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Cognitive mediation of intervention effects on physical exercise: Causal models for the adoption and maintenance stage

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Objective: To investigate how the effects of a group-based intervention program (MoVo-LISA) on exercise behaviour were mediated by cognitive variables. Different causal models mapping the short-term (adoption) and long-term (maintenance) intervention effects were tested using path analyses.
Design: $N = 220$ in-patients of a rehabilitation clinic were assigned to an usual care or intervention group (quasi-experimental design). Questionnaire-based assessment was conducted at baseline; discharge; and at six weeks, six months and 12 months post discharge.
Measures: The potential mediator variables were outcome expectations, self-efficacy, strength of goal intention (intention strength), self-concordance, action planning and barrier management.
Results: Observed intervention effects on exercise behaviour ($p < 0.05$) were mediated by intention strength at the adoption and maintenance stages, by action planning only at the adoption, and by barrier management only at the maintenance stage. Self-efficacy and outcome expectations were only indirectly involved in these mediations by affecting intention strength and self-concordance.
Conclusion: This is the first study to track the cognitive mediation processes of intervention effects on exercise behaviour over a long time-period by differentiating the adoption and maintenance stages of behaviour change. The findings emphasise the importance of deconstructing intervention effects (modifiability *vs.* predictive power of a mediator) to develop more effective interventions.

Keywords: mediator; physical activity; group intervention; path analysis

Introduction

Even though population-based health promotion and individual health education for physical activity have been given increasingly more attention in the last two decades, the high percentage of inactive people in Western developed countries has not substantially declined (European Commission, 2010). Given this situation, health professionals are challenged to develop more effective and efficient

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interventions to help people achieve a physically active lifestyle (Marcus et al., 2006). One important aspect of realising this goal is to improve our understanding of how psychological variables mediate the effects of intervention programs on exercise behaviour. Mediation analyses are based on the assumption that intervention programs change the target behaviour by changing the cognitive parameters (psychological mediators) controlling this behaviour (Nigg, Borrelli, Maddock, & Dishman, 2008). The aim of this article is to extend our knowledge about these psychological mediation processes, by examining the role of specific cognitive variables in an exercise intervention program.

Previous studies which have analysed how the effects of exercise intervention programs are mediated by cognitive changes suggest the following variables to play a critical role (for a systematic review see: Rhodes & Pfaeffli, 2010): self-efficacy (Anderson, Winett, Wojcik, & Williams, 2010; Lewis et al., 2006), outcome expectations/decisional balance (Pinto, Lynn, Marcus, DePue, & Goldstein, 2001), goal intentions (Chatzisarantis & Hagger, 2009), autonomous motivation (Chatzisarantis & Hagger, 2009), self-regulation/barrier management (Anderson et al., 2010; Hallam & Petosa, 2004; Lubans, Plotnikoff, Jung, Eves, & Sigal, 2011), social support (Anderson et al., 2010; Cerin, Taylor, Leslie, & Owen, 2007) and behavioural processes (Napolitano et al., 2008). However, these studies did not systematically discriminate between mediation processes during the adoption and maintenance stages of exercise behaviour. Furthermore, volitional variables were often assessed by summary measures of 'self-regulation' (Andersen et al., 2010; Hallam & Petosa, 2004) or 'processes of change' (Napolitano et al., 2008) that are unspecific and do not provide insight into the volitional processes that are needed to transfer goal intentions into concrete actions. In particular, no studies have yet analysed the mediating role of action planning (implementation intentions) and coping planning (barrier management), separately (cf. Sniehotta, Scholz, & Schwarzer, 2006).

The current research addresses some of these shortcomings. We report results from an exercise-related intervention study based on the *MoVo concept* (Fuchs, Göhner, & Seelig, 2011). The acronym 'MoVo' stands for 'motivation' and 'volition' indicating that this approach is related to motivation theories of health behaviour (Ajzen, 1991; Bandura, 2004) as well as volition theories of action planning and action control (Kuhl, 2000; Schwarzer, 2008). The MoVo concept consists of two components: the MoVo process model, which provides the theoretical framework, and the MoVo intervention program, which specifies the contents and procedures to change health behaviour (Göhner & Fuchs, 2007).

The MoVo process model

The MoVo process model (Figure 1) integrates central elements of two different lines of research in this field: social cognition research, with its focus on motivational aspects (Conner & Norman, 2005), and self-regulation research, which emphasises the volitional side of behavioural control (Vohs & Baumeister, 2011). The model hypothesises that health behaviours, such as exercise, are basically controlled by five factors: strength of the goal intention, self-concordance of this goal intention, action planning, barrier management and outcome experiences.
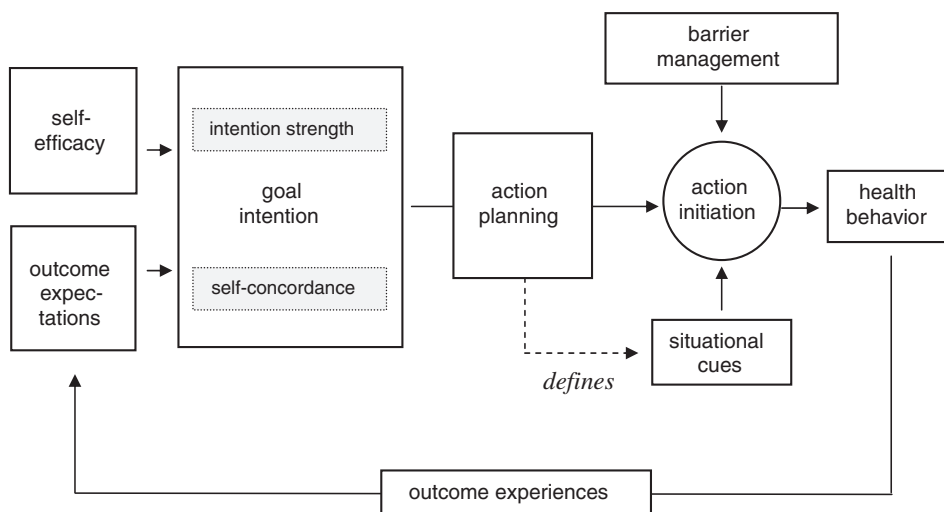
Figure 1. The MoVo process model.

