

An Age-Tailored Intervention Sustains Physical Activity Changes in Older Adults: A Randomized Controlled Trial

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Abstract

Background A randomized controlled trial compared an age-tailored intervention to increase physical activity levels in older adults to an age-neutral intervention.

Purpose Both interventions communicated activity planning strategies and messages to improve self-efficacy. On top of this, the age-tailored intervention also included two lifespan components that targeted present orientation and emotional focus, and fostered strategies of selection, optimization, and compensation.

Method A total of 386 German older adults (aged 60–95 years) were randomized to receive either the age-tailored intervention (age-specific strategy training and short-term emotional focus) or the age-neutral intervention. Physical activity was measured by questionnaires at baseline (T1) and at 6-month (T2) and 12-month follow-ups (T3). Latent true change modeling was applied by creating latent change scores (T2–T1 and T3–T2).

Results After controlling for gender, age, and physical and mental health, allocation to the age-tailored intervention predicted a latent physical activity difference at T3–T2, but not at T2–T1.

Conclusion Compared to the age-neutral intervention, the age-tailored intervention led to superior maintenance of physical activity within these older adults.

Keywords Lifespan · Socioemotionalselectivity · Selection · Optimization · Compensation (SOC) · Intervention · Physical activity · Latent true change

Introduction

Despite a broad range of benefits (e.g., [1, 6, 23, 27, 41]) associated with regular physical activity, many older adults are not sufficiently active to enjoy these health benefits [8, 42]. Only 31.5 % of American adults aged 65 to 74 report regular leisure-time physical activity. Of those aged 75 and older, only 17.6 % participate in regular physical activity [38]. Thus, there is a need for effective interventions to change activity levels.

Lifespan concepts of selection, optimization, and compensation (SOC, [2]), as well as social-emotional selectivity (SST, [4]) might play key roles when trying to understand and modify health behaviors among older adults. The purpose of the present randomized controlled trial is to examine whether an age-tailored intervention that includes an age-specific coping strategy training based on the theory of selection, optimization, and compensation [2], and messages framed in terms of a present orientation and emotional focus [4], is superior to an age-neutral intervention that targets planning and self-efficacy only.

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Psychological Interventions to Foster Physical Activity in Older Adults

In a meta-analysis including 33,090 older adults from 43 studies, Conn et al. [9] found a small-to-medium mean effect size for comparisons of treatment groups versus control groups of $d=0.26$ across diverse studies designed to increase physical activity among older adults. In terms of mode of delivery, mail-delivered interventions had a number of advantages, including time effectiveness and flexibility, lower costs, and a larger reach [24]. Conn et al. [9] found mail-delivered interventions as effective as other modes of delivery. Marcus et al. [24] found at 6-month follow-up, that both telephone and mail interventions increased physical activity levels compared with controls; and at 12-month follow-up, the mail intervention generated a higher activity level than both telephone and control conditions. Results suggest that mail-delivered physical activity interventions may be a reasonable way to approach older adults.

Planning and self-efficacy interventions are often effective in changing physical activity in older adults [34, 35, 39]. Findings from $k=23$ experimental studies ($N=6,773$) on the impact of planning interventions on health behaviors showed a medium-to-large effect size [18] of $d=0.59$. A meta-analysis on the association between self-efficacy and physical activity identified a mean correlation of $r=0.35$ [36]. Although interventions designed to increase physical activity seem to be effective, the components of such interventions remain largely age-unspecific.

Interventions Tailored to Age

Health-behavior change interventions are frequently applied to older populations [39, 40], but often the contents are not tailored to the needs of older adults. It has been shown that lifespan constructs such as selection, optimization, and compensation [2] and socioemotional selectivity [4] can be useful for describing health-behavior change in older adults. As such, these constructs can be incorporated into models of health-behavior change (e.g., [45]).

In their theory of SOC, Baltes and Baltes [2] spell out four life-management strategies for pursuing and maintaining personally relevant goals, which can be seen as a key facet of successful aging [14]. The four life-management strategies entail: (a) elective selection (i.e., developing and committing to a hierarchy of personal goals), (b) optimization (i.e., engaging in goal-directed actions and means), (c) loss-based selection (i.e., changes in the goal or the goal system in response to loss), and (d) compensation (i.e., the acquisition and use of means in response to loss). One empirically supported assumption of the SOC theory is that as individuals grow older, they refine their knowledge of SOC strategies [13]. Further, the selection, optimization, and compensation

life-management strategies have been shown to be positively associated with physical activity in middle-aged ([31]) and older adults [43]. They may constitute a valuable theoretical backdrop for health-behavior change interventions [44].

