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Coprogression: Simultaneous Intervention for Multiple Health Behavior Risks

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ABSTRACT

Objective: The objective of this research is to provide the first empirical data to support the phenomenon of coprogression, which can be defined as the extent to which progressing toward healthy criteria on one behavior is associated with progressing toward healthy criteria on a second behavior at the same follow-up time point for individuals who met risk criteria for both behavior risks at baseline.

Methods: Participants (N=9,461) were predominantly middle-aged (*M*= 43.9 years, SD=10.74), White (93.8%), and female (65.4%) adults from the United States who were proactively recruited by telephone. Each participant met criteria for both behavior risks at baseline and were assessed at 24-month follow-up for the following three behavior pairs: 1) smoking and diet, 2) smoking and unprotected sun exposure, and 3) unprotected sun exposure and diet. All participants were randomized to either the TTM-tailored treatment condition (N=4,800) or the assessment-only control (N=4,661).

Results: Twenty-six out of 27 odds ratios (ORs) revealed that participants were more likely to progress toward healthy criteria on both behaviors in each behavior pair than progressing to criteria on only the second behavior in each behavior pair.

Conclusion: The significant results and occurrence of 26/27 ORs being greater than 1.0 provide empirical support for including coprogression as a phenomenon in the emerging science of multiple health behavior change (MHBC).

ARTICLE HISTORY

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Introduction

Despite the well-established association between certain behavioral risks, surprisingly little is known multiple health behavior change (MHBC). In fact, only recently has research started to address the efficacy of behavioral interventions designed to simultaneously change two or more health behavior risks (Prochaska, 2008). More specifically, only in the past few years has research started to shift toward understanding the mechanisms of action, synergistic effects and particular interrelationships among health behaviors and the interventions designed to promote change in more than one behavior risk simultaneously [1]. Toward that end, the Transtheoretical Model (TTM) has provided a theoretical framework to guide behavioral interventions across numerous health behavior risks.

The TTM is an integrative model of intentional behavior change that is centrally organized around the temporal stages of change (SOC) [2]. The SOC are five distinct time points that help advance the science of behavior change. The first stage is Precontemplation (PC) and describes the time where an individual does not intend to take action (i.e., change a behavior) in the next six months. An example would be a smoker who has no intention of quitting smoking in the next six months. The second stage is Contemplation (C) and describes the time that an individual intends to take action (i.e., quit smoking) in the next 6 months. The third stage is Preparation (PR) and describes the time when an individual intends to take action (i.e., quit smoking) in the next thirty days. The next stage is Action (A) and describes the time when an overt behavior change has occurred (i.e., quit smoking) but the change has not been maintained for six months. The last stage is Maintenance (M) and describes the time that a behavior change has been maintained (i.e., abstinence) for at least six months. Both Action and Maintenance (A/M) are equivalent to meeting healthy criteria/treatment outcomes. Critical to the SOC process is that movement through the SOC varies as some people remain in a certain SOC for a period of time while others may relapse to earlier stages before behavioral change goals are met [3]. For example, it is very common for smokers to progress and regress through the SOC several times before they finally achieve 7-day point prevalence abstinence.

Another important construct to the TTM and the science of behavior change is an individual's decisional balance (DB). Specifically, DB is the Pros and Cons of a behavior change [4] and refers to an individual's perception about the relative weights about making a particular behavior change [4]. The benefits of

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change are labeled the Pros, whereas the costs of a change are labeled the Cons. For example, a Pro of quitting smoking may be reduced cancer risk or saving money, while a Con may be experiencing nicotine withdrawal symptoms or weight gain. DB is important as it has been shown to be a reliable predictor of treatment outcomes as individuals progress through the SOC [5] and because the relationship between the Pros and Cons has been replicated across 48 problem areas [6]. In fact, the consistent pattern across multiple problem areas is referred to as the strong and weak principles [7], respectively. The former refers to progression from PC to A as a function of approximately one standard deviation increase in the Pros of a health behavior change, while the latter refers to the progression from PC to A as a function of approximately one-half standard deviation decrease in the Cons of a health behavior change. Although the strong and weak principle criteria have been replicated across 48 different problem areas, to date, there are minimal data on the relationship of the Pros or Cons during simultaneous intervention for MHBC.

