Short Report: Care Delivery

Successful behavioural strategies to increase physical activity and improve glucose control in adults with Type 2 diabetes

L. Avery1*, D. Flynn2*, S. U. Dombrowski3, A. van Wersch4, F. F. Sniehotta2 and M. I. Trenell1

1Institute of Cellular Medicine, 2Institute of Health and Society, Newcastle University, Newcastle Upon Tyne, 3School of Natural Sciences, Division of Psychology, University of Stirling, Stirling, and 4School of Social Sciences and Law, Teesside University, Middlesbrough, UK

Accepted 10 March 2015

Abstract

Aims To explore which behaviour change techniques and other intervention features are associated with increased levels of physical activity and improved HbA1c in adults with Type 2 diabetes.

Methods Moderator analyses were performed on a dataset of 21 behaviour change techniques and six intervention features identified in a systematic review of behavioural interventions (N = 1975 patients with Type 2 diabetes) to establish their associations with changes in physical activity and HbA1c.

Results Four behaviour change techniques (prompt focus on past success, barrier identification/problem-solving, use of follow-up prompts and provide information on where and when to perform physical activity) had statistically significant associations with increased levels of physical activity. Prompt review of behavioural goals and provide information on where and when to perform physical activity behaviour had statistically significant associations with improved HbA1c. Pedometer use was associated with decreased levels of physical activity.

Conclusions These data suggest that clinical care teams can optimise their consultations by incorporating specific behaviour change techniques that are associated with increased levels of physical activity and improved long-term glycaemic control.

Diabet. Med. 32, 1058–1062 (2015)

Introduction

There is substantial evidence to demonstrate that physical activity/exercise (hereafter referred to as physical activity) is of benefit to people with Type 2 diabetes [1–3]. However, the greatest clinical challenge is understanding how to support people to change their physical activity behaviour in the context of their everyday lives. Our 2012 systematic review and meta-analysis [4] reported that behavioural interventions targeting free-living physical activity behaviour in adults with Type 2 diabetes (age range 35 to 75 years, with the majority of studies having recruited adults aged 60 to 64 years) yielded long-term clinically significant improvements in HbA1c. However, identification of which components of these interventions produce the greatest improvements in physical activity behaviour and subsequently HbA1c has not been formally tested. With clinical consultations and resources limited, insights into the efficacy of behaviour change techniques may assist in optimising the consultation.

Our objective was to explore which behaviour change techniques [5] and other intervention features (mode of delivery, intensity, duration, use of model/theory of behaviour change, use of pedometers and supervised physical activity and exercise sessions) used in behavioural interventions were associated with change in physical activity behaviour and clinically significant improvements in HbA1c (i.e. a decrease in HbA1c ≤ 0.3%) to help inform clinical practice and the development of new interventions.

Methods

In accordance with previously published research [6], effect size measures for physical activity and HbA1c were mean difference and Hedges’ g. Subgroup analyses were conducted...
What’s new?

• This study reports on statistically significant associations between evidence-based behaviour change techniques, changes in physical activity behaviour and clinically significant improvements in glycaemic control in adults with Type 2 diabetes.
• The findings provide guidance for clinicians on five context-appropriate behaviour change strategies for use during time-constrained consultations, which can help to support people with Type 2 diabetes to increase their levels of physical activity in order to maximise long-term glycaemic control.
• The five behaviour change techniques identified were: prompt focus on past success, barrier identification/problem-solving, use of follow-up prompts, provide information on where and when to perform the behaviour and prompt review of behavioural goals.

for behaviour change techniques and other categorical intervention features using a mixed-effect model where: (1) subgroups are pooled using a random-effects model; and (2) tests for statistically significant differences between subgroups are conducted with a fixed-effects model. All moderator analyses were undertaken using comprehensive meta-analysis. Associations between effect sizes and continuous variables were examined with meta-regression using the ‘metareg’ command in STATA applying a restricted maximum likelihood (REML) approach to estimate between-study variance.

