Health Psychology

ISSN: 0278-6133

2021, Vol. 40, No. 3, 166–177
https://doi.org/10.1037/hea0001060

Psychological Mediators of Exercise Adherence Among Older Adults in a Group-Based Randomized Trial

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Objective: To examine the psychological mediators of exercise adherence among older adults in a group-based physical activity randomized controlled trial. ***Method*:** Older adults (≥65 years) were randomized to one of three conditions as part of the "GrOup-based physical Activity for oLder adults" (GOAL) randomized controlled trial. These included similar age same gender (SASG) and similar age mixed gender (SAMG) exercise programs that were informed by the tenets of self-categorization theory, and a "standard" mixed age mixed gender (MAMG) exercise program. Participants represented a subgroup (n = 483, M_{age} = 71.41 years) from the larger trial (n = 627) who completed measures of the trial's putative psychological mediators (i.e., group cohesion and affective attitudes) over the course of the 24-week exercise programs. ***Results:*** Piecewise latent growth modeling revealed different trajectories between participants in the two intervention conditions (SASG, SAMG) when compared with the comparison MAMG condition with regard to perceptions of group cohesion and affective attitudes. Results of subsequent cross-lagged panel modeling revealed that better program adherence in the two intervention conditions, when compared with the referent MAMG condition, was mediated by perceptions of group cohesion. ***Conclusions:*** The findings provide insight into how the two intervention programs differentially strengthened perceptions of group cohesion and affective attitudes over time. Consistent with self-categorization theory, the results also shed light on the role of group cohesion, in particular, as a psychological mechanism of action to promote older adults' exercise adherence behaviors.

Keywords: physical activity, older adults, self-categorization theory, group dynamics, intervention

Supplemental materials: https://doi.org/10.1037/hea0001060.supp

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Funding for this research was provided by the Canadian Institutes of Health Research (Grant MOP-125911). The trial was pre-registered with clinicaltrials.gov (Identifier: NCT02023632).

Mark R. Beauchamp served as lead for conceptualization, data curation, funding acquisition, investigation, methodology, project administration, supervision, writing—original draft and writing—review and editing, contributed equally to resources and served in a supporting role for formal analysis. Yan Liu served as lead for formal analysis, methodology and software, contributed equally to visualization and served in a supporting role for writing—review and editing. William L. Dunlop served in a supporting role for writing—review and editing. Geralyn R. Ruissen served in a supporting role for writing—review and editing. Toni Schmader served in a supporting role for writing—review and editing. Samantha M. Harden contributed equally to resources and served in a supporting role for writing—review and editing. Svenja A. Wolf contributed equally to resources and served in a supporting role for writing—review and editing. Eli Puterman served in a supporting role for writing—review and editing. A. William Sheel served in a supporting role for writing—review and editing. Ryan E. Rhodes served in a supporting role for writing—review and editing.

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In light of global prevalence of physical inactivity (Guthold et al., 2018) as well as the concomitant physical and mental health benefits of regular activity (Rhodes et al., 2017) considerable attention has been directed in recent years to develop, implement, and scale up interventions with different populations (Ding et al., 2020; Reis et al., 2016). At particular risk of inactivity are older adults, who across the globe represent the least active age-cohort (Hallal et al., 2012). In recent years, several narrative and systematic reviews (Devereux-Fitzgerald et al., 2016; Farrance et al., 2016; de Lacy-Vawdon et al., 2018; McPhee et al., 2016) as well as a review of systematic reviews (Olanrewaju et al., 2016) have highlighted the utility of group-based interventions/programs as a means of supporting older adults' sustained involvement in health-enhancing physical activity.

The utility of group-based programs for supporting older adults' physical activity behavior is well established. The mechanisms (i.e., mediators) through which group-based health-promotion interventions lead to behavior change, however, are not fully understood (Borek et al., 2019). This limitation is not restricted to group-based physical activity interventions among older adults, but reflects an overriding and pervasive restriction of the broader preventive medicine literature (Rhodes & Pfaeffli, 2010). Nevertheless, there has been a greater uptake and implementation in recent years of physical activity intervention studies that have conducted formal tests of mediation (Murray et al., 2018; Rhodes et al., 2020; Teixeira et al., 2015); although it also should be noted that the overwhelming majority of these studies have involved younger and middle-aged adults (Rhodes et al., 2020). The knowledge gleaned from conducting mediation analyses can help to understand the *mechanisms of action* that contribute to the success of a given intervention (Cerin & Mackinnon, 2009; Papandonatos et al., 2012), and as such can provide invaluable information to better support subsequent intervention design and delivery.

The Present Study

The current study sought to examine putative psychological mediators of physical activity adherence behavior among older adults in the context of the GrOup-based physical Activity for oLder adults (GOAL) randomized controlled trial (Beauchamp et al., 2015). The GOAL trial was a three-arm parallel randomized controlled trial (RCT) wherein older adult participants (n = 627; aged ≥65 years) were randomized to exercise within similar age same gender (SASG), similar age mixed gender (SAMG), or "standard" mixed age mixed gender (MAMG) exercise group conditions (see Method for details). The SASG and SAMG conditions were informed by the tenets of self-categorization theory (Haslam et al., 2018; Turner, 1985; Turner et al., 1987, 1994) that, broadly speaking, posits that people will tend to feel more socially connected to others whom they perceive to be similar to themselves on the basis of salient characteristics. Building on the findings of prior observational research (Beauchamp et al., 2007; Dunlop & Beauchamp, 2011, 2012, 2013); the GOAL trial provided an opportunity to experimentally test whether intragroup similarity on the basis of age and/or gender was related to improved exercise adherence, when compared with a typical group exercise program that was made up of men and women from across the age spectrum (MAMG). The classes in both experimental conditions (SASG, SAMG) were led by older adult instructors, which in the SASG condition were also matched by gender. The experimental conditions were further underpinned by self-categorization theory by providing program t-shirts to foster a sense of distinctiveness, as well as opportunities to socially connect after the classes had ended.