Using stage-based, interactive and computer-tailored intervention (i.e., TTM) to analyze simultaneous intervention on multiple behavior risks, Paiva et al. [8] recently identified the phenomenon of coaction. Specifically, coaction was defined as the extent to which change on one behavior is associated with change on a second behavior at the same follow-up time point for individuals who met both behavioral risks at baseline. Investigating multiple behavior change, they found that individuals in the treatment condition who progressed to Action/Maintenance (A/M) (i.e., public health criteria) on one behavior were more likely to progress to criterion on a second behavior compared to those participants in the same treatment condition group who did not move to criterion on the first behavior. Despite coaction helping to advance the field, a notable limitation of this phenomenon is that it has a very stringent criterion. Specifically, coaction requires participants to meet criteria for two behavioral risks at baseline and then meet healthy criteria (i.e., A/M) for both behaviors at the same 6-month follow-up assessment.

To address this limitation, the following research investigated the phenomenon of coaction but broadened treatment outcomes to include a series of smaller, incremental steps as participants progressed toward A/M. Coprogression, as it may be called, clearly falls under the umbrella of coaction. However, coprogression represents a distinct phenomenon that will help reveal the subtle interrelationships between baseline behavioral risks and treatment outcomes. For example, extant literature demonstrates how the dynamic variables of stage of change (SOC), decisional balance (DB) and problem severity (PS) at baseline predict treatment outcomes [9-11] for single behaviors. Applying these findings to MHBC, the following research investigated the interrelationships of stage of change (SOC), decisional balance (DB) and problem severity (PS) during simultaneous intervention on multiple behavior risks. Coprogression is an important advance in the field because it provides empirical data on how and whether individuals either progress to later SOC (i.e., healthy criteria) or regress to earlier SOC (i.e., relapse) on one, both or neither behavior during simultaneous intervention. To test these hypotheses, this research analyzed the behavior pairs: 1) smoking and diet, 2) smoking and unprotected sun exposure, and 3) unprotected sun exposure and diet. Analyzing three very different behavior risks that include an addictive behavior (i.e., smoking), an energy balance behavior (e.g., diet), and a preventive care behavior (i.e., sun protection) from a theoretically grounded rationale presents unique challenges and opportunities to reveal mechanisms of action and synergistic effects undetected by current analytic approaches.

Hypothesis 1: Participants who make stage progress (i.e., progress at least one stage) from baseline to 24-months on one behavior will also make stage progress on a second behavior, with more coprogression observed in the treatment than the control.

Hypothesis 2: Participants who increase their Pros 0.4 standard deviation (SD) from baseline to 24-months on one behavior will also do the same on a second behavior, with more coprogression observed in the treatment than the control.

Hypothesis 3: Participants who decrease their problem severity 0.3 standard deviation (SD) from baseline to 24-months will also decrease their severity on a second behavior, with more coprogression observed in the treatment than the control group.

Methods

Participants

Data for this secondary data analysis were drawn from a National Cancer Institute (NCI)-funded Center grant (P01 CA27821, PI, Prochaska) that assessed the effectiveness of home, school, worksite, and medical practice-based prevention programs designed to reduce multiple behavior risks for cancer. The sample of adults (N=9,461) included parents of adolescents who were participants in a school-based study, patients from a health insurance provider, and employees from 22 identified worksites. Participants were predominantly middle-aged (X= 43.9 years, SD=10.74), White (93.8%), and female (65.4%) adults in the United States who were proactively recruited by telephone. Each participant was randomized to either the TTM-tailored treatment condition (N=4,800) or to the assessment-only control (N=4,661).

Treatment

The treatment group received computer-tailored intervention materials by mail at baseline and at 6-month intervals through 24 months, which included TTM-tailored feedback reports for all behaviors for which the participant was at-risk. In addition, participants also received an integrated stage-matched multiple behavior self-help manual [12]. This manual contained exercises to assist participants in applying change principles across multiple behaviors, including increasing the Pros of change in the early stages of the intervention.

