発表者氏名	論文タイトル名	発表誌名	巻号	ページ	出版年
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中谷友樹	「健康な街・不健康な街」を視る-GIS を用いた小地域における地理的健康格差の視覚化-	日循予防誌	46(1)	38-55	2011
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齋藤義信、小熊祐子、井上茂、他	移動および余暇の歩行行動に関連する環境要因－藤沢市在住の60～69歳を対象とした横断研究－	運動疫学研究			In press
Tudor-Locke C, Craig CL, Inoue S, et al	How Many Steps/day are Enough? For Adults	Int J Behav Nutr Phys Act.			In press
Inoue S, Okada S, Kamada M, Nakaya N, Shimomitsu T, et al	Perceived neighborhood environment and walking for specific purposes among Japanese elderly	J Epidemiol			In press

Ⅳ. 研究成果に関する刊行物・別冊

連載

運動・身体活動と公衆衛生(4)
「身体活動と環境要因」

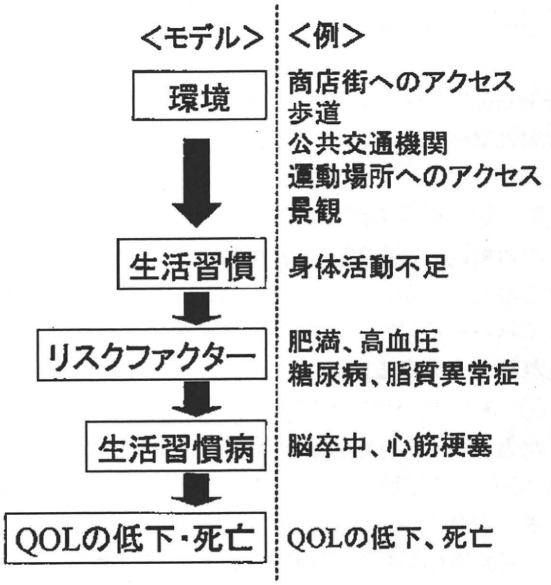
東京医科大学公衆衛生学講座　井上　茂

1. 環境要因が注目される背景

身体活動の推進は公衆衛生学上の重要課題である。効果的な対策を実施するためには，その決定要因を明らかにして，これらの要因にアプローチする必要がある。これまで身体活動の決定要因に関する研究は，個人の社会的要因や心理的要因に関するものがほとんどであった。そして，これらの研究成果をもとに多くの介入研究が実施され，一定の成果をあげてきている。しかし，介入に要するコスト，効果の持続性，モチベーションに欠ける対象者へのアプローチ方法など，課題も多く残されており，個人を対象とした介入によって，国民全体の身体活動レベルをどこまで変えることができるのかは未知数の部分が大きい。ここで注目されるのが個人を取り巻く環境である（図1）。人々の身体活動はどのような環境で高まるのだろうか？　ある地域では住民の身体活動レベルが高いのに，ある地域では低い（実際に日本人の歩数は都会で多く地方で少ない）とするならば，やはり「環境」には無視できない影響力があると考えるべきだろう。また予防医学の戦略上も「環境」は重要である。予防医学の方法として，ハイリスク戦略，ポピュレーション戦略という考え方があるが，これまで生活習慣病対策で積極的に行なわれてきたのは主にハイリスク戦略であった。一方，ポピュレーション戦略には方策に欠ける面があり，有効な方法が確立されているとは言い難い。環境介入の確立がポピュレーション戦略の手法として期待されている。

このような背景のもと，最近，身体活動の分野において環境に関する研究が盛んになってきている。環境が一人ひとりの行動（身体活動）に及ぼす影響は，あるいはさほど大きくないかもしれないが，環境はそこに生活する全ての人に（活動的な人にも，不活動で行動変容のモチベーションが低い人にも）影響を与え，その効果は長期間にわたる。したがって，集団全体で見ると相当のインパクトが期待できる。現在，病院，地域，職域等で行われている生活指導も，良好な環境のもとでより効果的に実施されるだろう。

図1　環境と生活習慣病



2. 身体活動支援環境とは

表1にこれまでの研究で検討されてきた環境要因の例をまとめてみた。環境に関する研究は地理学，都市計画学などとの協力により進められてきた経緯があるため，いくつかの概念は公衆衛生学の研究者には目新しいものとなっている。この表では類似した要因をできるだけまとめたが，それぞれの要因を細分化してより詳細に検討することも可能である。最近，環境が歩行に適しているかどうかを表現する言葉としてwalkabilityという用語が使われており，表に示した要因を組み合わせてインデックス化し，walkability indexとして扱っている研究もみられる。

この他にも気候，大気汚染，ソーシャルサポート，野良犬，近所づきあいなど，様々な要因が研究の対象になっている。現在のところ，研究者の関心は「介入できるもの」，「客観的に評価できるもの」に向かっており，physical environment，あるいは

表1　身体活動支援環境の例

身体活動支援環境	内　　容
土地利用の多様性	住居，商業，就業，教育等の機能が混在した土地利用となっているかどうか。多様性の高い地域では，たとえば商店街や職場が近接していて歩く機会が増えると考える
運動場所へのアクセス	運動施設，遊歩道，公園等の利便性が良いかどうか
公共交通機関の利便性	駅，バス停等へのアクセスがよく，公共交通機関が整っているかどうか
歩道	歩道の存在，整備状況
自転車道	自転車道の存在，整備状況
交通安全	安全に歩いたり，自転車に乗ったりできるかどうか
治安	犯罪が少なく，安心して外出できるかどうか
景観	地域の景観がよいかどうか。景観は単に自然の景色だけでなく，街並みが美しい，建物に個性がある，清掃が行き届いているといったことも含まれる

built environment と呼ばれる環境要因が主な研究の対象となっている。

3.　環境要因の評価方法

それでは，身体活動支援環境はどのように評価できるのだろうか。これまで行われてきた研究を整理してみるとその評価方法は大きく以下の3つに分けられるようである。

①　質問紙を用いた方法

たとえば，「自宅近くに商店街はありますか」，「自宅近くに運動施設はありますか」，「近所を歩くとき，安全に歩くことができますか」といったように，対象者の環境の認知を尋ねる方法である。対象者の主観によっているため，この方法で評価された環境は perceived environment，subjective environment などと呼ばれている。

②　チェックリストなどによる観察

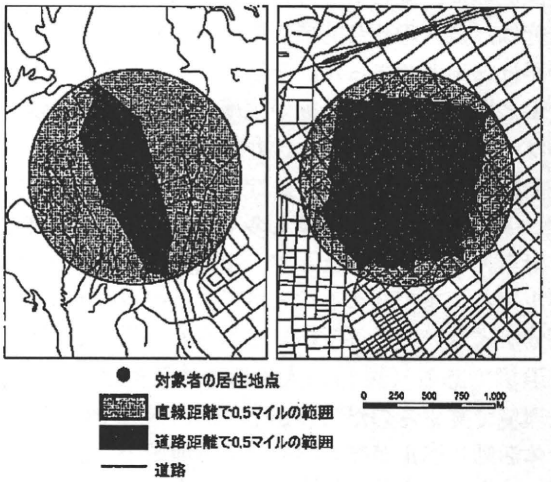
評価対象の地域を観察し，研究者がチェックリストに沿って評価する方法である。

③　地理情報システムを用いた評価

地理情報システム（GIS: Geographic information system）とは位置情報を含む情報を地図上に表示したり，空間的な解析行ったりするソフトである。このソフトを活用するには，道路の構造，運動施設の位置，施設の種類，土地利用の状況などのデータベースが必要となる。データは調査により新たに収集するか，政府統計等の既存データを用いる方法が考えられる。②の方法も含めて，評価の客観性が高いことより objective environment と呼ばれている。

どの方法を用いる場合でも，物理的な環境を評価するには，まず評価の対象となる環境の空間的な広がりを定義する必要がある。最もよく研究されているのは「自宅周辺の環境」だが，「職場，あるいはその周辺の環境」，「町丁，市町村などの行政単位」などを評価の対象とした研究も散見される。空間の大きさをどのように定義するのかも問題となる。質問紙等では「自宅から歩いて10–15分程度の範囲」といった具合に，環境の広がりが定義されることが多い。また，GIS を用いた評価では，自宅から1/2マイル，1 km, 1マイルなど様々な範囲が想定されている。どのような大きさで環境を評価すれば最もよく身体活動が予測できるのかは十分に明らではない。さらに，GIS による評価では，空間の広がりとして単純な半径を想定するのではなく，図2のようにネットワーク距離を考慮して環境の評価範囲を決める方法も用いられている。左図は道路のネットワークが悪い地域のため，500 m の道路距離で到達できる範囲が，右図に比較すると非常に小さい。このように道路距離で定義にした範囲における境（たとえば，運動施設の数，商店の数など）を評価しようという考え方である。

