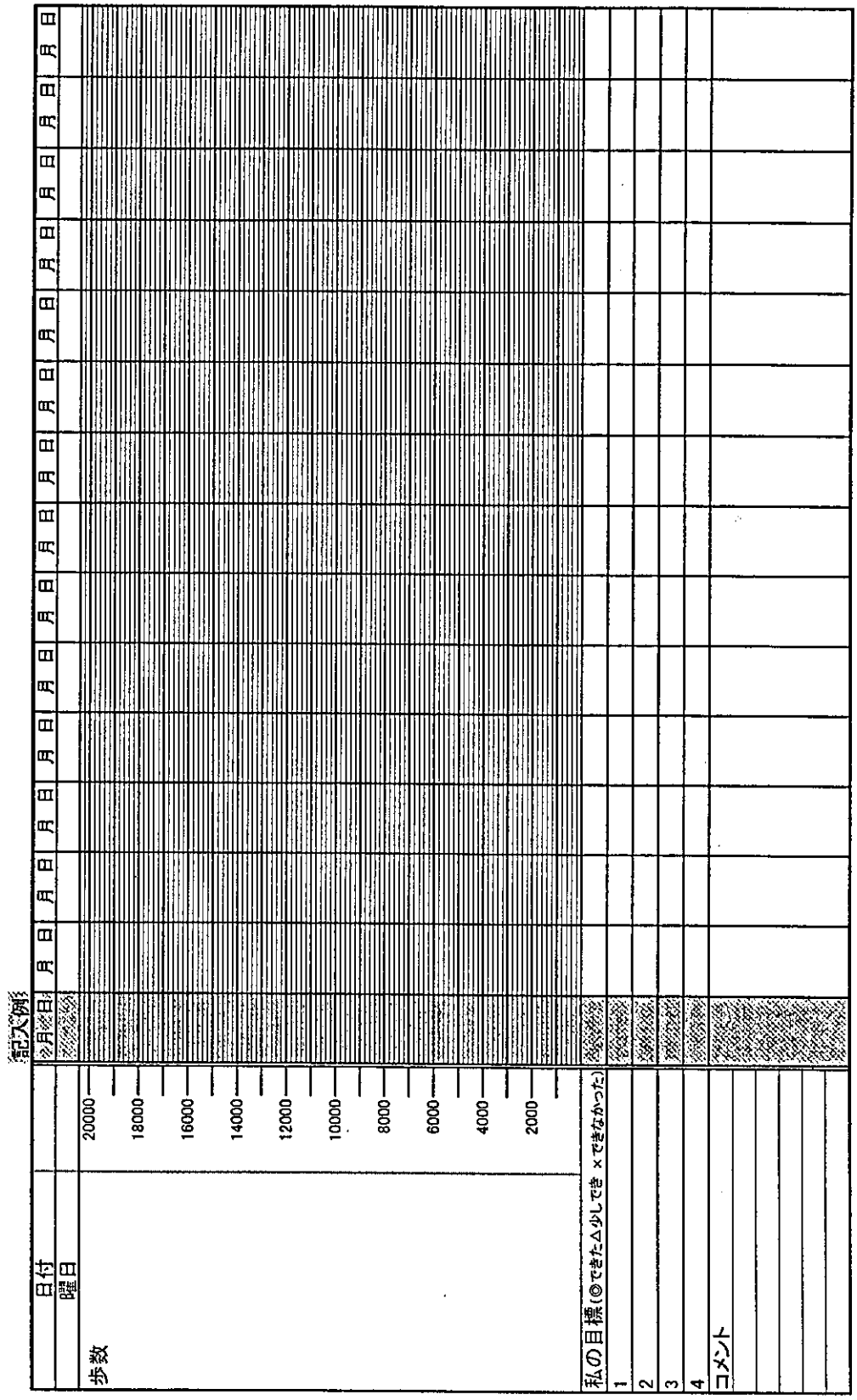
図3　運動習慣の記録表の例



2❷セルフ・モニタリング

自分自身の運動実施状況を記録していきます。記録が励みになるとともに、自分自身の運動量を客観的に把握できます。記録表を壁などに張ると、励みが大きくなります。これらの方法では負担感が大きい時には、カレンダーや手帳に○をつけるなどの方法をすすめます。図3に運動習慣記録表の例を示します。

3❸誓約書の作成

どのような運動を行っていくのかを誓約書に書いてサインをするとともに、家族、同僚などのサインをもらい指導者もサインをします。何としてもやり遂げる決意を表明することが運動の継続につながります。

4❹刺激統制法

運動を行おうと考える刺激を増やす方法です。ふだんから歩きやすい靴、動きやすい服装を心がける、家に運動選手のポスターを張る、運動の好きな友人とつきあう時間を増やす、いつも玄関に運動靴を置いておくなど、運動がしたくなる仕掛けを身のまわりに増やしていくように指導します。

5❺オペラント強化法

何かを行って、楽しいことが起こったり、好ましいご褒美がもらえると、ヒトはその行動をくり返します。これを応用した方法で、運動後によいことが起こる（ご褒美が得られる）ように仕組む方法です。目標を達成したら洋服を買う約束をする、ウォーキング・コースに自分の好きな場所を加える、気持ちよく終われる程度の運動内容にとどめて、筋肉痛、疲労感などが強くなりすぎないように注意するなどが、この方法にあたります。

6❻脱落防止法

実際に運動を行っている人に有効な方法です。けが、病気、季節の変化（冬になった）、参加していた運動プログラムが終了した、転居、妊娠、転勤など運動が中断しそうな機会をあらかじめ予測して、対処方法を考えておく方法です。

これらの方法は運動の指導だけではなく、栄養指導、禁煙指導など、いろいろな分野で応用可能です。使えそうな方法には積極的にチャレンジしてみましょう。

［井上　茂、下光輝一］

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行動科学からみた運動療法

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Key word
身体活動，運動，トランスセオレティカルモデル，行動変容のステージ，行動変容技法

はじめに

運動の必要性を認識しても，実際に運動療法を継続することは容易ではない．指導者にとって運動習慣の継続率をどのように高めるのかは日々直面する重要な課題である．継続率の高いプログラムを作成するためには安全性，運動処方，運動技術などさまざまな視点からの考慮が必要であるが，行動科学の応用は考慮すべき一つの有力な視点と考えられる．

そこで本稿では，まず筆者らがどのような考え方に基づいて身体活動・運動指導を行ってきたかを述べ，つぎにこの方法を用いて実施した運動教室の効果に関する研究を紹介する．最後に，「運動療法」の視点から，紹介した方法をどのように実際のプログラムに反映していくのかについて，若干の考察を加えたい．

行動科学的手法を用いた身体活動・運動指導

健康教育に応用されている行動科学の理論・モデルとしては，健康信念モデル，社会的認知理論，計画的行動理論などがあげられるが，とくに近年盛んに用いられているのが，トランスセオレティカルモデルである[1]．このモデルは禁煙教育に活用するためのモデルとして，Prochaska らがさまざまな行動科学の理論やモデルを統合して提唱したもので，近年では運動を含むさまざまな健康行動に積極的に応用されている[2~4]．その中心となる概念は行動変容のステージ（stage of change）で，行動変容に対する準備性が異なる5つのステージ（表1，図1）に応じて指導を行うことによ

表1　行動変容のステージの定義

	一般的定義	運動習慣のステージ
無関心期	健康行動を実践せず，行動変容の意図もない者	運動習慣をもたず，今後6カ月以内に運動を開始する意図もない者
関心期	健康行動は実践していないが，行動変容の意図はある者	運動習慣をもたないが，今後6カ月以内に運動を開始する意図のある者
準備期	行動が少しずつ変化しつつある者	不定期だがなんらかの運動を実践している者
実行期	健康行動を実践しているが，十分に定着していない者	定期的に運動を行っているが，その習慣が6カ月以上続いていない者
維持期	健康行動を実践しており，習慣として定着している者	定期的に運動を行っており，その習慣が6カ月以上続いている者