Goal intention is the central motivational construct of the model (Gollwitzer, 1999). Goal intentions are the result of weighing up the costs and benefits of the behaviour (*outcome expectations*) and appraising one's own ability to perform it successfully (*self-efficacy*) (Ajzen, 1991; Bandura, 2004). The MoVo process model purports that it is not only the *strength* but also the *self-concordance* of a goal intention that is important to set up and maintain a new behaviour. 'Self-concordance' denotes the extent to which a specific goal intention is in accordance with the general interests and values of the person (Sheldon & Houser-Marko, 2001). A meta-analysis by Koestner, Lekes, Powers, and Chicoine (2002) shows that the likelihood of attaining a personal goal increases with the degree to which the underlying goal intention is self-concordant.

In order to translate goal intentions into real actions, goal intentions need to be furnished with an *action plan* in which a person specifies the when, where, and how of an intended action (cf. implementation intentions; Gollwitzer, 1999). Action plans significantly enhance the likelihood of beginning and continuing regular physical exercise (Scholz, Schüz, Ziegelmann, Lippke, & Schwarzer, 2008). Even carefully elaborated action plans can be challenged by external (e.g. workload) and internal (e.g. lethargy) barriers. Volitional strategies of *barrier management* such as mood regulation, stimulus control, cognitive restructuring or attention control (Kuhl, 2000) can keep the intended action on target. Such self-regulatory processes play an important role in the realisation of exercise-related action plans (Sniehotta et al., 2006).

Finally, the MoVo process model introduces a construct called *outcome experiences*. This variable reflects the personal experiences and appraisals of the new behaviour. For example, after the first exercise meeting a person may conclude: 'This training is really helping me to improve my fitness' or 'The pain in my arm has reoccurred'. Based on positive or negative outcome experiences, people confirm or change their corresponding outcome expectancies and thus maintain or modify their future goal intentions (cf. Rothman's (2000) concept of 'perceived satisfaction with received outcomes').

The MoVo intervention program

The MoVo process model suggests that effective intervention programs should encompass motivational as well as volitional strategies of behaviour change. While motivational strategies aim to form a strong and self-concordant goal intention, volitional strategies focus on developing implementation competencies and action control abilities. The MoVo intervention program includes the following *motivational strategies*: (a) clarification of personal health objectives, (b) contemplation of different actions to achieve the health objectives, (c) formation of specific goal intentions, (d) checking self-concordance of these goal intentions, (e) reflection of outcome experiences; and *volitional strategies*: (f) generating action plans, (g) anticipating personal barriers, (h) developing counter strategies and (i) self-monitoring the new behaviour. The MoVo intervention program exists in different versions to fit the needs of particular settings and target groups (e.g. overweight groups). MoVo-LISA ('Lifestyle-Integrated Sport Activity') is one of these specific intervention programs. It was developed for an in-patient rehabilitation setting and its specific features have been described elsewhere (Fuchs et al., 2011; Göhner & Fuchs, 2007; Göhner, Seelig, & Fuchs, 2009).

Research question

In a previous publication, we documented the significant effects of the MoVo-LISA program on exercise behaviour and health indicators (Fuchs et al., 2011). At 12-month follow-up, level of physical exercise in the intervention group was 28.5 min per week higher than in the usual care group ($p = 0.05$) with intent to treat analyses confirming the pattern of findings from complete analyses. In this article, we examine the cognitive mediation processes that may be responsible for the observed intervention effects. Based on the MoVo process model (Figure 1) two causal models were specified to differentiate the short-term intervention effects in the initiation phase of behaviour change (Adoption Model) and the long-term intervention effects in the continuation phase (Maintenance Model). Both models were tested by path analyses using data from five points of measurement. The overall aim of the current study was to examine how the intervention effects on exercise behaviour were mediated through cognitive factors of outcome expectations, self-efficacy, intention strength, self-concordance, action planning and barrier management.

Method

Participants, sample flow and sample description

The target sample was people with chronic orthopaedic conditions (arthritis, chronic back pain, etc.) who registered for a three week in-patient rehabilitation program in a clinic in Southern Germany, between December 2005 and September 2006. Of the 1720 invited patients, 1113 agreed to participate and completed baseline assessment. The first 681 participants formed the *control sample* (sequential control-intervention group design). Of these, $n = 252$ (37%) met the inclusion criteria of not participating in any regular exercise during the last months and became the *control group*. Of those, $n = 215$ (85%), $n = 179$ (71%), $n = 156$ (62%) and $n = 155$ (61%) patients completed the second, third, fourth and fifth assessment, respectively.

The next 432 patients formed the *intervention sample*; of these, 151 met the inclusion criteria and were therefore eligible for participation. Of those, 15 patients did not complete the intervention program (due to interference with other therapeutic activities), resulting in $n = 136$ patients in the *intervention group*. Of those, $n = 132$ (97%), $n = 122$ (90%), $n = 103$ (76%) and $n = 105$ (77%) completed the second, third, fourth and fifth assessment, respectively. The analyses reported in this article are based on the *longitudinal sample* ($N = 220$), comprising $n = 88$ in the intervention group and $n = 132$ in the control group, who provided complete data on the relevant variables at all five assessments. The study was adequately powered to detect intervention effects at T3 with a size of $d = 0.5$, with 80% power and an alpha level of $p < 0.05$.

Participants had a mean age of 51.1 (SD $= 6.9$) years (range 30–64), and more than half (57%) were female. There were no significant socio-demographic differences between the intervention group and the control group participants except for age (intervention group: $M = 52.3$ years, SD $= 6.3$; control group: $M = 50.2$, SD $= 7.2$; $p = 0.03$).

