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Motivational "Spill-Over" During Weight Control: Increased Self-Determination and Exercise Intrinsic Motivation Predict Eating Self-Regulation

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Objective: Successful weight management relies on at least two health behaviors, eating and exercise. However, little is known about their interaction on a motivational and behavioral level. Based on the Hierarchical Model of Motivation the authors examined whether exercise-specific motivation can transfer to eating regulation during a lifestyle weight control program. The authors further investigated whether general, treatment-related, and exercise motivation underlie the relation between increased exercise and improved eating regulation. ***Design:*** Overweight/obese women participated in a 1-year randomized controlled trial ($N = 239$). The intervention focused on promoting physical activity and internal motivation for exercise and weight loss, following Self-Determination Theory. The control group received general health education. ***Main Outcome Measures:*** General and exercise specific self-determination, eating self-regulation variables, and physical activity behavior. ***Results:*** General self-determination and more autonomous exercise motivation predicted eating self-regulation over 12 months. Additionally, general and exercise self-determination fully mediated the relation between physical activity and eating self-regulation. ***Conclusion:*** Increased general self-determination and exercise motivation seem to facilitate improvements in eating self-regulation during weight control in women. These motivational mechanisms also underlie the relationship between improvements in exercise behavior and eating regulation.

Keywords: Multibehavior change, autonomy, obesity, randomized controlled trial, physical activity

In contrast to many other health-enhancing treatments, weight management programs almost always target changes in two different behaviors: eating and physical activity. These two behaviors tend to cluster in cross-sectional studies (Pronk et al., 2004) and may also display interactive effects in intervention studies (C. L. Dunn et al., 2006; Jakicic, Wing, & Winters-Hart, 2002). Baker and Brownell (2000) suggested that exercise may play a key role in long-term weight management by influencing both physiological processes such as energy metabolism and appetite (see also Martins, Morgan, & Truby, 2008 for a review), as well as psychological aspects like self-efficacy, body image, or mood. Baker and Brownell argued it was important that the latter mechanisms might also result in stronger motivation and confidence, which would in turn improve eating self-regulation leading to better dietary compliance (as well as long-term exercise adherence). This model has since been partially tested and supported (Annesi & Unruh, 2008).

Yet another pathway by which exercise might positively affect the regulation of eating behavior is through its influence on variables such as motivation, commitment, and feelings of efficacy (Baker & Brownell, 2000). These effects could involve both quantitative and qualitative dimensions. On the one hand, success in adopting an exercise plan could increase confidence (self-efficacy), internal locus of control, and the overall motivational drive toward other behaviors involved in weight management, such as restricting energy-dense foods, self-monitoring, and adopting stress management practices. At the same time, it is possible that this motivational "spill-over effect" could also depend upon the *quality* of the motivation involved, specifically whether the exercise motivation is characterized by an internal locus of causality, more intrinsic motives to be active, and fueled by feelings of autonomy and self-determination (high sense of volition), as opposed to motivation being externally driven, such as to please others, and subject to strong controlling influences (lower autonomy and volition).

More autonomous and intrinsic motivation have been shown to be powerful predictors of successful self-regulation in the domains of exercise (Fortier, Sweet, O'Sullivan, & Williams, 2007), eating (Pelletier & Dion, 2007; Pelletier, Dion, Slovinec-D'Angelo, & Reid, 2004), weight loss, and weight loss maintenance (Teixeira et al., 2006; Williams, Grow, Freedman, Ryan, & Deci, 1996). However, it is unclear if affecting self-determination in one health

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domain has repercussions on the motivational regulation for other health behaviors. The hierarchical model of motivation (Vallerand, 1997; Vallerand & Ratelle, 2002) predicts that such a motivational transference is possible. It suggests that motivation operates at three hierarchically ordered levels, the situational, contextual, and global level. Situational motivation relates to a specific scenario, for example a run on a Saturday morning. Contextual motivation refers to a specific life context or domain, such as physical activity. Global motivation is the most general construct, akin to a personality construct, such as whether a person's motivation is generally more internally or more extrinsically oriented. The three levels dynamically influence each other through both top-down and bottom-up processes. Top-down processing refers to the impact of motivation of a higher level on a lower level. For example, if a person is generally self-determined toward physical activity, she will likely feel self-determined while engaging in a specific exercise activity that is relevant to her. Bottom-up processes occur when experiences on a lower level affect motivation at a higher level; for example, repeated experiences of autonomy and strong volition in specific exercise situations might affect contextual motivation toward physical activities in general, which would eventually contribute to a more self-determined motivation style (Vallerand, 1997).

A number of observational studies have shown how different levels of motivation affect each other and also how they affect behavior. Both bottom-up and top-down processes in motivation were shown in the domains of exercise between all three levels of motivation (Blanchard, Mask, Vallerand, de la Sablionnière, & Provencher, 2007). Pelletier and colleagues (Pelletier et al., 2004) reported an association between global self-determined orientation at baseline and eating-specific self-determination at follow-up 13 weeks later. Also, a positive relationship between a general level of self-determination and autonomous regulation of eating behavior was shown (Pelletier & Dion, 2007). In how far global self-determination directly affects behavior was studied in a quasi-experiment by Williams and colleagues (Williams et al., 1996): They found that general and treatment autonomy orientation predicted both attendance to a weight loss program and actual weight loss in a 6-month weight loss intervention, and also weight loss maintenance and exercise behavior at 2-year follow up.

