed, accounting for 87.8% of all eligible residents ($N = 852$).

After the interview, residents who were able to walk (unassisted or using a cane) were invited to participate in a series of medical examinations and physical performance tests. Over ninety-one percent (685/748) of subjects interviewed completed all the medical examinations and physical performance tests. We limited the subjects of this particular study to those who were independent in both B-ADL and I-ADL at the time of the baseline survey. Data collected at the baseline survey were used to characterize the study population for analyses in the present study.

These people have been followed by interview survey and medical examinations on a yearly basis using methods similar to the baseline survey. All the surveys have been conducted in municipal community centers in Nangai Village. In 1997, excluding 47 deceased, 10 institutionalized or hospitalized, and 4 who refused or did not participate for other reasons, 624 participants who were independent at least in B-ADLs in 1997 and underwent baseline medical examinations and physical performance tests in 1992 were analyzed in the present study (Table 2).

Assessment of functional capacity and measurements of physical performance

The interview survey employed at the baseline (1992) and follow-up (1997) surveys contained scales for assessing functional health status, lifestyles, and life satisfaction. Functional health status was assessed by questions on B-ADL and I-ADL. B-ADL was measured using five items: (1) walking, (2) feeding, (3) continence, (4) bathing, and (5) dressing. I-ADL was derived from the sublevel of competence consisting of five questions concerning 'Instrumental self-maintenance' in the TMIG Index of Competence as mentioned before.

The response to each item in I-ADL was given a score of 1 for 'yes' and 0 'no'. A total score was created by simply summing the item scores. Thus, a score of 5 represents no difficulty and 0 represents total incapability in I-ADL. We defined 'dependence in I-ADL' as a loss of independence in item of I-ADL (e.g. the decline of I-ADL was defined in practice as decrease from full mark (= 5) at baseline to below four during follow-up period). Since the primary objective of this study was to identify the predictors of decline in I-ADL during a 5-year follow-up period, we used only the data of I-ADL obtained from the 1997 follow-up survey as the outcome measure.

In the medical examinations, anthropometric measurements included body height (cm; measured to the nearest mm), body weight (kg; measured to the nearest 100 g) and dermal thickness (cm; sum of measurements at triceps and sub scapular regions). The Quetelet's index (kg/m^2) was adopted as a measure of body mass index (BMI).

During the medical examination, blood sample was collected from the antecubital vein for routine hematological and biochemical tests. Serum albumin (Alb:

Table 2 Subjects in the present study (1992–1997/TMIG-LISA)

Baseline survey in 1992		Male	Female	Total
Interviewed		300	448	748
Medical exam including phys. perform. tests		278	407	685
↓	deceased 47 institutionalized 10 others 4			
Follow-up survey in 1997		Male	Female	Total
Interviewed and Medical exam including phys. perform. tests		251	373	624

g/dL) was measured by a standard kit using the BCG method. Serum total cholesterol was determined enzymatically by an autoanalyzer (HITACHI 736). For measurements of serum cholesterol, coefficients of variation (CV) of internal quality controls ranged within 1.1%, and that of external quality controls ranged within 2.1%. Systolic and diastolic blood pressures in the sitting position were measured by a registered nurse using an automated sphygmomanometer (BP-103, Nippon Colin Ltd). The mean of duplicate measurements was used in principle. Masticatory ability was evaluated by geriatric dentists using jelly (G-1 Jelly™). The hardness of jelly was graded 1 (soft) to 3 (hard) according to the hardness of daily foods.[20]

A short physical performance battery consisting of items assessing grip strength, manual function, balance function, and walking ability, was administered to the participants.[21] The grip strength of the preferred hand was measured using a hand-held Smedley-type dynamometer. Manual function was assessed using a finger-tapping test, in which the maximum tapping rate, and constant and variable errors for tapping in time to a 4-Hz metronome were measured. The maximum tapping rate was used in the present study. Duration of standing while using the preferred leg was measured for a maximum of 60 s with eyes open, and 30 s with eyes closed. In the walking test, the participant walked along a straight walkway of 11 meters on a flat floor. The speed and number of steps were measured for the middle 5-meter portion of the walkway. The participant first took the test by walking at preferred speed, and then by walking as fast as possible. Walking at both preferred and maximum speed were repeated and the faster speed was recorded in each walking. Only the speed data of the walking test were used in this study. Good reproducibility of these walking tests has been reported previously.[21]

Statistical analysis

Descriptive statistics were generated for the subjects classified into presence and absence of declined I-ADL measured by the sublevel of TMIG Index of Competence, and stratified by sex.

We used *t*-test to compare each baseline variable between the subjects showing declined I-ADL and those not showing any decline during the follow-up period, for both sexes. The relation between baseline variables and decline of I-ADL was evaluated using stepwise multiple logistic regression models after controlling confounding variables. Decline of I-ADL (the dependent variable) was transformed into two dummy variables: one dummy variable of score 1 for the presence of decline and 0 for the absence of decline. Thus, predictors of decline of functional capacity represented by decline of I-ADL could be established.

