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地域在住高齢者の身体活動と
認知機能に関する縦断的研究

李 成喆

西田 裕紀子

金 興烈

幸 篤武

森 あさか

丹下 智香子

安藤 富士子

下方 浩史



日本未病システム学会


 発表研究
論文

地域在住高齢者の身体活動と 認知機能に関する縦断的研究

李 成喆¹⁾ 西田 裕紀子¹⁾ 金 興烈^{1,2)} 幸 篤武¹⁾ 森 あさか¹⁾
丹下 智香子¹⁾ 安藤 富士子^{1,3)} 下方 浩史¹⁾

1. 緒言

老年期の認知症は発症後の治療が非常に困難であり、予防に努めることが重要であると考えられる。認知症の発症および進行を遅らせる有効な予防法があれば、認知症高齢者の生活の質 (quality of life : QOL) の改善、自立した生活の継続、また経済的社会的負担の軽減などの効果をもたらすことが予想される。

身体活動や運動は、高齢者にとって、健康の維持に必要なものであり、身体機能の改善をもたらすだけでなく、認知機能や脳機能低下の予防の手段として、その適用が期待されており、運動や余暇活動に注目した研究が数多くされてきた¹⁻⁸⁾。しかし、日常身体活動には運動や余暇活動だけでなく家事・仕事身体活動も含まれているため、それらの要因を考慮した検討が必要とされる。日常の身体活動の内容は男女で異なり、加齢によるその内容の変化にも性差があると考えられる。

仕事身体活動と認知機能との関連についてこれまでの研究は、関連があるとする報告⁹⁾ やないとする報告¹⁰⁾ に分かれているが、いずれも家事のような家庭内の身体活動が含まれてないか、性差に注目した検討は行われていない。

そこで、本研究では地域在住の60歳以上の男女を対象とした縦断的検討により、認知機能と余暇および家事・仕事身体活動との関連について性差による検討を行った。

2. 方法

1) 対象

対象者は、「国立長寿医療研究センター・老化に関する長期縦断疫学研究 (NILS-LSA : National Institute for Longevity Sciences -Longitudinal Study of Aging)」¹¹⁾ の第2次調査 (2000～2002) および6年後の第5次調査 (2006～2008) に共に参加した60～81歳の男女のうち、第2次調査のMMSE得点が28点以上の668人 (男:339人、女:329人、平均67.9±5.5歳) である。NILS-LSAは愛知県大府市 (人口約70,000人) および知多郡東浦町 (人口約40,000人) の地域住民を対象とした老化と老年病に関する縦断的コホート研究である。本研究の参加者は、年齢別・性別に層化無作為抽出されている。

本研究は国立長寿医療研究センターにおける倫理委員会の下に参加者に対して事前に調査・検査内容とその意義についての説明を行い、調査への参加の文書による同意 (informed consent) の得られた者を対象として行われている。

2) 測定項目

(1) 身体活動

過去1年間の身体活動内容は質問紙¹²⁾ を用いて、専門スタッフの聞き取り形式によって調査した。対象者の1日の生活状況を把握する上で、1週間あたりの身体活

1) (独) 国立長寿医療研究センター予防開発部 2) 東海学園大学人間健康学部 3) 愛知淑徳大学健康医療科学部

動を2ヶ月ごとにまとめ、最終的には1年にわたる余暇、家事・仕事身体活動時間（家事の時間+仕事の時間）を強度別に把握した。まず、2.5 Mets 以上の余暇身体活動時間と2.5 Mets 以上の家事・仕事身体活動時間を算出し、この合計を2.5 Mets 以上の総身体活動時間とした。さらに4.5 Mets 以上の総身体活動時間についても同様にして求めた。

(2) 認知機能

認知機能評価はMMSE (Mini-Mental State Examination)¹³⁾を用いた。認知機能の低下の判断基準としてcut-off pointは27/28とした¹⁴⁾。MMSE検査は主に記憶力、計算力、言語力、見当識（現在の日時や、自分がどこにいるかなどの状況把握力）を測定するためのテストである。

(3) 統計解析

各変数の測定結果は平均±値標準偏差で示した。連続変数の群間比較にはt検定を、カテゴリ変数の群間比較には χ^2 検定を用いた。また、第5次調査時MMSE得点の27点以下への低下の有無を目的変数とし、説明

変数は第2次調査時の2.5 Mets 以上の総身体活動時間、4.5 Mets 以上の総身体活動時間、2.5 Mets 以上の余暇身体活動時間、2.5 Mets 以上の家事・仕事身体活動時間を2分位で上位群、下位群に分け、それぞれの影響について多重ロジスティック回帰分析を用いて性別に検討した。調整因子は、第2次調査時の年齢、糖尿病、狭心症・心筋梗塞、高脂血症、脳卒中既往、慢性関節リウマチの既往歴の有無、BMI、教育年数とした。統計処理はSAS ver 9.1.3を利用し、有意水準は $p < 0.05$ とした。

3. 結果

本研究の結果、第2次調査時の対象者の特性を男女別に表1に示した。2.5 Mets 以上の余暇身体活動時間は男性の方が有意に高かった。一方、2.5 Mets 以上の総身体活動時間や2.5 Mets 以上の家事・仕事身体活動時間においては女性の方が高い値を示した。4.5 Mets 以上の総身体活動時間には有意な性差は認められなかった（表1）。

図表1 対象者の特性

	男性 (n= 339)	女性 (n= 329)	p
	Mean ± SD	Mean ± SD	
年齢	67.5 ± 5.4	68.2 ± 5.6	0.099
BMI	22.9 ± 2.6	22.8 ± 2.9	0.419
MMSE	28.2 ± 1.6	28.3 ± 1.7	0.322
教育年数 (年)	11.7 ± 2.8	10.5 ± 2.2	<0.0001
身体活動時間 (分/日)			
2.5Mets 以上			
総身体活動時間 (分/日)	149.9 ± 110.7	222.7 ± 104.9	<0.0001
余暇身体活動時間 (分/日)	48.9 ± 49.1	30.2 ± 40.7	<0.0001
家事・仕事身体活動時間 (分/日)	101.0 ± 112.4	192.5 ± 104.1	<0.0001
4.5Mets 以上			
総身体活動時間 (分/日)	35.7 ± 55.2	28.6 ± 44.0	0.069
既往歴 (%)			
高血圧	114 (33.6)	118 (36.1)	0.506
狭心症・心筋梗塞	26 (7.7)	27 (8.3)	0.788
高脂血症	54 (16.0)	88 (26.9)	0.001
糖尿病	37 (10.9)	18 (5.5)	0.011
脳卒中	19 (5.6)	8 (2.5)	0.040
慢性関節リウマチ	29 (8.6)	60 (18.4)	0.000