Another important aspect of motivation transfer between two or more behaviors is the different contexts in which they might occur. For example, eating likely occurs in a family or work-related setting, whereas physical activity within a weight loss program could occur in exercise classes, group activities, or individual leisure time. Hagger and colleagues (Hagger, Chatzisarantis, Culverhouse, & Biddle, 2003) suggest that motivation underlying one behavior can transfer from one context to the next ("trans-contextual model"). Specifically, they showed that perceived autonomy support and intrinsic motivation in the context of physical education classes affects leisure time physical activity locus of causality and identified regulation. These findings have been replicated cross-culturally, showing that perceived autonomy support and autonomous exercise motives in physical education class at school transfer at least partially to exercise motivation in leisure time activities (Hagger, Chatzisarantis, Barkoukis, Wang, & Baranowski, 2005). To our knowledge, the dynamic interplay between the different contexts and hierarchical levels of motivation across different behaviors has not been tested in an experimental weight control trial.

Goals

We sought to investigate how general, treatment, and exercise-specific self-determined motivation relate to markers of eating self-regulation in the context of a weight management program. Specifically, we hypothesized that i) general, treatment, and exercise-specific self-determination and motivation transfer to, that is, are associated with important markers of eating self-regulation, and that ii) self-reported physical activity is associated with eating self-regulation through its effects on (i.e., mediated by) general self-determination, treatment motivation, as well as exercise-specific motivation.

Method

Design

The study was a randomized controlled trial in overweight and moderately obese women, primarily focused on increasing exercise self-motivation and exercise adherence, aiming at long-term weight control. The intervention group participated in weekly or biweekly sessions for approximately 1 year. Intervention targets included increasing physical activity and energy expenditure, adopting a diet consistent with a moderate energy deficit, and ultimately establishing exercise and eating patterns that would support weight maintenance. The program's principles and style of intervention were based on Self-Determination Theory (Deci & Ryan, 1985; Ryan & Deci, 2000) and focusing on increasing efficacy and self-determination toward exercise and weight control, while supporting participants' autonomous decisions as to which changes they wanted to implement and how. The control group received a general health education program. The intervention and its theoretical rationale have been described in detail elsewhere (Silva et al., 2008). The Faculty of Human Kinetics Ethics Committee reviewed and approved the study.

Participants

Participants were recruited from the community at large through media advertisements. By design, only premenopausal women ($N = 258$) were accepted into the study. Of these, 19 women were subsequently excluded from all analyses because they started taking medication (e.g., antidepressants, anxiolytics, antiepileptics) susceptible to affect weight ($n = 10$), had a serious chronic disease diagnosis or severe illness/injury ($n = 4$), became pregnant ($n = 2$) or entered menopause ($n = 3$). These 19 women were of similar age ($p = .58$) and Body Mass Index (BMI; $p = .42$) as the 239 participants considered as the valid initial sample.

Participants were between 23 and 50 years old (38 ± 6.8 years) and were overweight or mildly obese, with an initial BMI of 31.3 ± 4.1 kg/m^2. They were relatively well educated: 67% had at least some college education, 23% had between 10 and 12 years of school and 10% had 9 years or less of school education. Regarding marital status, 32% of the sample was unmarried, 56% was married, and 12% was divorced or widowed.

Women in the intervention group did not differ from those in the control group in terms of BMI, age, education, or marital status.

There were also no differences between the 208 women who completed the 12-month intervention and the 31 who quit the program for any demographic or baseline psychosocial variable, with the exception of age; women who stayed in the program were on average 4 years older ($p = .01$).

Measurements

Psychosocial measures. General self-determination was assessed with the Self-Determination Scale (Sheldon, Ryan, & Reis, 1996) which evaluates individual differences for functioning in a self-determined way. That is, being aware of one's sense of self and feeling a sense of choice toward one's behaviors. For each of 10 statement pairs such as "I always feel like I choose the things I do" and "I sometimes feel that it's not really me choosing the things I do" participants evaluated each pair on a 5-point scale from "only A feels true" to "only B feels true" (Cronbach's $\alpha = .63$).

Reasons for staying in treatment (autonomous vs. controlled) were measured using the Treatment Self-Regulation Questionnaire (Williams, Freedman, & Deci, 1998; Williams et al., 1996) which consists of 13 items and assesses the degree to which a person's motivation for participating in treatment is autonomous. On a 7-point scale, participants are asked to evaluate how well each statement represents their reasons for staying in the program (e.g., "I would have felt bad about myself if I didn't."). The questionnaire consists of two subscales, autonomous ($\alpha = .86$) and controlled ($\alpha = .80$) treatment self-regulation.

Exercise autonomous versus controlled self-regulation was assessed with the Self-Regulation Questionnaire for Exercise (adapted from Ryan & Connell, 1989). Items such as "I exercise...because I simply enjoy working out" were evaluated on a 7-point scale, ranging from not at all true to absolutely true. The scale can be divided into two subscales, autonomous (Cronbach's $\alpha = .91$) and controlled exercise self-regulation (Cronbach's $\alpha = .72$).