定期的運動習慣の定義には，推奨される運動習慣を当てる．多くの先行研究では，アメリカスポーツ医学会のガイドラインを根拠として，週3日以上の運動習慣，あるいは週5日以上，30分以上の中等度以上の身体活動とされている．

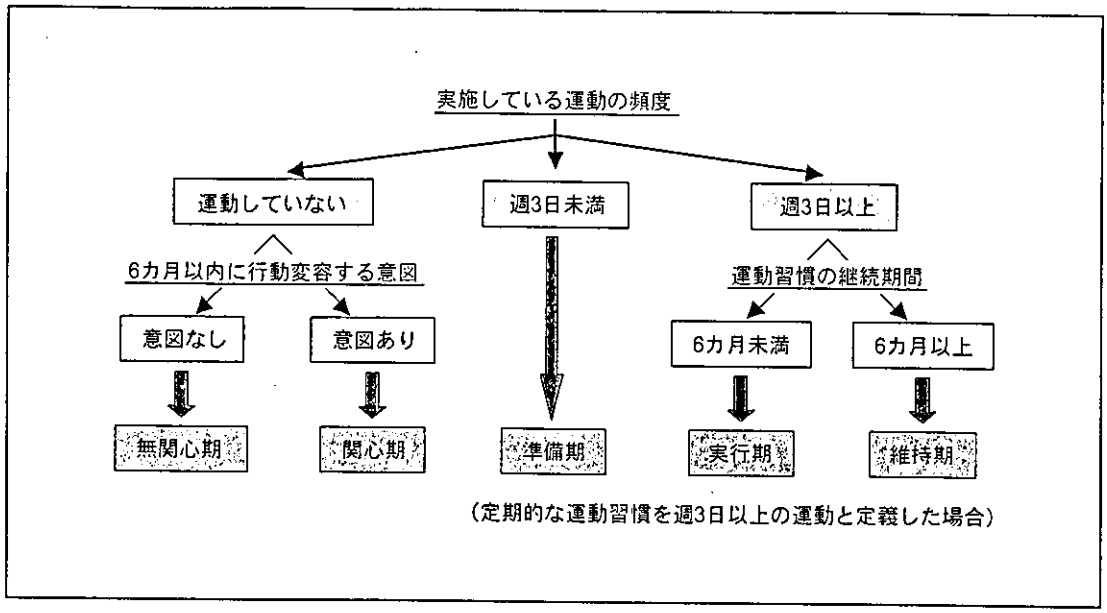

図1　運動習慣のステージ

表2　運動指導に活用したい行動科学的概念や技法

	内容	具体例
運動習慣のステージ	行動変容の準備性に応じた指導を行う	無関心期，関心期，準備期，実行期，維持期の各ステージに応じた指導
目標設定	これから実施していく運動の内容を具体的な目標として定めること	いつ，どこで，なにをするのか話し合い，目標とする． 例：来週からウォーキングをはじめます．週3日，近所のコースを30分歩きます．
セルフモニタリング	自分自身の行動を記録すること	運動した日には手帳に○をつける． 記録表を冷蔵庫に張り，毎日実施した内容と時間を記録する．
シェイピング	簡単な行動からはじめて，少しずつ目標とする行動に近づけていくこと	週3日，15分のウォーキングからはじめて，次第に目標を高くしていく．
モデリング	運動を実施している人を観察して学習すること	運動習慣のある糖尿病患者の話を聞く． 運動習慣のある人と付き合うようにする．
利益不利益分析	自分にとっての運動の利益や不利益について検討すること	利益や不利益のリストなどを提示して話し合う． 利益が大きく，不利益の少ない運動計画を立てる．
刺激統制法	運動を実施しようと思う刺激を増やすこと	普段から動きやすい服装にする． 体重記録を目につく場所に掲示する．
オペラント強化法	運動した後によい結果（賞賛，ご褒美，気持ちよさなど）が得られるように工夫すること	目標体重を達成したら洋服を買うように決めておく． 運動したらほめてもらう，あるいは自分自身をほめる． ウォーキングコースにお気に入りの場所，店，図書館などを取り入れる．
社会的支援	運動を理解してくれたり，励ましてくれたり，一緒に実施してくれたりしてくれる人を増やすこと	家族と運動や自分の目標について話をするようにする． 一緒に運動する仲間を増やす．
コミットメント	運動することを宣誓すること	宣誓書を作成する．
ポジティブ・セルフトーク	前向き，建設的に考えるようにすること	否定的に考えてしまうパターンを尋ね，前向きに考える練習をする
逆戻り防止法	運動をやめてしまいそうになる機会を予測して，対策を立てること	季節の変化，けが，忙しい時期，引越しなどを予測して対策を考えておく．

表3　ステージに応じた行動変容技法の活用例

行動変容技法	無関心期	関心期	準備期	実行期	維持期
目標設定		○	◎	◎	○
セルフモニタリング		○	◎	◎	○
シェイピング			◎		
モデリング	○	◎	◎	◎	○
利益不利益分析	◎	◎	○		
刺激統制法	○	○	◎	◎	○
オペラント強化法			◎	◎	○
社会的支援		○	◎	◎	◎
コミットメント		○	◎	◎	
ポジティブ・セルフトーク			◎	◎	◎
逆戻り防止法				◎	◎

◎：活用が推奨される，○：状況に応じて活用が推奨される

り，効果的な行動変容を促すことがその目的となっている．筆者らはこのモデルを用いて日本人の運動習慣の決定要因に関する研究を行うとともに[5,6]，ステージに応じて行動科学の技法を活用した身体活動・運動指導を行ってきた[3,7,8]．活用している主な技法の概要（表2）と，それらの技法が推奨されるステージ（表3）を示す．これらの技法は行動変容を容易にするために対象者が用いる技術（スキル）であり，指導者の役割は，実際に運動療法を行う者がこれらのスキルを活用できるように理解させて，支援することである．スキル活用の詳細は成書に譲り[8]，ここでは運動習慣のステージ別に指導のポイントを述べる．

1．無関心期

「運動療法が必要であることを理解して運動に関心をもつこと，現在自分自身が直面している問題に取り組む姿勢になること」が指導の目標となる．このステージの者は運動不足である現状に対して理由づけを行い，それを合理化していることがある．このような場合には，無理な指導や価値観の押しつけが逆効果になることもあるので注意する．もっとも重要なことは，指導者との間に信頼関係を築くことである．信頼された者からのアドバイスは受け入れられやすい．

一度の指導で考え方や行動が変わることは少ないので，指導内容に緊急性がなければ，指導したい内容を繰り返し伝えて，本人の姿勢が変化するのを待つ気持ちが重要である．とくに，立場上医師の一言は非常に影響が大きいので，あやふやで誤解されやすい指導にならないように注意する．必要以上の時間をかけても効率的ではないので，シンプルで趣旨の明確なメッセージを繰り返し伝える．可能であるならば歩数計などを用いて身体活動量を把握し，不活動への気づきを促す．

行動変容技法については刺激統制法，利益不利益分析，社会的支援等が活用できる．刺激統制法では，運動用具などを目につく場所に置く，歩きやすい靴・服装に心がける，定期的に体重を測る，歩数計をつける，犬を飼うなどの方法が考えられる．利益不利益分析では運動に関する考え方を尋ねて，とくに不利益要因（疲れる，時間がとられるなど）に着目し，運動の計画を上手に行うことによって不利益が少なくなることに気づかせる．社会的支援については，たとえば，活動的な友人との交流を深めるなどの方法が考えられる．

2．関心期

「わずかなことでも，なにかはじめること」を目標に指導を行う．このステージの者は運動の必要性を理解しているが，運動することに対する負担感が高く，なかなか実行に移せずにいることが多い．本人の負担感が小さい，実行できそうな種目（自己効力の高い種目）を選択し，最初の一歩を踏

