REVIEW

Are activity promotion interventions based on the transtheoretical model effective? A critical review

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The health benefits of physical activity are well documented yet 70% of adults remain sedentary. It has been suggested that inverventions based on the transtheoretical model of behaviour change (TTM) may be useful in promoting physical activity. Published work on the effectiveness of such inteventions is therefore critically reviewed. Although there is evidence that TTM based activity promotion interventions are effective in promoting activity adoption, initial results on longer term adherence are disappointing.

Optimum activity levels can delay or prevent the development of ischaemic heart disease, type 2 diabetes mellitus, obesity, hypertension, colon cancer, osteoporosis, anxiety, depression, and the institutionalisation of elderly people.[1] In the United Kingdom, current recommendations for the maximisation of health are that "every adult should accumulate 30 minutes or more of moderate intensity physical activity on most, preferably all, days of the week".[2] However, typically, only about one third of adults in developed countries meet these recommendations.[3]

The transtheoretical model of behaviour change (TTM) was first described in 1982 as a proposed mechanism of smoking cessation.[4] Understanding behaviour change as a process rather than a single event, the TTM attempts to explain how, rather than why, behaviour change occurs. Unlike previous behavioural models, it takes a pragmatic approach and offers explicit suggestions for how people can be helped to change their behaviour. With current adaptations, the TTM states that there are five distinct stages involved in long term behaviour change (table 1) during which 10 different processes of change[5] may be used. Figure 1 shows the interaction of the stages and processes of change. The TTM suggests that, for successful behaviour change, interventions must be tailored to a person's current stage of change and make use of the appropriate processes of change.

Traditional interventions to improve physical activity participation have had some short term success but have been minimally effective in achieving long term activity adherence.[6] Although the TTM was originally developed to explain smoking cessation behaviour, its application to the uptake of physical activity has been confirmed.[7 8] This, and its success in helping people change other unhealthy behaviours, particularly smoking,[9] has led to recommendations for its use in activity promotion.[6 10] This paper critically reviews published reports of TTM based, activity promotion interventions and attempts to answer the question: is there evidence of an additional effect of TTM based activity promotion interventions over non-staged interventions?

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METHODS

To identify relevant papers for inclusion in the review, we searched the Medline and PsycINFO databases from 1982 (when the TTM was first described[4]) to 2001 using the keywords "transtheoretical" OR "stages of change" AND "activity" OR "exercise".

Papers identified by these searches that met the following criteria were included.

- An intervention explicitly based on the TTM that aimed to promote physical activity levels was described and evaluated
- Study participants were adult (more than 16 years of age) and living within the community
- Some assessment of physical activity levels both before and after implementation of the intervention was included
- English language
- Publication between 1982 and 2001 inclusive.

The presence of a control group was not a specific criterion for inclusion in the present review.

This process identified 10 relevant papers. A further 16 that also met the above criteria were identified from scrutinising the reference lists of the 10 papers identified by electronic searches. Thus a total of 26 papers were identified for inclusion in the review.

FINDINGS

Table 2 summarises the 26 papers documenting 16 intervention programmes; they are discussed briefly below. Overall, seven programmes used TTM based counselling only, four used TTM based written materials only, and five used a mixture of TTM based counselling and written information. In the short term (six months or less), 11 of 15 (73%) programmes reported some significant benefit of TTM based interventions over control conditions—in terms of stage progression, activity levels, or both. One further study[11] was not controlled, but reported an effect of the intervention over characteristics at baseline. Longer term (more than six months), two of seven (29%) programmes reported some benefit of TTM based programmes. We used more than six months as our definition of long term because, by definition, six months must have elapsed before a person can be classified as being in the maintenance stage of activity change (table 1).

Table 1 Definitions of the stages of activity change[8]

Stage	Definition
Pre-contemplation	Individuals are not participating in any physical activity and have no intention to do so in the future
Contemplation	Individuals are not participating in any physical activity but intend to start doing so in the next six months
Preparation	Individuals intend to start participating in regular physical activity in the next six months and are starting to make small changes in their activity behaviour
Action	Individuals meet defined criteria* for physical activity but have done so for less than six months
Maintenance	Individuals have met defined criteria for physical activity for more than six months

*Different authors use different criteria for defining acceptable levels of physical activity; these are often related to current activity recommendations.

Study of Marcus *et al*[11]

This uncontrolled study used a before and after comparison design to assess the effects of stage specific, written activity promotion information. It recruited subjects through an advertising campaign and therefore participants were probably unusually motivated and not representative of the sedentary population in general.[8] However, short term effects of the intervention were seen in terms of both stage progression and activity levels.

