brain damage）にまで大きな影響を及ぼす（図3C）[9]．

もう一つの測定方法としてstiffness parameter（β）がある．β=ln（収縮期血圧／拡張期血圧）×（血管径／血管径の変化）の方程式で算出されるもので，頸動脈や大動脈の超音波所見から直接算出するものである[4]．

以上より，頸動脈IMTと動脈壁硬化（Arterial stiffness）とは『Together they stand』と言っても過言ではない．生理的な脈波の加齢に伴う変化は心臓における後負荷を増加し，また冠動脈血流（coronary flow）にも悪影響をきたしやすくなる[10]．

3）血管内皮機能：内皮依存性血管拡張反応 Flow Mediated Dilation（FMD）

血管内皮機能障害は動脈硬化の第一段階（初期変化）として位置づけされており，血管内皮細胞における一酸化窒素（Nitric oxide：NO）等の産生能低下による血管弛緩作用低下が起こる．実際には，超音波を用いて虚血反応性充血後の血流依存性血管拡張反応（Flow Mediated Dilation（FMD））を血管径の変化で評価するものであり，導管血管レベルでの血管内皮機能を反映していると考えられる．実際，高血圧患者も含めて数多くの臨床研究が進められており，血管内皮機能障害高度群は低度群に比し，イベント発生率が3倍以上であったと報告している．

血管内皮障害の機序として，高血圧，糖尿病，高脂血症あるいは喫煙，加齢，肥満といった危険因子では，いずれも酸化ストレスが高く，活性酸素の産生増加によるNO捕捉（NOの不活性化）が血管内皮機能異常の機序の一つとして注目されている．活性酸素はNOと非常に高い結合親和性を有しているためNOの不活性化に寄与し，さらに，産生された活性酸素はNOと結合することにより非常に強い細胞毒性を有するペルオキシナイトライト（peroxynitrate）に変換される．これにより，血管壁細胞の直接の障害，さらに血管内皮細胞や血管平滑筋細胞でのNOの生物学的活性が低下する．酸化ストレス状態はNOの産生低下とNOの不活性化により血管内皮機能障害に働き，この血管内皮機能障害は結果として動脈硬化を進展させる悪循環を形成する．動脈硬化の第一段階としての血管内皮機能障害は，生活習慣の修正や薬物治療などにより改善可能であるので，血管合併症の発症予防を達成する上でも血管内皮機能の関与を検討することは重要である．

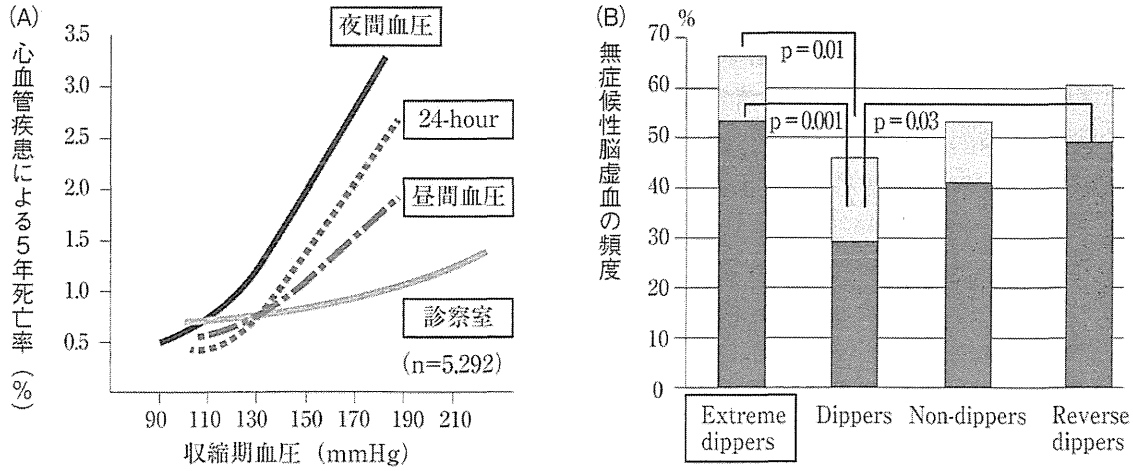
4）心エコー

収縮能だけでなく，拡張機能（E/A，E/e'など）にも大きな意義が含まれており，特に高齢者心不全を語る上では避けられない．大動脈も含めた大血管の壁硬化と心臓から見た後負荷（afterload）の増大は大きな関係がある．

3. 未病から見た血圧管理

「どのタイミングの血圧を意識するのか？」という問題は非常に重要である．短期変動としての日内変動を評価するための24時間血圧測定（ambulatory blood pressure monitoring：ABPM），そして日間変動のような中長期変動を示す家庭血圧を行うことにより，様々な血圧パターンが見えてくる．日中と夜間の自由行動下血圧を24時間血圧測定ABPMによって測定し，致死的な心血管イベントの追跡を行い予後予測の精度を検討したコホート研究では，デンマーク，ベルギー，日本，スウェーデン，ウルグアイ，中国で実施された住民対象前向き研究：登録症例7458人であった．総死亡は大きな差は認められなかったが，脳心血管イベント発症においては生理的なdipper型と比較するとnon-dipper型はイベント発症が多く，中でも夜間に血圧上昇するriser型は著明に危険度が大きかった[11]．また，様々な測定による収縮期血圧と心血管疾患による5年死亡率との関係では，診察室での血圧は予測能が低く，むしろ24時間の血圧，特に夜間の血圧の状態が心血管イベントに対する予測能に優れていることが証明された（図4A）[12]．すなわち，Non-dipper症例をどう見極めていけるのかが課題となる．夜間の血圧上昇は様々な臓器障害と相関することがすでに数多くの論文にて報告されており，左室拡張能障害につながる心肥大（LV mass），前述のような動脈壁硬化，腎機能障害（尿中アルブミン排泄），脳血管性認知症につながり易いラクナ梗塞を中心とする脳血管障害などである．面白いことに，この調査ではextreme-dipper型（相対的な夜間の過降圧）は一番イベント発症が少なかった．

一方，別の報告では，高齢者における無症候性脳虚血はむしろextreme-dipper型に多く，もしかしたら認



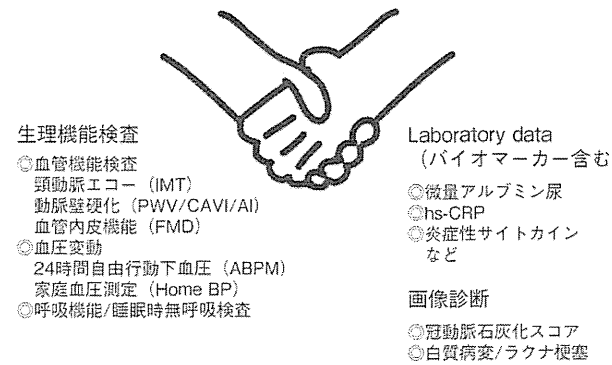
■図4 様々な血圧測定と心血管イベント：診察室血圧による評価の限界
(A) 様々な測定による収縮期血圧と心血管疾患による5年死亡率との関係．診察室血圧よりも夜間血圧および24時間自由行動下血圧の方が心血管疾患による5年死亡率の予後予測能が高い．この結果から，いかに夜間血圧の管理が不十分な症例を早期に発見できるかが課題となる．(n=5,292，観察期間8.4年，論文11より引用改変)
(B) 高齢者における夜間血圧低下（Dipping）と無症候性脳虚血の関係．夜間の過降圧（extreme dipper型）はハイリスクと言われるnon-dipper型よりも無症候性脳虚血が多い．(論文12から引用改変)

知機能低下に寄与している可能性がある(図4B)[13]．よって，一概にextreme-dipper型はリスクなしと決めつける訳にはいかず，脳白質病変の有無やその程度などを並行して診ていくべきである．

4. まとめ

『未病≒sub-clinical』と考えてみると，疾患が顕在化するまでの未病の時期をいかに発見し，いかに薬物または非薬物療法によって管理するのかが重要である．特に「治未病」のためには，生理機能検査の「請け負う位置付け」は非常に大きい．個々の動脈硬化関連危険因子の管理達成率を向上させるためには，未病管理における検査の標準化も必要となってくるのであろう．そして，そこには総合検診や人間ドック，ひいては遠隔検診や在宅検診なども包含した検査受診率の確実な向上が避けられない．