性差の検定は、連続変数の場合はt検定を、カテゴリ変数の場合は χ^2 検定を用いた。2.5Mets 以上の総身体活動時間 = 2.5Mets 以上の余暇身体活動時間 + 2.5Mets 以上の家事・仕事身体活動時間。

追跡期間中 MMSE 得点が 27 点以下に低下した人は、男性 82 (24.9%) 人、女性 76 (22.4%) 人であった。また、ロジスティック回帰分析の結果では、女性の場合、家事・仕事身体活動時間が上位群 (毎日 150 分以上) に比べ下位群 (毎日 150 分未満) の方が MMSE 得点の 27 点以下への低下リスクが約 2 倍であった (オッズ比: 1.878, 95%信頼区間: 1.022-3.452, $p=0.0423$)。しかし、2.5Mets 以上の総身体活動時間や 2.5Mets 以上の余暇身体活動時間および 4.5Mets 以上の総身体活動時間は MMSE 得点の 27 点以下への低下と関連は認められなかった。また、男性の場合ほどの項目においても有意な関連が認められなかった (表 2)。

4. 考察

本研究では、無作為抽出された地域在住中高年者を

対象として 2.5 Mets 以上の総身体活動時間を 4.5 Mets 以上の身体活動時間、2.5 Mets 以上の余暇や家事・仕事身体活動時間に分け、それぞれ認知機能との関連について検討を行った。その結果、2.5 Mets 以上の家事・仕事身体活動時間が毎日 150 分未満である女性は、認知機能の低下するリスクが約 2 倍となり、普段から家事を含めた仕事身体活動量を一定に保つことは認知機能低下の予防に繋がる可能性が示唆された。

近年、毎日の雑用や介護などで多くのエネルギーを消費している高齢者は、加齢による認知機能低下が生じにくいことが明らかになった¹⁵⁾。運動と思わずに行っていることでも、心拍数を上げ、血流を増加させる効果があるとしている。また、正式な運動プログラムが優れていることには変わりはないが、残りの時間の活動の重要性を見逃してはならないと指摘している。本研究におい

図表 2 MMSE の得点と身体活動との関連

項目	n (%)	オッズ比	95% 信頼区間	p	
男性					
2.5Mets 以上					
総身体活動時間	下位群	168 (49.6)	0.981	0.550 - 1.749	0.948
	上位群	171 (50.4)	1	Referent	
余暇身体活動時間	下位群	167 (50.6)	1.263	0.699 - 2.282	0.440
	上位群	163 (49.4)	1	Referent	
仕事身体活動時間	下位群	169 (50.6)	0.652	0.362 - 1.174	0.154
	上位群	165 (49.4)	1	Referent	
4.5Mets 以上					
総身体活動時間	下位群	166 (49.4)	1.024	0.578 - 1.816	0.935
	上位群	170 (50.6)	1	Referent	
女性					
2.5Mets 以上					
総身体活動時間	下位群	156 (48.5)	1.01	0.550 - 1.856	0.974
	上位群	166 (51.5)	1	Referent	
余暇身体活動時間	下位群	160 (50.0)	1.032	0.575 - 1.853	0.917
	上位群	160 (50.0)	1	Referent	
仕事身体活動時間	下位群	158 (49.2)	1.878	1.022 - 3.452	0.042
	上位群	163 (50.8)	1	Referent	
4.5Mets 以上					
総身体活動時間	下位群	161 (50.2)	1.476	0.819 - 2.659	0.195
	上位群	160 (49.8)	1	Referent	

解析方法: 各身体活動は上位群、下位群の 2 分位によってカテゴリー化した。年齢、既往歴、(高血圧、狭心症・心筋梗塞、高脂血症、糖尿病、脳卒中、慢性関節リウマチ)、教育年数を調整したロジスティック回帰分析を用いた。

て女性で、家事を含めた仕事身体活動時間と認知機能との関連が認められたことは、余暇活動の時間が短くても家事などで2.5 Mets以上の身体活動時間を維持することで多くのエネルギーを消費し、認知機能低下を予防できる可能性が示唆されたと考えられる。

一方、Rovioらの報告¹⁰⁾では、認知機能の低下は仕事身体活動との関連は認められず余暇身体活動との関連について認めている。その原因として、退職後の身体活動内容の変化や仕事の機械化による仕事身体活動の強度が低いことを指摘している。本研究において男性の場合、仕事身体活動と認知機能低下との関連が認められなかったのは先行研究と同じ原因が考えられる。

身体活動の内容は性差を含め加齢にもなってその内容が変化し、生活に現れるそれぞれの身体活動が示す割合も変わっていく。そのため、それらの要因を考慮し、認知機能のどの側面と関連しているかについてさらなる検討が望まれる。

5. 結論

地域在住の60歳以上の男女を対象とし縦断的研究により、認知機能と家事・仕事身体活動および余暇身体活動との関連について検討した。2.5 Mets以上の家事・仕事身体活動時間が毎日150分未満の女性高齢者は、150分以上である女性高齢者と比べて認知機能の低下するリスクが約2倍であった。

謝辞

本研究の発表に際し「国立長寿医療研究センター・老化に関する長期縦断疫学研究 (NILS-LSA)」に参加いただいている愛知県大府市ならびに東浦町の住民の皆様、および調査スタッフに感謝いたします。

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成人後期における日常生活活動能力と主観的幸福感の関連に認知機能が及ぼす影響

丹下 智香子¹⁾ 西田 裕紀子¹⁾ 富田 真紀子^{1,2)} 安藤 富士子^{1,3)} 下方 浩史¹⁾

1. 緒言

高齢化率が増加し続けている我が国においては、高齢者のサクセスフル・エイジングをサポートすることは社会の重要な課題であると考えられる。このサクセスフル・エイジングの心理的側面である「主観的幸福感」を扱った研究では、日常生活活動能力の低さが主観的幸福感の低さに関連することや、その傾向に年代差が存在する可能性などが指摘されている¹⁾。一般的に活動能力は加齢とともに低下するため、それにより生ずる主観的幸福感の低下を防ぐ緩衝要因（あるいは相乗的に主観的幸福感を低下させる可能性のある要因）の解明が必要であると考えられる。そこで本研究ではその要因として認知機能を取り上げて、成人後期における日常生活活動能力と主観的幸福感の関連に対して、認知機能が及ぼす影響を明らかにすることを目的とした。

2. 方法

1) 対象

「国立長寿医療研究センター・老化に関する長期縦断疫学研究 (NILS-LSA : National Institute for Longevity Sciences - Longitudinal Study of Aging)」²⁾ の第3次調査 (2002年5月～2004年6月)・第4次調査 (2004年6月～2006年7月)・第5次調査 (2006年7月～2008