The association between changes in physical activity and HbA1c across all 21 behaviour change techniques was calculated with Spearman’s correlation.

Results

Four behaviour change techniques were associated with increased levels of physical activity when present (Table 1). These were in rank order of effect size (Q): (1) prompt focus on past success; (2) barrier identification/problem-solving; (3) use of follow-up prompts; and (4) provide information on where and when to perform physical activity behaviour. Two behaviour change techniques were associated with improvements in HbA1c when present (Table 2). These were in rank order of effect size: (1) prompt review of behavioural goals, and (2) provide information on where and when to perform physical activity behaviour.

Pedometer use was associated with decreased levels of physical activity (Table 1). There were no other statistically significant associations between intervention features and effect size changes.

A negative statistically significant relationship was found between effect size changes in physical activity and HbA1c across the 21 behaviour change techniques included in the analysis using 21 comparisons for which full data was available ($r_s = -0.62, P = 0.004$).

Conclusions

The field of behavioural science is beginning to establish the principles of how to effectively support patients to make positive behavioural changes. The analyses presented are the first to link behavioural outcomes with clinically meaningful outcomes and to identify behaviour change techniques that may help to optimise diabetes care consultations: (1) prompt focus on past success (identifying and emphasising successful behaviour change from the individual’s past); (2) barrier identification/problem-solving (identifying salient barriers to physical activity for the individual and strategies to overcome them); (3) use of follow-up prompts (such as reminder postcards or motivational telephone calls); (4) provide information on where and when to perform the behaviour (individuals are given explicit information on locations, times and opportunities available locally for changing physical activity behaviour); and (5) prompt review of behavioural goals (review whether physical activity goals were achieved followed by revisions or adjustments).

By examining behavioural and clinical outcomes, these data suggest that clinical care teams could optimise the limited time they have with patients by focusing on selected behaviour change techniques to change physical activity behaviour.

There are interesting contrasts in the literature reporting on behaviour change techniques to target other lifestyle behaviours. In a 2011 systematic review, provision of instruction, self-monitoring of behaviour and relapse prevention were most strongly associated with weight loss when targeting diet in obese adults with additional risk factors for co-morbidity [3]. A 2014 systematic review reporting on behavioural interventions targeting physical activity behaviour in older adults showed associations between self-monitoring and a decrease in physical activity behaviour. The authors suggested that specific self-regulatory techniques may carry greater cognitive burden, making utilisation and thus behaviour change difficult [7]. Practically, this highlights that different behaviour change techniques may be required to initiate changes in different target behaviours (e.g. physical activity and diet), outcomes of behaviour (e.g. HbA1c and weight) and demographics of individuals (e.g. age), and that a tailored approach is necessary. Combined, these data suggest that a ‘one size’ behavioural intervention may not fit all and that clinical care teams should have an array of behaviour change techniques at their disposal and be aware of the context in which they may be most effective.

The specificity of behaviour change techniques is highlighted by the use of pedometers. Meta-analyses [8] show that pedometer use, a way to actualise self-monitoring of behaviour, is effective for increasing physical activity behaviour. However, more specific analyses reveal that the benefits of pedometer use may not carry across all users and that some
groups benefit less, particularly older people [7]. The present analyses suggest that people with Type 2 diabetes, the majority of which were older adults (aged > 60 years), may be a group who benefit less from pedometer use. It is not that pedometers do not yield effective behaviour change, but that specific groups may require greater support to use them as an effective self-monitoring tool. Furthermore, age of participants included in the current analyses may account for other behaviour change techniques failing to reach statistical significance such as plan social support/social change. In their 2014 systematic review, French and colleagues reported that social support was associated with lower levels of physical activity behaviour in older adults aged > 60 years [7].

Overall, these data highlight the pressing need to understand more about the specific requirements of people with Type 2 diabetes, and also the transferability of behaviour change techniques and other intervention features across groups and clinical conditions.