With increasing age, goals that foster present-oriented and emotionally gratifying experiences in the here and now win relative priority over sets of long-term goals (positivity effect, [4, 5]). Therefore, it seems appropriate to incorporate such emotional preferences as intervention ingredients: for example, one could stimulate participants to reappraise exercise as an emotionally meaningful activity. Older adults might be willing to invest greater resources in emotionally meaningful goals and activities [45]. Older adults seem to prefer a representation of goals focused on the means (e.g., enjoying exercise) rather than on the associated outcomes (e.g., weight loss), as shown by Freund et al. [15]. In line with that, Gellert [17] found that expectations about the emotional benefits of exercising (e.g., enjoying exercise) were important in predicting intentions and physical exercise in older adults. That study also highlighted the importance of separating emotional and health-related outcome expectancies on a conceptual level, to enhance both theory development and health promotion. But despite their potential for changing physical activity, interventions that change emotional beliefs are scarce ([10, 17]).

As both SOC theory and socioemotional selectivity theory (SST) are lifespan theories that are applicable to adults of all ages, these theories make specific assumptions about individuals in different stages of the lifecycle. Thus, SOC and SST can be used as a backdrop for interventions tailored to older adults.

Aims

We examine the effects of an age-tailored intervention to promote physical activity in more or less active older adults who want to change or maintain their levels of physical activity. In a randomized controlled trial we analyze the latent change of activity levels over a period of 12 months. We compare an *age-neutral activity program* that aimed at enhancing planning and self-efficacy with an *age-tailored add-on intervention* (fostering present orientation and emotion focus and strategies of selection, optimization, and compensation). As the main intervention effect, we hypothesize that individuals who participate in the age-tailored intervention would benefit more in terms of their change in physical activity from baseline to the 6-month follow-up and from the 6-month follow-up to the 12-month follow-up, as opposed to those in the age-neutral intervention.

Method

Participants and Procedure

This randomized controlled trial aimed at fostering self-regulation and physical activity in $N=386$ older adults (mean age=66.6 years, $SD=4.8$ years; age range 60–95 years; 21 % ≥ 70 years) over a period of 12 months with three measurement points in time: at baseline (T1), 6 months (T2), and 12 months (T3) later. Inclusion criteria were being older than 59 years and not having a medical contraindication to perform physical activity. Participants were recruited via German newspaper announcements, and data collection started in June 2009. Ethical clearance was obtained from the ethics committee of the German Psychological Society. After sending back the informed consent form, participants were randomized into one of the two intervention conditions (the age-neutral condition or the age-tailored condition). An online random number generator was used to randomize participants to conditions.

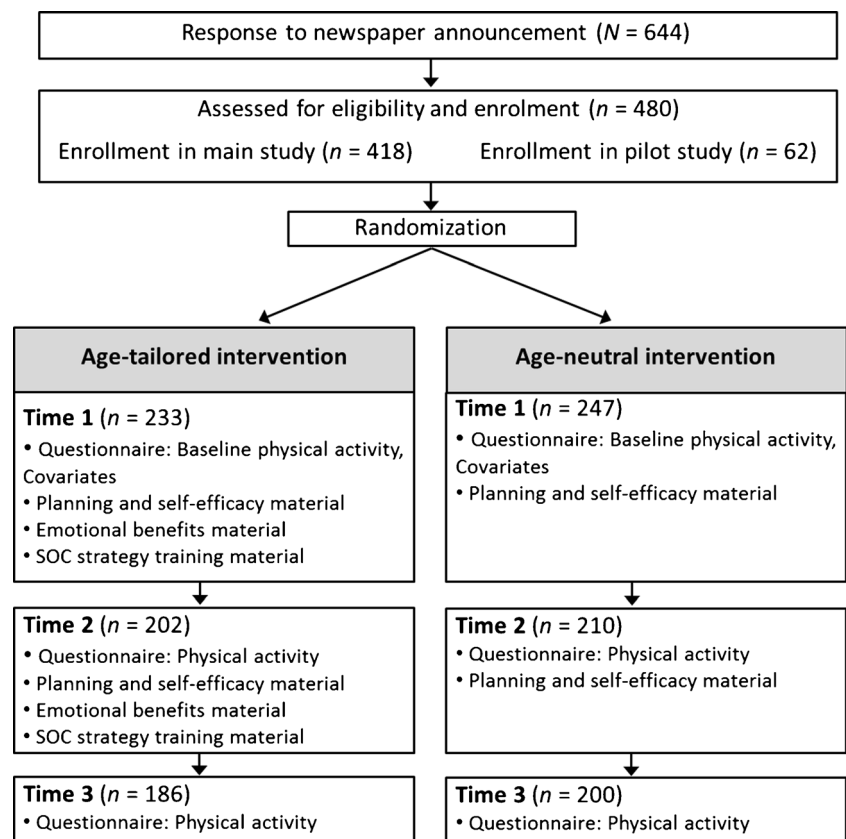
At baseline (T1), 480 participants completed the questionnaire and intervention material. Directly after completing the T1 (main intervention following T1) and T2 (booster following T2) questionnaires, participants were instructed to work on the respective intervention material (i.e., age-neutral versus age-tailored). The questionnaire given 6 months later (T2) was