Table 3 Frequency (%) of the elderly who had the decline of I-ADL during five-year follow-up period

Age at baseline	Male	(%)	Female	(%)
65–69	8/122	−6.5	12/160	−7.5
70–74	9/69	−13	20/118	−17
75–79	5/41	−12.2	15/54	−27.8
80+	3/19	−15.8	12/41	−29.3
Total	25/251	−10	59/373	−15.8

Results

During the five-year follow-up period, 25 men (10.0%) and 59 women (15.8%) showed decline of I-ADL as assessed by the 5-item 'Instrumental self-maintenance' scale of TMIG Index of Competence, showing a significant sex difference in the frequency of decline ($\chi^2 = 4.419, P = 0.036$). Table 3 shows the frequencies of the elderly who had decline of I-ADL during the 5-year follow-up period. The frequency tended to increase according to the age increase in both sexes.

Table 4 shows the differences in all baseline variables measured in 1992, by sex and by presence or absence of decline of I-ADL. In men, significant differences between subjects with and without I-ADL decline were found in six variables: grip strength, time of standing on one leg with eyes open and with eyes closed, and preferred and maximum walking speeds in physical performance tests; as well as masticatory ability. In women, significant differences were also observed between the two groups in eight variables: age, weight, dermal thickness, grip strength, time of standing on one leg with eyes open, preferred and maximum walking speeds, and masticatory ability. Thus, both sexes showed significant differences in five common baseline variables; grip strength, time of standing on one leg with eyes open, preferred and maximum walking speeds, and masticatory ability. On the other hand, there were no significant differences in systolic and diastolic blood pressures, BMI, finger tapping test, serum albumin and serum total cholesterol levels in both sexes.

Figure 1 shows the percentage of subjects (both sexes) who had I-ADL decline during the follow-up period according to quartiles of baseline maximum walking speed, grip strength, and time of standing on one leg with eyes open. The percentage with decline was greatest in the lowest quartile of these physical-performance measurements. Subjects who walked faster, had stronger handgrip, and maintained good balancing capability have lower possibility of decline in I-ADL in the future.

The effects of baseline measurements of these physical variables on the decline of I-ADL during the follow-up period were estimated with stepwise multiple logistic

Table 4 Comparison of baseline characteristics between subjects with and without decline of I-ADL during 5-year follow-up period

Baseline variables		Male			Female		
		decline ($n = 25$)	non-decline ($n = 226$)	Significance†	decline ($n = 59$)	non-decline ($n = 314$)	Significance†
Age	(year old)	72.3 ± 5.9	70.7 ± 4.9	n.s.	74.4 ± 5.4	71.1 ± 5.1	***
Systolic blood pressure	(mmHg)	139.2 ± 17.2	144.1 ± 22.9	n.s.	141.9 ± 18.1	145.2 ± 20.5	n.s.
Diastolic blood pressure	(mmHg)	77.4 ± 11.1	79.9 ± 11.4	n.s.	76.7 ± 9.1	78.8 ± 10.3	n.s.
Height	(cm)	156.5 ± 4.1	157.4 ± 5.6	n.s.	143.3 ± 5.0	144.7 ± 5.8	n.s.
Weight	(kg)	52.5 ± 7.9	54.8 ± 7.7	n.s.	46.2 ± 6.8	48.7 ± 8.6	*
BMI	(kg/m^2)	21.5 ± 3.0	22.1 ± 2.7	n.s.	22.5 ± 3.1	23.2 ± 3.5	n.s.
Dermal thickness	(cm)	20.0 ± 8.1	19.8 ± 7.4	n.s.	22.8 ± 9.1	25.9 ± 9.4	*
Hand grip strength	(kg)	26.7 ± 6.8	31.3 ± 6.5	**	17.4 ± 4.6	18.9 ± 4.8	*
One leg stand. eye open	(s)	23.4 ± 22.4	42.0 ± 22.5	***	20.8 ± 20.7	29.5 ± 23.4	**
One leg stand. eye close	(s)	2.88 ± 2.51	5.26 ± 5.15	*	3.44 ± 3.24	3.9 ± 4.32	n.s.
Preferred walking speed	(m/s)	1.06 ± 0.25	1.22 ± 0.23	**	0.97 ± 0.26	1.05 ± 0.24	*
Maximum walking speed	(m/s)	1.72 ± 0.50	1.99 ± 0.39	**	1.44 ± 0.33	1.62 ± 0.39	**
Finger-tapping test	(m/s)	183.6 ± 28.2	181.6 ± 29.4	n.s.	204.3 ± 28.8	198.3 ± 32.3	n.s.
Masticatory ability by Jelly test	(1–3)	1.47 ± 0.80	2.04 ± 1.14	**	1.71 ± 0.90	1.86 ± 1.12	*
Serum albumin	(g/dL)	4.07 ± 0.24	4.05 ± 0.24	n.s.	4.1 ± 0.3	4.15 ± 0.23	n.s.
Serum total cholesterol	(mg/dL)	172.6 ± 40.2	174.8 ± 31.8	n.s.	202.1 ± 39.1	201.8 ± 32.4	n.s.