年7月)・第6次調査 (2008年7月～2010年7月)のいずれかに参加した60歳以上の1851名 (男性920名、女性931名、平均2.7回参加) を分析対象とした。対象者の参加時点での年齢は60～89歳に分布し、平均年齢は70.7歳 (SD=6.8) であった。

なお、NILS-LSAは性および年代ごとに層化無作為抽出された地域住民を対象とした研究で、約2年ごとに追跡調査を行っている。すべての調査・検査内容は国立長寿医療研究センターの倫理委員会の承認を得ており、参加者に対しては事前に調査・検査内容とその継続の意義を説明し、文書による同意を得ている。

2) 調査内容

下記の (a), (b), (c) を含む自記式質問紙調査、および (d) を含む面接調査を第3次～第6次調査で施行した。

(a) LSI-K

主観的幸福感の肯定的側面の測定尺度として生活満足度尺度 K (Life Satisfaction Index K)³⁾ を施行した。この尺度は9項目から成り、得点可能範囲は0～9点であった。

(b) CES-D

主観的幸福感の否定的側面の測定尺度としてうつ病の疫学研究用の自己評価尺度 (Center for Epidemiologic Studies Depression Scale の日本語版)^{4,5)}

1) (独) 国立長寿医療研究センター予防開発部 2) 名古屋大学大学院教育発達科学研究科 3) 愛知淑徳大学健康医療科学部

を施行した。この尺度は20項目から成り、得点可能範囲は0～60点であった。

(c) ADL

日常生活活動能力の測定尺度として、「手段的自立」、「知的能動性」、「社会的役割」の3側面から総合的な活動能力を査定する老研式活動能力指標⁶⁾を施行した。この尺度は13項目から成り、得点可能範囲は0～13点であった。

(d) MMSE

認知機能を査定するために、Mini Mental State Examination^{7,8)}を施行した。この尺度は「見当識」、「記銘」、「注意と計算」、「再生」、「言語」の5領域(11項目)から成り、得点可能範囲は0～30点であった。

3) 解析

男女別に、LSI-KおよびCES-Dを従属変数とした線型混合モデルによる解析を行った(一次自己回帰を設定、測定時期を調整)。説明変数としてMMSE、ADL、年代(参加時点の年齢により60歳代/70歳代/80歳代と

した)の主効果、およびこれらの1次・2次の交互作用項を投入した。なお、解析にはSAS 9.1.3を用いた。

3. 結果

解析の結果を表1に示す。本研究はADLと主観的幸福感の関連に対するMMSEの効果の検討が目的であるため、MMSEとADLの交互作用を含む項(MMSE×ADL、およびMMSE×ADL×年代の交互作用項)の効果に注目した。

まず、男性ではLSI-KにおけるMMSE×ADL×年代の交互作用が有意であった($p<0.05$)。そこで、年代別にMMSE30点/25点(平均±1SDに近い値を選定)それぞれでのADLに対するLSI-Kの傾きの推定およびその差の検定を行ったところ(図1-a)、60歳代でMMSE30点(傾き推定値=0.03、 $t=0.44$, *n.s.*)と25点(傾き推定値=0.19、 $t=3.12$, $p<0.01$)間で傾きの差の有意傾向が示された($t=-1.88$, $p<0.10$)。70歳代(MMSE30点の傾き推定値=0.32、 $t=5.79$, $p<0.001$ 、MMSE25点の傾

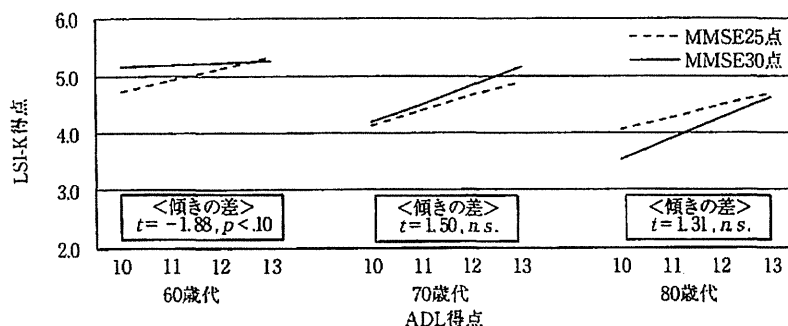


図1-a 男性：ADL得点とMMSE得点から推計されたLSI-K得点(年代別)

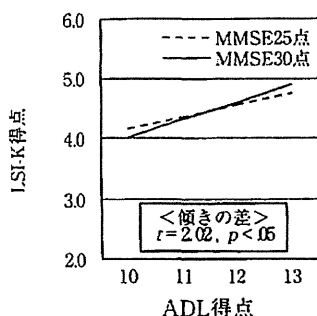


図1-b 女性：ADL得点とMMSE得点から推計されたLSI-K得点

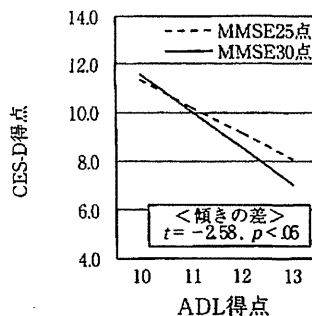


図1-c 女性：ADL得点とMMSE得点から推計されたCES-D得点

図表 1 線型混合モデルによる解析結果

固定効果の検定: F 値						
変動因	LSI-K		CES-D			
	男性	女性	男性	女性		
MMSE	0.09	3.93	0.05	5.55		
ADL	0.24	1.13	0.25	1.36		
年代	2.66	1.16	1.60	2.41		
MMSE × ADL	0.11	4.08	0.40	6.66		
MMSE × 年代	3.56	1.04	2.09	3.21		
ADL × 年代	2.60	0.70	1.84	1.41		
MMSE × ADL × 年代	3.33	0.73	2.33	2.06		

