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ORIGINAL PAPER

Mechanisms of Change Underlying Mindfulness-Based Practice Among Adolescents

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Abstract

Objectives The purpose of this study was to investigate how mindfulness-based practice influenced self-regulation and self-compassion during adolescence. Of particular interest was the reciprocal interplay between the subcomponents of these two constructs.

Methods The participants included 538 high school students (52.2% male), mean age 16.59 ($SD = .74$) recruited from three high schools in Philadelphia, PA. Students participated in a 12-week school-based mindfulness intervention and completed the Self-compassion Scale-Short Form and the Adolescent Self-regulation Inventory at pretest (T1) and posttest (T2).

Results A key finding was that the models with directional paths from self-regulation to self-compassion best fit the data. Specifically, long-term self-regulation at T1 was positively associated with mindfulness and self-kindness at T2 while short-term self-regulation at T1 was negatively associated with self-judgment, over-identification, and isolation at T2.

Conclusions These findings suggest that self-regulation precedes and enables the actualization of self-compassion within the context of mindfulness practice. The implications for understanding the specific mechanisms underlying mindfulness-based practice and its benefits for adolescents' psychological well-being are discussed.

Keywords Self-regulation · Self-compassion · Adolescence · School-based mindfulness programs

The promotion of adolescent emotional health has become a significant educational and societal goal in the USA. Recent reports indicate that teen rates of anxiety and depression have increased significantly over the last decade (Bitsko et al., 2018; SAMHSA, 2019) and suggest that nearly one in five adolescents has a diagnosable mental health disorder (SAMHSA, 2015). Concomitantly, adolescents are also reporting increased levels of stress, and many admit that they are unsure of how to manage these school and social stressors (American Psychological Association, 2015).

One of the promising approaches for reducing student stress and promoting social-emotional competencies is mindfulness-based programs and interventions (Bergen-Cico & Krishnakumar, 2017; Felver et al., 2016; Roeser & Eccles, 2015; Sibinga et al., 2016a; Waters et al., 2014). Mindfulness-based programs have been increasingly adopted in schools as they promote multiple constructs associated with psychological well-being and working memory (Farb et al., 2010; Goldin & Gross, 2010; Jha et al., 2010; Tang et al., 2012). School-based mindfulness programs have been found to be particularly meaningful and practicable for adolescents' emotional well-being and cognition, specifically in the areas of reducing stress, improving focus, promoting emotional regulation and social skills, and improving academic performance (Biegel et al., 2009; Britton et al., 2014; Broderick & Jennings, 2012; Burke, 2010; Sibinga et al., 2016b). The results of multiple reviews indicate both cognitive and social-emotional benefits of school-based mindfulness interventions (Felver et al., 2016; McKeering & Hwang, 2019; Waters et al., 2014; Zenner et al., 2014). Two key constructs supporting these outcomes include self-compassion and self-regulation. Indeed, mindfulness interventions have

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been associated with the promotion of self-compassion as a mechanism underlying the actualization of other emotional outcomes, such as positive affect (Birnie et al., 2010; Hollis-Walker & Colosimo, 2011; Neff, 2003; Van Dam et al., 2011). Similarly, school-based mindfulness programs have highlighted the important role of self-regulation in improving attentional processes and emotional regulation and reducing stress in adolescents (Burke, 2010; Zenner et al., 2014). As most of the studies in the above reviews focused on investigating the effectiveness of mindfulness programs for self-compassion and self-regulation separately, very little empirical research has examined how these two constructs change interrelatedly among adolescents.

Self-regulation is generally defined as the degree to which individuals can control their attention, emotions, activities, and reactivities to environmental stimuli (Kopp, 1982). Adolescents with high levels of self-regulation are advantaged academically and socially, as demonstrated in high academic achievement and social functioning; low involvement in delinquency, risky substance use, and risky sexual behaviors; and better mental health (Bowers et al., 2011; Brody & Ge, 2001; Moilanen, 2007; Moilanen et al., 2018; Parto & Besharat, 2011). Adolescents are purported to achieve self-regulation in two temporal contexts, short-term and long-term, due to their advanced cognitive flexibility and perseverance in achieving proximal and/or distal goals, respectively (Gestsdottir & Lerner, 2008; Moilanen, 2007). Related to the ability to moderate emotions and behaviors, short-term self-regulation is defined as "the control in the heat of the moment or regulation in the immediate context" (Moilanen, 2007, p. 836). For instance, adolescents may need to regulate negative emotions in the moment such as when responding to an undesirable grade. In contrast, long-term self-regulation describes the control of immediate impulses and/or to direct the effort over a longer period of time in order to reach long-term goals (Moilanen, 2007). Given that adolescents are cognitively more capable of making plans for future events and intentionally regulating moods, activities, and attention to achieve personally designed long-term goals (Moilanen et al., 2018), it is important to see how short-term self-regulation and long-term self-regulation evolve, change, and related with other psychological constructs when studying adolescents.