†$*P < 0.05$, $**P < 0.01$, $***P < 0.001$, n.s., no significance.

regression analysis (using dummy dependent variables). Table 5 shows the result of analysis with this model in χ^2 value, probability, odds ratio, and 95% confidence interval. Aging significantly increased the decline of I-ADL. On the other hand, maximum walking speed and systolic blood pressure had significant protective effects against the decline of I-ADL. Particularly, the odds ratio of maximum walking speed (0.351) implies that the odds of decline in I-ADL increased 2.85 times for every 1 m/s decrease of maximum walking speed when the effects of other confounding factors are controlled. This means that the faster the walking speed, the lower possibility is decline in I-ADL.

Although systolic blood pressure was inversely proportional to decline in I-ADL, the 95% confidence interval was almost 1.0 (0.976–0.999), implying that the effect of systolic blood pressure as a predictor would be very small.

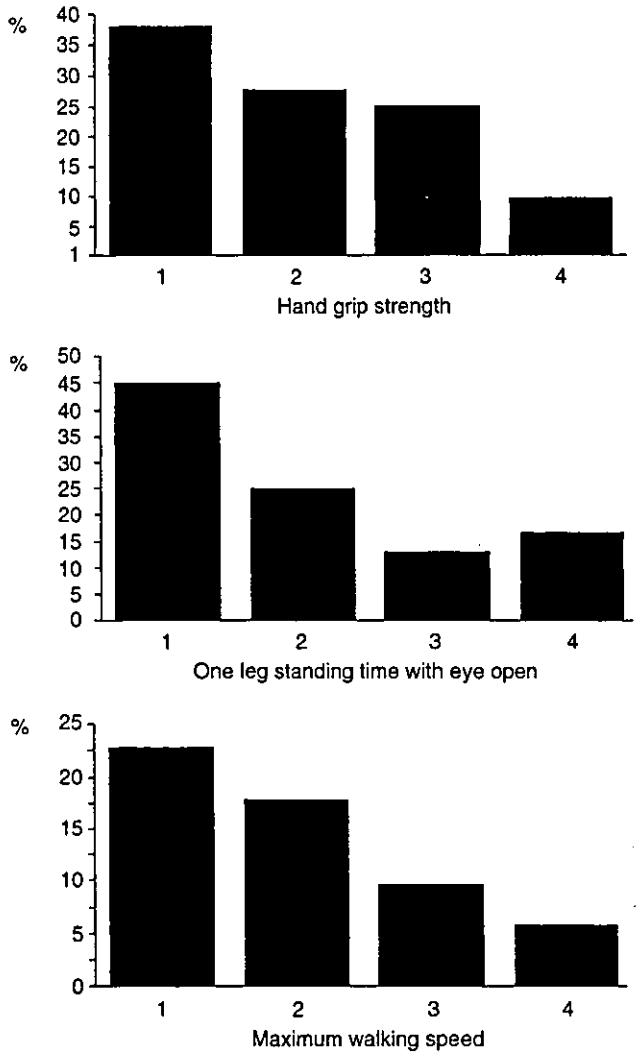

Figure 1 The percentage of the person who had decline in I-ADL during 5-year follow-up period according to a quartile (1 = low → 4 = high) of three variables at baseline (sex combined).

Discussion

Health status in the elderly is a strong predictor of subjective well-being.[22] Functional capacity is an adequate indicator of health of the elderly as noted by WHO in 1984. Most scales of functional capacity used in gerontology focus exclusively on the B-ADL. However, since B-ADL scales cannot detect the variety of competence in the elderly from disability or frailty, B-ADL is no longer a good indicator of autonomy for the elderly living in the community where the vast majority of older people have higher functional capacity. In this study, using I-ADL as an indicator of higher level functional capacity, a longitudinal observation of elderly subjects living in the community over a five-year period was conducted in order to investigate the frequency of I-ADL decline and associated risk factors measured at baseline. This study indicates that physical factors may be amenable to prevention of long-term decline of functional capacity.

Before interpreting the results and establishing a final conclusion, some limitations of our study must be considered. First of all, TMIG-Index of Competence was developed to cover the highest level of functional capacity based on Lawton's model mentioned earlier. Although this tool is a particularly appropriate measure health status for the elderly living in the community because most of them are free from disability in Japan,[23] it has not been used in other countries. Therefore, the applicability of these study findings to other populations

Table 5 Predictor of functional decline in I-ADL during 5-year follow-up among the Japanese rural-community elderly who were initially independent in I-ADL (n = 624), 1992–1997

Risk factor	Odds Ratio	95% Confidence Interval	*P* Value
Age	1.07	1.02–1.12	0.007
Systolic Blood Pressure	0.99	0.98–0.99	0.034
Maximum walking speed	0.35	0.19–0.66	0.001

Stepwise multiple logistic regression analysis was performed to compare subjects who were independent in I-ADL in both 1992 and 1997 (n = 540) and those who were initially independent but became dependent in I-ADL in 1997 (n = 84). Dependent variable was the decline of I-ADL during follow-up period (presence/absence). Independent variables are those as listed in the Table 4.

may be debatable.[24] Nevertheless, the results obtained in the present study were similar to investigations in the United States and Europe who used Lawton's I-ADL.[14,17,25]

Second, among 669 subjects examined in 1997, 45 subjects were excluded from the analyses of identifying risk factors of functional decline, because of missing data due to death, hospitalization, and other reasons. These subjects who were excluded from analyses were likely to be older and weaker than those who were analyzed using logistic regression. Therefore, the selection bias would have weakened the predictive value of each predictor for functional decline in this study.