図2　道路距離に着目した環境範囲の設定



4.　環境と身体活動との関連

環境と身体活動に関する研究はこれまでのところ

そのほとんどが横断研究で実施されている。表1に示した環境要因は，何らかの形で身体活動と関連しているようだが，研究によってその結果は必ずしも一致していない。その原因の一つとして，「環境と行動の特異的な関係」が指摘できる。たとえば，同じ身体活動であっても，「運動」と日常生活の中で行う「生活活動」ではその決定要因が異なってくるだろう。運動施設へのアクセスは「運動」習慣と関係するかもしれないが，「生活活動」にはあまり関係しないかもしれない。また，環境と身体活動との関連は，対象者の性別，年齢，社会的状況によって異なるだろう。たとえば，歩行に影響している環境を考えるとき，高齢者では交通の安全性が重要かもしれないが，健常な若年者ではその影響は小さいかもしれない。このように，身体活動と環境との関連は，対象者の属性，行う身体活動の種類によって異なることが予想される。したがって，このことを十分に考慮していない研究では，環境と身体活動との特異的な関連を見逃してしまう可能性がある。最近の研究では特定の種類の身体活動と環境との関連を，特定の対象者で検討する研究が増えてきている。

5. 環境への介入

環境への介入研究はまだ少ないが，いくつかの先進的な試みがなされているようである。これまで行われてきた研究をもとに，環境介入に関するいくつかのアイディアを列記してみたい。

1) 人々の環境の認知を変える

身近に身体活動を行なえる施設や設備があっても，その存在や利用方法を知らなければ身体活動は行われない。したがって，身体活動支援環境に関する情報発信を強化する方法が考えられる。保健指導にあたる指導者は身体活動支援環境の存在を十分に把握しているだろうか？　最近，地域でウォーキングマップを作成する活動などがみられるが，既存の道路，歩道をウォーキングに適した設備と考えて情報を発信していることになる。これもこのカテゴリーの対策の一つと考えられる。

2) 既存の施設・プログラムの利便性の向上

既存の施設・プログラムは住民にとって利便性の高いものだろうか？　運動施設がそこにあることと，これが利用しやすいかどうかは別の問題である。環境の研究では「アクセス」という用語が好んで用いられるが，本来この用語は単に目的とする対象がそこに存在するかどうかだけを問題にしたものではなく，利便性が高いかどうか，魅力があるかどうかをも含めた概念である。施設を訪れたり，プログラムを利用したりするのはどんな人で，どこから，どのような交通手段を用いてやって来るのだろうか？　施設の利用時間帯，利用料金，利用資格等は十分に検討されただろうか？　利用してほしい住民と，実際に利用している住民に違いはあるだろうか？　このように利便性の向上に関する視点は多い。既にある施設の有効活用も環境介入の一つと考えられる。

3) 都市計画など多分野の専門家との協力

たとえば，土地利用の多様性が身体活動に影響しているとしても，このエビデンスをどのように街づくりに生かしていくことができるかのアイディアは，我々保健医療職だけでは十分に発想できない。したがって，地理学，都市計画学，都市交通学，犯罪学，教育学など多分野の専門家の協力が不可欠である。たとえば，都市計画の分野では「コンパクトシティー」と呼ばれる街づくりの考え方がある。これは住居，就業，商業，医療，教育，娯楽といった多様な都市機能をコンパクトに集積した土地利用（街づくり）を目指すもので，これによって，環境負荷の少ない持続可能な都市を構築しようとするものである。身体活動の視点からは walkability の高い街づくりといえるだろう。最近コンパクトシティをコンセプトとした街づくり計画を掲げる都市もあり，このような流れの中に walkability のアイディアを加えることも身体活動推進の効果的な対策となりうる。このように，様々な分野と協力することにより，新しい対策のアイディアが生まれてくる。

4) セクター間の協働の推進

人が歩く街づくり，歩道や公園の整備，交通の安全の確立，スポーツの振興などの環境整備にあたり，健康関連部門だけで事業展開することは困難な場合が多い。しかし，街づくりにせよ，歩道の整備にせよ，事業は日々展開されており，土木，都市交通，教育などの関連部門はこれらを実施するための予算を持っている。したがって，環境整備のカギは，費用面以上に行政内での連携，協働体制の確立にかかっていると言えるだろう。他部門との協力により環境整備事業は格段に促進できるものと考えられる。

5) 環境を規定する法律，施策への介入

現在の環境を決定している法律や施策はどのようなものだろうか？　たとえば，都市計画に関する法律や施策は身体活動支援環境を規定しており，人々の身体活動に影響していると予想される。これらの要因を同定してこれに介入することも課題である。喫煙対策における健康増進法の成果はよい前例といえるだろう。

6. 今後の課題

これまで環境に関する研究の多くは米国，オーストラリアで実施されてきた。ここで得られた結論がヨーロッパや日本，あるいは地球上の他の地域でも成り立つかどうかは明らかでない。日本の環境には，日本での研究が必要と考えられる。また，これまでの研究の限界点として，環境や身体活動の評価方法として質問紙を用いた研究が多いこと，ほとんどが横断研究であったことなどが指摘できる。今後は，評価尺度としては客観的な手法（環境ならば環境観察やGISを用いた方法，身体活動ならば歩数計や加速度計）を加えていくこと，研究デザインの面からは縦断研究，介入研究を実施することが期待されている。

この研究分野に対する認知や理解はまだまだ十分とは言えない。本稿では介入のためのいくつかのアイディアを述べたが，これらを実現するためには，この研究分野の議論の盛り上がりと，多くの人々を納得させるより強力なエビデンスの確立が必要と考えられる。

次回は，「日常生活における生活活動評価の重要性」について，独立行政法人 国立健康・栄養研究所の田中茂穂先生にご報告いただく予定です。

連載

運動・身体活動と公衆衛生(11)
「社会のニーズにこたえる運動疫学研究を」

東京医科大学　公衆衛生学講座　下光　輝一

1.　はじめに

内藤義彦氏の企画である今回の連載は，大変時宜にかなった企画である[1]。国の健康づくり施策が，健康日本21からメタボリックシンドロームの概念を導入した特定健診・保健指導へと展開する中で，「1に運動，2に食事，しっかり禁煙，最後にクスリ」というようなスローガンが掲げられているように，健康づくりにおける身体活動・運動の重要性がかつてないほどに高まってきている。しかるに，身体活動・運動と健康に関する疫学研究のエビデンスや身体活動・運動推進の方策に関する研究の蓄積は未だ十分とは言えない。この分野における我が国の研究の現状を憂いた有志が結集し1998年9月15日に運動疫学研究会を設立してから10年が経過した。ようやく，本誌に「運動・身体活動と公衆衛生」と題した連載を組むことができるまでになった，といえるかもしれない。これまでの連載を読みながら，研究会発起人の一人として，若手研究者の成長とこの分野の研究の深化と広がりを実感しているところである。

2.　運動疫学研究会の発足と健康日本21

運動疫学研究会発足時の状況について，少し述べてみよう。1988年より開始された国の第2次国民健康づくり施策「アクティブ80ヘルスプラン」は，栄養・運動・休養を健康づくりの三要素として施策が展開された。1989年には「健康づくりための運動所要量」が策定されたが，そのエビデンスについては，わが国における運動や身体活動に関する疫学研究の蓄積が少なかったが故に乏しいものであった。当時のわが国の体力・スポーツ医科学研究は，日本体力医学会などを中心に行われていたが，運動生理学的研究や臨床医学的研究が主であり疫学的手法を用いた研究が少なかったのである。また，疫学的研究についても，そのほとんどが横断研究であり，因果関係を推定することのできるコホート研究や症例対照研究，さらには運動の効果を実際に調べることのできる介入研究などはきわめて少なかった。すなわち，身体活動や運動の疾病発症や健康に与える影響について因果関係を証明し，それを予防や対策に役立てうる研究が乏しかったのが現状であった。このように体力・スポーツ医科学の分野で，疫学的研究手法と知識が要求される時代となりつつあるにもかかわらず，わが国においては，この分野の研究者の層の薄さと指導者の不足に直面していたのである。一方，疫学の専門家が集う日本疫学会は比較的新しい学会であり，当時は運動や身体活動に関する研究が比較的少なく，運動や身体活動の健康への影響や評価方法もあまり論議されていなかった。

このような中で，体力・スポーツ医科学の分野において疫学的手法を駆使した質の高い研究を数多く生み出し，わが国の健康増進・疾病予防に貢献すること，および，21世紀の体力・スポーツ医科学研究と運動疫学研究を担う若手研究者の育成を目的として1998年に運動疫学研究会が設立され，「運動疫学研究」が発刊されることになった[2~4]。