completed by 412 participants (86 % of baseline). Finally, the T3 questionnaire given 12 months later was completed by 386 participants (81 % of baseline, see Fig. 1). The final longitudinal sample comprised 194 women and 192 men with a mean age of 66.6 years ($SD=4.3$) in the age-tailored condition and $M=66.7$ years ($SD=5.2$) in the age-neutral condition. The subjective physical ($M=49$) and mental health status ($M=53$) of the sample (SF-12, [3]) was comparable across intervention conditions and did not differ from population norms with a mean t value of $M=50$ ($SD=10$) in the 1998 general U.S. population. In the longitudinal sample, 66.1 % were married, 17.5 % were divorced, 10.8 % were widowed, and 5.6 % were single. In terms of education, 67.5 % had obtained a higher education entrance qualification, 23.1 % finished the 10th grade, and 8.0 % finished the 9th grade (1.4 % had another educational qualification). A total of 77 % of the participants were retired. The proportions of gender, marital status, education, and retirement did not differ significantly across the intervention conditions.

Intervention Conditions

Directly after completing the baseline questionnaire (T1), the participants received the intervention material via mail. At the T2 booster, intervention material was sent containing

Fig. 1 Flow chart of the intervention procedure. *Note.* A total of $n=386$ participants remained in the study until Time 3. Drop out at Time 3: age-tailored intervention ($n=186$; 80 % of 233), age-neutral intervention ($n=200$; 81 % of 247). All available information of all $n=480$ randomized participants were included in the subsequent analyses. Time 1=baseline, Time 2=6-month follow-up, Time 3=12-month follow-up



material similar to the material from T1. Measurement point T3, 12 months after baseline (T1), was the final follow-up assessment without intervention material. At T1 and T2, participants in both intervention conditions were sent the age-neutral intervention material consisting of the *planning* and *self-efficacy* prompting components. Additionally, participants in the age-tailored condition received an age-specific strategy training based on the selection, optimization, and compensation theory, and received material with present orientation and emotional focus to induce the reappraisal of exercise as an emotionally meaningful activity. All participants were also instructed to check the adequacy of their types and levels of physical activity with their physician.

The age-neutral intervention based on planning and self-efficacy Participants were requested to set a general physical activity goal with the categories “adopting”, “increasing”, or “maintaining” their current level of activity. To foster *action planning*, participants were prompted to generate up to three plans regarding when (e.g., every morning), where (e.g., in the forest), and how (e.g., walking) they wanted to implement their physical activity goal. Participants were encouraged to formulate when-, where-, and how-components as concrete, precise, and personal as possible. To better cope with relapse and critical situations, participants were also asked to write down up to three barriers and *coping plans* to overcome these barriers [34, 35]. At the T2 booster, participants were asked to adjust their former plans to their current situation. For coping planning, they were asked which plans they used and which plans had worked well.

In the *self-efficacy* part of the booklet, participants were asked to envision their former mastery experience in various life domains. At the T2 booster, only the planning-related self-efficacy part was again presented to the participants.

The age-tailored intervention: Emotional benefits and strategy training on top of planning and self-efficacy The age-tailored intervention condition consisted of (a) a strategy training that underscored age-specific demands and barriers to attaining and maintaining one’s activity goals based on the action theory of selection, optimization, and compensation [14], and (b) components from SST that highlighted the present-oriented and emotion-focused benefits of physical activity, which were designed to encourage participants to reappraise physical activity as an emotionally beneficial activity that is expected to be salient to older adults [4, 17].

Strategy training was done separately for the strategies of *selection* (*elective* and *loss-based*), *optimization*, and *compensation* [2]. Introducing these strategies in a first step, the intervention booklet prompted a list of general examples of

compensation strategy use showing how to perform physical exercise using this strategy (e.g., “Sometimes it is sufficient to execute the activity in a slightly different way: Should you be in pain, it helps to go walking instead of running”). Then participants were required to adapt one of the strategies to their own context and to write this down. Finally, they were asked to mentally simulate this strategy to memorize it. This procedure was also completed for the strategies of *elective selection* (integrating physical activity into the personal goal hierarchy, committing to an age-appropriate subset of activity goals), *optimization* (acquisition and investment of goal-relevant means), and *loss-based selection* (reformulation of activity goals after a loss, e.g., dealing with age decline). The T2 booster followed the T1 scheme, but provided new strategy examples.

