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Changes in social-cognitive variables are associated with stage transitions in physical activity

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Abstract

When it comes to the adoption or maintenance of physical activity, individuals can be placed along a continuum or into stages of change. The Health Action Process Approach proposes three such stages: non-intentional, intentional and actional. Intraindividual differences are reflected by stage transitions: either progression or regression. The present study examines social-cognitive factors of stage transitions: outcome expectancies, self-efficacy and planning.

In an online study on physical activity, 660 adults completed questionnaires at baseline and approximately 3 weeks later. Social-cognitive factors were converted into standardized residual change scores to account for changes in outcome expectancies, self-efficacy and planning within the observation period.

Discriminant function analyses revealed stage-specific patterns: progression out of non-intentional stage was associated with self-efficacy increases. Out of intentional stage, regression was correlated with decreases in planning, whereas progression was linked to increases in self-efficacy and planning. Regression from action stage was associated with decreases in self-efficacy.

Physical activity promotion should focus on improving self-efficacy for non-intending, intending and acting individuals, whereas planning interventions are recommended for intending individuals. Interventions may be more effective by considering specific mechanisms instead of providing generic interventions for all individuals at different stages.

Introduction

'Physical activity' is defined as any movement of the body produced by the skeletal muscles that results in energy expenditure and includes the subcomponent 'exercise', which requires planned, structured and repetitive bodily movement [1]. Engagement in regular physical activity has been proven to enhance personal well-being and to contribute substantially to the maintenance and recovery of health. Physical inactivity is considered to be a modifiable risk factor for osteoporosis, cardiovascular disease, diabetes mellitus, obesity, depression and different types of cancer [2]. As physical activity strengthens the immune system, reduces stress hormones and improves muscle strength, it can help reduce the risk of those diseases. Although most people know about the beneficial effects of physical activity, the initiation and maintenance of regular physical activity behavior is difficult: The majority of individuals do not meet the recommendations of being physically active for at least 30 min on five or more days a week [3]. In 2008, 31% of the

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worldwide population did not attain the recommended activity levels. In high-income countries, the prevalence is even higher with 48% of women and 41% of men not being sufficiently physically active on a regular basis [4]. These figures reveal the need for effective interventions promoting the adoption and maintenance of physical activity in everyday life.

Stages of behavior change

Effective health promotion interventions need to be theory and evidence based [5, 6]. Regarding health behavior change, one can distinguish between continuum models and stage models [6, 7]. Continuum models assume a linear relationship between predictors of behavior and the likelihood of subsequent behavior. Thus, interventions based on continuum models aim at positively influencing behavioral intentions and its associated predictors as they are assumed to increase the likelihood of the target behavior. In contrast, stage models of health behavior change propose that individuals pass through qualitatively different stages during the behavior change process and that predictors of behavior change vary across stages. Subsequently, interventions ought to target stage-specific predictors [7].

Stages can be defined as qualitatively distinct, ordered phases that are characterized by similarities within stages and psychological differences between stages. By providing a theoretical framework for tailored health education interventions, stage models such as the Transtheoretical Model (TTM) [8] offer practical implications. Health interventions that are tailored to stage-specific needs of individuals have proven to be parsimonious and more effective than one-size-fits-all interventions [9–13].

The Health Action Process Approach (HAPA) [14] is a hybrid model that combines the assumptions of stage and continuum models. The HAPA differentiates between a non-intentional, intentional and an action stage. The idea is that individuals experience a shift of mindset when moving from one stage to another. In addition, it includes motivational and volitional components.

Longitudinal studies have investigated the HAPA as well as its predictors of intentions and behavior targeting different behaviors such as physical activity, dietary behavior and breast self-examination [15–17]. Several studies comparing stage-matched interventions based on the HAPA with standard care and non-stage-matched interventions, respectively, could demonstrate its value for evidence-based practice [18, 19]. Evidence is available on HAPA variables as predictors of stage transitions [10, 20] which ought to be extended by the present study to the area of physical activity. Finding that positive outcome expectancies, planning, motivational and maintenance self-efficacy are differentially important for HAPA stages, would facilitate the development of more effective interventions.