Fresh start[12]

This study represented a pragmatic attempt to modify cardiovascular risk using TTM based videoed counselling and written information. Doctors were asked to devise and implement their own methods of recruiting suitable subjects. Although this represents what may happen in "real life", it led to inconsistencies in recruitment procedures and significant intergroup differences in key variables at baseline.

Furthermore, all subjects, independent of their stage of activity change, were shown the same intervention videos—one for each risk factor (obesity, hypertension, and hypercholesterolaemia). It seems unlikely that a single intervention such as this could be truly stage matched.

Finally, the "high risk" approach adopted by this study runs counter to both accepted wisdom[13] and TTM philosophy. The TTM proposes that everyone, no matter what their motivational readiness to change, can be helped to adopt or maintain healthier behaviours. Targeting only those who are at "high risk" of cardiovascular disease ignores this important innovation.

Study of Cardinal and Sachs[14]

This study trialled stage specific, written, activity promotion interventions, which advocated either structured or lifestyle activity. As with all single worksite interventions, there was a risk in this study of contamination between the intervention and control group. The study recruited only working, high school educated women, making the results difficult to generalise to the wider sedentary population.

Physical activity levels were not measured in this study, and stage of activity change was the only outcome measure. Although stage of activity change is an important variable, it is activity, rather than stage of change, that affects health. Stage progression does not necessarily result in increased physical activity levels (table 1) and cannot be assumed to be a good proxy for physical activity.

Study of Loughlan and Mutrie[41]

This study assessed the use of exercise consultations compared with traditional fitness assessment and feedback, and non-staged, written information in subjects originally in the contemplation and preparation stages of activity change. The authors propose that these people are most likely to respond to a staged intervention. As mentioned above, this contradicts TTM theory, which states that everyone can

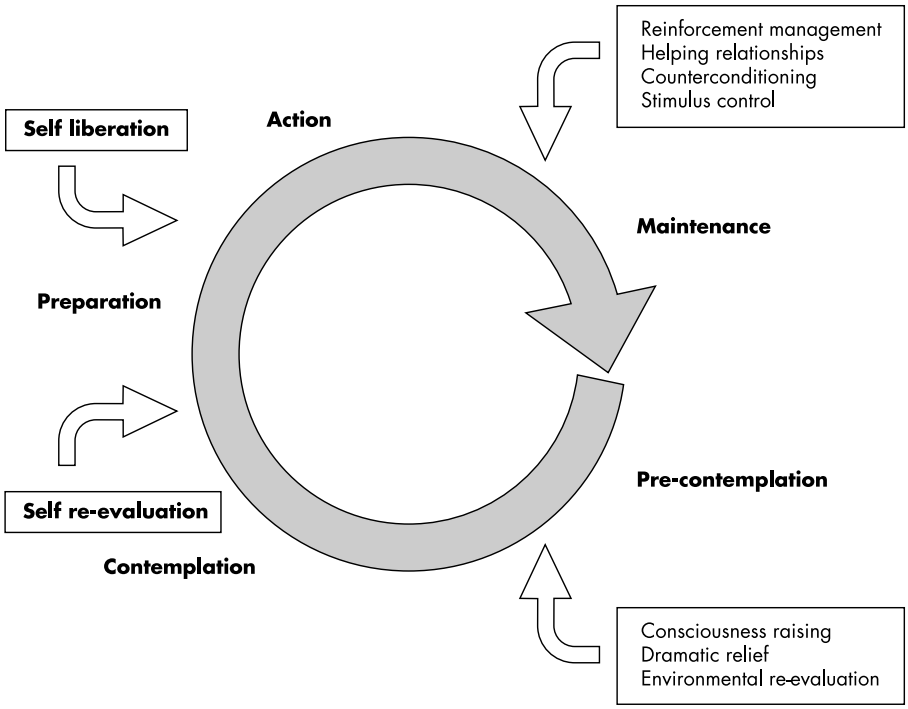

Figure 1 The transtheoretical model of behaviour change; stages are shown in bold, and processes in boxes.