Self-compassion is a multi-faceted construct that includes the capacity to be kind toward oneself, to be mindful of one's own feelings, and to keep a sense of connection to others when facing similar challenging situations (Neff, 2003). Specifically, according to Neff (2003), the combined components of self-compassion are self-kindness (taking an active role to do something supportive rather than judgmental toward oneself), mindfulness (observing one's feelings and thoughts rather than becoming fully absorbed by them), and common humanity (realizing one's personal challenges as a common phenomenon in the life of all others rather than an isolated unique suffering). Research indicates that individuals high in self-compassion adopt positive ways of connecting to oneself and others when met with challenges and adversities in life (for reviews see Barnard & Curry, 2011; Marsh et al., 2018; Yang et al., 2021; Zessin et al., 2015).

Adolescence as a developmental stage can be notably challenging and is characterized by decreases in self-compassion; adolescents are often consumed with self-judgment and self-questioning as they become skillful to be aware of the surroundings and making comparisons with peers (Galla, 2016). Thus, self-compassion has been considered a particularly prominent construct to cultivate during adolescence because of its positive impact on emotional and psychological well-being (Galla, 2016; Marsh et al., 2018; Neff & McGehee, 2010; Turk & Waller, 2020). For example, adolescents who reported higher levels of self-compassion, ruminated less when facing stressful events compared with peers with lower levels of self-compassion (Ciesla et al., 2012), were happier and more satisfied with their lives (Brown et al., 2011), and experienced fewer negative feelings such as fearful, angry, and sad (Ciarrochi et al., 2011). Self-compassion was also associated with lower levels of stress and higher levels of self-control during adolescence (Galla, 2016; Lathren et al., 2019). Moreover, a self-compassion intervention for adolescents was linked to positive outcomes including decreases in perceived stress and depressive symptoms and increases in resilience and curiosity (Bluth & Eisenlohr-Moul, 2017; Muris et al., 2021; Stefan & Cheie, 2020).

Despite the increased research on self-compassion, few studies have investigated the impact of mindfulness programming on its subcomponents. Recent work examining the factor structure of the Self-Compassion Scale (SCS) confirms six related, yet distinct subscales including self-kindness, common humanity, mindfulness, self-judgment, isolation, and over-identification (Neff et al., 2019). The results of this research examining the scale across 20 diverse samples suggested that while the first three subscales may reflect compassionate self-responding, self-judgment, isolation, and over-identification are unique dimensions and are not merely the opposite of self-kindness, mindfulness, and common humanity. Moreover, the study highlights the value of examining the six constituent components of self-compassion in future work to better understand how the facets may be uniquely impacted by intervention or have specific links with well-being. Therefore, it would be valuable to examine whether there are facets of self-compassion that are particularly sensitive to mindfulness interventions among youth and whether select subcomponents have implications for other relevant constructs.

As current research on school-based mindfulness programs suggested that mindfulness exercises are beneficial

for both self-compassion and self-regulation (Bergen-Cico et al., 2015; Razza et al., 2015, 2021), one critical question is whether and how changes in self-compassion and self-regulation are related within the context of mindfulness during adolescence. The results of the few studies that have examined the directionality among these constructs in other contexts were inconclusive. According to some models, self-compassion promotes self-regulation and influences healthy behaviors by lowering the self-blame and negative emotionality that interfere with self-regulation (Terry & Leary, 2011). For example, the Self-Regulation Resource Model (SRRM) brings together current research on self-compassion, self-regulation, and health behaviors into one theoretical framework that takes a self-regulation resource view toward understanding intentions behind the engagement in health-promoting behaviors in emerging adults that are bolstered by the trait of self-compassion (Sirois, 2015). Specifically, positive and negative affects, in combination with self-efficacy in health, serve as self-regulatory resources that play an intermediary role between self-compassion and health-promoting behaviors. Consistent with this theoretical model, emerging studies have found that individuals fueled with self-compassion could act kindly toward themselves to alleviate painful emotions when facing stressful moments via increased emotional regulation (Inwood & Ferrari, 2018). Empirical support for this link includes one cross-sectional study with adults that found that self-compassion explained variance in emotional flexibility beyond what was accounted for by trait mindfulness (Beshai et al., 2018). Another study that purposely examined two components of self-compassion among adolescents found that self-judgment was associated with executive functioning, a cognitive aspect of self-regulation, whereas self-kindness was not (Shin et al., 2016). Thus, it is possible that the subcomponents of self-compassion may link with self-regulation in unique ways.

On the other hand, other research has found that self-regulation may be critical for the development of traits and abilities needed to demonstrate self-compassion in the moment. Self-regulation could direct attention and enable individuals to stop negative thoughts and to implement cognitive reappraisal (Inwood & Ferrari, 2018). For example, there is evidence that in the context of mindfulness, the controlled sense-of-self was positively associated with self-compassion (Verhaeghen, 2019). Another cross-sectional study with adolescents suggested that dispositional mindfulness and executive functioning may reciprocally influence each other first, and then possibly lead to the development of self-compassion (Holas & Jankowski, 2013). There are also other studies that purported that the positive effects of self-compassion were based on the deployment of adaptive cognitive and emotional regulatory strategies (Allen & Leary, 2010; Inwood & Ferrari, 2018; Muris et al., 2019; Scoglio et al., 2018). Unfortunately, however, this area of research is limited by its heavy reliance on cross-sectional design and global measures of self-compassion and self-regulation.