For the present-orientation and emotion-focus components of SST [4], participants were asked to write down their long-term and short-term expectations of physical exercise outcomes. Additionally, they were asked to think about more immediate emotionally gratifying outcomes of being physically active and not only about long-term health benefits. Then, a list of possible emotional benefits was given, and participants had to judge which ones were important to them. Further, the social benefits of being physically active were highlighted so that participants were prompted to write down emotionally meaningful outcomes of physical exercise (e.g., being close to family members while exercising). The same components with new examples were provided with the T2 booster material.

Intervention engagement. The intervention booklets and questionnaires were mailed to the participants, and all materials were returned after completion using a self-addressed envelope. A copy that summarized the intervention content remained with the participants. At T1, only 8.5 % of the participants did not fill out the booklets (8.0 % at T2), implying that almost all participants were actively engaged in the intervention tasks. Intervention material-related nonadherence was not associated with any study variable, but only to study dropout, $t(478)=3.42$, $p<0.001$, which is likely due to the overlap of these concepts (adherence and dropout).

Measures

Physical activity as the *primary outcome measure* was assessed at baseline (T1) and at the 6-month (T2) and 12-month follow-ups (T3). Based on the PAQ-50+ (adopted from [22]), participants separately reported the frequency of physical exercise/sports and physical activity that had the goal of covering distances over the last 7 days (therefore, both scales ranged from 0 to 7). For physical exercise, participants were asked “Within the last 7 days, how often, on average, did you engage in sports/exercise

(e.g., swimming, ball games, running, walking, water sports)”; and for covering distances: “Within the last 7 days, how often, on average, did you engage in activities that had the goal of covering distances/transportation (e.g., walking or cycling to reach a destination or going shopping)?”

Physical and mental health were assessed at T1 with the SF-12 [3], a generic short-form measure of subjective physical and mental health status. The SF-12 Health Survey includes 12 questions from the SF-36 Health Survey (Version 1).

Age and gender were recorded to be included as covariates in the statistical model.

Auxiliary variables. A two-item physical activity Likert scale and a two-item behavioral-intentions scale [32] were included as saturated background correlates to decrease estimation bias that was due to participant attrition [19].

Analytical Procedure

In *true intraindividual change models*, Steyer et al. [37] presented an approach for modeling interindividual differences in intraindividual change. In these models, the true intraindividual change scores (i.e., the difference between two true score variables) between different occasions of measurement are the values of the latent variables (for recent applications of latent true change modeling, see: [16, 30]).

Applying this approach (see Fig. 3, “Results” section), by a reparametrization a three latent physical activity factor (T1, T2, T3) autoregressive model is decomposed into a baseline value (T1), a T2–T1 difference value, and a T3–T2 difference value. Once a model involving latent difference variables is formulated, the latent difference variables were treated as ordinary latent variables in a structural equation model. In our case, the latent physical activity difference variables served as endogenous variables to be explained by the intervention condition (dummy coded: 0=age-neutral, 1=age-tailored) variable and the covariates (gender, age, physical and mental health).

For parameter estimation, a nonparametric bootstrapping procedure [28] with 5,000 resamples was employed. Missing data (incomplete values = 11.4 %) were handled by the full information maximum likelihood algorithm. We employed bootstrapped unstandardized (*b*) and fully standardized parameter estimates. The models were evaluated based on the recommended fit indices using Mplus 5.21 ([26]–2007).

Indicator-specific effects that are often encountered in longitudinal research [11] were modeled by introducing an indicator-specific (method) factor for the second indicator (loadings on the indicator-specific factors were also assumed to be time invariant by fixing them to 1 at each time point).

Results

Intercorrelations and latent means are shown in Table 1. The manifest estimated means by intervention condition are displayed in Fig. 2.

Preliminary Results

Attrition analyses yielded no baseline differences between participants in the longitudinal sample and those who dropped out in terms of gender, marital status, education level, physical, and mental health status. But a selective dropout occurred for baseline physical activity for covering distances, $t(472)=-2.35$, $p=0.02$, and baseline physical exercise, $t(473)=-2.29$, $p=0.02$. Participants who dropped out (14 % over 1 year) had lower baseline values than those who remained in the longitudinal sample, with a difference corresponding to a small-to-medium effect size ($d=-0.28$ for baseline physical activity for covering distances; $d=-0.26$ for baseline physical exercise).

A *randomization check* was performed using a MANOVA to examine the success of the randomization procedure. The intervention condition (0=age-neutral: planning and self-efficacy only, 1=age-tailored: emotional benefits and strategy training) served as the independent variable, whereas the dependent variables were age, physical and mental health status (SF-12), and physical activity (for covering distances and for exercise) at baseline. The multivariate test, $F(5, 368)=0.49$, $p=0.78$, $\eta^2=0.01$, and all post hoc tests were nonsignificant, indicating that the randomization was successful. Furthermore, these results show that before participants were randomized to the conditions, they were equal in terms of their levels of exercise and activities with the goal of covering distances.