動脈硬化性疾患予防のためにも，「真の血管年齢」を医療従事者だけでなく国民全体に意識させるためにも，粥腫形成（atherosis）と血管壁硬化（sclerosis）の両面へのアプローチを様々な生理機能検査を駆使して評価を行い，経年変化を追う必要がある．そして，ラボデータ異常（微量アルブミン尿など），バイオマーカー（hs-CRPや炎症性サイトカインなど），画像診断（冠動脈CTにおける冠動脈石灰化の程度など）と上手く組み合わせて，総合評価する必要がある（図5）．



■図5 潜在性動脈硬化症（sub-clinical atherosclerosis）への早期診断
動脈硬化には粥腫形成（atherosis）と壁硬化（sclerosis）の2つの側面がある．臨床診療の中でいかにsub-clinical atherosclerosis（潜在性動脈硬化症）を早期に見出し，そして受診者への教育・啓発を促すかが大きな比重を占める．また，幅広い診断をするためには，Laboratory data（バイオマーカー含む）の異常値や画像診断における包括的アプローチが必要である．(著者作成)
IMT；intima media thickness, PWV；pulse wave velocity, CAVI；cardio-ankle vascular index, AI；augmentation index, FMD；flow-mediated dilation, hs-CRP；high sensitive C reactive protein

最後に，今後は「Sub-clinical atherosclerosis」対策のための普及・啓発・教育，システム構築，そして“予防医学”と“臨床医学”の緊密な連携が今まで以上により一層求められてくる．

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第19回日本未病システム学会学術総会
■ プロシーディング（発表研究論文）5

セカンドライフ就労を介したシニア世代の身体活動量の変化に対する検討：Aging in Placeを目指して

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要 約

超高齢社会を迎えた我が国において，60歳を超え定年退職を迎えた人の社会参加を促し，生きがいを見つけることは重要な課題である．本研究では我々が提唱している「住み慣れた場所で自分らしく老いることのできるまちづくり：AGING IN PLACE」を目指して定年退職を迎えたシニアを対象に，地域コミュニティで就労をすることが身体活動量の上昇や余暇活動などの社会参加を促すかどうかを検討した．

対象は定年退職後のシニア12名で，日記による行動記録及び携帯型活動量計を装着し，社会参加や余暇活動，身体活動量に変化が生じるかを検討した．日記は1日の活動状況を（1）自宅から出なかった，（2）少し出かけた，（3）1日中外にいた，の3段階で記載した．活動量の定量評価として3軸加速度センサーを用いたリストバンド型活動量計を用いて歩数，運動強度（metabolic equivalents；METS），消費カロリーの3項目を算出し，それぞれの指標に対し就労開始前，就労開始後の出勤日，休日と分け，就労開始前後の変化を検討した．

リストバンド型活動量計より算出される指標での検討では歩数，METS，消費カロリーは就労開始後の就労日において，全ての指標で有意な上昇が認められた．興味深いことに就労開始後の休日においても全ての指標で有意な上昇を認め，日記による活動状況記録においてもリストバンド型活動量計の結果をサポートする内容であった．

今回の取り組みに対する検討から，退職したシニアが就労することにより出勤日の活動量が上昇するだけでなく，休日の活動量も増加し社会参加の機会が増えていることが示された．セカンドライフための就労へ積極的に取り組むことは地域コミュニティとの繋がりも強め，AGING IN PLACEを実現するだけでなく，結果的に生活の質の向上を通じて未病にもつながる可能性がある．

Key words Aging in Place，セカンドライフ，就労，身体活動量，虚弱

1 緒言

平成24（2012）年，我が国における65歳以上の高齢者人口は3000万人をすでに超え，人口ピラミッドの推移から考えれば，今後も著明な超高齢化が進んでいくことは間違いない[1]．また平成22（2010）年は高齢者1人に対する現役世代（20～64歳）の人数は2.6人であるのに対し，平成67（2055）年には高齢者1人に対して現役世代は1.3人にまで減少し，就労人口の割合が大きく低下すると予測されている[2]．一方で文部科学省の実施している握力，上体起こし，長座体前屈，開眼片足立ち，10m障害物歩行，6分間歩行，activities of daily living（ADL）をそれぞれ1～10点で評価する新体力テストにおいて，高齢者の身体機能は平成10（1998）年に実施した65～69歳の点数より平成23（2011）年実施した70～74歳のほうが高く，高齢者の体力や身体機能は維持，向上していることが知られている．これはシニア世代においても十分就労は可能であり，就労人口割合の低下を補う可能性が示唆される[3]．

千葉県柏市の高齢化率は約20%と全国と比べ大きな差はないが，同市内の豊四季台団地は平成22（2010）年10月で40%を超える高齢化率となっている．我々は同団地を有する独立行政法人都市再生機構と柏市の三者で協定を結び「柏市豊四季台地域高齢社会総合研究会」を立ち上げ，「住み慣れた場所で自分らしく老いることのできるまちづくり：Aging in Place」を提案し，将来の長寿社会の在り方を模索している[4]．

今後，団塊の世代が65歳を迎え，特に千葉・埼玉・神奈川という東京近郊のベットタウンでは定年退職を迎えたシニア世代が地域で過ごす時間が増えることが予想され

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る. こうした現状を踏まえ, 我々は60歳を超え定年退職を迎えた人の社会参加を促し, 生きがいを見つけることを重要な課題とし, 地域でのつながりを持ってもらうきっかけとして「生きがい就労」プロジェクトを開始した.

本プロジェクトの一端として, 我々は社会参加が多い人と手段的活動度 (instrumental activities of daily living: IADL) が高く自立していることの間の相関関係をすでに明らかにし, 社会参加の重要性を報告した[5]. 一方で身体活動量低下は高齢者の心身の虚弱にも関連していることが分かっており, 高齢者の虚弱 (frailty) の診断基準の一つとなり, 身体活動量低下は生命予後悪化とも関連していることが示されている[6]. 本研究では定年退職を迎えた60歳以上のシニアを対象に, 地域コミュニティで就労をすることが身体活動量の上昇や余暇活動などの社会参加を促し, 個々の生活の質を向上し得るかどうかを検討し, その取り組みが我々の提唱しているAging in Placeにより近づける手法になり得るかどうかを検証した.

2 方 法

生きがい就労プロジェクト対象者の選定において, まずは本プロジェクトの趣旨説明のため就労セミナーを開催した. 同セミナー募集の案内を千葉県柏市内に配布, さらに市の広報を用いて呼びかけ, 平成23 (2011) 年11月から平成24 (2012) 年12月までに同セミナーを6回開催し, 約480人のシニアが参加した. 身体活動量や余暇活動などの社会参加を検討する本研究の対象者は同セミナー参加者の中から選定し, 対象者本人の希望である分野の就労が初めて決まった方より同意が得られた連続12名を対象とした. 対象者には就労開始前後それぞれ約2週間にわたり, 日記による行動記録, およびリストバンド型活動量計を装着し, 社会参加や余暇活動, 身体活動量に変化が生じるかを検討した. 日記は起床時間, 就寝時間, 昼寝の有無, 食事摂取状況と1日の活動状況を (1)自宅から出なかった, (2)少し出かけた, (3)1日中外にいた, の3段階で記載し, 活動内容を (1)働いた, (2)地域の活動やボランティア活動などをした, (3)趣味・娯楽・稽古をした, (4)運動・スポーツをした, (5)友人や知人等とつきあい・交際・おしゃべりをした, (6)いずれもしなかった, の6項目から選択形式とした. 活動内容の項目の中で「(1)働いた」を選択した場合は就労時間とその内容を記載し, さらに行事や出来事をフリーコメント記載とした.

1日の活動状況 (1)自宅から出なかった, (2)少し出かけた, (3)1日中外にいた, について就労開始前と開始後, さらに就労開始後を就労日と休日 (非就労日) に分けてその割合を比較した.

活動量の定量評価として3軸加速度センサーを用いたリストバンド型活動量計 (Hitachi wristband-based life recorder system, HT-PB3)[7] を非利き腕に, 入浴時以外の全ての時間装着とした. 身体活動量の指標として, 歩数, 運動強度 (metabolic equivalents; METS), 消費カロリーの3項目を算出した. 加えて, それぞれの指標に対し就労開始前, 就労開始後の就労日, 就労開始後の休日と分け, 就労開始前と開始後との変化を検討した. 加えて, 休日の身体活動量の指標が上昇していた対象者に対して日記とインタビューによりその活動内容を調査した.