当時は，少子高齢社会の到来の中で，国民の疾病予防と健康づくりは喫緊の課題となりつつあり，国の健康づくり施策も2次予防から1次予防へ，さらには健康増進へと施策の重点がシフトしつつある中で，第2次国民健康づくり施策「アクティブ80ヘルスプラン」が1997年に終了し，2000年より新たな健康づくり施策「健康日本21」が開始されるところであった。この施策の策定にあたり厚生省（現厚生労働省）は，生活習慣病予防と健康づくりを目的として，栄養・食生活，身体活動・運動など5つの生活習慣と，歯周病，糖尿病，循環器病，がんの4つの生活習慣病の合計9項目についてむこう10年間の計画の数値目標を設定することとした。

ちょうど発足したばかりの運動疫学研究会の川久保清氏，荒尾孝氏と筆者の3人は，1999年春に厚生省より身体活動・運動に関する分科会の委員を委嘱され，至急目標値を設定するよう依頼された。「健康日本21」は，一言で云えば，国民の疾病による早世と高齢期における障害を防止し，生涯にわたり高いQoLを維持することにより健全で持続可能な社会を創造することを目的として，良い生活習慣の獲

得と生活習慣病予防のためのエビデンスに基づいたゴール(目標値)を設定し，高リスク者へのアプローチだけでなく国民や地域住民を対象としたポピュレーションアプローチによって目標の達成を図り，国民全体の行動変容を促そうというものである。そのためには，個人個人が主体的に健康づくりを行うばかりでなく，家庭，職場，学校，地域，メディア，保険者，保健・福祉の専門家，医学研究者というような環境の支援の下に実現していこうというものであり，1986年にオタワで開かれた第1回ヘルスプロモーション国際会議におけるヘルスプロモーションの理念を体現しようとするものである。

このような「健康日本21」の戦略的背景の下に，身体活動・運動分科会は，従来の「運動・スポーツによる心肺持久力の向上」から「身体活動量を高めることによる疾病予防と健康増進へ」という流れを受け，国民の身体活動を高めることを目標に国民の身体活動・運動推進のための具体的な目標値を設定しようと試みた。

まず，分科会は，どのような種類の身体活動や運動・スポーツをどの程度の強さでどのくらいの頻度で推奨したらよいか，なぜ身体活動・運動を推奨するのか，その効果はどの程度で，また年令，性などによりどう異なるのか，その効果をどのように評価するか，など様々な問題について討議したが，それらの検討に必要なわが国における集団，地域，国レベルでの疫学的なエビデンスが極めて少なく，欧米の研究成果を借りながら討議せざるを得ない状況であった。また目標値の設定にあたっては，国民の身体活動・運動の現状を調べたベースラインデータに乏しく，かろうじて国民栄養調査で行われていた性年代別の運動習慣者の割合と一日の歩数があるのみであった。これをもとに目標値設定を試みざるを得なかったのである[5,6]。

3. 米国における身体活動・運動推進のための勧告

米国における身体活動・運動に関する研究と施策とのかかわりをみてみると，身体活動・運動に対する勧告は，1990年に出された「活発な（vigorous）有酸素運動を少なくとも20分，3回以上行うこと」（米国スポーツ医学会ACSM）というものから，それまでの運動と健康に関する疫学研究などの成果の蓄積を基に，「少なくとも30分の中等度の（moderate）強度の身体活動を，週のほとんど毎日行うことが望ましい」(1995年の米国疾病予防管理センターCDCとACSMの身体活動・運動推進のためのガイドライン）というものに変化した。これは運動の推進から運動を含んだ日常生活における身体活動を推進するというものに大きく変換したことを意味し，いわばパラダイムの変換ともいうべきものであった。これを受けて1996年には膨大な疫学研究をまとめた報告書が米国政府により発表された（Surgeon General Report)。さらに最近では，2007年にACSMと米国心臓病学会AHAの合同で新しいガイドラインが発表され，また，2008年10月には米国保健福祉省から国民に向けた詳細なガイドライン「米国人のための身体活動ガイドラインが発表された[7]。Surgeon General Reportや2008年の身体活動ガイドライン作成にあたっては，関連するあらゆる研究分野の第一線の研究者が集まり総力で作成にかかわっており，実際に圧倒されるほど膨大で詳細な内容の報告書が書かれている。もともと人口が倍以上の国の規模の相違と言ってしまえばお終いだか，国のガイドライン作成と前後して，ACSMやAHAなどの学協会がエビデンスに基づいたしっかりとしたガイドラインを作成し定期的に改定していることが素地にあるのではないか。翻って考えると，わが国では関連する学協会が積極的に研究成果に基づいた身体活動や運動推進のためのガイドラインを作成しようとしたことはなかったのではないだろうか。もちろん立派なガイドラインや提言を作成し発表すればそれでよしとするものではない。内藤義彦氏がいみじくも言及しているように，立派なガイドラインが示されているにもかかわらず，肥満者や糖尿病患者が増加し続けている米国の現状は，ガイドライン作成だけでは問題は解決せず，それをいかに国民に啓発し，いかにして国民の行動変容を促すことができるか，ということが問われているのである。

4. わが国の2006年の運動指針と関連学協会の活動

2006年に策定されたわが国の「健康づくりのための運動基準」,「健康づくりのための運動指針」ではどうだったのだろうか？　筆者もこの策定に深くかかわらせていただいたが，1989年の「健康づくりための運動所要量」や1997年の「健康づくりのための運動指針」の改定を目的としたものであった。その理由は，①「運動所要量」や「指針」が，身体活動推進という視点よりも運動・スポーツの推進という1980年代の旧い理論的な枠組みのもとに組み立てられていたこと，②当時はまだ身体活動・運動と生活習慣病や健康に関する疫学研究の成果が少なかったこともあり，必ずしもしっかりした疫学的エビデンスに基づいたものとはいえなかったこと，③「運動指針」が「運動所要量」と連動して展開されていな

かったこと，などが挙げられる。また，旧「運動指針」が国民に十分に周知されておらず，健康づくり運動や施策のなかで十分に活用されてこなかったことも反省点として挙げられた[8]。今回の改定に当たっては，わが国の学協会レベルでの健康人を対象とした身体活動・運動についてのシステマティックレビューがなく，それによるガイドラインや提言も存在しなかったために，委員会はシステマティックレビューから始めなければならなかった。それによると，健康維持増進のための身体活動・運動の量や体力についての集団レベルでの疫学研究のエビデンスは数多くヒットしたが，わが国における日本人を対象とした報告がきわめて少なく，欧米の研究成果を借りながら作業せざるを得なかった。実際，ワーキンググループが行ったシステマティックレビューに残った80編の質の高い論文のうちわが国の研究論文は数編と極めて少なかった。また，3Mets以下の強度の運動や生活活動については，研究のエビデンスがほとんどないことから，3Mets以上の強度の活動について評価し指針に盛り込むこととした。これについては，田中茂穂氏が連載(5)で運動以外の身体活動（NEAT：Nonexercise activity thermogenesis）について詳細に述べておられるが[9]，3Mets以下のこまごまとした低強度の活動が，日常における身体活動量の多くを占めているという問題は，それらの活動の評価と健康に与える影響についての研究の推進が必要であることを示している。

また，このような国民の健康増進にかかわる重要な指針の作成には，身体活動・運動と健康にかかわる研究の主だった研究者（とくに運動疫学研究者）が多く参画すること，また，関連学協会が総力を挙げて協力していくことが必要と思われる。

5. 健康づくり施策立案とその実施における学協会の役割

1986年オタワで開かれた第1回ヘルスプロモーション国際会議においてヘルスプロモーションの概念が確立したが，わが国では，この概念を基に健康日本21施策が立案された。しかし，健康日本21では，健康づくり支援のための環境整備については総論的に言及されているものの目標値の設定や具体的な方策については十分なものとは言えなかった。さらにその後，わが国の健康づくり施策は，メタボリックシンドロームの概念を導入して生活習慣病対策を行うとした特定健診・保健指導に重きがおかれるようになっている。日本公衆衛生学会が平成19年3月に厚生労働省に提出した「『標準的な健診・保健指導プログラム』に対する意見表明について」では「ハイリスクストラテジーのみならずポピュレーションストラテジーも重要です」と遠慮がちに書かれているが，はっきりいってしまえば，ポピュレーションアプローチはあまり進んでおらず，むしろハイリスクアプローチに戻りつつあるような流れである。また，特定健診・保健指導から期待される効果についてのエビデンスも十分とはいえない。今日のメタボリックシンドロームの診断基準についての混乱はその典型例といえよう。このことは，逆に健康づくりに関連する学協会が，施策立案の過程でもっと十分な影響力を発揮できるような活動を行っていかなければならないということを意味しているのではないだろうか。