固定効果の解の推定値 (SE)						
変動因	LSI-K		CES-D			
	男性	女性	男性	女性		
切片	12.66 (7.26)	4.74 (4.89)	43.03 (25.25)	30.83 (17.89)		
MMSE	-0.42 (0.28)	-0.10 (0.19)	-0.93 (0.97)	-0.48 (0.69)		
ADL	-0.57 (0.63)	-0.10 (0.45)	-2.52 (2.19)	-1.13 (1.64)		
年代	60 歳代	-20.13 (9.32)	9.14 (7.80)	-30.54 (32.49)	-56.49 (28.02)	
	70 歳代	-8.08 (7.62)	-0.72 (5.53)	-45.55 (26.48)	-37.93 (20.29)	
	80 歳代	0	0	0	0	
MMSE × ADL	0.03 (0.02)	0.01 (0.02)	0.06 (0.08)	0.01 (0.06)		
MMSE × 年代	60 歳代	0.84 (0.35)	-0.34 (0.29)	1.15 (1.22)	2.29 (1.05)	
	70 歳代	0.31 (0.29)	0.01 (0.21)	1.94 (1.02)	1.82 (0.78)	
	80 歳代	0	0	0	0	
ADL × 年代	60 歳代	1.60 (0.80)	-0.55 (0.67)	2.13 (2.78)	3.83 (2.43)	
	70 歳代	0.52 (0.66)	0.10 (0.50)	3.99 (2.29)	2.60 (1.83)	
	80 歳代	0	0	0	0	
MMSE × ADL × 年代	60 歳代	-0.06 (0.03)	0.02 (0.03)	-0.08 (0.10)	-0.16 (0.09)	
	70 歳代	-0.02 (0.03)	-0.00 (0.02)	-0.17 (0.09)	-0.13 (0.07)	
	80 歳代	0	0	0	0	

注: 測定時期で調整. * $p < 0.05$

き推定値 = 0.26, $t = 6.33$, $p < 0.001$) および 80 歳代 (MMSE30 点の傾き推定値 = 0.37, $t = 3.18$, $p < 0.01$, MMSE25 点の傾き推定値 = 0.21, $t = 2.85$, $p < 0.01$) ではそれぞれの傾きは有意であったものの, MMSE30 点 / 25 点間での傾きの差は有意ではなかった。

次に, 女性では LSI-K, および CES-D における MMSE × ADL の交互作用が有意であったため (いずれも $p < 0.05$), MMSE30 点 / 25 点それぞれでの ADL に対する LSI-K, CES-D の傾きの推定およびその差の検定を行った。LSI-K については, MMSE30 点 (傾き推定値 = 0.29, $t = 6.13$, $p < 0.001$) と 25 点 (傾き推定値 = 0.20,

$t = 5.33$, $p < 0.001$) 間で傾きの有意差が示された ($t = 2.02$, $p < 0.05$: 図 1-b)。CES-D については, MMSE30 点 (傾き推定値 = -1.51, $t = -8.87$, $p < 0.001$) と 25 点 (傾き推定値 = -1.09, $t = -8.28$, $p < 0.001$) 間で傾きの有意差が示された ($t = -2.58$, $p < 0.05$: 図 1-c)。

4. 考察

まず男性では, 日常生活活動能力と主観的幸福感の関連に対して認知機能が及ぼす影響には年代による差異があることが示唆された。60 歳代で高い認知機能を保

持する場合には活動能力の高低にかかわらず主観的幸福感が高いのに対し、認知機能がやや低い場合には年長の世代と同様に、活動能力の低下とともに主観的幸福感も低下する可能性が示された。すなわち、この年代においては高い認知機能が、活動能力の低下に伴い主観的幸福感の低下が生ずることに対する緩衝要因となる可能性が示唆されたといえよう。

他方、女性では基本的に活動能力が高ければ主観的幸福感も高いが、その関係は認知機能の影響を受けることが示された。すなわち、認知機能が高い場合の方が活動能力の低下に伴う主観的幸福感の低下が顕著であり、認知機能と活動能力が両方高ければ認知機能がやや低い場合よりも主観的幸福感が高いものの、活動能力がやや低下すると認知機能が低い場合と同程度まで主観的幸福感が低下することが示唆された。

これらのことから、一般的に加齢とともに生ずる日常生活活動能力の低下は主観的幸福感を低下させる方向で影響を与えるが、その際、認知機能の高低が年代や性別により異なる形で関与する可能性が示唆されたといえよう。

【付記】

本研究の一部は平成23年度科学研究費補助金（若手（B））「サクセスフル・エイジングの心理的側面への直接影響要因およびその緩衝要因の解明（課題番号21730540）」、平成23年度長寿医療研究開発費「老化及び老年病に関する長期縦断疫学研究（課題番号23-33）」により行われた。

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Regular exercise history as a predictor of exercise in community-dwelling older Japanese people

Rumi Kozakai^{1,2*}, Fujiko Ando^{2,3}, Heung Youl Kim^{2,4}, Taina Rantanen¹ and Hiroshi Shimokata²

¹*Gerontology Research Center, University of Jyväskylä, P.O. Box 35 (Viveca), Jyväskylä, FIN-40014, Finland*

²*Department for Development of Preventive Medicine, National Center for Geriatrics and Gerontology, 35 Gengo, Morioka-cho, Obu, Aichi, 474-8511, Japan*

³*Faculty of Health and Medical Sciences, Aichi Shukutoku University, 9, Katahira, Nagakute, Aichi, 480-1197, Japan*

⁴*Department of Sport and Health Science, Tokai Gakuen University, 21-233, Nishinohora, Ukigai-cho, Miyoshi, Aichi, 470-0207, Japan*

Received: November 1, 2011 / Accepted: February 6, 2012

Published by
The Japanese Society of Physical Fitness and Sports Medicine

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Rumi Kozakai^{1,2*}, Fujiko Ando^{2,3}, Heung Youl Kim^{2,4}, Taina Rantanen¹ and Hiroshi Shimokata²

¹ Gerontology Research Center, University of Jyväskylä, P.O. Box 35 (Viveca), Jyväskylä, FIN-40014, Finland

² Department for Development of Preventive Medicine, National Center for Geriatrics and Gerontology, 35 Gengo, Morioka-cho, Obu, Aichi, 474-8511, Japan

³ Faculty of Health and Medical Sciences, Aichi Shukutoku University, 9, Katahira, Nagakute, Aichi, 480-1197, Japan

⁴ Department of Sport and Health Science, Tokai Gakuen University, 21-233, Nishinohora, Ukigai-cho, Miyoshi, Aichi, 470-0207, Japan

Received: November 1, 2011 / Accepted: February 6, 2012

Abstract A physically active lifestyle is important across the entire life span. However, little is known about life-long participation in regular exercise among older people. The purpose of the present study was to describe regular exercise throughout a person's lifetime and evaluate the impact of exercise earlier in life on participation in exercise at age 60 and over. The participants were 984 community-dwelling older people aged 60 to 86 years. Each participant's life was divided into five age categories: 12-19, 20-29, 30-39, 40-59, and 60 years and over. The association between exercise at an earlier age and that at 60 years and over was assessed using logistic regression analysis adjusted for potential confounders. Men had exercised throughout their lives more than women. Among women, participation in exercise during their 20s and 30s showed a sharp decline. The preference for exercise differed according to age and gender. Among men, the most common patterns of exercise throughout life were exercise during all the age categories, and starting exercise at age 60 and over; whereas in women the most common pattern was no exercise at all. The adjusted odds ratio of exercise at 40-59 years for exercise at age 60 and over was 5.85 (95% confidence interval: 3.82-8.96) among men and 6.89 (4.23-11.23) among women. Regular exercise in the younger age categories affected exercise at age 60 and over among men, but not among women. Regular exercise at 40-59 years was a strong predictor of exercise at 60 years and over in both men and women.