Exercise intrinsic motivation was measured with the Intrinsic Motivation Inventory (Ryan, 1982; Ryan & Connell, 1989). The questionnaire consists of 16 items measuring enjoyment, competence, involvement, and (absence of) pressure toward exercise, and yielding an overall score of intrinsic motivation, used in this study. It includes items such as "I think I'm good at being physically active compared to other people," evaluated on a 5-point scale from not totally agree to totally disagree ($\alpha = .94$).

Eating behavior was measured with the Three-Factor Eating Questionnaire (Stunkard & Messick, 1985). The 51-item scale is divided into three subscales: cognitive restraint ($\alpha = .82$), disinhibiton ($\alpha = .68$), and perception of hunger ($\alpha = .78$). Statements include "On social occasions, like parties, I generally eat too much," that are evaluated on a 4-point scale from agree to disagree or "If I ate too much on one day I try to make up for it on the next day," with answer format "true" or "false." Because in this study we were primarily interested in measuring markers of the cognitive control of eating behavior, we did not use the scale perception of hunger, which is highly influenced by physiological states.

The Dutch Eating Behavior Questionnaire (Van Strien, Frijters, Bergers, & Defares, 1986) was applied to assess external eating (Cronbach's $\alpha = .88$) and emotional eating ($\alpha = .95$). It consists of 31 questions such as "Do you have a desire to eat when you are irritated?" Answers are given on a 5-point scale from "never" to "very frequently."

Eating self-efficacy, the belief in one's capacity for changing eating behavior, was assessed with the Weight Management Efficacy Questionnaire (Clark, Abrams, Niaura, Eaton, & Rossi, 1991). Statements include "I can resist food when I'm nervous," to be evaluated on a 10-point scale from not at all confident to very confident. A global score including all items was used ($\alpha = .95$).

Exercise/physical activity. Minutes per week of leisure-time moderate and vigorous physical activities were estimated with the 7-Day Physical Activity Recall interview (Blair et al., 1998; A. Dunn et al., 1999). Habitual activities with a metabolic equivalent task (MET) value above 3.0 and performed during the last 7 days (or on a typical week of the past month) were quantified to produce this variable.

Statistical analyses. Twelve-month scores were used for all analyses. This choice was based on the fact that not all psychosocial variables were assessed at baseline. Most participants did not engage in regular exercise at the beginning of the intervention, which yielded exercise self-regulation measures less valid (e.g., "I exercise because I" . . .). Also, treatment self-regulation (i.e., reasons to *stay* in treatment) could only be assessed after the start of the intervention. For consistency, we decided to also use physical activity measures at 12 months, instead of change in physical activity. Because this sample was mostly sedentary at baseline, the outcome (12-month) measure was considered to represent well the result of the intervention for this variable.

Stepwise hierarchical linear regressions with general self-determination, treatment motivation, and exercise autonomous motivation were used to test our first hypothesis. Because of covariance in predictors (see Table 1), they were entered into the model in a stepwise fashion; for models in which general self-determination, treatment and exercise specific variables were entered as predictors, general self-determination and treatment measures were entered first and exercise predictors in a second step. This was done to determine the explanatory power of exercise regulation variables above and beyond general self-determination and treatment motivation.

Treatment motivation was included in the analyses to test for the effects of exercise motivation on eating self-regulation independent of more autonomous versus controlled reasons to remain in the program, thus making the test of our hypotheses more conservative. Given that exercise was an integral part of the treatment in this weight loss program, there might have been some overlap between treatment regulations (more internal or more externally controlled reasons to participate in the program) and exercise regulations. The present analyses help distinguish these processes.

Analyses were conducted for all participants (intervention and controls) together. This was done to preserve statistical power and increase variability in all measures under analysis, and also because the associations under scrutiny (self-determination as a predictor of eating self-regulation) were hypothesized to hold constant regardless of group membership. Still, it is possible that the bivariate relationships between general self-determination, treatment and exercise specific motivation, and eating variables were confounded by the intervention effect, which could have influenced both. Thus, regression analyses were further adjusted by group membership.

Table 1
Correlation Matrix of the Variables in the Study

	2	3	4	5	6	7	8	9	10	11	12	13
1. General self-determination	.30**	−.17*	.24**	−.11	.31**	.35**	.25**	−.26**	−.25**	−.23**	.17*	−.20**
2. Autonomous treatment self-regulation	—	.10	.42**	.15*	.59**	.37**	.35**	−.37**	−.29**	−.18*	.35**	−.43**
3. Controlled treatment self-regulation		—	−.04	.57**	.04	−.17*	−.07	.15+	.14+	.19**	−.11	.02
4. Intrinsic motivation			—	.07	.72**	.36**	.29**	−.28**	−.30**	−.24**	.41**	−.26**
5. Controlled exercise self-regulation				—	.19**	−.08	.11	.14+	.08	.08	.03	.03
6. Autonomous exercise self-regulation					—	.35**	.30**	−.29**	−.28**	−.17*	.36**	−.32**
7. Eating self-efficacy						—	.41**	−.70**	−.68**	−.66**	.26**	−.37**
8. TFEQ-cognitive restraint							—	−.25**	−.43**	−.19**	.30**	−.36**
9. TFEQ-disinhibition								—	.64**	.66**	−.19*	.28**
10. DEBQ-external eating									—	.57**	−.27**	.22**
11. DEBQ-emotional eating										—	−.15*	.24**
12. Minutes of physical activity											—	−.36**
13. Weight change (%, 0–12 mo.)												