Measures

Participants in both groups were assessed on common variables at baseline and at 24-month follow-up. Outcomes were defined as stage progress toward meeting healthy criteria (A/M). Specifically, stage progress was defined as forward transition of at least one stage toward, including meeting, Action/Maintenance criteria at 24-months. The Pros outcome measure reflected whether the participant achieved an increase

of at least 0.40 SD from baseline to 24-months. The rationale for a 0.40 increase in Pros from baseline to 24-month follow-up was drawn from the strong principle of behavior change for single behaviors. Specifically, progression from PC to A is a function of approximately one standard deviation increase in the Pros of a health behavior change for single behaviors. However, given this measure was defined as an increase in Pros for each behavior risk from baseline to 24-month follow-up for both behaviors in the behavior pair at 24-month outcome, the criterion was divided by 2. Without any empirical data for reference, this reasoned criterion is aimed to at least try to address this gap in the literature. Similarly, for the reduction of problem severity outcome, the criterion was drawn from the weak principle for single health behavior change. Specifically, the progression from PC to A is a function of approximately 0.5 standard deviation decrease in the Cons of a health behavior change. Therefore, reduction in problem severity for smoking in this research was defined as a 30% reduction in number of cigarettes smoked per day; which is approximately .50 SD divided by 2. All outcomes were dichotomous (i.e., met criteria, yes or no).

Stage of Change (SOC)

Smoking: SOC was measured by a staging algorithm that assessed participants' readiness to quit smoking with response options of 1=Precontemplation (i.e., PC- not intending to quit smoking in the next six months), 2=Contemplation (i.e., C- intending to quit smoking in the next six months), 3=Preparation (i.e., PR- intending to quit smoking in the next thirty days), 4=Action, (i.e., A- quit smoking less than six months ago), and 5=Maintenance (i.e., M- quit smoking more than six months ago).

Diet

SOC was assessed in a 3-step process. First, intention to change was assessed by the following question, "Do you consistently avoid eating high-fat foods?" Subjects responding "No" were assigned to either: a) Precontemplation– "No, and I do not intend to in the next 6 months"; b) Contemplation– "No, but I intend to in the next 6 months; or c) Preparation– "No, but I intend to in the next 30 days." Second, subjects responding "Yes," must have met a behavioral criterion of estimated fat intake ≤ 30% calories (based on the Dietary Behavior Questionnaire) to be classified into Action– "Yes, but for less than 6 months" or Maintenance– "Yes, for more than 6 months." Third, subjects who perceived that they consistently avoid high fat foods, but fail to meet the behavioral criterion were classified into Precontemplation (PC), Contemplation (C), or Preparation (PR) based on intention to change eating habits (Greene et al., 1999).

Sun Exposure

Decisional Balance and Problem Severity (Table 1).

Procedures

Adults who lived in a Northeastern state in the United States were proactively recruited by telephone. Adults who met criteria for either smoking, unhealthy diet or unprotected sun exposure were enrolled and randomized to treatment after providing informed consent. In the following analyses, each participant at baseline met criteria for both behaviors in the behavior pairs: smoking and diet, smoking and sun protection, or diet and sun protection. Analyses were conducted on participants who completed a baseline assessment and each 6-month follow-up through 24 months. The experimental condition was comprised of interactive, stage-based, computer-tailored intervention for each behavioral risk (i.e., Transtheoretical Model) and the control was assessment-only on each behavioral risk in the behavior pair.

Analysis

Coprogression rates were assessed at 24-months for all three behavior pairs on complete cases of participants who met risk criteria (i.e., either in Precontemplation (PC), Contemplation (C), or Preparation (PR) stages) for both behaviors in the pair at baseline and completed each 6-month assessment through 24 months. Stage coprogression was defined as progressing at least one stage forward through the SOC toward healthy criteria on a second behavior having progressed at least one stage forward through the SOC on the first behavior. Pros coprogression was defined as increasing a participant's Pros 0.40 SD from baseline to 24-months on a second behavior having increased his/her Pros 0.40SD from baseline to 24-months on the first behavior. Reduction on problem severity coprogression was defined as reducing problem severity by at least 0.30 SD from baseline to 24-months on the second behavior having reduced severity 0.30 SD on the first behavior from baseline to 24-months.