Table 2 Summary of studies reviewed

Project	Nature of sample completing study	Country	Design	Experimental intervention	Control condition	Follow up period	Results	Effective*	
								Short term**	Long term
Marcus *et al*[11]	236 of 610 (39%) adults in contemplation, preparation and action stages of activity change, recruited via advertising campaign. Follow up results from stratified random sample of participants.	USA	Before and after, uncontrolled	Stage specific written activity information on how to start and continue physical activity and leisure facilities in area – one pamphlet for each stage of change.	N/A	6 weeks	Subjects significantly more active after intervention than before ($p<0.0001$). 62% of those originally in contemplation stage and 61% of those originally in preparation stage showing stage progression. 9% of those originally in action stage showed stage regression.	Yes	N/A
Fresh start[12]	382 of 758 (50%) adults with ⩾1 modifiable cardiovascular risk factors (BMI>25 kg/m^2, blood pressure>140/95 mm Hg, cholesterol>5.5 mmol/l, current smoker) recruited in primary care using methods devised and identified as suitable by individual physicians	UK	Randomised (by GP practice), controlled	TTM based videoed activity counselling +/– TTM based written information – one video and information leaflet per risk factor	Routine care – assessment of cardiovascular risk with appropriate, routine feedback	4–6 months and 12–18 months	Significant increase in energy expenditure in all groups but no difference between groups (figures not given). At 4 months, 20% of those in intervention groups and 27% of those in control group ($p=0.02$) showed stage progression At 12 months, 20–22% of subjects in all groups made stage progression ($p=0.81$).	No	No
Cardinal and Sachs[14]	81 of 113 (72%) female university clerical staff in all stages of activity change. Recruitment method not described.	USA	Stratified (by baseline stage of activity change), randomised (by individual), controlled	Stage specific written information promoting structured (traditional exercise classes and sessions) or lifestyle (integrating exercise into daily routine) activity using TTM theory	Non-staged written feedback on current activity levels	1 and 7 months	Significant stage progression in all groups at 1 and 7 months ($p<0.05$). No intergroup differences. At 1 month, of those who could show stage progression (i.e. not in maintenance stage at baseline), 39% did. At 7 months, 57% of subjects who could show stage progression did, 30% maintained their original stage and 13% regressed.	No	No
Loughlan and Mutrie[41]	Unknown number completed of 179 recruited. Sedentary adults in preparation and contemplation stage recruited in workplace	UK	Randomised (by individual), controlled	'Exercise consultation' (a 30 minute, one-to-one consultation based in TTM theory), delivered by trained research assistants	Fitness assessment and feedback or written activity information (unstaged)	1, 3 and 6 months	All subjects increased number of hours of exercise per week from 3.5 hours at baseline, to 6.75 hours at 1 month, to 6 hours at 3 months and 5 hours at 6 months ($p<0.001$). No intergroup differences	No	N/A
Project PACE - 1[16–18]	212 of 255 (83%) adults in contemplation stage of activity change recruited in primary care by telephone assessment of all those booked for non-acute visits over study period	USA	Non-randomised, controlled	Stage specific activity counselling delivered by trained physician, selected for interest in activity counselling, following written stage assessment completed in waiting room, and follow up phone call delivered by research team	Routine care – from physicians selected for lack of interest in activity counselling, given training in hepatitis B diagnosis and treatment	4–6 weeks	Significantly more stage progression in intervention compared with control subjects (figures not given). 52% of intervention subjects regularly active at follow up compared with12% of control subjects. Intervention subjects reported 40 min increase in time spent walking per week compared with 10 min increase in control subjects ($p<0.05$)	Yes	N/A
Project PACE - 2[19]	822 of 847 (97%) adults in all stages of activity change recruited in primary care by telephone assessment of all those booked to attend for a non-acute visit over the study period	USA	Randomised (by physician), controlled	Stage specific activity counselling delivered by trained physician following written stage assessment in waiting room + follow up 'phone call at 1 month from research assistant +/– follow up phone calls at 2, 3 and 4 months and postcard reminders at 2, 3, 4 and 5 months	Routine care from physicians receiving minimal information on study (physicians randomly allocated to intervention or control groups)	6 months	No overall intergroup differences in physical activity variables. Overall significantly more stage progression in intervention than control group: 33% ($p=0.05$) more contemplators made stage progression in intervention compared to control group.	Yes	N/A