Keywords : regular exercise, older people, life course, random sampling data

Introduction

Physical activity is an important health behavior across the course of one's life. The benefits of physical activity in preventing health decline and physical function loss have been demonstrated, especially for frail and aged people¹. The Ministry of Education, Culture, Sports, Science and Technology in Japan reported that the participation rate of older people in physical activity and fitness has slightly increased in the past decade^{2,3}. However, more than 40 % of older people aged 70 years and older did not participate in any exercise during the past year⁴. Insufficient physical activity remains a public health concern among older people in Japan.

Engaging in sports activities in childhood and adolescence is known to predict physical activity in adulthood⁵. A low level of physical activity in early life has been found to predict physical inactivity in adulthood⁶. However,

most longitudinal studies have demonstrated that sports activities in early life have an effect on physical activity in young adulthood^{5,6}. It remains unclear whether sports activities in early life are associated with physical activity at an older age. Some studies have found that a history of physical activity was associated with current physical activity in older people^{7,8}. In an earlier study we found that the experience of exercise in adolescence was associated with a higher level of leisure-time physical activity in middle-aged and elderly Japanese women⁹. However, little basic descriptive data exists on individual variation in participation in exercise throughout the life span and the impacts of early exercise on physical activity in later life among community-dwelling Japanese older people.

The purpose of the present study was to describe regular exercise throughout the life course and evaluate the effect of early exercise on the participation in exercise at the age of 60 years and over.

*Corresponding author. kozakai@ncgg.go.jp

Methods

Study population. The investigation is a part of the 4th survey of the National Institute for Longevity Sciences - Longitudinal Study of Aging (NILS-LSA), which is a follow-up study on the causes of geriatric diseases and health problems in older people. The NILS-LSA was based on data obtained from interviews and laboratory examinations of medical, nutritional, psychological, and physical fitness variables. The details of the study can be found elsewhere¹⁰. The initial survey of the NILS-LSA involved 2,267 men and women aged 40-79 years, including almost 300 men and 300 women for each decade (40s, 50s, 60s and 70s). The participants were gender- and decade age-stratified random samples of the residents of Obu-shi and Higashiura-cho, Aichi Prefecture, in central Japan. The participants were drawn from resident registrations in cooperation with local governments. All subjects lived or had lived at home in the community. The participants in the present study comprised 523 men and 461 women aged 60-86 years. All the NILS-LSA procedures were already approved by the Ethical Committee of the National Center for Geriatrics and Gerontology, and all of the participants signed a written informed consent.

Measures and Procedures. Regular exercise was assessed using a questionnaire and an interview. The questionnaire was based on a questionnaire developed by the Japanese Lifestyle Monitoring Group¹¹. The participants were asked for the type, time, frequency and duration of their regular exercise from the age of 12 years to the present with the question "What physical activities or sports have you participated in during these age categories?" The participants reported the types of physical activities and sports they had engaged in from a list of alternatives. These were coded as 1) light activities such as walking, gymnastic exercise and gardening, 2) moderate activities such as brisk walking, dancing and swimming for pleasure, 3) vigorous activities with increased breathing and sweating such as jogging and playing tennis, 4) exhausting activities such as various competitive sports. Frequency of participation was defined as how often they participated in physical activities or sports per week. The duration of each activity was calculated with 1 year as the basic unit. Physical activities or sports that were engaged in for at least 20 minutes, once a week and over 1 year, excluding physical education at school, were defined as regular exercise. Life span was divided into five age categories: 12-19, 20-29, 30-39, 40-59 and 60 years and over. The age categories of 40 and over included more years with reference to previous studies^{7,8}, showing physical activity to be stable in middle age¹².

If participants engaged in a number of regular exercises during the same period, the exercise with the longer duration was selected. Interviews were performed by trained staff.

Potential confounders, included age, education, marital

status (never married, married, separated, divorced and be-reaved), annual income (6,500,000 yen or less vs. more than 6,500,000 yen) and chronic conditions including smoking status (never, former and current), self-rated health (excellent, very good, good, fair and poor) and prevalent diseases (hypertension, ischemic heart disease, diabetes, osteoporosis, arthritis and cancer), were investigated using a questionnaire and interview by a physician. Height and weight were measured using a digital scale. Body mass index was calculated by weight divided by height squared (BMI; kg/m²). Body fat mass was assessed by dual X-ray absorptiometry (DXA; QDR-4500A, Hologic, USA). Work-related physical activity was estimated using the same questionnaire developed by the Japanese Lifestyle Monitoring Group¹¹. Work activities were assigned an intensity coefficient of 1.5, 2.5, 4.5 and 7.5 METs (metabolic equivalents) for sedentary work, work done standing or walking, moderately strenuous work and strenuous work, respectively. The work activity scores were calculated by multiplying the intensity coefficients by the total number of minutes spent on the activity over the last 12 months.

Statistical analysis. The statistical significance of the differences in social and health conditions were analyzed by the Cochran-Mantel-Haenszel test for categorical variables and Student's t-test for continuous variables according to participation in regular exercise at age 60 and over. The participation rate in regular exercise was calculated as the percentage of participants who engaged in exercise in each age category. Gender differences in the participation rate in each age category were analyzed using Pearson's chi-squared test. The relationship between regular exercise in the younger age categories and at age 60 and over was evaluated using multiple logistic regression analysis. Both the unadjusted model and the model adjusted for all potential confounders were analyzed. The analyses were performed for men and women separately, as the gender difference in the participation rate in regular exercise was considerable. Statistical testing was performed using the Statistical Analysis System (SAS), release 9.1.3 (SAS Institute Inc. NC, USA). Probability levels of less than 0.05 were considered to be significant.

Results

Table 1 shows the characteristics of the participants by gender according to participation in regular exercise at age 60 and over. The mean age of the study population was 70.0±6.6 years in men and 69.8±6.7 years in women. Age, weight, BMI, annual income, work-related physical activity, smoking, self-rated health, hypertension and arthritis for men; and height, education, work-related physical activity for women were associated with regular exercise at age 60 and over (p<0.05).