ポピュレーションアプローチの重要性に関しては，本連載の中でも，何人かの執筆者が述べているが，特に井上茂氏[10]は，環境要因へのアプローチについてその重要性について強調し，歩道や運動場所へのアクセス，商店街へのアクセス，公共交通機関などの物理的な環境への介入により身体活動・運動による健康づくりを進めることが必要であるとしている。その意味で，環境の評価や介入方法に関する研究が急務であろう。そして，健康づくり施策の中に環境に関する目標値を設定していくことが重要である。また，物理的な環境ばかりでなく，貧困，健康格差，ソーシャルキャピタルなどの社会環境との関係についての研究も進めていく必要があろう。

さて，身体活動・運動に関しては，日本学術会議の中の関連委員会で何度か，問題提起を行っている。第17期体力科学研究連絡委員会（高石昌弘委員長）は，その報告「21世紀における体力科学の将来展望」において，体力科学の現状から見た今後の課題の一つとして「関連学会が共同で体力・身体活動に関する測定・評価法の標準化，健康増進・疾病予防に関する様々な勧告や指針の作成，行政などによる国民や地域住民の健康づくり施策のエビデンスを提供すること（研究成果の社会への還元）」を挙げている。第18期体力科学研究連絡委員会（下光輝一委員長）では，さらにその詳細について「日本人のための健康体力指標の標準化，及び健康増進・疾病予防のための身体活動に関する推奨・指針作成への提言」という報告を行い，関連学協会が一致協力して，健康増進・疾病予防の観点から，日本人のための身体活動・運動の推奨や指針の作成を進めることを提言している。また，第20期健康・スポーツ科学分科会（加賀谷淳子委員長）では「子どもを元気にするための運動・スポーツ推進体制の整備」という報告をまとめ，子どもを元気にするための運動の指針を早急に策定すべきであるとし，また子どもの運

動指針策定の根拠となるエビデンスのより一層の蓄積に積極的に取り組むべきであると提言を行っている。

公衆衛生学会は，他の学協会とは少し性格を異にしており，健康福祉行政にかかわる現場の実践家や施策を立案する行政官も多数会員として活動する学会である。その意味において，研究成果の社会への還元を推進することに最も適した学会といえる。公衆衛生学会をはじめとする学協会の研究者が横断的な交流を行い，身体活動・運動ばかりでなく，健康にかかわるあらゆるテーマについて社会に対してどのような研究成果の還元を行っていくか，どのような社会的貢献を行うかについて議論し，行動する時が来ているのではないだろうか。

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Preventive Medicine 48 (2009) 321–325

Contents lists available at ScienceDirect

Preventive Medicine

journal homepage: www.elsevier.com/locate/ypmed

Association of physical activity and neighborhood environment among Japanese adults

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ARTICLE INFO

Available online 30 January 2009

Keywords:
Walking
Exercise
Built environment
Public health

ABSTRACT

Objective. Although environmental attributes related to physical activity is an emerging research topic, most studies have been reported from Western countries. This study aimed to examine the relationship between perceived environment and physical activity among Japanese adults.

Methods. The sample included 492 adults aged 20 to 74 years (61%: male) living in Tokyo and Himeji in Japan. Primary measures were the short version of International Physical Activity Questionnaire and its Environmental Module. Data were collected between October and December 2003. Odds ratio (OR) of meeting physical activity recommendations was examined in relation to neighborhood environmental characteristics, adjusted for age, sex, employment status and education.

Results. Three perceived environmental attributes were significantly related to walking 150 min/week or more: high residential density (OR = 1.82), good access to shops (OR = 1.65) and presence of sidewalks (OR = 1.65). Two environmental attributes, access to shops (OR = 2.32) and the presence of bike lanes (OR = 1.57), were related to high levels of moderate to vigorous physical activity (950 MET*min/week or more).

Conclusion. Associations of physical activity with four environmental attributes emerged in this Japanese sample. These results support the generalizability of findings on physical activity environments across Western countries and Japan.

Introduction

Regular physical activity reduces the risk of mortality, incidence of cardiovascular diseases, diabetes and some kinds of cancers (U.S. Department of Health and Human Services, 1996). However, large proportions of the population in Japan and in many countries in the world are insufficiently physically active (Haskell et al., 2007; Sjöström et al., 2006). According to pedometer measurements in the Japan National Health and Nutrition Survey 2005, only 21.3% of Japanese walk more than 10,000 steps a day (Ministry of Health, Labour and Welfare of Japan, 2008). Physical activity promotion is one of the priorities of public health, but to establish effective intervention strategies, evidence of physical activity correlates is needed. To date, many studies have focused on individual demographics and psychological correlates. More recent research has revealed that certain neighborhood environmental characteristics, such as residential density, access to destinations, walking facilities, aesthetics, and safety also are consistently associated with physical activity (Saelens and Handy, 2008; Gebel et al., 2007; Trost et al., 2002; Sallis and Owen, 2002; Hill et al., 2003; Humpel et al., 2002; Owen et al., 2004). Manipulations of environmental variables are expected to have a long-term and substantial impact on the population, which could complement the usually short-term effects of individually-targeted interventions.

Although an increasing number of studies examining the association between physical activity and environment have been reported, most studies were conducted in Western countries, especially in the United States and Australia (Humpel et al., 2002; De Bourdeaudhuij et al., 2003; Saelens et al., 2003; Owen et al., 2004; Wendel-Vos et al., 2007). On the other hand, few studies on physical activity and neighborhood environments could be located in English language journals from Asian countries including Japan (Takano et al., 2002). Limited variability of environmental attributes where the studies were conducted is one of the limitations of this research area. Thus, one of the directions of this research area is to conduct studies in a greater variety of cultures and geographic settings and to examine if evidences from US and Australia could be generalized to other countries.

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0091-7435/$ – see front matter © 2009 Elsevier Inc. All rights reserved.
doi:10.1016/j.ypmed.2009.01.014

Japan is the most economically developed Asian country, but it has a population density that is more than ten times greater than that of the US. Because both the culture and physical environment are very different from the US and Australia, while the level of economic development is roughly comparable, Japan is an interesting country in which to test the generalizability of built environment–physical activity associations. The physical activity environment in Japan appears to be different from the US and Australia on several dimensions. For instance, in contrast to Australia, the low proportion of commuters who drive their cars to work, only 32% in the Tokyo metropolitan area and 36% in the Osaka metropolitan area (Ministry of Land, Infrastructure, Transport and Tourism, 2008), compared with 80.1% in Australia (Australian Bureau of Statistics. 2006), may be due to environmental differences, such as the extent of walkable environment and the development of public transportation network, between the two countries. The difference of overweight prevalence (BMI≥25 kg/m^2) between Japan; 27.6% in males, 21.4% in females (Ministry of Health, Labour and Welfare of Japan, 2008) and the US; 70.8% in males, 61.8% in females (Ogden et al., 2006) may be partially explained by the differences in environment and physical activity.

In the present study, we examined the association between the perceived neighborhood environment and physical activity among Japanese adults using the International Physical Activity Questionnaire and its Environmental Module.

Methods

Participants and data collection

Four hundred and ninety-two Japanese adults aged 20 to 74 years (61%: male) were recruited. Study collaborators at eight worksites, including four universities and four private companies, approached employees at the worksites or their acquaintances as potential research volunteers. Seven of eight worksites were located in and around the Tokyo metropolitan area, while one was in Himeji city, located in western Japan, which has a population of about 536,000. If the person was interested in joining the survey, the collaborator delivered a study consent form and a set of self-administered questionnaires for data collection. To examine the test–retest reliability, 93 of the 492 participants were asked to answer the same questionnaire after a 7-day interval. Written informed consent was obtained from all participants. Data were collected between October 2003 and December 2003.

Environmental measure and its translation

The International Physical Activity Questionnaire Environment Module (IPAQ-E) was used to measure perceived neighborhood environmental attributes related to physical activity. This questionnaire was originally developed as an optional component of the International Prevalence Study of Physical Activity (Craig et al., 2003). Most questions were taken or adapted from previous measures developed in the United States (Addy et al., 2004; Saelens et al., 2003). The IPAQ-E consists of 17 questions; 7 core items, 4 recommended items, and 6 optional items. In this study, we used 11 items, including core and recommended items (Table 1). These questions refer to a neighborhood environment where the person could walk within 10 to 15 min from their residences. Nine of 11 items, excluding residential density and household motor vehicles, involve statements which explain neighborhood features believed to be related to physical activity, followed by four response options: strongly disagree, somewhat disagree, somewhat agree and strongly agree. The residential density item asks about the main types of houses in neighborhoods (e.g., detached single-family residences, condos, apartments), with higher scores indicating higher densities. The question about motor vehicles concerns the number of motor vehicles in the participant's household. The Swedish version of IPAQ-E has shown good test–retest reliability (Alexander et al., 2006).