Although mindfulness-based intervention is considered a promising approach for reducing student stress and promoting social-emotional competencies (Felver et al., 2016; Roeser & Eccles, 2015; Sibinga et al., 2016a; Waters et al., 2014), little is known about how these positive outcomes interact to drive change over time. Elucidating the interactive processes of change may provide key insights into the mechanisms of mindfulness approaches in protecting against psychopathology. Thus, moving beyond models that evaluate how mindfulness interventions impact individual outcomes, the purpose of the present study was to examine how two key social-emotional constructs, self-regulation and self-compassion, change within the context of a mindfulness-based intervention for teens (Inner Strength Teen mindfulness program). The results of a prior quasi-experimental evaluation indicated that the program was associated with significant benefits in both self-compassion and long-term self-regulation for intervention participants compared to their peers who served as controls (Razza et al., 2021). The current study focused exclusively on adolescents who received the intervention and examined changes over time in their self-compassion and self-regulation. Special consideration was given to the unique associations among subcomponents of these constructs, including six facets of self-compassion (self-kindness, mindfulness, common humanity, self-judgment, over-identification, and isolation), and two dimensions of self-regulation (short-term self-regulation and long-term self-regulation). The aims of the study were to examine (1) whether and how self-compassion and self-regulation changed over time and in relation to each other, and (2) whether there was specificity in the associations between subcomponents of self-compassion and self-regulation. Based on the previous literature, we hypothesized reciprocal associations between self-compassion and self-regulation, whereas, the examination among subcomponents was exploratory.

Method

Participants

The initial sample included 651 high school students (52.2% male, $n = 340$) with an age range 15 to 19 years old ($M = 16.51$, $SD = 0.74$). Participants were recruited from three urban high schools ($N = 196$, 190, and 313) in Philadelphia, PA. All three schools serve ethnically diverse students represented by the following ranges: Asian (14–33%), Black/African American (5–54%), Hispanic (9–20%), and White non-Hispanic (10–41%). There was also variability in social-economic status; economic disadvantage (indexed using the

community eligibility provision rate) ranged from 31 to 93% across the schools according to district data, reflecting the percentage of students eligible for free lunch. Students who did not complete either the self-regulation and self-compassion items at time 1 (T1; 4%) or time 2 (T2; 18%) were excluded from the data analyses. Little's missing completely at random (MCAR) test suggested no differences in missing patterns (T1: $\chi^2 = 68.06$, $df = 51$, $p = 0.06$ and T2 $\chi^2 = 32.90$, $df = 38$, $p = 0.70$) between missing data and complete data (Little & Rubin, 1989). Therefore, the final analyses in this study included 538 students (76% of the original students) who participated in the mindfulness intervention and completed both the pretest and the posttest.

Procedure

The current study is part of an ongoing evaluation of a mindfulness-based program designed for urban teens. Given that the intervention was considered part of the schools' curriculum, informed consent was not required for youth to participate in the program, but it was required to participate in the research study. Information about the research study was sent home to guardians. Passive parental consent and youth assent were required for students under the age of 18; students over the age of 18 provided written consent. There were no instances of parental refusal and limited youth refusal (less than 5%). All procedures followed a standard protocol approved both by the Philadelphia City School Board and the University IRBs.

The Inner Strength Teen mindfulness program is a 12-lesson curriculum (Edelstein, 2016) endorsed by the Collaborative for Social and Emotional Learning (CASEL). Lessons were typically delivered once per week via 45-min sessions over 12 weeks (86%) or twice per week over 6 weeks (14%); the shorter time period was requested for some classes due to other grade-level requirements. Three Inner Strength instructors, who completed the program's teacher training 56-h program including virtual training, conference calls, and a 3-day in-person weekend session, led the interventions. Each lesson reflected one of four core themes (self-identification, evolutionary neuroscience, cultural development, compassion building) and included an average of 15 minutes of mindfulness-based practice, 20 minutes of didactic instruction, and 15 minutes of peer discussion and/or written exercises. Over the course of the intervention, students practiced seven mindfulness techniques, including awareness of breath, open awareness, thought bubble, sound meditation, body scan, mindful eating, and self-compassion. Students completed the survey during the school day in a paper-pencil format individually in their classrooms at both pretest and posttest, approximately 3 months apart. The survey took approximately 20 minutes to complete and included assessments of both self-regulation and self-compassion.

Measures

Self-compassion The Self-Compassion Scale–Short Form (SCS-SF; Raes et al., 2011) is a 12-item measure. The 5-point Likert scale ranged from 1 = "Almost never" to 5 = "Almost always." For the three compassionate dimensions of self-compassion, a higher score represents a higher level of self-compassion. Example items include "I try to be understanding and patient towards those aspects of my personality I don't like" and "I try to see my failings as part of the human condition." For the three uncompassionate dimensions of self-compassion, a higher score represents a lower level of self-compassion. Example items include "When I fail at something important to me, I become consumed by feelings of inadequacy" and "I'm intolerant and impatient towards those aspects of my personality I don't like." The SCS-SF includes the original six dimensions in measuring self-compassion, with two items tapping each dimension. Each dimension showed a high correlation to its long-form version, ranging from 0.84 to 0.97, as reported by using an adolescent sample (Raes et al., 2011).