The primary outcome for the trial corresponded to participants' exercise adherence behaviors, which were assessed via objective measures (via swipe card technology) over the course of the 24-week exercise programs. The results revealed that older adults randomized to the SAMG (d = .47, $p < .001$) and SASG (d = .29, p = .016) conditions displayed improved adherence than those in the MAMG comparison condition (Beauchamp et al., 2018). There were no significant differences between the SAMG and SASG conditions, and across all three conditions the effects were directly comparable for men and women (Beauchamp et al., 2018). These findings suggest that when older adults exercise in the company of other older adults, are instructed by other older adults, and receive additional supports designed to foster a sense of togetherness (e.g., program t-shirts), their adherence behavior tends to be superior to that of older adults who exercise in standard exercise classes.

Nevertheless, it remains largely unknown *why* older adults adhered to a greater extent in those group-based programs informed by self-categorization theory. That is, what were the mediating mechanisms that explained these intervention effects? Group cohesion and affective attitudes were the a priori theoretical mediators that were examined in the GOAL trial (see Beauchamp et al., 2015). As highlighted by Carron and colleagues (1998), group cohesion is "a dynamic process that is reflected in the tendency for a group to stick together and remain united in the pursuit of its instrumental objectives and/or for the satisfaction of member affective needs" (p. 213), and includes both task-related and social components. Task cohesion relates to members' attraction to, and unity in relation toward the group's instrumental objectives, which in the physical activity domain typically involves the exercise activities embedded within the class. Social cohesion is concerned with members' attraction to, and unity toward, the group's social activities. Group cohesion within physical activity groups has consistently been found to positively relate to participant exercise adherence behaviors (Burke et al., 2008), and is malleable through intervention (Harden et al., 2015; Lee et al., 2012). From a self-categorization theory perspective, when a sense of "we" or "us" is developed through intervention, this results in enhanced group cohesion, and (in physical activity settings) subsequent affiliative behaviors in the form of improved adherence (Beauchamp & O'Rourke, 2020). In a recent conceptual review that examined "mechanisms of action" in group-based health behavior interventions, Borek and colleagues (2019) highlighted that "change may be facilitated through social identification with others who are perceived as belonging to similar social groups or categories" and that such "identification may contribute to development of group cohesion and attractiveness (i.e., bonds that members have with the group and each other). Stronger cohesion and perception of attractiveness of the group to its members (e.g., that it fulfils their needs and goals) can affect members wanting to belong to, and remain in, the group" (p. 237). In short, group cohesion represents a theoretically (vis-à-vis self-categorization theory) and empirically supported variable that might explain how group-based interventions (designed to foster social connectivity) can bolster participant adherence behaviors over time.

As for the trial's second theoretical mediator variable, affective attitudes correspond to how enjoyable (or unenjoyable) an activity is perceived to be (Lawton et al., 2009). Across settings, an extensive body of research in social psychology that has found the level of affect (enjoyment) experienced by a person in a particular context predicts the extent to which people choose to experience that context in the future (Emmons & Diener, 1986). A recent meta-analysis of intervention studies that sought to target participants' affective evaluations related to physical activity revealed that those programs (a) derived changes in affective attitudes, and (b) in so doing also produced concomitant improvements in physical activity behavior (Rhodes et al., 2019). With regard to the capacity of the two intervention programs to bolster affective experiences, Schmader and Sedikides (2018) suggest that when people feel that their identity "fits" (i.e., matches or is supported by others in) the environment, they feel positive affect and authenticity that motivates their return to that context. In the GOAL trial we hypothesized that the covariance of the assigned conditions (SASG, SAMG, and MAMG) on adherence would be mediated by older adults' perceptions of group cohesion as well as their affective attitudes (see Beauchamp et al., 2015; for pretrial articulation of this hypothesis, along with an extended discussion of the theoretical bases). Specifically, in light of the higher levels of adherence in the two experimental conditions (SAMG, SASG) relative to the comparison MAMG condition (with no significant differences between the SASG and SAMG conditions; Beauchamp et al., 2018), we expected that improvements in adherence in the two experimental conditions would be mediated by participants' perceptions of cohesion as well as their affective attitudes.

Method

Recruitment and Inclusion Criteria

The study procedures were approved by the behavioral research ethics board at The University of British Columbia, and preregistered at clinicaltrials.gov, with the design, conduct, and reporting of this study adhering to the Consolidated Standards of Reporting Trials (CONSORT) guidelines (Moher et al., 2010). Participants were recruited via advertisements that were placed through multiple outlets (e.g., local media, recreation centers, health care centers, hospitals, physician general practices, and online interest sites) in the Lower Mainland of British Columbia. Participants were eligible if they were 65 years of age or older and did not have any medical contraindication preventing them from engaging in moderate-to-vigorous physical activity. For full details related to the design and conduct of the GOAL trial, including a priori sample size calculations, randomization procedures, recruitment methods, and inclusion criteria see Beauchamp et al. (2015, 2018).

Sample Description

Participants in this study represent a subgroup of those from the larger trial (Beauchamp et al., 2018) aged 65–90 (M_{age} = 71.41 years, SD = 5.46, 71.80% female) who completed measures of the trial's putative mediators, namely affective attitudes and/or group cohesion. Overall, 483 of the total 627 participants (77.03%) completed at least one assessment of cohesion or affective attitudes. There were no significant differences in either the age or gender composition of participants in this study relative to the proportions in the larger study; $F(1, 551) = .06$, $p = .810$ for age, and $\chi^2(1) = .61$, $p = .434$ for gender. Participant demographic information relevant to this study is presented in Online Supplemental Materials Table S1. A description of the detailed demographic characteristics of the entire trial sample (n = 627) is published elsewhere (Beauchamp et al., 2018). In addition, and of direct relevant to the current study, there were no differences at baseline (i.e., before randomization) in self-reported physical activity between the three conditions (p = .563) or between men and women (p = .148) within the full trial sample (as reported in Beauchamp et al., 2018).