In this study, the Japanese version of the IPAQ-E was used. The original English version was directly translated into Japanese. The

Table 1
Items of international physical activity questionnaire environmental module in original English version

Scale composition	Items	Response categories
Residential density	What is the main type of housing in your neighborhood?	Detached single-family residences/townhouses, row houses, apartments, or condos of 2–3 storeys/mix of single-family residences and townhouses, row houses, apartments or condos/apartments or condos of 4–12 storeys/apartments or condos of more than 12 storeys
Access to shops	Many shops, stores, markets or other places to buy things I need are within easy walking distance of my home. Would you say that you...	
Access to public transport	It is within a 10–15 minute walk to a transit stop (such as bus, train, trolley, tram) from my home. Would you say that you...	
Presence of sidewalks	There are sidewalks on most of the streets in my neighborhood. Would you say that you...	
Presence of bike lanes	There are facilities to bicycle in or near my neighborhood, such as special lanes, separate paths or trails, shared use paths for cycles and pedestrians. Would you say that you...	
Access to recreational facilities	My neighborhood has several free or low-cost recreation facilities, such as parks, walking trails, bike paths, recreation centers, playgrounds, public swimming pools, etc. Would you say that you...	Strongly disagree/somewhat disagree/somewhat agree/strongly agree
Crime safety	The crime rate in my neighborhood makes it unsafe to go on walks at night. Would you say that you...	
Traffic safety	There is so much traffic on the streets that it makes it difficult or unpleasant to walk in my neighborhood. Would you say that you...	
Social environment	I see many people being physically active in my neighborhood. Physically active means doing things like walking, jogging, cycling, or playing sports and active games. Would you say you...	
Aesthetics	There are many interesting things to look at while walking in my neighborhood. Would you say that you...	
Household motor vehicles	How many motor vehicles in working order (e.g., cars, trucks, motorcycles) are there at your household?	Number of household motor vehicles

translation was conducted according to the standardized translation manual of IPAQ (IPAQ website, 2008). At first we made sure of the concept of each question via discussion with the IPAQ Reliability and Validity Committee. Then the questionnaire was translated into Japanese by two independent physical activity researchers. These translations were reviewed by a group of bilingual individuals to develop the first draft. After the pilot test of the first draft, the wording was revised. Then a bilingual person who was not a researcher and who had no conflicts of interest in this research back-translated it into English. Finally, the translation was checked up by the IPAQ Reliability and Validity Committee. Then, the Japanese version of IPAQ-E was adopted. Table 1 indicates the contents of IPAQ-E according to the wording of the original English version. The Japanese version of IPAQ-E is available from website (Japanese version of IPAQ-E website, 2008).

Physical activity measure

To assess physical activity, the self-administered, short form of IPAQ was used (Craig et al., 2003; Murase et al., 2002). Participants were asked about the frequency and duration of vigorous activity, moderate activity and walking for all purposes such as transportation, work, recreation and household chores. To avoid overlap, moderate activity did not include walking.

In this study, two variables, walking time (min/week) and total moderate to vigorous physical activity (MVPA) energy expenditure (MET*min/week) were used as dependent variables. MET means Metabolic Equivalent and is a unit of intensity of activity. One MET is equivalent to the intensity of resting while sitting. Walking time was calculated using frequency and duration of walking. MVPA was calculated according to the IPAQ scoring manual (IPAQ website, 2008). MET values used in the calculation were 8 METs for vigorous activity, 4 METs for moderate activity and 3.3 METs for walking.

The reliability and validity of this questionnaire in 12 countries, including Japan, has been reported. Test–retest reliability for total physical activity of the Japanese IPAQ was adequate (Spearman's rho = 0.76). Criterion validity for total physical activity assessed against the accelerometer was comparable to other survey measures (Spearman's rho = 0.32) (Craig et al., 2003).

Statistical analyses

The reproducibility of the Japanese IPAQ-E was evaluated by test–retest with a 7-day interval, calculating the Spearman rank-correlation coefficient and Kappa statistic for each question.

To examine the relationship between the neighborhood environment as the independent variable and physical activity, i.e. walking time and MVPA, as the dependent variable, odds ratios of meeting walking and physical activity criteria were examined using logistic regression models. For the analysis, environmental variables were converted into dichotomous variables. For residential density, the choice of 'detached single-family residences' formed a category indicating low residential density, while others were included in another category indicating high residential density. As to the number of household motor vehicles, responses were categorized as 'none' and as 'one or more'. Regarding other questions, responses were classified into two categories of agree (strongly agree and somewhat agree) and disagree (somewhat disagree and strongly disagree). For walking, participants were classified as active if they walked 150 min or more, consistent with current physical activity guidelines (Haskell et al., 2007). MVPA was divided into two levels at the median of all participants: >950 MET*min/week or more, and <950 MET*min/week. To calculate odds ratios, the references were environmental characteristics expected to be associated with lower levels of physical activity, meaning that an odds ratio of more than 1.00 indicates an expected positive association. All odds ratios were adjusted for reported age, sex, employment status and educational level.

Significance was considered to be at a level of $P<0.05$. Analyses were conducted by SPSS ver15.0 for Windows (SPSS Inc., Chicago, IL, USA).

Results

Table 2 presents the demographic characteristics of participants. The sample included 62% of male. Age was widely distributed from 20 to 74 years, and the mean age (SD) was 42 (12) years. The locations of participants were mainly urban settings. In this population, 43% of participants walked more than 150 min/week. The characteristics of 93 participants for test–retest reliability were similar to the overall sample.

Spearman correlation coefficients and Kappa statistics for test–retest reliability of the questionnaire are shown in Table 3. Spearman correlation coefficients were from 0.79 for the presence of bike lanes to 0.99 for residential density. Kappa statistics were also good and ranged from 0.63 for the presence of bike lanes to 0.97 for residential density.

Logistic regression analyses revealed that three of eleven environmental attributes were significantly associated with walking (Table 4). Participants were more likely to walk 150 min/week or more when they perceived high residential density (OR, 95% CI: 1.82, 1.16–2.84), good access to shops (OR, 95% CI: 1.65, 1.05–2.58) and presence of sidewalks (OR, 95% CI: 1.65, 1.13–2.42). The number of household motor vehicles indicated borderline association with walking. Participants who did not have motor vehicles in their household were more likely to satisfy the criterion of 150 min of walking per week (OR, 95% CI: 1.54, 0.99–2.41). All of these associations were in the expected direction. Regarding the association of meeting the MVPA criterion with environmental attributes, people who perceived good access to shops (OR, 95% CI: 2.32, 1.47–3.66) and presence of bike lanes (OR, 95% CI: 1.57, 1.04–2.36) reported more physical activity. Three additional environmental attributes, the presence of sidewalks, aesthetics and

Table 2
Characteristics of participants (Tokyo and Himeji, Japan, 2003)

	Overall sample *n* (%)	Test–retest reliability sample[a] *n* (%)
Sex		
Male	303 (61.6)	58 (62.4)
Female	189 (38.4)	35 (37.6)
Age (years)		
20–39	253 (51.4)	49 (52.7)
40–59	181 (36.8)	30 (32.3)
60–	58 (11.8)	14 (15.1)
Education (years)		
–12	125 (25.7)	19 (20.7)
13–	361 (74.3)	73 (79.3)
Employment status (h/week)		
≥40	336 (68.6)	62 (68.1)
<40	154 (31.4)	29 (31.9)
Location (population of city)		
100,000–	227 (55.6)	51 (64.6)
30,000–99,999	99 (24.3)	18 (22.8)
–29,999	74 (18.1)	2 (2.5)
Unknown	8 (2.0)	8 (10.1)
BMI (kg/m^2)		
–24.9	400 (81.5)	72 (78.3)
25.0–29.9	80 (16.3)	18 (19.6)
30.0–	11 (2.2)	2 (2.2)
Walking (min/week)		
150–	211 (42.9)	38 (40.9)
–149	281 (57.1)	55 (59.1)
MVPA[b] (MET*min/week)		
950–	245 (49.8)	45 (48.4)
–949	247 (50.2)	48 (51.6)

[a] Participants in the test–retest reliability sample are included in the overall sample.
[b] MVPA: moderate to vigorous physical activity.

Table 3
The reproducibilities of each item of the Japanese IPAQ Environmental Module estimated by test–retest with a seven day interval (Tokyo and Himeji, Japan, 2003)

	Spearman's correlation coefficients	P values	Kappa statistics	P values
Residential density	0.99	<0.001	0.97	<0.001
Access to shops	0.90	<0.001	0.85	<0.001
Access to public transport	0.83	<0.001	0.79	<0.001
Presence of sidewalks	0.85	<0.001	0.67	<0.001
Presence of bike lanes	0.79	<0.001	0.63	<0.001
Access to recreational facilities	0.82	<0.001	0.75	<0.001
Crime safety	0.86	<0.001	0.71	<0.001
Traffic safety	0.82	<0.001	0.69	<0.001
Social environment	0.88	<0.001	0.78	<0.001
Aesthetics	0.90	<0.001	0.83	<0.001
Household motor vehicles	0.96	<0.001	0.91	<0.001

household motor vehicles, also showed borderline associations with MVPA.