The *reliability coefficients* (sum of squared loadings) were between 0.51 and 0.74 for all indicators. The standardized factor loadings of the first indicator “exercise” ranged between 0.80 and 0.86. For the second indicator “covering distances” the loadings on the state factor ranged only between 0.22 and 0.23, whereas their more substantial loadings on the indicator-specific factor ranged between 0.68 and 0.73. Thus, there is only weak statistical overlap between the two facets of physical activity, namely physical exercise and covering distances, indicating their distinctness. Nevertheless, the facets covaried to a reasonable extent and jointly created stable latent factors. Therefore, both were modeled: homogeneity by the latent factors, but also heterogeneity of the indicators given by the indicator-specific factor (method factor).

Table 1 Estimated means, intercorrelations, variances, and covariances for manifest variables and latent variables

	1	2	3	4	5	6	7	8	9	10	11
1 Physical activity T1	<i>2.84</i>	1.79	1.92	−1.05	0.13	0.08	0.00 ^a	0.03	0.42	2.11	1.38
2 Physical activity T2	0.60***	<i>3.18</i>	2.43	1.39	−0.75	−0.02	−0.06	−0.03	−0.13	0.13	1.63
3 Physical activity T3	0.67***	0.81***	<i>2.86</i>	0.52	0.42	0.02	0.07	−0.01	−0.39	1.11	1.93
4 Difference T2−T1	−0.40***	0.50***	0.20***	<i>2.43</i>	−0.87	−0.09	−0.06	−0.06	−0.54	−1.98	0.25
5 Difference T3−T2	0.07	−0.39***	0.23***	−0.52***	<i>1.17</i>	0.04	0.12	0.02	−0.26	0.98	0.30
6. Indicator-specific factor	0.03	−0.01	0.01	0.04	0.00	2.78	0.04	0.14	0.58	0.53	−0.03
7 Group	0.00	−0.06	0.08	−0.07	0.23***	0.04	0.25	0.00 ^a	0.00 ^a	0.00 ^a	0.00 ^a
8 Gender ^b	0.03	−0.04	−0.02	−0.08*	0.04	0.17***	0.00 ^a	0.25	0.04	−0.74	−0.60
9 Age	0.05	−0.01	−0.05	−0.07	−0.05	0.07	0.00 ^a	0.00	25.31	−8.49	−1.76
10 Physical health	0.15**	−0.01	0.08	−0.15**	0.11*	0.04	0.00 ^a	−0.18***	−0.20**	69.75	−2.17
11 Mental health	0.09	0.10	0.13*	0.02	0.03	−0.02	0.00 ^a	−0.14**	−0.04	−0.03	79.55
Mean	2.41	2.30	2.58	−0.10	0.28	0.00	−	−	66.6	48.87	52.64

N=386. Intercorrelations (with levels of significance: **p*<0.05, ***p*<0.01, ****p*<0.001; two-tailed) are presented below the diagonal, covariances are presented above the diagonal, and variances are presented within the diagonal and in italics