Intervention, study design and procedure

All participants received the three week standard clinic rehabilitation program. Patients in the intervention group also participated in the six modules of the MoVo-LISA program: (1) first group meeting: 60 minutes in the second week of the three-week clinic stay, (2) one-on-one interview: 10 minutes on the second last day before discharge, (3) second group meeting: 90 minutes on the last day of the clinic stay, (4) postal reminder sent out three weeks after discharge, (5) telephone call: 10 minutes six weeks after clinic discharge and (6) self-monitoring over the first six weeks after discharge. To avoid contamination, the MoVo-LISA program was implemented with the intervention participants only after discharge of all patients in the control group. The content and didactics of MoVo-LISA are standardised (Göhner & Fuchs, 2007) and have been described in detail elsewhere (Fuchs et al., 2011; Göhner et al., 2009). Questionnaires were filled out in both groups at five time points: two weeks before the start of the clinic stay (time 1; T1), at the end of the clinic stay (T2), then six weeks (T3), six months (T4) and 12 months (T5) after discharge from the clinic.

Measures

All data were collected via questionnaires (T1–T5) which contained identical items.

Exercise behaviour was assessed by asking the participants whether they currently participated in one or more sport or exercise activities on a regular basis. If so, respondents were asked to write these activities, and to indicate for each activity the frequency (per month) and the duration (per episode). Only activities that involve larger groups of skeletal muscles and lead to the acquisition or maintenance of endurance capacity (e.g. jogging), strength (e.g. gym exercises), flexibility (e.g. yoga) and/or coordination skills (e.g. dancing) were counted. Activities such as billiards, fishing and chess were, therefore, excluded. To derive an 'Exercise Index' (minutes per week), the products of monthly frequency and duration were summed up for all relevant activities and then divided by 4.3. Similar measures which rely on recall

of exercise frequency and duration are known to have acceptable reliability and validity (Sallis & Owen, 1999).

Self-efficacy. Consistent with Schwarzer (2008) we assessed two types of exercise self-efficacy: the confidence to begin regular exercise (*adoption self-efficacy*), and the confidence to maintain regular exercise over a longer time period (*maintenance self-efficacy*). Each variable was measured using a single item with a response format ranging from $0 =$ 'I am not confident at all' to $5 =$ 'I am confident to 100%'. Descriptive statistics for adoption/maintenance self-efficacy at T1 were: $M = 3.35/3.25$; $SE = 0.09/0.09$; $SD = 1.39/1.34$; median $= 3.00/3.00$; skewness $= -0.40/-0.42$; range $= 0$–5.

Outcome expectations were assessed using an instrument developed and validated by Fuchs (1994) that included nine *positive* and seven *negative* outcome expectations of physical exercise. The positive and negative expectations were summed separately, and then the difference (positive–negative) was derived to provide an 'outcome expectations index', Descriptive statistics for the outcome expectations index at T1 were: $M = 1.27$; $SE = 0.05$; $SD = 0.77$; median $= 1.32$; skewness $= -0.43$; range $= -1.41$–2.86.

Intention strength was assessed using one item: 'How strong is your intention to exercise regularly within the next weeks and months?' The response format was a six-point Likert-scale ranging from 0 ('I don't have this intention at all') to 5 ('I have a strong intention'). Descriptive statistics for the intention strength index at T1 were: $M = 3.08$; $SE = 0.10$; $SD = 1.54$; median $= 3.00$; skewness $= -0.54$.

Self-concordance was measured by the SSK-scale, a German-language 12-item instrument that has proven to be a reliable and valid measure of exercise-related goal self-concordance (Seelig & Fuchs, 2006). Consistent with the self-concordance model by Sheldon and Elliot (1999) the SSK-scale consisted of four subscales that measured the intrinsic, identified, introjected and extrinsic reasons for exercising. Each subscale was formed by three items. The items were launched with: 'I intend to exercise regularly within the next weeks and months because...' and were followed by statements like '...it's just fun for me' (*intrinsic*), '...I have good reasons to be active' (*identified*), '...otherwise I would have a guilty conscience' (*introjected*) and '...others tell me to become physically active' (*extrinsic*). Participants who indicated to have at least a weak exercise-related goal intention (strength of goal intention ≥ 1) were asked to respond on a four-point Likert-scale ranging from 1 ('not true') to 4 ('true'). Those who reported no intention to exercise were asked to skip this part of the questionnaire (number of 'non-intenders' at Time 1–Time 5 was: $n = 22, 2, 5, 12, 14$; respectively). In this study, Cronbach's alpha for the subscales at T1 ranged from $\alpha = 0.67$ (introjected) to $\alpha = 0.76$ (extrinsic). A 'self-concordance index' was derived by summing the identified and intrinsic mean scores and subtracting the introjected and extrinsic mean scores (cf. Sheldon & Elliot, 1999). Descriptive statistics for the self concordance index at T1 were: $M = 1.95$; $SE = 0.10$; $SD = 1.41$; median $= 2.00$; skewness $= -0.27$; range $= -1.67$–5.33.

Action planning. Participants were asked whether they already knew which exercise they would do in the following weeks and months, and if so, what this was. Participants were then asked if they knew when and where they would do it, how they would get there, and how often and with whom they would do it (no $= 0$; yes $= 1$). A score for the index 'action planning' was derived by counting the number of positive answers. Descriptive statistics for the action planning index at T1 were: $M = 3.43$; $SE = 0.29$; $SD = 4.28$; median $= 0.00$; skewness $= 0.82$; range $= 0$–12.

Barrier management consisted of two components: Perceived barriers and counter strategies. To assess *perceived barriers*, participants were presented with a list of 19 potential barriers and asked to indicate how strongly each one prevented exercise, using a four-point response scale ranging from 1 ('not at all') to 4 ('very much'). A Perceived Barriers subindex was derived as the mean of the 19 scores. To assess *counter strategies*, participants were presented with a list of 15 possible ways to manage barriers, and asked whether or not they used each of these (no $= 0$/yes $= 1$). Example items are: 'I make an appointment with a friend to exercise together'; 'I avoid situations that could keep me from exercising (e.g. switching on the TV)'. The Counter Strategies subindex was the mean of the 15 scores. A Barrier Management index was derived from the quotient of the Counter Strategies subindex (numerator) and the Perceived Barriers subindex (denominator): a high score (range 0–1) indicated a favourable ratio of available counter strategies and perceived barriers. Descriptive statistics for the Barrier Management index at T1 were: $M = 0.23$; $SE = 0.01$; $SD = 0.13$; median $= 0.23$ and skewness $= 0.43$.