Discussion

The results of this study demonstrated that 4 of 11 environmental variables: residential density, access to shops, presence of sidewalks and presence of bike lanes, were significantly associated with walking or MVPA among Japanese adults. Adults who reported living in neighborhoods with high residential density, good access to shops, presence of sidewalks, and presence of bike lanes had higher physical activity levels. In addition, borderline significant associations between physical activity and 2 additional environmental variables: aesthetics and household motor vehicles were observed. The environmental measures used in the present study have been developed and used mainly in Western countries, such as the United States and Australia (Humpel et al., 2002; Saelens et al., 2003; Owen et al., 2004, Mota et al., 2005). To date, few studies have been reported from Asian countries, where neighborhood environmental characteristics and physical activity patterns of people are different from Western countries (Takano et al., 2002). Present results indicate that the same kinds of neighborhood attributes related to physical activity in Western countries are also related to physical activity among Japanese. In other words, these results support the generalizability of previous findings in Western countries to different environments and cultures like Japan.

On the other hand, five environmental variables: access to public transport, access to recreational facilities, crime safety, traffic safety and social environment were not significantly related to physical activity among Japanese adults. There are some possible reasons for these results. As for access to public transport, 85% of participants in this study reported good access. This clustering of responses may cause weak statistical power and the result of no significant relationship. Access to recreation facilities has been related repeatedly to leisure time physical activity (Humpel et al., 2002; Gebel et al., 2007). However, in this study, we used the short version of IPAQ which did not assess specific purposes of physical activity, leading to a limited test of the hypothesis regarding recreation facilities. Environmental attributes regarding crime safety and traffic safety were not related to physical activity. These issues may be more relevant in specific populations such as women, children, and older adults. Results, especially for crime safety, have been inconsistent in the previous

Table 4
Odds ratios for environmental variables and likelihood of subjects meeting walking and physical activity criteria (Tokyo and Himeji, Japan, 2003)

	n (%)	Walking>=150 min/week			MVPA[a]>=950 MET*min/week		
		Odds ratios	95% CI[b]	P values	Odds ratios	95% CI	P values
Residential density							
High	111 (23.6)	1.82	(1.16, 2.84)	0.009	1.07	(0.69, 1.68)	0.753
Low	360 (76.4)	1.00			1.00		
Access to shops							
Good	373 (76.7)	1.65	(1.05, 2.58)	0.029	2.32	(1.47, 3.66)	<0.001
Poor	113 (23.3)	1.00			1.00		
Access to public transport							
Good	420 (86.4)	1.43	(0.82, 2.48)	0.205	1.50	(0.87, 2.59)	0.148
Poor	66 (13.6)	1.00			1.00		
Presence of sidewalks							
Yes	288 (59.6)	1.65	(1.13, 2.42)	0.010	1.39	(0.95, 2.04)	0.087
No	195 (40.4)	1.00			1.00		
Presence of bike lanes							
Yes	140 (29.0)	0.93	(0.62, 1.40)	0.739	1.57	(1.04, 2.36)	0.032
No	343 (71.0)	1.00			1.00		
Access to recreational facilities							
Good	283 (58.4)	1.14	(0.79, 1.66)	0.484	1.09	(0.75, 1.58)	0.663
Poor	202 (41.6)	1.00			1.00		
Crime safety							
Safe	321 (66.6)	1.30	(0.87, 1.94)	0.200	1.37	(0.92, 2.04)	0.126
Not safe	161 (33.4)	1.00			1.00		
Traffic safety							
Safe	309 (63.8)	0.80	(0.55, 1.17)	0.258	1.01	(0.69, 1.48)	0.963
Not safe	175 (36.2)	1.00			1.00		
Social environment							
Good	318 (65.6)	1.05	(0.72, 1.55)	0.795	1.35	(0.92, 1.99)	0.128
Poor	167 (34.4)	1.00			1.00		
Aesthetics							
Good	216 (44.5)	1.04	(0.71, 1.50)	0.855	1.38	(0.95, 2.02)	0.090
Poor	269 (55.5)	1.00			1.00		
Household motor vehicles							
None	107 (22.0)	1.54	(0.99, 2.41)	0.055	1.47	(0.93, 2.32)	0.097
One or more	379 (78.0)	1.00			1.00		

Note. All odds ratios were calculated, adjusted for age, sex, employment status and educational attainment. The references were the categories which were hypothesized to be associated with lower levels of physical activity.

[a] MVPA: moderate to vigorous physical activity.

[b] CI: confidence interval.

studies (Humpel et al., 2002). Due to the relatively small sample size of this study, stratified analyses of these demographic characteristics were not conducted in this study. Further studies are needed to examine associations of specific environments with specific physical activities among specific populations.

IPAQ (Craig et al., 2003) and IPAQ-E, internationally-standardized measurement tools, were used in this study. Translation into Japanese was strictly conducted according to the standardized manual of IPAQ. Test–retest reliability of the Japanese IPAQ-E was supported in this study. The ICCs of items in the Swedish version were from 0.47 to 0.98 (Alexander et al., 2006). The Japanese version of IPAQ-E also demonstrated good reliability in this study.

There are several limitations in this study. Due to the cross-sectional design, we were unable to address the direction of the causality. Secondly, the sample was relatively small and consisted of volunteers as participants and therefore not a representative of the general population in Japan. This study supports the generalizability of findings from previous studies in Western countries to Japan. However, there might be limited generalizability of findings among the Japanese population. Thirdly, we used the short form of IPAQ which did not differentiate domain-specific physical activity, such as leisure time and transportation activities. Thus, we were not able to examine activity-specific associations with environmental attributes that were expected (Owen et al., 2004). Fourth, residential preference which is controlled as covariate in recent studies was not assessed in this study. However, this study, conducted in Japan where people live in different environmental characteristics and have different physical activity patterns from Western countries, is important for better understanding environmental attributes related to physical activity. Studies of specific physical activity–environment relationships in specific populations living in a variety of environments are needed to clarify the role of environmental effects in shaping physical activity.

Conclusion

Four environmental variables, residential density, access to shops, presence of sidewalks and presence of bike lanes, were significantly associated with walking or moderate to vigorous physical activity among Japanese adults. These results support the generalizability of findings from previous studies conducted in Western countries to Japan and suggest that targeting these environmental characteristics could be an effective strategy for promoting physical activity.

Conflict of interest statement

The authors declare that there are no conflicts of interest.

Acknowledgments

The authors gratefully acknowledge the collaboration of Dr. Eiji Koshimizu, Tokyo University of Pharmacy and Life Sciences and the Japanese Society of Test and Measurement in Health and Physical Education in this study. This study was supported by the Grant-in-Aid for Scientific Research of the Ministry of Education, Culture, Sports, Science and Technology, Japan.

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Preventive Medicine 49 (2009) 490–496

Contents lists available at ScienceDirect

Preventive Medicine

journal homepage: www.elsevier.com/locate/ypmed

Environmental correlates of physical activity in driving and non-driving rural Japanese women

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ARTICLE INFO

Available online 18 September 2009

Keywords:
Exercise
Walking
Environment design
Social environment
Public health
Automobile driving

ABSTRACT

Objective. This study examined the relationship between physical activity and the environment among rural Japanese women, and whether that relationship varied with driving status.

Methods. 434 women aged 40–64 years in Unnan City, rural Japan, were surveyed in 2006 about physical activity and their neighborhood environments. The proximity and frequency of public transport were measured using geographic information systems software.

Results. Perceived good access to public transport and recreational facilities, presence of bike lanes, and good aesthetics were among factors positively associated with being physically active. The interaction between the convenience of bus service and driving status was statistically significant ($P=0.023$). Non-drivers residing in areas where bus service was moderately convenient were more likely to be active than those who were without it.

Conclusion. These findings suggested that driving status is a potential modifier of the relationship between physical activity and the convenience of bus service and that convenient bus service is important for promoting physical activity especially in non-drivers.

Introduction

Since engaging in regular physical activity reduces the risks of chronic diseases, promoting physical activity should be a public health priority (Hayashi et al., 1999; U.S. Department of Health and Human Services, 1996; Haskell et al., 2007; Lee et al., 2001). Along with demographic, psychological, behavioral, and social factors, environmental factors have also been suggested as determinants of physical activity from an ecological perspective (Trost et al., 2002; Humpel et al., 2002; Sallis et al., 1998; Spence and Lee, 2003; Owen et al., 2004).

To better understand people's behavior and plan effective interventions, examining for moderators (effect modifiers) of relationships between environmental attributes and physical activity is a key issue (Bauman et al., 2002). Gender differences in perceived environmental correlates of physical activity have been suggested in previous studies (Garcia Bengoechea et al., 2005; Santos et al., 2008) as well as other effect modifications by weight (Santos et al., 2008; Blanchard et al., 2005), race (Hooker et al., 2005), socioeconomic status (Van Lenthe et al., 2005), and degree of urbanization (Wilcox et al., 2000).

