〈原　著〉

都市部在住高齢者における老年症候群改善介入プログラムへの不参加者の特性：—介護予防事業推進のための基礎資料(「お達者健診」)より—

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金　憲経[1)]　杉浦　美穂[1)]　古名　丈人[2)]　鈴木　隆雄[1)]

要　約　**目的**：地域高齢者を対象に実施された老年症候群の改善介入プログラムへの不参加者の特性を明らかにすることを目的とした．**対象と方法**：2002年に実施された介護予防を目的とした包括的健診(「お達者健診」)の参加者（1,784人）のうち，転倒，尿失禁，うつ，低栄養の各老年症候群の改善介入プログラム対象基準に該当する607人（男性208人，女性399人）を選出し分析の対象とした．このうち介入プログラムに参加した者を「参加者」，参加しなかった者を「不参加者」とし特性を比較した．また，介入プログラムへの不参加の関連要因を明らかにするため，多重ロジスティック回帰分析を実施した．**結果**：介入プログラムへの全体の参加率は，男性16.8%，女性32.6%であった．多重ロジスティック回帰分析の結果，男性では，グループ活動（Odds ratio（OR）＝2.46，95% Confidence Intervals（CI）1.08～5.59），心臓病既往（OR＝0.38，95% CI 0.17～0.89），一方，女性では，居住形態（OR＝0.53，95% CI 0.34～0.83），高脂血症既往（OR＝0.54，95% CI 0.34～0.84）が不参加の関連要因としてあげられ，男性では，グループ活動に参加していない，心臓病既往が無いことが，女性では，同居者がいる，高脂血症の既往が無いことが不参加に関連していた．**結論**：介入プログラムへの参加には，個人の生活環境や社会活動性，既往症が影響することが示された．介入プログラムなど介護予防事業の実施にあたっては，個々の背景やニーズに合わせた内容と，様々な参加促進の工夫が必要であることが考えられた．

Key words：地域高齢者，介入不参加者，社会活動性，老年症候群，介護予防

（日老医誌　2007；44：231-237）

緒　言

平成18年4月より介護予防を柱とした改正介護保険法が実施されている．そこでは高齢者人口の増加に伴い，いかにして高齢者の自立を維持させるかが課題であり，高齢者の介護予防プログラムの開発およびその普及が急務である．

近年，地域高齢者を対象とした転倒予防[1)~3)]や身体機能の維持など介護予防を目的とした各種の介護予防教室が各地で展開され，高齢期の介入プログラムの効果について報告されている．しかし，その一方で健康調査や介入プログラムへの参加率の低さが問題としてあげられている．高齢者を対象とした健康調査の不参加者の特徴として，疾病があることや認知機能が低い[4)]，退院後一年以内であることや主観的健康感が低い[5)]などが報告されている．一方，介入プログラム不参加者の特徴として，年齢が高いことや身体機能が低い[6)]などがあげられている．このように，健康調査や介入プログラムへの不参加者は心身の機能が低いことが報告されている．すなわち，健康度が低く，本来健診や介入が必要である者が健診や介入に参加していないことが考えられる．

高齢期の介護予防事業の目的は，加齢に伴う機能の低下の予防およびその遅延であり，介入プログラムの普及のためには，いかにしてその参加者を増加させるかが課題である．そのため，不参加者の特徴を把握し，プログラムへの勧誘方法の工夫や個々のニーズに合ったプログラムの提供が必要である．そこで本研究では，高齢者の介護予防を目的とした包括的健康診査の参加者を対象に実施された老年症候群の改善介入プログラムへの不参加者の特徴について明らかにすることを目的とした．本知見は今後の介護予防サービスプログラムの提供のあり方について寄与するものである．

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方　法

1. 対象

平成14年10月1日時点で70歳以上であった東京都I区（同区総人口506,478名，65歳人口割合16.9%）に在住する高齢者を対象に実施された健康調査(「お達者健診」)[7)~10)](ベースライン調査）に1,786人（男性770人，女性1,016人）が参加した．このうちデータに不備がある者を除く1,784人（男性769人，女性1,015人）から，調査結果をもとに，転倒，尿失禁，うつ，低栄養のうち一つ以上の老年症候群を持つ688人（男性258人，女性430人）を選出した．本研究では，老年症候群を持つ者に対して実施した老年症候群の改善介入プログラムスクリーニング基準に該当する607人(男性208人，女性399人）を分析の対象とした．

2. 改善介入プログラム対象者のスクリーニング基準

老年症候群介入改善プログラム対象者のスクリーニングは，面接聞き取り調査および血液生化学値により定義した．転倒は「過去一年間に転倒あり」，尿失禁はその頻度が「月に1~3回以上」，低栄養は「血清アルブミン値が3.8g/d*l*以下（一部3.9g/d*l*以下)」，うつはうつ鑑別尺度Mini International Neuropsychiatric Interview[11)]および医師による問診で「うつ傾向あり」と判断された場合とした．

3. 改善介入プログラム

4つの老年症候群に対してそれぞれの改善介入プログラムを実施した．介入プログラムへの参加は，各改善介入プログラム対象者に対して募集の案内状を郵送し希望者を募った．介入プログラムの内容は，転倒，尿失禁，うつについては下肢の筋力の増強を中心としたトレーニング内容から構成された．また，低栄養は料理教室を中心に構成された．実施されたプログラムの頻度および期間は，転倒改善プログラムが3カ月間（週2回），尿失禁改善プログラムが3カ月間（週2回），うつ改善プログラムが2カ月間（週1回）低栄養改善プログラムが3カ月間（週1回）であった．各プログラムの詳細については先に報告している[12)]．

分析にあたり，介入プログラム参加者および不参加者を定義した．すなわち，介入プログラムに参加を希望し，プログラムに参加および事前・事後調査を完了した者を「参加者」，参加希望しなかった者または応答なしに加え，プログラムへ参加を希望しながらも説明会等で中途脱落した者を「不参加者」とした．

4. 分析項目

分析項目は，ベースライン調査の基本属性(性，年齢)，体格指数（Body Mass Index：BMI)，健康度自己評価，総合的移動能力[13)]，外出頻度，身体的な痛みの有無，疾病既往症の有無(高血圧既往，脳卒中既往，心臓病既往，糖尿病既往，高脂血症既往)，外出時の歩行補助具の使用の有無，外出時の介助の必要性，横断歩道を青信号の時間内に渡れるか否か，聴力・視力の問題の有無，飲酒の有無，喫煙の有無，散歩・体操習慣の有無，趣味や稽古ごとの有無，グループ活動の有無，居住形態（同居者あり，独居)，教育歴（中等教育以上，初等教育以下)，高次生活機能（老研式活動能力得点[14)])，認知機能（Mini Mental State Examination：MMSE[11)])，身体機能の項目として，握力，5m歩行速度（通常歩行速度，最大歩行速度)[15)]，座位膝伸展筋力であった．膝伸展筋力は，計測器に対象者の膝角度が90度になるよう座してもらい，足首の位置にHand-held Dynamometer（MUSCLATOR GT-30，OG GIKEN）のセンサーを設置し，最大で膝を伸展するよう指示し筋力を測定した．

分析にあたり，健康度自己評価については「非常に健康」，「まあ健康な方」，「あまり健康ではない」，「健康でない」のうち，「非常に健康」，「まあ健康な方」を「健康」とした．総合的移動能力は「1人で外出できる」，「近隣のみ」，「少しは動ける」，「あまり動けない」，「寝たり起きたり」のうち，「1人で外出できる」を「遠出可能」とした．外出頻度は「1日1回以上」，「2~3日に1回程度」，「1週間に1回程度」，「ほとんど外出しない」のうち，「1日1回以上」を「毎日」とした．聴力については「普通（不自由しない)」，「大きい声でないと会話が不自由」，「ほとんど聞こえない」のうち，「大きい声でないと会話が不自由」，「ほとんど聞こえない」を「問題あり」，視力については「普通（不自由しない)」，「1m位離れていて誰かが分かる程度」，「ほとんど見えない」のうち，「1m位離れていて誰かが分かる程度」，「ほとんど見えない」を「問題あり」，飲酒の有無および喫煙の有無は「飲む/吸う」，「やめた」，「なし」のうち「飲む/吸う」を「あり」，趣味や稽古ごとは「ほとんどしない」，「ときどきする」，「よくする」のうち，「ときどきする」，「よくする」を「する」とした．