A series of logistic regression (LR) analyses were conducted using SPSS v18. Analyses resulted in a series of coprogression odds ratios (ORs) that estimated whether the likelihood of making stage progress, increasing Pros on decisional balance (DB), and reducing problem severity (PS) on one behavior was related to the likelihood of making similar progress on the second behavior in participants who were at-risk for the pair of behaviors at baseline. Coprogression rates were examined for each behavior pair within treatment, control and the entire sample. With three different behavior pairs and 3 conditions for each of the three hypotheses, analyses produced 9 ORs for each hypothesis and 27 ORs overall.

Results

Table 1 presents the measures and psychometric properties of decisional balance (DB) and problem severity for smoking, diet and unprotected sun exposure.

Table 2 provides demographics and stage distributions for the treatment and control groups who were at-risk for both behaviors in the behavior pair at baseline. The majority was middle-aged (X=44.9, SD=10.7), married, non-Hispanic, White females.

Table 3 presents the stage coprogression ORs and the actual proportions of participants that progressed at least one stage of change (SOC) toward criteria on both behaviors in the behavior pair from baseline to 24 months. Proportions are presented for participants who changed on both behaviors and for those who changed on only the second behavior in the pair. The table includes data for the sun protection and diet, smoking and diet, and the smoking and sun protection behavior pairs by treatment and control conditions as well for the entire sample. The results show there were significant coprogression for sun protection and diet in the full sample at

Table 1: Decisional Balance and Problem Severity: Smoking, Diet, and Sun Exposure.

	Number of Items	Response Options	Reliability	Reference
Decisional Balance				
Smoking	4 Pros of quitting 4 Cons of quitting	1="Not At All Important" to 5="Extremely Important"	Pros (α=.87) Cons (α=.90)	Velicer, DiClemente, Prochaska, & Brandenburg, 1985
Diet	3 Pros of high fat diet 3 Cons of high fat diet	1="Not At All Important" to 5="Extremely Important"	Pros (α = .52) Cons (α = .47)	Greene, Rossi, Rossi, Fava et al., 2001;Greene, Rossi, Rossi, Velicer et al., 1999; Prochaska et al., 1994; Rossi et al., 1994b; Rossi, Rossi, & Hargreaves, 1997
Sun Exposure				
Problem Severity				
Smoking	2 items	Continuous measures: number of cigarettes time to first cigarette	n/a	Fagerstrom, Heatherton, & Kozlowski, 1990
Diet	Dietary Behavior Questionnaire: 22-items (4 subscales)	Previous month: 1="Never" to 5="Almost Always"	α ranges from 0.67 to 0.84	Greene et al., 1996
Sun Exposure				

Table 2. Demographics and descriptive statistics for control, treatment, and total sample, baseline-24 months[#].

		Control			Treatment		Total	
		(N=4800)			(N=4661)		(N=9461)	
		N	%		N	%	N	%
Study	Parent	1238	25.8%		1197	25.7%	2435	25.7%
	Patient	2620	54.6%		2550	54.7%	5170	54.6%
	Worksite	942	19.6%		914	19.6%	1856	19.6%
Gender	Male	1596	34.6%		1545	34.6%	3141	34.6%
	Female	3017	65.4%		2921	65.4%	5938	65.4%
Marital Status	Married	3265	70.9%		3176	71.3%	6441	71.1%
	Not Married, living w/Partner	163	3.5%		157	3.5%	320	3.5%
	Not Married	460	10.0%		462	10.4%	922	10.2%
	Separated	89	1.9%		90	2.0%	179	2.0%
	Divorced	480	10.4%		452	10.1%	932	10.3%
	Widowed	149	3.2%		119	2.7%	268	3.0%
Ethnicity	American Indian, Alaskan	21	0.5%		20	0.4%	41	0.5%
	Asian, Pacific Islander	40	0.9%		34	0.8%	74	0.8%
	Black, Non-Hispanic	74	1.6%		82	1.8%	156	1.7%
	Hispanic	46	1.0%		45	1.0%	91	1.0%
	White	4319	93.7%		4184	93.8%	8503	93.7%
	Other/Combination	109	2.4%		96	2.2%	205	2.3%
		Mean	SD	N	Mean	SD	Mean	SD
	Age	44.07	10.7	4589	43.74	10.7	43.90	10.7

[#] Recruited in 1999 in the United States.