Third, the subjects of our population-based and prospective study were older Japanese living in a rural area, who are not necessarily representative of all older Japanese. Older Japanese in Nangai Village are more likely to lead an old and traditional Japanese lifestyle. However, despite the second and third limitations, it is likely that certain physical factors can predict functional decline among all older Japanese because the biomechanical principles of functional deterioration are common, at least in Japan.

We have previously investigated predictors of functional decline in both B-ADL and I-ADL among non-disabled older people living in the community during a 3-year follow-up, analyzing 28 variables selected from demographical, physiological, psychosocial, and life-style-related domains.[18] Our conclusion was that having high-level handgrip strength, good intellectual activities and good social roles were strongly associated with maintaining independence in I-ADL for the elderly aged 65 and over. However, handgrip strength was the only physical performance variable selected in the previous study.

In the present study, besides the basic confounding variables, six physical performance variables with proven validity and usefulness for assessing physical functions of community elderly were additionally selected as independent variables. We identified age increase, lower systolic blood pressure, and lower maximum walking speed as significant predictors of functional decline in I-ADL in a 5-year period among older Japanese who were initially independent in I-ADL. Appropriate blood pressure is important from the perspective of prevention of cardiovascular disease, particularly stroke, in this Japanese sample, and also maintenance of other physical function. However, lower (maximum) walking speed is not only most sensitive in predicting the decline of I-ADL of the community elderly, but is also a factor that can be improved for the elderly.

Walking ability of the elderly has been studied in association with disability,[26–29] self-perceived function,[30] depressive status,[31] institutionalization,[11,32] and mortality.[11,33] Summarizing these previous studies, walking speed may be an indicator of general morbidity as well as a good indicator of any level of functional capacity in the community elderly. Regarding the term 'walking speed', two kinds of walking speed are usually measured for the elderly: normal (usual, preferred, comfortable) walking speed; and maximum walking speed. According to Nagasaki *et al.*[21] maximum walking speed has the highest correlation coefficient with basic motor ability of the elderly in their structural model of physical performance of the elderly, which consists of six variables adopted also in this study. Shinkai *et al.*[13] reported that these two walking speeds have different predictive values for the onset of the disability in B-ADL among the community elderly; maximum walking speed was more sensitive in predicting the onset of functional dependence for younger (65–74 years) people, while usual walking speed was more sensitive for older (+75 years) people. Our findings also implicate that maximum walking speed is the best indicator for the maintenance of I-ADL in our cohort in which the young-old predominates.

One of the reasons for the relationship between walking speed and decline of I-ADL may be related to the fall occurrence. A considerable volume of research has been conducted on walking ability in relation to the occurrence of fall in the elderly. Increased body sway, uneven distance, or uneven timing during walking were identified as risk factors for falls.[34–36] Declining walking ability with advancing age contributes to decreasing walking speed, step length, and cadence. The authors have already reported that together with fall experience within one year preceding the baseline survey, walking speed was a highly sensitive and very important predicator for the occurrence of frequent falls during a five-year follow-up period among the elderly, using the same set of data as the present study.[37]

Muscle function or strength as the single most important component for locomotor competence[9] has been consistently identified as the main risk factor for falls and hip fracture in the elderly. The incidence of hip fracture increases exponentially with age. More than 90% of hip fractures are caused by falls, and result in heavy loss of both B-ADL and I-ADL.

Although the bone mass of Japanese women is lower than that of Caucasians even after adjusting for body size,[38,39] the incidence of hip fracture is lower among Japanese than among Caucasians.[40–42] A recent international cross-cultural study on the relationship between muscle strength and fall rates among residents of Japanese and American nursing homes revealed that the traditional Japanese lifestyle, such as squatting in toilet or sleeping on the floor, maintained quadriceps strength and resulted in fewer falls.[43] These daily activities of the traditional Japanese lifestyle may increase muscle bulk and play an important role in hip fracture prevention.[44,45] In this context, the present study con-

firmed that decreased walking speed certainly increases the risk of falls and therefore increases the decline of I-ADL either from fracture itself or post-fall syndrome in the community-dwelling elderly. For the prevention of falls and the ensuing against decline of I-ADL, walking ability should be maintained in the elderly through long-term practice, and perhaps training, of walking.