The participation rates in regular exercise for age categories 12-19, 20-29, 30-39, 40-59 and 60 years and over

Table 1. Characteristics of the participants according to regular exercise at age 60 and over for men and women

		Men		<i>p</i> -value	Women		<i>p</i> -value
		Regular exercise			Regular exercise		
		Yes n=342	No n=181		Yes n=263	No n=193	
Age	years	70.4 ± 6.3	69.2 ± 7.2	0.048	69.7 ± 6.4	70.2 ± 7.0	0.503
Height	cm	163.6 ± 5.7	162.7 ± 5.9	0.108	150.5 ± 5.6	149.1 ± 6.2	0.010
Weight	kg	62.3 ± 9.0	59.2 ± 8.3	<0.001	51.8 ± 7.7	51.7 ± 8.7	0.829
BMI	kg/m ²	23.3 ± 2.8	22.3 ± 2.8	<0.001	22.9 ± 3.0	23.2 ± 3.4	0.246
Body fat	%	22.9 ± 4.4	22.5 ± 4.6	0.395	32.4 ± 5.1	32.6 ± 5.5	0.688
Education	years	11.9 ± 2.9	11.7 ± 3.0	0.513	11.1 ± 2.3	10.6 ± 2.5	0.033
Marital status	%			0.097			0.295
Never		0.0	2.2		3.1	3.7	
Married		94.4	91.2		71.7	64.0	
Separation		0.6	0.6		0.4	0.0	
Divorce		0.6	0.6		1.9	4.2	
Bereavement		4.5	5.5		23.0	28.0	
Annual income	%						
6,500,000 yen and higher		24.8	35.2	0.013	25.8	29.4	0.401
Work-related physical activity	METs*min* 10 ⁻³	130.8 ± 135.9	170.7 ± 151.7	0.002	183.0 ± 85.5	206.8 ± 109.0	0.010
Smoking	%			<0.001			0.910
Never		24.8	20.3		93.9	94.2	
Former		58.1	47.3		2.3	2.6	
Current		17.1	32.4		3.8	3.1	
Self-rated health	%			0.001			0.287
Excellent		6.5	0.6		3.8	5.2	
Very good		33.3	24.7		21.7	15.6	
Good		52.2	63.2		65.0	66.2	
Fair		7.7	9.9		9.1	12.5	
Poor		0.3	0.6		0.4	0.5	
Prevalent diseases	%						
Hypertension		44.5	31.3	0.003	40.7	41.2	0.921
Ischemic heart diseases		6.2	9.3	0.188	7.2	6.8	0.852
Diabetes		11.5	11.0	0.860	7.2	5.2	0.385
Osteoporosis		1.2	3.3	0.093	16.4	17.2	0.827
Arthritis		4.4	11.5	0.002	11.8	17.2	0.102
Cancer		6.2	6.6	0.859	5.7	9.4	0.136

Continuous variables are presented as means ± standard deviation (SD), and categorical variables are presented as percentages. The differences between groups were analyzed by Student's t-test for continuous variables and by Cochran-Mantel-Haenszel test for categorical variables. Bold represents significant p-value (<0.05). BMI, Body mass index. METs, Metabolic equivalents

are shown Table 2. The percentage of men who had regular exercise was significantly higher than that of women in all of the age categories (*p*<0.05), except for 40-59 years. Among women, a large drop in the percentage reporting participation in exercise was found during the ages of 20-29 and 30-39 years.

The popular type of exercise reported for the different age categories is presented in Tables 3a and 3b. The most popular activities and sports differed both by gender and

by age category. Men frequently reported team sports such as baseball and softball up to 40-59 years of age. In women, volleyball was frequently reported up to 30-39 years of age, while dancing and gymnastics exercise were more likely to be reported among those over 20 years of age. At age 60 and over, walking was the most popular exercise among both men and women.

All the possible patterns of participation in regular exercise from age 12 to the present were examined. Thirty-two

different patterns were identified (Figure 1). In men, the most common patterns were participation in regular exercise during all the age categories (12.6%) and participation in regular exercise at age 60 and over (12.6%). In women, the most common pattern was no regular exercise in any age category (21.1%), followed by participation in regular exercise at age 40 and over (14.3%).

Table 4 shows that participating in regular exercise at age 60 and over is related to participation in regular exercise across one's life span. The participants who had exercised at younger age categories were more likely to participate in exercise at age 60 and over for both men and women.

The odds ratios (OR) and 95% confidence intervals (CI) for those who regularly exercised at age 60 and over are shown in Table 5. Although, among men, the results of the unadjusted model for the age category 12-19 years

was of borderline statistical significance (OR1.42, 95% CI 0.99-2.05), the odds ratio for participating in exercise at age 60 and over was higher for men who had regular exercise during each age category. The highest odds ratio was 4.63 (95%CI 3.07-6.98) among men who had regular exercise at 40-59 years. In women, regular exercise in the earlier age categories did not correlate with exercise at age 60 and over. However, the odds ratio for participating in exercise at age 60 and over was about six times higher among those who had regular exercise at 40-59 years (OR 5.85, 95%CI 3.82-8.96). After adjusting for age (continuous variable), BMI (continuous variable), education (continuous variable), annual income (6,500,000 yen or less/more than 6,500,000 yen), work-related physical activity (1SD), smoking (never/ former/ current), self-rated health (excellent/ very good/ good/ fair/ poor) and chronic diseases (Yes/ No), the associations remained in both men and women. Regular exercise at 40-59 years was strongly associated with exercise at age 60 and over in both men (OR 5.96, 95%CI 3.72-9.57) and women (OR 6.89, 95%CI 4.23-11.23).

Table 2. Participation rate in regular exercise across the life course

age (years)	Men (n=523)		Women (n=461)		p - value
	n	%	n	%	
12-19	311	59.5	198	43.0	<0.001
20-29	173	33.1	29	6.3	<0.001
30-39	155	29.8	62	13.5	<0.001
40-59	233	44.6	203	44.0	0.871
60 and over	342	65.4	263	57.1	<0.001

Numbers and percentages are shown for those who participated in regular exercise divided into five age categories. Pearson's chi-squared test. df=1.

Discussion

The present study described regular exercise throughout a person's life and evaluated the impact of early regular exercise on participation in exercise at age 60 and over.

Previous longitudinal studies suggest that physical activity in early life tracks to later life^{5,6}. However, most studies have tracked physical activity from childhood and adolescence to young adulthood and the coefficients re-

Table 3a. Popular types of regular exercise across the life course among men (n=523)

age (years)	1st		2nd		3rd	
		%		%		%
12-19	Baseball	16.6	Track & Field	11.9	Judo	8.4
20-29	Baseball	11.9	Softball	4.6	Table tennis	4.0
30-39	Golf	7.6	Softball	6.5	Baseball	5.9
40-59	Golf / Walking *		16.1		Softball	7.6
60 and over	Walking	34.4	Brisk walking	18.4	Golf	13.2

Percentages are shown for those who participated in the exercise. *, Both golf and walking share in 1st place with the same percentage.