Targeting physical activity behaviour is an important self-management option for people with Type 2 diabetes and

### Table 1 Behaviour change technique moderator analyses for physical activity

| Intervention feature | k present (absent) | n present (absent) | Meta-analysis (random effects model) | Subgroup analysis |
|----------------------|--------------------|--------------------|-------------------------------------|------------------|
|                      | Present (absent)   | Present (absent)   | Standardised mean difference: intervention | Standardised mean difference: control |
|                      | Present (absent)   | Present (absent)   | 95% CI | Present (absent)   | Present (absent)   | 95% CI |
|                      | Present (absent)   | Present (absent)   | Lower limit | Upper limit | Present (absent)   | Present (absent)   | Lower limit | Upper limit |
|                      | Present (absent)   | Present (absent)   | Q   | P |
| Behaviour change techniques | | | |
| Prompt focus on past success | 4 (17) | 415 (1352) | 122 0.147 0.91 2.03 0.48 | 0.19 0.26 | 0.28 0.69 | 10.72 0.001 |
| Barrier identification/ problem-solving | 15 (6) | 1016 (751) | 0.81 | 0.50 1.13 0.31 | 0.16 0.45 | 8.16 0.004 |
| Use of follow-up prompts | 14 (7) | 989 (778) | 0.78 | 0.44 1.12 0.36 | 0.33 0.50 | 5.07 0.024 |
| Provide information on where and when to perform the behaviour | 8 (13) | 680 (1087) | 0.95 | 0.52 1.38 0.45 | 0.24 0.66 | 4.21 0.040 |
| Plan social support/social change | 13 (8) | 894 (873) | 0.81 | 0.45 1.17 0.45 | 0.22 0.67 | 2.84 0.092 |
| Provide information on consequences of behaviour to the individual | 5 (16) | 476 (1291) | 1.17 | 0.38 1.96 0.53 | 0.32 0.73 | 2.37 0.124 |
| Prompt review of behavioural goals | 14 (7) | 920 (847) | 0.77 | 0.43 1.12 0.47 | 0.22 0.72 | 1.97 0.160 |
| Relapse prevention/coping planning | 11 (10) | 543 (1224) | 0.51 | 0.19 0.83 0.81 | 0.45 1.18 | 1.48 0.223 |
| Goal setting (behaviour) | 16 (5) | 984 (783) | 0.73 | 0.41 1.04 0.49 | 0.17 0.80 | 1.11 0.291 |
| Provide information on consequences of behaviour in general | 10 (11) | 417 (1350) | 0.80 | 0.34 1.25 0.58 | 0.29 0.88 | 0.59 0.444 |
| Provide instruction on how to perform the behaviour | 13 (8) | 990 (777) | 0.72 | 0.44 1.01 0.53 | 0.10 0.96 | 0.54 0.464 |
| Motivational interviewing | 3 (18) | 156 (1611) | 0.49 | 0.05 0.93 0.68 | 0.41 0.94 | 0.52 0.470 |
| Goal setting (outcome) | 3 (18) | 123 (1644) | 0.88 | 0.16 1.60 0.62 | 0.36 0.88 | 0.44 0.510 |
| Prompt generalisation of a target behaviour | 3 (18) | 123 (1644) | 0.88 | 0.16 1.60 0.62 | 0.36 0.88 | 0.44 0.509 |
| Set graded tasks | 10 (11) | 1252 (515) | 0.72 | 0.35 1.10 0.60 | 0.30 0.90 | 0.26 0.612 |
| Teach to use prompts/cues | 4 (17) | 231 (1536) | 0.69 | 0.28 1.09 0.64 | 0.36 0.93 | 0.03 0.862 |
| Action planning | 6 (15) | 339 (1428) | 0.66 | 0.32 0.99 0.66 | 0.35 0.97 | 0.00 0.991 |
| Prompt self-monitoring of behaviour | 16 (5) | 656 (1111) | 0.66 | 0.37 0.94 0.64 | 0.16 1.12 | 0.00 0.958 |
| Provide feedback on performance | 7 (14) | 336 (1431) | 0.65 | 0.22 1.09 0.66 | 0.36 0.95 | 0.00 0.984 |
| Modes of delivery | | | | | |
| Pedometer use | 8 (13) | 377 (1390) | 0.36 | 0.08 0.64 0.83 | 0.51 1.16 | 4.60 0.032 |
| Theory based | 18 (3) | 1638 (129) | 0.71 | 0.44 0.98 0.34 | -0.01 0.69 | 2.74 0.098 |
| Individual and group contact | 3 (18) | 78 (1689) | 1.42 | 0.07 2.76 0.58 | 0.34 0.81 | 1.44 0.230 |
| Group contact | 5 (16) | 203 (1564) | 0.58 | 0.29 0.87 0.68 | 0.39 0.97 | 0.20 0.655 |
| Individual contact | 12 (9) | 1428 (339) | 0.64 | 0.34 0.94 0.70 | 0.26 1.14 | 0.05 0.820 |
| Supervised | 8 (13) | 817 (950) | 0.67 | 0.29 1.05 0.64 | 0.32 0.95 | 0.02 0.892 |
would be an optimal approach in the following circumstances: patients who lack confidence for participation in more intensive or supervised activities; [9] patients who report poor adherence to dietary change or first-round medication; [10] and patients who experience side effects of medication that contributes to non-adherence [11].