Specification of models

Two different causal models, the Adoption Model and Maintenance Model, were tested using path analysis of observed variables (AMOS; version 19.0; Arbuckle, 2010). The causal assumptions of these two models were based on the MoVo process model (Figure 1).

The *Adoption Model* focuses on the short-term impact of the intervention program, on those who are just starting regular exercise (Figure 2; including data from T1, T2 and T3). On the left-hand side, the Adoption Model specifies the motivational (adoption self-efficacy, outcome expectations, self-concordance and intention strength) and volitional (action planning, barrier management) variables measured at T1 and T2. Not all of these variables are hypothesised to influence exercise behaviour directly: adoption self-efficacy and outcome expectations do so only indirectly through their impact on intention strength and self-concordance. On the right-hand side, the Adoption Model specifies the effects of those mediators on exercise behaviour at T3 (six weeks follow-up). Finally, the Adoption Model hypothesises a direct path from the intervention to exercise behaviour to account for all other intervention effects that were not mediated by the cognitive variables under consideration.

The *Maintenance Model* examined the behaviour change process from a long-term perspective (Figure 3; including data from T1, T3, T4 and T5). The model attempted to unravel the more proximal intervention effects on maintenance self-efficacy and outcome expectancies at T3, from the more distal effects on intention strength, self-concordance, action planning, and barrier management at T4 (six months follow-up). The model also specified how those psychological mediators contribute to exercise behaviour at T5 (12 months follow-up).

Statistical analyses

To test the causal structure specified in the two models, standardised direct, indirect and total effects were estimated (Tables 1 and 2). Each variable's total effect comprises its direct and its indirect effects. The direct effect is the portion of a
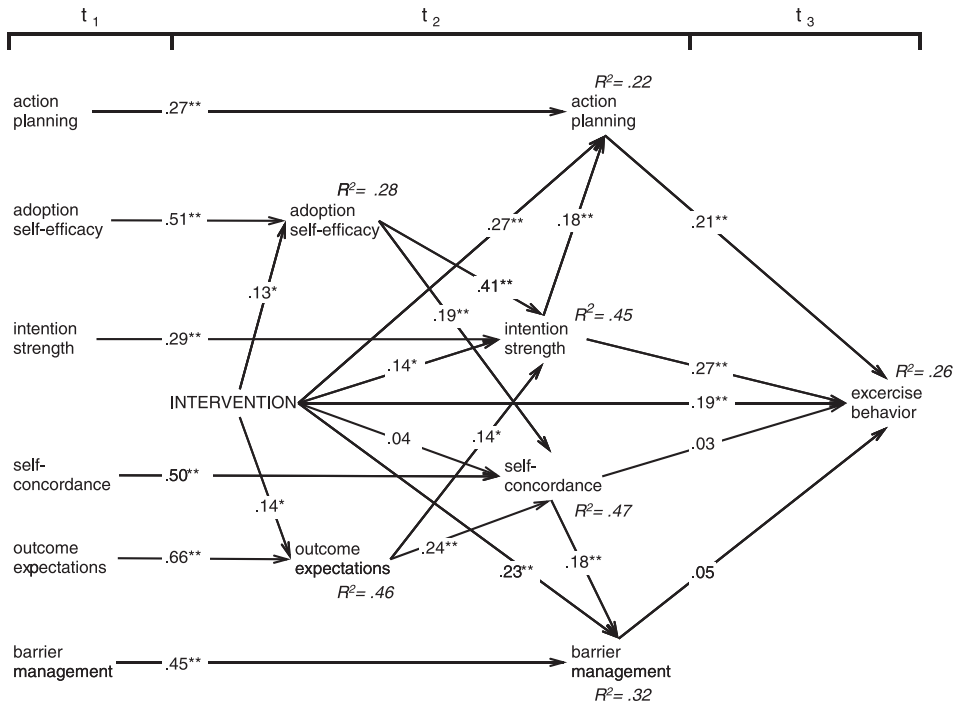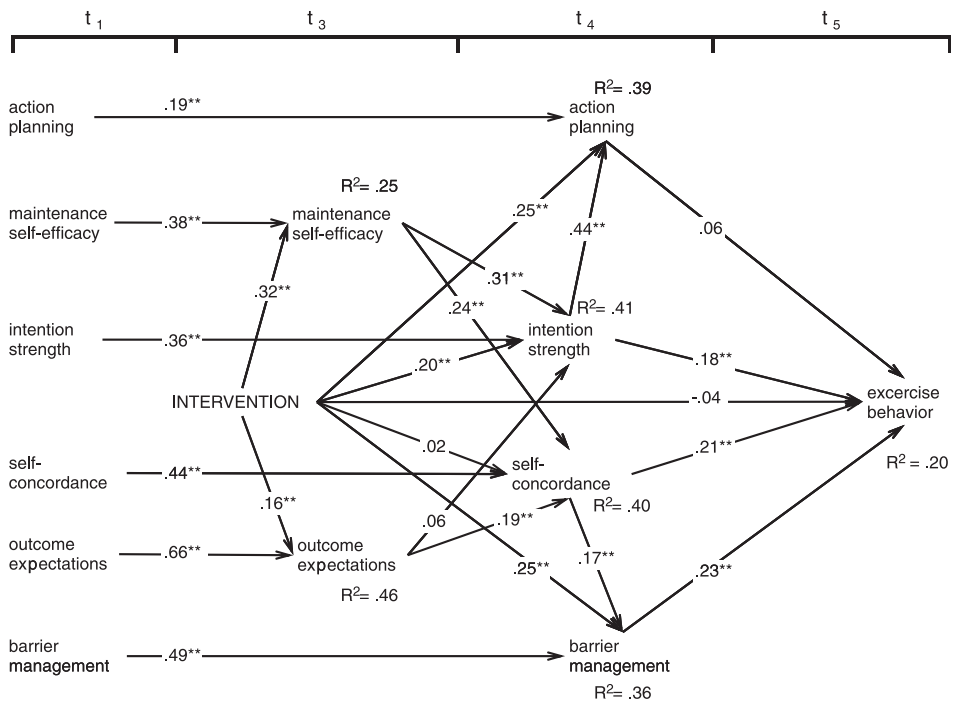
Figure 2. Adoption model. *$p < 0.05$; **$p < 0.01$.