Table 2 continued

Project	Nature of sample completing study	Country	Design	Experimental intervention	Control condition	Follow up period	Results	Effective*	
								Short term**	Long term
Physically active for life[20–22]	322 of 355 (91%) sedentary subjects over 50, recruited in primary care by telephone assessment of all those booked to attend for a non-acute visit over the study period	USA	Randomised (by physician), controlled	Stage specific activity counselling delivered by trained physicians (who were paid to take part) following written stage assessment in waiting room + stage specific written information, a written exercise prescription, a free follow up clinic visit at 4 weeks and non-staged monthly mailings listing the benefits of exercise and local facilities	Routine care from physicians who received no intervention but were paid to take part	6 weeks and 8 months	At 6 weeks, 89% of intervention group and 74% of control group were in preparation or action stage (p<0.001). 27% of intervention group and 21% of control group met activity recommendations (30 minutes of moderate exercise on 5+ days per week or 20 minutes of vigorous exercise on 3+ days per week) (p=0.27). At 8 months, 79% of intervention group and 88% of control group were in preparation or action stage (p=0.07). 28% of intervention group and 23% of control group met activity recommendations (p=0.41).	Yes	No
Newcastle exercise project[23]	442 of 523 (85%) sedentary adults recruited in primary care either opportunistically at appointments or via mailed invitations to participate	UK	Randomised (by individual), controlled	TTM based activity counselling delivered by trained lifestyle advisor +/– financial incentive. Four intervention groups: one interview, one interview plus tokens for free use of local leisure facilities (financial incentive), six interviews or six interviews plus financial incentive	Routine care – no further intervention from study team	3 and 12 months	At 3 months, 55% of most intensive intervention group (six interviews & financial incentive) and 38% of combined intervention groups showed improved activity scores compared with 16% of controls (p=0.001). At 12 months, no intergroup differences (23% of controls and 26% of combined intervention groups showed increased activity scores, p>0.05).	Yes	No
Marcus *et al*[24] and Bock *et al*[25]	150 of 194 (77%) sedentary adults recruited through newspaper advertisements	USA	Randomised (by individual), controlled	Computer generated TTM based individualised written activity counselling compiled from a large bank of standardised messages in response to individuals reported stage of activity change and current activity levels + stage specific written activity information (as used in Jump Start to Health[28]) sent at baseline, 1 and 3 months	One of five non-staged written activity information developed by American Heart Association and of similar length to intervention information	1, 3, 6 and 12 months	At 6 months, intervention group reported an average of 151.4 minutes of activity/week compared to 97.6 in control group (p<0.01) (improved from 5.5 and 20.0 minutes respectively at baseline). 43.6% of intervention group and 18.1% of control groups reached recommended levels of activity (30 minutes on 5 or more days/week) (p<0.05). 42.3% of intervention group and 18.8% of control group reached action stage of activity change (p<0.05). At 12 months, intervention group reported an average of 187 minutes of activity/week compared to 133 in control group (p=0.1). 42% of intervention group and 25% of control groups reached recommended levels of activity (p<0.05). 45.1% of intervention group and 23.5% of control group reached action/maintenance stage of activity change (p<0.05).	Yes	Yes
Jump start to health[28]	903 of 1559 (58%) adults in all stages of activity change, recruited from worksites involved in a wider health promotion intervention, exact recruitment method not stated	USA	Randomised (by individual), controlled	Stage specific written activity information on how to start and continue physical activity and facilities in their area – one pamphlet for each stage of change. Appropriate stage pamphlet delivered at baseline, and pamphlet for next consecutive stage delivered at one month	Two of five non-staged, "action orientated" written activity pamphlets developed by American Heart Association and of similar length to intervention information delivered at baseline and one month	3 months	Overall, 31% of subjects showed stage progression: 37% of intervention group and 27% of control group (p<0.01). Overall, 13% of subjects showed stage regression : 11% of intervention group and 15% of control group. No significant effect of intervention on overall activity levels but those who showed stage progression, showed an average increase from 39 to 115 minutes of activity/week.	Yes	N/A