Note. For weight change (%, 0–12 months): negative numbers represent weight loss, positive numbers weight gain.
+ $p < .10$ level (two-tailed). * $p < .05$ (two-tailed). ** $p < .01$ (two-tailed).

To examine whether general self-determination, treatment, and exercise-specific motivation mediated the relationship between physical activity and eating self-regulation, multiple mediation with tests of indirect effects were conducted (Preacher & Hayes, 2008). This procedure tests the first two formal steps of mediation (predictor to mediator, mediator to outcome) and then provides total, direct (not mediated) and indirect (mediated) effects of the predictor (physical activity) on outcomes (eating variables). The latter effects are then tested for significance, providing a formal test of indirect or mediated effects of the predictor on the outcomes.

Results

In the intervention group, 86% of participants attended more than 75% of the intervention sessions. In the control group (for whom attending health education sessions was not mandatory), 20% of participants attended more than 75% of the sessions. At 12 months (end of intervention), the intervention group had increased weight loss (−7.3% of initial body weight) and higher levels of physical activity/exercise (M = 300 min/wk moderate plus vigorous exercise; M = 9932 steps/day) than participants in the control group (−1.7% of initial body weight; M = 162 min/wk moderate plus vigorous exercise; M = 7852 steps/day; all ps < 0.001). Group differences in main psychosocial intervention targets were medium to large favoring the intervention group (all ps < 0.001), including general self-determination ($d = 0.40$), and autonomous self-regulation for treatment ($d = 1.35$) and exercise ($d = 1.08$). We also found group differences in eating-related variables (all ps $< .001$); the intervention group had higher eating self-efficacy ($d = 0.64$), higher cognitive restraint ($d = 0.48$), lower disinhibition ($d = -0.53$), lower emotional eating ($d = -0.28$), and lower external eating scores ($d = -0.66$). The effects of the intervention trial are reported in detail elsewhere (Silva et al., in press).

There were no baseline differences between intervention and control group for all predictor and dependent variables used in this study, except for exercise intrinsic motivation, $t(205) = -2.04$, $p = .04$. However, effect size was small ($d = 0.28$) and there was no baseline difference in autonomous exercise self-regulation; therefore, this difference was not interpreted. Table 1 shows intercorrelations among all variables in the study.

Table 2 shows the results for stepwise multiple regression models, separately for three different models as predictors of eating self-regulation: General and treatment self-determination (Model A), exercise-specific self-determination (Model B), and general, treatment, and exercise-specific self-determination (Model C). Measures of general self-determination and treatment motivation consistently predicted eating self-regulation variables with all relationships in the expected direction: positive relationships between measures of autonomy and eating variables typically associated with successful weight management (cognitive restraint and eating self-efficacy) and negative relationships for hindering eating variables (disinhibition, emotional and external eating). With the exception of disinhibition and restraint, eating measures were predicted by general self-determination. Every eating measure was predicted by at least one measure of treatment motivation (autonomous or controlled). Intrinsic exercise motivation (or autonomous exercise self-regulation) also predicted all eating variables; however, the percent variance accounted for by exercise-specific measures was slightly lower than that observed for general and treatment-related measures. Nevertheless, the exercise-specific measures which entered the model (i.e., exercise intrinsic motivation) generally predicted eating self-regulation even after accounting for general self-determination and treatment motivation.

To test whether these relationships hold when adjusting for group membership (i.e., controlling for the intervention effect), the same regression models were run, this time with the group membership always forced into the model as one predictor. Results were comparable to the unadjusted models; in particular, all five eating regulation measures that were predicted by intrinsic motivation for exercise without group adjustment were still predicted by exercise motivation when controlling for

Table 2
Stepwise Regression Analyses. Self-Determined Motivation as Predictor for Eating Self-Regulation