Intervention Arms

The GOAL trial was a three-arm parallel randomized controlled trial (RCT) conducted in partnership with the YMCA (Young Men's Christian Association) in Greater Vancouver, Canada, between March 2014 and August 2015. The trial was delivered via two cohorts, in which group-based exercise classes ran between the beginning of March and end of August in 2014 and 2015; respectively, with programs running for 24 weeks in total. Participants were randomized to SASG, SAMG, or MAMG conditions, with the former two representing the study's experimental conditions, and the MAMG condition representing a comparison "control" condition that was designed to reflect a typical group-based exercise program. In the MAMG condition, classes were led by professional instructors provided by the YMCA and included adults across the age spectrum (i.e., classes were not restricted to only include older adults). Instructors in the experimental conditions were older-adult volunteers, who were provided with extensive training (up to 45 hr) to deliver moderate-intensity physical activity classes that included exercises designed to target strength, agility, balance, as well as aerobic function (see Beauchamp et al., 2015, 2018). Classes in each condition were offered three times per week (lasting 50–60 mins in duration) for the duration of the 24-week programs. In the SASG condition instructors were matched on the basis of gender to the gender composition of the applicable group. In addition, participants in the two experimental conditions were provided with program t-shirts that were designed to foster a sense of group identity, and were also provided with opportunities to socialize and connect after the classes had ended (e.g., coffee and other refreshments).

Timelines for Assessments

Demographic data were collected at baseline before randomization. The trial's primary outcome measure was assessed in real time, based on electronic attendance records of participants within the respective exercise programs (see Measures described below). Assessments of the trial's putative mediator variables (i.e., cohesion and affective attitudes) were conducted at Weeks 2, 7, 12, 14, 19, and 24 over the course of the respective exercise programs.

Measures

Physical Activity Class Adherence

The primary outcome measure for the trial corresponded to objective measures of class attendance over the course of the

program that were derived from reports generated by the use of participants' electronic access cards (providing date and time stamped data related to program attendance). We also collected data on participants' self-reported involvement in physical activity at baseline using the Godin Leisure Time Exercise Questionnaire (LTEQ; Godin, 2011).

Cohesion

Exercise class cohesion was assessed using the Physical Activity Group Environment Questionnaire (PAGEQ; Estabrooks & Carron, 2000). The PAGEQ is a 21-item self-report questionnaire designed to assess four dimensions of cohesion within exercise classes; namely, attraction to the group's task (ATG-T), and social (ATG-S) activities, as well as perceptions of group integration around the group's task (GI-T), and social (GI-S) activities. Responses are anchored on a 9-point scale, with exemplar items including "I enjoy my social interactions within this physical activity group" (ATG-S), "I like the amount of physical activity I get in this program" (ATG-T), "We spend time socializing with each other before and after our activity sessions" (GI-S), and "Our group is united in its beliefs about the benefits of the physical activities offered in this program" (GI-T). The PAGEQ was developed for use by older adults taking part in physical activity classes, with scores derived from this instrument found to demonstrate good reliability ($\alpha \geq .72$; Estabrooks & Carron, 2000), factorial validity, and predictive utility. In the current study scores derived from each of the PAGEQ subscales displayed acceptable internal consistency (αs $\geq .859$) as well as measurement invariance over time (see Online Supplemental Materials Section 2 and Table S2).

Affective Attitudes

Affective attitudes toward physical activity were assessed using the procedures described by Rhodes and Matheson (2005). Specifically, participants were asked to indicate how they felt about exercising within their classes over the next 2 weeks, using three 7-point semantic differential items that comprised separate adjective pairs. Items were prefaced by "For me, regular exercise in my class (at the YMCA) over the next two weeks would be . . ." with anchors applied to "Enjoyable—Unenjoyable," "Pleasant—Unpleasant," "Interesting—Boring." Previous research with older adults has found support for both the internal consistency and predictive utility of scores derived from this three-item instrument (Gretebeck et al., 2007). Scores derived from the affective attitudes measures obtained at each time point in this study displayed good internal consistency ($\alpha \geq .928$), as well as measurement invariance over time (see Online Supplemental Materials Section 2 and Table S2).

Statistical Analyses

The statistical analyses are consistent with those reported in our pretrial registration and associated reporting protocol (see Beauchamp et al., 2015); which centered on the use of cross-lagged panel modeling (CLPM). Before running these models, and to determine whether a CLPM approach is empirically supported, a first "step" involved examining the trajectories of change in the trial's putative mediators, which was done through use of latent growth modeling.[1] Both sets of modeling approaches are described in detail below.