Figure 3. Maintenance model. **$p < 0.01$.

Table 1. Standardised direct, indirect and total effects of variables in the Adoption Model.

		Intervention	Self-efficacy T2	Outcome expect T2	Intention strength T2	Self-concord T2	Action planning T2	Barrier manage T2
Self-efficacy T2	Direct	0.13*						
	Indirect							
	Total	0.13*						
Outcome expectations T2	Direct	0.14*						
	Indirect							
	Total	0.14*						
Intention strength T2	Direct	0.14*	0.41**	0.14*				
	Indirect	0.07*						
	Total	0.21**	0.41**	0.14*				
Self-concordance T2	Direct	0.04	0.19**	0.24**				
	Indirect	0.06						
	Total	0.10*	0.19**	0.24**				
Action planning T2	Direct	0.27**	0.07*	0.02*	0.18**			
	Indirect	0.04						
	Total	0.30**	0.07*	0.02*	0.18**			
Barrier management T2	Direct	0.23**	0.03*	0.04*		0.18**		
	Indirect	0.02						
	Total	0.25**	0.03*	0.04*		0.18**		
Exercise behaviour T3	Direct	0.19**	0.13**	0.05*	0.27**	0.03	0.21**	0.05
	Indirect	0.14*			0.04	0.01		
	Total	0.33**	0.13**	0.05*	0.31**	0.04	0.21**	0.05

Notes: Variables in the horizontal dimension are exogenous parameters; those in the vertical dimension are endogenous parameters.
*$p < 0.05$.
**$p < 0.01$.
$N = 220$.

Table 2. Standardised direct, indirect and total effects of variables in the Maintenance Model.

		Intervention	Self-efficacy T3	Outcome expect T3	Intention strength T4	Self-concord T4	Action planning T4	Barrier manage T4
Self-efficacy T3	Direct	0.32**						
	Indirect							
	Total	0.32**						
Outcome expectations T3	Direct	0.16**						
	Indirect							
	Total	0.16**						
Intention strength T4	Direct	0.20**	0.31**	0.06				
	Indirect	0.11**						
	Total	0.31**	0.31**	0.06				
Self-concordance T4	Direct	0.02	0.24**	0.19**				
	Indirect	0.11**						
	Total	0.12	0.24**	0.19**				
Action planning T4	Direct	0.25**	0.14**	0.03	0.44**			
	Indirect	0.14**						
	Total	0.38**	0.14**	0.03	0.44**			
Barrier management T4	Direct	0.25**	0.04*	0.03*		0.17**		
	Indirect	0.02						
	Total	0.27**	0.04*	0.03*		0.17**		
Exercise behaviour T5	Direct	−0.04	0.12**	0.06*	0.18**	0.21**	0.06	0.23**
	Indirect	0.17**			0.02	0.04*		
	Total	0.13	0.12**	0.06*	0.21**	0.25**	0.06	0.23**

Notes: Variables in the horizontal dimension are exogenous parameters; those in the vertical dimension are endogenous parameters.
*p < 0.05.
**p < 0.01.
N = 220.

variable's total effect that is independent of other variables in the model. A variable's indirect effect is the portion of its total effect that is dependent on other variables in the model; self-concordance, for example, influences exercise behaviour indirectly through barrier management (Figure 3). Indirect effects are calculated by summing the products of the path coefficients associated with each of these indirect routes. The indirect effect for self-concordance on exercise behaviour (0.04) is the product of the direct effect of self-concordance on barrier management (0.17) and the direct effect of barrier management on exercise behaviour (0.23) (Figure 3 and Table 2).

Indirect effects of the intervention on exercise behaviour through cognitive variables – as specified in the Adoption and Maintenance Model – were tested by calculating *multiple mediation models*. Based on a recommendation by MacKinnon (2000) and articulated further by Preacher and Hayes (2008) the current study used both normal theory and bootstrapping approaches to test for significance of indirect (mediated) effects (total and specific for each mediator). Bootstrap procedures are considered preferable because they do not assume normality of the distribution of the indirect effects and hence provide stronger protection against type 2 error, compared to normal theory procedures such as the Sobel test. We report results for bootstrap tests in which a point estimate of the indirect effect was derived from the mean of 5000 bootstrap samples (bias corrected and accelerated estimates and 95% CI). Coefficients with confidence limits that did not include zero were interpreted as statistically significant.

Results

Evaluation of the Adoption Model

Standardised direct, indirect, and total effect coefficients for the Adoption Model are listed in Table 1. Figure 2 shows the direct effects (standardised path coefficients), along with the variance explained (R^2) for each dependent variable in the model. The special features of the Adoption Model are: (a) all participants ($N = 220$) were non-exercisers at T1; (b) baseline values [T1] of all psychological variables were controlled for; (c) intervention effects on psychological variables were assessed at T2 and (d) exercise behaviour was evaluated at T3. The test of the Adoption Model provided satisfactory fit-scores: $\chi^2(52) = 93.8$; $p < 0.001$; χ^2/df ratio $= 1.804$; RMSEA $= 0.061$; standardised RMR $= 0.0638$; GFI $= 0.942$; TLI $= 0.931$.