み出すことができれば成功である．たとえば，身体活動・運動種目のリストを用意して話し合ってみるとよい．設定した運動目標の達成によって目的とする効果（たとえば血糖値の改善など）が得られるのかどうかは，運動を継続していくうえでも非常に大きな問題である．しかし，一度に大きな目標を立てても失敗することが多く，少しずつ目標をアップして運動習慣を定着することが結局は近道であることを伝えて，運動の開始，継続を励ます．

目標設定のポイントとしては，①具体的であること，②やりたいことで，できそうな運動（自己効力の高い運動）であること，③本人が決めることと，④実際に文字にして表現してみること，などがあげられる．具体的であるということは，いつ，どこで，なにを行うのかをイメージできることで，後から目標が達成されたかどうかを客観的に評価できるようにする．簡単な宣誓書のようなものを作成してコミットメント（誓約・決意）を高めるのもよい．どうしても身体活動・運動の目標を設定できない場合には，たとえば刺激統制法を用いた目標設定などが考えられる（無関心期の項を参照）．このほかにも関心期から準備期，実行期にかけてはさまざまな技法の活用が可能であり，積極的に試みたい（表3）．

3．準備期

「目標とする運動量まで少しずつ高めていく」ことを目標に指導を行う．目標とする行動を小さなステップに分けて，達成が容易な行動から順に行動を形成していく方法はシェイピングと呼ばれている．小さな変化でも行動変容に成功すると自己効力が高まり，つぎの行動変容に対する意欲が生まれる．シェイピングを成功させるコツは，ターゲットとする行動（最終的にどのようなメニューで運動療法を行いたいのか）を明確にすること，大きすぎず小さすぎないステップのサイズを設定することなどである．したがって，目標を柔軟に見直して対象者に合った運動方法を選択していくことが重要である．

セルフモニタリング（自己行動記録）は客観的に行動を把握することに有用で，シェイピングを活用するうえで役に立つ．また，自己の行動を記録することが運動継続の動機づけとなる．手帳や記録表などに実施した運動，歩数などを記入していくが，記録することそのものが新たな行動でもあり，どこに，なにを，いつ，記入するのか，記録表はどこに保管（掲示）するのかなどを申し合わせておくとよい．また，可能ならば結果に対しては速やかにフィードバックを行い，行動変容を励ますと効果的である．「がんばりましたね」「先週は○○歩でしたね」などと，簡単なコメントでよいので，できるだけ前向きなコメントに心がけて，みていること，応援していることを伝える．

準備期は行動が変化しつつあるステージであり，ほとんどの行動変容技法が活用可能である．一度にすべての方法を試して消化不良にならないように注意しながら可能な方法，有効そうな方法から試していく．

4．実行期

「運動習慣を継続すること」を目標に指導を行う．ある程度の期間，習慣を継続することにより学習効果が高まることを過剰学習という．たとえば，自動車の運転を学習した（免許を取った）すぐその後に運転をやめてしまうと運転ができなくなってしまうが，免許取得後に一定の期間，運転を行うと，その後に運転を行わない期間があっても運転という獲得された行動の学習効果は維持される．これと同様に，運動習慣を一定期間継続することが習慣化のために重要という考え方である．ステージモデルでは半年間が目標となっている（半年間続けると維持期となる）が，これはProchaskaらが禁煙者の行動について観察した結果，半年間の健康行動の継続をもって維持期と定義したことに由来する[1]．運動習慣においてどの程度の期間の継続が重要かについては十分な研究がなされていないが，筆者らはまず半年間ないしは1年間程度の継続を目標として指導を行うようにしている．

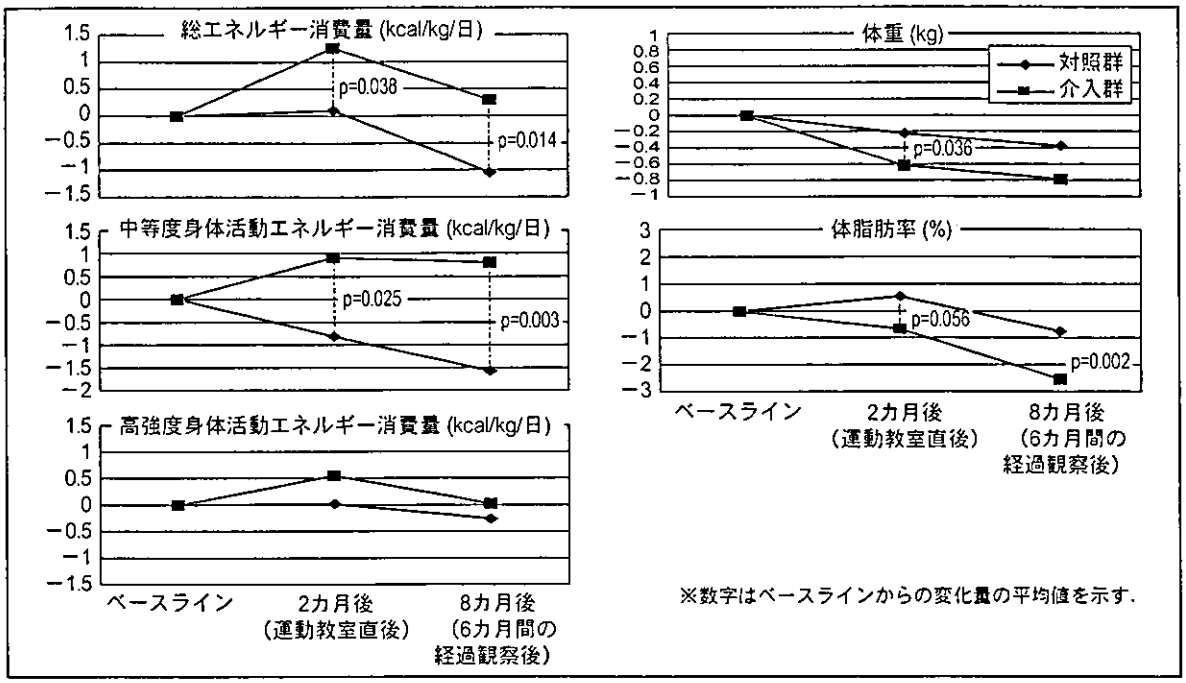

図2　行動科学的手法を用いた運動指導の効果　(文献9を改変)

実行期は運動習慣がまだ十分に定着しておらず，準備期同様にさまざまな行動変容技法の活用を行い，継続を支援したい．中断してしまう要因としては，運動プログラムの終了，退院，季節の変化，けがなどがとくに重要と考えられるので，予測される要因についてはあらかじめ対策を考えておく．運動教室等のプログラムが終了するときには，その後どのような運動を行うのか，あらかじめ考えておくとよい．

5. 維持期

「脱落予防」を目標に運動を行う．脱落のきっかけとしては，けが，病気，結婚，出産，転勤，転居といったライフイベントが考えられる．過去に運動を中断したきっかけを参考にして，これから起こりそうな中断理由を予測し，対策を考えておく．運動習慣をさらに定着させる方法としては，新しい種目への挑戦，運動技術の向上，運動仲間を増やすこと，自分自身が運動療法のリーダーとなることなどがあげられる．さまざまな運動に挑戦することは，健康上のメリットも大きい．

行動科学的手法を用いた身体活動・運動指導の効果に関する介入研究

表2，3に示した考え方のもとに運動教室を実施して，その効果を検討した(図2)[9]．研究は8カ月間の無作為割付対照試験（2001年4月～12月）により行った．対象者は新聞広告により募集した45歳から69歳の女性で，スクリーニング検査を行って，申し込み者237名のなかからあらかじめ定めた参加基準に適合する86名（57.2±5.4歳，154.1±5.2 cm，54.6±7.3 kg，体脂肪率30.1±7.7％）を決定した．この対象者を無作為に2群に分け，介入群に運動教室を実施した．教室は8週間（週1回，1回2時間）にわたって行い，毎回，行動科学的手法を応用したグループワーク1時間，運動実技1時間の計2時間で構成した．対象者の大部分が関心期，準備期であったことよりプログラムは関心期の者が準備期，実行期，維持期へと変化することを想定して構成し，ステージの変化とともに指導する行動変容技法が変化するように工夫した．介入は運動施設で実施したが，指導の