Dependent variable	Predictors	Model A General treatment & self-determination β	p	Model B Exercise-specific self-determination β	p	Model C General treatment & exercise-specific self-determination β	p
Eating self-efficacy	Self-determination (SDS)	0.23	.001	not tested		0.23	.001
	Autonomous treatment self-regulation (TSRQ)	0.31	<.001	not tested		0.24	.002
	Controlled treatment self-regulation (TSRQ)	−0.15	.02	not tested		not entered	
	Autonomous exercise self-regulation (ExSRQ)	not tested		0.38	<.001	not entered	
	Intrinsic motivation (IMI)	not tested		not entered		0.19	.01
	$R^2(p)$	*.23 (<.001)*		*.15 (<.001)*		*.27 (<.001)*	
TFEQ-cognitive restraint	Self-determination (SDS)	not entered		not tested		0.12	.10
	Autonomous treatment self-regulation (TSRQ)	0.34	<.001	not tested		0.24	.003
	Intrinsic motivation (IMI)	not tested		0.29	<.001	0.16	.004
	$R^2(p)$	*.12 (<.001)*		*.10 (<.001)*		*.17 (<.001)*	
TFEQ-disinhibition	Autonomous treatment self-regulation (TSRQ)	−0.38	<.001	not tested		−0.32	<.001
	Controlled treatment self-regulation (TSRQ)	0.17	.01	not tested		0.14	.05
	Autonomous exercise self-regulation (ExSRQ)	not entered		−0.33	<.001	not entered	
	Controlled exercise self-regulation (ExSRQ)	not tested		0.17	.02	not entered	
	Intrinsic motivation (IMI)	not tested		not entered		−0.16	.04
	$R^2(p)$	*.16 (<.001)*		*.12 (<.001)*		*.16 (<.001)*	
DEBQ-external eating	Self-determination (SDS)	−0.24	.001	not tested		−0.14	.06
	Autonomous treatment self-regulation (TSRQ)	−0.18	.01	not tested		−0.19	.01
	Intrinsic motivation (IMI)	not tested		−0.30	<.001	−0.19	.01
	$R^2(p)$	*.12 (<.001)*		*.09 (<.001)*		*.15 (<.001)*	
DEBQ-emotional eating	Self-determination (SDS)	−0.15	.04	not tested		−0.15	.05
	Autonomous treatment self-regulation (TSRQ)	−0.16	.03	not tested		−0.09	.23
	Controlled treatment self-regulation (TSRQ)	0.18	.01	not tested		0.17	.02
	Intrinsic motivation (IMI)	not tested		−0.26	<.001	−0.19	.01
	$R^2(p)$	*.10 (<.001)*		*.06 (<.001)*		*.12 (<.001)*	

Note. Model A: General and treatment self-determination as predictors of eating regulation. Model B: Exercise-specific self-determination as predictor of eating regulation. Model C: General, treatment, and exercise-specific self-determination as predictor of eating regulation. SDS, TSRQ autonomous and controlled were always tested as predictors of eating regulation for Model A and C; IMI, ExSRQ autonomous and controlled, were always tested as predictors of eating regulation for Model B and C. If a predictor is not listed, it did not enter any of the three models. "not-tested" means that this variable was not tested in the specific regression model; "not entered" means that this variable was tested in this specific stepwise regression model but did not enter the model due to poor empirical fit. *p*-values are based on two-tailed tests.

group (all βs between .16 and .21 or −.16 and −.21, all *p*s < .05; results not shown).

To test our second hypothesis, that is, whether general, treatment, and exercise-specific measures mediated the relationship between physical activity and eating self-regulation, mediation analyses were conducted. Variables that most consistently predicted eating self-regulation in the regression analyses were chosen as putative mediators (see Table 3). Physical activity (the predictor) was significantly correlated to all mediators, general self-determination, autonomous treatment regulation, and intrinsic exercise motivation (Table 3A). All mediators were significantly related to all eating regulation variables (the outcomes), except intrinsic exercise motivation was not related to restraint and autonomous treatment regulation was not associated with emotional eating (Table 3B). As hypothesized, physical activity was associated with all eating regulation variables in the expected directions (Table 3C). When the mediators were added to the model, the relationship between physical activity and all types of eating regulations became nonsignificant (Table 3D). Results for indirect effects (i.e., the magnitude of the mediation effect) for individual mediators were significant for most of the eating regulation variables (Table 3E). General self-determination was not significant for disinhibition and external eating, and autonomous treatment motivation not significant for emotional eating. Collectively, results showed that overall general self-determination, autonomous treatment motivation, and intrinsic exercise motivation fully mediated the relationship between physical activity and eating regulation.

Discussion

As hypothesized, exercise motivation and self-regulation was associated with several important markers of eating self-regulation. Exercise intrinsic motivation predicted eating regulation beyond general self-determination and treatment motivation. This suggests that not only general self-determination and treatment motivation "spilled-over" to eating regulation, but also that exercise-specific motivation additionally contributed to improved eating behavior. Furthermore, the relationship between self-reported physical activity and eating regulation was mediated by general self-determination, autonomous treatment motivation, and

Table 3
Summary of Mediation Analyses

A. Predictor (minutes of moderate and vigorous physical activity) to mediators (motivation)

	β	*SE*
General self-determination	.19*	.08
Autonomous treatment regulation	.34**	.07
Intrinsic motivation to exercise	.40**	.06

B. Direct effects of mediators (self-determined motivation) to outcomes (eating variables)

	Eating self-efficacy		TFEQ-cognitive restraint		TFEQ-disinhibition		DEBQ-external eating		DEBQ-emotional eating	
	β	*SE*	β	*SE*	β	*SE*	β	*SE*	β	*SE*
General self-determination	.22**	.07	.12+	.07	−.13+	.08	−.14+	.07	−.18*	.07
Autonomous treatment regulation	.24**	.08	.21**	.08	−.29**	.08	−.17*	.08	−.07	.08
Intrinsic motivation exercise	.17*	.08	.11	.08	−.15+	.09	−.16+	.09	−.21*	.09