検定は，連続量についてはt検定，離散量についてはχ^2検定を用いた．また，介入プログラムへの不参加の関連要因を明らかにするため，従属変数を介入プログラム参加の有無，独立変数に二群間（参加群，不参加群）の比較で有意な関連がみられた変数とした多重ロジスティック回帰分析を実施した．解析にはSPSS13.0J for windowsを用い，危険率5%未満を有意差あり，10%未満を有意傾向ありとした．介入プログラムのうち尿失

表1　調査対象者の基本属性

	男性（n = 208）	女性（n = 399）
年齢（歳；平均 ±SD）	76.3 ± 4.0	76.1 ± 4.1
年齢階層（%）		
～74歳	34.1	41.4
75～79歳	45.2	37.6
80～歳	20.7	21.1
BMI（kg/m²；平均 ±SD）	23.2 ± 3.1	23.1 ± 3.5
健康度自己評価（健康；%）	73.8	69.7
総合的移動能力（遠出可能；%）	94.7	91.2
外出頻度（毎日；%）	74.9	77.2
老研式活動能力指標（点；平均 ±SD）	11.5 ± 2.0	12.0 ± 1.6

BMI：Body Mass Index

表2　各改善介入プログラムの参加状況

	該当人数（男/女）	全体（%）	男性（%）	女性（%）
全体	607（208/399）	27.2	16.8	32.6
転倒	324（122/202）	20.1	15.6	22.8
尿失禁	150（—/150）	37.3	—	37.3
低栄養*	141（75/66）	24.8	17.3	33.3
うつ	108（39/69）	21.3	12.8	26.1

* $p < 0.05$，男女間の比較

禁については女性のみを対象としたため，分析は男女別に実施した．

なお，本研究は東京都老人総合研究所の倫理委員会の審査を経て実施した．

成　績

介入プログラムへの全体の参加率は，男性16.8%，女性32.6%であった（表2）．介入参加群と不参加群の特性について比較した（表3）．その結果，男性では参加群に比べて不参加群で，年齢が高い（P<0.05），老研式活動能力指標得点が低い（P<0.001），グループ活動への参加ありの割合が低い（P<0.05），認知機能得点が低い（P<0.01），心臓病既往ありの割合が少ない（P<0.05），膝伸展筋力が低い（P<0.05），中等教育以上の教育歴の割合が少ない傾向（P=0.05），上肢の痛みありの割合が多い傾向（P=0.07），通常歩行速度が遅い（P=0.07）傾向がみられた．女性では参加群に比べて不参加群で，趣味ありの割合が少ない（P<0.01），独居の割合が少ない（P<0.01），認知機能得点が低い（P<0.05），高脂血症の既往ありの割合が少ない（P<0.01），最大歩行速度が遅い（P<0.01），老研式活動能力指標得点が低い傾向（P=0.09），中等教育以上の割合が少ない傾向（P=0.07），通常歩行速度が遅い傾向（P=0.05）がみられた．

介入プログラムへの参加の有無に関連が認められた変数を独立変数，介入プログラム参加の有無を従属変数とする多重ロジスティック回帰分析を行った（表4）．その結果，男性の不参加の関連要因には，グループ活動（Odds ratio（OR）=2.46，95% Confidence Intervals（CI）1.08～5.59），心臓病既往（OR=0.38，95% CI 0.17～0.89），一方，女性では，居住形態（OR=0.53，95% CI 0.34～0.83），高脂血症既往（OR=0.54，95% CI 0.34～0.84）があげられ，男性では，グループ活動に参加していない，心臓病既往がないことが，女性では，同居者がいる，高脂血症の既往がないことが不参加に関連していた．

考　察

本研究ではベースライン調査に参加した比較的身体機能が自立していると考えられる高齢者を対象に，老年症候群の改善プログラムへの不参加の関連要因を明らかにすることを目的とした．その結果，男性の不参加者は参加者に比べ，年齢が高い，高次生活機能が低い，認知機能が低い，グループ活動をしていない者の割合が多い，心臓病既往ありの割合が少ない，身体機能が低いという特徴がみられた．女性では，趣味を持つ割合が少ない，独居の割合が少ない，高脂血症既往ありの割合が少ない，

表3　介入プログラム参加者と不参加者のベースライン調査時の特性の比較

	男性		女性	
	参加（n = 35）	不参加（n = 173）	参加（n = 130）	不参加（n = 269）
年齢（歳）	75.0 ± 3.8	76.5 ± 4.0 *	75.9 ± 4.0	76.1 ± 4.2
BMI（kg/m²）	23.3 ± 2.7	23.1 ± 3.2	23.1 ± 3.6	23.1 ± 3.5
健康度自己評価（健康）	71.4	74.3	71.5	68.8
総合的移動能力（遠出可能）	100.0	93.6	93.8	89.9
老研式活動能力指標（点）	12.2 ± 1.0	11.4 ± 2.2 ***	12.1 ± 1.2	11.9 ± 1.7 #
外出頻度（毎日）	74.3	75.0	80.0	75.8
飲酒習慣（あり）	74.3	64.5	33.1	30.9
喫煙習慣（あり）	20.0	28.5	4.6	5.2
散歩や運動（あり）	74.3	72.1	70.8	69.1
趣味の有無（あり）	71.4	59.9	78.5	65.8 **
グループ活動（あり）	48.6	27.3 *	40.8	43.9
教育歴（中等教育以上）	80.0	62.8 #	74.6	64.9 #
居住形態（独居）	14.3	16.2	46.9	32.3 **
MMSE得点（点）	28.5 ± 1.5	27.6 ± 2.4 **	28.2 ± 2.0	27.7 ± 2.6 *
高血圧既往（あり）	51.4	39.3	43.8	50.2
脳卒中既往（あり）	8.6	18.5	7.7	5.9
心臓病既往（あり）	42.9	25.4 *	23.1	25.3
糖尿病既往（あり）	8.6	14.5	10.0	6.3
高脂血症既往（あり）	17.1	15.6	43.1	28.3 **
痛みの有無（あり）	45.7	52.9	65.4	61.7
上肢の痛み（あり）	5.7	17.9 #	20.8	15.6
背中の痛み（あり）	0.0	1.7	3.8	4.5
下肢の痛み（あり）	34.3	39.3	55.4	51.7
杖や歩行器の使用（あり）	5.9	8.7	9.3	14.7
外出時の介助（必要）	5.7	4.7	5.4	7.1
横断歩道が渡りきる（いいえ）	0.0	2.9	1.5	2.6
聴力（問題あり）	5.7	16.3	11.5	14.1
視力（問題あり）	2.9	7.6	4.6	3.3
握力（kg）	29.0 ± 6.7	27.8 ± 6.6	18.2 ± 4.3	17.7 ± 4.6
膝伸展筋力（Nm）	78.9 ± 22.8	68.2 ± 25.9 *	48.7 ± 14.6	45.9 ± 15.8
通常歩行速度（m/s）	1.24 ± 0.24	1.15 ± 0.27 #	1.17 ± 0.25	1.11 ± 0.26 #
最大歩行速度（m/s）	1.95 ± 0.45	1.83 ± 0.41	1.73 ± 0.33	1.61 ± 0.37 **

平均 ± SD，割合（%）．
# $p < 0.1$，* $p < 0.05$，** $p < 0.01$，*** $p < 0.001$

身体機能が低いという特徴がみられた．また，多重ロジスティック回帰分析の結果，不参加の関連要因には，男性では，グループ活動，心臓病既往が，女性では，居住形態，高脂血症既往があげられ，個人がおかれている生活環境や，普段の社会活動性，身体的な背景が介入プログラムへの参加・不参加の決定に影響していることを示した．

介入プログラムの参加者と不参加者を比較した結果，男性でMMSE得点に有意な差がみられ，不参加者で低かった．地域高齢者を対象とした調査への不参加者の特徴に，認知機能が低いことが報告されている[6]．また，介入事業への参加者は不参加者に比べMMSE得点が高いことが報告されており[16]，本研究の結果は先行研究と同様の傾向を示した．

介入プログラム不参加者は参加者に比べ，男女ともに教育歴が低い傾向がみられた．地域に在住する高齢者を対象とした健康調査や[4]，健康介入や健康活動などに参加しない者の特徴として教育歴が低いことが報告されている[6][17]．教育歴は保健活動の実施と関連する．また，介入の参加には教育歴に加え，就業状況や経済状況が介入参加に関連することが報告されている[18]．本研究では，就業や経済状況について調査を行っていないが，先行研究の結果をふまえると，介入プログラムへの参加には社会経済的要因の関与が考えられた．