Examination of Trajectories of Putative Mediators Over Time: Growth Modeling

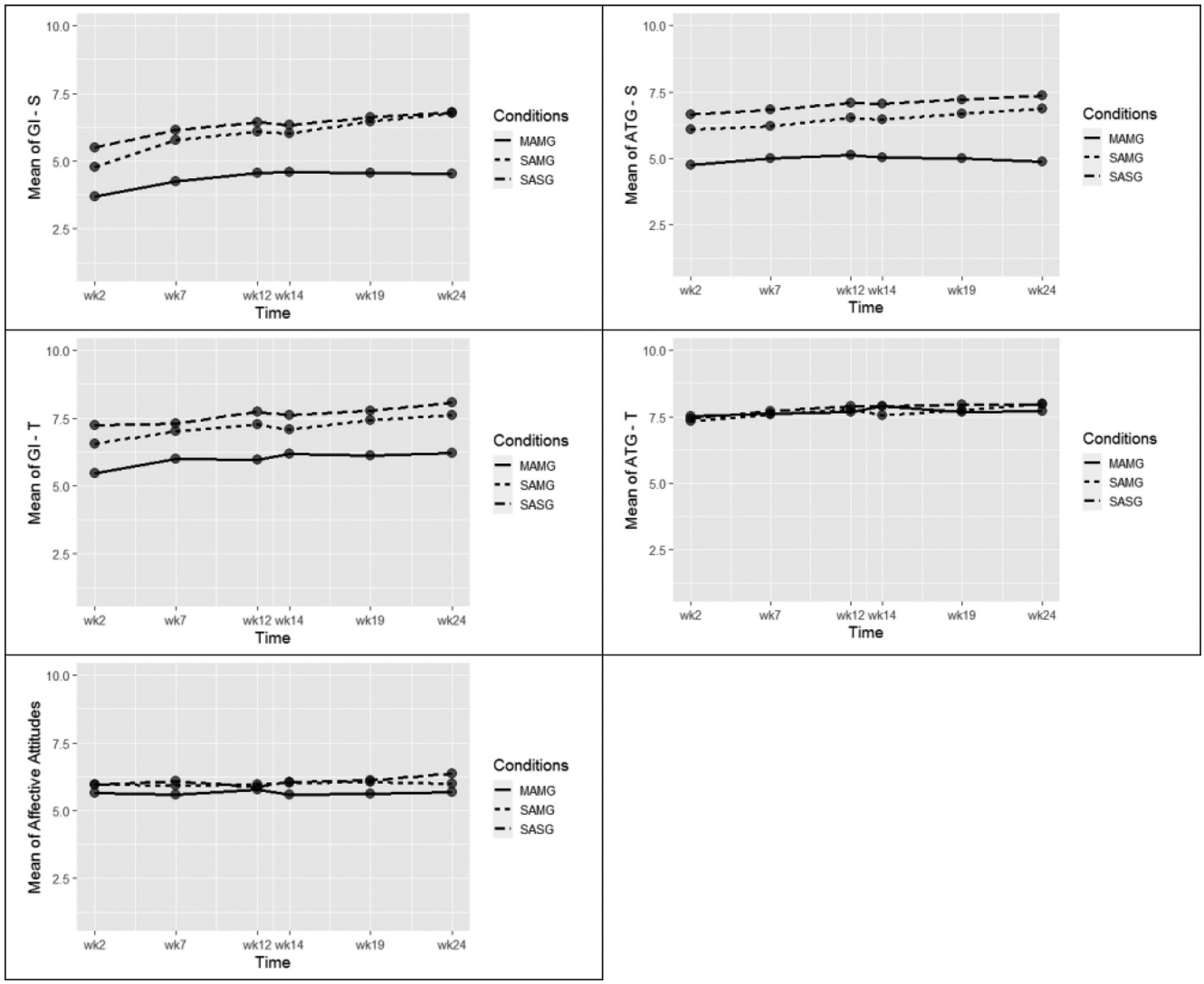
In light of the fact that the theoretical mediator variables (i.e., cohesion and affective attitudes) were assessed on multiple occasions after condition assignment, this required an initial examination of the longitudinal trajectories of these variables, before conducting the main mediation analyses. Given that measures of the putative mediator variables were collected across six time points over 24 weeks, the underlying assumptions of linear growth trajectories are likely violated (to some degree). A more flexible approach to model nonlinear forms of growth corresponds to the use of piecewise latent growth modeling (PWLGM; Li et al., 2001; Muthén, 2004). This approach decomposes growth trajectories into separate linear segments, which can capture different phases of the growth development and allow for different slopes for each phase. In this study we used PWLGM to examine the patterns of change over the 24-week programs for each theoretical mediator (affective attitudes as well as four cohesion dimensions) using M*plus* Version 7.4 software (Muthén & Muthén, 1998–2017). Maximum likelihood robust estimation was used for the PWLGM analyses. Three commonly used model fit indices were used to ascertain model fit, namely a comparative fit index (CFI), the root mean square error of approximation (RMSEA), and the standardized root-mean-square residual (SRMR). The criteria for evaluating model fit was designated with CFI values $> .90$, and RMSEA and SRMR values $< .08$ (Hu & Bentler, 1998, 1999). The respective trajectories for each putative mediator variable across the three conditions are presented in Figure 1 using data visualization derived from *ggplot2* R package (Wickham, 2016).

Mediation Modeling

In light of the distinct trajectories displayed by each of the cohesion measures over time (see Results) this precluded us from combining the four cohesion dimensions into a single cohesion measure (i.e., as each cohesion construct behaved differently to each other over time). In addition, because three of the four cohesion dimensions (GI-S, ATG-S, and GI-T) were highly correlated (rs $\geq .715$; see Online Supplemental Materials Tables S3 and S4), we were precluded from operationalizing the separate cohesion dimensions within single mediation model (i.e., because of multicollinearity that might occur with highly correlated mediator variables). Running a single mediation model that included the separate cohesion dimensions alongside affective attitudes (as distinct mediators) was further hindered by model complexity that prevented model convergence. Accordingly, we conducted separate

[1] As reported in the trial primary outcomes paper (see Beauchamp et al., 2018) examination of both intra-class correlations (ICCs) and design effects (1 + (average cluster size −1) × intraclass correlation; Muthén & Sartorra, 1995, equation 35), in relation to the trial's exercise adherence measures, were used to ascertain whether class clustering was required modeling in the main analyses (Hox, 2010). As the ICCs were <.03 and design effects were < 2 for the adherence measures (Beauchamp et al., 2018) this indicated that multi-level modeling was not required (see Muthén & Sartorra, 1995).

Figure 1
Trajectories of Cohesion and Affective Attitude Measures Across Groups Over Time



Note. MAMG = mixed age mixed gender condition; SAMG = similar age mixed gender condition; SASG = similar age same gender condition; GI-S = group integration social; ATG-S = attraction to the group social; GI-T = group integration task; ATGT-T = attraction to the group task.

mediation analyses that included the separate cohesion dimensions as well as affective attitudes as target mediator variables (for details see below).

On the basis of significant intercept and slope effects for the two social dimensions of cohesion, namely GI-S and ATG-S, as well as affective attitudes (see Results section), this required subsequent mediation analyses that accounted for changes in these putative mediators over time. Specifically, a CLPM approach was adopted to estimate both time-specific direct and indirect effects (Cole & Maxwell, 2003; Selig & Preacher, 2009), again using the M*plus* 7.4 software (Muthen & Muthen, 1998–2017). This analytic approach enables an examination of mediation effects across time, including nonlinear effects/trajectories. By taking this CLPM approach, the relationships between the independent variables (i.e., the two experimental conditions in relation to the MAMG comparison condition), the putative mediator (e.g., GI-S), and the dependent variable (i.e., adherence) were examined over time (see Figure 1). The panel models used full information maximum likelihood estimation with robust standard errors (MLR), computed with a Huber-White "sandwich" estimator, to handle missing data. This procedure uses all available data for parameter estimation under the assumption that the data are missing at random. In this study, we modeled the adherence data over the first 12 weeks and last 12 weeks of the respective exercise programs. In light of more missed classes in the second 12 weeks than the first 12 weeks (i.e., more zeros, for missed classes, in the second block of 12 weeks), we utilized the zero-inflated Poisson methods (Long, 1997) to model the outcome variable (adherence) over time.