目標は身体活動量の増加であり，運動施設を利用した運動の実施にはこだわらなかった．身体活動の目標としては①1日10,000歩，②週3回以上の運動，③1日30分以上の中等度強度以上（3METS以上：METS＝Metabolic equivalents，代謝当量）の身体活動，のどれかを満たすことを推奨したが，あくまでも各個人にあった目標があることを強調し，シェイピングの考え方に基づいて少しずつ身体活動量を高めていくように指導した．

対照群にはメディカルチェックの結果のフィードバックと15分程度の簡単な保健指導を実施したが，それ以上の積極的な指導は行わなかった．なお，介入群，対照群ともに研究期間中は会場となった運動施設を利用できることとした．身体活動量は，連続7日間の24時間活動記録により算出した．図2は2カ月後（運動教室直後），8カ月後（6カ月間の経過観察後）の身体活動量の変化を，総エネルギー消費量，中等度身体活動（3～6METS）によるエネルギー消費量，高強度身体活動（>6METS）によるエネルギー消費量に分けて示し，また，体重，体脂肪率の変化を示したものである．エネルギー消費量はとくに中等度身体活動において増加し，介入の効果は6カ月間の経過観察後も維持されていた．また，身体活動量の変化にともない体重，体脂肪率の低下が認められた．

さまざまな指導場面への応用

行動科学的手法を用いた運動指導の方法とその効果について述べたが，これらの方法は漫然と実施しようとすると，比較的手間のかかる方法である．今後はそれぞれの指導場面に，どのように効率よく応用していくかが課題である．「運動療法」といっても，たとえば，健診後の生活習慣指導，頻繁な外来通院の必要がない生活習慣病，定期的な外来通院が必要な生活習慣病，糖尿病などの教育入院，入院中の心臓病のリハビリテーション，退院後のリハビリテーションなど指導の場面はさまざまである．また，個別に指導する場合，集団で指導する場合では状況が異なる．

筆者の経験よりいくつか感じている点を述べてみる．まず，行動科学的手法を活用する際の切り口は，個別指導においてはステージに応じた指導が適しているが，集団指導においては，ステージ別の指導というよりはむしろ行動変容技法の切り口から考えて，これらの技法の理解と活用を支援するほうが指導を行いやすい．指導の回数に関連しては，定期的な外来通院などと比較して，健診後の生活習慣指導などでは面接の回数が限られているので，状況に応じて指導内容の取捨選択が必要である．目標設定とセルフモニタリングはさまざまな場面に活用しやすい重要な技法と考えられるので，これを“上手に”指導のなかに組み込む工夫が必要である．定期的な面接が期待できる場合には，目標の見直しやセルフモニタリングを実施しながら，各種の行動変容技法を指導していけばよい．

入院で運動療法を実施する場合の最大の問題点は，退院後の継続であろう．入院中に行動変容技法の指導を行いながら，退院後の対策を考えていく．退院後に運動を行うということは，同じ運動療法であっても，むしろ新しい行動をはじめるのに近い．退院後にどのような運動を実施するのかをしっかりと計画しておくとともに，外泊等で運動実践の予習をしてみるなどの方法が考えられる．

最後に，行動変容をめざした指導における重要事項として標的行動を明確にすることの重要性を強調したい．「運動」と一言で表現されるが，実施する状況，運動の種類，時間などが異なればそれは違った行動であり，運動を継続する要因も異なってくる．どのような運動療法を推奨するのかについて，指導者の考えがあいまいな場合には問題点の整理がむずかしく，継続のための十分な支援が行えない．なにを推奨するのかを明確にすることによって，継続のための具体的な問題点が把握されるものと考えられる．

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Randomized controlled trial to evaluate the effect of a physical activity intervention program based on behavioral medicine

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Abstract

In spite of health benefits of physical activity, a large part of the population keeps a sedentary lifestyle. Thus, it remains an important public health challenge to develop intervention programs to promote physical activity. In this study, the effect of a physical activity program using behavioral approaches was examined by 8-month randomized controlled trial (2 months intensive intervention+6 months follow-up). Subjects were 86 sedentary women, aged from 47 to 68 years old, and were randomly classified into two groups, an intervention group and a control group. Results showed that the intervention group increased their total energy expenditure by a significantly large degree compared with the control group in both the short-term (2 months) and long-term (8 months) ($p=0.038$ and $p=0.014$, respectively). According to the analysis of physical activity intensity, these increases were mainly due to the increase of moderate activity. Some other measures of physical fitness and body composition were significantly improved in the intervention group compared with the control group. In conclusion, the present program based on behavioral medicine was effective to promote physical activity and to improve physical fitness and body composition over 8 months.

Introduction

It is well documented that regular physical activity is beneficial for reduction of mortality[1], for prevention of cardiovascular disease[2], diabetes[3], and some kinds of cancer[4], and for maintenance of physical function in older adults[5]. These evidences were widely accepted, and were summarized as recommendation statements on physical activity[6]-[8]. However, a large part of the population is not sufficiently active. In the United States, more than 60% of people are not sufficiently active[9][10]. In Japan, only 30.2% of men and 27.5% of women engage in 20 minutes or more of exercise two or more times per week[11]. Thus, it remains a public health challenge to promote physical activity for prevention and control of chronic diseases, and the development of physical activity promotion methods is eagerly awaited.

Given this background, behavioral theories and models such as the learning theory[12] the social cognitive theory[13], the relapse prevention model[14], and the transtheoretical model[15][16], are expected to be applied for physical activity interventions. These theories and models of human behavior are useful for understanding health behavior[17] and have played important roles in the development and refinement of intervention programs for smoking cessation and other health behaviors. Recently, applications of these theories to physical activity programs have begun to spread, and the results of some intervention trials have been reported in the United States[18][19]. Review articles on 127 intervention studies concluded that intervention based on behavioral science is an effective and recommended method to promote physical activity[20][21]. However, applications of behavior theories and models to physical activity programs are still in development, and further studies to

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examine the effects of programs are needed, especially in Japan. In this study, a physical activity program was developed based in large part on the transtheoretical model, a model spreading to heath education, and the effects of the program on sedentary middle-aged and senior women were examined by a randomized controlled trial.

Methods

This study was conducted with the permission of the Ethics Committee of Tokyo Medical University.

1. Study design

The study design was an eight-month randomized controlled trial, conducted from April through December, 2001. The eight months consisted of a 2-month intensive intervention period and a 6-month follow-up period.

2. Subjects

Participant flow is shown in Fig. 1. Women with obesity and hyperlipidemia were recruited by newspaper advertisements. Inclusion criteria were: 1) sedentary women aged from 45 to 69 years old who engage in exercise less than once a week as of the occasion of the explanation of the project, 2) meeting the criteria for serum total cholesterol <280 mg/dl, triglyceride <400 mg/dl, fasting plasma glucose <126 mg/dl, resting blood pressure <160/100 mmHg, 3) taking no medications affecting lipid metabolism such as antihyperlipidemic drugs, antihypertensive drugs, etc., 4) no cardiovascular or orthopedic disorders limiting participation in an exercise program, 5) others. Women with obesity or hyperlipidemia were given priority for participation. A total of 237 women applied for participation in this study. Initial screening was done through application forms, and 195 women were invited to a research explanation meeting. Of the 157 participants, 156 signed informed consent forms. After a second screening conducted at the meeting, 90 women were invited for baseline assessment. At baseline assessment, including exercise test and blood sampling, one woman had exercise-induced arrhythmia, and three had cholesterol levels higher than the inclusion criteria. These four subjects were excluded. Finally, 86 participants were confirmed as subjects of this study and were randomized into two groups, 42 females in the control group and 44 females in the intervention group.