24-months, OR= 1.46 [1.25, 1.70], p < .001. This indicates that participants who made stage progress on sun protection were almost one and a half times more likely to make stage progress on diet, compared to participants who did not make stage progress on sun protection. For smoking and diet, results for the entire sample and control condition were significant, OR= 1.40 [1.05, 1.86], p < .021 and OR= 1.56 [1.07, 2.28], p < .021, respectively. This indicates that participants who made stage progress on smoking were each approximately one and a half times more likely to make stage progress on diet compared to participants who did not make stage progress on smoking. However, results were not significant for the treatment group, OR= 1.17 [0.76, 1.80], p < .484. For the smoking and sun protection behavior pair, results were not significant for the entire sample, treatment or control with OR= 1.16 [0.87, 1.55], p < .305, OR= 1.22 [0.81, 1.85], p < .358, and OR= 1.03 [0.70, 1.55], p < .907, respectively.

Table 4 presents the increased Pros coprogression rates and percentages of participants who increased their Pros by 0.4 standard deviation (SD) on the second behavior given a .4 SD increase on Pros on the first behavior compared to the odds of participants who only increased their Pros .4 SD on the second behavior from baseline to 24-months for the same three behavior pairs in each condition. Proportions are presented for participants who changed on both behaviors compared to those participants who only changed on the second behavior in the pair. For sun protection and diet, results for the entire sample and control condition were significant, OR= 1.38 [1.14, 1.67], p < .001 and OR= 1.71 [1.33, 2.19], p < .000, respectively. This indicates that participants who increased their Pros by .4 SD on diet given a .4 SD increase on their Pros on sun protection were more than one and a third and almost one and three quarter times more likely to increase their Pros .4 SD on diet compared to participants who only increased their Pros .4 SD on diet. However, results were not significant in the treatment group,

Table 3. Stage coprogression rates from baseline to 24-months by treatment condition # ; Percentages in control and treatment conditions reflect proportion within that condition, not total.

	Proportion (n/condition N) [95% Confidence Interval]		
	Control	Treatment	Total
Sun Protection & Diet			
Participants who made stage progress on diet given stage progress on sun protection	.34 (167/498) [.29, .38]	.48 (256/536) [.33, .57]	.41 (423/1034) [.38, .44]
Participants who made stage progress on diet given no stage progress on sun protection	.32 (399/1266) [.29, .34]	.33 (256/774) [.30, .36]	.32 (655/2040) [.30, .34]
Coprogression odds ratio[a]	1.10 (0.88, 1.37)	1.85***(1.48, 2.32)	1.46***(1.25, 1.70)
Smoking & Diet			
Participants who made stage progress on diet given stage progress on smoking	.37 (69/188) [.30, .44]	.39 (57/148) [.31, .46]	.38 (126/336) [.32, .43]
Participants who made stage progress on diet given no stage progress on smoking	.27 (95/351) [.22, .32]	.35 (74/212) [.28, .41]	.30 (169/563) [.26, .34]
Coprogression odds ratio[a]	1.56**(1.07, 2.28)	1.17 (0.76, 1.80)	1.40** (1.05, 1.86)
Smoking & Sun Protection			
Participants who made stage progress on sun protection given stage progress on smoking	.27 (47/175) [.20, .33]	.39 (65/167) [.32, .46]	.33 (112/342) [.23, .43]
Participants who made stage progress on sun protection given no stage progress on smoking	.26 (91/345) [.22, .31]	.34 (76/221) [.28, .41]	.30 (167/586) [.26, .34]
Coprogression odds ratio[a]	1.03 (0.70, 1.55)	1.22 (0.81, 1.85)	1.16 (0.87, 1.55)

[*] p< .05. ** p< .001;
[a] Coprogression rates of stage progress on second behavior given stage progress on the first behavior;
[#] Recruited in 1999 in the United States.