In conclusion, the findings in this study suggest that there are indeed ways by which the quality of life in the elderly can be influenced. Preventive measures should primarily be directed toward lifestyle in a broad sense and in particular to the maintenance of optimal walking ability. In addition to looking into predictors of functional capacity based on observational studies, further intervention trials are urgently needed aiming to maintain and even promote functional capacity in the community elderly in Japan as one of the leading longevity societies in the world.

Acknowledgments

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Aging-related changes of food intake in elderly subjects living in an urban community and relation with vital prognosis: Results of an 8-year longitudinal study (TMIG-LISA)

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Purpose: We conducted an 8-year longitudinal study to investigate aging-related changes in food and nutrient intake in a cohort of elderly subjects living in an urban community, and attempted to relate food intake with vital prognosis.

Procedures: The first (baseline) nutrition survey was conducted in 1991 on 161 subjects (72 males and 89 females; aged 65–79) living in Koganei City. The second nutrition survey was conducted 8 years later in 1999. Excluding death or illness, 98 subjects (61%) were available for follow-up. Nutrition survey was conducted by a three-day dietary record method with daily home visits by dieticians. Aging-related changes in physical attributes, food intake, nutrient intake, and intake adequacy were analyzed. The relationship between nutrition intake and mortality was analyzed by Cox proportional hazard model.

Results: (i) Weight and body mass index in females decreased significantly accompanying aging. (ii) Among all food groups, consumption of fruits was significantly lowered in males and females. (iii) Significantly decreased intake of protein, fats, carbohydrate, iron, sodium was observed in females. (iv) No change in protein–fat–carbohydrate energy ratio was observed. (v) Nutrient intake was greater than the recommended dietary allowances at baseline and also eight years later. (vi) A significant correlation was observed between vegetable protein intake and vital prognosis in males.

Conclusion: In the present cohort, although nutrient and food intake changed with aging, nutrient intake was higher than the recommended dietary allowances. These results show that a 'diet for healthy longevity' is achieved by continuing to maintain the recommended dietary allowances despite age advancement.

Keywords: aging, nutrient intake, nutrition survey, recommended dietary allowance, vital prognosis.

Introduction

Accompanying the arrival of an aging society in Japan, the promotion of national policies aiming at healthy longevity has become an important issue.[1] The health promotion campaign for the 21st century (Healthy Japan 21) is moving ahead with the aim to prolong a healthy lifespan, and recommendation of safe and adequate daily dietary intake have been published.[1] However, since implementation of these policies has only just started, there are very few reports of nutrition survey/research or actual dietary habit survey in elderly subjects living in the community with the main theme of healthy longevity. As a result, the

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implementation at individual level has not been reached. The purpose of the present study was to provide basic data for planning the policy 'dietary habit for a long and healthy life' aiming at a healthy longevity. We surveyed elderly subjects who led an independent life in the urban community, and examined the aging-related changes in food intake during eight years. Furthermore, using the mortality by all causes as an indicator of health, we attempted to relate the status of food intake with lifespan or vital prognosis.

Methods

Subjects

This study was conducted as a part of the Tokyo Metropolitan Institute of Gerontology – Longitudinal Interdisciplinary Study on Aging (TMIG-LISA).[2] The TMIG-LISA was reviewed and approved by the Tokyo Metropolitan Institute of Gerontology Ethical Review Committee. Informed consent was obtained from all subjects before participation in the study. Confidentiality of subjects has been protected.

The target area was Koganei City in the suburb of Tokyo. The first (baseline) nutrition survey was conducted in 1991. From 996 persons representing a one-tenth random sample of residents aged 65–84 years who were living in Koganei City as of June 1 1991, 814 subjects who responded to an interview were included as potential subjects. Among the 814 subjects, 405 attended the Comprehensive Health Check for the Elderly. Of 405 subjects, 170 were requested to participate in a nutrition survey. Nine subjects were excluded (5 subjects were on a trip or went out and 4 refused to be surveyed), and the remaining 161 subjects (72 males and 89 females; aged 65–79 years) were recruited in the first survey.

The second nutrition survey was conducted 8 years after the first survey, from July to September 1999. During this period, survey of vital outcome confirmed 25 deaths (18 males [25%], 7 females [8%]). An additional 22 subjects were hospitalized or sick and 16 subjects rejected being surveyed or had moved. Therefore, of the 161 subjects who participated in the first survey, 98 subjects were surveyed the second time, with an overall follow-up rate of 61%. Excluding those who died or were hospitalized or under medical treatment, the follow-up rate was 86%.

The analysis on longitudinal changes in two nutrition surveys was conducted on 98 subjects who could be surveyed in both the first and the second nutrition surveys. Analysis of survival was conducted on all 161 subjects who participated in the first survey, and subsequent survival or date of death of these subjects was confirmed.

Nutrition survey

Nutrition survey was conducted according to the three-day dietary record method, which was based on the recollection method coupled with direct interview. This method is a survey of individuals, and a dietary record form was handed to the subject in person before the survey. The subject was asked to write down on the form the contents of the food and the approximate amounts taken on specified days. The authors and other dieticians conducted home visits to each of the subjects once a day for three consecutive days. Food intake was monitored by confirming the contents of the record with the subject him/herself, spouse or family using photographs taken during interviews, scales, spoons and other instruments. The dietary record form was checked for omissions or mistakes. The quantities of intake were estimated from the approximate volume of food, or the approximate weight per slice, plate, or piece.