表 4-a　介入プログラム参加の有無に対する多重ロジスティック回帰分析（男性）

	OR	95% CI
年齢	1.36	(0.79 ～ 2.37)
教育歴	2.46	(0.92 ～ 6.61)
老研式活動能力指標得点	0.85	(0.62 ～ 1.16)
MMSE 得点	0.83	(0.66 ～ 1.03)
通常歩行速度	0.45	(0.08 ～ 2.58)
グループ活動	2.46	(1.08 ～ 5.59)*
上肢の痛み	4.90	(0.99 ～ 24.1)
心疾患既往	0.38	(0.17 ～ 0.89)*

全ての変数を同時に投入し分析を実施した
従属変数：介入プログラム参加の参加状況（0. 参加，1. 不参加）
独立変数：年齢（0. ～ 74 歳，1. 75 ～ 79 歳，2. 80 歳～），教育歴（0. 中等教育以上，1. 初等教育以下），老研式活動能力指標得点（実数），MMSE 得点（実数），通常歩行速度（実数），グループ活動（0. 参加，1. 不参加），上肢の痛み（0. なし，1. あり），心疾患既往（0. なし，1. あり）
OR：Odds Ratio，CI：Confidence Intervals
* $p < 0.05$

表 4-b　介入プログラム参加の有無に対する多重ロジスティック回帰分析（女性）

	OR	95% CI
年齢	0.86	(0.62 ～ 1.19)
教育歴	1.42	(0.85 ～ 2.38)
老研式活動能力指標得点	0.95	(0.80 ～ 1.12)
MMSE 得点	0.95	(0.85 ～ 1.07)
通常歩行速度	0.63	(0.24 ～ 1.64)
趣味	1.51	(0.90 ～ 2.54)
居住形態	0.53	(0.34 ～ 0.83)**
高脂血症既往	0.54	(0.34 ～ 0.84)**

全ての変数を同時に投入し分析を実施した
従属変数：介入プログラム参加の参加状況（0. 参加，1. 不参加）
独立変数：年齢（0. ～ 74 歳，1. 75 ～ 79 歳，2. 80 歳～），教育歴（0. 中等教育以上，1. 初等教育以下），老研式活動能力指標得点（実数），MMSE 得点（実数），通常歩行速度（実数），趣味（0. あり，1. なし），居住形態（0. 同居者あり，1. 独居），高脂血症既往（0. なし，1. あり）
OR：Odds Ratio，CI：Confidence Intervals
** $p < 0.01$

また，参加者と不参加者を比較すると，不参加者の男性ではグループ活動に参加している割合が少なく，女性では趣味を持つ割合が少ないなど，不参加者では社会活動性が低いことが示された．

本研究ではベースライン調査に参加した高齢者を対象に分析を実施している．すなわち，本研究の対象は，総合的移動能力について「単独で遠出可能」と回答している割合が男性で 94.7%，女性で 91.2% と（表 1），その多くが一定以上の自立度を持つ高齢者であり，参加者と不参加者の間に外出に必要な能力に大きな違いがないことを仮定した．実際，介入プログラム参加者と不参加者を比較したところ，総合的移動能力，歩行器具の使用や外出時の介助，視力，聴力など，面接聞取り調査による身体機能に差は認められなかった．しかし，筋力，歩行速度など実測値による身体機能には，二群間に有意差が認められ，不参加者では下肢筋力が低い，歩行速度が遅いなど身体機能が低いことが示された．歩行速度の低さは死亡や IADL 低下の予測因子であり[15]，不参加者は参加者に比べてより虚弱が進むことが予測されるため，重点的な対処が必要であることが考えられた．

介入プログラムへの不参加の関連要因を検討したところ，男性の介入プログラムへの不参加にグループ活動が関連し，グループ活動に参加していない場合に介入プログラムに不参加であることが示された．男性は，健康行動の開始に集団での活動を希望する割合が女性より低いことが報告されている[19]．また，介護予防事業や健康教室などへの参加についての研究では，女性に比べ，男性の参加者の割合は少ないことが報告されている[20]．本研究で用いた介入プログラムはグループ指導型の介入であり，このことが男性の参加を抑制した可能性が考えられた．このことから，男性に対して介入プログラムを実施する際には，グループ活動を好まないケースがあることを考慮した上で，プログラムへの勧誘の工夫が必要であることや，自宅や個人で実施可能なプログラムの提供が必要であることが考えられた．他方，本研究で取り上げた介入プログラム 4 つのうち 3 つは運動プログラムであった．対象者の中には，運動を好まないまたは運動の実施が難しい場合も考えられる．これらのケースに対しては，運動以外の介入プログラムの提案も必要であることが考えられた．

女性の介入プログラムの不参加に居住形態が関連し，同居者がいる場合にプログラムに不参加になりやすく，独居者がより参加していることを示した．先行研究によると独居高齢者と家族と同居している高齢者との間には，身体機能，認知機能などに差はみられないが，独居者はより介護サービスやフットケア，訪問看護などの医療サービスを利用していることが報告されている[21]．これは，独居者が積極的に様々なサービスを利用していることを示す．本研究の結果も，独居者がより自身の健康の維持に注意を払い，積極的に介入プログラムを利用していることが考えられた．

介入プログラムへの不参加の関連要因に，男性では心

臓病既往，女性では高脂血症既往があげられ，それぞれの既往症が無い場合に不参加になりやすいことが示された．しかしながら先行研究では，健康調査への不参加の要因に，疾病があることや退院してから期間が短い[4]など，疾病により健康度が著しく低いことが調査への参加を抑制していることを示している．この点についてであるが，本研究では，地域で生活を送りベースライン調査に参加できる比較的自立度の高い高齢者を対象としている．これら両者間の結果の違いは，対象集団の違いによるものと考えられた．また，軽度の心疾患の治療の一環に運動療法を[22][23]，高脂血症の治療に栄養管理や運動療法を用いる[24]．そのため，既往症を持つ者は，運動療法や食事療法などの経験があり，保健行動や保健活動に対する関心が高いことから，介入プログラムへの参加を促した可能性が考えられた．

最後に本知見の限界点について述べる．第1に，本研究で得られた結果は，自立度の高い高齢者集団によるものである．第2に，本研究では，不参加者に対し不参加の理由についての聴取を行っていない．先行研究によると不参加の理由には，健康状態が悪すぎる，健康状態が良好である，興味がないなど，いくつかの理由に分類され[25]，不参加の理由が心身の虚弱のみではないことが報告されている．不参加の理由を把握することは，本来の虚弱リスクを持つ者を選別するために重要である．この点については今後さらに詳細な調査が必要である．

結　語

本研究の結果，介入プログラム不参加者は参加者に比べ，筋力や歩行速度など身体機能が低く，不参加者は将来的に虚弱がより進行しやすい集団であることが考えられた．また，介入プログラムへの不参加の関連要因には，生活環境や社会活動性，既往症が影響することが示され，男性では集団指導型の介入には参加しにくい，女性では，家族と同居している場合に介入プログラムへの参加が少ないことが考えられ，介入プログラムの実施にあたっては，個々の背景やニーズに合わせた内容と，様々な参加促進の工夫が必要であることが考えられた．

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Characteristics of geriatric syndrome-subjects who did not participate in proffered intervention trial

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Abstract

Background: The present study was conducted to identify the characteristics of non-participants in intervention for geriatric syndrome among community-dwelling elderly.

Methods: The subjects were 208 men and 399 women aged 70 years and over who were eligible for participation in intervention programs for geriatric syndrome (falls, urinary incontinence, depression, and malnutrition) after recruitment based on a baseline health examination survey in 2002. Multiple logistic regression analysis was performed to assess non-participation in the intervention program as a dependent variable, and the relevant characteristics for participation in the baseline survey as the independent variables.

Results: The rates of participation in the intervention were 16.8% for men and 32.6% for women. Logistic regression analysis showed that male non-participants had not participated in group social activity (odds ratio (OR) = 2.46, 95% confidence interval (CI) 1.08-5.59), and had no medical history of heart disease (OR = 0.38, 95%CI 0.17-0.89), whereas female non-participants had not lived alone (OR = 0.53, 95%CI 0.34-0.83), and had no medical history of hyperlipemia (OR = 0.54, 95% CI 0.34-0.84).

Conclusion: Social activity, living arrangement, and medical history are related to non-participation in intervention for geriatric syndrome. It is necessary to devise various intervention programs and approaches to encourage participation.