3. Measurements

Assessments were conducted three times, at baseline, immediately after intensive intervention (at 2 months), and after 6-month follow-up period (at 8 months) for all measurements.

1) Measurements of physical activity energy expenditure, exercise behavior, physical fitness, and nutrition

Physical activity energy expenditure

For physical activity energy expenditure assessment, a 24-hour physical activity record was used. Participants were asked to record all kinds of physical activities that they did every ten minutes for seven consecutive days. The intensity of each activity was self-classified into one of 5 categories: intensity 1 - sleeping, intensity 2 - sedentary activity mainly in a sitting position, intensity 3 -

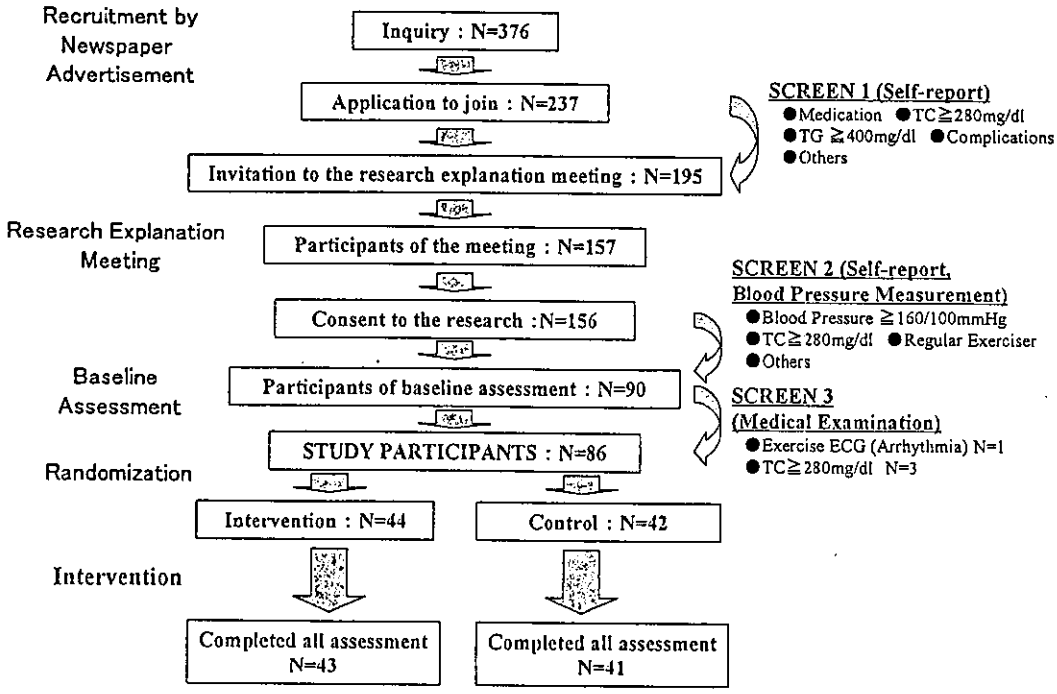

Fig. 1 Participant flow

light activity in a standing position, intensity 4 - moderate activity (3-6 metabolic equivalents : METs), intensity 5 - vigorous activity (>6 METs). To help subjects to classify the intensity, face to face instruction was given to each subject. In addition, a table of concrete examples of activities and intensities, which was constructed with reference to the compendium of physical activities reported by Ainsworth et al.[22], were provided. The records were confirmed by interviews at collection. Energy expenditure was calculated according the equation below[23].

Energy expenditure (kcal/kg) = Intensity (METs)× Duration(min)×3.5 (ml/min/kg)×0.005 (kcal/ml)

3.5 ml/min/kg : Oxygen uptake for 1 MET

0.005 kcal/ml : Energy expenditure per 1 ml oxygen uptake

On calculation of energy expenditure, METs values of physical activity below were assigned to each intensity category.

Intensity 1 : 0.9 METs, Intensity 2 : 1.5 METs, Intensity 3 : 2.0 METs,

Intensity 4 : 4 METs, Intensity 5 : 7 METs

In this study, 3 measurements of energy expenditure - total energy expenditure (kcal/kg/day), energy expenditure by moderate activity (kcal/kg/day), and energy expenditure by vigorous activity (kcal/kg/day) were used.

Exercise behavior

Three measurements regarding exercise behavior : frequency of exercise per week (times per week), stage of change for exercise behavior, and exercise self-efficacy, were assessed by a self-administered questionnaire.

The stage of change is the main concept of the transtheoretical model proposed by Prochaska and DiClemente[15][16]. It is the scale that estimates motivational readiness of behavior change and consists of 5 stages : Precontemplation (individuals who do not exercise and do not intend to start exercise in the next 6 months), Contemplation (individuals who do not exercise, but intend to start exercising in the next 6 months), Preparation (individuals who do some exercise but not regularly), Action (individuals who exercise regularly, but only began doing so within the last 6 months), and Maintenance (individuals who exercise regularly and have done so for longer than 6 months). Regular exercise was defined as exercising three times per week[24]. People are thought to progress through these stages, moving back and forth before attaining the goal of maintenance. Participants were classified into one of these five stages depending on answers to three questions regarding frequency of exercise, intention to start exercise within the next 6 months, and duration of continuing the current exercise habit.

Self-efficacy is originally a concept in social cognitive theory, proposed by Bandura[13]. It means the perception of one's ability to perform the behavior. The transtheoretical model adopted this concept as one of the predictors of the stage of change[15][16]. This scale is related to the stage of change, meaning that persons in a higher stage have higher self-efficacy[25][26]. In this study, self-efficacy was rated by one question that asked subjects to evaluate their perception of ability to perform exercise on a 11-point scale ranged from "not at all confident"=0% to "very confident"=100%[26][27].

Physical fitness

Physical fitness was estimated by grip strength (kg), sit-ups (times/30 sec.), jumping reaction time (msec.), vertical jump (cm), and sitting trunk flexion (cm). Grip strength, vertical jump, and sitting trunk flexion were tested twice in each subject and the better performances were recorded. Grip strength was expressed as the mean of the right and left hands. Sit-ups were counts of performance over 30 seconds. Jumping reaction time was the duration from the moment of the light signal until jumping, and this was tested 5 times. After maximum and minimum data were excluded, three performances were averaged. A few subjects were unable to perform the tests because of their orthopedic disorders. Therefore, the number of data that could be analyzed varied from 79 to 84 depending on the kind of tests.

Nutrition

As a parameter of nutrition, total energy intake (kcal/day) was calculated by a self-administered questionnaire including questions on frequency and amount of food intake[27].

2) Measurements of physique and blood lipids

Physique measurements included body weight (kg), body mass index (BMI) (kg/m^2), and percent body fat. Percent body fat was measured by the caliper method, and calculated using the Nagamine[29] and Brozek[30] equation. BMI was defined as weight in kilograms divided by the square of height in meters. Fasting blood samples were obtained and analyzed for total serum cholesterol (TC), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), and triglyceride (TG). Samples were analyzed using enzymatic technique (TC, LDL-C, TG) and direct technique (HDL-C).