Determininants of stage transitions

HAPA proposes specific factors as being essential for passing through different stages of health behavior change. The 'non-intentional stage' comprises individuals who have not yet set a behavioral goal. As a precondition for acting, individuals in this stage need to form an intention [21]. Therefore, determinants assumed to be important in this stage are motivational factors such as positive outcome expectancies (pros) and motivational self-efficacy [14].

The beliefs people hold about beneficial effects of performing physical activity are referred to as positive outcome expectancies. Individuals without an intention to act perceive fewer pros than intentional or active individuals [22, 23]. However, evidence on outcome expectancies in physical activity research is inconsistent [24]. A few studies have shown that outcome expectancy has a small to moderate association with physical activity intention, whereas other studies did not find a relationship. A meta-analysis of TTM applications to physical activity and exercise [25] demonstrated that individuals not intending to act in comparison to individuals intending to act and already acting reported lower scores for response-efficacy (pros) and that pros increase with advancing stages. Further, higher scores on pros have been found to significantly predict forward stage transition out of precontemplation (comparable to the non-intentional stage) [26, 27]. In contrast, negative outcome expectancies

seem to be less correlated with behavioral intentions and progression to volitional phase [24, 27–29].

Perceived self-efficacy [30] is individuals' belief in their capability to successfully meet novel or difficult demands. There is evidence for the relevance of self-efficacy in motivational and volitional phases of behavior change [10, 20, 30, 31]. Particularly with regard to physical activity, self-efficacy was found to facilitate exercise stage progression [28, 32, 33]. A phase-specific distinction of self-efficacy was suggested by Marlatt *et al.* [34]. According to the HAPA, motivational self-efficacy is assumed to be a predictor of intentions and can help initiate a new behavior and, therefore, plays a major role in the pre-action phase. In contrast, maintenance self-efficacy is assumed to be a predictor of the performance of the intended behavior and, therefore, is crucial in the volitional (intentional, action and maintenance) phases [35]. The optimistic belief about one's capability to overcome obstacles possibly occurring in this phase helps maintain the initiated behavior [16]. To our knowledge, phase-specific forms of self-efficacy have not yet been examined with regard to stage transitions.

Individuals, who are motivated to pursue their behavioral goals but do not yet act according to their intentions, belong to the 'intentional stage'. Self-efficacy and planning have been found effective in translating intentions into behavior [14, 16]. It becomes apparent from previous findings that higher scores on self-efficacy go along with progression to the action stage [26, 27, 36]. Planning is a prospective self-regulatory strategy facilitating the initiation of the target behavior (e.g. implementation intentions) [15, 19, 21, 37, 38] and there is evidence that individuals high in planning are more likely to progress to the action stage [10, 38]. Vice versa, a negative change in planning and self-efficacy, respectively, is supposed to lead to regression from the intentional to the non-intentional stage.

Individuals who already perform the target behavior are assigned to the 'action stage'. Maintenance self-efficacy [14, 39] and planning are assumed to help maintain the initiated health behavior on a regular basis [40, 41]. Previous studies on stage transitions regarding different health behaviors demonstrated that low levels of self-efficacy and planning are associated with regression from the action to the intentional stage [20, 27, 36].

Changes in social-cognitive variables and stage transitions

A considerable amount of cross-sectional and longitudinal studies on health behavior change have been conducted to find evidence for stage models. A promising approach is using stage transition as an outcome variable instead of behavior because cognitive changes that occur prior to behavioral changes, can be observed and considered as well. In previous studies, baseline values of social-cognitive variables have been used to predict subsequent stage transition [10, 20, 26, 42]. This approach is useful to identify variables that are associated with stage transition. However, a procedure reflecting increases or decreases, respectively in social-cognitive determinants of stage transition, would be more meaningful [18, 43]. Thus, we will focus on changes in the determinants of stage transitions.