The current study further examined the factor structure using confirmatory factor analyses (CFA) that examined 6-factor correlated models and correlated two-factor models (2 correlated factors each with 6 items representing compassionate or uncompassionate self-responding items; see the supplemental material for detailed procedure and results). In the following analyses, the compassionate and uncompassionate components of self-compassion were placed into two different sets of models to examine the reciprocal relationships between them and the two facets of self-regulation. This approach was chosen to reduce the number of variables for model convergence while exploring the specificity between facets of self-regulation and components of self-compassion. As each dimension of the self-compassion scale has only two items, it grants the use of Intraclass Correlation Coefficients (ICC) to represent the internal consistency (Koo & Li, 2016; Rammstedt & Beierlein, 2014). The ICC (two-way mixed random effect, consistency) for six facets of self-compassion ranged between 0.61 and 0.71 suggesting good reliability. McDonald's $\omega = 0.79$ at T1 and 0.80 at T2 for the 12-item SCS-SF.

Self-regulation The Adolescent Self-Regulation Inventory (ASRI; Moilanen, 2007) was used to assess short-term and long-term self-regulation. The short-term self-regulation scale consisted of 13 items that reflected adolescents' capacity to regulate their emotions and actions in the immediate context. Example items include "When I'm sad, I can usually start doing something that will make me feel better" and "When I'm bored, I fidget or can't sit still." The long-term self-regulation subscale included 14 items measuring an individual's ability to plan, prepare, and self-monitor in

order to achieve long-term goals (Moilanen, 2007). Example items include "I can stay focused on my work even when it's dull" and "I am usually aware of my feelings before I let them out." The 5-point Likert scale ranged from 1 = "Not at all true for me" to 5 "Really true for me." The negatively worded items were reverse coded so that higher scores represented greater self-regulation. The subscales showed satisfactory internal consistency, with Cronbach's α as 0.72 and 0.70 for short-term regulation at pretest and posttest and 0.76 for long-term regulation at both times. McDonald's $\omega = 0.72$ and 0.70 for short-term self-regulation at T1 and T2, respectively, and McDonald's $\omega = 0.74$ and 0.76 for long-term self-regulation at T1 and T2, respectively.

Data Analyses

Preliminary Analyses The means and standard deviations of all variables in the analyses were calculated and presented in Table 1 along with the correlation matrix. Paired sample *t*-tests were conducted to examine the change in scores between the two points in time. There were no significant changes in the scores of either the short-term or long-term facets of self-regulation. For the self-compassion subcomponents, self-kindness increased significantly, $t\,(537) = 2.01$, $p = 0.044$, Cohen's $d = 0.087$ ($d < 0.2$ represents a small effect by Cohen, 1988), so as did common humanity, $t\,(537) = 5.14$, $p < 0.001$, Cohen's $d = 0.22$ ($0.2 < d_2 < 0.5$ represents a small to moderate effect size by Cohen, 1988). In addition, the over-identification subcomponent showed a significant decrease across the two points in time, with $t\,(537) = 4.88$ and $p < 0.001$, Cohen's $d = 0.21$.

Cross-Lagged Models This study used a cross-lagged panel which allowed the examination of the predictive effect across two time points between facets of self-regulation and facets of self-compassion while accounting for the correlations between these constructs (measured at the prior time point). The inclusion of the autoregressive paths between constructs over time and the covariate paths among independent variables allowed us to assess the effect of prediction by only using predictors' residual variances at time 1. By doing this, we can rule out the possibility that the effects between variables across time are the reflections of the cross-sectional effects at time 1 (Selig & Little, 2012).

To test the hypotheses, a series of cross-lagged competing models were examined using AMOS 23.0 (Selig & Little, 2012). Compassionate self-responding items (mindfulness, self-kindness, and common humanity) and two facets of

Table 1 Means, standard deviations, and correlations among the study variables, $N = 538$

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	Sex	1																	
2	Age	-.034	1																
3	Mindful T1	-.192**	.083	1															
4	Mindful T2	-.220**	.032	.456**	1														
5	SK T1	-.147**	-.009	.421**	.325**	1													
6	SK T2	-.130**	.025	.286**	.520**	.488**	1												
7	CH T1	-.039	-.003	.315**	.170**	.390**	.236**	1											
8	CH T2	-.103*	.045	.208**	.329**	.289**	.415**	.441**	1										
9	SJ T1	.200**	.065	-.166**	-.152**	-.338**	-.230**	-.226**	-.109*	1									
10	SJ T2	.136**	.065	-.171**	-.203**	-.297**	-.306**	-.142**	-.173**	.522**	1								
11	OI T1	.227**	-.014	-.261**	-.242**	-.296**	-.235**	-.169**	-.119**	.528**	.386**	1							
12	OI T2	.208**	.036	-.229**	-.225**	-.261**	-.264**	-.118**	-.156**	.430**	.548**	.545**	1						
13	Isolation T1	.182**	-.041	-.201**	-.217**	-.227**	-.191**	-.160**	-.136**	.477**	.320**	.628**	.460**	1					
14	Isolation T2	.155**	.022	-.184**	-.201**	-.197**	-.226**	-.135**	-.134**	.349**	.509**	.478**	.652**	.536**	1				
15	ST SR T1	-.013	-.065	.351**	.181**	.330**	.203**	.140**	.108*	-.292**	-.260**	-.387**	-.273**	-.303**	-.262**	1			
16	ST SR T2	-.025	-.055	.236**	.314**	.273**	.317**	.115**	.199**	-.223**	-.319**	-.277**	-.335**	-.234**	-.332**	.644**	1		
17	LT SR T1	.002	-.069	.424**	.282**	.345**	.260**	.226**	.151**	-.252**	-.207**	-.261**	-.204**	-.202**	-.210**	.631**	.552**	1	
18	LT SR T2	-.011	-.059	.321**	.369**	.279**	.329**	.124**	.213**	-.130**	-.243**	-.205**	-.215**	-.141**	-.219**	.473**	.674**	.599**	1
	Mean	.51	16.43	3.36	3.41	3.04	3.12	2.87	3.09	2.86	2.83	3.32	3.11	3.03	2.97	3.11	3.11	3.62	3.62
	SD	.50	.70	.91	.89	.83	.85	.99	.99	1.07	1.01	1.06	1.02	1.10	1.04	.53	.49	.54	.52