Table 2 continued

Project	Nature of sample completing study	Country	Design	Experimental intervention	Control condition	Follow up period	Results	Effective*	
								Short term**	Long term
Project active[5] [29–31]	190 of 235 (81%) sedentary adults recruited via mass media, word of mouth, and recontact of participants in previous studies	USA	Randomised (by individual), controlled	TTM based group activity counselling in groups of 10–13, weekly to week 16, fortnightly to week 24, monthly to week 52 and bimonthly to week 104. Monthly assessment of stage of activity change and delivery of appropriate stage matched activity pamphlet. Significant effort made to ensure attendance including reminder letters before and thank you letters after meetings and phone calls to non-attendees.	Free gym membership for 6 months. Three weeks of closely supervised instruction followed by less supervision and long term planning session with trainer at six months including receipt of all stage matched pamphlets used in intervention group. Participants encouraged to attend at least three gym sessions per week and contacted by phone if attended less than one session in any one week.	6 and 24 months	At 6 months, both groups significantly increased physical activity and cardiorespiratory fitness. Control group increased fitness more than intervention group ($p<0.001$), no significant intergroup differences in activity levels or % meeting recommended activity levels (30 minutes of moderate intensity activity on most days of the week). At 24 months, both groups increased average energy expenditure from baseline ($p<0.001$ in intervention group and $p=0.002$ in control group). Intervention group increased moderate intensity activity 3 times more than control group ($p=0.08$), control group increased vigorous activity 2 times more than intervention group ($p=0.07$). No significant intergroup differences in activity levels.	No	No
Naylor *et al*[32]	180 of 294 (61%) adults in all stages of activity change, recruited in primary care from those attending routine health checks	UK	Non-randomised, controlled	TTM/non-TTM based brief (<5 minutes) activity counselling delivered by practice nurse +/– stage specific written activity information. Three intervention groups: TTM based counselling plus stage specific written information; written information only; non-TTM based brief activity counselling. All participants received information on, and discount vouchers for, local leisure facilities.	Standard practice advice including asking participants about current activity levels and giving advice at nurse's discretion.	2 and 6 months	At 2 months, overall, 25% showed stage progression compared with baseline ($p=0.003$). No intergroup differences in stage progression or activity levels. At 6 months, overall, 20% showed stage progression compared with baseline ($p=0.009$). No intergroup differences in stage progression or activity levels. Stage progression was not significantly associated with increased activity levels. No effect of time or intervention on activity levels.	No	N/A
Peterson and Aldana[33]	527 of 784 (67%) adults in all stages of activity change recruited by random sampling of all employees of a large telecommunications firm	USA	Randomised (by individual), controlled	Stage specific written activity information or generic written activity information. Two intervention groups: stage specific written information drawing on stages and processes of change or generic written information focusing on known benefits of exercise and recommended levels. Both interventions similar in size, layout, and length.	No intervention	6 weeks	Subjects receiving staged information increased activity by 13%, those receiving generic information increased activity by 1% and control group decreased activity by 8% ($p<0.05$). 33% of staged intervention group showed stage progression, 19% of generic intervention, and 14% of control group ($p<0.0001$).	Yes	N/A
Change of heart[34–36]	473 of 699 (68%) adults with BMI>25 and taking part in less than 12 exercise sessions in last month recruited in primary care as part of multiple risk factor intervention project (targeting overweight and sedentary, smoking, high cholesterol)	UK	Randomised (by GP practice), controlled	TTM based activity counselling (2 or 3 sessions – depending on number of risk factors – of 20 minutes each) and 1 or 2 follow up phone calls delivered by practice nurses	Counselling from practice nurses not trained in TTM based counselling	4 and 12 months	At 4 months, 32% of intervention and 24% of control subjects were in action/maintenance: odds of having moved into action/maintenance stage in intervention compared with control group was 1.89 (95% CI=1.07, 3.36). Intervention subjects had increased the number of sessions of exercise they undertook to 169% of baseline, control subjects had to decreased to 64% of baseline. At 12 months, 31% of intervention and 29% of control subjects in action/maintenance stage: odds ratio 1.68 (95% CI=1.08, 2.61). Intervention subjects had increased the number of sessions of exercise they undertook to 146% of baseline, control subjects had to decreased to 89% of baseline.	Yes	Yes

Table 2 continued

Project	Nature of sample completing study	Country	Design	Experimental intervention	Control condition	Follow up period	Results	Effective*	
								Short term**	Long term
Hassler *et al*[37]	22 of 34 (65%) sedentary adults with type 1 diabetes mellitus recruited at 6 month diabetes review clinic	UK	Randomised (by individual), controlled	"Exercise consultation" (a 30 minute, one-to-one consultation based in TTM theory)	Non-staged written information	3 weeks	Leisure time physical activity increased from 398 to 598 minutes per week in intervention group (p=0.045) and decreased from 420 to 376 minutes per week in control group (p>0.05). This represents a significant intergroup difference (p=0.025).	Yes	N/A
Kirk *et al*[38]	23 of 26 (88%) sedentary adults in contemplation or preparation stage with type 2 diabetes mellitus, recruited via patient databases and at diabetes outpatient clinics	UK	Randomised (by individual), controlled	"Exercise consultation" (a 30 minute, one-to-one consultation based in TTM theory) plus written information	Written information plus 30 minutes of non-exercise specific contact with researcher	5 weeks	82% of intervention group and 33% of control group showed stage progression (p=0.02). Electronic activity measurement showed 4% increase in intervention group and 9% decrease in control group (p value not given). Self reported participation in activity increased in 55% of intervention group and decreased in 6% of control group (p>0.05).	Yes	N/A

*Effective represents any evidence of superiority of TTM based intervention compared with control in terms of stage progression or activity levels using a significance level of p<0.05.
**Short term effectiveness represents studies that show an effect over 6 months or less; long term effectiveness represents studies that show an effect over more than 6 months.
BMI, Body mass index; GP, general practitioner; TTM, transtheoretical model of behaviour change; N/A, not applicable.

benefit from a staged intervention. The study is therefore of limited generalisability, and it cannot be clear that exercise consultations are truly staged if they are only applicable to people in particular stages of activity change.