データの解析にはSPSS statistics (ver20) を使用し, 日記による行動記録については就労開始前, 就労開始後, 就労日, 休日 (非出勤日) の4群に分けてKruskal-Wallis検定を行い, リストバンド型活動量計の各指標に対しては就労前と就労後の2群間の比較をpaired-t検定を用いて検定した. $P<0.05$を統計学的有意差ありと判定した.

本研究については東京大学の倫理審査委員会の承認を得て, 参加者全員から書面による同意を得た.

3 成 績

対象者は千葉県柏市在住で定年退職後の60歳以上のシニア12名 (平均年齢66.7±5.7歳, 男性7名, 女性5名) であった. 実際の就労内容は英語塾の講師や福祉施設での清掃業, 園芸作業などであり, 全ての就労場所は同市内であった. 日記の平均記載日数は34.8日で, 就労前, 就労後の平均記載日数はそれぞれ15.0日, 19.8日あった. さらに就労後を就労日と休日 (非就労日) に分けるとそれぞれ6.3日, 13.5日であった. これは1週間で表わすと実際の就労日数は2.2日, 休日 (非就労日) は4.8日であった.

1日の活動状況を記録した日記の検討では, (1)自宅から出なかった, (2)少し出かけた, (3)1日中外にいた, のそれぞれについて12人の合計出現頻度 (%) は就労開始前が25回 (15.4%), 113回 (69.8%), 24回 (14.8%) であったのに対し, 就労開始後はそれぞれ19回 (9.2%), 152回 (73.4%), 36回 (17.4%) と, (1)自宅から出なかった, の割合が減少し (2)少し出かけた, (3)1日中外にいた, の割合が増加していた. 就労開始前, 就労開始後, 就労日, 休日 (非出勤日) の4群間に出現頻度の統計

学的な差は認めなかったものの（p=0.493），就労開始前と比較し就労日，休日（非出勤日）においても（1）自宅から出なかった，の割合が減少し，（3）1日中外にいた，が増加していた（Table 1）．

代表的な1例の日記による記録を示すと，積極的なスポーツ活動が就労開始前には認められなかったにもかかわらず開始後に「ゴルフや卓球などのスポーツ活動」が増加し，結果的に自宅からの外出頻度が著明に増加していた．

次にリストバンド型活動量計による検討では，歩数が就労前4,484±3,157歩であったのに対し，就労後の出勤日7,998±4,392歩と有意に増加した．興味深いことに，休日までも5,466±4,185歩と就労前に比べて有意に増加していた．同様に運動強度と消費カロリーについてもそれぞれ就労前1.29±0.09METS，1,897±501カロリーであったのに対し，出勤日は1.39±0.10METS，2,429±520カロリーと有意に増加し，休日も1.30±0.10METS，2195±439カロリーと有意な増加を認めた（Figure 1a～1c）．休日の歩数，運動強度，消費カロリーが上昇した理由を対象者にインタビュー形式で調査したところ，女性は就労セミナーや職場を通して知り合った友人との買い物に出かける頻度が増え，男性はゴルフなどのスポーツや飲食に出かける頻度が増えていたことが分かり，社会参加の機会が増えていることが認められた．

4 考察

千葉県柏市は東京のベットタウンで，埼玉県や神奈川県と同様に多くの就労者が都内に通勤している．一方，定年退職を迎えたシニア世代は地域での活動の割合が低く，居住地域での知り合いはそれほど多くない[9]．このシニア世代が定年退職を迎えると，社会参加や外出頻度が減少する可能性がある．今回の取り組みに対する検討から，従来から言われているように，退職した高齢者は自宅からの外出頻度が低く，活動量も低値であったにもかかわらず，就労することにより就労前と比べ出勤日の歩数や運動強度，消費カロリーが上昇するだけでなく，休日においても上昇することが認められた．

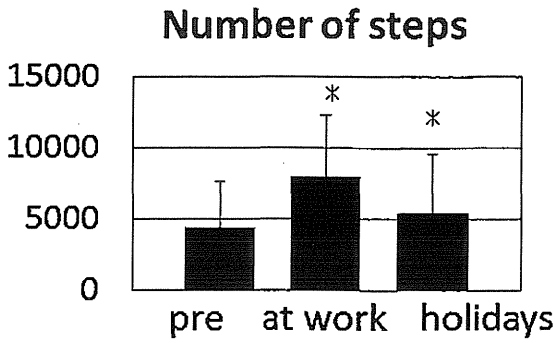
定年退職を迎えたシニアに対する身体機能，認知機能に及ぼす影響を検討したこれまでの研究では，フランスやオランダなどの海外では定年退職したシニアの余暇活動は上昇するとの報告がある[8]．しかしながら我が国では都心部を中心に地方都市より地域の活動や行事に誘い合う人の割合が少なく[9]，都心部の定年退職者の社会参加を促すことの重要性が示唆され[10]，さらに65歳以上の男性は1987年と比較し，1999年には友人・近所の人・親戚と会ったり出かけたりする回数が減っており，定年退職後の地域との関わりが少ないことが示されている[10]．一方でウェクスラー成人知能検査改訂版の簡易実施法での情報処理の速さ，正確さを反映する「符号」が就労していない群より有意に保持されると言う報告もあり[11]，定年退職を迎えたシニアが就労することで身体活動量，知能検査が維持される可能性がある．

就労日数については1週間のうち平均2.2日であったが，これはシニアの働き方として我々がワークシェアリングを提案し，一つの仕事に対して複数人数のシニアで就労したことによる結果であると考えられる．定年退職を迎えたシニア世代の働き方は収入よりも，人との関わりや，やりがいを持つことを希望しており，また一方で生産年齢が敬遠し，雇用者が希望する短時間や短期間労働のニーズと適合し，シニア世代に有用な就労の仕組みと考えられた．

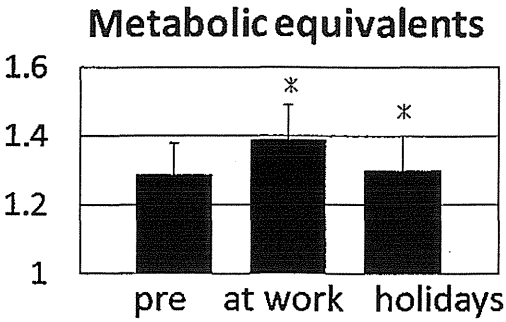
❑ Table 1 The frequency of going outside

	(1) at home all day long	(2) go outside for a minute	(3) go outside all day long
pre	25 (15.4%)	113 (69.8%)	24 (14.8%)
post	19 (9.2%)	152 (73.4%)	36 (17.4%)
at work	1 (1.4%)	61 (82.4%)	12 (16.2%)
holidays	18 (13.5%)	91 (68.4%)	24 (18.0%)

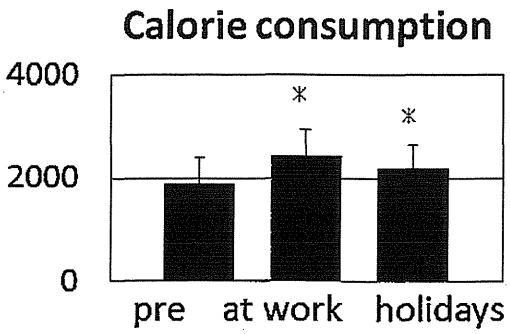
pre: before start working, post: after start working
The daily activity reports from diary. Although statistical significant was not found, it was increased activity statement after employment compared with before start working.



❑ Figure 1a　Number of steps



❑ Figure 1b　Metabolic equivalents (METS)



❑ Figure 1c　Calorie consumption

*p＞0.05　vs. pre
pre: before start working
Number of steps, metabolic equivalents (METS) and calorie consumption comparison between before and after starting to work.