Key words: *Community-dwelling elderly, Non-participants in intervention, Social activity, Geriatric syndrome, Prevention of long-term care status*

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Concomitant Lower Serum Albumin and Vitamin D Levels Are Associated with Decreased Objective Physical Performance among Japanese Community-Dwelling Elderly

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Key Words
Serum albumin · Vitamin D · Physical performance · Community-dwelling elderly

Abstract
Background: Previous studies have shown that serum albumin or vitamin D is associated with physical performance. We hypothesized that older adults with concomitant lower serum albumin and vitamin D (25-hydroxyvitamin D, 25OHD) levels are associated with decreased physical performance compared to those with 1 or none of the 2 risk factors. ***Objective:*** To investigate the association of combined serum albumin and 25OHD levels with physical performance (muscle strength and balance capability) in community-dwelling elderly. ***Methods:*** A cross-sectional study in a community-based population in the province of Tokyo, Japan, was performed. For the study, 1,094 community-dwelling people aged 70 and older underwent an interview, anthropometric measurements, blood analysis and physical performance testing. The subjects were classified into 4 types by combining serum albumin and 25OHD levels: lower albumin only, lower vitamin D only, lower albumin and lower vitamin D, higher albumin and higher vitamin D. ***Results:*** Men with concomitant lower albumin and lower 25OHD levels had significantly decreased knee extension power, usual timed Up & Go and maximal timed Up & Go, even after adjusting for age and body mass index (BMI). In women, concomitant lower albumin and lower vitamin D was associated with significantly decreased handgrip strength and functional reach, even after adjusting for age and BMI. Subjects with combined lower albumin and lower vitamin D levels showed a significant decline in muscle strength and balance capability compared to higher albumin and higher vitamin D, even after adjusting for age, current drinking or smoking status, physical activity, history of chronic disease, basic activities of daily living, instrumental activities of daily living, BMI and bone mineral density. ***Conclusion:*** Concomitant lower serum albumin and lower vitamin D levels are associated with decreased muscle strength and balance capability in both men and women. These results suggest that serum albumin and 25OHD together may be an important target for strategies aiming to achieve a healthy life and prevent loss of independence in community-dwelling elderly.

Introduction

Many studies have reported that the serum albumin level in the elderly is significantly associated with muscle mass, muscle strength and functional capacity [1–4]. We

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have previously shown that physical performance is certainly associated with the serum albumin level and tends to decrease at low serum albumin levels [5]. Particularly, handgrip strength and knee extension power were significantly declined at low serum albumin levels compared to normal levels in elderly men.

Low vitamin D level is also significantly related to decline of muscle strength [6–9], sarcopenia [8], functional limitations and disability [6, 9]. Moreover, vitamin D deficiency is common in healthy, community-dwelling elderly as well as geriatric patients [10–12].

Deterioration in physical performance has been found to be associated with serum albumin and serum vitamin D independently. However, few studies focused on the combination of serum albumin and vitamin D in relation with physical performance in the elderly.

Concomitant low serum albumin and vitamin D is not an unusual phenomenon among community-dwelling elderly. We hypothesized that older adults with both lower serum albumin and lower vitamin D levels are associated with decreased physical performance compared with those with only 1 or none of the 2 risk factors.

This study was conducted to investigate the association of combined serum albumin and vitamin D levels with physical performance in the community-dwelling elderly.

Methods

Population

The subjects analyzed in this study consisted of 1,094 residents (456 men and 638 women) aged 70 or older living in Itabashi-ku, Tokyo, who had participated in mass health checkups for the community elderly ('Otasha-kenshin') conducted in November 2004. Otasha-kenshin, literally meaning 'health checkups for successful aging', is a comprehensive health examination for the community elderly aiming to prevent the 'geriatric syndrome' including fall and fracture, incontinence, poor oral health, mild cognitive impairment, depression and undernutrition, in order to prevent loss of independence in the late life. Details of the survey, including subject details, investigation methods and contents have been described in our previous paper [13]. None of the subjects who participated in the present study had a history of malignant disease.

Data Collection

Interview

An interview was conducted to assess the age, living arrangements, current drinking or smoking status, physical activity, chronic disease conditions and activity limitation. Physical activity was assessed by whether the subject performed regular exercises defined as walking outdoors, running, exercises and sports at least once per week. History of chronic disease was self-reported and included hypertension, stroke, heart disease and diabetes. Heart disease included angina pectoris, acute myocardial infarction, congestive heart failure, aortic aneurysm and various arrhythmias. Activity limitation was assessed by questions on basic activities of daily living (BADL) and instrumental activities of daily living (IADL) [14]. BADL was measured using 5 items: walking, feeding, continence, bathing and dressing. IADL was assessed by 5 questions of the 'instrumental self-maintenance' sublevel in the Tokyo Metropolitan Institute of Gerontology index of competence: utilizing public transportation, shopping for daily living, preparing meals, paying bills, and managing bank deposits and savings. The response to each item in BADL and IADL was given a score of 1 for 'yes' and 0 for 'no', and the total score for 5 items was calculated. Thus, a score of 5 represents no difficulty and 0 represents total incapacity in BALD and IADL.

Anthropometrics Measurement

Body mass index (BMI) was computed as weight (in kilograms) divided by the square of height (in meters). Bone mineral density (BMD, g/cm^2) was evaluated at the forearm by dual energy X-ray absorptiometry using a DTX-200 osteometer (Osteometer MediTech, Hawthorne, Calif., USA). The measurements were performed by specially trained personnel. The osteometer was set to automatically measure BMD at a site 24 mm proximal to the position where the radius and ulna are separated by 8 mm.

Measurement of Serum Levels of Albumin and Vitamin D

Blood samples were collected in a nonfasting state, in a sitting position. The analyses were carried out centrally in one laboratory (Special Reference Laboratories Inc., Tokyo, Japan). Serum albumin level was measured by a standard kit using the biconjugate gradient method and the coefficient of variation for serum albumin was within less than 1%. Serum 25-hydroxyvitamin D (25OHD) level was used as a measure of vitamin D status [9], and was measured with an RIA2 kit (DiaSorin, Stillwater, Minn., USA). The RIA2 method is based on an antibody specific to 25OHD.

We summarized the serum albumin and 25OHD levels of these subjects into quartiles, and used the 25 percentile cutoff to classify the subjects into higher versus lower albumin and 25OHD groups. Thus, lower serum albumin was defined as 42.0 mg/dl or below for men and women. Lower serum vitamin D (25OHD) was defined as 62.5 nmol/l or below for men and 57.5 nmol/l or below for women. The subjects were classified into 4 types by combining serum albumin and vitamin D levels: lower albumin only (serum albumin $\leq$42.0 mg/dl in men and women), lower vitamin D only (serum 25OHD $\leq$62.5 nmol/l in men and $\leq$57.5 nmol/l in women), lower albumin and lower vitamin D (serum albumin $\leq$42.0 mg/dl and serum 25OHD $\leq$62.5 nmol/l in men, serum albumin $\leq$42.0 mg/dl and serum 25OHD $\leq$57.5 nmol/l in women), and higher albumin and higher vitamin D (serum albumin >42.0 mg/dl and serum 25OHD >62.5 nmol/l in men, serum albumin >42.0 mg/dl and serum 25OHD >57.5 nmol/l in women).

Physical Performance

Physical performance was assessed by muscle strength (handgrip strength and knee extension power) and balance capability (functional reach and timed Up & Go test). These assessments are routinely conducted for the community elderly as described pre-

viously [13–15]. Handgrip strength was measured by Smedley's Hand Dynamometer (Yagami, Tokyo, Japan). Knee extension power (Nm) was measured in the dominant leg, using a handheld dynamometer (Musculator GT-30; OG Giken, Tokyo, Japan). The subject was asked to sit in a chair with the knee bent at a right angle. The dynamometer was placed at the ankle joint. The muscle strength was measured as the peak force during isometric extension when the subjects were asked to extend the knee by their maximum leg power. The test was performed twice and the higher of the 2 measurements made on the dominant leg was recorded. For functional reach, the subject stood sideways against a wall in a natural position and stretched both arms to shoulder height. The positions of the fingertips were taken as the zero point. Then one arm was lowered. With the body tilted forward as far as possible, the subjects continued to stretch the arm parallel to the ground. The greatest distance of forward reach was measured. Three measurements were made, and the mean value was recorded. The timed Up & Go test measures the time (in seconds) it takes an individual to stand up, walk a standard distance of 3 meters, turn, walk back to the chair and sit down again. The timed Up & Go tests were recorded in usual and maximal speeds.