Aim and hypotheses

The aim was to investigate whether changes in social-cognitive variables are associated with transitions between the three stages of the HAPA in the domain of physical activity. We decided to focus on determinants that have emerged as most important in the health behavior change process including positive outcome expectancies, motivational self-efficacy, maintenance self-efficacy and planning. Based on the current HAPA literature regarding stage transition [10, 20] and previous findings testing stage-specific determinants [26–28, 32, 33, 36, 38], we hypothesized:

(i) A positive change in outcome expectancies and motivational self-efficacy is associated with progression from the non-intentional stage to a further stage.
(ii) A negative change in motivational self-efficacy and planning is associated with regression from the intentional stage into the non-intentional stage.

(iii) A positive change in maintenance self-efficacy and planning is associated with progression from the intentional stage to the action stage.
(iv) A negative change in maintenance self-efficacy and planning is associated with regression from the action stage to an earlier stage.

Method

Participants and procedure

An online intervention study promoting physical activity was launched, and German-speaking participants were recruited by press releases (newspaper, TV and radio) with a link to the health promotion program. At baseline, 2122 participants responded to the initial survey and a brief intervention focusing on physical activity. The online treatment aimed at improving positive outcome expectancies by providing information on beneficial consequences of behavior, self-efficacy by focusing on past successes and role models' testimonials on exercise achievements as well as prompting plans and facilitating time management strategies. Additionally, all participants were asked to set a specific and attainable personal goal with regard to physical activity (e.g. to be physically active for at least 30 min on 3 days a week). Thus, they were not obliged to set a personal goal that meets the frequently recommended criterion of being physically active for at least 30 min on 5 days a week. Then, participants could note a realistic date as their personal deadline at which the goal should be attained. One week later, all participants who had provided their e-mail address received an invitation for a follow-up assessment. At Time 2, approximately 3 weeks after Time 1 (ranged from 7 to 98 days), 660 of them revisited the website and completed the follow-up assessments (31.1%). The longitudinal sample comprised individuals between the ages of 16 and 76 [$M = 42.4$, standard deviation (SD) = 13.9] with more women (72%) than men. Most of them were living with a partner (61.7%) and had graduated from high school (74.4%). Of the whole sample, only 35 (5.3%) participants met the World Health Organization's recommendations of engaging in moderate physical activity for at least 30 min on at least 5 days per week [4].

Measures

Social-cognitive variables and HAPA stages were measured at Time 1 (T1) and Time 2 (T2). One week after their personal deadline for goal achievement, participants received an e-mail with the invitation to complete the follow-up questionnaire (T2). Therefore, the time span between T1 and T2 varied across participants depending on their personal deadline. On average, T2 assessments took place 20 days after baseline.

At the beginning of each assessment, participants were asked to 'please think of the recent past' when answering the questionnaire. If not otherwise reported, response formats of the items were 6-point Likert scales, ranging from 'completely disagree' (1) to 'completely agree' (6). All instruments have been validated in previous studies (e.g. [14, 15]). Example items are translations from German.

Physical activity was defined as any intentional activity that was somewhat exhausting (e.g. biking, running or swimming) and assessed by asking participants on how many days per week they were physically active. A pull-down menu allowed responses from '0' to '7' days. Furthermore, participants were asked how much time they had spent on average performing these activities on each of these days. Participants could select responses from '0' to '300 or more' minutes a day. Frequency and average duration per session were multiplied to obtain a measure of duration of recently performed physical activity on a weekly basis.

Positive outcome expectations regarding behavior change were assessed with four items (Cronbach's $\alpha = 0.79$ and 0.81 for T1 and T2, respectively). All items had the stem 'If I am physically active on a regular basis …' followed by positive consequences 'then I will feel well balanced and satisfied', 'then I will do something good for my health and my fitness', 'then I am more alert' and 'then it will favorably affect the way I look'.

Motivational self-efficacy was measured with two items (r = 0.87 and 0.88 for T1 and T2, respectively) namely 'I am confident that I can be physically active even if it is difficult for me' and 'I am certain that I can live a physically active lifestyle even if it is difficult for me'.