T1 Time 1, T2 Time 2, T3 Time 3

^a Fixed estimates

^b Gender is coded 0=men, 1=women

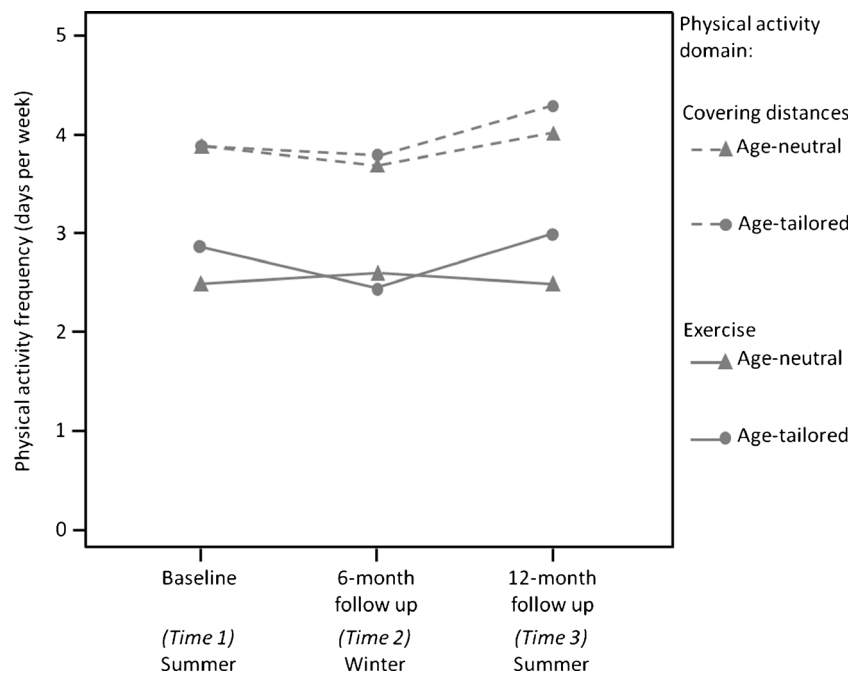
Main Results

Figure 3 displays the bootstrapped unstandardized parameter estimates (*b*) and level of significance. For bootstrapped fully standardized parameter estimates (shown in bold and in brackets, see Fig. 3), Mplus does not provide standard errors and level of significance. The hypothesized model fit the data well, RMSEA=0.01 (90 % CI=0.00, 0.04), SRMR=0.02, CFI=0.99, TLI=0.99, $\chi^2(24)=26.01$, *p*=0.35, AIC=21232,

BIC=21453. A preliminary latent change model without covariates or the intervention condition variable, portraying only physical activity change over time, also fit the data well, RMSEA=0.03 (90 % CI=0.00, 0.06), SRMR=0.03, CFI=0.99, TLI=0.99, $\chi^2(9)=12.60$, *p*=0.18, $\chi^2/df=0.70$, AIC=10,238, BIC=10,313).

Changes in physical activity over time for the manifest indicator levels (covering distances and physical exercise) are shown in Fig. 2: In the age-tailored intervention, the

Fig. 2 Manifest indicator means by intervention condition



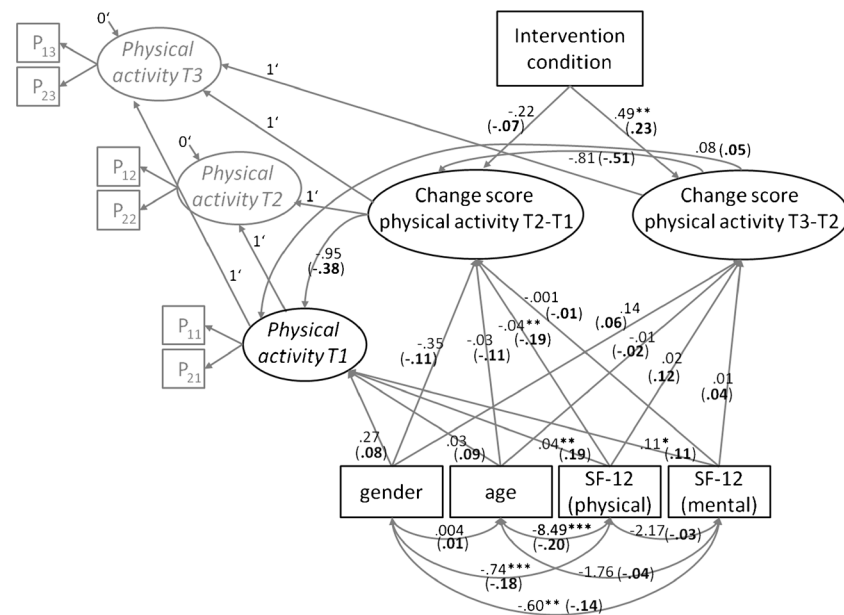


Fig. 3 Latent true change of physical activity. *Note.* T1=Time 1; T2=Time 2; T3=Time 3. Reformulation of a latent state model (Physical activity T1, T2, T3; shown in *italics*) as a latent change model (neighbor-change-score model: Physical activity T1, change T2–T1, change T3–T2). The T2 physical activity state factor is perfectly determined by physical activity at T1 and change from T1 to T2 and thus has no residual term; the T3 physical activity state factor is also perfectly determined by physical activity at T1, the change from T1 to T2, and the change from T2 to T3. Bootstrapped unstandardized parameter estimates (*b*) and level of significance ($*p<0.05$, $**p<0.01$, $***p<0.001$) are displayed. For bootstrapped fully standardized parameter estimates (shown in *bold* and in *brackets*), Mplus

does not provide standard errors and level of significance. To simplify the figure, the indicator-specific factor and auxiliary variables were not drawn. Fixed parameters are marked with a prime ('). P_{ij} denotes the i th observed variable (1=physical exercise, 2=physical activity for covering distances) on occasion j (1=T1, 2=T2, 3=T3). T1=baseline, T2=6-month follow-up, T3=12-month follow-up. The intervention condition variable was coded: 0=planning and self-efficacy only condition 1=additional emotional benefits and strategy training condition. All correlations between the intervention condition and variables measured at baseline were set to zero (fixed parameter)