Statistical Analysis

All data were analyzed with the SPSS software for Windows, version 13.0 (SPSS Inc., Chicago, Ill., USA) and the level of significance was set at 5%. Comparisons of physical performance by combined serum albumin and vitamin D levels were conducted using ANCOVA controlled for age and BMI. To investigate the association of combined serum albumin and 25OHD levels with physical performance (muscle strength and balance capability), multiple regression analysis was conducted using 4 combined serum albumin and vitamin D groups. Similar group analysis was used in a previous report [16]. The analyses were adjusted for age, current drinking or smoking status, physical activity, history of chronic disease, BADL, IADL, BMI and BMD.

Table 1. Characteristics of study subjects

	Men (n = 456)	Women (n = 638)
Age, years	77.7 ± 4.0	77.8 ± 4.2
Living alone, %	9.0	39.7
Current drinkers, %	61.6	26.3
Current smokers, %	20.4	3.3
Regular exercise (every day), %	46.1	42.3
History of chronic disease, %	63.2	62.4
Hypertension, %	48.9	50.0
Stroke, %	13.6	9.1
Heart disease, %	22.8	24.6
Diabetes, %	8.8	5.8
BADL (full markers = 5)	4.99 ± 0.15	4.99 ± 0.10
IADL (full markers = 5)	4.78 ± 0.61	4.93 ± 0.36
BMI	23.0 ± 2.7	22.6 ± 3.3
BMD, g/cm^2	0.455 ± 0.081	0.291 ± 0.064
Albumin, mg/dl	43.3 ± 2.2	43.5 ± 2.0
25OHD, nmol/l	71.7 ± 13.2	65.8 ± 12.5
Combined serum albumin and vitamin D levels, %		
Low albumin only	26.5	22.7
Low vitamin D only	17.5	19.3
Low albumin and low vitamin D	9.2	6.9
High albumin and high vitamin D	46.8	51.1
Physical performance		
Handgrip strength, kg	28.4 ± 6.2	17.4 ± 4.2
Knee extension power, Nm	79.6 ± 25.8	52.6 ± 16.3
Functional reach, cm	35.3 ± 5.4	32.7 ± 5.6
Timed Up & Go (usual), s	6.3 ± 1.7	7.1 ± 2.8
Timed Up & Go (maximal), s	6.0 ± 1.6	6.7 ± 2.7

Results

The basic characteristics of the subjects – serum albumin and vitamin D concentrations, combined serum albumin and vitamin D levels, and physical performance – are shown in table 1. The mean age was 77.7 ± 4.0 years in men and 77.8 ± 4.2 years in women. The mean serum albumin concentrations were 43.3 ± 2.2 mg/dl in men and 43.5 ± 2.0 mg/dl in women. The mean vitamin D concentrations were 71.7 ± 13.2 nmol/l in men and 65.8 ± 12.5 nmol/l in women. The prevalence of lower serum albumin and vitamin D levels was 9.2% in men and 6.9% in women.

The comparisons of physical performance adjusted for age and BMI in the 4 groups classified by serum albumin and vitamin D levels are shown in table 2. Men with lower albumin and lower vitamin D (serum albumin ≤42.0 mg/dl and serum 25OHD ≤62.5 nmol/l) had significantly lower mean knee extension power ($p < 0.01$) and significantly slower timed Up & Go (usual $p < 0.01$, maximal $p < 0.05$) compared to low albumin only, low vitamin D only, and high albumin and high vitamin D. In women, lower serum albumin and lower serum vitamin D (serum albumin ≤42.0 mg/dl and serum 25OHD ≤57.5 nmol/l) meant significantly declined handgrip strength ($p < 0.01$) and functional reach ($p < 0.05$) compared to low albumin only, low vitamin D only, and high albumin and high vitamin D.

Table 3 shows the associations of combined serum concentrations of albumin and 25OHD with physical performance by multivariate regression models adjusted for age, current drinking or smoking status, physical activity, history of chronic disease, BADL, IADL, BMI and BMD. Men with lower albumin and lower vitamin D had significantly lower knee extension power ($p < 0.05$) and significantly slower timed Up & Go (usual $p < 0.001$, maximal $p < 0.05$) compared to higher albumin and higher vitamin D. In women, lower albumin and lower

Table 2. Relation between combined serum albumin and vitamin D levels and physical performance for men and women

	Low albumin only	Low vitamin D only	Low albumin and low vitamin D	High albumin and high vitamin D	p value[a]	p value[b]
Men						
Handgrip strength, kg	27.8 ± 6.0	28.4 ± 6.0	27.1 ± 6.6	29.1 ± 6.2	0.529	0.388
Knee extension power, Nm	74.9 ± 23.4	81.7 ± 27.6	67.1 ± 23.4	83.9 ± 25.6	0.005	0.002
Functional reach, cm	35.2 ± 5.5	34.5 ± 5.2	33.5 ± 6.4	36.0 ± 5.1	0.061	0.080
Timed Up & Go (usual), s	6.2 ± 1.5	6.3 ± 1.6	7.4 ± 2.9	6.0 ± 1.5	0.003	0.001
Timed Up & Go (maximal), s	6.0 ± 1.3	6.1 ± 1.5	6.8 ± 2.3	5.9 ± 1.6	0.044	0.018
Women						
Handgrip strength, kg	17.0 ± 4.0	17.3 ± 4.0	14.1 ± 4.7	18.1 ± 4.1	0.009	0.002
Knee extension power, Nm	50.8 ± 16.3	51.4 ± 16.4	46.3 ± 14.5	54.7 ± 16.3	0.550	0.228
Functional reach, cm	32.5 ± 5.1	31.9 ± 5.4	29.3 ± 6.2	33.5 ± 5.7	0.012	0.009
Timed Up & Go (usual), s	7.3 ± 2.4	7.1 ± 1.8	9.0 ± 4.7	6.7 ± 2.8	0.067	0.036
Timed Up & Go (maximal), s	6.9 ± 2.0	6.8 ± 1.8	8.3 ± 4.3	6.5 ± 2.9	0.270	0.199

[a] ANCOVA adjusted for age and BMI among 4 groups.
[b] ANCOVA adjusted for age and BMI between low albumin + low vitamin D and high albumin + high vitamin D.

Table 3. Associations of combined serum albumin and vitamin D levels with physical performance for men and women

	Handgrip strength			Knee extension power			Functional reach			Timed Up & Go (usual)			Timed Up & Go (maximal)		
	B	SE	p value	B	SE	p value	B	SE	p value	B	SE	p value	B	SE	p value
Men															
Low albumin only	−0.06	0.68	0.194	−0.12	2.80	0.017	−0.04	0.59	0.468	0.06	0.19	0.249	0.03	0.18	0.576
Low vitamin D only	−0.02	0.79	0.635	−0.01	3.27	0.933	−0.06	0.68	0.184	0.02	0.20	0.698	0.02	0.21	0.750
Low albumin and low vitamin D	−0.05	1.04	0.353	−0.12	4.28	0.010	−0.06	0.89	0.250	0.17	0.29	<0.001	0.12	0.28	0.016
Women															
Low albumin only	−0.05	0.39	0.255	−0.03	1.58	0.423	−0.12	0.53	0.635	0.01	0.24	0.892	−0.01	0.24	0.885
Low vitamin D only	−0.02	0.41	0.708	−0.02	1.66	0.666	−0.06	0.56	0.110	−0.02	0.26	0.590	−0.02	0.26	0.629
Low albumin and low vitamin D	−0.12	0.66	0.003	−0.03	2.66	0.430	−0.09	0.88	0.022	0.09	0.41	0.022	0.06	0.41	0.135

Values are adjusted for age, current drinking or smoking status, physical activity, history of chronic disease, BADL, IADL, BMI and BMD. p values are derived from multiple regression analysis. B = Regression coefficient; SE = standard error.

25OHD meant significantly declined handgrip strength ($p < 0.001$), functional reach ($p < 0.05$) and timed Up & Go (usual $p < 0.05$) compared to higher albumin and higher vitamin D.

Discussion

The maintenance of physical performance in old age is an important factor for a healthy and independent life in the community. It has been reported that physical performance of the elderly living in the community is associated with serum albumin [1–5] and vitamin D levels [6–10] separately. Since our previous study has demonstrated a significant relationship between serum albumin and physical performance of the elderly [5], the present study further examined the association by adding serum vitamin D. Through this study, we found that elderly persons with lower albumin and lower vitamin D levels at the same time had decreased muscle strength and balance capability not only when compared to higher albumin and higher vitamin D but also when compared to lower albumin only and lower vitamin D only. It has been suggested that concomitant lower serum albumin and lower

vitamin D levels contribute synergistically to decreased muscle strength and balance capability. To our knowledge, we are the first to report a combined effect of serum albumin and vitamin D levels on physical performance in an older population.