We ran four CLPMs (with GI-S, ATG-S, GI-T, and affective attitudes) that modeled the relationships between the independent variables (SAMG and SASG), the putative mediator (e.g., GI-S)

and the outcome (adherence). For ATG-T, the latent growth analysis (see Results) revealed a nonsignificant effect for both intercept and slope, and so no further mediation analyses were conducted for this cohesion dimension. For the remaining putative mediators, each panel model (see Figure 2) examined the effects of randomized condition (i.e., intervention assignment) on the mediator variables as assessed at Week 2 (i.e., first questionnaire assessment after beginning the respective programs) and Week 12 (i.e., midway through the 24-week programs), and operationalized adherence behavior over the first 12-week block and second 12-week block of the respective programs. Each CLPM adjusted for participant gender even if gender was not statistically significant in the model. We operationalized each CLPM with two assessments of the mediator variables (Weeks 2 and 12), and two blocks of adherence data (first and second 12-week blocks), rather than using, for example, all six assessments of the mediator variables and the corresponding adherence data over these shortened time periods, because of model complexity and sample size limitations that prevented model convergence. Within each CLPM, factor scores (derived from confirmatory factor analysis, using full information maximum likelihood estimation) for the putative mediators were used to reduce measurement error (Gorsuch, 1983; Schumacker & Lomax, 2016). The CLPMs (see Figure 1) were comprised of two components (Cole & Maxwell, 2003; Selig & Preacher, 2009): (a) an autoregressive part (i.e., the mediator and outcome at a given point in time are regressed on the same variable measured at the previous time [paths d and e in Figure 2]); and (2) a cross-lagged part in which the mediator is regressed on the independent variables (path a), the outcome is regressed on the mediator measured at the previous time (path b), and the outcome is regressed on independent variables (path c, direct effect) while controlling for the mediator. The total indirect effects are calculated for the outcome (adherence behavior) over the first 12 weeks and second 12 weeks, separately.[2]

Results

Trajectories of the Putative Mediator Variables Over Time

Data visualization related to the respective trajectories of each of the theoretical mediators is presented in Figure 1. The findings derived from the PWLGMs are presented below (see also Online Supplemental Materials Tables S5 to S9).

Social Dimensions of Cohesion

The PWLGM displayed good model fit (CFI = .983, RMSEA = .046, SRMR = .032) for GI-S (see Online Supplemental Materials Table S5). Specifically, participants in both the SAMG (estimate = 5.060, *SE* = .817), $p < .001$, 95% confidence interval, CI [3.459, 6.662] and SASG (estimate = 7.355, *SE* = .948, $p < .001$, 95% CI [5.497, 9.213]) condition displayed a significantly higher intercept for this dimension of cohesion than the comparison MAMG condition. In addition, the SAMG condition also displayed a significant slope effect for GI-S over the second 12-week block (estimate = .845, *SE* = .290, $p = .004$, 95% CI [.277, 1.414]), although there was no slope effect (i.e., change over time) for the SASG condition in either the first or second 12-week block (see Figure 1 and Online Supplemental Materials Table S5).

Model fit for the PWLGM for ATG-S was good; CFI = .983, RMSEA = .044, SRMR = .039. As with the latent growth model for GI-S, participants in the SAMG (estimate = 7.844, *SE* = 1.146), $p < .001$, 95% CI [5.597, 10.090] and SASG (estimate = 10.971, *SE* = 1.328, $p <$. 001, 95% CI [8.368, 13.575]) conditions displayed a significantly higher intercept for ATG-S than the comparison MAMG condition (see Online Supplemental Materials Table S6). In addition, the SAMG condition also displayed a significant slope effect for ATG-S over the second 12-week block (estimate = 1.302, *SE* = .357, $p < .001$, 95% CI [.601, 2.002]), as did the SASG condition (estimate = .722, *SE* = .364, $p = .047$, 95% CI [.009, 1.435]) during the same period of time (see Figure 1 and Online Supplemental Materials Table S6).

Task Dimensions of Cohesion

The PWLGM for GI-T displayed good fit; CFI = .977, RMSEA = .039, SRMR = .028. Participants in both the SAMG (estimate = 5.361, *SE* = 1.082), $p < .001$, 95% CI [3.240, 7.482] and SASG (estimate = 7.611, *SE* = 1.118, $p < .001$, 95% CI [5.420, 9.803]) conditions displayed a significantly higher intercept than the comparison MAMG condition (see Online Supplemental Materials Table S7). Neither the SAMG nor SASG condition displayed a significant slope effect over the first or last 12-week block.

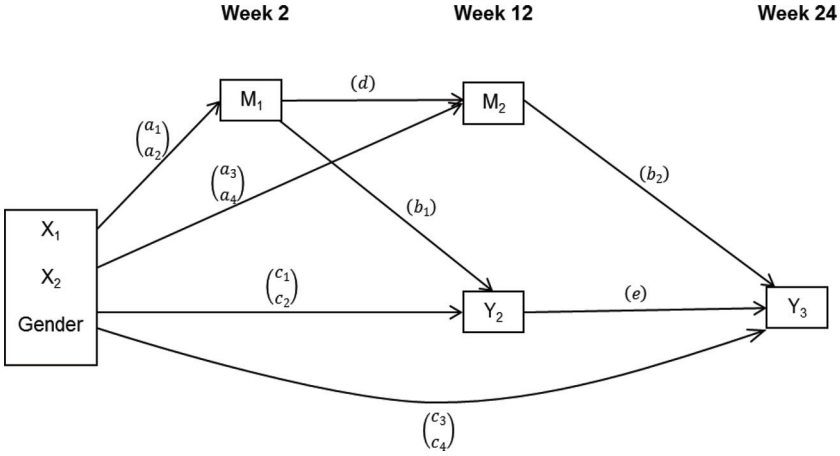
The PWLGM for ATG-T displayed good model fit; CFI = .951, RMSEA = .042, SRMR= .036. For ATG-T there was no difference between participants in the two intervention (SAMG, SASG) conditions when compared with the comparison MAMG at the first cohesion assessment (Week 2), as illustrated by nonsignificant intercepts ($ps > .05$) for both conditions (see Online Supplemental Materials Table S8). In a similar vein, there were no significant slope effects ($ps > .05$) for either experimental condition over the first or second 12-week block of time (see Figure 1 and Online Supplemental Materials Table S8).