本プロジェクトを通して平成23（2011）年11月より平成24（2012）年12月までに就労セミナーを6回開催し，約480人のシニアが同セミナーに参加した．その多くが就労を希望しているが，機械化された農作業において，農作物の泥を落とす作業や機械に農作物を入れる単純作業も多く，単純作業を好まないシニアの希望と適合しない場合や，経営状態により千葉県の定める最低賃金を支払えず，雇用を断念するケースもある．全てのシニアにおいて就労が決められる訳ではなくシニア世代の就労機会，就労場所，賃金体系についてさらなる検討が必要であると考えられた．

まとめとして，本研究によりセカンドライフのための就労へ積極的に取り組むことは定年退職を迎えたシニア世代において，出勤日だけでなく休日においても身体活動量を上昇させ，さらに社会参加も促すことが明らかとなった．本プロジェクトは地域コミュニティとの繋がりを強め，結果的にAging in Placeを実現するだけでなく，ひいては生活の質を向上させることを通じて未病にもつながる可能性があることが分かり，今後さらなる検討をする必要があると考えられた．

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The effect of second life working in motor activity in the community-dwelling seniors who once retired: To achieve 'Aging in Place'

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Introduction: In Japan, where society is aging rapidly, it is important to consider the lives of retired seniors aged 60 or older, and whether they can increase social involvement and find new purpose. Therefore, we aggressively advocate the 'AGING IN PLACE' program, where seniors live and grow old in their home-town (region). In this study, we investigated whether working in the community improved physical activity, which included leisure-time activities and social involvement, not only during days at work but also during holidays.

Methods: Subjects were 12 retired community-dwelling seniors. Diaries were written by all subjects to record physical activities and social involvement. To assess their physical activity quantitatively, number of steps, metabolic equivalents (METS) and calorie consumption were all measured using wristband-type activity monitoring devices. We investigated and compared the changes in these parameters before and after the subjects began working (including days on and off the job).

Results: Quantitative measurement of their activity, including the number of steps, METS, and calorie consumption, showed a significant increase in all parameters on work days after beginning employment. Intriguingly, even on the days where subjects did not work, we found a significant increase in all parameters. These findings were also reflected in subject diaries.

Conclusion: This study suggests when retired persons over 60 years of age start to work again there is an increase in the amount of activity, which may lead to an increase in leisure-time activities and social involvement. In addition, it also suggests that working prevents the elderly from becoming frail and, thereby, has the potential to become one means through which a greater realization of our concept AGING IN PLACE may be accomplished.

Key words Aging in Place, Second life, Work, Motor activity, Frailty

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COMMUNITY DENTISTRY AND ORAL EPIDEMIOLOGY

Interrelationship of oral health status, swallowing function, nutritional status, and cognitive ability with activities of daily living in Japanese elderly people receiving home care services due to physical disabilities

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Furuta M, Komiya-Nonaka M, Akifusa S, Shimazaki Y, Adachi M, Kinoshita T, Kikutani T, Yamashita Y. Interrelationship of oral health status, swallowing function, nutritional status, and cognitive ability with activities of daily living in Japanese elderly people receiving home care services due to physical disabilities. Community Dent Oral Epidemiol 2013; 41: 173–181.

Abstract – *Objectives:* Malnutrition and cognitive impairment lead to declines in activities of daily living (ADL). Nutritional status and cognitive ability have been shown to correlate with oral health status and swallowing function. However, the complex relationship among the factors that affect decline in ADL is not understood. We examined direct and indirect relationships among oral health status, swallowing function, nutritional status, cognitive ability, and ADL in Japanese elderly people living at home and receiving home care services because of physical disabilities. *Methods:* Participants were 286 subjects aged 60 years and older (mean age, 84.5 ± 7.9 years) living at home and receiving home care services. Oral health status (the number of teeth and wearing dentures) was assessed, and swallowing function was examined using cervical auscultation. Additionally, ADL, cognitive ability, and nutritional status were assessed using the Barthel Index, the Clinical Dementia Rating Scale, and the Mini Nutritional Assessment-Short Form, respectively. Path analysis was used to test pathways from these factors to ADL. *Results:* The mean number of teeth present in the participants was 8.6 ± 9.9 (edentates, 40.6%). Dysphagia, malnutrition, and severe cognitive impairment were found in 31.1%, 14.0%, and 21.3% of the participants, respectively. Path analysis indicated that poor oral health status and cognitive impairment had a direct effect on denture wearing, and the consequent dysphagia, in addition to cognitive impairment, was positively associated with malnutrition. Malnutrition as well as dysphagia and cognitive impairment directly limited ADL. *Conclusions:* A lower number of teeth are positively related to swallowing dysfunction, whereas denture wearing

Key words: activities of daily living; cognitive ability; elderly people with physical disabilities; nutritional status; oral health status

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contributes to recovery of swallowing function. Dysphagia, cognitive impairment, and malnutrition directly and indirectly decreased ADL in elderly people living at home and receiving home nursing care. The findings suggest that preventing tooth loss and encouraging denture wearing when teeth are lost may indirectly contribute to maintaining or improving ADL, mediated by recovery of swallowing function and nutritional status.

In almost every country, the proportion of older people is increasing relative to younger age groups (1). Especially in Japan, the population is aging rapidly because of dramatic reductions in early mortality and declines in fertility. Indeed, the population aged 65 years old and older in Japan accounts for 23% of the total population in 2011 (2), and this percentage is the highest in the world. As the number of elderly people increases, so does the number of those requiring long-term nursing care, such as those who are bedridden and suffering from dementia (3).

Since 2000, nursing services supporting the daily lives of elderly individuals who require long-term care because of physical disability have been provided through the social insurance system enacted in Long-term Care Insurance Act in Japan (4). In this system, applicants for services are classified into five grades according to the severity of their physical disability, and the amount of nursing care service provided is determined by grade (5). The number of elderly receiving long-term care based on this act was about 4 million in 2010 according to a report by Japanese Ministry of Health, Labour and Welfare (6). Another report showed that 29% of elderly Japanese requiring long-term care deteriorated as measured by the grade of care service needed, and 23% of them died within 2 years (7). For elderly people receiving nursing care, further deterioration in their ability to conduct activities of daily living (ADL) such as bathing, dressing, and walking is an important concern.

Previous studies have suggested that malnutrition and cognitive impairment can lead to deterioration in ADL (8, 9), and malnutrition has been associated with cognitive impairment in elderly people (8). Moreover, nutrition and cognitive function have also been shown to correlate with oral health status (10, 11) and swallowing function (12, 13). However, these studies focused on direct relationships between bivariates. We need to also take into account that decline in ADL is affected by complex direct and indirect interactions among multiple factors. That is, it is not enough to analyze an association incorporating multiple factors as independent variables to show comprehensively how these risk factors affect deterioration in ADL.

Furthermore, most studies about the effects of oral condition on malnutrition and decline in ADL have been limited to elderly people in nursing homes and hospitals (11–13); few studies have examined these associations in elderly people living at home. In Japan, about 3 million people received home care services, and about 1 million people received facility services, such as at a nursing home, via long-term care insurance in 2010 (5, 14). In the United States, because of social trends toward reduced nursing home use, the number of disabled elderly people needing home care support has increased (15). Considering the growing number of aged people and the inevitable subsequent increase in the number who will require long-term nursing care in most developed countries, an increase in the number of elderly people requiring home care is expected to be a major issue in modern societies worldwide. Therefore, it is useful to investigate the many factors leading to a decline in ADL among elderly people living at home.

In the present study, we examined the direct and indirect effects of oral health status, including number of teeth and denture wearing, swallowing function, nutritional status, and cognitive ability, on ADL in Japanese elderly people living at home and receiving home care services because of physical disabilities. We hypothesized the following: (i) cognitive impairment leads to eating difficulties (e.g., difficulty chewing food, difficulty swallowing food), and these difficulties impair nutritional status (16); (ii) oral health status affects eating difficulties (17); (iii) cognitive impairment affects oral health status (18), or, conversely, oral health status affects cognitive impairment (19); (iv) cognitive impairment and malnutrition lead to a decline in ADL (9) (Fig. 1). The conceptual model was proposed, based on empirical evidence.

Materials and methods

Study setting and study population

This cross-sectional study was undertaken in two midsized municipalities in Fukuoka prefecture (western Japan) between November 2010 and

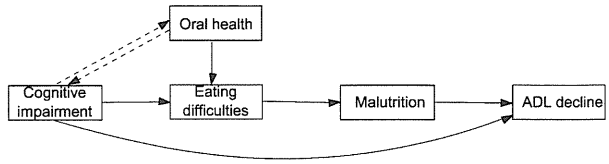

Fig. 1. The conceptual model. Dotted lines indicate paths explored the direction in this study.

February 2011. The study population comprised 337 participants aged 60 years or older who were living at home and using an in-home long-term care support center that coordinates home care services such as home nursing care, visiting rehabilitation, visiting bathing service, day service, and day care (rehabilitation) by service providers. Of these, 51 participants with missing data were excluded. Finally, 286 participants (75 men, 211 women) were included.