Intervention effects

Within the Adoption Model the intervention program exerted a substantial total effect on exercise behaviour ($\beta_{total} = 0.33$; last row in Table 1). This total effect was composed of a direct intervention effect ($\beta_{direct} = 0.19$) that was stronger than the sum of all indirect intervention effects ($\beta_{indirect} = 0.14$). Furthermore, there were significant, although small direct intervention effects (β_{direct}) on adoption self-efficacy T2 (0.13), outcome expectations T2 (0.14), and intention strength T2 (0.14) (Figure 2). The direct intervention effect on self-concordance T2 (0.04) did not reach statistical significance. In contrast, the direct intervention effects on action planning T2 (0.27) and barrier management T2 (0.23) were significant and larger reflecting the major focus of the intervention.

Table 3. Multiple mediation analyses[a]: indirect effects of the intervention on exercise behaviour through mediators in the Adoption and Maintenance Models (standardised coefficients).

Model	Mediators	Coeff[d]	SE[d]	Normal theory Z	Normal theory p	Bootstrap 95% *CI*
Adoption	Total[b]	0.14	0.04	4.00	0.001	0.09; 0.21
	Intention strength T2[c]	0.06	0.02	2.64	0.008	0.03; 0.12
	Self-concordance T2	0.00	0.01	0.40	0.688	−0.01; 0.03
	Action planning T2	0.07	0.02	2.76	0.006	0.03; 0.12
	Barrier management T2	0.01	0.02	0.78	0.434	−0.02; 0.06
Maintenance	Total	0.17	0.04	3.93	0.001	0.09; 0.25
	Intention strength T4	0.05	0.03	2.13	0.033	0.01; 0.11
	Self-concordance T4	0.02	0.02	1.50	0.133	−0.00; 0.07
	Action planning T4	0.02	0.03	0.72	0.470	−0.04; 0.09
	Barrier management T4	0.07	0.02	2.66	0.008	0.03; 0.13

Notes: [a]Based on a SPSS macro provided by Preacher and Hayes (2008) that calculates indirect effects (total and specific for each mediator), including tests of significance using both normal theory and bootstrap procedures.
[b]Indirect effect of the intervention on exercise behaviour through *all* mediators.
[c]Indirect effect of the intervention on exercise behaviour through the *specific* mediator.
[d]Identical values for normal theory tests and bootstrap results.

Prediction of mediators and exercise behaviour

The results are presented in Figure 2: *Intention strength* T2 ($R^2 = 0.45$) was predicted by intention strength T1 ($\beta_{\text{direct}} = 0.29$), adoption self-efficacy T2 (0.41), outcome expectations T2 (0.14) and intervention (0.14). *Self-concordance* T2 ($R^2 = 0.44$) was mainly predicted by self-concordance T1 ($\beta_{\text{direct}} = 0.50$), but also by outcome expectations T2 (0.24), and adoption self-efficacy T2 (0.19). More than one quarter (26%) of interindividual variance in *exercise behaviour* T3 could be explained by intention strength T2 ($\beta_{\text{direct}} = 0.27$), action planning T2 (0.21) and the intervention (0.19). Self-concordance T2 (0.03) and barrier management T2 (0.05) did not play a significant role in the prediction of exercise behaviour at T3.

Mediation analyses

Table 3 summarises the indirect effects of the intervention on exercise behaviour through the mediator variables intention strength T2, self-concordance T2, action planning T2 and barrier management T2 using tests of significance based on normal theory and bootstrap procedures (Preacher & Hayes, 2008). Within the Adoption Model, of the four mediator variables only intention strength ($p = 0.008$; 95% CI = 0.03; 0.12) and action planning ($p = 0.006$; 95% CI = 0.03; 0.12) showed significant indirect effects.

Evaluation of the Maintenance Model

Standardised total, direct, and indirect effect coefficients for the Maintenance Model are listed in Table 2. Figure 3 shows the path-analytic results for this model. The special features of this analysis are: (a) all participants ($N = 220$) were

non-exercisers at T1; (b) baseline values [T1] of all psychological variables were controlled for; (c) intervention effects on self-efficacy and outcome expectations were assessed at T3 (short-term impact); (d) intervention effects on intention strength, self-concordance, action planning and barrier management were assessed at T4 (middle-term impact; six months follow-up) and (e) exercise behaviour was evaluated at T5 (long-term impact; 12 months follow-up). The test of the Maintenance Model also provided satisfactory fit-scores: $\chi^2(52) = 123.0$; $p < 0.001$; χ^2/df ratio $= 2.366$; RMSEA $= 0.079$; standardised RMR $= 0.0744$; GFI $= 0.932$; TLI $= 0.894$.

Intervention effects

The total intervention effect on exercise behaviour T5 ($\beta_{total} = 0.13$; last row in Table 2) was due mainly to indirect effects ($\beta_{indirect} = 0.17$) and not to the direct effect ($\beta_{direct} = -0.04$). Figure 3 shows significant short-term intervention effects on maintenance self-efficacy T3 ($\beta_{direct} = 0.32$) and outcome expectations T3 (0.16). Although the middle-term direct intervention effects on intention strength T4 ($\beta_{direct} = 0.20$), action planning T4 (0.25), and barrier management T4 (0.25) were significant, direct intervention effects on self-concordance T4 (0.02) were not.

Prediction of mediators and exercise behaviour

The results are shown in Figure 3. *Intention strength* T4 ($R^2 = 0.41$) was predicted by intention strength T1 ($\beta_{direct} = 0.36$), maintenance self-efficacy T3 (0.31), and intervention (0.20); however, outcome expectancies T3 did not contribute to this prediction (0.06). *Self-concordance* T4 ($R^2 = 0.40$) was mainly predicted by self-concordance T1 ($\beta_{direct} = 0.44$), but also by maintenance self-efficacy T3 (0.24) and outcome expectations T3 (0.19). A total of 20% of interindividual variance in *exercise behaviour* at T5 could be explained by intention strength T4 ($\beta_{direct} = 0.18$), self-concordance T4 (0.21), and barrier management T4 (0.23). In contrast to the Adoption Model, action planning T4 (0.06) and the intervention (−0.04) did not play a significant role in the prediction of exercise behaviour at T5.

Mediation analyses

Table 3 shows the indirect effects of the intervention on exercise behaviour through the mediator variables intention strength T4, self-concordance T4, action planning T4 and barrier management T4 in the Maintenance Model. Only the paths via intention strength ($p = 0.033$; 95% CI $= 0.01$; 0.11) and barrier management ($p = 0.008$; 95% CI $= 0.03$; 0.13) turned out to be significant.