Affective Attitudes

Model fit for the PWLGM for affective attitudes was good; CFI = .987, RMSEA = .022, SRMR = .050. As can be seen from Online Supplemental Materials Table S9, participants in both the SAMG (estimate = 1.030, *SE* = .380), $p = .007$, 95% CI [.007, 2.85] and SASG (estimate = 1.077, *SE* = .436, $p < .013$, 95% CI [.013, .223]) conditions displayed a significantly higher intercept for affective attitudes than the comparison MAMG condition. In addition, the SASG condition also displayed a significant slope effect over the second 12-week block (estimate = .456, *SE* = .178, $p = .010$, 95% CI [.010, .108]), although there was no slope effect (i.e., change over time) for the SAMG condition in either the first

[2] Unlike the PWLGM approach, the CLPM analytic approach, which used zero-inflated Poisson methods (Long, 1997) does not provide indices of absolute model fit (e.g., CFI, RMSEA, SRMR). Instead, model fit information for the CLPMs are available for model comparison based on Akaike information criterion (AIC), Bayesian information criterion (BIC), Sample-size adjusted Bayesian information criterion (SABIC). As the analysis (i.e., CLPMs) did not involve model 'comparisons' (via model building iterations), such fit indices are not informative for establishing absolute fit.

Figure 2
Cross-Lagged Panel Mediation Modeling Approach



Note. X_1 = similar age mixed gender condition; X_2 = similar age same gender condition; M_1 = mediator variable assessed at Week 2; M_2 = mediator variable assessed at Week 12; Y_2 = dependent variable (program adherence) assessed over the first 12-week block; Y_3 = dependent variable (program adherence) assessed over the second 12-week block. Separate cross-lagged panel modeling (CLPMs) were run with group integration social (GI-S), attraction to the group social (ATG-S), group integration task (GI-T), and affective attitudes as the putative mediator variable.

or second 12-week block of time (see Figure 1 and Online Supplemental Materials Table S9).

Mediation Models

The results of the CLPMs are presented below (see also Table 1 as well as Online Supplemental Materials Tables S10–S12). As indicated in the "statistical analyses" section, we conducted four CLPM analyses (with GI-S, ATG-S, GI-T, and Affective Attitudes as mediator variables).

Social Dimensions of Cohesion

The results of the CLPM in which perceptions of social group integration (GI-S) was operationalized as the mediator are presented in Table 1. Involvement in the two experimental conditions (SAMG, SASG), when compared with the referent MAMG condition, had a significant effect on GI-S at Week 2 (see a_1 = .957, $p < .001$; a_2 = 1.484, $p < .001$ in Figure 2 and Table 1) and at Week 12 (see a_3 = .458, $p < .001$; a_4 = .322, p = .016). Of note, SAMG and SASG intervention conditions (when compared with the referent MAMG condition) had an effect on adherence behavior over the second 12-week block (Y_3) that was mediated by GI-S at both Weeks 2 and 12 (see $a_1 \times d \times b_2$ = .029, p = .004; $a_2 \times d \times b_2$ = .045, p = .003; $a_3 \times b_2$ = .022, p = .018; total indirect effect for Y_3 = .116, p = .002). There were no significant effects for gender in any of paths within the structural model ($ps > .05$).

When individual members attractions to the group's social activities (ATG-S) were operationalized as mediator in the CLPM, the results were very similar to those observed when GI-S was modeled as the mediator. Specifically, both intervention conditions displayed a significant effect on the ATG-S at both Week 2 (see a_1 = 1.189, $p < .001$; a_2 = 1.683, $p < .001$ in Figure 2 and online Supplemental Materials Table S10) and at Week 12 (see a_3 = .333, $p < .021$; a_4 = .494, p = .001). Similarly, both intervention conditions had an effect on adherence over the second 12-week block (Y_3) that was mediated by ATG-S at both Weeks 2 and 12 ($a_1 \times d \times b_2$ = .036, p = .002; $a_2 \times d \times b_2$ = .051, p = .002; $a_4 \times b_2$ = .023, p = .016; total indirect effect for Y_3 = .13, p = .001). There were no significant effects for gender in any of paths within the structural model ($ps > .05$).

Task Dimensions of Cohesion

When perceptions of group task integration (GI-T) were operationalized as a mediator, both intervention conditions (SAMG, SASG) displayed a significant effect on GI-T at Week 2 (see a_1 = .849, $p < .001$; a_2 = 1.235, $p < .001$ in Online Supplemental Materials Table S11) and Week 12 (see a_3 = .468, p = .003; a_4 = .502, p = .002). The effects of both intervention conditions on adherence over the second 12-week block (Y_3) was mediated by GI-T at both Weeks 2 and 12 ($a_1 \times d \times b_2$ = .016, p = .041; $a_2 \times d \times b_2$ = .023, p = .030; total indirect effect for Y_3 = .074, p = .022). There were no significant effects for gender in any of paths within the structural model ($ps > .05$), other than for GI-T at Week 2 with men reporting higher GI-T than women (estimate = .546, p = .001).

Affective Attitudes

When Affective Attitudes were operationalized as the putative mediator in the CLPM both intervention conditions (SAMG, SASG) displayed a significant effect on affective attitudes at Week 2 (see a_1 = .324, p = .014; a_2 = .279, p = .046; online Supplemental Materials Table S12). Week 2 affective attitudes had a subsequent effect on Week 12 affective attitudes and thereafter adherence behaviors over the last 12-week block in the respective exercise programs. The only significant indirect effect

Table 1
Cross-Lagged Panel Model: Mediation Effects of GI-S on Adherence of Participants Across Three Trial Conditions