Maintenance self-efficacy was assessed with the item stem 'I am confident that I can be physically active on a permanent and regular basis . . .'. The items then were 'even if I have to overcome barriers' and 'even if I have sorrows and problems' (r = 0.78 and 0.76 for T1 and T2, respectively).

Planning was assessed with three items starting with the wording 'I have already planned . . .' (Cronbach's α = 0.65 and 0.73 for T1 and T2, respectively). The stem was followed by the items 'on which days I will be physically active', 'for how long I will be physically active' and 'what I can do in difficult situations to stick to my intentions'.

Stage was assessed with a validated algorithm, 'Are you physically active on 5 days a week for at least 30 min?'[44]. Those answering 'No, and I do not intend to do so' and 'No, but I am thinking about it' were classified as non-intenders (non-intentional stage, coded '1'), those indicating 'No, but I strongly intend to do so' were categorized as intenders (intentional stage, coded '2') and those replying 'Yes, but it is difficult for me' and 'Yes, and it is easy for me' were categorized as actors (action stage, coded '3').

Statistical analyses

All analyses were conducted using SPSS 17.0. The Expectation Maximization Algorithm was used to impute missing data within each measurement point in time. Attrition analyses revealed no differences between participants who did not respond and participants who responded to follow-up assessments with regard to marital status, education, motivational and maintenance self-efficacy at T1. However, participants of the longitudinal subsample were more frequently women (72.1% in comparison to 57.4%; $\chi 2$ (1) = 48.1; $P < 0.001$). Furthermore, respondents at T2 compared with non-respondents were older ($M_{\text{Responder}}$ = 42.4, $\text{SD}_{\text{Responder}}$ = 13.9; $M_{\text{Non-Responder}}$ = 40.9, $\text{SD}_{\text{Non-Responder}}$ = 12.8; t (935) = −2.646; $P < 0.01$), more frequently physically active ($M_{\text{Responder}}$ = 100.8, $\text{SD}_{\text{Responder}}$ = 118.2; $M_{\text{Non-Responder}}$ = 85.3, $\text{SD}_{\text{Non-Responder}}$ = 113.3; t (3598) = −3.178; $P < 0.005$), reported higher levels of baseline positive outcome expectancies ($M_{\text{Responder}}$ = 5.3, $\text{SD}_{\text{Responder}}$ = 0.7; $M_{\text{Non-Responder}}$ = 5.2, $\text{SD}_{\text{Non-Responder}}$ = 0.7; t (3598) = −2.778; $P < 0.01$) and planning ($M_{\text{Responder}}$ = 3.6, $\text{SD}_{\text{Responder}}$ = 0.9; $M_{\text{Non-Responder}}$ = 3.4, $\text{SD}_{\text{Non-Responder}}$ = 1.0; t (3598) = −4.997; $P < 0.001$).

Data were analyzed using several discriminant function analyses. Discriminant function analysis is mathematically similar to multivariate analysis of variance (MANOVA), whereas only discriminant function analysis allows the prediction of group membership from a set of predictor variables. At first, a comparison of all non-intenders at T1 who were differentiated between stagnating and progressing individuals at T2 was accomplished. Stagnating intenders were once compared with regressing intenders in the second analysis and once with progressing intenders in the third analysis. The fourth analysis contained all actors at T1 whereupon maintaining individuals were compared with regressing individuals. Stage distribution at T1 and stage transitions at T2 are shown in Fig. 1.

Stage transition was selected as grouping variable and was assessed by subtracting T1 stages from T2 stages. A positive difference (coded 1) indicates stage progression and a negative difference (coded −1) indicates stage regression. A difference of zero (coded 0) represents no changes. Thus, non-intenders *at* T1 could only remain in the non-intentional stage or progress to a further stage. Intenders *at* T1 could regress to the non-intentional stage, maintain in the intentional stage or progress to the action stage and actors *at* T1 could maintain their action stage or regress to a qualitative lower stage.