**Correlation is significant at the 0.01 level (2-tailed)

*Correlation is significant at the 0.05 level (2-tailed)

CH common humanity, *LT* long term, *OI* over identification, *SC* self-compassion, *SJ* self-judgment, *SK* self-kindness, *SR* self-regulation, *ST* short term, *T1* pre-time 1, *T2* post-time 2

self-regulation (short-term and long-term) were entered into a single model. First, a model without cross-lagged paths, but with autocorrelations and synchronous correlations (stability model: Model 1a), was assessed (Pitts et al., 1996; Xanthopoulou et al., 2009). This autocorrelation allowed us to present the autoregressive coefficients that indicated the strengths of the associations across times for the pairs of constructs. The synchronous correlations reflected the associations among the constructs at the same time point. The second model (model 2a) was identical to the baseline model, but it included additional structural paths from the three dimensions of self-compassion at time 1 to short- and long-term self-regulation at time 2. The third model (model 3a) was identical to the baseline model, but it included paths from the dimensions of self-regulation at time 1 to the facets of self-compassion at time 2. Finally, the reciprocal model (model 4a) was tested, which included all of the paths from the previous models (as shown in Fig. 1). Age and sex (0 = male and 1 = female) were placed in all models as control variables (Bluth et al., 2017), with age linked to facets of self-regulation, and sex linked to the facets of self-compassion. As a robustness check, we further controlled for program type to account for the potential influence of the type of program, and the model outcomes did not change significantly in terms of the model fit. Therefore, we are presenting a singular model in our results. The program type was found to be positively predicting mindfulness ($\beta = 0.095$, $p = 0.01$) and short-term self-regulation ($\beta = 0.10$, $p = 0.02$) at time 2. A similar series of models were run for the uncompassionate self-responding items of self-compassion (self-judgment, over-identification, and isolation) with short-term and long-term self-regulation. Differences in these competing nested models were compared by the significance of c^2 test (Joreskog & Sorbom, 1984). Other model-fitting indices were also used, including comparative fit index (CFI) and Tucker–Lewis index (TLI); for these two indices, scores should be above 0.9 and a higher score (closer to 1) represents a better model fit (Hoyle, 1995). The root mean square of error approximation (RMSEA) was also used with a result less than 0.08 demonstrating a good model fit (Hoyle, 1995).

Results

The model fit indices and model comparisons for the two sets of cross-lagged models are presented in Table 2. For the analyses that included compassionate self-responding of self-compassion and self-regulation, the stability model (M1a) showed a poor fit with the data. Among the four competing models, the third model with only paths from self-regulation to self-compassion (M3a) fit

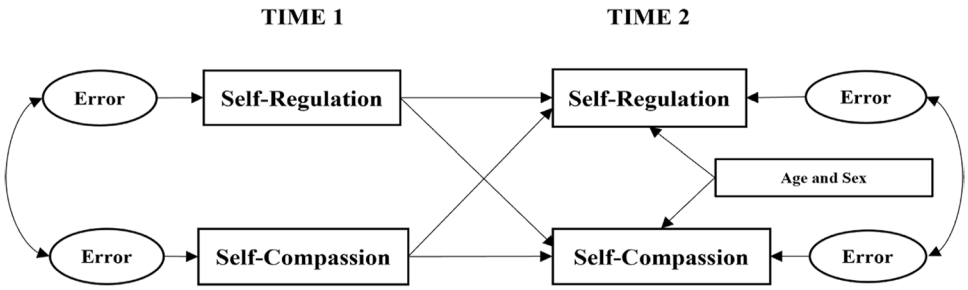

Fig. 1 Proposed reciprocal model

Table 2 Model index and model comparison, $N = 538$

Model	X^2	*df*	*p*	CFI	TLI	RMSEA	Comparison	ΔX^2	Δdf
M1a. Stability model	60.45	30	.001	.987	.967	.043	-		
M2a. Positive Self-compassion T1 → Self-regulation T2	51.12	24	.001	.989	.963	.046	M1a-M2a	9.33	6
M3a. Self-regulation T1 → Positive Self-compassion T2	**42.87**	**24**	**.01**	**.992**	**.974**	**.038**	**M1a-M3a**	**17.58****	**6**
M4a. Reciprocal model	34.67	18	.01	.993	.964	.041	M3a-M4a	8.2	6
M1b. Stability model	98.43	30	.000	.976	.937	.065	-		
M2b. Negative Self-compassion T1→ Self-regulation T2	93.21	24	.000	.976	.907	.073	M1b-M2b	5.22	6
M3b. Self-regulation T1 → Negative Self-compassion T2	**76.76**	**24**	**.000**	**.981**	**.940**	**.064**	**M1b-M3b**	**21.67****	**6**
M4b. Reciprocal model	71.05	18	.000	.981	.919	.074	M3b-M4b	5.71	6