Much attention is given to the translation of well-resourced proof of principle studies (e.g. Look Ahead) into everyday clinical care [12]. The present analyses take steps towards understanding how complex interventions may be optimised by identifying specific behaviour change techniques and other intervention features for use in routine clinical practice. Furthermore, the analyses show that counselling and resource burden can be reduced by focusing on behavioural strategies with a more robust evidence base. However, there is an urgent need for the field to explore the evidence underpinning how behaviour is changed and the needs of individual patients.

Notwithstanding the value of our findings, they are not without limitation. Studies utilised both subjective and objective methods of free-living physical activity assessment. Moreover, it was not possible to establish the type, intensity and frequency of physical activity attributable to the effect sizes observed. Future work could utilise factorial designs to further understand how behaviour change techniques impact on the type, intensity and duration of physical activity that is maximally effective for sustaining improved clinical outcomes in adults with Type 2 diabetes as a function of stage on the life course.

Table 2 Behaviour change technique moderator analyses for HbA1c.

| Intervention feature | k present (absent) | n present (absent) | Meta-analysis (random effects model) | Subgroup analysis |
|----------------------|-------------------|-------------------|-------------------------------------|-----------------|
|                      |                   |                   | Mean difference intervention 95% CI | Mean difference control 95% CI | Q | P |
| Prompt review of behavioural goals | 14 (7) | 920 (847) | −0.53 | −0.71 | −0.34 | −0.23 | −0.41 | −0.06 | 5.09 | 0.024 |
| Provide information on when and how to perform the behaviour | 8 (13) | 680 (1087) | −0.54 | −0.74 | −0.34 | −0.26 | −0.45 | −0.07 | 3.86 | 0.050 |
| Prompt generalisation of a target behaviour | 3 (18) | 123 (1644) | −0.73 | −1.16 | −0.31 | −0.31 | −0.47 | −0.16 | 3.29 | 0.070 |
| Plan social support/social change | 13 (8) | 894 (873) | −0.50 | −0.69 | −0.32 | −0.24 | −0.49 | 0.00 | 2.78 | 0.095 |
| Prompt self-monitoring of behaviour | 16 (5) | 636 (1111) | −0.23 | −0.44 | −0.02 | −0.47 | −0.68 | −0.25 | 2.41 | 0.120 |
| Goal setting (behaviour) | 16 (5) | 984 (783) | −0.45 | −0.63 | −0.27 | −0.23 | −0.48 | 0.03 | 2.02 | 0.156 |
| Prompt focus on past success | 4 (17) | 415 (1352) | −0.54 | −0.80 | −0.29 | −0.32 | −0.49 | −0.15 | 2.02 | 0.155 |
| Provide information on consequences of behaviour to the individual | 5 (16) | 476 (1291) | −0.51 | −0.75 | −0.28 | −0.33 | −0.51 | −0.14 | 1.50 | 0.221 |