Discussion

Few studies have examined whether intervention effects on exercise behaviour are due to changes in the psychological constructs targeted by the intervention (Napolitano et al., 2008). The goal of the present study was to contribute to this research by investigating how the effects of a group-based intervention program (MoVo-LISA) on exercise behaviour – evidenced in an earlier analysis (Fuchs et al., 2011) – were mediated by cognitive variables. Based on the MoVo

process model as a theoretical framework, two causal models were specified: the Adoption Model was designed to map the proximal intervention effects on cognitions and exercise in the first six weeks of the behaviour change process; the Maintenance Model was set up to picture the distal intervention effects during the six and 12 months follow-up. Overall, the three most important findings from this study were as follows: (1) the observed intervention effects on exercise behaviour were – at least in part – mediated by intention strength, action planning, and barrier management, but not by self-concordance. (2) Self-concordance had the largest total effect on exercise maintenance, but was not directly modified by our intervention, neither in the short-run (Adoption Model) nor on the long-term (Maintenance Model). (3) Intention strength was a significant mediator in both the Adoption and Maintenance Model, whereas action planning was only significant at the adoption, and barrier management only significant at the maintenance stage. The latter finding supports the view that action planning should be a major intervention target in the first weeks of the program, with barrier management emphasised in the months thereafter to stabilise behaviour change. These findings are discussed in more detail below.

Intervention effects on behaviour

Our path analysis for the *Adoption Model* indicated that the short-term intervention effects on exercise behaviour were mediated only partially by the psychological constructs under consideration. The total intervention effect on exercise behaviour at T3 ($\beta_{total} = 0.33$) was based on a direct effect ($\beta_{direct} = 0.19$) that was even larger than the sum of all indirect effects ($\beta_{indirect} = 0.14$) suggesting that the observed behaviour change was not completely due to changes in the cognitive structures specified in the causal model of Figure 2. Other mediating factors (e.g. risk perceptions; Stephan, Boiche, Trouilloud, Deroche, & Sarrazin, 2011) or processes (e.g. nonspecific treatment effects) may therefore have been responsible for the intervention effects not accounted for in the Adoption Model. Within the *Maintenance Model* the situation was different. Here, the total intervention effect on exercise behaviour at T5 ($\beta_{total} = 0.13$) was entirely due to indirect effects ($\beta_{indirect} = 0.17$) implying that the long-term impact of MoVo-LISA on exercise after 12 months was fully mediated by the cognitive constructs. Taken together these findings indicate that our modelling of cognitive mediation processes was more successful for the (smaller) distal than the (larger) proximal intervention effects. This result is intriguing because it challenges the often held position (Marcus et al., 2006; Rothman, 2000) that psychological processes of exercise adoption are better understood than those of exercise maintenance.

Mediation analyses

The indirect (mediated) intervention effect through intention strength turned out to be significant in both the Adoption and Maintenance Model, whereas the indirect intervention effect through action planning was significant only at the adoption, and through barrier management significant only at the maintenance stage (Table 3). This is in line with results reported by Ziegelmann, Lippke, and Schwarzer (2006), who found action planning to be more predictive than barrier management (coping planning) in the adoption phase of strenuous exercise, and barrier management to be more predictive than planning in the maintenance phase. However, our results

extend this finding by showing that action planning was not only a significant predictor of exercise behaviour (0.21; $p < 0.01$) at the adoption stage, but also a variable that could be substantially modified through the MoVo-LISA program (0.27; $p < 0.01$), and that the combination of both (predictive power and modifiability) resulted in a larger indirect effect ($p < 0.01$) for action planning than for all the other mediator variables at this stage of behaviour change. The same was true for barrier management at the maintenance stage: not only was this a significant predictor of long-term exercise behaviour (0.23; $p < 0.01$), it was also substantially modifiable by the MoVo-LISA program (0.25; $p < 0.01$). A different intervention program might have led to other optimal modifiability-by-predictive power combinations. For this reason, our findings also illustrate that the relevance of any mediating path is strongly determined by the specific characteristics of the intervention program.

Modifiability: Intervention effects on mediator variables

In the *Adoption Model*, the intervention showed significant but small direct effects on adoption self-efficacy, outcome expectations and intention strength, and markedly larger direct effects on action planning and barrier management. These findings may reflect the fact that the MoVo-LISA program focussed more on volitional factors (developing specific 'when-where-and-how plans' and counter strategies against internal and external barriers) than motivational factors (self-efficacy, outcome expectations). Consistent with earlier results by Sniehotta et al. (2006) and Rhodes, Naylor, and McKay (2010), the current study indicates that exercise-related planning and barrier management can be substantially improved by intervention programs such as MoVo-LISA. The test of the *Maintenance Model* confirms these findings from a long-term perspective. Here, again, intervention effects on action planning and barrier management were relatively strong, supporting the notion that the program yielded longer-lasting improvements in self-regulative strategies.

In both the Adoption and Maintenance Models, direct intervention effects on *self-concordance* did not reach statistical significance. This was unexpected, because the intervention did address self-concordant goal intentions (e.g. by getting participants to reflect on whether their exercise intentions and plans were really their own, or had been imposed by partners or doctors). The results suggest that this intervention goal was not achieved by our program. A recent study by Chatzisarantis and Hagger (2009) demonstrated that significant changes in students' motivational orientation (autonomous *vs.* controlling), a construct very similar to our variable of self-concordance, could be accomplished by an autonomy-supportive style of teaching (providing individual feedback, acknowledging difficulties, enhancing sense of choice) and that these changes were predictive of future exercise levels. Maybe the development of self-concordant (or autonomous) goal intentions needs more individualised counselling, e.g. in face-to-face sessions, than a group-intervention such as MoVo-LISA can provide.