4. Intervention procedures

The intervention program was conducted at the Tokyo Metropolitan Health Promotion Center. After baseline assessment, results of tests were reported for each subject in both groups. General information including how to interpret the data and recommendation on physical activity was also offered for both groups in 30-minute group lectures. Recommended physical activity was to meet one of three criteria : 1) walking

more than 10,000 steps per day[31], 2) accumulation of 30 minutes or more moderate intensity physical activity more than 5 days a week[6], 3) three times or more exercise a week[24]. The point of recommendation was to increase energy expenditure by either lifestyle activity or structured exercise. In addition to the lecture, subjects in both groups received guidance in the use of facilities of the Tokyo Metropolitan Health Promotion Center, and they were allowed to use the center during the research period. The processes written above were common for both groups. For the control group, no more intervention was conducted

The intervention program for the intervention group aimed for long-term adherence to active lifestyle. The 8-week intensive program and the 6-month follow-up period were set. Eight weeks included eight sessions (one session a week), and each session consisted of one hour of group work and one hour of exercise practice. The program was based on a behavior change model called the "stage of change." The model postulate that the stage-specific intervention is useful. We engaged various behavioral management skills in the program depending on the stage of change shown in Table 1. These skills were originally derived from various theories and models of human behavior[32][33] such as the learning theory[12], the social cognitive theory[13] and the relapse prevention model[14]. For example, self-efficacy is originally the concept of the social cognitive theory and also a component of the transtheoretical model. Stimulus control and reinforcement management are skills derived from the learning theory. Practical educational procedures were prepared based on these skills. The procedures were combined depending on the stage of change (Table 1), and the subjects were trained to use these skills. In practice, the group work was conducted according to the schedule shown in Table 2. Although the concepts and methods of goal setting and self-monitoring were explained in the second week, subjects continued to practice these two skills every week during intensive intervention period. Goal setting was conducted in two forms, short-term (the goal of that week) and long-term (the goal of 8 weeks). Since almost all subjects (92.9%) were in Contemplation (71.4%) and Preparation stages (21.4%), we prepared only one program, a program for the Contemplation/Preparation stage. We included skills for the Contemplation stage and the Preparation stage early in the 8-week period, and skills for the Action stage and the Maintenance stage later in the 8-week period. Although the behavioral approaches were used mainly in group work, exercise practice also included the concepts of behavioral science. For example, we expected that the exercise practice would be a good chance to increase the self-efficacy through enactive attainments, vicarious experiences and verbal persuasions that are pointed out by Bandura as effective in raising self-efficacy[34].

During the 6-month follow-up period, newsletters were mailed to intervention group subjects every 2 months.

5. Data analysis

Analysis of variance with repeated measures was used to test the change of values of all measures, except stage of change, from baseline to 2 months and to 8 months. For the comparison between two groups, analysis of covariance was performed. Covariance factors were age and baseline data for the tests of physical activity energy expenditure, exercise behavior, physical fitness, nutrition, and physique. In the analysis of blood lipids, age, BMI, postmenopausal status and baseline data were adjusted as covariance factors. The χ^2 test was used to compare the distribution change in stage of change between the two groups. All statistical analyses were performed with the SPSS 11.0J for Windows, SPSS Inc., Chicago, USA. A p value of less than 0.05 was taken

Table 1 Combination of behavioral management skills depending on the stage of change for exercise behavior in the present program

Behavioral management strategies	The stage of change				
	Precontemplation	Contemplation	Preparation	Action	Maintenance
Knowledge of physical activity	◎	◎	○		
Sellf-monitoring	○	○	◎	◎	○
Goal setting		○	◎	◎	○
Self-efficacy	○	◎	◎	◎	○
Decisional balance	◎	◎	○		
Stimulus control		○	◎	◎	○
Reinforcement management		○	◎	◎	○
Social support		○	◎	◎	◎
Contracting		○	◎		
Positive self-talk			◎	◎	○
Relapse prevention				◎	◎

◎ : strongly recommended skills, ○ : recommended skills

Table 2 Behavioral management skills taught in group sessions

week 1	Knowledge of physical activity, Recommendation	Explanation of benefits and recommended amounts of physical activity to help participants to have realistic expectations.
week 2	Goal setting	To set concrete goals including the type, place, time and duraton of physical activity.
	Self-monitoring	To record one's own behavior. In the program, activity diary and accerelometer were delivered for self-monitoring.
	Contracting	To agree with the contract to maintain an active lifstyle to enhance commitment. Subjects signed the contract to formalize the agreement.
week 3	Decisional balance	To discuss benefits, costs and barriers of physical activities in order to overcome barriers and to support participants in setting goals with more benefits and with fewer costs.
week 4	Stimulus control	To increase environmental cues or stimuli to do physical activity such as wearing sports shoes in daily life, putting a written note on the wall, having a routine time and place for exercise, etc.
week 5	Social support	To seek support of family, friends and coworkers who understand the subject's effort, encourage participation in physical activity or do physical activity together.
week 6	Reinforcement management	To control reinforcers encouraging physical activity such as giving self-praise, recording the activity chart, setting favorite walking course, etc.
week 7	Positive self-talk	To train positive thinkings in difficult situations in order to maintain the active lifestyle.
	Relapse prevention	To identify high-risk situations for relapse and to prepare ways of coping with them
week 8	Summary	Summary of above skills

to indicate a statistically significant difference.

Results

1. Baseline characteristics and program adherence

In total, 84 subjects participated in all three assessments (follow-up rate: 97.7%). One subject in the intervention group declined to participate in the program due to a disease in the family. However, she did participate in all three assessments. Therefore, according to the intention-to-treat analysis principle, the data were analyzed as the data of the intervention group. Thus, data with regard to 84 women (43 subjects in the intervention group, 41 subjects in the control group) were analyzed.

Baseline characteristics of subjects are shown in Table 3. The mean (SD) age was 57.2 (5.4) years old, ranging from 47 to 68 years old. Almost all (90.5%) engaged in exercise less than once a week and were considered to be sedentary women. The mean (SD) BMI was 22.9 (2.8) kg/m^2. According to the guidelines for diagnosis and treatment of atherosclerotic diseases of the Japan Atherosclerosis Society[35], 50.0% of subjects had high LDL-C level (≧140 mg/dl), 2.4% had low HDL-C level (<40 mg/dl), and 17.9% had high triglyceride level (≧150 mg/dl). Most of the subjects had normal levels of blood glucose and blood pressure. In all outcome measures, no significant difference between groups was observed at baseline.

Table 3 Baseline characteristics of participants

Variables	n=84
Age, years old	57.2±5.4
Employment (full time worker) rate, %	47.6 (7.1)
Total energy expenditure, kcal/kg/day	39.8±2.7
Stage of change for exercise behavior[#], %	3.6 : 71.4 : 21.4 : 2.4 : 1.2
Frequency of exercise, times/week	0.29±0.91
Height, cm	154.1±5.2
Weight, kg	54.6±7.3
BMI, kg/m^2	22.9±2.8
Body fat, %	30.1±7.7
Total cholesterol, mg/dl	235.9±23.7
HDL-C, mg/dl	66.5±15.7
LDL-C, mg/dl	137.0±21.5
Triglyceride, mg/dl	106.5±59.9
Fasting plasma glucose, mg/dl	92.3±7.0
Systolic blood pressure, mmHg	114.2±14.5
Diastolic blood pressure, mmHg	74.1±8.4
Postmenopausal status, %	88.1

Values are mean±SD except sex, work status, stage of change, and postmenopausal status.
[#]: values indicates distribution of stage in form as Precontemplation : Contemplation : Preparation : Action : Maintenance.
BMI : body mass index,
HDL-C : High density lipoprotein cholesterol
LDL-C : Low density lipoprotein cholesterol

2. Effects on physical activity, exercise behavior, physical fitness, and nutrition

1) Results at 2 months

Table 4 shows mean changes in measures of physical activity, exercise behavior, physical fitness, and nutrition.