T1 time 1, *T2* time 2, *CFI* goodness-of-fit index, *TLI* Tucker-Lewis index, *RMSEA* root mean square error of approximation

*$p < .01$; **$p < .01$

Boldface indicates the models fit the data best

Table 3 Path analysis summaries for cross-lagged models

	Positive facets of self-compassion				Negative facets of self-compassion		
	B	SE	*β*		*B*	SE	*β*
Stability model (M1a)				**Stability model (M1b)**			
ST SR T1 → ST SR T2	0.58***	0.03	0.63	ST SR T1 → ST SR T2	0.56***	0.03	0.62
LT SR T1 → LT SR T2	0.54***	0.03	0.57	LT SR T1 → LT SR T2	0.56***	0.03	0.58
SK T1 → SKT2	0.40***	0.03	0.41	SJ T1 → SJ T2	0.41***	0.03	0.44
Mindful T1 → Mindful T2	0.36***	0.03	0.38	OI T1 → OI T2	0.39***	0.03	0.43
CH T1 → CH T2	0.37***	0.03	0.41	Isolation T1 → Isolation T2	0.40***	0.03	0.44
Paths from SC- > SR (M2a)				**Paths from SC → SR (M2b)**			
SK T1 → ST SR T2	0.02	0.02	0.04	SJ T1 → ST SR2	−0.01	0.02	−0.00
Mindful T1 → ST SR 2	−0.00	0.02	−0.02	OI T1 → ST SR T2	−0.00	0.02	0.00
CH T1 → ST SR T2	0.02	0.02	0.01	Isolation T1 → ST SR T2	−0.00	0.02	−0.02
SK T1 → LT SR T2	0.03	0.02	0.05	SJ T1 → LT SR T2	0.04	0.02	0.07†
Mindfulness T1 → LT SR T2	0.04†	0.02	0.08	OI T1 → LT SR T2	−0.03	0.02	−0.06
CH T1 → LT SR T2	−0.03	0.02	−0.06	Isolation T1 → LT SR2	−0.00	0.02	−0.00
Paths from SR → SC (M3a: Best fitting)				**Paths from SR → SC (M3b: Best fitting)**			
ST SR T1 → SK T2	−0.02	0.08	−0.01	ST SR T1 → SJ T2	−0.24**	0.09	−0.13
ST SR T1 → Mindfulness T2	−0.09	0.08	−0.05	ST SR T1 → OI T2	−0.18†	0.09	−0.10
ST SR T1 → CH T2	0.03	0.08	0.02	ST SR T1 → Isolation T2	−0.20*	0.09	−0.10
LT SR T1 → SK T2	0.23**	0.08	0.15	LT SR T1 → SJ T2	−0.05	0.09	−0.03
LT SR T1 → Mindfulness T2	0.29***	0.08	0.18	LT SR T1 → OI T2	−0.08	0.09	−0.05
LT SR T1 → CH T2	0.08	0.08	0.05	LT SR T1 → Isolation T2	−0.13	0.09	−0.07

Note: †$p < 0.1$, *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

CH common humanity, *LT* long term, *OI* over-identification, *SC* self-compassion, *SJ* self-judgment, *SK* self-kindness, *SR* self-regulation, *ST* short term, *T1* pre-time 1, *T2* post-time 2

the data best, with the highest CFI = 0.994 and the lowest RMSEA = 0.032, and the significance of c^2 change. The regressive coefficients (Table 3) indicated that long-term self-regulation at time 1 was positively associated with mindfulness and self-kindness at time 2. Specifically, with each one unit increase in long-term self-regulation, mindfulness would increase by 18%, and self-kindness would increase by 15%. Sex was negatively linked to all three facets of self-compassion, such that females reported lower scores across the positive facets of self-compassion compared with males.

For the models examining the three uncompassionate dimensions of self-compassion, the stability model (M1b) also showed a poor fit with the data. Still, the model (M3b) with only paths from the two dimensions of self-regulation to the three dimensions of self-compassion fit the data best, with the highest CFI = 0.979 and the lowest RMSEA = 0.066. The regressive coefficients (Table 3) indicate that short-term self-regulation at time 1 was negatively associated with all three dimensions of uncompassionate self-compassion at time 2. Because for the three dimensions, a higher score actually represents lower self-compassion, the significant negative path between short-term self-regulation and uncompassionate dimensions of self-compassion suggested that with one unit increase in short-term self-regulation, there was a 13% drop in self-judgment, a 10% drop in over-identification, and a 10% drop for isolation. For these three dimensions of self-compassion, sex was positively associated with over-identification and isolation, such that females reported higher scores in these two dimensions of self-compassion compared to males.

Discussion

The current study investigated the reciprocal interplay between facets of self-compassion and self-regulation among adolescents participating in a mindfulness program using a longitudinal design. The findings indicated that self-regulation preceded and supported changes in self-compassion, but not vice versa. Moreover, there was specificity in these associations, such that long-term self-regulation was significant for compassionate self-responding dimensions of self-compassion while short-term self-regulation was

linked to uncompassionate self-responding dimensions of self-regulation.