Predictive power: Effects of mediator variables on exercise behaviour

In both the Adoption and Maintenance Model, *intention strength* was a significant predictor of future exercise behaviour supporting once again the central role of goal intentions in the initiation and continuation of regular exercise (e.g. Chatzisarantis &

Hagger, 2009). Contrary to our hypotheses (as specified in the two causal models) *action planning* contributed significantly to the prediction of exercise behaviour only in the Adoption (time span: six weeks) but not in the Maintenance Model (12 months). Previous studies (Lippke, Ziegelmann, & Schwarzer, 2004; Renner, Spivak, Kwon, & Schwarzer, 2007), focusing on the short-term prediction of regular exercise, confirm our finding that action planning is a major determinant of regular exercise in the adoption phase. However, little is known about the predictive power of action planning under a long-term perspective (maintenance phase). The argument that the non-significance of the predictor 'action planning T4' in the Maintenance Model was due to its presumably high instability over time ('when, where, and how-plans' need to be permanently adapted to changing circumstances and therefore are instable) was not supported by a relatively large autocorrelation of 0.55 ($p < 0.01$) for action planning at T4 and T5 (not reported in the results section).

Barrier management did not emerge as a significant predictor of exercise behaviour at the adoption stage. Maybe the time interval of six weeks after discharge from the clinic was too short for this mediator to exert a substantial impact on the behaviour. Barrier management is a dynamic self-regulatory strategy (Sheeran, Milne, Webb, & Gollwitzer, 2005) which has not reached any stable 'end state' by the time participants leave the clinic (T2) or even six weeks after (T3). Rather, barrier management – instigated by the intervention program – is likely to impact on exercise in the middle- and long-term by becoming more and more elaborated under real-world experiences with the newly acquired behaviour. The results for the Maintenance Model seem to support this view. Here, barrier management at T4 was the strongest predictor of exercise behaviour at T5. Ziegelmann et al. (2006) also found a 'delayed effect' of barrier management (coping planning) on regular physical activity suggesting that this mediator is important particularly for long-term maintenance.

In contrast to the Adoption Model, *self-concordance* played an important role in the Maintenance Model. Among all the cognitive variables, self-concordance exerted the strongest total effect on exercise behaviour at the 12-month follow-up (Table 2). This result is in line with previous research showing that the type of goals people pursue (whether the goals are self-concordant or not) is critical for the persistence of goal pursuit, and through this, for the maintenance of health behaviours in general and exercise behaviour in particular (Ntoumanis, 2001). For instance, Vansteenkiste et al. (2004) found intrinsic (self-concordant) goals had strong effects on physical activity level after four months. Our research adds to this knowledge by suggesting that influencing goal self-concordance may not be important for the short-term adoption of the new exercise behaviour, but it is likely to play a crucial role in its maintenance.

Strengths and limitations of the current study

This is the first study to track the cognitive mediation processes of intervention effects on exercise behaviour over a relatively long time-period (12 months), differentiating the adoption and maintenance stage of behaviour change. Similar studies have used shorter time periods of 10 weeks (Chatzisarantis & Hagger, 2009) or six months (Napolitano et al., 2008; Ziegelmann et al., 2006). Anderson et al. (2010) based their mediator analyses on a 16-months follow-up study, but did not look at proximal (adoption) and distal (maintenance) intervention effects separately.

In this study, we had five assessment time points, with time intervals that allowed for a more accurate detection of mediated effects than in previous studies. For example, in the investigation by Napolitano et al. (2008) measures of mediators and exercise behaviour were both taken six months after the treatment was initiated (without further measurements in-between). Therefore, it was not clear whether changes in the mediators had led to changes in the behaviour or – vice versa – changes in the behaviour had led to changes in the mediator. In contrast, our analyses were based on a temporal ordering of treatment, assessment of mediators, and assessment of exercise behaviour, providing the base for longitudinal analyses more suited to examine the theoretically expected causal ordering.

Some limitations of the study should be noted: As discussed elsewhere (Fuchs et al., 2011), the design of the current study was quasi-experimental because individual randomisation to intervention and control groups was not feasible. Thus, factors other than the intervention could account for the difference in groups. MoVo-LISA was implemented into the whole clinic; all medical personnel played a specific role within this program. If we had implemented MoVo-LISA at the same time as we collected data from the control group, patients could have had informal talks and exchanged information about the program. Also, medical personnel may not have been neutral with regard to the control group. Therefore, we chose a sequential control-intervention group design, where we collected data from the intervention group only after the patients of the control group had left the clinic. This procedure might have produced another problem: patients' discharge from the clinic took place during different seasons, and this could have influenced their exercise behaviour over the follow-up. One would assume that warm summertime might be more conducive for exercise than cold and rainy winter days, for example. We could not, however, find any evidence for this assumption, there was no increase in exercise (minutes per week) during summer in either of the study groups.

Another potential limitation of the study is the measurement of exercise behaviour, which was based on self-report and may be subject to memory bias. However, in this study we were less interested in actual amounts of exercise participation but rather in group differences in the exercise behaviour. Assuming that self-report biases affected both the intervention and control groups to the same extent, we do not expect our findings to be substantially distorted.

Conclusions

Our findings have implications for the design of intervention programs: Strengthening goal intentions by fostering self-efficacy beliefs and outcome expectations provides the base for the change process. However, these goal intentions need not only to be strong, they also need to be self-concordant (intrinsic, autonomous) to ensure persistence in the long term. While action planning is likely to be important to initiate the exercise behaviour, barrier management may come in later to deal with internal and external barriers that challenge the newly acquired behaviour. Based on the results from this study future mediation analyses should focus on two questions: (1) intervention effects on exercise were not fully mediated by the cognitive variables considered in the Adoption Model. We therefore need to refine our theoretical models to account for factors and processes that are not yet adequately represented (cf. Rothman, 2000). (2) The role of self-concordance,

particularly in the process of exercise maintenance, needs to be further explored. In the current study there was clear evidence that this construct is critical for long-term maintenance of exercise behaviour; however, it also became clear that we were not able to change self-concordance by our intervention. We need, therefore to think of new ways to effectively intervene on this factor, which is likely to be crucial for exercise maintenance.

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