Variables	Estimate	*SE*	*p*-value	95% CI
(Outcome #1: GI-S M_1)				
Predictors: SAMG (a_1)	0.957	0.167	<.001	[0.631, 1.284]
SASG (a_2)	1.484	0.194	<.001	[1.103, 1.865]
Gender	0.174	0.149	.241	[−0.117, 0.466]
(Outcome #2: GI-S M_2)				
Predictors: SAMG (a_3)	0.458	0.127	<.001	[0.209, 0.706]
SASG (a_4)	0.322	0.133	.016	[0.060, 0.583]
GI-S M_1 (d)	0.642	0.032	<.001	[0.579, 0.704]
Gender	−0.074	0.113	.514	[−0.296, 0.148]
(Outcome #3: Adherence Y_2)				
Predictors: GI-S M_1 (b_1)	−0.009	0.013	.500	[−0.035, 0.017]
SAMG (c_1)	0.096	0.049	.048	[0.001, 0.191]
SASG (c_2)	0.093	0.057	.099	[−0.017, 0.204]
Gender	0.065	0.038	.088	[−0.01, 0.140]
(Outcome #4: Adherence Y_3)				
Predictors: GI-S Y_2 (b_2)	0.047	0.015	.001	[0.019, 0.076]
Adherence-Y_2 (e)	0.024	0.003	<.001	[0.018, 0.03]
SAMG (c_3)	−0.056	0.057	.330	[−0.167, 0.056]
SASG (c_4)	0.017	0.057	.769	[−0.095, 0.128]
Gender	0.057	0.045	.210	[−0.032, 0.146]
Indirect effects (Individual paths)				
ind1 = $a_1 \times b_1$	−0.009	0.013	.508	[−0.034, 0.017]
ind2 = $a_2 \times b_1$	−0.013	0.02	.504	[−0.052, 0.026]
ind3 = $a_3 \times b_2$	0.022	0.009	.018	[0.004, 0.040]
ind4 = $a_4 \times b_2$	0.015	0.008	.055	[0.000, 0.031]
ind5 = $a_1 \times b_1 \times e$	0.002	0.001	.052	[0.000, 0.005]
ind6 = $a_2 \times b_1 \times e$	0.002	0.001	.104	[0.000, 0.005]
ind7 = $a_1 \times d \times b_2$	0.029	0.010	.004	[0.009, 0.049]
ind8 = $a_2 \times d \times b_2$	0.045	0.015	.003	[0.015, 0.075]
(Total indirect effects)				
Adherence − Y_2 = ind1 + ind2	−0.022	0.033	.505	[−0.086, 0.042]
Adherence − Y_3 = ind3 + ind4 +ind5 + ind6 +ind7 + ind8	0.116	0.037	.002	[0.043, 0.189]

Note. CI = confidence interval; SASG = similar age same gender (anchored against referent MAMG condition); SAMG = similar age mixed gender (anchored against referent MAMG condition); gender = male (anchored against referent female); M_1 = mediator variable assessed at Week 2; M_2 = mediator variable assessed at Week 12; Y_2 = dependent variable (program adherence) assessed over the first 12-week block; Y_3 = dependent variable (program adherence) assessed over the second 12-week block. See Online Supplemental Materials Tables S10–S12 for the cross-lagged panel models (CLPMs) in which attraction to the group social (ATG-S), group integration task (GI-T), and affective attitudes were operationalized as mediator variables.

corresponded to the effects of the SAMG condition on the second block of adherence behavior (Y_3) that was mediated by Week 2 and Week 12 affective attitudes ($a_1 \times d \times b_2 = .009$, $p = .048$). However, it should also be noted that the total indirect effect for Y_3 was nonsignificant ($p > .05$). There were no significant effects for gender ($ps > .05$) in relation to any of the pathways.

Discussion

The overall purpose of this study was to examine potential psychological mediators of group-based physical activity adherence behaviors among older adults as part of a randomized controlled trial. Older adults were randomized to one of two experimental conditions that were underpinned by the tenets of self-categorization theory (Haslam et al., 2018; Turner, 1985; Turner et al., 1987, 1994) or a comparison control condition, as part of the GOAL Trial (Beauchamp et al., 2015, 2018). Previous research revealed that older adults adhered to both SAMG and SASG experimental conditions to a greater extent than those randomized to a MAMG comparison control (Beauchamp et al., 2018). The current study revealed several unique insights related to the relative *development* of the trial's theoretical mediators over time, as well as the extent to which those psychological variables acted as explanatory variables for the trial's intervention effects.

The latent growth analyses of the trial's theoretical mediator variables indicated that by the second week of the respective exercise programs, participants in the two intervention conditions displayed higher levels of task and social group integration (GI-T, GI-S), greater attractions to the group's social activities (ATG-S), and higher enjoyment (i.e., affective attitudes), when compared with the MAMG comparison condition (as indicated by the higher intercepts). There were no differences in intercepts between the two intervention groups and the comparison MAMG group in terms of participants attraction to the group's task activities (ATG-T). In addition to the above differences in intercepts (for GI-T, GI-S, ATG-S, and affective attitudes), it is notable, that participants in the two intervention conditions also displayed significant slope effects in relation to the two social cohesion dimensions (ATG-S, GI-S) whereby participants in those conditions perceived their respective groups to become even more cohesive over time. There were no significant slope effects (i.e., changes over time) for either of the two task cohesion dimensions. Previous research within the field of behavioral medicine has highlighted that group

cohesion is dynamic and changes over time within physical activity groups (Carron & Brawley, 2000); although it should also be noted that very few studies have actually tested this postulate. In one of the first studies that examined the dynamic/changeable nature of cohesion within exercise classes, Dunlop et al. (2013) found that mean levels of social cohesion changed significantly over time whereas mean levels of task cohesion did not, with the respective patterns largely consistent across persons and groups. The findings derived from the latent growth analyses in the current study are consistent with those earlier findings by Dunlop and colleagues (2013) and suggest that social and task cohesion might operate distinctly from one another. Although affective attitudes also displayed changes after the initial Week 2 assessments (as reflective of a significant slope effect), those changes were only observed in the SASG Condition and not in the SAMG condition.

Each cohesion measures displayed distinct trajectories from one another (as illustrated in Figure 1). This precluded us from combining the four cohesion dimensions into a single latent or omnibus measure. Nonetheless, the fact that the four cohesion dimensions operated differently to one another (vis-à-vis different trajectories over time), would appear to add credence to the contention that group cohesion is a multidimensional construct, with the constituent dimensions possessing unique psychometric properties from one another (Carron & Brawley, 2000). Balanced against the fact that the different cohesion dimensions appeared to be empirically distinct from each other in one sense (in terms of different trajectories), three of the cohesion dimensions (GI-S, ATG-S, and GI-T) were highly correlated at both the Week 2 and 12 assessments ($rs \geq .715$). This meant that we were unable to operationalize these separate cohesion measures as distinct mediator variables within a single mediation model (i.e., because of potential multicollinearity).