This study longitudinally examined the associations between self-regulation and self-compassion within the context of mindfulness intervention among high school students. Overall, the results indicated that self-regulation contributed to changes in self-compassion. These findings are consistent with research on positive adolescent development suggesting that adaptive self-regulation plays a role in setting and pursuing goals across different domains of functioning, including self-care and compassion (Gestsdottir & Lerner, 2008). Additionally, our results demonstrated how self-compassion requires engagement in metacognitive activities to evaluate situations for the self and others (Bergen-Cico & Cheon, 2014; Neff, 2003). As indicated by the definition of self-compassion, the process of self-compassion is the reflection of inhibiting negative thoughts and feelings toward oneself and placing attention on the positive aspects of stressful events (Strauss et al., 2016); these self-regulatory processes require inhibitory control and attentional flexibility, which are key facets of executive function (Schuman-Olivier et al., 2020).

In previous studies based on the Self-Regulation Resource Model (SRRM), self-compassion was hypothesized to promote self-regulation by reducing the heated emotional states and self-blame that hinder emotional self-regulation (Sirois, 2015; Terry & Leary, 2011). These studies, however, were based on cross-sectional links between the global measures of self-compassion and self-regulation. In the current study using longitudinal cross-lagged models to evaluate the directionality of this relationship, results supported the predictive role of self-regulation. One explanation for these findings may be related to how much of the current literature on self-compassion focuses on its positive impact and buffering effects when individuals are faced with stressful events and challenges. Specifically, questions such as how self-compassion develops within the context of mindfulness practice and what cognitive processes are involved are less discussed. Therefore, while self-compassion may contribute to self-regulation in some contexts (Terry & Leary, 2011), the current study highlights the critical role of self-regulation in the attainment of self-compassion via mindfulness.

Another contribution of the current study is that it revealed the associations among facets of self-compassion and self-regulation. Six constituent components entail the overall concept of self-compassion, including self-kindness rather than self-criticism and judgment, mindfulness rather than over-identification, and common humanity rather than isolation (Neff et al., 2019). These components could be seen as a dynamic balance between compassionate versus uncompassionate ways in which individuals respond to challenging situations that involve attentional, cognitive, and emotional processes (Neff, 2016). In this study, we chose to model the three compassionate and uncompassionate facets in separate models to examine the specificity in the associations among two aspects of self-regulation and six components of self-compassion. Results suggested that short-term regulation at time 1 was associated with decreases in uncompassionate components of self-compassion at time 2, while long-term regulation at time 1 was associated with increases in compassionate components of self-compassion at time 2. In other words, short-term regulation may help to inhibit self-judgment and rumination when facing stress in the moment, while long-term regulation may promote self-kindness and mindfulness that are important for future endeavors.

When facing challenges in the immediate context, individuals may need to activate short-term self-regulatory processes that comprise inhibitory control, sustained attention, and attentional shifting (Moilanen et al., 2018) in order to stop negative judgmental thoughts against oneself, to avoid exaggeration of feelings of failure, and to modulate negative emotional reactions to stress. The associations between short-term self-regulation and uncompassionate components of self-compassion reported here are in accordance with another study that found an association between executive function and self-judgment (an uncompassionate component), but not between executive functioning and self-kindness (a compassionate component) (Shin et al., 2016). At the same time, it could be that long-term self-regulation drives one's attention to focus on distal goals that require planning and situational evaluations that activate self-soothing behaviors, including self-kindness. It also could be that, on a daily basis, the capacity for monitoring one's goal, changing perceptions of attention to goal-relevant stimuli, and actively motivating oneself to obtain long-term goals support the positive aspects of self-compassion (e.g., self-kindness and mindfulness). This link between long-term self-regulation and the compassionate component of self-compassion was partially supported by one study that found that goal regulation was significantly associated with self-compassion for college students (Neely et al., 2009).

As past literature has shown that positive and negative thoughts are functionally and statistically independent, it is reasonable to consider the compassionate and uncompassionate components of self-compassion as the representation of two underlying cognitive processing that demands different aspects of the self-regulatory processes (Amsel & Fichten, 1990; Folkman, 2008). Moreover, there was recent evidence suggesting that these items represented two distinct factors of self-compassion among youth (Sutton et al., 2017). Interestingly, in tests of construct validity, compassionate components of self-compassion were significantly correlated with perspective-taking and prosocial goals whereas the uncompassionate components were significantly linked with depression and anxiety (Sutton et al., 2017). By taking a closer examination on the compassionate components of self-compassion, the wording of some items tended to reflect

a general kindness toward oneself across situations (e.g., "I try to be understanding and patient towards those aspects of my personality I don't like" and "I try to see my failings as part of the human condition"). These items may capture the trait of self-compassion (Neff et al., 2017). On the contrary, the uncompassionate component items tend to focus on one's responses to more difficult moments (e.g., "When I fail at something that's important to me, I tend to feel alone in my failure" and "When I fail at something important to me, I become consumed by feelings of inadequacy"). Thus, it is possible that uncompassionate component items of self-compassion may guide participants to respond to their current state of mind (a state of self-compassion in the moment). Extending this to self-regulation, it may be that the items that tap long-term self-regulation also capture a more enduring trait that aligns more closely with compassionate facets of self-compassion, while the items tapping short-term regulation are more in line with the moment, state-like behaviors, similar to the uncompassionate components of self-compassion. Given that this is the first study to examine the specificity in the links among these constructs, these findings require replication in other samples.