C. Total effect of predictor (physical activity) on outcomes (eating variables)

	Eating self-efficacy		TFEQ-cognitive restraint		TFEQ-disinhibition		DEBQ-external eating		DEBQ-emotional eating	
	β	*SE*	β	*SE*	β	*SE*	β	*SE*	β	*SE*
Min moderate and vigorous physical activity	.26**	.08	.27**	.07	−.19*	.08	−.28**	.07	−.15*	.07

D. Direct effect of predictor (physical activity) on outcomes (eating variables)

	Eating self-efficacy		TFEQ-cognitive restraint		TFEQ-disinhibition		DEBQ-external eating		DEBQ-emotional eating	
	β	*SE*	β	*SE*	β	*SE*	β	*SE*	β	*SE*
Min moderate and vigorous physical activity	.06	.08	.13+	.07	−.02	.08	−.13	.08	−.01	.08

E. Normal theory tests for indirect effects

	Eating self-efficacy		TFEQ-cognitive restraint		TFEQ-disinhibition		DEBQ-external eating		DEBQ-emotional eating	
	β	*SE*	β	*SE*	β	*SE*	β	*SE*	β	*SE*
Total indirect effect	.20**	.05	.14**	.04	−.18**	.05	−.15**	.04	−.14**	.04
General self-determination	.05*	.02	.02*	.02	−.02	.02	−.02	.02	−.03+	.02
Autonomous treatment regulation	.08*	.03	.07*	.03	−.10**	.04	−.06+	.03	−.02	.03
Intrinsic motivation exercise	.08*	.04	.04*	.03	−.06+	.03	−.06+	.04	−.08*	.04

Note. + $p < 0.10$ (two-tailed). * $p < 0.05$ (two-tailed). ** $p < 0.01$ (two-tailed).

(for most eating-related outcomes) intrinsic exercise motivation. This suggests that, besides physiological effects of exercise which may affect appetite regulation, motivational mechanisms may also explain the association between physical activity and eating behaviors.

When controlling for intervention effects, the unique contribution of exercise motivation for eating regulation persists, suggesting that increase in exercise motivation is associated with eating regulation independent of the intervention treatment. One interesting difference in the group-adjusted analyses was that autonomous motivation for treatment was no longer predictive of emotional eating and external eating. This suggests a strong intervention effect on these particular variables, a fact consistent with the intervention curriculum which covered these topics to a considerable extent and in various sessions (Silva et al., 2008).

Our study's results relate to findings from other weight management intervention trials suggesting that changing both eating and exercise behavior might have synergistic effects (C. L. Dunn et al., 2006; Jakicic et al., 2002) or longer-lasting effects than diet or exercise change alone (see Miller, Koceja, & Hamilton, 1997, for a meta-analysis). However, few studies have included or reported on the effect of psychological factors, such as motivation, on multiple behavior change (J. O. Prochaska et al., 2008), thus identifying potential mechanisms underlying this synergistic change. Taking multiple behavior intervention from a behavioral to a motivational level is a promising step to discover underlying mechanisms, which in turn can be powerful targets for more successful, long-term interventions.

Qualitative changes in motivation, from less to more autonomous, may not happen in isolation but instead apply to various domains simultaneously, even if to varying degrees. In this study, more autonomous general self-determination, treatment autonomous motivation, and exercise-specific intrinsic motivation resulting from a theory-guided intervention were related to several eating self-regulation variables. The predictive power of general self-determination for eating regulation could support Vallerand's (1997) assumption of motivational bottom-up processes (e.g., an increase in exercise specific self-determination affecting increased general self-determination), which would in turn influence eating regulation (through top-down processes). However, exercise-specific motivation was associated with eating regulation beyond change in general self-determination (although explaining fewer variance than general self-determination), thus suggesting also a dynamic interplay between the two contextual levels (i.e., physical activity and eating) of motivation, in line with Hagger and colleagues' trans-contextual model (Hagger et al., 2003).

General and specific motivational change resulting from interventions is one plausible mechanism underlying the association between increased physical activity and improved eating regulation. In future studies, it could be promising to measure psychological factors simultaneously with other factors that may be involved in the relationship between physical activity and eating regulation, such as physiological (e.g., appetite regulation) or behavioral (e.g., stress management strategies), to compare their relative influences on eating behavior. It should be noted that although we specifically wanted to explore the hypothesis that led from exercise behavior and exercise motivation to eating behavior, one cannot exclude reciprocal effects at the motivational level, where, for instance, success at eating self-regulation would also positively influence motivation and/or confidence for exercising.

Our results concerning self-reported physical activity echo previous observational research suggesting physical activity as a gateway behavior for motivational changes in eating regulation (Blakely, Dunnagan, Haynes, Moore, & Pelican, 2004; Nigg et al., 1999; Tucker & Reicks, 2002). However, intervention studies have not generally found physical activity to have such a gateway function (Dutton, Napolitano, Whiteley, & Marcus, 2008; Wilcox, King, Castro, & Bortz, 2000). One possible explanation for these inconsistent findings is that motivational change toward health behaviors was not the target of the intervention trials but rather implementation of behavioral programs. For example, Wilcox and colleagues (2000) reported that both physical activity and eating behavior changed after a behavioral intervention targeting physical activity. However, change in physical activity did not explain change in eating behavior, suggesting the existence of a third factor that would underlie the change in eating through physical activity change. Such a factor could be motivational in nature, namely the extent to which motivation regulation is more self-directed and less contingent on external demands. A strictly behavior-focused intervention, not directed at creating an autonomy-promoting climate may insufficiently influence internal self-regulation and intrinsic motivation.