Table 3b. Popular types of regular exercise across the life course among women (n=461)

age (years)	1st		2nd		3rd	
		%		%		%
12-19	Volleyball	15.8	Softball	7.8	Table tennis	6.1
20-29	Volleyball	1.7	Dancing	1.3	Tennis	0.9
30-39	Volleyball	3.5	Walking	2.8	Tennis, Dancing or Softball	1.5
40-59	Walking	13.9	Gymnastics exercise	8.7	Dancing	8.5
60 and over	Walking	24.7	Gymnastics exercise	15.4	Brisk walking	9.5

Percentages are shown for those who participated in the exercise.

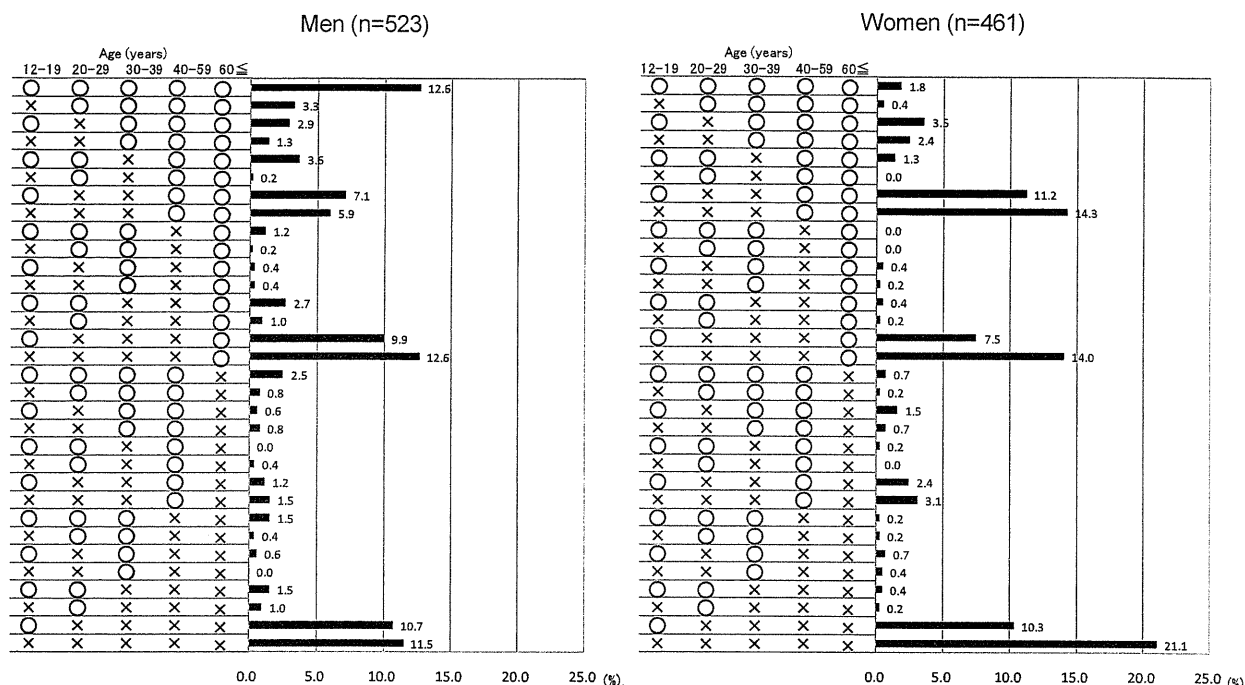


Fig. 1 Participation pattern in regular exercise across the life course for men and women, separately
 Regular exercise status: (o) = participants who engaged in regular exercise, (x) = participants who did not engage in regular exercise

Table 4. Distribution of participation in regular exercise at age 60 and over according to participation in regular exercise across the life course

age (years)	Regular exercise	Men (n=342)		Women (n=263)	
		n	%	n	%
12-19	No	130	61.3	144	54.8
	Yes	212	62.0	119	60.1
20-29	No	213	60.9	244	56.5
	Yes	129	74.6	19	65.5
30-39	No	225	61.4	223	56.0
	Yes	117	75.5	40	64.5
40-59	No	148	51.3	104	40.3
	Yes	194	83.3	159	78.3

Numbers and percentage are shown for those who engaged in regular exercise at age 60 and over.

ported have been only low or moderate⁵). In another study, the correlation between the time points studied was found to weaken over time¹³). Only a few studies have examined whether physical activity in early life tracks to an older age. Retrospective findings that past physical activity predicts physical activity in older people^{7,8}) can help to explain the positive association between experiences of exercise and physical activity later in life. However, basic descriptive data on individual exercise history throughout life is lacking for the community-dwelling older people in Japan. Assessing life-long regular exercise and the contribution of past exercise experience to engagement in regular exercise later in life are the underlying considerations when promoting an active lifestyle throughout a person's life.

Our finding that men are more physically active than women throughout their lives is partially supported by pre-

Table 5. Odds ratio and 95% confidence interval for those who had regular exercise at age 60 and over

	Model 1				Model 2			
	Men		Women		Men		Women	
	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI
Regular exercise								
At 12-19 years of age	1.42	0.99 - 2.05	1.30	0.89 - 1.90	1.69	1.10 - 2.58	1.06	0.71 - 1.60
At 20-29 years of age	2.03	1.35 - 3.05	1.43	0.65 - 3.14	1.87	1.21 - 2.90	1.26	0.55 - 2.87
At 30-39 years of age	2.02	1.32 - 3.09	1.47	0.84 - 2.58	2.00	1.27 - 3.15	1.29	0.69 - 2.41
At 40-59 years of age	4.63	3.07 - 6.98	5.85	3.82 - 8.96	5.96	3.72 - 9.57	6.89	4.23 - 11.23

OR, odds ratio; CI, confidence interval. Model1: unadjusted, Model2: adjusted for age, BMI, education, income, work-related physical activity, smoking, self-rated health, chronic diseases. Bold represents significant p-value (<0.05)

vious studies^{14,15}). Women may perceive more traditional, social and environmental barriers than men to engaging in exercise^{8,15}). For instance, exercise has been considered “not ladylike”¹⁶). These aspects may in part be responsible for the lower rate of participation in exercise throughout life among women. Furthermore, a large drop in participation in exercise was observed among women in their 20s and 30s. The transition from adolescence to adulthood is a period of general decline in physical activity¹⁷). Some life changes, such as getting married and having children, affect physical activity in young adulthood in women more than in men⁹). National data in Japan show that the age of first marriage for men was 26.9 years and for women 24.2 years in 1970¹⁸). The most common age range for giving birth is 20-39 years¹⁹). After the fourth decade of life, most people’s family and job situations seem to be established and stable. Retirement, in turn, tends to increase physical activity²⁰). These life events may be associated with regular exercise. Further research on the relationship between life events and exercise is needed to clarify this issue.