In general, a serum albumin level of 38.0 mg/dl is frequently used as the cutoff point for lower serum albumin [1]. On the other hand, some researchers have advocated that the appropriate cutoff points for serum albumin are 40.0 mg/dl for ambulatory elderly [17] and 43.0 mg/dl for community elderly living at home [16]. The subjects in this study had a mean serum albumin level of 43.3 ± 2.2 mg/dl in men and 43.5 ± 2.0 mg/dl in women, and only 1.6% had a level below 38.0 mg/dl. For vitamin D (25OHD), various optimal levels have been reported, ranging from 70.0 to 80.0 nmol/l [18] and there are no consistent criteria for low vitamin D and vitamin D insufficiency or deficiency. Furthermore, the serum vitamin D level is well known to vary depending on the season. Although the results of some Japanese studies offer suggestions, the cutoff value for elderly Japanese is still uncertain. For example, serum 25OHD concentrations of less than 30.0 [19], 40.0 [20] or 50.0 nmol/l [21] were defined as cutoff values for vitamin D insufficiency. Therefore, we summarized the serum albumin and 25OHD levels of these subjects into quartiles, and use the 25 percentile cutoff to classify the subjects into higher versus lower albumin and 25OHD groups.

Serum albumin is the main protein synthesized by the liver and the levels change with protein intake, by trauma or infection, and in chronic renal or hepatic diseases [2]. Vitamin D can be synthesized in the skin or consumed in the diet, vitamin D-fortified milk or margarine, and multivitamins [7]. After it is synthesized or consumed, vitamin D is transported to the liver where it is hydroxylated to 25OHD. Vitamin D level is affected by exposure to ultraviolet light, food intake, season [12, 19] and deterioration of creatinine clearance [22]. Serum 25OHD declines to significantly lower levels during autumn and winter [12, 23] and is strongly influenced by vitamin D intake in winter in ambulant elderly [19], but this is not observed in summer [19, 22].

The mechanism connecting serum albumin and muscle mass is not clear [2, 4]. But serum albumin concentration may be a marker of protein status of the body, with lower values indicating a diminished protein reserve, stimulating catabolic processes leading to muscle breakdown [4]. With an undernourished status, the main source of amino acids for protein synthesis may lead to muscle strength decline. Thus, low serum albumin, even within the normal range, is independently associated with weaker muscle strength and future decline in muscle strength in older men and women [3]. Oral amino acids and protein supplements improve muscle strength and ambulatory capacity [24]. The main function of vitamin D is to preserve calcium and phosphate homeostasis in order to promote skeletal mineralization [9]. In a role of vitamin D on physical performance, vitamin D supplementation has also been reported to be significantly effective in maintaining or improving physical performance and preventing falling of frail elderly persons living in the community [25].

In our study, elderly with concomitant lower albumin and lower vitamin D levels showed a significant decline in muscle strength and balance capability, even after age, current drinking or smoking status, physical activity, history of chronic disease, BADL, IADL, BMI and BMD had been taken into account compared with those with 1 or none of the 2 risk factors. Some studies have reported a significant positive association between serum albumin and vitamin D concentrations [20], while other studies found no significant relation [11]. No association was found between these 2 parameters in our present study (data not shown). This means that serum albumin and vitamin D concentrations are independent factors, in our study at least. Both serum albumin and vitamin D concentrations are associated with physical performance among the community-dwelling elderly. Therefore, in order to maintain a higher level of physical performance, it is important to maintain higher serum albumin and vitamin D levels. Incidentally, fish consumption seems to play an important role in maintaining adequate vitamin D nutrition in elderly Japanese, especially in winter [19].

Before establishing a final conclusion, some limitations of our study must be considered. (1) The subjects analyzed were not selected randomly from the study population, and they were relatively healthy elderly persons who were able to travel from their homes to the health checkup venue. As a result, elderly persons with lower physical functional capacity were excluded. (2) Plasma calcium, albumin-corrected calcium, phosphate and parathyroid hormone, which would provide information on the extent of primary vitamin D deficiency [9], and creatinine clearance that may affect the metabolism of vitamin D via the kidney [22], were not assessed in this study. (3) This study was a cross-sectional study and therefore does not provide cause/effect relationships, although we demonstrated a significant correlation between physical performance and serum albu-

min and vitamin D (25OHD) levels. Therefore, longitudinal follow-up studies and controlled clinical trials are necessary to confirm the role of serum albumin alone, serum vitamin D alone, and combined serum albumin and vitamin D in influencing physical performance of the elderly.

While these results confirm that albumin and vitamin D are without doubt important nutritional elements directly linked to the physical performance of elderly persons, so far no study has examined the effect of a combination of serum albumin and vitamin D levels on physical performance. The present study is significant in that it examined the association of combined serum albumin and vitamin D levels with physical performance such as muscle strength and balance capability.

In conclusion, concomitant lower serum albumin and vitamin D levels were associated with decreased muscle strength and balance capability. This finding indicates that combined lower serum albumin and lower vitamin D levels were associated with low physical performance. To maintain physical performance and lead an independent life in the community, we therefore suggest that it is more important to maintain optimal serum albumin and vitamin D levels through a continuous healthy lifestyle, including dietary habit, physical activities and appropriate supplementations, before the functional status declines to a frail state. Further work is required to validate our findings and monitor the effect of concomitant serum albumin and vitamin D levels on interventional programs for the prevention of functional decline with aging.

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SECTION ON LONGITUDINAL STUDIES

A mortality comparison of participants and non-participants in a comprehensive health examination among elderly people living in an urban Japanese community

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ABSTRACT. ***Background and aims:*** *Recent studies have revealed that there are critical differences between participants and non-participants in health examinations. The aim of this study was to examine mortality differences between participants and non-participants in a comprehensive health examination for prevention of geriatric syndromes among community-dwelling elderly people, using a three-year prospective cohort study.* ***Methods:*** *The study population included 854 adults aged 70 to 84 at baseline. The following items were all studied: the status of participation in the comprehensive health examination as an independent variable, age, gender, number of years of education, living alone, presence of chronic diseases, experience of falls over one year, history of hospitalization over one year, self-rated health, body mass index, instrumental activities of daily living, and subjective well-being as covariates; and all-cause mortality during a three-year follow-up as a dependent variable.* ***Results:*** *In an adjusted Cox's proportional hazard regression model, the mortality risk for participants in the comprehensive health examination was significantly lower than that of non-participants (Risk Ratio (for participants)=0.44, 95% confidence interval=0.24 to 0.78).* ***Conclusions:*** *The present study shows that there is a large mortality difference between participants and non-participants. Our findings suggest two possible interpretations: 1) There is a bias due to self-selection for participation in the trial, which was not eliminated by adjustment for the covariates in the statistical model; 2) There is an intervention effect associated with participation in the comprehensive health examination which reduces the mortality risk.*

(Aging Clin Exp Res 2007; 19: 240-245)

INTRODUCTION

Along with the worldwide aging of populations, the maintenance of functional capacity and prevention of long-term care dependence among the elderly have become major issues in geriatrics and gerontology (1, 2). The term "geriatric syndromes", referring to a group of medically significant findings which are experienced by older - particularly frail - persons, occur intermittently rather than either continuously or as single episodes. They may be triggered by acute insults, and are often linked to subsequent functional decline (3), and include delirium, dementia, depression, dizziness, emesis, falls, gait disorders, hearing loss, insomnia, urinary incontinence, language disorders, functional dependence, lower extremity problems, oral and dental problems, malnutrition, osteoporosis, pain, pressure ulcers, silent angina pectoris, sexual dysfunction, syncope, and vision loss (4-8). These problems are major factors that result in long-term care dependence among the elderly.

Early screening for geriatric syndromes is important for the prevention of long-term care dependence among community-dwelling elderly. We have recently been attempting to design a system for early detection of geriatric syndromes and subsequent intervention strategies within the community (7, 8). A comprehensive health examination for elderly people living in the community has been

Key words: All-cause mortality, comprehensive health examination for the elderly, prevention of geriatric syndromes and long-term care dependence, self-selection bias.