Project PACE[16–19]

The PACE (physician based assessment and counselling for exercise) intervention has been assessed in two different trials. It has been found to be acceptable to both patients and doctors[18] and entails a realistic procedure whereby doctors are trained to deliver brief, TTM based activity counselling to patients, based on the results of an initial written assessment completed by patients in the waiting room. The first evaluation of the PACE trial[16–18] (listed in table 2 as PACE 1) used only motivated doctors to deliver the intervention and used patients of doctors selected for their lack of interest in activity promotion as a control group. Although this procedure will amplify any effect of the intervention, such a control condition may not represent routine care as it is experienced by the average patient. Furthermore, PACE 1 only assessed the effect of the intervention on those initially in the contemplation stage of activity change—a limited interpretation of the TTM, as discussed above.

A concurrent analysis of the effect of the PACE intervention on a number of psychological mediators of activity change identified by the TTM was also made.[17] This found that changes in measured constructs explained about 9% of the change in activity measured, suggesting that the PACE intervention has a measurable effect on the mediators of change as identified by the TTM.

The second PACE trial (PACE 2) randomly assigned doctors to intervention or control groups and reported results on patients initially in all stages of activity change. This study again found that the intervention was most effective in those initially in the contemplation stage of activity change, suggesting that the PACE intervention works better in particular groups. Truly staged interventions would be expected to be equally effective in all subjects.

Physically active for life[20–22]

The Physically active for life intervention used a similar protocol and intervention to the PACE studies, although it targeted people over 50 and added a four week review visit and stage specific, written information to the intervention protocol. The review visit was free to patients in the trial but would represent a considerable cost if implemented widely.

As with Project PACE, a concurrent study assessed the impact of the intervention on a number of theoretically determined mediators of exercise change.[21] Although some differences were seen between the groups at six weeks, these were not sustained at eight months.

The Newcastle exercise project[23]

This study compared the effect of brief and more intensive TTM based activity counselling with and without the addition of financial incentives. Despite the fairly intensive intervention delivered to some participants (up to six counselling sessions), no long term effects on activity levels were reported.

Unlike many other studies reviewed, physical measures of lung function and fitness were made of all participants in this study. This assessment procedure is a significant intervention in itself and may account for the increase in overall activity levels seen throughout the study groups.

Studies of Marcus *et al*[24] and Bock *et al*[25]

This study built on the finding that smokers receiving individually tailored letters were significantly more likely to give up smoking than those receiving a standard letter.[26 27] The intervention was innovative and potentially low cost, requiring little trained staff time after the initial development of the computerised messages and programme.

Participants were recruited by newspaper advertisements, which may account for the rather unrepresentative sample, consisting primarily of white, middle class, non-smoking women with at least a high school level of education. However, the programme is the first reviewed here to report evidence of long term effectiveness of a TTM based activity promotion intervention.

Jump start to health study[28]

This worksite based study made a randomised, controlled assessment of the effect of the stage specific, written, activity promotion pamphlets developed for a previous uncontrolled, study.[11] As with other written interventions reviewed, this was a relatively low cost intervention which would be fairly easy to incorporate into clinical practice.

However, as with other worksite interventions,[14] there is a possibility of contamination leading to a dilution of the real effect of the intervention. As with other studies, those completing the intervention were more likely to be white collar workers and regularly active at baseline, limiting the generalisability of the results.

Project active[5 29–31]

Project active assessed the effect, in terms of activity adoption and adherence and cardiovascular risk, of a traditional, structured, gym based, exercise programme compared with a TTM based programme advocating lifestyle activity. One of the important outcomes of this study was to confirm that moderate intensity lifestyle exercise is as effective, in terms of cardiovascular risk reduction, as vigorous, structured activity sessions. However, the study did not detect any additional benefit of the TTM based behavioural programme over and above the structured programme, in either the short or long term.

The behavioural intervention in Project ctive was, perhaps, more intensive than any other reviewed here and therefore of limited cliniacal applicability. Participants were asked to attend more than 30 group counselling sessions over a two year period. Despite this, the behavioural intervention was found to be more cost effective than the structured programme.[31]

Study of Naylor *et al*[32]

This non-randomised trial is the first study reviewed here that compared TTM based counselling and generic activity counselling. This process should allow the specific TTM component of counselling to be assessed. The intervention was also pragmatic and realistic, with practice nurses undertaking only very brief (five minutes) counselling.

Despite showing an overall effect on stage progression, the study did not show any additional benefit of the TTM based interventions over the non-TTM based counselling. This seriously questions the importance that has been placed on the type and theoretical foundation of counselling and suggests that any counselling, if well delivered, can have some effect on activity levels.