Table 4. 0.40 SD Pros coprogression rates from baseline to 24-months by treatment condition[#]; Percentages in control and treatment conditions reflect proportion within that condition, not total;

	Proportion (n/condition N) [95% Confidence Interval]		
	Control	Treatment	Total
Sun Protection & Diet			
Participants with .4 SD Pros increase on diet given a .4 SD Pros increase on sun protection	.29 (124/425) [.25,.33]	.21 (79/384) [.17,.25]	.25 (203/809) [.22,.28]
Participants with .4 SD Pros increase on diet given no .4 SD Pros increase on sun protection	.19 (249/1281) [.17,.21]	.20 (170/867) [.17,.23]	.20 (419/2148) [.18,.22]
Coprogression odds ratio[a]	1.71*** (1.33, 2.19)	1.06 (0.79, 1.43)	1.38*** (1.14, 1.67)
Smoking & Diet			
Participants with .4 SD Pros increase on diet given a .4 SD Pros increase on smoking	.24 (35/145) [.20,.28]	.28 (23/82) [.18,.38]	.26 (58/227) [.20,.32]
Participants with .4 SD Pros increase on diet given no .4 SD Pros increase on smoking	.21 (82/389) [.17,.25]	.18 (51/280) [.13,.23]	.20 (133/669) [.17,.23]
Coprogression odds ratio[a]	1.19 (0.76, 1.87)	1.75** (0.99, 3.09)	1.38 (0.97, 1.97)
Smoking & Sun Protection			
Participants with .4 SD Pros increase on sun protection given a .4 SD Pros increase on smoking	.35 (46/130) [.27,.43]	.28 (27/96) [.19,.37]	.32 (73/226) [.26,.38]
Participants with .4 SD Pros increase on sun protection given no .4 SD Pros increase on smoking	.23 (95/420) [.19,.27]	.25 (82/306) [.212,.32]	.24 (177/726) [.21,.27]
Coprogression odds ratio[a]	1.87** (1.22, 2.87)	1.07 (0.64, 1.78)	1.48** (1.07, 2.05)

[**] p< .05. ** p< .001;
[a] Coprogression rates of stage progress on second behavior given stage progress on the first behavior;
[#] Recruited in 1999 in the United States.

OR= 1.06 [0.79, 1.43], p < .693. For smoking and diet, results were significant in the treatment group, OR=1. 75 [0.99, 3.09], p < .052, indicating that smokers who increased their Pros .4 SD on diet given a .4 SD increase on Pros on smoking had a one and three quarter increased likelihood of increasing their Pros .4 SD on diet compared to smokers who only increased their Pros by .4 SD on diet. Results were not significant in the entire sample or control condition, OR= 1.38 [0.97, 1.97], p < .072 and OR= 1.19, [0.76, 1.87], p < .448, respectively. For smoking and sun protection, results were significant in the entire sample and the control condition, OR= 1.48 [1.07, 2.05], p < .019 and OR= 1.87 [1.22, 2.87], p < .004, respectively. This indicates that participants who increased their Pros .4 SD on sun protection given a .4 SD increased Pros on smoking were almost one and a half times and almost two times more likely to increase their Pros .4 SD on sun protection compared to smokers who only increased their Pros .4 SD on sun protection. Results were not significant in the treatment group, OR= 1.07 [0.64, 1.78], p < .799.

Table 5 presents the reduction on problem severity coprogression rates and the percentages of participants who reduced problem severity on a second behavior given reduced

Table 5. Reduction on severity coprogression rates from baseline to 24-months by treatment condition[#]; 30% reduction in smoking and a .3 SD reduction in severity on diet and sun total behavior scores; Percentages in control and treatment conditions reflect proportion within that condition, not total.