The study was approved by Kyushu University Institutional Review Board for Clinical Research. We obtained participants' or their family members' consent, as required for approval by the review board.

Assessment of oral health status and swallowing function

Oral health status and swallowing function were assessed by qualified dental hygienists. Oral health status was assessed by recording the number of teeth and denture wearing.

Swallowing function was examined by cervical auscultation, a non-invasive method of listening with a stethoscope to the sounds of swallowing 3 ml of water during the pharyngeal phase, following the method of Zenner et al. (20) with minor modifications. When breath sounds after swallowing material were clear, we evaluated swallowing function as normal. When stridor, coughing, or throat clearing was heard after swallowing material or when swallowing was repeated, we evaluated this as impaired swallowing function (i.e., dysphagia).

Measurement of ADL, cognitive ability, and nutritional status

Participant's ADL, cognitive ability, and nutritional status were recorded by a nurse or a care worker at the in-home long-term care support center. ADL was assessed using the Barthel Index, which covers all aspects of self-care independence in daily living activities such as transfer, walking stairs, toilet use, dressing, feeding, and bathing (21). A total score of 100 points indicates complete self-sufficiency, whereas a score of zero indicates that the person is completely dependent (21).

Cognitive ability was assessed using the Clinical Dementia Rating (CDR). CDR status was assigned according to the presence or absence of dementia and, if present, its severity (none, questionable or very mild, mild, moderate, or severe cognitive impairment), as described previously (22).

Nutritional status was evaluated using the Mini Nutritional Assessment-Short Form (MNA-SF) (23). The MNA-SF has the option of using calf circumference when body mass index is not available because of a bedridden and immobile state. Nutritional status was defined in three classifications by the MNA-SF: 0–7 points = malnourished; 8–11 points = at risk of malnutrition, and 12–14 points = well nourished.

Comorbid conditions

We assessed comorbidity with the Charlson comorbidity index (24, 25), which provides a weighted score for a participant's comorbidities taking into account how many of 19 predefined comorbid conditions an individual has, because elderly people generally live with multiple diseases, and the presence of comorbidities has a negative effect on both physical and cognitive function (26).

Statistical analysis

Bivariate associations between oral health status and swallowing function, nutritional status, cognitive ability, ADL, or confounding variables such as age, gender, and comorbid conditions were tested with the chi-square or ANOVA test. Oral health status was categorized as 20 or more teeth with dentures; 20 or more teeth without dentures; 10 to 19 teeth with dentures; 10 to 19 teeth without dentures; 0 to 9 teeth with dentures; or 0 to 9 teeth without dentures. A P value < 0.05 was considered to indicate statistical significance. The SPSS software (ver. 19.0 for Windows; IBM SPSS Japan, Tokyo, Japan) was used for data analyses.

To test the hypothesis, we conducted path analysis using the M-plus statistical package (27). Path analysis can be used instead of several separate regressions to examine mediating effects within a single model (28). Additionally, path analysis allows testing of causal relationships among a set

of observed variables (29). We tested the hypothesized model using path analysis (Fig. 2). The model examined the interactive effects of nine constructs. We hypothesized that cognitive ability and nutrition status directly affect ADL. We also hypothesized that the number of teeth, denture wearing, and cognitive ability precede swallowing function. Additionally, the number of teeth, denture wearing, and swallowing function precede nutrition status. Considering the association between cognitive ability and oral health status, it is possible that cognitive impairment affects oral health status (18) or, conversely, that oral health status affects cognitive impairment (19). We tested alternative path models each with different directionalities among the number of teeth, denture wearing, and cognitive ability. We adjusted for age, gender, and comorbid condition.

Data used in this study included both continuous and dichotomous variables. Thus, the path model was analyzed using weighted least-squares mean and variance adjustment estimation (WLSMV). WLSMV uses a diagonal weight matrix with robust standard errors and mean- and variance-adjusted chi-square test statistics (27). We used a significance level of $P < 0.05$ for the regression coefficients. The degree of correspondence between the hypothesized models and the actual data was assessed with a goodness-of-fit test. Criteria for the goodness-of-fit test include a comparative fit index (CFI), a Tucker-Lewis index (TLI), a root-mean-square error of approximation (RMSEA), and the weighted root-mean-square residual (WRMR). Values of >0.95 for the CFI, >0.95 for the TLI, <0.06 for the RMSEA, and <0.90 for the WRMR are considered to indicate a good fit of the data to the model (27) (30).

Statistical power was considered for this analysis. In path analysis, sample sizes of around 150 to 200 are more desirable (31). With an alpha level of 0.05 and 286 subjects, it is estimated that the statistical power for this study reached 0.95.

Results

The participants were 75 men and 211 women. The age of the study population ranged from 61 to 104, and the mean age ± SD was 84.5 ± 7.9 years (79.1 ± 7.9 years for men and 86.4 ± 6.9 years for women). The mean number of teeth present was 8.6 ± 9.9, and 40.6% of participants were edentulous, while the mean number of teeth present was 14.4 ± 8.9 in 170 dentate subjects. The proportion of participants who did not visit a dental clinic was 75.9%.

Activities of daily living, cognitive ability, and nutritional status according to different categories of oral health status (including number of teeth, denture wearing), and swallowing function are presented in Tables 1 and 2. Subjects having 0 to 19 teeth and no dentures showed lower levels of ADL, cognitive function, and nutritional status than did those who had more than 20 teeth or who wore dentures. Subjects with dysphagia had lower ADL, more severe cognitive impairment, and more malnutrition than those with normal swallowing (Table 3).

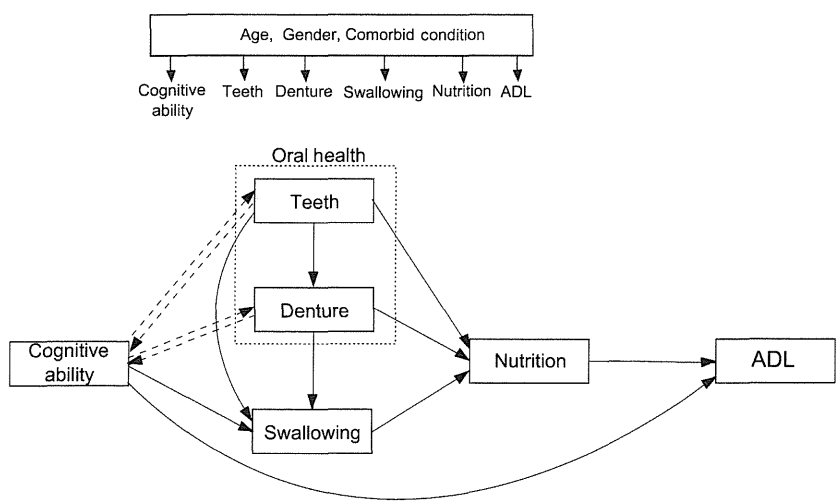

Fig. 2. The hypothesized model. The model consists of nine observed variables including confounding variables such as age, gender and comorbid conditions. Dotted lines indicate paths explored the direction in this study.

Table 1. Functional ability, cognitive function, and nutritional status according to the number of teeth [*n* (%)]

Variable	0–9 teeth (*n* = 179)	11–19 teeth (*n* = 48)	≥20 teeth (*n* = 59)	Total	*P* value
Age, mean ± SD	86.4 ± 7.1	82.8 ± 7.2	80.0 ± 8.5	84.5 ± 7.9	<0.001
Female	144 (80.4)	33 (68.8)	34 (57.6)	211 (71.3)	0.002
Dysphagia	57 (31.8)	16 (33.3)	16 (27.1)	89 (31.1)	0.743
Functional ability (Barthel Index), mean ± SD	57.2 ± 26.7	59.8 ± 28.4	62.1 ± 30.2	58.6 ± 27.7	0.467
Nutritional status (MNA-SF), mean ± SD	10.2 ± 2.1	9.7 ± 2.4	10.3 ± 2.6	10.1 ± 2.2	0.361
Nutrition status category					0.311
Normal (12–14)	52 (29.1)	13 (27.1)	23 (39.0)	88 (30.8)	
Risk of malnutrition (8–11)	105 (58.7)	25 (52.1)	28 (47.5)	158 (55.2)	
Malnutrition (0–7)	22 (12.3)	10 (20.8)	8 (13.6)	40 (14.0)	
Cognitive function (CDR)					0.262
None/Questionable	48 (26.8)	11 (22.9)	23 (39.0)	82 (28.6)	
Mild/Moderate	90 (50.3)	25 (52.1)	28 (47.5)	143 (50.0)	
Severe	41 (22.9)	12 (25.0)	8 (13.6)	61 (21.3)	
Comorbid condition (Charlson Comorbidity Index), mean ± SD	1.3 ± 1.1	1.5 ± 1.2	1.7 ± 1.3	1.4 ± 1.2	0.100

SD, standard deviation.