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used in an attempt to screen for geriatric syndromes. The comprehensive health examination that we have been designing is different from the usual multiphasic health check-ups that are used for detecting lifestyle-related illnesses among middle-aged and elderly people in Japan and Western countries (9-12). While prevention of lifestyle-related diseases is undeniably important, prevention of long-term care dependence calls for a different approach. For example, the major causes of death in Japanese people over 65 years old are cancer, heart disease, and stroke (Vital Statistics in Japan, 2001). On the other hand, although stroke remains a cause of long-term care dependence, the other major causes are age-related frailty, falls and fractures, and dementia, which are included together in geriatric syndromes (National Livelihood Survey in Japan, 2001). Therefore, the prevention and management of geriatric syndromes, as well as the prevention of lifestyle-related diseases, is crucial for the prevention of long-term care dependence. The present study examined mortality differences between participants and non-participants in a comprehensive health examination for the prevention of long-term care dependence, using a population-based, prospective approach. Since we asked individuals to participate in the health examination and they took part voluntarily, there may be a bias among those who chose to participate, compared with those who did not (non-participants). It is well-known that participants who choose to undergo health examinations are healthier, both physically and psychologically, than those who do not (7, 13-18), and they are more likely to have desirable health-related behavior (18, 19); therefore, participants have a higher likelihood of longevity than non-participants (15, 16, 20, 21). We tried to eliminate any self-selection bias by using statistical controls for demographic and health status, in both participants and non-participants in the comprehensive health examination. We used demographic data and health status information from both groups, collected one year before baseline, to control for self-selection bias.

METHODS

Participants

The source of data for the present study was the Longitudinal Interdisciplinary Study on Aging, conducted by the Tokyo Metropolitan Institute of Gerontology (22). The study was conducted in Itabashi ward, which is located in the north of Tokyo. As of 1 October 1991, of a total of 507,073 people (255,238 men, 251,835 women), 126,173 (24.9%, 58,996 men and 67,177 women) aged 50 to 74 years were registered as residents in the Itabashi ward. A sample of 4440 residents was obtained systematically from the municipal resident registration files on that date (i.e., 1 out of every 28 people were selected sequentially from the registration files). We acquired 3097 complete sets of data (for 1362 men and 1735 women) in the first round of home-visit surveys in 1991 (70.1% participation). We conducted home-visit surveys every year until 2000, with high response rates (80% to 90% participation). We obtained 1812 complete sets of data (725 men and 1087 women) in the final round of surveys in 2000.

Of the 1812 participants in the home-visit survey for 2000, 854 people aged 70 to 84, who were living in Itabashi ward on 1 October 2001, were asked, by letter, to participate in the comprehensive health examination for the elderly, conducted in October 2001. Four hundred and thirty-eight people (168 men and 270 women) took part in the examination voluntarily (51.3% participation) (7, 8). We followed the 854 adults (331 men and 523 women) as a prospective cohort and checked their mortality over a three-year follow-up period. We divided them into two groups - participants and non-participants - according to their participation in the comprehensive health examination in 2001. Non-participants included individuals who refused to participate in the comprehensive health examination and those who did not respond. Since the health examination was completed by the end of October 2001, we defined 1 November 2001 as the baseline for the follow-up period in the present study. Lastly, we carried out three-year mortality surveillance, from 1 November 2001 to 1 November 2004.

Comprehensive health examination

We carried out comprehensive health examinations for the elderly in 2001 and 2003, including medical examinations (blood pressure, history of past illnesses, bone mineral density, electrocardiogram, blood testing, and dental examination), physical fitness tests (hand-grip strength, walking ability, and balance ability tests), interviews regarding life-style and some risks of geriatric syndromes, cognitive function tests (Mini-Mental State Examination [23], digit symbol substitution test [24], verbal fluency test [25]), and a basic physician's medical check-up by interview. The complete examination took 90 min per participant (7, 8). Participants were then given summary reports of the results. In addition, those participants who were judged to be especially frail were encouraged to seek intervention via the community network, including health centers, clinics and hospitals.

Mortality follow-up

Current residence in Itabashi ward on 1 November 2004 was determined from the municipal resident registration files for Itabashi ward. Twelve people (1.4%) had moved away and were lost to follow-up. Seventy-eight (9.1%) had died. The dates on which residents moved away or died were identified from the registration files and used to calculate survival times. Certifications of all decedents and those moving away, and the relative dates were obtained from the Itabashi ward authorities.

Covariates

Data collected during the final round of the home-visit surveys in 2000 were used as covariates in analyzing for an independent association between participation in the health examination and mortality. Data for age, gender, number of years of education, living alone, presence of chronic diseases, experience of falls over one year, history of hospitalization over one year, self-rated health, body mass index (BMI), instrumental activities of daily living (IADL) (measured according to the Tokyo Metropolitan Institute of Gerontology Index of Competence (2, 26), range: 0 to 13), and subjective well-being (measured according to the revised version of the Philadelphia Geriatric Center Morale Scale (27); range: 0 to 17), were used. Presence of chronic diseases was defined as having at least one disease among cancer, diabetes, heart disease, stroke, and hypertension.

Statistical analysis

All statistical procedures were performed using SAS version 9.1 software (SAS Institute Inc., Cary, NC, USA). We used a Kaplan-Meier survival curve and a Cox's proportional hazards regression model to investigate the difference in mortality between participants and non-participants in the comprehensive health examination over a three-year follow-up period, with the SAS LIFETEST and PHREG procedures, respectively.

The dependent variable in the analyses was survival time, calculated as the number of days between baseline (1 November 2001) and the date of death or censoring. Survivors were censored on 1 November 2004. Drop-outs were censored on the date of moving away from Itabashi ward.

A Kaplan-Meier survival curve was used to examine whether the survival of participants was significantly different from that of non-participants.

To assess the independent relationship between participation status in the comprehensive health examination and all-cause mortality, the above-mentioned covariates were included in the Cox's proportional hazard regression model. Before analysis, we checked relationships between independent variables in the regression model by calculating Pearson correlation coefficients and verified relatively low to mild relationships among them (range of absolute value of correlation coefficients, 0.00-0.44). Therefore, we confirmed that the likelihood of any occurrence of multi co-linearity in the regression model was relatively low.

Ethical considerations

The study was approved by the Ethics Committee of the Tokyo Metropolitan Institute of Gerontology. We were given access to municipal resident registration files by the Itabashi ward authorities. The study was explained to all participants and all were advised that: 1) their participation would be entirely voluntary; 2) they could withdraw from the study at any time; and 3) if they chose not to participate or to withdraw, then they would not be disadvantaged in any way.

RESULTS

Table 1 lists the characteristics of members in the follow-up cohort (number of participants, age, proportion of women, number of years of education, proportion of living alone, presence of chronic diseases, experience of falls over one year, history of hospitalization over one

Table 1 - *Demographic, health and functional status of participants and non-participants in 2000 and vital status over a 3-year follow-up period.*

	Participants (n=438)	Non-participants (n=416)	p-value†
Age in 2001 (years)	74.2±3.9	75.2±4.2	<0.001
Gender (% women)	61.9	60.6	0.698
Number of years of education (years)	10.5±2.7	9.9±2.9	0.002
Living alone (% living alone)	17.1	18.3	0.661
Presence of chronic diseases (% present)*	41.8	51.2	0.007
Experience of falls over one year (% present)	19.2	18.7	0.873
History of hospitalization over one year (% present)	9.1	16.3	0.002
Self-rated health (% fair/poor)	20.6	29.0	0.005
Body Mass Index (Kg/m^2)	22.5±3.0	22.2±3.4	0.120
Instrumental activities of daily living (points)	11.5±1.8	10.3±3.0	<0.001
Subjective well-being (points)	12.3±3.4	11.6±3.9	0.009
Vital status:			
Death (% present)	3.9	14.7	<0.001
Drop-out (% present)	1.3	1.4	0.888

*Presence of chronic disease was defined as having at least one disease among cancer, diabetes, heart disease, stroke, and hypertension. †p-value refers to t-test for continuous variables and χ^2 test for categorical variables, testing differences in characteristics between two groups.