It is important to note that the purpose of this study was to investigate the changes and the interplay between self-compassion and self-regulation among urban high school students who received a school-based mindfulness intervention. School-based mindfulness interventions are purported to be a promising avenue for promoting self-regulation and self-compassion, two important constructs for adolescents' achievement and psychological well-being (Zenner et al., 2014). Moreover, both self-regulation and self-compassion were collectively believed to serve as the mechanisms through which mindfulness-based interventions influence behavioral changes (Schuman-Olivier et al., 2020).

Findings from this study inform our understanding of the order of changes between these mechanisms among adolescents participating in mindfulness programs. These two constructs were found to be closely related, with self-regulation as the precursor to change in self-compassion. Therefore, adolescents with greater self-regulation could potentially experience more growth in self-compassion. One related implication is that adolescents may demonstrate greater changes in self-compassion through a mindfulness program which has elements that also enhance self-regulation, such as raising awareness and mindful attention practices. In summary, self-regulation is a critical mechanism that not only links mindfulness practices to healthy behaviors in adolescents (Parto & Besharat, 2011), but also promotes changes in self-compassion that lead to broader mental health outcomes.

Limitations and Future Research

There are a few notable limitations worth discussing with respect to the current study. First, the participants were all from the mindfulness programs' treatment group. Without the inclusion of a randomly assigned treatment group and control group, the observation of improved self-compassion in this study cannot rigorously support that the changes were due to responses to the mindfulness program. However, this study was not aimed to validate the effectiveness of the program, but to investigate the reciprocal associations among the two constructs of interest under the conditions of receiving the mindfulness intervention. The presence of the mindfulness program, in fact, allowed us to observe the changes of the two constructs (self-regulation and self-compassion) over time and across adolescents receiving the same type of intervention.

A second limitation of this study is the use of the short version of the Self-Compassion Scale. Although the short form allowed for quicker assessment, and thus was less of a time burden for students, it contained only two questions per facet of self-compassion. Although this approach was still validated on the measurement level in the previous studies (Raes et al., 2011) and the current one, it should still be interpreted with caution. As such, future studies could investigate associations with adopting the original 26-item measure of self-compassion (Neff, 2003) to better illuminate the interrelation between the subcomponents of the two constructs. Moreover, there is now a Self-Compassion Scale for Youth that was adapted for adolescents ages 10–14 (Neff et al., 2021); this measure would allow us to better understand self-compassion among younger adolescents. Additionally, although the ASRI is helpful in differentiating between two temporal aspects of self-regulation, the specific skills tapped by these facets are unclear. Mindfulness has been speculated to influence well-being via a variety of self-regulatory mechanisms, including executive function, attention, and emotion regulation (Broderick & Jennings, 2012; Tang et al., 2012). Thus, there is also a need for more comprehensive batteries for measuring self-regulation.

It is also worth noting the potential existence of common methods bias in this study as it relied solely on adolescents' self-report. Although this study's data collection procedure introduced a time lag between measures at two points in time that could potentially mitigate this bias to some extent, the fact that adolescents were asked to report on their self-perceived self-regulation and self-compassion is likely to produce spurious correlations among the items due to response styles and priming effects (Podsakoff et al., 2012). Future studies could use multiple informants or varied methods to mitigate the potential common methods bias (Podsakoff et al., 2012). Additionally, given that this study investigated high-school students living in one large urban city, it is uncertain whether the findings would generalize to other populations of students. Future studies could investigate these associations among more diverse samples of students.

In summary, the findings from this study suggested that self-regulation was a stronger predictor of self-compassion within the context of mindfulness intervention than vice versa. Moreover, results indicate that the positive- and negative-worded dimensions of self-compassion are not the flip sides of each other, but rather represent two distinct psychological processes that showed differential change and associations with self-regulation. Specifically, long-term self-regulation was uniquely associated with the compassionate components of self-compassion that reflect positive emotional status and self-motivation. In contrast, short-term self-regulation showed unique links with uncompassionate components of self-compassion and thus may help control the immediate impulses of criticizing oneself and curb immersion into the negative emotions that have particular meanings in adolescents' emotional and psychological well-being.

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Author Contribution YZ: designed and executed the study, conducted data analyses, and drafted the manuscript. RR: collaborated with the design and writing of the study. QW: collaborated with the design and statistical consultation. DB: collaborated with result interpretation and editing of the final manuscript. QL: collaborated with the literature search and reference checks. All authors contributed to the revisions and approved the final version of the manuscript for submission.

Data Availability The authors were not allowed to share or upload the dataset following the ethics protocol and informed consent procedure of this study that ensured the participants that all data we collected were confidential and would not be shared. We will be glad to answer any questions about the data collected in this study and to share unpublished information on this dataset.

Declarations

Ethics Approval All procedures performed were approved by the Institutional Review Board (IRB) at Syracuse University and were in accordance with the ethical standards of the IRB and with the Helsinki Declaration of 1964 and its later amendments.

Consent to Participate Informed consent was obtained from all individual participants included in the study.

Conflict of Interest The authors declare no competing interests.

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