In conclusion, this study shows that spill-over effects may occur between treatment and exercise motivation and eating self-regulation, in the course of a weight control intervention. Furthermore, the qualitative nature of motivational regulation (i.e., intrinsic and autonomous vs. externally controlled) seem to be underlying mechanisms for the relationship between actual physical activity and eating regulation. Research concerning multiple behavior change is the future of preventive medicine (J. O. Prochaska, 2008). However, so far there has been little effort to develop theories of health behavior that directly address intervention in more than one behavior simultaneously (J. J. Prochaska, Spring, & Nigg, 2008) or programmatic research showing the effectiveness of interventions targeting two or more health behaviors (J. O. Prochaska, 2008). Investigating motivation in more detail in the context of behavioral weight management programs holds promise for the development of psychological models of multiple behavior change. It also has direct applied value, informing possible effective strategies for weight management in clinical practice.

References

Annesi, J. J., & Unruh, J. L. (2008). Relations of exercise, self-appraisal, mood changes and weight loss in obese women: Testing propositions based on Baker and Brownell's 2000 model. *The American Journal of Medical Sciences, 335,* 198–204.

Baker, C. W., & Brownell, K. D. (2000). Physical activity and maintenance of weight loss: Physiological and psychological mechanisms. In B. Christopher (Ed.), *Physical Activity and Obesity* (pp. 311–328). Champaign, IL: Human Kinetics.

Blair, S., Applegate, W., Dunn, A., Ettinger, W., Haskell, W., King, A., et al. (1998). Activity Counseling Trial (ACT): Rationale, design, and methods. *Medicine & Science in Sports and Exercise, 30,* 1097–1106.

Blakely, F., Dunnagan, T., Haynes, G., Moore, S., & Pelican, S. (2004). Moderate physical activity and its relationship to select measures of a healthy diet. *Journal of Rural Health, 20,* 160–165.

Blanchard, C., Mask, L., Vallerand, R. J., de la Sablionnière, R., & Provencher, P. (2007). Reciprocal relationships between contextual and situational motivation in a sports setting. *Psychology of Sport & Exercise, 8,* 854–873.

Clark, M. M., Abrams, D. B., Niaura, R. S., Eaton, C. A., & Rossi, J. S. (1991). Self-efficacy in weight management. *Journal of Consulting and Clinical Psychology, 59,* 739–744.

Deci, E., & Ryan, R. (1985). *Intrinsic motivation and self-determination in human behavior.* New York: Plenum Press.

Dunn, A., Marcus, B., Kampert, J., Garcia, M., Kohl, H., & Blair, S. (1999). Comparison of lifestyle and structured interventions to increase physical activity and cardiorespiratory fitness. *Journal of the American Medical Association, 281,* 327–334.

Dunn, C. L., Hannan, P. J., Jeffery, R. W., Sherwood, N. E., Pronk, N. P., & Boyle, R. (2006). The comparative and cumulative effects of a dietary restriction and exercise on weight loss. *International Journal of Obesity, 30,* 112–121.

Dutton, G. R., Napolitano, M. A., Whiteley, J. A., & Marcus, B. H. (2008). Is physical activity a gateway behavior for diet? Findings from a physical activity trial. *Preventive Medicine, 46,* 216–221.

Fortier, M. S., Sweet, S. N., O'Sullivan, T. L., & Williams, G. C. (2007). A self-determination process model of physical activity adoption in the context of a randomized controlled trial. *Psychology of Sport and Exercise, 8,* 741–757.

Hagger, M. S., Chatzisarantis, N. L., Culverhouse, T., & Biddle, S. J. H. (2003). The process by which perceived autonomy support in physical education promotes leisure-time activity intentions and behavior: A trans-contextual model. *Journal of Educational Psychology, 95,* 784–795.

Hagger, M. S., Chatzisarantis, N. L. D., Barkoukis, V., Wang, C. K. J., & Baranowski, J. (2005). Perceived autonomy support in physical education and leisure-time physical activity: A cross-cultural evaluation of the trans-contextual model. *Journal of Educational Psychology, 97,* 376–390.

Jakicic, J. M., Wing, R. R., & Winters-Hart, C. (2002). Relationship of physical activity to eating behaviors and weight loss in women. *Medicine & Science in Sports & Exercise, 34,* 1653–1659.

Martins, C., Morgan, L., & Truby, H. (2008). A review of the effects of exercise on appetite regulation: An obesity perspective. *International Journal of Obesity, 32,* 1337–1347.

Miller, W. C., Koceja, D. M., & Hamilton, E. J. (1997). A meta-analysis of the past 25 years of weight loss research using diet, exercise or diet plus exercise intervention. *International Journal of Obesity and Related Metabolic Disorders, 21,* 941–947.