Table 2. Functional ability, cognitive function, and nutritional status according to oral health status [*n* (%)]

Variable	0–9 teeth, no denture (*n* = 26)	0–9 teeth with denture (*n* = 153)	10–19 teeth, no denture (*n* = 18)	10–19 teeth with denture (*n* = 30)	≥20 teeth, no denture (*n* = 49)	≥20 teeth with denture (*n* = 10)	*P* value
Age, mean ± SD	88.5 ± 6.6	86.1 ± 7.2	81.8 ± 7.5	83.3 ± 7.1	78.4 ± 8.2	87.6 ± 5.4	<0.001
Female	19 (73.1)	125 (81.7)	12 (66.7)	21 (70.0)	26 (53.1)	8 (80.0)	0.005
Dysphagia	15 (57.7)	42 (27.5)	7 (38.9)	9 (30.0)	13 (26.5)	2 (20.0)	0.061
Functional ability (Barthel Index), mean ± SD	38.1 ± 29.6	60.4 ± 24.8	53.9 ± 28.6	63.3 ± 28.2	59.8 ± 30.3	73.5 ± 28.0	0.001
Nutritional status (MNA-SF), mean ± SD	9.2 ± 2.1	10.4 ± 2.0	9.3 ± 2.4	10.0 ± 2.4	10.1 ± 2.8	11.4 ± 1.2	0.041
Nutritional status category							0.313
Normal (12–14)	4 (15.4)	48 (31.4)	4 (22.2)	9 (30.0)	18 (36.7)	5 (50.0)	
Risk of malnutrition (8–11)	16 (61.5)	89 (58.2)	10 (55.6)	15 (50.0)	23 (46.9)	5 (50.0)	
Malnutrition (0–7)	6 (23.1)	16 (10.5)	4 (22.2)	6 (20.0)	8 (16.3)	0 (0.0)	
Cognitive function (CDR)							0.038
None/Questionable	4 (15.4)	44 (28.8)	3 (16.7)	8 (26.7)	17 (34.7)	6 (60.0)	
Mild/Moderate	10 (38.5)	80 (52.3)	9 (50.0)	16 (53.3)	25 (51.0)	3 (30.0)	
Severe	12 (46.2)	29 (19.0)	6 (33.3)	6 (20.0)	7 (14.3)	1 (10.0)	
Comorbid condition (Charlson Comorbidity Index), mean ± SD	1.3 ± 0.9	1.3 ± 1.2	1.1 ± 0.5	1.7 ± 1.4	1.7 ± 1.4	1.6 ± 1.3	0.151

SD, standard deviation.

Path analysis

First, we estimated an initial model with all hypothesized pathways corresponding to the estimated variables directly or indirectly affecting ADL. Then, some insignificant paths were eliminated, and others who showed significant bivariate correlations were added while confirming the model-fit indices. A final model was then estimated with only statistically significant paths retained. The final model was a fairly good fit [χ^2 (14) = 19.805; P = 0.136; CFI = 0.972; TLI = 0.945; WRWR = 0.571; RMSEA = 0.038 (0.001 to 0.074)]. Figure 3 shows parameter estimates for the final path model. The model showed the following

Table 3. Activities of daily living, cognitive ability, and nutrition status with or without dysphagia [*n* (%)]

Variable	Dysphagia (*n* = 89)	Normal (*n* = 197)	*P* value
Age, mean ± SD	84.5 ± 8.6	84.5 ± 7.5	0.991
Female	55 (61.8)	156 (79.2)	0.002
ADL (Barthel Index), mean ± SD	42.8 ± 28.3	65.8 ± 24.3	<0.001
Nutritional status (MNA-SF), mean ± SD	9.3 ± 2.3	10.5 ± 2.1	<0.001
Nutritional status category			<0.001
Normal (12–14)	16 (18.0)	72 (36.5)	
Risk of malnutrition (8–11)	52 (58.4)	106 (53.8)	
Malnutrition (0–7)	21 (23.6)	19 (9.6)	
Cognitive impairment (CDR)			<0.001
None/Questionable	32 (36.0)	60 (30.5)	
Mild/Moderate	35 (39.3)	108 (54.8)	
Severe	22 (24.7)	29 (14.7)	
Comorbid condition (Charlson Comorbidity Index), mean ± SD	1.4 ± 1.1	1.4 ± 1.2	0.976

SD, standard deviation.

significant direct paths: (i) ones from 'Age' and 'Gender' to 'Teeth'; that is, increasing age decreased the number of remaining teeth [β (standardized coefficient) = −0.36] and females had fewer teeth than males (β = −0.14); (ii) one from 'Teeth' to 'Denture'; fewer teeth led to wearing denture (β = −0.79); (iii) one from 'Teeth' and 'Denture' to 'Swallowing'; having many teeth and wearing dentures promoted normal swallowing function (β = 0.78, 0.81, respectively); (iv) one from 'Gender' to 'Swallowing'; female tended to have normal swallowing function (β = 0.22); (v) one from 'Cognitive Ability' to 'Denture' and 'Nutrition'; a high level of cognitive ability led directly to wearing dentures and better nutritional status (β = 0.23 and 0.34, respectively); (vi) one from 'Swallowing' to 'Nutrition'; normal swallowing function promoted normal nutritional status (β = 0.25); (vii) ones from 'Swallowing', 'Cognitive Ability', and 'Nutrition' to 'ADL'; normal swallowing function, a high level of cognitive ability, and normal nutritional status resulted in a higher level of ADL (β = 0.33, 0.26, and 0.35, respectively); (viii) one from 'Comorbid Condition' to 'ADL'; severer comorbid condition caused a lower level of ADL (β = −0.10); and (ix) double-headed arrows among 'Age', 'Gender', 'Comorbid Condition', and 'Cognitive Ability'; age was correlated with cognitive ability, gender, and comorbid conditions. On the other hand, the number of teeth and denture wearing were not directly associated with either nutritional status or ADL.

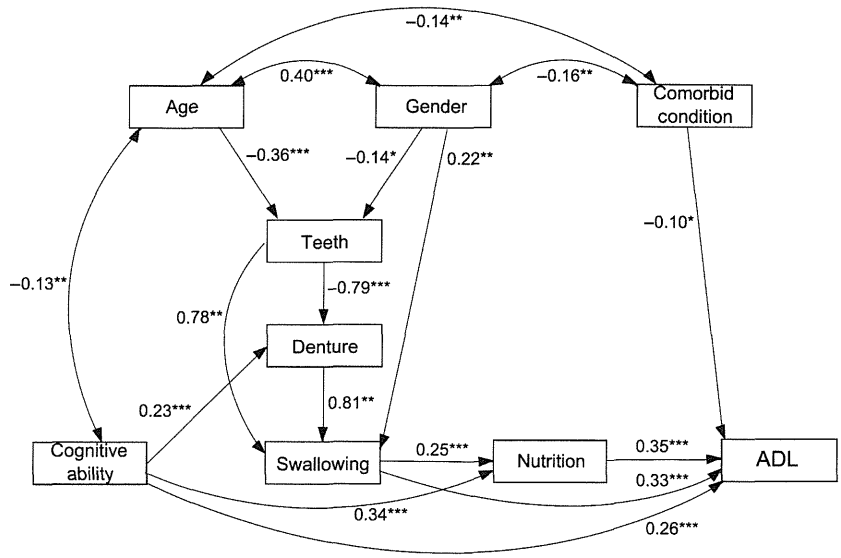

Fig. 3. The final model. Double-headed arrows indicate covariance. All significant values (*$P < 0.05$, **$P < 0.01$, ***$P < 0.001$) indicate standardized coefficients. Continuous variables are 'Age', 'Comorbid Conditions' (Charlson Comorbidity Index), 'Nutrition' (MNA-SF), 'Teeth', and 'ADL' (Barthel Index). Categorical or ordered variables are 'Gender' (1 = male, 2 = female), 'Dentures' (0 = not wearing, 1 = wearing), 'Swallowing' (0 = dysphagia, 1 = normal swallowing function) and 'Cognitive Ability' (1 = severe cognitive impairment, 2 = moderate, 3 = mild, 4 = questionable, 5 = none).