| Prompt rewards contingent on effort or progress towards behaviour | 3 (18) | 123 (1644) | −0.65 | −1.23 | −0.07 | −0.34 | −0.49 | −0.19 | 1.21 | 0.271 |
| Action planning | 6 (15) | 339 (1428) | −0.23 | −0.53 | 0.07 | −0.41 | −0.57 | −0.25 | 1.09 | 0.296 |
| Set graded tasks | 10 (11) | 1252 (515) | −0.33 | −0.48 | −0.18 | −0.49 | −0.75 | −0.22 | 1.09 | 0.296 |
| Goal setting (outcome) | 3 (18) | 123 (1644) | −0.65 | −1.23 | −0.07 | −0.34 | −0.49 | −0.19 | 1.04 | 0.308 |
| Provide information on consequences of behaviour in general | 10 (11) | 417 (1350) | −0.24 | −0.50 | 0.02 | −0.41 | −0.61 | −0.20 | 0.96 | 0.326 |
| Provide instruction on how to perform the behaviour | 13 (8) | 990 (777) | −0.28 | −0.49 | −0.08 | −0.42 | −0.64 | −0.20 | 0.83 | 0.362 |
| Motivational interviewing | 3 (18) | 156 (1611) | −0.19 | −0.58 | 0.19 | −0.38 | −0.55 | −0.22 | 0.78 | 0.376 |
| Barrier identification/problem-solving | 15 (6) | 1016 (751) | −0.44 | −0.61 | −0.26 | −0.31 | −0.61 | −0.01 | 0.55 | 0.457 |
| Use of follow-up prompts | 14 (7) | 989 (778) | −0.47 | −0.65 | −0.29 | −0.15 | −0.45 | −0.21 | 0.16 | 0.693 |
| Provide feedback on performance | 7 (14) | 336 (1431) | −0.31 | −0.61 | −0.01 | −0.37 | −0.55 | −0.19 | 0.12 | 0.730 |
| Teach to use prompts/cues | 4 (17) | 231 (1536) | −0.42 | −0.86 | 0.03 | −0.35 | −0.51 | −0.19 | 0.08 | 0.784 |
| Relapse prevention/coping planning | 11 (10) | 543 (1224) | −0.33 | −0.56 | −0.10 | −0.37 | −0.58 | −0.15 | 0.05 | 0.828 |
| Modes of delivery | 16 (3) | 1638 (1299) | −0.38 | −0.53 | −0.23 | 0.03 | −0.40 | 0.47 | 3.07 | 0.080 |
| Theory based | 3 (18) | 78 (1689) | −0.77 | −1.55 | 0.00 | −0.32 | −0.46 | −0.18 | 1.26 | 0.261 |
| Individual and group contact | 5 (16) | 203 (1564) | −0.17 | −0.53 | 0.20 | −0.37 | −0.55 | −0.19 | 0.92 | 0.338 |
| Supervised | 8 (13) | 817 (950) | −0.26 | −0.51 | −0.01 | −0.39 | −0.58 | −0.19 | 0.57 | 0.450 |
| Pedometer use | 8 (13) | 377 (1390) | −0.24 | −0.52 | 0.03 | −0.37 | −0.55 | −0.18 | 0.52 | 0.471 |
| Individual contact | 12 (9) | 1428 (339) | −0.33 | −0.52 | −0.14 | −0.33 | −0.63 | −0.03 | 0.00 | 0.985 |
In summary, physical activity is a viable self-management option for people with Type 2 diabetes [4]. Our findings indicate that use of five behaviour change techniques may facilitate people with Type 2 diabetes to traverse the behavioural–physiological/biochemical gap. Experimental research is warranted in applied clinical settings to elucidate the maximally effective combinations, sequencing and delivery of behaviour change techniques within behavioural interventions in diabetes care. However, the data presented suggest that clinical care teams can optimise their consultations by incorporating specific evidence-based behaviour change techniques that are context appropriate and sensitive to the needs of people with Type 2 diabetes.