In order to assess change in social-cognitive variables, the standardized residual change scores of positive outcome expectancies, motivational self-efficacy, maintenance self-efficacy and planning were entered directly in the analysis. Using standardized residual change scores compared with

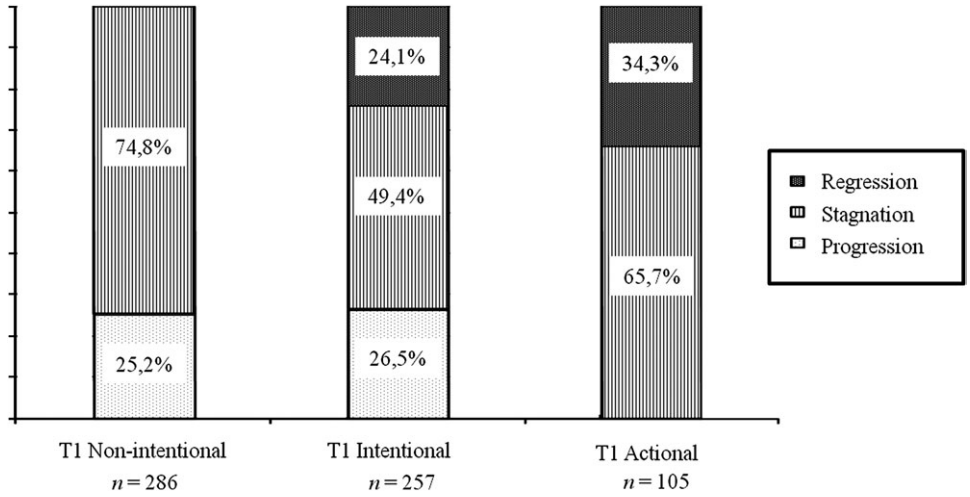

Fig. 1. Stage transition from Time 1 to Time 2.

simple change scores has the advantage that the change is put into perspective of the baseline level [45]. To calculate standardized residual change scores, regression analysis were used with the T1 scores being the independent variable and T2 scores the dependent variable.

Results

Preliminary results

Stage distribution at T1 and stage transitions at T2 are shown in Fig. 1.

At T1, the majority of the participants were in non-intentional stage (n = 286, 44.1%). Two hundred and fifty-seven individuals were identified in the intentional stage and 105 participants were identified in the action stage. Most participants remained in the same stage (n = 410, 63.3%), and more participants progressed (n = 140, 21.6%) than regressed (n = 98, 15.1%). Non-intenders at T1 were slightly less likely to progress than T1 intenders; and T1 actors were more likely to regress than T1 intenders.

Means and SD of baseline measurements separated for the three HAPA stages are shown in Table I. ANOVAs and Bonferroni *post hoc* tests revealed that actors were significantly more physically active than non-intenders and intenders ($P < 0.001$). Furthermore, non-intenders had significant lower positive outcome expectancies than intenders ($P < 0.001$) and actors ($P < 0.05$). Also, non-intenders reported lower motivational self-efficacy compared with intenders ($P < 0.001$). Mean differences across HAPA stages were significant regarding maintenance self-efficacy ($P < 0.05$) and planning ($P < 0.001$) with lowest means in non-intentional stage and highest in action stage.

Intercorrelations of standardized residual change scores for social-cognitive variables indicated exclusively positive and significant associations (see Table II, last section). Intercorrelations were also computed for the different categories used for discriminant function analyses (see Table II, section 1–4). None of the correlations exceeded r = 0.45, therefore, multicollinearity is not an issue here.