The most popular activities and sports changed between the earlier and later age categories; there was also a gender difference in popular types of activities throughout life. Previous studies have reported a high frequency of ball games among men across ages 14 to 31 years²¹). Dance and gymnastics were more popular with women^{15,22}). Our finding supports the previous gender difference in the traditional preferences for specific types of exercise. From the perspective of age, team sport activities were common in adolescence and young adulthood, and individual sports in middle age and older. A possible explanation of the shift is that social situations and lifestyle change according to age, for instance, it is more difficult for a large number of adults to get together, whereas individual sports can be performed in one’s own time²¹). Individual sports are sometimes labeled lifetime sports²³) and adult-like activities¹⁷). Previous studies have reported walking and gardening as the most common activities among older adults²⁴). To maintain their exercise levels, people may have to choose specific types of exercise as their lifestyles change with aging²⁵). We may consider that older people who engage in regular exercise in our study are those who are able to find suitable activities to match their life changes.

In this study, we tracked regular exercise from adolescence to age 60 and over, and described the individual variation in participation in exercise. A number of participants reported participating in regular exercise at some time in their life, although reports of consistent engagement in regular exercise across several decades were scarce. We have already shown cross-sectionally in Table 2 that the prevalence of regular exercise in the 20s and 30s was low. Figure 1 illustrates the findings as individual transitions of regular exercise throughout life. Although the percentage in each pattern was small, and the patterns of exercise frequency seemed to be similar in both men and women, we found that among men the most frequent

pattern was participation in regular exercise at all the life stages; whereas among women the most frequent pattern was no regular exercise at all. Results suggest that encouragement and support for older women should be provided by health professionals as well as the community, since participation in exercise may induce a major behavioral change among older women. There may be a need to tailor health promotion messages and interventions according to gender and personal exercise history.

After fully adjusting for confounding factors such as age, BMI, education, annual income, smoking, work-related physical activity, self-rated health, and chronic diseases, both men and women who had participated in regular exercise during 40-59 years of age had a 5 to 7-fold higher rate of participation in exercise at age 60 and over. This result suggests that participation in exercise during 40-59 years of age predicts exercise at age 60 and over. Our findings are in line with those of some previous studies^{7,8}). Frändin et al. , who studied age groups from the age of 10 years, found that physical activity during earlier life was not correlated with physical activity at the age of 76, except for the last age period 66-76 years⁷). Other studies also found the last age group to be better predictors than earlier ones^{8,26}). The short interval may be one of the causes for the strong relationship between regular exercise at 40-59 years of age and that at age 60 and over. A number of studies have suggested that childhood is usually considered the best time for socialization into physical activity⁸), for encouraging physical activity in adults through the developing of habits²⁵) and for promoting exercise-related feelings of pleasure and joy⁷). Furthermore, sports activities may have an effect on motor and coordination skills that may be of value later in life²¹). We believe that the positive effects of exercise in early life are associated with physical activity in older life. In fact, regular exercise during all the age categories studied affected exercise at age 60 and over among men. However, demographic, psychological, behavioral, social and environmental factors are associated with adulthood participation in physical activity²⁷). These multiple factors may decrease the positive effect of earlier exercise at older ages. Health problems were reported to be the most common barrier to increasing physical activity²⁸). We found that the effect of regular exercise at 40-59 years of age on participation in exercise at age 60 and over increased among women who had a history of hypertension in the sub-analyses (data not shown). Chronic health problems may also have influenced the motivation for physical activity as a part of clinical care. Our finding that regular exercise during 40-59 years of age was associated with that at age 60 and over was true for a lot of people who had not engaged in regular exercise earlier in their lives. The motivation to engage in regular exercise in the fourth and fifth decades of life may have important implications for promoting increased physical activity in older age.

This study has several limitations. The first limitation

is that our study was a retrospective study and the regular exercise data were based on self-reports. Possible memory failure and potential recall bias may have influenced the results. In addition, we were not able to take into account the short-term substitution of one exercise for another as regular exercise was defined as an activity lasting one year. Therefore our study may underestimate regular exercise as an indicator of physical activity. Secondly, social and environment factors, which have been indicated as predictors of physical activity, were not widely examined in our study. Environmental factors are among the important factors promoting participation in physical activity¹⁶⁾. Recent studies suggested that environmental problems, such as poorly lit streets or noisy traffic, are correlated with inactivity²⁹⁾. Further studies are needed to confirm the association between regular exercise and a comprehensive range of factors. Finally, the definition of regular exercise in this study was lower than the well-known recommendation of physical activity for adults by the American College of Sports Medicine³⁰⁾. However, we previously found that continuation of regular exercise by the same definition as used in this study was associated with higher muscle strength and power in both elderly men and women³¹⁾. A number of older people are physically inactive. "Tojikomori", being housebound, which has been defined in recent studies as going outdoors once or less than once a week, is a serious concern in relation to older people³²⁾. Pate et al. suggest that an active lifestyle does not require a regimented, vigorous exercise program³³⁾. To avoid causing undue stress coming from misconceptions, it may be sufficient just emphasizing to older people the importance of being physically active as opposed to having to maintain a disciplined workout schedule.

The strengths of the present study include a large number of randomized community-dwelling people and regular exercise data tracked from age 12 to 60 years and over. These data provide important information for demonstrating the value of life-long physical activity. The participants had a face-to-face interview by trained staff, which increases the reliability of the answers and reduces missing data in the questions. We were able to take into account essential social and health condition data such as education, smoking and disease as confounders. Our study described individual variation in regular exercise throughout the various stages of a person's life and showed the positive impact of experiences of exercise in earlier life on regular exercise in later life; and thus lays a good foundation for persuading the general population of the importance of maintaining physical activity throughout life.

Conclusion

The present study found that men engaged in regular exercise more than women throughout their lifetime. Exercise preferences differed depending on age and gender. Among women, those reporting no regular exercise were

the largest group. Among men, regular exercise earlier in life positively affected regular exercise at age 60 years and over. Regular exercise in middle age markedly increased participation in exercise later in life regardless of social and health conditions among both men and women.

Acknowledgments

The authors would like to thank the participants and also colleagues in the NILS-LSA. This study was supported by a Grant-in-Aid for Young Scientists (A) from the Japan Society for the Promotion of Science (#20680034).

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