manifest mean level of physical exercise at baseline was $M=2.58$ days per week ($SD=2.01$; T2: $M=2.26$, $SD=2.10$; T3: $M=2.74$, $SD=2.21$), whereas for the age-neutral intervention, physical exercise at T1 was $M=2.27$ ($SD=1.93$; T2: $M=2.38$, $SD=2.03$; T3: $M=2.37$, $SD=2.01$). For covering distances (second manifest indicator of physical activity), the mean level at T1 was $M=3.86$ ($SD=2.31$; T2: $M=3.73$, $SD=2.47$; T3: $M=4.19$, $SD=2.24$) for the age-tailored condition, and at T1, it was $M=3.64$ ($SD=2.32$; T2: $M=3.62$, $SD=2.48$; T3: $M=3.91$, $SD=2.32$) for the age-neutral intervention. Looking at the latent change scores in the primary model, there was a small but nonsignificant decrease in the latent mean from T1 to T2 ($M=-0.10$, $p=0.36$). But for the estimated mean level change from T2 to T3, a significant increase was observed ($M=0.27$, $p=0.01$).

Looking at the *intervention effects*, within the initial phase of the intervention from baseline until the 6-month follow-up, the intervention condition (0=age-neutral, planning and self-efficacy only; 1=age-tailored, emotional benefits and strategy training) did not significantly predict the physical activity difference score, T2–T1 ($b=-0.22$, $p=0.21$). Subsequently, for the second phase, the intervention condition significantly predicted the latent difference score, T3–T2, indicating that individuals in the age-tailored group had

experienced a stronger increase from the 6-month follow-up to the 12-month follow-up, as opposed to individuals in the age-neutral condition ($b=0.49$, $p=0.01$). The mean difference in physical exercise at T3 ($d=0.18$) and in physical activity for covering distances at T3 ($d=0.12$) between the age-tailored intervention condition and the age-neutral condition corresponded to a small effect size.

There were only a few associations between the physical activity variables and the present *set of covariates*. Mainly, subjective physical ($b=0.04$, $p=0.01$) and subjective mental health status ($b=0.11$, $p=0.05$) were related to baseline activity at T1. Subjective physical health was also significantly related to activity change from T1 to T2 ($b=-0.04$, $p=0.01$). These results demonstrate that individuals starting at a higher level of past behavior (physical activity T1) were physically and mentally fitter (according to their self-rated health status) compared to individuals with lower baseline activity.

Relations between baseline and change are represented by the correlation of the latent physical activity T1 factor and the latent change scores in the model. Differences in baseline levels between individuals did not result in different strengths of change in physical activity either from T1 to T2 ($cov=0.08$, $p=0.67$) or from T2 to T3 ($cov=-0.95$, $p=0.36$).

Discussion

An age-neutral condition (communicating activity planning strategies and messages to improve self-efficacy) to promote physical activity in older adults was compared with an age-tailored intervention (including two additional lifespan theoretical components that affected (a) present orientation and emotional focus and (b) fostered strategies of selection, optimization, and compensation) within an experimental design over a 12-month period. Latent true change modeling was applied to reflect changes in physical activity.

Intervention Effect

In terms of the *intervention effect* (age-tailored versus age-neutral interventions), there was no change from baseline to 6 months later. However, from 6 months (T2) to 12 months (T3) after baseline (T1), there was a significant effect of the intervention condition of $b=0.49$ ($p=0.01$) on the latent activity change, indicating that individuals in the age-tailored condition were superior in changing their activity, compared to controls (age-neutral condition). The mean difference in physical exercise at T3 ($d=0.18$) and in physical activity for covering distances at T3 ($d=0.09$) between the age-tailored intervention and the age-neutral control corresponded to only a small effect size, but this implies that the age-tailored components had an additional effect above and beyond the combined planning and self-efficacy components. Conn et al. [9] found in a meta-analysis of 43 studies on physical activity in older adults an effect size for comparisons of mail-delivered treatments versus passive controls of $d=0.26$ which is not directly comparable to the effect sizes found in the present study. We had no passive control group, but rather tested the age-tailored intervention condition against an active comparison condition, which focused on self-efficacy and planning. The latter are well-established and frequently administered treatment ingredients that have been found effective [18, 36]. In an observational study, Reuter et al. [30] found effects of planning and self-efficacy (which were the basic components in both conditions) on physical activity within a latent true change model with two measurement occasions (T2–T1) of $\beta=0.40$ for self-efficacy and $\beta=0.14$ for planning (total effects). In a nonexperimental intervention design [29] also observed evidence for the dynamic interplay between latent changes in health cognitions and health behavior. Phase-specific health cognitions facilitated the adoption as well as the maintenance of behavior change.