In the USA and Japan, 87.0% (U.S. Department of Transportation, Federal Highway Administration, 2008) and 72.7% (National Police Agency, Government of Japan, 2007), respectively, of people of driving-age (16 and over) have a driver's license. Such statistics confirm that many do not have a driver's license. In rural areas, where public transport is less used than in urban areas (Frank and Pivo, 1994), while adjusting for socioeconomic status, driving status (i.e., with or without a driver's license) reportedly has a significant impact on health-related behaviors, such as the frequency of health-care visits (Arcury et al., 2005). Rates of licensed drivers among women and the elderly are lower than among adult men (U.S. Department of Transportation, Federal Highway Administration, 2008; National Police Agency, Government of Japan, 2007; Alsnih and Hensher, 2003). Thus, better understanding of the influences of driving status on their daily behavior is important for planning interventions that promote physical activity among those populations. However, it remains unclear whether environmental factors influence people's physical activity levels differently in any population groups according to their driving status.

Research studies on the relationship between physical activity and environments in urban areas are many, but few have been done in

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doi:10.1016/j.ypmed.2009.09.014

rural settings. The impact of public transport on physical activity in rural areas has not received much attention (Wilcox et al., 2000, 2003; Sanderson et al., 2003; Eyler, 2003).

Therefore, this study aimed to (1) describe environmental correlates of physical activity among rural Japanese women, including closer analyses of public transport, and (2) examine whether these relationships vary with driving-status categories (i.e., drivers vs. non-drivers). We hypothesized that the convenience of public transport would be positively associated with physical activity, especially in non-drivers.

Methods

Data collection

Questionnaires were mailed to 1,000 women aged 40 to 64 years living in Unnan City (population 45,364, area 553.7 km^2), a rural mountainous region in Shimane, Japan. They were randomly sampled from the highest and lowest quartile population density areas equally so as to represent the diverse attributes of their environment. A total of 516 women (51.6%) responded between October and November 2006. Those unable to walk unaided ($n=4$), or who lived in the Kakeya area, which is served by a public transport system different from neighboring localities ($n=78$), were excluded from analyses. Therefore, 434 respondents (84.1%) had usable data.

Respondents were divided into drivers ($n=319$) and non-drivers ($n=111$) based on their self-reported driving status. Drivers were defined as those currently licensed to operate a motor vehicle, including cars and motorbikes; non-drivers were those not licensed for any motor vehicle ($n=87$) or licensed but not currently driving ($n=24$). Four respondents without driving status data were excluded from subgroup analyses.

This study was approved by the research ethics committee of the Physical Education and Medicine Research Center UNNAN.

Measures

Sociodemographic variables included age, body mass index (BMI) calculated from self-reported weight and height in kg/m^2, general state of health (very good; good; poor; very poor), self-rated household economy (very good; good; bad; very bad), engaged in farming (yes or no), employed (yes or no), parenting (yes or no) and caregiving (yes or no). Most of these variables were suggested to relate to physical activity (Trost et al., 2002; Sanderson et al., 2003; Sternfeld et al., 1999).

Age was categorized into three groups: 40-49; 50-59; and 60-64. Dichotomous variables were constructed for BMI, general state of health, and household economy (Table 1).

Physical activity

Respondents were asked about time spent on physical activity during occupation, transportation and recreation-related activities over a typical 7-day week. We used the Japanese short version of the International Physical Activity Questionnaire (IPAQ) (IPAQ website, 2008), the reliability and validity of which have been reported previously (Craig et al., 2003; Murase et al., 2002).

Based on their reported physical activity, respondents were divided into three categories: (1) sufficiently active (engaged in 150 min or more per week of moderate physical activity or 60 min or more per week of vigorous

Table 1
Sociodemographic characteristics and median physical activity time among rural Japanese women (Shimane, Japan, 2006).

	Total ($n=434$)			Drivers ($n=319$)	Non-Drivers ($n=111$)	P value[c]
	Number (%)	MVPA[a] (median)	P value[b]	Number (%)	Number (%)	
Age (years)			0.29			0.053
40–49	122 (28.1)	0		92 (28.8)	29 (26.1)	
50–59	199 (45.9)	60		155 (48.6)	41 (36.9)	
60–64	112 (25.8)	45		71 (22.3)	41 (36.9)	
Body mass index (kg/m^2)			0.43			0.50
<25	364 (83.9)	40		272 (85.3)	88 (79.3)	
25+	61 (14.1)	40		41 (12.9)	20 (18.0)	
General state of health			0.84			0.32
Very good/good	321 (74.0)	30		233 (73.0)	85 (76.6)	
Poor/very poor	112 (25.8)	50		85 (26.6)	26 (23.4)	
Household economy			0.18			0.84
Very good/good	142 (32.7)	100		107 (33.5)	33 (29.7)	
Bad/very bad	288 (66.4)	45		208 (65.2)	78 (70.3)	
Employed			0.43			<0.001
Yes	276 (63.6)	20		224 (70.2)	50 (45.0)	
No	149 (34.3)	60		89 (27.9)	58 (52.3)	
Farming			<0.001			0.64
Yes	182 (41.9)	150		136 (42.6)	44 (39.6)	
No	240 (55.3)	0		175 (54.9)	63 (56.8)	
Parenting			0.25			0.37
Yes	49 (11.3)	95		39 (12.2)	10 (9.0)	
No	376 (86.6)	30		274 (85.9)	98 (88.3)	
Caregiving			0.12			0.35
Yes	43 (9.9)	105		28 (8.8)	13 (11.7)	
No	382 (88.0)	30		285 (89.3)	95 (85.6)	
Driving status			0.99	-		-
Drivers	319 (73.5)	30				
Non-drivers	111 (25.6)	40				
MVPA[a,d]		30[†]	-			0.99
Sufficiently active	174 (40.1)			128 (40.1)	45 (40.5)	
Insufficiently active	47 (10.8)			35 (11.0)	11 (9.9)	
Inactive	202 (46.5)			151 (47.3)	49 (44.1)	

Note. Sample sizes vary due to missing values.

[a] MVPA, moderate to vigorous physical activity (min/w).

[b] Calculated for group differences by Mann–Whitney test, except for age by Kruskal–Wallis test.

[c] Compares prevalences between driving status using Mann–Whitney test, except for body mass index using *t*-test.

[d] Sufficiently active: engaging in 150 min or more per week of moderate physical activity or 60 min or more per week of vigorous physical activity. Insufficiently active: engaging in some moderate to vigorous physical activity but insufficient to satisfy "sufficiently active" level. Inactive: engaging in neither moderate nor vigorous physical activities.

[†] Median value in total respondents.

physical activity, corresponding to the ACSM/AHA recommendation (Haskell et al., 2007)); (2) insufficiently active (moderate to vigorous physical activity insufficient to attain a "sufficiently active" level); and (3) inactive (no moderate or vigorous physical activities).

Perceived environments

Perceived neighborhood environments were assessed by the Japanese version of the Environmental Module of the IPAQ (IPAQ-E) (IPS, 2002). We used 7 core and 4 recommended items regarding: residential density; access to destinations including public transport; neighborhood infrastructure; aesthetics; social environment (seeing active people); neighborhood safety; and number of household motor vehicles. The question, residential density, which probed the main housing types in a neighborhood, included 5 response options: detached single-family housing; townhouses, row houses, apartments or condos (2–3 stories); a mix of single-family residences and townhouses, row houses, apartments or condos; apartments or condos (4–12 stories); and apartments or condos of over 12 stories. One question concerned the number of motor vehicles per household. The other 9 used a four-point Likert response scale: strongly disagree; somewhat disagree; somewhat agree; and strongly agree. Both the original English and Japanese versions of IPAQ-E have proven reliability (De Bourdeaudhuij et al.; 2003, Mota et al., 2005; Alexander et al., 2006; Inoue et al., 2009) and are available from their websites (IPS, 2002; Japanese version of IPAQ-E website, 2008).

Objective environments

Objective measures of physical environments regarding public transport were determined for each respondent using the administrative geographic information systems (GIS) database of Shimane Prefecture (2006). This database included locations of neighborhood communities, train stations, and bus stops as well as the frequency of bus and train service. Neighborhood communities were defined as the minimum administrative unit, and respondents lived in 173 of a total of 539 neighborhood communities in Unnan City. The median population and area of neighborhood communities in Unnan City were 86 and 0.99 km^2, respectively. Locations of neighborhood communities were determined as the geographical points nearest, on average, to all region inhabitants (i.e., centers of population in demographic terms) (Moriyama et al., 2005; Fujiyama, 2004).

Distance to train and bus transportation

Euclidean (straight-line) distances from each neighborhood community location to the nearest train station and bus stop were calculated using the GIS software package, ArcView version 9.1 (Environmental System Research Institute Inc., Redlands, CA, 2005), and were assigned to each respondent as their residential community's proximity to public transport. Road network distances were not calculated due to insufficient data on narrow community roads.