Discriminant function analyses

To test our hypotheses, discriminant function analyses were run to determine whether changes in social-cognitive variables discriminate between stage transition and remaining in the same stage. Four analyses were conducted separately: (i) stagnation versus progression in T1 non-intenders, (ii) regression versus stagnation in T1 intenders, (iii) stagnation versus progression in T1 intenders and (iv) regression

Table I. *Means, SDs and ANOVA results of baseline measures for non-intenders, intenders and actors*

	NI (n = 291) M (SD)	I (n = 263) M (SD)	A (n = 106) M (SD)	F
Physical activity (minutes per week)	72.55 (81.50)	79.43 (80.67)	231.25 (180.60)	101.15**
Outcome expectancies	5.16 (0.65)	5.41 (0.58)	5.35 (0.69)	11.37**
Motivational self-efficacy	4.77 (0.86)	5.16 (0.77)	4.96 (1.00)	14.20**
Maintenance self-efficacy	3.86 (1.08)	4.11 (1.08)	4.46 (1.11)	12.36**
Planning	3.33 (0.96)	3.62 (0.81)	4.16 (0.93)	33.86**

NI = Non-Intender, I = Intender, A = Actor. F statistics are reported. **$P < 0.01$. Bonferroni's test revealed no significant differences for outcome expectancies between I and A, for motivational self-efficacy between NI and A and between I and A. A significant difference ($P < 0.05$) was found for positive outcome expectancies between NI and A, for maintenance self-efficacy between NI and I and between I and A. All other differences were highly significant ($P < 0.01$).

Table II. *Intercorrelations of standardized residual change scores for each stage separately and in total*

Measure	Motivational self-efficacy	Maintenance self-efficacy	Planning
Non-intentional stage			
Outcome expectancies	0.21**	0.19**	0.19**
Motivational self-efficacy	—	0.44**	0.23**
Maintenance self-efficacy		—	0.45**
Intentional stage (stagnation and regression)			
Outcome expectancies	0.22**	0.14	0.22**
Motivational self-efficacy	—	0.36**	0.23**
Maintenance self-efficacy		—	0.30**
Intentional stage (stagnation and progression)			
Outcome expectancies	0.18**	0.12	0.19**
Motivational self-efficacy	—	0.23**	0.12
Maintenance self-efficacy		—	0.30**
Actional stage			
Outcome expectancies	0.02	0.11	−0.01
Motivational self-efficacy	—	0.27**	0.03
Maintenance self-efficacy		—	0.26**
Total			
Outcome expectancies	0.19**	0.17**	0.18**
Motivational self-efficacy		0.37**	0.20**
Maintenance self-efficacy			0.39**

**$P < 0.01$.

versus maintaining in T1 actors. Results of the discriminant function analyses are displayed in Table III.

For participants in the non-intentional stage at baseline, results indicated significant differences between those who stagnated versus those who progressed in motivational ($\lambda = 0.97$) and maintenance self-efficacy ($\lambda = 0.98$). Pairwise F-tests comparing progressors against static individuals indicated that stage progression was significantly associated with a positive change in motivational and maintenance self-efficacy. Effect sizes for these variables were small with both $\eta^2 = 0.02$.

Contrasting regressing versus remaining participants of the intentional stage at baseline, the function with planning as predictor significantly discriminated regressing from static ($\lambda = 0.98$). A negative change in planning was associated with

Table III. *Results of discriminant function analyses of the study variables*

Social-cognitive variables	*df*s	Regress mean	Static mean	Progress mean	Univariate *F*s
Progression from Non-intentional stage (n = 286)	(1, 284)				
Outcome expectancies			−0.10	0.04	1.13
Motivational self-efficacy			−0.09	0.23	7.09**
Maintenance self-efficacy			−0.11	0.16	4.52*
Planning			−0.05	0.11	1.21
Regression from Intentional stage (n = 189)	(1, 187)				
Outcome expectancies		−0.13	0.08		2.44
Motivational self-efficacy		−0.12	0.09		1.87
Maintenance self-efficacy		−0.20	0.04		2.27
Planning		−0.20	0.07		3.63*
Progression into Intentional stage (n = 195)	(1, 193)				
Outcome expectancies			0.08	0.09	0.00
Motivational self-efficacy			0.09	−0.05	0.91
Maintenance self-efficacy			0.04	0.31	3.67*
Planning			0.07	0.29	3.16*
Regression in Action stage (n = 105)	(1, 103)				
Outcome expectancies		0.05	0.24		1.03
Motivational self-efficacy		0.03	0.30		2.94*
Maintenance self-efficacy		−0.11	0.15		1.66
Planning		−0.23	0.01		1.59