Changes in Physical Activity Over Time

Looking for *changes in physical activity over time*, there was no significant change (increase or decrease) of the level of

physical activity from baseline to the 6-month follow-up for the total sample (for both intervention conditions). This could be largely due to the fact that baseline behavior was measured in the month of June (T1), whereas the 6-month follow-up was in January (T2). Again, for the whole sample, from winter (January, T2) to summer (June, T3), there was an increase in activity. Chan et al. [7] demonstrated that mean daily temperature, rainfall, and snowfall accounted for 1–20 % of the variance in daily pedometer counts, depending in part on the individual's motivation to exercise and perception of the environment. Health recommendations should underline the importance of maintaining physical activity during adverse environmental conditions by adapting clothing, modifying behavior, and exploiting any available air-conditioned indoor facilities [33]. For the exercise indicator, the age-tailored group decreased their exercise level in the winter term as compared to the age-neutral group, which remained stable over the one year period. This might be due to potential effects of over adaptation as result of the SOC strategy training components, as outlined in Freund and Baltes [14]. The selection (S) training might stimulate participants to set avoidance goals for risky exercises in the winter term (tackling the risk of falling in old age), whereas the compensation (C) training might not have resulted in plans to fully compensate the avoidance of risky situations by replacing risky outdoor activities with indoor activities for instance. It might have come to an “over selection effect” without sufficient compensation [13]. Future research has to look into possibilities of avoidance of potentially maladaptive instantiations of SOC in more detail.

The studies on promoting physical activity reported by Conn et al. [9] were also delivered to older adults, but our study includes additional features that are supposed to make a unique contribution. The present study not only employed an active control group with competitive ingredients, but it was also explicitly based upon leading lifespan theories. First, the age-specific coping strategy training was based on the theory of selection, optimization, and compensation [2]. Second, the messages framed in terms of a present orientation and emotional focus were based on socioemotional selectivity theory [4]. The critical research question was whether these age-specific add-ons would strengthen the treatment that was initially generated with more common planning and self-efficacy components, that were also included in the active control condition. Another study combining planning with strategy use in 86 older women who received a telephone-based treatment yielded an interaction between planning and strategy use on long-term adherence to exercise [12].

Limitations

Some limitations need to be addressed. The attrition analysis revealed a selective dropout in terms of baseline physical activity indicators. But as only 14 % of the participants dropped out across a period of 1 year, the effect of the selective dropout in creating an estimation bias was reduced strongly. Nevertheless—and despite the use of state-of-the-art methods to compensate for missingness (i.e., full information maximum likelihood and background missing data correlates [20])—the generalizability of the results from the sample to the population is somewhat restricted, not only because of the study dropout per se, but mainly because the baseline sample was already highly preselected with regard to educational, health, and physical activity status. Both factors—the selective drop out of less active people and the preselection bias—may indicate that both interventions were less suitable for sedentary adults than for active ones. In a systematic review of physical activity interventions by Greaves et al. [21], analyses provided mixed evidence as to whether targeting interventions at people who are more sedentary was associated with larger increases in the amount of physical activity (two analyses of medium quality: one positive, one negative), three low-quality analyses (two negative, one trend). In the present intervention, we mainly targeted motivated adults fostering their self-regulatory strategies, but encouraging sedentary older adults would be a challenge for future interventions. Although the validity of self-reports appears to be satisfactory (e.g., [25]), supplementation by more objective measures of physical activity is desirable (e.g., using pedometers or accelerometers). Furthermore, there is also a need to identify the most active mechanisms via mediation analyses (e.g., via strategy use and beliefs about emotional benefits of physical activity). Beyond the measurement of mediators, also a detailed process analysis might provide a better comprehension, which intervention components were most effective or which ones were difficult to understand. Within the population of older adults, the sample was relatively young and healthy. Therefore, it remains unclear whether such effects can be replicated within other populations. Future research should be extended to inactive high-risk populations or frail people.

Conclusions and Outlook

Latent true change modeling was applied to model changes in physical activity across time. The experimental condition predicted the latent physical activity difference at T3–T2 but not T2–T1. The age-tailored intervention was superior in sustaining physical activity in older adults than the age-neutral intervention.

Future studies might evaluate single intervention components as we examined only combinations of different sets of

intervention components (planning and self-efficacy versus planning, self-efficacy, emotion focus/appraisal of emotional benefits of exercise, and selection, optimization, and compensation strategies). Also, the test against a passive control condition could yield further insights into the effectiveness of the intervention components as we had only an active self-efficacy and planning control condition. Another alternative in future studies might be using more intense delivery modes such as interactive training workshops including provision of feedback to adjust the individual strategies. In a meta-analysis of physical activity interventions among older adults, Conn et al. [9] found that interventions that used intense contact between interventionists and participants and those that were delivered in groups resulted in increased effect sizes, compared to other modes of delivery. The application of the age-tailored intervention components in different populations, using different modes of delivery or different health behaviors, would be a next step.

In the present study, an age-tailored intervention, based on lifespan theory, led to greater changes in physical activity than an age-neutral intervention. As there is a need for effective interventions to change physical activity and other health behaviors, particularly in old age, it might be fruitful to design more interventions in a lifespan-theory-based and age-sensitive manner for this target population.

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