Nigg, C. R., Burbank, P. M., Padula, C., Dufresne, R., Rossi, J. S., Velicer, W. F., et al. (1999). Stages of change across ten health risk behaviors for older adults. *Gerontologist, 39,* 473–482.

Pelletier, L. G., & Dion, S. C. (2007). An examination of general and specific motivational mechanisms for the relation between body dissatisfaction and eating behaviors. *Journal of Social and Clinical Psychology, 26,* 303–333.

Pelletier, L. G., Dion, S. C., Slovinec-D'Angelo, M., & Reid, R. (2004). Why do you regulate what you eat? Relationships between forms of regulation, eating behaviors, sustained dietary behavior change, and psychological adjustment. *Motivation and Emotion, 28,* 245–277.

Preacher, K. J., & Hayes, A. F. (2008). Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. *Behavioral Research Methods, 40,* 879–891.

Prochaska, J. J., Spring, B., & Nigg, C. R. (2008). Multiple health behavior change research: An introduction and overview. *Preventive Medicine, 46,* 181–188.

Prochaska, J. O. (2008). Multiple Health Behavior Research represents the future of preventive medicine. *Preventive Medicine, 46,* 281–285.

Prochaska, J. O., Butterworth, S., Redding, C. A., Burden, V., Perrin, N., Leo, M., et al. (2008). Initial efficacy of MI, TTM tailoring and HRI's with multiple behaviors for employee health promotion. *Preventive Medicine, 46,* 226–231.

Pronk, N. P., Anderson, L. H., Crain, A. L., Martinson, B. C., O'Connor, P. J., Sherwood, N. E., et al. (2004). Meeting recommendations for multiple healthy lifestyle factors. Prevalence, clustering, and predictors among adolescent, adult, and senior health plan members. *American Journal of Preventive Medicine, 27,* 25–33.

Ryan, R. M. (1982). Control and information in the intrapersonal sphere: An extension of cognitive evaluation theory. *Journal of Personality and Social Psychology, 43,* 450–461.

Ryan, R. M., & Connell, J. (1989). Perceived locus of causality and internalization: Examining reasons for acting in two domains. *Journal of Personality and Social Psychology, 57,* 749–761.

Ryan, R. M., & Deci, E. L. (2000). Intrinsic and extrinsic motivations: Classic definitions and new directions. *Contemporary Educational Psychology, 25,* 54–67.

Sheldon, K., Ryan, R., & Reis, H. (1996). What makes for a good day? *Personality and Social Psychology Bulletin, 22,* 1270–1279.

Silva, M. N., Markland, D. A., Minderico, C. S., Vieira, P. N., Castro, M. M., Coutinho, S. R., et al. (2008). A randomized controlled trial to evaluate Self-Determination Theory for exercise adherence and weight control: Rationale and intervention description. *BMC Public Health, 8,* 234.

Silva, M. N., Vieira, P. N., Coutinho, S. R., Matos, M. G., Sardinha, L. B., & Teixeira, P. J. (in press). Using self-determination theory to promote physical activity and weight control: A randomized controlled trial in women. *Journal of Behavioral Medicine.*

Stunkard, A., & Messick, S. (1985). The three-factor eating questionnaire to measure dietary restraint, disinhibition and hunger. *Journal of Psychosomatic Research, 29,* 71–83.

Teixeira, P. J., Going, S. B., Houtkooper, L. B., Cussler, E. C., Metcalfe, L. L., Blew, R. M., et al. (2006). Exercise motivation, eating, and body image variables as predictors of weight control. *Medicine & Science in Sports & Exercise, 38,* 179–188.

Tucker, M., & Reicks, M. (2002). Exercise as a gateway behavior for healthful eating among older adults: An exploratory study. *Journal of Nutrition Education & Behavior, 34,* S14–S19.

Vallerand, R. J. (1997). Toward a hierarchical model of intrinsic and extrinsic motivation. In M. P. Zanna (Ed.), *Advances in experimental social psychology* (pp. 271–360). New York: Academic Press.

Vallerand, R. J., & Ratelle, C. F. (2002). Intrinsic and extrinsic motivation: A hierarchical model. In E. L. Deci & R. M. Ryan (Eds.), *The motivation and self-determination of behavior: Theoretical and applied issues.* Rochester, NY: University of Rochester Press.

Van Strien, I., Frijters, J., Bergers, G., & Defares, P. (1986). The Dutch Eating Behavior Questionnaire (DEBQ) for assessment of restrained, emotional and external eating behavior. *International Journal Eating Disorders, 5,* 295–315.

Wilcox, S., King, A. C., Castro, C., & Bortz, W. (2000). Do changes in physical activity lead to dietary changes in middle and old age? *American Journal of Preventive Medicine, 18,* 276–283.

Williams, G. C., Freedman, Z. R., & Deci, E. L. (1998). Supporting autonomy to motivate patients with diabetes for glucose control. *Diabetes Care, 21,* 1644–1651.

Williams, G. C., Grow, V. M., Freedman, Z. R., Ryan, R. M., & Deci, E. L. (1996). Motivational predictors of weight loss and weight-loss maintenance. *Journal of Personality and Social Psychology, 70,* 115–126.