Discussion

This study showed the complex pathway from cognitive ability and oral health status via swallowing function and nutritional status to ADL in aged Japanese people living at home and receiving home care, using path analysis. To the best of the authors' knowledge, this is first study to show the interaction between multiple factors leading to a decline in ADL. Path analysis is an analytical technique that allows the testing of causal models using cross-sectional data. Possible pathways leading to ADL decline, based on our findings and those of previous studies, are as follows. Having fewer teeth leads to wearing dentures, but severe cognitive impairment disrupts denture wearing because of problems in accessing dental care; chewing difficulties resulting from having fewer teeth and no dentures can lead to dysphagia; dysphagia impairs the ability of elderly people to consume adequate amounts of food to meet their nutritional needs, leading to malnutrition (16); cognitive impairment, in turn, causes potential problems related to the inability to eat or to lack of access to food (32), hence leading to malnutrition. Swallowing function, cognitive ability, and nutritional status had direct effects on ADL. This finding agrees with previous studies in elderly people (9, 13). Malnutrition and cognitive impairment are associated with poor muscle strength and reduced physical performance (33), leading to disability, which reduces the ability to perform the basic activities of daily living. Although the effect of oral health status on ADL was indirect in this study, we cannot ignore it because of the moderate association between oral health status and swallowing function. Understanding various factors related to deterioration in ADL among these subjects would contribute to considering a multilateral approach for maintaining ADL in elderly people who are living at home.

The results of the present study suggested that oral health status, as measured by indicators such as the number of teeth and denture wearing, had a direct effect on swallowing function. A previous study reported that laryngeal penetration, usually because of neuromuscular disorder, occurs with much greater frequency in edentulous elderly people who are not wearing dentures than in those who dentulous (34). In our study, when the effect of denture wearing on swallowing function in edentulous persons was examined, 10 of 15 edentates (66.7%) without dentures showed dysphagia, whereas 29 of 101 edentates (28.7%) wearing dentures did. Tamura et al. described that wearing dentures and keeping the appropriate mandible position and proper occlusion were important for smooth swallowing in elderly individuals (35). Additionally, loss of occlusal support and loss of mandibular stopping by occlusion may disturb the coordination of swallowing function (34).

In this study, we did not find a statistically significant association between oral health status and nutritional status in the path analysis. This finding conflicts with those of previous studies (11, 12). There may be at least two reasons that oral health status was not associated with nutritional status in the present study. First, our path model included some factors related to nutritional status, such as oral health status, swallowing function, cognitive ability, and ADL. However, previous studies (11, 12) that demonstrated an association between oral health status and nutritional status failed to incorporate these factors into their analyses. Probably, because factors other than oral health status more strongly affect nutritional status, the relationship would be less obvious in our study. Second, even when elderly people do not have enough teeth, do not wear dentures, and do not chew satisfactorily, food preparation by a caregiver may make food easy to chew and thereby prevent nutritional deterioration. Nutritional status was related to swallowing function, but not to oral health status, in this study, suggesting that swallowing function may have a greater direct effect than chewing ability on malnutrition. However, there was an association between swallowing function and oral health status in our study, and oral health status may still indirectly influence nutritional status.

Our results suggest that maintaining or improving oral health status and swallowing function indirectly or directly contribute to preventing a decline in ADL in elderly people who require home care. Yoneyama et al. (36) reported that oral care reduced febrile days and the risk of pneumonia in older patients receiving nursing care. These findings indicate that dental interventions, such as provision of dentures, treatment for dental caries or periodontal disease, professional oral care, swallowing training, and oral care training for caregivers, have a beneficial indirect effect on general health in those requiring long-term nursing care. However, our results also showed that 75.9% of participants had not received dental treatment; many elderly people requiring home care have difficulty in gaining access to professional dental care. Further efforts are needed to develop a long-term

care system or community system that provides ready access to dental services.

Our study had some limitations. Using path analysis, our study made causal inferences about the relationships among various factors related to ADL; however, the cross-sectional design means that we cannot rule out reverse causation. Further longitudinal study is needed to examine a temporal relationship. Second, we did not incorporate sociological factors, such as socioeconomic status and education level, into this study. Several studies have reported a relationship between sociological factors and oral health status, ADL, cognitive ability, and nutritional status (9, 37–39). ADLs are associated with psychosocial factors (9). Because sociological factors and psychosocial factors were considered to have more indirect effects on ADL than oral health status, cognitive ability, and nutritional status, we did not gather this information in this survey. Third, we did not assess the prevalence of specific oral diseases such as dental caries and periodontal disease. Finally, we recruited the subjects using an in-home long-term care support center in two midsized municipalities in Japan. Our sample may limit the ability to extrapolate our findings to all Japanese elderly people. Caution is warranted in generalizing our findings to the rest of the Japanese population.

In conclusion, based on the present study, we propose a potential causal pathway by which oral health status directly affects swallowing function, and dysphagia, cognitive impairment, and malnutrition directly or indirectly affect ADL in elderly people living at home and receiving home nursing care. These findings suggest that maintaining the number of teeth from a younger age and wearing dentures when teeth are lost may indirectly reduce malnutrition and subsequent ADL decline in these people.

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ORIGINAL ARTICLE: EPIDEMIOLOGY, CLINICAL PRACTICE AND HEALTH

Effects of the reappearance of primitive reflexes on eating function and prognosis

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Aim: Primitive reflexes can reappear with diseases of the brain, particularly those affecting the frontal lobes. Most studies on primitive reflexes have reported an association between such reflexes and brain damage, and the clinical symptoms of dementia. These reflexes can also be present during eating; however, their effects on eating function are difficult to evaluate. The purpose of the present study was to identify the frequency at which primitive reflexes reappear in elderly people, and to determine the effects that such reflexes have on eating function, nutritional status and prognosis.

Methods: We followed 121 nursing home residents for 6 months. All patients required long-term care and were examined for the presence of a sucking reflex, snout reflex and phasic bite reflex for baseline measures. Demographic characteristics, physical and cognitive function, and nutritional status were obtained from chart reviews, interviews with nurses, and a brief physical examination at baseline and incidence of aspiration pneumonia during the study period.

Results: The sucking reflex was confirmed in 31 patients (25.6%), snout reflex in 15 patients (12.3%) and phasic bite reflex in 28 patients (23.1%). One or more of these reflexes was identified in 38 patients (31.4%). A relationship between the presence of a primitive reflex and nutritional status was shown. An association with the presence of these reflexes and the development of aspiration pneumonia during 6 months was also confirmed.

Conclusions: The appearance of primitive reflexes appears to be associated with the risk of malnutrition and developing aspiration pneumonia. **Geriatr Gerontol Int 2014; 14: 190–197.**

Keywords: dementia, dysphagia, elderly people, nutrition, primitive reflexes.

Introduction

Primitive reflexes are observed during the neonatal and infant periods, but later they recede as a result of cerebral cortex inhibition and brain stem activity.[1] However, they reappear in healthy elderly people and in patients with diseases of the nervous system.[2,3] It is also known that the incidence at which these reflexes reappear increases with age.[4,5] They can also reappear as a result of trauma to the brain.[6] Although any combination of these reflexes is considered to be indicative of damage to cognitive function, it is believed that this relationship is a result of age and is not in itself specific for brain disease.[7] It has been reported that in cases of Alzheimer's disease or cerebrovascular dementia, a relationship can be identified between the appearance of primitive reflexes and the severity of damage to cognitive function.[8] In contrast, no association with a decline in cognitive function has been recognized.[4]

The major primitive reflexes in the oral cavity are the sucking reflex, snout reflex and phasic bite reflex. Most studies on primitive reflexes to date have reported an association between such reflexes and brain damage, and the clinical symptoms of dementia. As these reflexes can also be recognized during eating, their effects on eating function cannot be ignored. Nevertheless, the association between these reflexes and eating function

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or nutritional status is unknown. In the many studies of elderly patients in long-term care, there is a high incidence of malnutrition.[9] Problems associated with malnutrition include reduced immunity and increased susceptibility to infection.[10] Malnutrition is also a risk factor for respiratory tract infections, including aspiration pneumonia[11] and in-hospital infections.[12] Furthermore, it has been found that malnutrition can result from masticatory disorders due to tooth loss,[13,14] but there have been no reports of malnutrition resulting from masticatory disorders due to motor impairment.[15] The purpose of the present study was to determine the incidence of primitive reflexes in older adults living in nursing homes, and to identify the effects of such reflexes on eating function, nutritional status and prognosis.