	Proportion (n/condition N) [95% Confidence Interval]		
	Control	Treatment	Total
Sun Protection & Diet			
Participants who reduced severity on diet given reduced severity on sun protection	.38 (307/814) [.35,.41]	.52 (379/733) [.48,.56]	.44 (686/1547) [.42,.46]
Participants who reduced severity on diet given no reduced severity on sun protection	.35 (339/962) [.32,.38]	.44 (262/590) [.40,.48]	.39 (601/1552) [.37,.41]
Coprogression odds ratio[a]	1.11 (0.92, 1.35)	1.34** (1.08, 1.67)	1.26** (1.09, 1.46)
Smoking & Diet			
Participants who reduced severity on diet given reduced severity on smoking	.43 (75/176) [.36,.50]	.44 (60/138) [.36,.52]	.43 (135/314) [.38,.48]
Participants who reduced severity on diet given no reduced severity on smoking	.31 (116/380) [.26,.36]	.45 (106/236) [.39,.51]	.36 (222/616) [.32,.40]
Coprogression odds ratio[a]	1.69** (1.17, 2.45)	0.94 (0.62, 1.44)	1.40** (1.01, 1.77)
Smoking & Sun Protection			
Participants who reduced severity on sun protection given reduced severity on smoking	.47 (80/170) [.39,.55]	.60 (84/141) [.52,.68]	.53 (164/311) [.47,.59]
Participants who reduced severity on sun protection given no reduced severity on smoking	.47 (179/381) [.42,.52]	.52 (136/261) [.46,.58]	.49 (315/642) [.45,.53]
Coprogression odds ratio[a]	1.00 (0.70, 1.44)	1.35 (0.90, 2.05)	1.16 (0.88, 1.52)

** p< .05. ** p< .001;
[a] Coprogression rates of stage progress on second behavior given stage progress on the first behavior;
[#] Recruited in 1999 in the United States.

problem severity on the first behavior compared to the odds of participants who only reduced problem severity on the second behavior from baseline to 24 months. Proportions are presented for participants who changed on both behaviors compared to those participants who only changed on the second behavior in the pair. The table includes data for the same three behavior pairs by treatment, control, and total condition. For sun protection and diet, results for the entire sample and treatment condition were significant, OR= 1.26 [1.09, 1.46], p < .002 and OR= 1.34 [1.08, 1.67], p < .008, respectively. This indicates that participants who reduced problem severity on diet given reduced problem severity on sun protection were more than one and a quarter times and one and a third times more likely to reduce problem severity on diet compared to participants who only reduced problem severity on diet. Results were not significant in the control group, OR= 1.11 [0.92, 1.35], p < .280. For smoking and diet, results were significant in the entire sample and the control condition, OR= 1.40 [1.01, 1.77], p < .039 and OR= 1.69 [1.17, 2.45], p < .005, respectively. This indicates that participants who reduced problem severity on diet given reduced problem severity on smoking were approximately one and a half times more likely to reduce severity on diet compared to participants who only reduced severity on diet. Results were not significant in the treatment group, OR= 0.94 [0.62, 1.44], p < .787. For smoking and sun protection, results were not significant in the entire sample, treatment or control group with OR= 1.16 [0.88, 1.52], p < .288, OR= 1.35 [0.90, 2.05], p < .152, and OR= 1.00 [0.70, 1.44], p < .987, respectively.

Discussion

Results provide empirical support for the phenomenon of coprogression as a distinct and important aspect of multiple health behavior change (MHBC). Specifically, results show there was significant coprogression for stage of change (SOC), increased Pros and reduced problem severity in each behavior pair analysis from baseline to 24-month follow-up across the treatment, control and entire sample. More specifically, participants who met the outcome criterion on one behavior were more likely to meet the outcome criterion on the second behavior in the behavior pair compared to participants who only met the criterion on the second behavior in the pair across each behavior pair analysis. Further, these data reveal that simultaneous intervention for addictive (i.e., smoking), energy balance (i.e., diet), and preventive care (i.e., sun protection) behaviors across treatment and control conditions increases the likelihood that participants will either meet healthy criteria (i.e., A/M) or at least make progress toward meeting healthy criteria on both behaviors compared to only one of the behaviors in the pair. Taken together, these data provide empirical support for the phenomenon of coprogression.

The strongest support for stage coprogression occurred in the behavior pair analyses in the entire sample, where 2/3 ORs were significant: 1) sun protection and diet and 2) smoking and diet behavior. However, it is important that the treatment condition was significant for sun protection and diet while the control condition was significant for smoking and diet. Together, 4/9 ORs in these analyses were significant and 9/9 stage coprogression ORs were greater than 1.0. This means that across the treatment and assessment-only control conditions, simultaneous intervention designed to accelerate participants through the SOC to meet healthy criteria actually increased the likelihood that participants would meet healthy criteria for both behaviors in the behavior pair compared to only meeting the criterion the first behavior in the behavior pair.