Study of Peterson and Aldana[33]

This study compared stage matched, written, activity promotion information with generic, activity promotion information and no information. This was the only study reviewed here that used a no intervention control group as well as the more usual non-staged intervention control group. It found a stepped effect of the generic and stage matched information, suggesting that, although generic information can have some effect on activity levels, stage matched information is more effective.

However, the study was worksite based, leading to possible contamination, had a very short follow up period, and only managed to retain a rather unrepresentative sample of white, female, well educated participants.

Change of heart study[34–36]

This study tackled inactivity as part of a multiple cardiovascular risk factor intervention trial. Practice nurses were trained to deliver TTM based counselling for all three risk behaviours (sedentary, high fat diet, smoking) together rather than solely focusing on activity, as in other trials. This procedure was compared with counselling delivered by nurses not trained in TTM theory. Despite having significant recruitment and retention problems such that the power requirements of the study were not met, the intervention was found to be successful in promoting both activity adoption and adherence. Unlike previous work,[32] it showed an effect of TTM based counselling over and above generic activity counselling, suggesting that the theoretical basis of counselling is important.

Study of Hassler *et al*[37]

This was a small, randomised, controlled trial of the use of exercise consultations[15] in sedentary people with type 1 diabetes mellitus. The study was small (only 22 subjects completed), and the follow up period (three weeks) was very short. Larger and longer studies of exercise consultations are needed to confirm whether this relatively intensive and potentially costly intervention (30 minutes of trained counsellor time) should be used more widely.

Study of Kirk *et al*[38]

This was a small pilot study of the utility of exercise consultation[15] in sedentary patients with type 2 diabetes mellitus. Unlike much previous work, this study controlled for the effect of contact time with counsellors by engaging patients in the control group in 30 minutes of non-activity related discussions about their diabetes. Again, the study was short and small, and the authors acknowledge the need for larger trials of exercise consultations.

DISCUSSION

We found 26 papers documenting 16 TTM based activity promotion interventions. These may not be all such reports published but we believe they represent the core work in this area.

The TTM based activity promotion programmes reviewed generally found some short term benefit in terms of activity levels or stage of activity change. Longer term effects seem to be harder to achieve and this questions the overall benefit of these programmes (table 2). A number of methodological and theoretical issues are common to the projects reviewed. We discuss these here and identify a number of areas for further work.

There was significant heterogeneity in the programmes reviewed in terms of intervention design, recruitment methods, participants recruited, outcome measures, length of follow up, and results reported making comparison difficult. In particular, this heterogeneity highlights the many different ways in which the TTM can be interpreted for intervention design. Many different TTM based interventions were reviewed, and the important question may not be "are TTM based activity promotion interventions effective?" but "which TTM based activity promotion interventions are effective?". Only one of the studies reviewed[12] attempted to compare different methods of delivering TTM based interventions. More comparative studies of TTM based interventions of known effectiveness should be made.

A further element of TTM interpretation, in terms of intervention design, is identified by the second PACE trial,[19] which reported that the intervention was most effective in people originally in the contemplation stage of activity change. Although this suggests that sedentary persons, in particular, were responding to the intervention, if a stage matched programme is to be claimed to be effective, it must be effective in people in all stages of activity change. Programmes based

on the TTM that provide a separate intervention for people in each of the different stages of activity change are complex and effectively comprise up to five different interventions. There may be a need to trial each stage matched intervention separately to ensure optimum design before combining interventions into fuller programmes. At the same time, it is important not to lose sight of the fact that the TTM advocates that all subjects can derive some benefit from appropriately designed interventions and that an effective intervention must be developed for people in each separate stage of change. The TTM promotes inclusion, and there is a need for more studies that recruit subjects in all stages of activity change, or at least all those before maintenance, rather than just those who are initially sedentary.

A number of the studies reviewed reported that, despite recruitment of initially representative samples, the subjects who completed all follow up measurements were primarily white, middle class, female, and regularly active[14 19 24 25 28 33] This problem may be exacerbated by the reliance that intervention studies must make on volunteer participants. It has been reported that non-random sampling strategies tend to under-recruit subjects in the precontemplation stage of activity change.[8] Differential retention limits the generalisability of results, but also highlights the problems of accessing and retaining those who may benefit most from the interventions. Further, innovative strategies to recruit and retain hard to reach population groups need to be devised.