Fig. 2 also shows the changes in energy expenditure depending on the intensity of activity. The intervention group significantly increased their total energy expendi-

Table 4 Mean changes in measures of physical activity energy expenditure, exercise behavior, physical fitness, and nutrition

Variables		baseline	Change from baseline after 2 months	Comparison between groups (p value)	Change from baseline after 8 months	Comparison between groups (p value)
Energy expenditure, kcal/kg/day						
Total	Control	40.11±3.07	0.10±2.19	0.38	−1.05±2.43*	0.14
	Intervention	39.53±2.23	1.26±2.20**		0.30±1.95	
Moderate activity	Control	4.24±3.97	−0.81±2.97	.025	−1.58±3.27**	.003
	Intervention	3.19±2.84	0.92±2.71*		0.81±2.93	
Vigorous activity	Control	0.43±1.49	0.02±1.75	.277	−0.27±1.38	.146
	Intervention	0.30±1.02	0.55±2.25		0.03±1.00	
Exercise behavior						
Frequency of exercise, days/week	Control	0.46±1.25	0.57±1.30**	<.001	0.34±1.75	.025
	Intervention	0.13±0.29	1.74±1.39***		1.27±1.09***	
Stage of change for exercise behavior, %	Control	2.4 : 65.9 : 24.4 : 4.9 : 2.4‡	39.0#	<.001	34.1#	.009
	Intervention	4.7 : 76.7 : 18.6 : 0 : 0‡	81.4#		62.8#	
Exercise self-efficacy	Control	62.4±19.6	−1.7±22.2	.035	−6.1±20.6	.001
	Intervention	60.0±20.4	8.8±19.5**		8.8±18.8**	
Physical fitness						
Grip strength, kg	Control	23.4±3.9	0.9±2.0**	.459	0.3±2.2	.137
	Intervention	24.6±4.9	0.3±3.0		0.5±2.2	
Sit-ups, times/30 sec.	Control	8.1±4.9	0.0±2.1	.012	1.1±2.9*	.127
	Intervention	8.6±5.7	1.2±2.3**		2.0±3.2***	
Jumping reaction time, msec.	Control	399.7±59.8	15.3±48.6	.025	8.2±41.8	.432
	Intervention	398.2±48.6	−5.0±34.8		2.4±38.5	
Vertical jump, cm	Control	26.8±5.7	0.0±4.5	.039	−0.8±4.8	.190
	Intervention	28.9±5.7	0.5±3.4		−1.0±4.1	
Sitting trunk flexion, cm	Control	11.8±8.3	1.1±3.3*	.230	0.7±4.0	.012
	Intervention	13.8±5.7	1.5±2.4***		1.9±2.3***	
Nutrition						
Total energy intake, kcal/day	Control	1,549±279	−54±235	.541	−85±260*	.138
	Intervention	1,440±242	−20±241		−64±228	

All values without stage of change are expressed as mean±SD.

P values were calculated after adjustment for age and baseline value except Stage of change.

‡: values indicate distribution of stage in form as Precontemplation : Contemplation : Preparation : Action : Maintenance.

#: Values indicate the proportion of subjects who improved their stage compared with baseline.

*: $p<0.05$, **: $p<0.01$, ***: $p<0.001$ for the comparison with the baseline

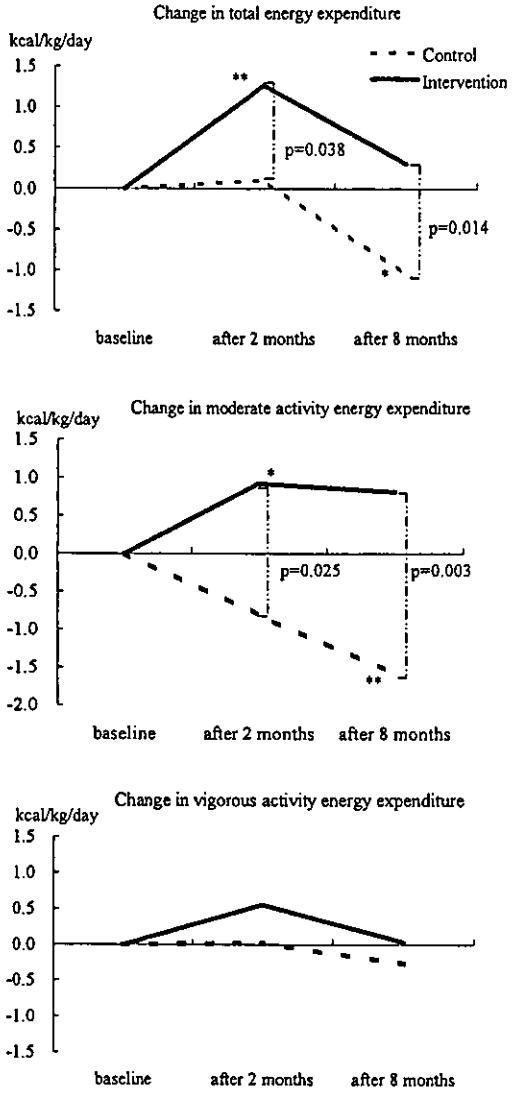

Fig. 2 Changes in energy expenditure depending on the intensity of activity
*: $p<0.05$, **: $p<0.01$ for the comparison with the baseline
p values indicate the results of comparison between groups

ture by 1.26 kcal/kg/day. The amount of increase was significantly larger than the control group (p=0.038). Analysis of the components of activity revealed that the intervention group significantly increased their energy expenditure only in moderate activity over time. Also, the amount of increase was significant larger in the intervention group compared with the control group (p=0.025). On the other hand, in vigorous activity, no significant difference was observed over time or between groups.

Significant improvements in frequency of exercise, stage of change for exercise behavior, and exercise self-efficacy were also observed in the intervention group at 2 months compared with baseline. Comparison of the changes in these measures between groups also showed significantly more improvement in the intervention group.

In physical fitness, grip strength and sitting trunk flexion in the control group, and sit-ups and sitting trunk flexion in the intervention group were significantly improved from baseline to 2 months. On comparison between the two groups, the intervention group significantly improved performance in sit-ups (p=0.012), jumping reaction time (p=0.026), and vertical jump (p=0.039). Total energy intake was unchanged in both groups.

2) Results at 8 months

Total energy expenditure and moderate activity energy expenditure were significantly decreased from baseline in the control group. In the intervention group, mean changes from baseline were 0.30 kcal/kg/day in total energy expenditure and 0.81 kcal/kg/day in moderate activity energy expenditure, but no significant difference was observed compared with baseline. The amounts of increase in total and moderate activity energy expenditure were significantly higher in the intervention group compared with the control group (p=0.014, and p=0.003, respectively). The differences in changes of energy expenditure between the two groups were+1.35 kcal/kg/day for total energy expenditure, and+2.39 kcal/kg/day for moderate activity energy expenditure. As observed at 2 months, vigorous activity energy expenditure was not significantly changed at 8 months.

Frequency of exercise, stage of change for exercise behavior, and exercise self-efficacy were improved by significantly large degrees in the intervention group compared with the control group at 8 months (p=0.025, p=0.009, and p=0.001, respectively).

In physical fitness, both groups improved their performance in sit-ups from baseline, but no significant difference between groups was observed. Sitting trunk flexion was significantly improved only in the intervention group. Significant difference between groups was also observed in the amount of improvement of sitting trunk flexion (p=0.012).

Total energy intake was significantly decreased in the control group, but there was no significant difference between groups.