Dieticians conducted individual home visits on three consecutive days to confirm the dietary records. The subjects in the dietary survey were individuals who were capable of reading and writing by themselves, and furthermore capable of recording food eaten on three consecutive days. At the same time, despite being at an advanced age, these subjects led an active and busy life, and had volunteered to participate in the present study based on a trust relationship that they had developed with our Institute. With this background, we conducted a baseline dietary habit survey on these subjects in 1991, and then the same survey eight years later to observe the aging-related changes in this cohort.

The nutritional value was calculated using the Program Library EIPAC at the Tokyo University Large-scale Computer Center. The two surveys were conducted during the same period by the same method, and analyzed using the same tables of food compositions[3] and programs for calculating nutritional values. From these calculations, the quantities of nutrient intake and quantities of food intake by food group were obtained. Nutrient energy ratio was expressed as the energy ratio for the respective nutrient, such as protein energy ratio (P energy ratio), fat energy ratio (F energy ratio) and carbohydrate energy ratio (C energy ratio).

The adequacy of nutrient intake was expressed as a percentage of the nutrient intake for the individual to the recommended dietary allowance for Japanese.[4] However, the adequacy of energy intake was calculated as the percentage of energy intake for the individual to the recommended energy allowance according to the height, weight, and physical activity of the subject.[5]

Statistical analyses

The items of analysis were height, weight, body mass index (BMI) (weight in kg/height in m),[2] quantity of food intake by food group, and quantity of nutrient

intake. Aging-related changes in physical measurements, quantity of food intake by food group, and quantity of nutrient intake were analyzed using paired *t*-test.

To examine the association between nutritional factors and vital prognosis indicated by mortality by all causes, Cox proportional hazard model was used including mortality by all causes and other confounding factors in the analysis. We chose Cox proportional hazard method because this model deals with continuous values, and would sensitively detect differences in mortality, which is a continuous value. The independent variable was mortality by all causes. The dependent variables consisted of quantities of nutrient intake for energy, total protein, total fat, vegetable protein, animal protein, vegetable fat, animal fat, and carbohydrate; as well as the physical factor of BMI. These factors were used as continuous variables and were adjusted for age. Then the hazard ratio for each factor was calculated. Statistical calculations were performed using SPSS 11.0 for Windows.

Results

Physical measurements

Table 1 shows the basic attributes of these subjects. For the family structure, there were only a few subjects living alone, and 59% were living in extended families of two or three generations. For the final academic achievement, no subject had 'no schooling', and 9.6% were university graduates. As for physical items, 92% were mobile and capable of travelling far utilizing bicycles, cars, or buses. Moreover, chewing ability was good in the majority of the subjects.

Table 2 shows the aging-related changes in height, weight, and BMI of the same individuals during 8 years.

Table 1 Basic attributes of subjects

Item	No. of subjects	%
Sex		
Male	72	44.7
Female	89	55.3
Age		
65–69 years	64	39.8
70–74	58	36.0
75–79	39	24.2
Family structure		
Living alone	17	10.6
Couple	48	30.0
Extended family (2 or 3 generations)	95	59.4
Education		
Primary school (old system)	43	26.8
Junior/Senior high school (old system)	98	63.8
University (old system/modern)	15	9.6
Using public transportation		
Can move inside home or in neighbourhood, Cannot travel far	13	8.1
Can travel far by bicycle, car or bus	147	91.9
Chewing ability		
Do not chew much	5	3.1
Can chew most thing	72	45.0
Can chew anything	83	51.9

Table 2 Aging-related changes in physical measurements

	Male (n = 41)			Female (n = 57)		
	1991	1999	Sig.	1991	1999	Sig.
Height (cm)	163.0 ± 5.1	162.8 ± 5.1	NS	148.6 ± 5.9	148.2 ± 5.8	NS
Body weight (kg)	55.9 ± 8.8	54.9 ± 9.3	NS	51.6 ± 8.7	50.2 ± 9.5	*
Body mass index (kg/m^2)	21.0 ± 3.0	20.5 ± 3.1	NS	23.4 ± 3.8	22.8 ± 4.0	*

Paired *t*-test; NS, not significant; *$P < 0.05$.

In females, the mean weight decreased significantly from 51.6 to 50.2 kg and the mean BMI also decreased significantly from 23.4 to 22.8. In comparison, no significant changes were observed in males.

Amounts of food intake by food group

At baseline, the intake amounts of green and yellow vegetables, fruits, and milk or milk products were high (Table 3). Especially the intake of milk or milk products was higher than the national average. As for the changes during 8 years, significant decreases were observed in fruits for both sexes, and fats and oils for females, while a tendency of decrease was observed for most of the other food groups. However, a tendency of slight increase in the intake of beans (soybeans and other processed products), green and yellow vegetables, and meat was seen in males.