**Funding sources**

This study was funded by the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement no Health-F2-2009-241762, for the project FLIP and by the Newcastle University Centre for Brain Ageing and Vitality; FFS is funded by Fuse, the Centre for Translational Research in Public Health, a UKCRC Public Health Research Centre of Excellence and MIT is supported by a Senior Fellowship from the National Institute of Health Research.

**Competing interests**

None declared.

**Acknowledgements**

The authors have no potential conflicts of interest to report. LA and DF are joint first authors and drafted the initial manuscript. LA and SUD conducted the data analyses and interpreted the findings. All authors provided input into the development of the methods and subsequent drafts of the manuscript. MIT is the guarantor of this work and had full access to the data and takes responsibility for the integrity and accuracy of the data and analyses.

**References**

1. Thomas DE, Elliott EJ, Naughton GA. Exercise for type 2 diabetes mellitus. *Cochrane Database Syst Rev* 2006; 3: CD002968.
2. Snowling NJ, Hopkins WG. Effects of different modes of exercise training on glucose control and risk factors for complications in type 2 diabetic patients: a meta-analysis. *Diabetes Care* 2006; 29: 2518–2527.
3. Umpierre D, Ribeiro PA, Kramer CK, Leitão CB, Zucatti AT, Azevedo MJ *et al*. Physical activity advice only or structured exercise training and association with HbA1c levels in type 2 diabetes: a systematic review and meta-analysis. *JAMA* 2011; 305: 1790–1799.
4. Avery L, Flynn D, Dombrowski SU, van Wersch A, Sniehotta FF, Trenell MI. A systematic review of behavior change interventions targeting physical activity, exercise and HbA1c in adults with type 2 diabetes. *Diabetes Care* 2012; 35: 2681–2689.
5. Michie S, Ashford S, Sniehotta FF, Dombrowski SU, Bishop A, French DP. A refined taxonomy of behaviour change techniques to help people change their physical activity and healthy eating behaviours: the CALO-RE taxonomy. *Psychol Health* 2011; 26: 1479–1498.
6. Dombrowski SU, Sniehotta FF, Avenell A, Johnston M, MacLennan G, Araujo-Soares V. Identifying active ingredients in complex behavioural interventions for obese adults with obesity-related co-morbidities or additional risk factors for co-morbidities: a systematic review. *Health Psychol Rev* 2012; 6: 7–32.
7. French DP, Olander EK, Chisholm A, McSharry J. Which behavior change techniques are most effective at increasing older adults’ self-efficacy and physical activity behavior? A systematic review. *Ann Behav Med* 2014; 48: 225–234.
8. Bravata DM, Smith-Spangler C, Sundaram V, Gienger AL, Lin N, Lewis R *et al*. Using pedometers to increase physical activity and improve healtha systematic review. *JAMA* 2007; 298: 2296–2304.
9. Kirk A, De Feo P. Strategies to enhance compliance to physical activity for patients with insulin resistance. *Appl Physiol Nutr Metab* 2007; 32: 549–556.
10. Krentz AJ, Bailey CJ. Oral antidiabetic agents: current role in type 2 diabetes mellitus. *Drugs* 2005; 65: 385–411.
11. Ross SA. Breaking down patient and physician barriers to optimize glycemic control in type 2 diabetes. *Am J Med* 2013; 126: s38–s48.
12. Look AHEAD Research Group, Wing RR, Bolin P, Brancati FL, Bray GA, Clark JM *et al*. Successful behavioural strategies to increase physical activity and improve glucose control in adults with Type 2 diabetes. *N Engl J Med* 2013; 369: 145–154.