3. Effects on physique and blood lipids

1) Results at 2 months

Table 5 shows the mean changes in measures of physique and lipid metabolism. The intervention group significantly decreased body weight and BMI from baseline to 2 months. Comparison between the two groups also showed significantly large decreases in body weight and BMI in the intervention group (p=0.036, p=0.006, respectively). In blood lipids, the interven-

Table 5 Mean changes in measures of physique and blood lipids

Variables		baseline	Change from baseline after 2 months	Comparison between groups (p value)	Change from baseline after 8 months	Comparison between groups (p value)
Physique						
Weight, kg	Control	54.9±7.7	−0.2±0.9	.036	−0.4±1.5	.184
	Intervention	54.4±6.9	−0.6±1.0***		−0.8±1.5**	
BMI, kg/m²	Control	23.1±3.0	−0.1±0.4	.006	−0.1±0.6	.124
	Intervention	22.8±2.6	−0.3±0.4***		−0.3±0.6**	
Body fat, %	Control	30.0±8.4	0.5±3.5	.056	−0.8±2.8	.002
	Intervention	30.2±7.1	−0.7±2.7		−2.5±3.0***	
Blood Lipids						
Total cholesterol, mg/dl	Control	234.4±27.6	−4.3±21.5	.207	−1.0±22.7	.877
	Intervention	237.3±19.6	−10.8±22.9		−1.7±25.5	
HDL-C, mg/dl	Control	68.7±15.0	−2.2±7.9	.432	−1.4±8.1	.934
	Intervention	64.5±16.2	−2.7±6.5**		−0.8±8.3	
LDL-C, mg/dl	Control	134.1±23.9	8.2±17.4**	.075	10.3±16.7***	.659
	Intervention	139.8±19.0	0.8±14.3		6.6±18.7*	
Triglyceride, mg/dl	Control	101.1±62.0	−8.0±39.3	.761	−13.4±47.9	.374
	Intervention	111.6±58.2	−8.0±63.9		−7.7±51.2	

All values are expressed as mean±SD.
P values were calculated after adjustment for age and baseline value in the enalysis of body weight, BMI, and body fat.
P values were calculated after adjustment for age, BMI, menopausal state and baseline value in the analysis of blood lipids.
*: $p<0.05$, **: $p<0.01$, ***: $p<0.001$ for the comparison with the baseline

tion group showed a significantly decreased HDL-C level, and the control group showed a significantly increased LDL-C level. However, no significant group difference was seen in any blood lipids.

1) Results at 8 months

The intervention group significantly decreased body weight, BMI, and percent body fat at 8 months compared with baseline, while no significant decrease was observed in the control group. The change in body fat was significantly greater in the intervention group ($p=0.002$). The LDL-C levels in both groups significantly increased, but change values were not statistically significant between the two groups.

Discussion

The major finding of this study is that a developed program based on behavioral science significantly increased physical activity and improved some measures of physical fitness and body composition at 2 months compared with baseline. Furthermore, the effects of intervention were maintained after a 6-month follow-up period.

1. Effects on physical activity and physical fitness

Observed differences in change of total energy expenditure at 8 months between groups was +1.35 kcal/kg/day. By calculation with the assumptions of walking speed = 70 m/min, 3 METs in intensity, width of a step = 70 cm, and body weight = 50 kg, +1.35 kcal/kg/day is parallel to an energy expenditure increase of 2,579 steps per day[23]. This effect is large enough to meet the target of Health Japan 21, an increase of 1,000 steps per day on average in the general population[31]. In this study we used 24-hour physical activity records to evaluate energy expenditure. In this method, all kinds of activities done by subjects were recorded and calculated. It is reported that the physical activity record method has fair to good validity in estimating energy expenditure[36][37]. In fact, a high correlation between total energy expenditure as estimated by 24-hour physical activity record used in this study and as measured by accelerometer ($r=0.68$) supports the validity of physical activity assessment in this study (data not shown).

Although a significant difference was observed in mean change of total energy expenditures between the two groups, the values in both groups were decreased by approximately 1 kcal/kg/day at 8 months compared with 2 months. The reasons for this may include seasonal change of physical activity, decrease of motivation in both groups, etc. Seasonal variation may play an especially important role for this result. Matthews et al. reported that women increased their activity level by 1 METs-hours/day (1.05 kcal/kg/day) during summer in comparison with winter[38]. Supposed that there was a comparable seasonal effect on physical activity in this study, the decrease of energy expenditure from 2 months (July) to 8 months (December) is understandable.

Regarding the intensity of activity, only moderate activity was increased by intervention. No significant change was observed in vigorous activity. In this study, the recommendation of physical activity for both groups emphasized the increase of energy expenditure without reference to intensity. Also, it is likely that moderate activity is more acceptable, easier to start, and easier to maintain for these subjects.

In three measures related to exercise behavior, the intervention group also improved behavioral parameters such as stage of change and self-efficacy in significantly large degrees compared with the control group over 8 months. The parallel increase of self-efficacy with the improvement of stage of change and with the increase in energy expenditure is consistent with the result of past studies[39]. Since self-efficacy is reported to be a strong predictor of behavior change in many studies, the improvement of this scale suggests the maintenance of active lifestyles among the intervention group.

2. Effects on physique and blood lipids

The effects of intervention were also observed in body weight, BMI, and percent body fat, although weight reduction was not the main focus in this program. As such, goal setting and self-monitoring were implemented mostly on physical activity and behavioral skills. These differences in the physique are mainly due to the increase of physical activity, as there was no significant group difference observed in total energy intake. It is thought that the improvement of body composition was due to the sequence of sustained physical activity.

In analysis of blood lipids, there was no significant group difference in change values. Regarding LDL-C, subjects of this study had slightly increased levels of LDL-C, and 50% of them had high levels of LDL-C defined as 140 mg/dl or more at baseline. The result was the same as if the analysis was limited to 42 women with elevated levels of LDL-C. However, this is not surprising, as these results are consistent with past studies. Stefanick reviewed five randomized trials on lipoprotein effects of aerobic exercise in individuals with mean BMI less than 25 kg/m^2 [40]. According to this review, only one of five trials that showed an improvement in LDL-C or TC with exercise involved an additional dietary component. In our study, mean BMI of subjects, 22.9 kg/m^2 was far less than 25 kg/m^2.

3. Limitations of this study and future direction

There are some limitations to this study. First, the limited variety of subjects; all subjects were middle-aged and senior women in a community setting. While 47.7% of subjects had jobs, only 7.1% were full-time workers. For different age groups and sex, there may be different types of barriers to increasing physical

activity, for example barriers such as lack of time due to work or childcare. The acceptability of the program may also be different depending on sex and age. Further studies are needed to examine the effects of the program in other settings and populations. Secondly, subjects in this study were volunteers who had relatively high levels of motivation of behavior change. Distribution of stage of change indicates that 71.4% of subjects had the intention to start exercise at baseline, and that 21.4% were doing some exercise even though the amount was not enough to obtain health benefits. The effects of the program on subjects in the Contemplation and the Preparation stages were the main observations in this study. Further studies are needed for people who have lower levels of motivation and for people in the Precontemplation, Action and Maintenance stages. However, even for people in the Contemplation stage and in the Preparation stage, it is not easy to adopt and maintain the active lifestyle, and practitioners most frequently have the opportunity to educate people in these two stages. Thus the result of this study is quite useful in health education practices. The third limitation is that the effects of elements of the program, i.e. the behavioral group work and the exercise practice, could not be differentiated from each other due to the study design. It may be pointed out that the effects of the program may be mainly due to the exercise practices themselves or due to the frequent contacts with educators (8 times in 8 weeks) even though the behavioral elements was emphasized in this program. What can be concluded from this study design is that the present program was more effective than the treatment for the control group in which subjects received explanations of the results of medical checks and were offered chances to use the exercise facility. According to past studies, however, intervention methods like health risk appraisal, exercise prescription or supervised exercise practice by itself demonstrated small effects to change behavior, while the behavior modification approaches showed large effects[20)21)]. It is likely that behavioral approaches played an important role in promoting physical activity in this program. In the future, studies that differentiate effects of each element in the program are expected to improve the intervention method.

In spite of these limitations, the results of this study suggested the potential of behavioral science in physical activity education. It is worthwhile in the public health context that the program was based on a theoretical framework, since a theoretical framework can guide the application of the program in many other kinds of health promotion practices such as the development of educational materials, the training of health professionals, and the development of modified programs in various settings.

Conclusion

The physical activity program using behavioral approaches effectively increased physical activity, and improved exercise behavior, physical fitness, and body composition over 8 months including a 2-month intensive intervention period and a 6-month follow-up period.

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