**P < 0.01; *P < 0.10. Progression from non-intentional stage included n = 214 remaining and n = 72 progressed individuals; regression from intentional stage included n = 127 remaining and n = 62 regressed individuals; progression in intentional stage included n = 127 remaining and n = 68 progressed individuals and regression in action stage included n = 69 remaining and n = 36 regressed individuals.

regression into the non-intentional stage, whereas maintenance of the intentional stage was associated with a positive change in planning. The effect size was small with η^2 = 0.02. No other variable was correlated with stage regression versus stage maintenance.

Differentiating between remaining and progressing participants in the intentional stage at T1, there were significant differences in maintenance self-efficacy (λ = 0.98) and planning (λ = 0.98). The function with maintenance self-efficacy as predictor variable significantly discriminated remaining from progressing as well as the function with planning as predictor variable significantly discriminated both groups. A higher positive change in both variables was associated with stage progression. Effect sizes for these variables were small with both η^2 = 0.02.

Another significant difference was revealed for participants in action stage at T1 (λ = 0.97). Pairwise F-tests contrasting regressing with static individuals showed that stage regression was significantly associated with motivational self-efficacy with regressing individuals scoring significantly lower in change of motivational self-efficacy than static individuals. Effect size was small with η^2 = 0.03.

Post hoc analyses

We conducted independent t-tests to check whether stage transitions were actually reflected in physical activity changes (in total minutes per week) from T1 to T2. We expected that participants progressing from the intention stage would have larger increases in physical activity than T1 intenders remaining or regressing at T2. The results showed that remaining participants [M = 22.2, standard error (SE) = 6.2] had a similar change in physical activity as regressing participants (M = 26.5, SE = 9.6, t (187) = 0.39, P > 0.05) and as expected significantly lower changes compared with participants progressing from intentional to action stage (M = 98.3,

SE = 17.8, t (83.8) = −4.05, $P < 0.001$). Then, we assumed that regressing actors would show a decrease in their activity that differs meaningfully from rather moderate increases in maintaining actors. Our findings were in line with this assumption as well. Differences in T1 and T2 physical activity between maintaining actors (M = 53.7, SE = 20.8) and regressing actors (M = −44.9, SE = 17.2) were significant (t (103) = −3.2, $P < 0.005$). Furthermore, we expected no differences between stagnating non-intenders and non-intenders progressing to the intentional stage regarding their changes in physical activity but significant differences between stagnating non-intenders and non-intenders progressing to the action stage. We found, that on average, individuals stagnating in the non-intentional stage (M = 17.8, SE = 6.0) had as low an increase in physical activity as individuals progressing to the intentional stage (M = 22.6, SE = 16.3, t (265) = −0.33, $P > 0.05$) and a significantly lower increase than individuals progressing directly from non-intentional to the action stage (M = 94.7, SE = 21.5, t (231) = −3.62, $P < 0.001$). Finally, the *post hoc* analyses underscore that stage transitions came along with changes in physical activity.

Discussion

This study tested whether changes in social-cognitive variables are associated with stage transitions in the domain of physical activity. We have observed 660 adults at two measurement points in time at an average interval of 20 days. For this purpose, we have divided them into three groups at T1 in terms of their stages of change. In line with the HAPA, participants were categorized into the non-intentional, intentional and action stages, reflecting their motivational and behavioral status regarding physical activity.

Four of the assumptions were confirmed by the data: An increase in motivational self-efficacy was related to progression from non-intentional to intentional stage. Findings of previous studies examining the interplay of self-efficacy and exercise stage progression are in line with our results [28, 32, 33]. This study investigated the relationship between phase-specific self-efficacy and stage transition. Enhancing maintenance self-efficacy was correlated with progression from intentional to action stage. This specific association has not been investigated before but is comparable with findings from other studies [26, 27, 36]. As hypothesized, a drop in planning was associated with regression from intentional stage and an increase in planning was related to progression out of the intentional stage. The latter is consistent with findings from studies on stage transitions regarding dietary behavior [38] and dental flossing [10].