Frequency of bus service

Bus service frequency to each of the nearest bus stops from each respondent's neighborhood community was assessed. Train service frequency was not included in analyses, since all stations were located along the same line, and frequencies were the same for all (approximately 20 operations per day).

Distance to bus stop	Daily frequency of bus service: high (3rd tertile, 10+)	moderate (2nd tertile, 5-9)	low (1st tertile, ≤4)
close (1st tertile, ≤95 m)	1	1	2
moderate (2nd tertile, 96-236 m)	1	2	3
far (3rd tertile, 237 m+)	2	3	3

Fig. 1. Categorization of convenience of bus service. Numbers in boxes indicate convenience of bus service based on GIS scores: 1 = high (nearest bus stop relatively close and frequency relatively high), 2 = moderate (combined category of three status; both distance to bus stop and frequency moderate, nearest bus stop close and frequency low, nearest bus stop far and frequency high), 3 = low (nearest bus stop relatively far and frequency relatively low). Both distance to bus stop and daily frequency of bus service were divided into tertiles according to total distribution (i.e., both drivers and non-drivers included). Data were collected from Japanese women in Shimane Prefecture, Japan in 2006.

Categorization of bus service convenience

Considering both the distance and the frequency of the nearest bus stop, the convenience of bus service was categorized into three scores (1: high; 2: moderate; 3: low) and assigned to each respondent. Definitions of categories are described in Fig. 1.

Statistical analyses

Descriptive statistics were calculated for sociodemographic variables, physical activity, and environmental attributes. Group differences in median time spent in moderate to vigorous physical activity by sample characteristics were analyzed using Mann–Whitney *U*-test, except for age, for which we used the Kruskal–Wallis *H*-test. Sociodemographic differences between drivers and non-drivers were determined using the Mann–Whitney *U*-test, except for BMI, which used a *t*-test.

Multinomial logistic regression was used to investigate which environmental variables were related with physical activity. Where appropriate, each perceived environment was divided into two approximately equal parts with the objective environment recoded into tertiles based on their distribution. The choice of "detached single-family residences" formed a category indicating low residential density, while the remainder was included in another category indicating high residential density. Crude and adjusted odds ratios (ORs) and 95% confidence intervals (CIs) for each environmental variable were calculated, with physical activity status as the dependent variable. Adjustments were made for age, BMI, general state of health, household economy, and selected variables, which were significantly associated with physical activity in univariate analyses based on type of employment, engagement in farming, and parenting and/or caregiving status. Given the high prevalence of active categories of physical activity, ORs here should not be interpreted as prevalence ratios (Zocchetti et al., 1997). Likelihood ratio tests were used to compare models with or without interaction terms between environmental variables and driving status. If a significant interaction was evident, the sample was then stratified, and subgroup analyses of driving status were conducted. We used binary logistic regressions in subgroup analyses to compensate for the low statistical power of subgroups. Adjustments the same as above were also made in subgroup analyses.

Significance was set at $P<0.05$. Analyses were conducted using SPSS 14.0J for Windows (SPSS Japan Inc., Tokyo, Japan, 2006).

Results

Description of samples

Sociodemographic characteristics of survey respondents and their group differences in physical activity are presented in Table 1 and the local census data of 40- to 64-year-old women in Unnan City in Table 2. Respondents were relatively old, un-employed, and with no driver's license. Drivers were significantly more likely to be employed than non-drivers ($P<0.001$). Approximately four out of ten respondents engaged in farming, the only sociodemographic variable that physical activity significantly differed with ($P<0.001$). About 40% of respondents were categorized as achieving a sufficiently active level of physical activity.

Table 2
The local census data of 40- to 64-year-old women in Unnan City.

	Number (%) or %
Age (years)[a]	
40–49	2262 (32.7)
50–59	3174 (45.9)
60–64	1483 (21.4)
Employment rate[a]	73.9
Licensed driver rate[b]	77.7

[a] Census data in 2005.
[b] Calculated from administrative data in 2004.

Table 3
Environmental characteristics among rural Japanese women (Shimane, Japan, 2006).

	Total ($n=434$)	Drivers ($n=319$)	Non-drivers ($n=111$)	P value[a]
	Number (%)	Number (%)	Number (%)	
Perceived environments				
Residential density				0.39
High	27 (6.3)	22 (6.9)	5 (4.6)	
Low	404 (93.7)	297 (93.1)	104 (95.4)	
Access to shops				<0.01
Good	226 (53.3)	157 (49.7)	68 (65.4)	
Poor	198 (46.7)	159 (50.3)	36 (34.6)	
Access to public transport				0.24
Good	200 (46.1)	145 (46.0)	53 (49.5)	
Poor	226 (52.1)	170 (54.0)	54 (50.5)	
Access to recreational facilities				0.12
Good	202 (47.6)	143 (45.5)	57 (53.8)	
Poor	222 (52.4)	171 (54.5)	49 (46.2)	
Sidewalks				<0.01
Yes	194 (44.7)	133 (43.0)	59 (57.8)	
No	221 (53.3)	176 (57.0)	43 (42.2)	
Bike lanes				0.021
Yes	193 (45.7)	137 (43.5)	56 (53.8)	
No	229 (54.3)	178 (56.5)	48 (46.2)	
Aesthetics				0.76
Good	194 (45.8)	142 (45.4)	50 (46.3)	
Poor	230 (54.2)	171 (54.6)	58 (53.7)	
Seeing people being active				0.59
Yes	223 (52.5)	163 (51.9)	57 (53.3)	
No	202 (47.5)	151 (48.1)	50 (46.7)	
Safety from crime				0.52
Yes	260 (61.8)	193 (60.5)	64 (61.0)	
No	161 (38.2)	119 (38.1)	41 (39.0)	
Traffic safety				0.67
Yes	148 (35.2)	110 (35.4)	36 (34.0)	
No	272 (64.8)	201 (64.6)	70 (66.0)	
Household motor vehicles				<0.001
0–2	154 (37.5)	107 (35.1)	47 (45.6)	
3+	257 (62.5)	198 (64.9)	56 (54.4)	
Objective environments				
Distance to train station (m)				0.26
Close (≤1147)	134 (33.6)	91 (32.7)	35 (37.6)	
Moderate (1148–4515)	133 (33.3)	90 (32.4)	36 (38.7)	
Far (4516+)	132 (33.1)	97 (34.9)	22 (23.7)	
Distance to bus stop (m)				0.53
Close (≤95)	136 (34.1)	91 (32.7)	34 (36.6)	
Moderate (96–236)	148 (37.1)	101 (36.3)	35 (37.6)	
Far (237+)	115 (28.8)	86 (30.9)	24 (25.8)	
Frequency of bus service				0.071
High (10+)	123 (30.8)	78 (28.1)	36 (38.7)	
Moderate (5–9)	59 (14.8)	41 (14.7)	16 (17.2)	
Low (≤4)	217 (54.4)	159 (57.2)	41 (44.1)	
Convenience of bus service[b]				0.047
High	107 (26.8)	77 (26.1)	30 (29.7)	
Moderate	132 (33.1)	99 (33.6)	36 (35.6)	
Low	160 (40.1)	119 (40.3)	35 (34.7)	

Note. Sample sizes vary due to missing values.
[a] Compares prevalences between driving status using Mann-Whitney test.
[b] See Fig. 1 for category definitions.

Table 3 shows environmental characteristics of survey respondents. Drivers were more likely to report poor access to shops ($P=0.004$), an absence of sidewalks ($P=0.006$) and/or bike lanes ($P=0.021$) in their neighborhood, owning more household motor vehicles ($P<0.001$), and apt to have less convenient bus service ($P=0.039$) than non-drivers.

Associations between physical activity and environments

Environmental variables associated with physical activity are shown in Table 4, which also listed ORs and 95% CIs before and after adjustments. Sufficiently active women were more likely to report good access to public transport (adjusted OR = 1.57), the presence of bike lanes (adjusted OR = 2.05) and good aesthetics (adjusted OR = 1.69) than inactive women. Good access to recreational facilities was reported significantly more often by the insufficiently active group but not more often by the sufficiently active group than by the inactive group. Some borderline significance was observed in positive associations between the objectively measured convenience of public transport and physical activity.

A significant interaction was observed only between the objectively measured convenience of bus service and driving status (Table 5). Therefore, subgroup analyses were conducted regarding bus service convenience among drivers and non-drivers. Among drivers, convenient bus service and physical activity were somewhat negatively, though not significantly, associated. However, non-drivers in an area where bus service was moderately convenient were more likely to be active than those where it was least convenient (adjusted OR = 3.23) (Table 6). Comparing the median physical activity score of each nine-cell status of the matrix in Fig. 1, the highest was "both