Methods

The participants were 121 of 127 elderly patients who lived in two nursing homes in Tokyo, Japan, and who required care (mean age 86.1 ± 7.9 years; 33 males [81.6 ± 8.3 years]; 94 females [87.7 ± 7.2 years]). Individuals under nutritional management by feeding tube were excluded.

The criterion for patient selection was that physical symptoms and cognitive impairment must have been stable for the preceding 3 months. During this 3-month period, no patient had acute disorders (e.g. severe infection, heart failure, or stroke requiring special treatment or intensive care).

In addition, the association between primitive reflexes and nutritional status was examined in 110 participants (mean age 86.2 ± 7.6 years; 30 males [82.4 ± 7.6 years]; 80 females [87.7 ± 7.2 years]) whose serum albumin could be measured. Under the approval of the Ethics Committee in the School of Life Dentistry, Nippon Dental University, the present study was carried out after obtaining informed consent from the participants or their families. The Clinical Dementia Rating (CDR)[16] was used for evaluating cognitive functions, and the Barthel Index[17] was used for evaluating activities of daily living (ADL). The basic survey was conducted in May 2009 and the subjects were then observed over the course of the next 6 months.

The protocol for this study was approved by the Ethics Committee of the Nippon Dental University School of Life Dentistry at Tokyo (#09–11).

Primitive reflex evaluation methods

The presence of primitive reflex was evaluated at the beginning of the present study.

Using the methods of Paulson,[18] participants were examined in the mornings in a quiet room of the nursing home for the presence or absence of a sucking reflex, snout reflex or phasic bite reflex.

Primitive reflexes were evaluated as follows by the same dentist:

Sucking. Incomplete sucking, with only weak contraction of the orbicularis oris muscle, or full sucking, with sucking movements of the tongue and pharynx, after the tip of the patient's index finger is firmly placed between his closed lips.

Snout. Weak puckering or protrusion of the lips, with elevation of the lower lip, after the examiner taps lightly on the midline of the subject's upper lip with his index finger.

Phasic bite. Vertical movement of the lower jaw, as in mastication, after the examiner presses downward with one finger on the molar region of the lower jaw.

Physical and oral examinations

ADL and cognitive functions

In the results of evaluation using the Barthel Index,[17] ADL was considered stable at 45 points or more, but as having declined at 40 points or less. In the present study, based on the results of evaluation by CDR, cognitive function was considered normal at code 1 or lower, and decreased at code 2 or higher.

Nutrition indicators

Nutritional status was evaluated at baseline.

Bodyweight and height were measured and body mass index (BMI) was calculated. In addition, blood samples were taken for the measurement of serum albumin. Values less than 3.5 mg/dL were considered to indicate malnutrition. The texture of the food served at each of the nursing homes was also recorded. Participants who could not ingest an adequate amount of calories as a result of dysphagia were supplemented with high-calorie foods; the participants supplemented with ≥200 kcal per day were assigned to a dietary supplementation group.

Swallowing function

Participants were asked to swallow 3 cc of water and underwent auscultation of the cervical area after swallowing. If choking was produced in conjunction with swallowing or if a wet or gargling sound was detected by auscultation, the participant was considered to have dysphagia.

Other

Medical information at the nursing facilities was examined in order to determine whether the participants had

a history of aspiration pneumonia over the past 12 months. Aspiration pneumonia was diagnosed by a medical doctor.

Statistical analysis

For comparison of two groups, unpaired *t*-tests were used. To examine the independence of each group, χ^2-tests were used. The presence or absence of malnutrition and the development of aspiration pneumonia during 6 months were evaluated as dependent variables. Associated factors were screened by means of logistic regression analysis. For the selection of variables, the stepwise method was applied. All statistical analyses were carried out using the Japanese version of SPSS for Windows (version 16; IBM Japan, Tokyo, Japan), and *P*-values less than 0.05 were considered to be significant. Numerical values in this text are expressed as mean ± standard deviation.

Results

The mean ages of the participants were 87.7 ± 7.2 years for females and 81.6 ± 8.3 years for males, which was a significant difference ($P < 0.001$). The mean Barthel Index was 29.6 ± 27.2; 41.9 ± 28.9 for males and 27.2 ± 25.5 for females, which was significantly different ($P < 0.05$). No sex-based differences in CDR were noted.

Present rate of primitive reflexes

The sucking reflex was noted in 31 (25.6%) participants (mean age 87.7 ± 8.3 years), the snout reflex was found in 15 (12.4%) participants (mean age 86.8 ± 9.3 years) and the phasic bite reflex was found in 28 (23.1%) participants (mean age 86.8 ± 7.6 years). All three reflexes were observed in 11 (9.0%) participants (mean age 89.6 ± 6.8 years). The sucking reflex plus the snout reflex were present in three (2.5%) participants (mean age 81.0 ± 13.8 years), the sucking reflex plus the phasic bite reflex were found in 10 (8.3%) participants (mean age 85.9 ± 9.2 years), the snout reflex plus the phasic bite reflex were found in one (73.0 years) participant, the sucking reflex alone was noted in seven (5.8%) participants (mean age 90.0 ± 5.9 years) and the phasic bite reflex alone was noted in six (5.0%) participants (mean age 85.7 ± 2.1 years); the snout reflex alone was not observed in any participants. One or more of these reflexes were found in 38 (31.4%) participants (mean age 86.9 years).

Relationship between primitive reflexes and characteristics

The presence of primitive reflexes was observed in a large number of participants who had a decline in cognitive function and/or a reduction in ADL. It was also recognized that a significant number of participants often ate foods in which the food texture was modified. In those who showed the sucking reflex, insertion of dentures in either the upper or lower jaw was very difficult. No relationship between age and the appearance of primitive reflexes was noted (Table 1).

Primitive reflexes and nutritional status

A relationship was found between the presence of primitive reflexes and current bodyweight (sucking reflex $P = 0.042$; snout reflex $P = 0.028$). In addition, a relationship was observed between the appearance of the phasic bite reflex at 6 months or 12 months and the rate of change in bodyweight (6 months $P = 0.009$; 12 months $P = 0.042$). The presence of the sucking reflex and phasic bite reflex was also related to serum albumin levels (sucking reflex $P = 0.015$, phasic bite reflex $P = 0.0001$). Participants who had any of the primitive reflexes showed a relationship between bodyweight and serum albumin levels (bodyweight $P = 0.022$, serum albumin level $P = 0.0001$; Table 2).

A serum albumin level of less than 3.5 mg/dL was considered to show malnutrition, and the relationship with each evaluation parameter was investigated.

The following results were obtained: presence/absence of assistance in eating ($P = 0.003$), sucking reflex ($P = 0.005$), snout reflex ($P = 0.02$), phasic bite reflex ($P = 0.001$), participants with some type of primitive reflex ($P = 0.003$) and age (76 participants with adequate nutrition, aged 85.1 ± 7.8 years; and 34 participants with malnutrition, aged 88.7 ± 6.7 years; $P = 0.025$). Malnutrition, viewed in terms of serum albumin levels, was taken as the response variable. Significant parameters (assistance in eating, some type of primitive reflex and age) were taken as explanatory variables, and in the logistic regression analysis, age and appearance of some type of primitive reflex were selected as significantly independent explanatory variables (age: exp = 1.070, 1.007–1.137, $P = 0.029$; some type of primitive reflex: exp = 3.886, 1.582–9.545, $P = 0.003$; Table 3).

Relationship between primitive reflexes and developing aspiration pneumonia

In the course of the study, 22 participants with a mean age of 86.9 ± 8.8 years (9 males: mean age 83.6 ± 6.6 years; 13 females: mean age 89.1 ± 9.6 years) developed aspiration pneumonia. The relationship between each evaluation parameter and the onset of aspiration pneumonia was investigated. Relationships were identified between aspiration pneumonia onset and ADL ($P = 0.026$), sucking reflex ($P = 0.022$), phasic bite reflex ($P = 0.009$), and some type of primitive reflex ($P = 0.011$; Table 4).