Nutrient intake

Table 4 shows the changes in nutrient intake with aging. Significant decreases common to males and females were observed for carbohydrate and sodium. In females, significant decreases were also found in energy, total protein, animal protein, total fats, vegetable fat, iron, and vitamin B_2. In males, a tendency of decrease was observed in these nutrients.

There were no changes in nutrient energy ratio (protein–fat–carbohydrate energy ratio [PFC energy ratio]), P energy ratio, and F energy ratio with aging.

The aging-related changes in nutrient intake adequacy rates are shown in Fig. 1. Except calcium in males, the intake of all nutrients was above the recommended dietary allowance both at baseline and also after 8 years.

Relationship between nutrition intake and vital prognosis

The relationship between nutrition intake and vital prognosis was analyzed by the Cox proportional hazards model. Mortality by all causes was used as the dependent variable, and parameters nutrient intake was used as independent variables. To extract variables for use in the model, simple correlation analysis was conducted on all the nutrient factors. Factors showing strong correlation were eliminated to extract the representative variables. A total of eight variables were extracted. Thus, the independent variables consisted of continuous values of energy, vegetable protein, animal protein, vegetable fat, animal fat, and carbohydrate intake; as well as the physical factor of BMI and age. Males and females were analyzed separately because we observed differences between males and females in the amount of nutrient intake, the amount of food intake according to food group, body weight, absolute values of BMI, and age-related changes in nutrient uptake.

After adjusting for age, the hazard ratios of these variables were calculated (Table 5). In males, the hazard ratio of mortality by all causes was significantly decreased for vegetable protein intake.

Discussion

Representative methods of nutrition surveys used in epidemiological studies include the weighing method,[6] and recollection method.[7] While the former method

Table 3 Aging-related changes in food intake according to food group

Food group (g/day)	Male (n = 41)			Female (n = 57)		
	1991	1999	Sig.	1991	1999	Sig.
Vegetable foods						
Rice	339.0 ± 132.1	313.6 ± 171.6	NS	241.7 ± 85.6	221.4 ± 88.9	NS
Soybean, processed product	52.1 ± 34.7	52.5 ± 47.1	NS	66.0 ± 39.4	60.6 ± 43.6	NS
Green and yellow vegetables	102.8 ± 59.0	113.4 ± 71.4	NS	118.4 ± 63.6	112.9 ± 69.3	NS
Light colored vegetables	134.2 ± 72.9	113.5 ± 61.9	NS	150.6 ± 73.1	135.3 ± 63.4	NS
Fruits	162.5 ± 109.3	91.6 ± 76.9	***	202.6 ± 129.4	127.0 ± 78.5	***
Animal foods						
Milk/milk products	138.4 ± 103.6	118.6 ± 104.4	NS	206.9 ± 163.6	185.7 ± 124.3	NS
Eggs	45.9 ± 24.0	43.0 ± 25.2	NS	38.2 ± 21.1	34.9 ± 24.6	NS
Meats	48.3 ± 24.4	51.4 ± 37.7	NS	45.4 ± 31.8	38.9 ± 31.8	NS
Fish and shellfish	95.3 ± 47.7	77.9 ± 39.1	NS	81.3 ± 40.1	71.7 ± 38.0	NS
Preference foods						
Fats and oils	18.4 ± 10.6	15.9 ± 8.8	NS	18.2 ± 10.4	12.7 ± 8.3	**
Sweets	32.0 ± 31.6	27.0 ± 31.7	NS	38.8 ± 33.1	39.6 ± 33.7	NS

Paired t-test; NS, not significant; **$P < 0.01$; ***$P < 0.001$.

Table 4 Aging-related changes in nutrient intake

Nutrient (mean of 3 days)	Male (n = 41)			Female (n = 57)		
	1991	1999	Sig.	1991	1999	Sig.
Energy (kcal)	1960 ± 295	1836 ± 445	NS	1760 ± 392	1553 ± 341	***
Protein (total) (g)	74.0 ± 14.1	71.3 ± 16.0	NS	70.2 ± 16.8	64.1 ± 14.6	**
Vegetable (g)	35.8 ± 5.8	35.4 ± 9.3	NS	32.8 ± 7.4	31.0 ± 7.4	NS
Animal (g)	38.2 ± 12.2	35.9 ± 11.9	NS	37.3 ± 12.7	33.1 ± 11.5	*
Fats(total) (g)	56.4 ± 15.9	53.7 ± 15.5	NS	54.1 ± 17.7	47.3 ± 16.0	**
Vegetable (g)	29.2 ± 10.7	28.4 ± 11.6	NS	28.8 ± 12.1	24.5 ± 10.0	*
Animal (g)	27.2 ± 10.3	25.3 ± 9.6	NS	25.3 ± 10.6	22.8 ± 10.7	NS
Carbohydrate (g)	268 ± 45	247 ± 71	*	242 ± 56	213 ± 53	***
Calcium (mg)	577 ± 16	563 ± 197	NS	679 ± 247	624 ± 240	NS
Iron (mg)	10.8 ± 2.6	10.0 ± 2.6	NS	10.5 ± 2.8	9.3 ± 2.5	***
Sodium (mg)	4733 ± 964	4110 ± 1162	**	4520 ± 1331	4069 ± 991	**
Vitamin A (IU)	2483 ± 1551	2496 ± 2123	NS	2694 ± 1449	2403 ± 1244	NS
Vitamin B_1 (mg)	1.10 ± 0.29	1.00 ± 0.31	NS	1.11 ± 0.51	1.18 ± 1.24	NS
Vitamin B_2 (mg)	1.36 ± 0.39	1.33 ± 0.39	NS	1.44 ± 0.40	1.35 ± 0.45	*
Vitamin C (mg)	108 ± 45	102 ± 53	NS	126 ± 57	111 ± 51	NS
Protein energy ratio (%)	15.1 ± 2.1	15.8 ± 2.4	NS	16.0 ± 2.2	16.6 ± 2.3	NS
Fat energy ratio (%)	25.6 ± 5.4	26.4 ± 5.1	NS	27.3 ± 4.9	27.2 ± 5.5	NS
Carbohydrate energy ratio (%)	55.1 ± 6.8	53.6 ± 7.0	NS	55.4 ± 6.0	55.1 ± 6.7	NS