In light of the different trajectories associated with each of the four cohesion dimensions and affective attitudes, over the course of the 24-week programs, we conducted separate mediation analyses with the separate cohesion dimensions and affective attitudes measures as putative mediators within the structural models. When taken together, the results revealed that both social cohesion dimensions displayed similar patterns within the respective CLPMs, whereby both intervention conditions (i.e., SAMG, SASG) displayed higher levels of social cohesion (GI-S, ATG-S) at both 12 and 24 weeks, which was related to higher levels of adherence, in particular over the second 12-week block of the respective physical activity programs. Perceptions of social cohesion did not mediate the effects on adherence behavior during the first 12-week block. When taken together these findings suggest that social cohesion was a more salient mediator of longer-term adherence (over Weeks 12 to 24), and as less capable of explaining shorter term adherence behavior (over the first 12 weeks). There were no gender effects for any of the paths within the social cohesion panel models, which suggest that the relations between the predictors (i.e., condition assignment), mediators (social cohesion at 2 and 12 weeks), and criterion measures (i.e., adherence) were comparable for men and women.

When GI-T was operationalized as a mediator within the CLPM, the pattern of findings was very similar to those observed for both social dimensions of cohesion. Specifically, the effects of both intervention conditions on adherence, in particular over the second 12-week block, were explained by the effects of the SAMG and SASG conditions on perceptions of GI-T at Week 2 and Week 12 (as per significant paths for both $a_1 \times d \times b_2$ and $a_2 \times d \times b_2$). As with the two social cohesion models, GI-T did not mediate the adherence behaviors over the first 12-week block, but did so for the second 12-week block, which suggests that this dimension of task cohesion may have been more salient in predicting longer term adherence, but less salient in accounting for shorter term program retention. Balanced against the significant indirect effects observed in the GI-T model (that were similar to the GI-S and ATG-S models), there were no differences in intercepts or slopes between the two interventions conditions and comparison MAMG condition based on ATG-T, which suggests that individual attractions to the group's task activities (ATG-T) was not a salient explanatory variable of the intervention adherence effects. That there were no differences in ATG-T between conditions is perhaps not surprising given that the nature of the physical activity exercises embedded within the two intervention conditions were designed to be comparable with those within the MAMG condition. That is, they each involved moderate-intensity physical activity classes that included exercises designed to target strength, agility, balance, as well as aerobic function (see Beauchamp et al., 2015).

When the mediation findings are considered together, the results suggest that group cohesion operated as an explanatory mechanism that accounted for how the two intervention conditions contributed to participants' sustained involvement in their respective programs. In particular, social cohesion appeared to be particularly salient, as well as perceptions of group unity around its task activities. In light of the fact that both intervention conditions were infused with several behavior change strategies that included the use of group composition (to facilitate greater intragroup similarity with regard to age), instructors who were themselves older adults, as well as clothing (i.e., t-shirts) and a program name that were designed to foster a sense of distinctiveness, we are unable to identify which feature of the respective programs exerted greatest influence. However, on the basis of the similar trajectories in the latent growth models as well as comparable indirect effects in the panel models, for both the SAMG and SASG conditions, these findings suggest that constructing groups on the basis of within-group gender similarity does not appear to have any substantive additional benefits for promoting cohesion and subsequent adherence behaviors.

When affective attitudes was operationalized as a mediator, there was a significant effect for both intervention conditions on affective attitudes at Week 2. The only significant indirect effect corresponded to the effect of the SAMG on adherence behaviors over the second 12-week block, which was mediated by affective attitudes at Weeks 2 and 12. It should be noted that this indirect effect was of borderline statistical significance ($p = .048$, 95% CI [.000, 017]), and the total indirect effects for the affective attitudes model were nonsignificant. There was no indirect effect linking the SASG condition to adherence, via affective attitudes at either Week 2 or 12. As affective attitudes displayed a medium sized correlation with each of the cohesion dimensions ($rs \geq .407$, see Online Supplemental Materials Tables S3 and S4) it is entirely conceivable that enjoyment of physical activity played some role in groups being cohesive. However, given the findings with regard to the four CLPMs, it appears that cohesion represents a more salient explanatory mechanism in supporting longer term adherence

behaviors among participants than affective attitudes related to physical activity in general.

The study has a number of strengths. These include the use of a preregistered randomized controlled trial design, mediation hypotheses (and analyses) that were specified a priori, missing within-person data handled within the modeling algorithms, the use of advanced latent growth and panel modeling approaches to address the study's research question, as well as mediation findings that directly complement the primary trial outcome findings (Beauchamp et al., 2018). That said, the study has some limitations. The first limitation is that our mediation analyses were based on a subsample from the trial that completed at least one measure of the trial's mediator variables, and so we were unable to include those who did not provide responses to those measures. Although there were no significant differences between this sample (n = 483) and the total trial sample (n = 627) on the basis of age or gender, any (between-participants) study attrition may undermine a study's internal validity to some extent. A second limitation is that we did not collect data on group cohesion or affective attitudes at baseline (before randomization). We were unable to obtain measures of cohesion and affective attitudes (associated with their forthcoming group exercise classes), before randomization, as participants would not have any frame of reference for those appraisals (i.e., groups had not been formed at that time). That said, it should also be noted that there were no significant differences between conditions with respect to baseline physical activity behavior, participant age or gender, and so there was no reason to expect that there would be any systematic differences in participants' (group-related or physical activity) appraisal processes at baseline. A third limitation corresponds to the fact that, while we were able to use questionnaire data from all six time points to assess cohesion and affective attitudes within the latent growth models, we were unable to model the relations between the putative mediators and adherence using all six time points because of model complexity, which prevented model convergence. In a similar vein, we were unable to include the separate cohesion dimensions alongside affective attitudes within a single CLPM, because of issues related to model complexity, as well as high correlations among three of the cohesion dimensions (i.e., to mitigate against multicollinearity). This meant that we cannot firmly conclude which of GI-S, ATG-S, or GI-T was the most pertinent explanatory dimension of participants' adherence behavior.

Despite these limitations, this study provides support for the contention that group-based exercise programs informed by the tenets of self-categorization theory have the potential to foster stronger group cohesion than standard group-based programs, and as a result are able to retain group member involvement to a greater extent. Indeed, the study provides empirical evidence that group cohesion operates as a *mechanism of action* (Borek et al., 2019) to promote health-enhancing physical activity behavior among older adults.

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Received June 17, 2020
Revision received November 17, 2020
Accepted November 24, 2020 ■