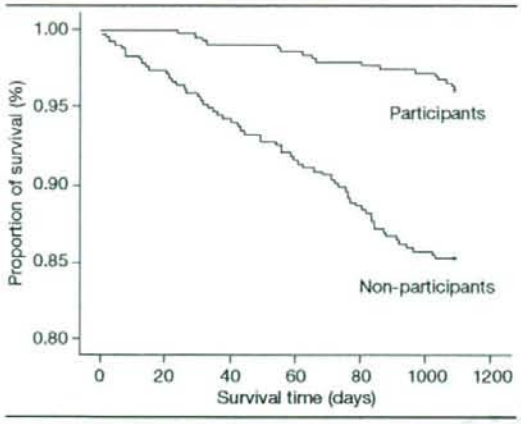

Fig. 1 - *Unadjusted Kaplan-Meier survival curves exploring difference in all-cause mortality between participants and non-participants in comprehensive health examination over a three-year follow-up period. Mortality risk was significantly lower for participants than non-participants (Log-rank test: p<0.001).*

year, self-rated health, BMI, IADL, and subjective well-being) collected from the two groups in 2000. We carried out a *t*-test for continuous measures and a χ^2 test for categorical measures, in order to clarify the difference in those characteristics between the two groups. Participants in the comprehensive health examination were younger ($p<0.001$) than non-participants, and had a higher education level ($p=0.002$), fewer chronic diseases ($p=0.007$), less hospitalization ($p=0.002$) and better self-rated health ($p=0.005$). Participants also were more likely to score better on IADL ($p<0.001$) and subjective well-being ($p=0.009$) than non-participants.

After three years, 78 of the 854 adults had died, i.e., 17 participants and 61 non-participants in the comprehensive health examination. Figure 1 shows the Kaplan-Meier survival curve ascertaining the relationship between status of participation in the health examination and all-cause mortality. The mortality risk was significantly lower for participants than for non-participants (Log-rank test: $p<0.001$).

Table 2 shows the associations between participation status in the comprehensive health examination, other factors, and all-cause mortality. In the unadjusted model, there was a significant inverse association between participation in the comprehensive health examination and all-cause mortality (RR=0.25, 95% CI= 0.14-0.42). In the adjusted model, there was a significant and independent inverse association between participation in the comprehensive health examination and all-cause mortality (RR=0.44, 95% CI= 0.24-0.78). Other factors such as age [RR= 1.08, 95% CI= 1.02-1.15], gender [RR (for women)=0.38, 95% CI= 0.23-0.64], self-rated health [RR (for fair/ poor)=1.91, 95% CI= 1.11-3.28] and IADL [RR (for a one-point increase)=0.88, 95% CI= 0.81-0.95] were also significantly and independently associated with mortality in the adjusted model.

DISCUSSION

Recent studies have revealed that there are critical differences between participants and non-participants in health examinations or health surveys for the elderly, both cross-sectionally and longitudinally (13-18, 21), and also large differences in survival between these groups (15, 16, 21). The present study examined mortality differences between participants and non-participants in a comprehensive health examination for prevention of geriatric syndromes among elderly people in the community over a three-year follow-up period, using a statistical technique designed to exclude any self-selection bias.

A significant and large difference in mortality between participants and non-participants in the comprehensive health examination was also observed in the adjusted model controlling for potential confounding factors. Our findings show that the mortality risk of participants in the comprehensive health examination is lower than that of non-participants, for which we suggest two possible explanations: 1) a self-selection bias may remain even after adjustment by the covariates in the statistical model; 2)

Table 2 - *Unadjusted and adjusted risk ratio of all-cause mortality associated with participation status in comprehensive health examination, participants' demographic, health, and functional status.*

Independent variable	Unadjusted	Adjusted*
Participation in comprehensive health examination in 2001 (for participants)	0.25 (0.14-0.42)†	0.44 (0.24-0.78)†
Age in 2001 (for one year)	1.17 (1.11-1.24)†	1.08 (1.02-1.15)†
Gender (for women)	0.48 (0.30-0.74)†	0.38 (0.23-0.64)†
Number of years of education (for one year)	0.89 (0.82-0.98)†	0.92 (0.84-1.01)
Living alone (for living alone)	0.76 (0.40-1.43)	1.01 (0.51-1.99)
Presence of chronic diseases (for present)	1.80 (1.14-2.83)†	1.27 (0.77-2.10)
Experience of falls over one year (for present)	0.70 (0.37-1.32)	0.76 (0.39-1.51)
History of hospitalization over one year (for present)	2.88 (1.76-4.72)†	1.47 (0.84-2.55)
Self-rated health (for fair/poor)	2.38 (1.52-3.73)†	1.91 (1.11-3.28)†
Body mass index (for 1 Kg/m^2)	0.89 (0.83-0.96)†	0.94 (0.87-1.02)
Instrumental activities of daily living (for 1 point)	0.79 (0.75-0.84)†	0.88 (0.81-0.95)†
Subjective well-being (for 1 point)	0.96 (0.91-1.02)	1.03 (0.97-1.11)

*Obtained from multivariate Cox's proportional hazard regression model adjusted for all other variables listed above. †Significantly different from 1.

there may be an intervention effect related to participation in the comprehensive health examination that results in a reduced mortality risk among participants.

It has been reported that a self-selection bias occurs in health examinations or health surveys both cross-sectionally and longitudinally, that is, the physical and psychological health status of participants is initially superior to that of non-participants (7, 13-18), participants are more likely to have desirable health behavior (18, 19) and, therefore, their survival time is likely to be longer than that of non-participants (15, 16, 20, 21). Hebert et al. reported that participants were more cognitively intact, less disabled in functional ability, and less depressed in mood state than non-participants in a postal questionnaire survey (15). Suzuki et al. showed that participants had much better dietary habits, which included higher intake of vegetables, carotene, vitamin C and dietary fiber, and had a lower prevalence of cigarette smoking than non-participants in cancer screening programs (19). Minder et al. showed that the mortality risk for participants during a five-year follow-up period was lower after controlling for potential confounders than that for non-participants in preventive home visit programs (21). In the present study, similar tendencies were observed; participants in the comprehensive health examination were younger than non-participants, had a higher level of education, fewer chronic diseases, less history of hospitalization and better self-rated health, and were more likely to have better scores on IADL and subjective well-being, than non-participants (see Table 1). These factors may affect the association between participation status in the comprehensive health examination and mortality and, therefore, explain the large difference in mortality between the two groups.

On the other hand, in an attempt to eliminate any self-selection bias, covariates were included in the multivariate model. After this adjustment, participation in the health examination had a significant association with all-cause mortality. This also suggests that interventions undertaken in response to the findings of a comprehensive health examination may reduce mortality risk among the elderly. We recommend that individuals who are judged to be especially frail according to the examination results should receive information on interventions via the community network, including health centers, clinics and hospitals. This process may affect longevity in participants. Further studies are needed to examine whether comprehensive health examination systems for the elderly reduce mortality risk and are beneficial in terms of better independence, health and longevity. Ideally, these studies should be conducted using randomized control trials that allow biases such as self-selection bias to be eliminated.

Our findings also highlight another crucial issue: non-participants include individuals who have a higher mortality risk and they require relatively urgent interventions. Minder et al. (21) found that individuals who refused to take part in an intervention trial because they considered themselves to be healthy had mortality rates during a five-year follow-up period which were similar to those of participants. However, those who were too ill to participate in the trial had a higher mortality risk than participants. Similarly, Ives et al. (16) found that individuals who refused to participate in a health survey had a similar mortality risk to participants during a three-year follow-up period, but individuals who did not respond to an invitation via telephone or mail to participate in the survey had a higher mortality risk than participants. Therefore, we also need to introduce new strategies such as home-visit surveys and in-home intervention trials to care for these higher-risk individuals (28-30), so that early detection and intervention for geriatric syndromes can be assessed more efficiently. We have been designing this kind of program for future studies.

The extent to which our findings can be generalized is limited for two reasons. First, non-participants in the present study include both individuals who refused to participate in the comprehensive health examination and those who did not respond to the invitation. It has been shown that the mortality risk for non-participating subjects in intervention trials depends on the self-reported reason for refusal (21). Second, the statistical power might not have been sufficient to exclude any self-selection bias. Since we used data from the final round of home-visit surveys in 2000 as covariates, instead of the data from the baseline in 2001, some covariates may have changed in the year from 2000 to 2001. Moreover, potential confounders like smoking, alcohol consumption and physical activity, were not used as covariates in analyzing for an independent association between participation in the health examination and mortality because, for practical reasons, the variables were not collected in 2000.

CONCLUSIONS

Our results suggest that there is a large difference in survival over a three-year period between participants and non-participants in a comprehensive health examination for prevention of geriatric syndromes among community-dwelling elderly people. This finding is probably caused by two factors: 1) a self-selection bias for participation in the trial, which was not eliminated by multivariate analysis; 2) an intervention effect associated with participation in the comprehensive health examination which reduces the mortality risk. Our finding also emphasizes another essential issue: non-participants include individuals who have a higher mortality risk and they require relatively urgent interventions. Therefore, we also need to introduce new strategies such as home-visit surveys and in-home intervention trials, to care for these higher-risk individuals, so that early detection and intervention for geriatric syndromes can be assessed more efficiently.

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