Paired t-test; NS, $P > 0.05$; *$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.

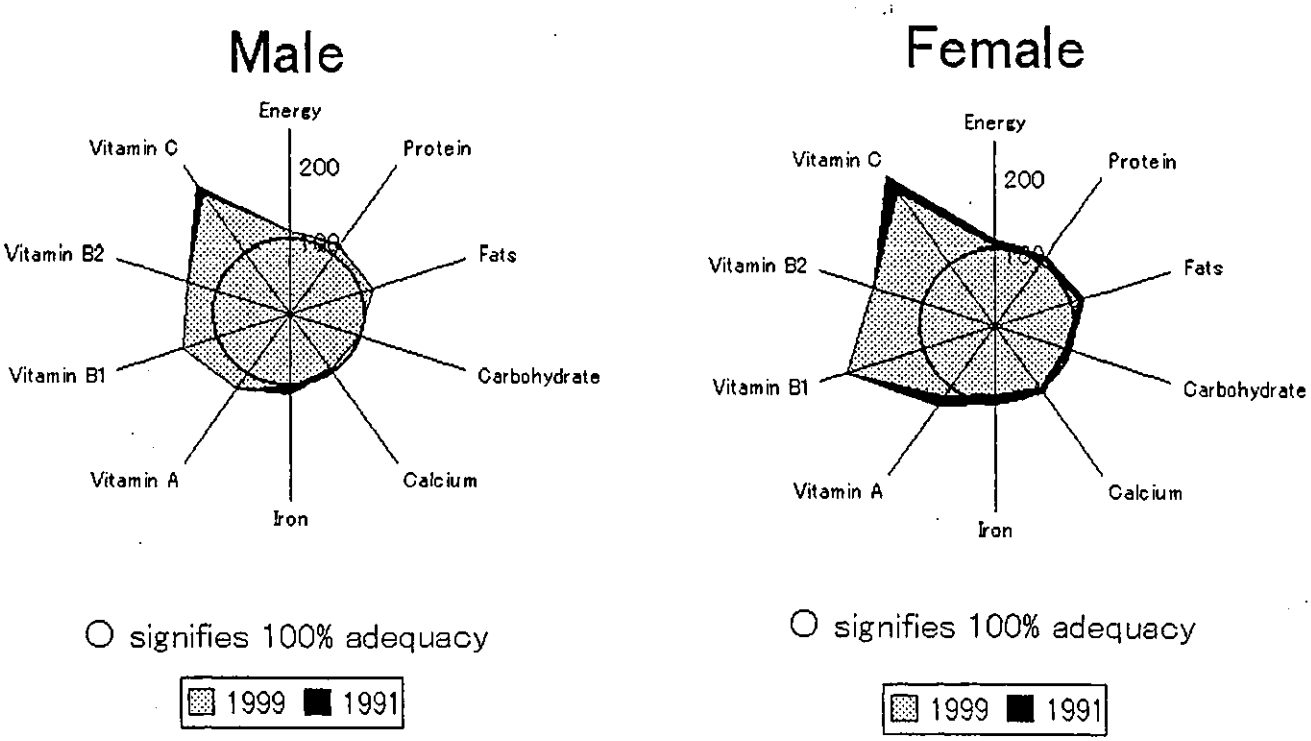

Figure 1 Age-related changes in adequacy of nutrition intake. The central circle in each graph signifies average dietary allowance of subjects examined = 100%. (▨) 1999; (■) 1991.

allows an accurate assessment of the amounts of food intake, the burden on the subjects being surveyed is also great. The recollection method involves interviewing the survey subjects and estimating the approximate amounts of food consumed during the 24 h before the interview. However, when the subject fails to recall food items that have been consumed or when the interviewer is not thorough in questioning there is a probability of omissions of food items or mistakes in the quantity of intake.[8] In this study, in order to mini-