The strongest support for Pros coprogression occurred in the behavior pair analyses in the entire sample, where 2/3 ORs were significant: 1) sun protection and diet and 2) smoking and sun protection. Similar to the stage coprogression analyses, it is important that the treatment condition was significant for smoking and diet while the control condition was significant for

smoking and sun protection as well as sun protection and diet. Together, 5/9 ORs were significant and 9/9 Pros coprogression ORs were greater than 1.0. Again, this means that across the treatment and assessment-only control conditions, simultaneous intervention designed to increase a participant's Pros about making a behavior change on one behavior actually increased the likelihood that the participant would increase his/her Pros on increasing both behaviors in the behavior pair compared to increasing his/her Pros on only the first behavior in the behavior pair. This is important as increasing the Pros of decisional balance has been long established as an important baseline predictor of behavior change for singular behaviors. Now, there are empirical data to support increasing Pros as an important aspect to multiple health behavior change (MHBC). Further, these data are among the first in this area. As such, they be used to help guide and eventually establish a strong principle criterion for MHBC.

The strongest support for the reduction on problem severity coprogression occurred in the behavior pair analyses in the entire sample, where 2/3 ORs were significant: 1) sun protection and diet and 2) smoking and diet. Similar to the previous findings, it is important that the treatment condition was significant for sun protection and diet while the control condition was significant for smoking and diet. Together, 4/9 ORs were significant and 8/9 reduction on problem severity coprogression ORs were greater than 1.0. The only exception was a non-significant .94 OR for the smoking and diet behavior pair analysis in the treatment condition. This means that intervention designed to reduce problem severity on multiple health behavior risks simultaneously increases the likelihood that participants will reduce problem severity on both behaviors compared to reducing problem severity on only the first behavior of the behavior pair.

Overall, 13/27 ORs were significant and 26/27 ORs were all greater than 1.0. Taken together, these findings provide empirical support to reveal that simultaneous intervention on multiple health behavior risks for three very different behaviors increases the likelihood that participants will either meet criteria or make important, incremental progress toward healthy criteria on both behaviors compared to meeting criteria or making progress only on the first behavior in the pair. Further, the combination of significant findings and the general pattern of results in expected and favorable directions lend empirical support for coprogression as a distinct and important aspect of MHBC. Finally, these findings provide an alternative analytical approach to help reveal the synergy of MHBC which is largely undetected by current analytic approaches.

Limitations

There were several limitations of this research. First, this was a secondary data analysis. Therefore, all analyses were limited to the existing dataset. Although the primary aim of the P01 used for this research utilized stage-based, interactive and computer-tailored intervention and simultaneous intervention for multiple health behavior risks, making it an ideal dataset, analyzing behavior pairs and calculating coprogression odds ratios (ORs) among treatment, control and the entire sample was not the primary aim of the original project. Therefore, while analyses compared differences between treatment and control conditions, conclusions cannot be drawn directly comparing the two groups to one another as in a randomized controlled trial (RCT). Second, the predominantly White (n=8,503, 93.7%), female (n=5,938, 65.4%), middle-aged recruitment from a Northeastern state may present limitations with external validity.

Recommendations for future research include efficacy trials to evaluate coprogression between treatment and control conditions. Research could also broaden the behavior pair analyses to investigate numerous other behavior risks. For example, investigating the interrelationships between medication adherence, diet, and substance abuse (e.g., smoking, alcohol) among diabetics may lead to important breakthroughs in treatment and prevention of type 2 diabetes mellitus (T2DM). Further, exploring coprogression in populations among diverse demographics may reveal specific, yet undetected interrelationships, which are particularly important to the field of multiple health behavior change. With countless other examples critical to issues of quality of life, disease management and prevention, healthcare costs, and public policy, continued research on multiple health behavior change is important. Such efforts will help advance the emerging area of MHBC and possibly help guide the future of prevention and intervention research toward an integrative model of multiple health behavior change.

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