Few studies investigating transitions in the stages of the TTM identified pros as predictor of progression out of precontemplation stage [26, 27, 46]. Present results showed that changes in positive outcome expectancies were not associated with progression out of the non-intentional stage, which is equivalent to precontemplation stage of the TTM. However, in accordance with our hypothesis, outcome expectancy was also not related to any other stage movement. Instead, a change in maintenance self-efficacy unexpectedly emerged to be relevant when moving from non-intentional to subsequent stages. The assumption that a negative change in motivational self-efficacy goes along with regression from intentional stage to non-intentional was not supported. A decrease in the individuals' beliefs in their capabilities to successfully meet new or difficult demands seems to be irrelevant in this relapsing process. Rather, a lack of planning was of importance. Individuals who wanted to change but did not plan became less motivated over time. Regression from action to previous stages was neither correlated with a lack of planning nor decreasing maintenance self-efficacy as hypothesized but by declining motivational self-efficacy. Actually, this unexpected result might be most relevant for future research. If people are highly motivated and act according to the given physical activity criteria, they might either experience mastery or failure. When realizing their lack of success, they might doubt their competence and reduce their activity levels, moving them into previous stages of change. As a consequence, one might want to extend the present stages of change model by subdividing

the actors into 'initiating actors' and 'maintaining actors' [47].

Some limitations of the current study need to be pointed out. A first limitation was the high attrition rate, which is an unsolved problem in internet-based studies with voluntary participation and without financial compensation (for more detailed reasons cf., [48]). Attrition analyses revealed differences between participants who did not respond and those who responded to follow-up assessments, which might have affected the results. Second, the follow-up assessment took place on average 20 days after baseline measurements and might have been too short for observing stage transitions in some individuals. However, we assume that the consideration of possible individual barriers (e.g. vacations, illness) and aim difficulty are substantial advantages of self-imposed deadlines compared with fixed follow-up deadlines.

It also needs to be noted that an underestimation of the intervention effect might have occurred because of the possibility to set goals below the recommended minimum of 5 × 30 min of physical activity per week. For instance, participants in the non-intentional stage, who set a rather low goal during the intervention, may well have reached this goal by T2 but were still classified as remaining in the same stage if it was below this criterion. However, although this might be risky, we have decided to do so because empirical findings indicate that overvalued and unrealistic goals have negative effects on task performance [49].

Although a previously tested stage measure was used in the current study [18, 44], misclassification of individuals into the wrong stage cannot be ruled out [47] and might have affected the results. There is no placement into categories without the inherent risk of misclassification. As some difficulties with the measurement of maintenance self-efficacy cannot be ruled out further studies should consider a better operationalization of this stage-specific construct. Additionally, some participants might have shown progression due to the fact that completing the study was part of their strategy.

Our results help enlighten the process that regulates behavior change, providing information for evidence-based practice. Thus, to enhance the effectiveness of interventions promoting physical activity, one should take intentions and behavior of the participating individuals into account in order to ensure that only stage-specific needs, feelings and thoughts are targeted. That means, interventions should be matched to a person's stage: Individuals who are not yet motivated to be physically active might benefit from self-efficacy enhancement. Individuals who are motivated but not yet acting might be supported by stabilizing their intentions and by prompts to initiate behavior with the aid of concrete plans. Additionally, maintenance self-efficacy can help dispose them to act. To prevent actors from relapses and encourage the maintenance of physical activity, self-efficacy enhancement is recommended. Interventions should consider these stage-specific variables to facilitate successful stage progression and stage maintenance, respectively. Taking this into account, health educational interventions can become more effective by mainly working on specific mechanisms instead of providing generic interventions for all individuals at different stages. Future research should test this experimentally and with inclusion of objective behavioral data.

Conflict of interest statement

None declared.

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