A number of studies reported an intervention effect on stage of activity change without a concurrent effect on actual activity levels.[19 22 28 32] Although this is perfectly possible (table 1) and of some interest and relevance, the ultimate aim of activity promotion interventions must be to increase activity adoption and adherence. Stage progression is only an intermediate in this process, and there is no guarantee that it makes a good proxy for eventual activity adoption and adherence; people are known to progress backwards as well as forwards through the stages of change.[39] Further studies should be careful to include activity as well as stage of change outcome measures.

The difference between activity adoption and adherence has been highlighted previously,[40] as well as the finding that long term adherence to increased activity levels is much harder to achieve than short term adoption.[6] This review confirms this finding: 73% of short term studies reported a positive effect of TTM based interventions over control conditions, whereas only 29% of long term studies did. The review also identifies that longer term studies are much less likely to be performed: less than half of the studies reviewed carried out follow up beyond six months. Future studies must give priority to performing long term follow up and achieving activity adherence as well as adoption.

A number of studies reviewed found that, although there was no additional benefit of the TTM based intervention over the control condition, significant increases in activity, or stage of activity change, was seen in all groups.[12 14 29 32 41] This suggests that even a brief measurement intervention can have some effect and should perhaps be exploited in future intervention development.

All of the studies reviewed are hampered by physical activity and stage of activity change measurement problems.[8 42 43] Numerous different methods of measuring physical activity were used by the studies reviewed including various self report measures (almost all studies), physical fitness assessment,[23 29] and electronic motion monitors.[38] None of these methods are necessarily valid, and all measure slightly different constructs. In addition, many different measures of stage of activity change were used which relied on different precise definitions of the different stages. There is a need for standardised measures of both physical activity and stage of activity change.

Seven of the programmes reviewed used some sort of TTM based activity counselling. It is very difficult to confirm that counselling interventions are delivered as intended, particularly when a number of different "counsellors" are used. The effectiveness of counselling will not only depend on training given, but also on rapport built and the wider skills and tools that each counsellor has available to them. Ensuring a consistent intervention across counsellors is almost impossible and limits the generalisability of any counselling intervention.[44] Checks of treatment fidelity should be introduced to confirm that TTM based interventions are delivered as intended.

Related to this is the limited attempts that have been made to confirm that it is the TTM based component of activity counselling that is effective. As noted, many other variables, other than the theoretical grounding of counselling, may influence its effectiveness. Only two studies reviewed[32 35] compared TTM based activity counselling with generic counselling. However, these studies had conflicting results on the benefit of TTM based counselling over generic counselling. Further work is needed to determine whether TTM based counselling is any more effective than well delivered, generic, activity promotion counselling.

One final aspect of study design that has been overlooked by research to date is the possibility of testing not whether stage matched interventions are more effective than non-stage matched interventions, but whether stage matching is particularly important. This could be investigated by randomising subjects to receive either an intervention matched to their stage of activity change or a randomly allocated, staged intervention.

Finally, the complexity of physical activity behaviour should not be underestimated. Individuals appear to treat different forms of activity as entirely different behaviours, and there is evidence that they can be in different stages of activity change for different activities.[45] Current measures of stage of activity change do not take this into account and interventions may also overlook it.

Conclusions

We have identified and critically reviewed 16 TTM based activity promotion interventions. From the evidence presented, it appears that TTM based activity promotion interventions are, in general, more effective than non-staged interventions in promoting short term activity adoption. The longer term effect of TTM based interventions on activity adherence has not been as thoroughly explored but preliminary findings are disappointing.

Future work in this area should focus on:

- Comparative studies to determine the most effective TTM based activity promotion interventions
- Careful design and evaluation of interventions to confirm that people in each stage of activity change receive a truly tailored and effective intervention
- Innovative strategies to recruit and retain candidates who are hard to reach—for example, men, those in the precontemplation stage of activity change, members of ethnic minorities, and socially disadvantaged groups
- Including people in all stages of activity change rather than just those who are initially sedentary or in the pre-action stages of activity change
- Measuring physical activity as well as stage of activity change and focusing on activity more than stage of change as an outcome measure
- Achieving adherence, as well as adoption, of increased activity levels and following up study participants long enough to confirm this
- Investigating the effects of brief measurement interventions
- Developing standardised measures of physical activity and stage of activity change

Take home message

TTM based activity promotion programmes are effective in promoting adoption of physical activity in the short term. Evidence on longer term adherence is limited but currently disappointing.

- Ensuring treatment fidelity
- Assessing whether TTM based activity promotion counselling is any more effective than well delivered, generic counselling
- Exploring whether a group of staged interventions allocated on the basis of the stage of activity change are any more effective than random allocation of the same group of interventions
- Acknowledging the complexities of physical activity behaviour and incorporating this into interventions and outcome measures

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