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A Longitudinal Examination of the Interrelationships between Multiple Health Behaviors in Cancer Patients

Abstract

Purpose

A healthy lifestyle following a cancer diagnosis is associated with reduced risk for a cancer recurrence. Better understanding the interrelationships between multiple health behaviors (HB) in cancer survivors could inform the development of more effective interventions to promote a healthy lifestyle.

Methods

This prospective study assessed the longitudinal interrelationships between smoking, physical activity, alcohol intake and caffeine consumption among patients with mixed cancer sites at the peri-operative period and 2, 6, 10, 14, and 18 months later. A cross-lagged design and structural equation modeling were used to assess the relationships between all four HBs over time.

Results

The study included 962 participants. The model showed a good fit to the data. For all four HBs, continuity paths consistently indicated that one particular health behavior was significantly predicted by the same health behavior at the previous time point. However, no consistent pattern of cross-lagged relationships between HBs emerged. Physical activity at 14- and 18-month evaluations was the HB most consistently involved either as a predictor as a predicted variable.

Conclusion

Overall, this study indicates that HBs assessed following cancer surgery are mostly independent and that interventions promoting HB changes during the cancer treatment trajectory need to target each health behavior separately.

Keywords

Multiple health behaviors; physical activity; health promotion; cancer; alcohol; caffeine; smoking

Introduction

The number of long-term cancer survivors has continued to grow in the last decade. Cancer survivors are nonetheless at risk for a cancer recurrence and at a greater risk to develop secondary cancers and other chronic diseases (e.g., metabolic syndrome, diabetes, obesity, cardiovascular disease) (Demark-Wahnefried, Aziz, Rowland, & Pinto, 2005). Health behaviors (HBs), such as alcohol intake, cigarette consumption, and physical activity, play a major role in disease-free survival among adults with cancer (Carmack, Basen-Engquist, & Gritz, 2011; Chen, Vazquez, Courquin, Donald, & Farwell, 2014; Twiss, Gross, Waltman, Ott, & Lindsey, 2006). More specifically, previous studies found a higher risk of recurrence of prostate, bladder and breast cancer in daily smokers (Cumberbatch et al., 2018; Foerster et al., 2018). A longitudinal association between a greater alcohol daily consumption and an increased risk of recurrence of breast and bladder cancer has also been shown (Cumberbatch et al., 2018; Simapivapan, Boltong, & Hodge, 2016; Weigl, Hauner, & Hauner, 2018). Moreover, being physically active is associated with a lower reccurence of colon cancer (Blarigan et al., 2018; Brenner & Chen, 2018). While the influence of caffeine intake on cancer recurrence has not been clarified, there is evidence showing a relationship between a greater caffeine intake and a reduced cancer incidence of endometrial, prostate and breast cancer (Lafranconi et al., 2017; Micek, Godos, Lagranconi, Marranzano & Pajak, 2018; Poole et al, 2017).

Cancer diagnosis, treatment, and survivorship phases are often considered teachable moments by health care providers for helping cancer patients to improve their HBs (Rabin, 2009). Patients may be more receptive to change their lifestyle habits at these moments because of increased negative affect and perceived vulnerability to this specific health threat, and because their self-concept (e.g., feeling like a good person) is endangered (McBride, Emmons, & Lipkus, 2003). However, in the report of the Center for Disease Control and Prevention (Underwood, 2012), which surveyed cancer survivors in 2009, 15.1% of cancer survivors were current cigarette smokers, 27.5% were obese, and 31.5% had not engaged in any leisure-time physical activity in the preceding year.

It is generally assumed that HBs are interdependent during the course of life and, consequently, that modifying one HB will lead to corollary changes in other HBs (Noble, Paul, Turon, & Oldmeadow, 2015; Spring, Moller, & Coons, 2012). Consistent with this view, a high co-occurrence of unhealthy behaviors has been found in the general population (39% to 93%) (Leatherdale & Rynard, 2013). Longitudinal trends of co-occurring unhealthy behaviors (e.g., physical activity and smoking) have also been observed in a Canadian representative sample (deRuiter, Cairney, Leatherdale, & Faulkner, 2016). However, this question remains controversial. For instance, analyses performed using the first seven waves of the Canadian National Population Health Survey revealed that an increase of physical activity and a reduction of alcohol consumption were both longitudinally associated with a reduced tobacco use, whereas no significant interdependence was found between alcohol intake and physical activity (deRuiter, Cairney, Leatherdale, & Faulkner, 2014). By contrast, in a large cross-sectional study of 250,000 respondents from the general population, Newsom et al. concluded that HBs (i.e., alcohol consumption, smoking, exercise and diet) were largely unrelated (Newsom, McFarland, Kaplan, Huguet, & Zani, 2005). These discordant findings may partly be related to different psychological variables driving particular HB changes, such as autonomous motivation (Hagger et al., 2014) or cognition transfert (Fleig et al., 2016). The different study designs or timeframes may also explain these conficting findings.

Little information is available on cross-sectional and longitudinal associations between various HBs in cancer survivors and, again, results have been inconsistent. A cross-sectional analysis, conducted in adult survivors of the 10 most common cancer types 9 years after their diagnosis, revealed that current smoking was significantly associated with greater alcohol consumption (Westmaas, Alcaraz, Berg, & Stein, 2014). A small cross-sectional association between a non-smoking status and greater regular physical activity was reported among breast and prostate cancer patients within the first year post-diagnosis (Demark-Wahnefried, Peterson, McBride, Lipkus, & Clipp, 2000). However, no cross-sectional association was found between smoking, alcohol consumption and physical activity more than 2-month after treatment in patients with breast and colon cancer (Kanera et al., 2016). In a study of adults with head and neck cancer (Duffy et al., 2008), an elevated baseline alcohol consumption was significantly associated with a greater daily tobacco use one year post-diagnosis while a smoker status at baseline was associated with a greater alcohol intake one year post-diagnosis. On the other hand, alcohol consumption and a smoker status at baseline were not associated with physical activity one year post-diagnosis. These results contrast with those of Mason et al. who showed that a pre-cancer smoker status was associated with lower levels of physical activity 5 years but not 10 years later in a cohort of breast cancer survivors (Mason et al., 2013).

In their review of this literature, Park & Gaffey proposed that different patterns of associations between various HBs could exist at different cancer treatment timeframes (Park & Gaffey, 2007). They also suggested examining the temporal disentanglement of directionality between HB changes. Indeed, examination of HBs in the context of cancer needs complex models that takes into account demographic factors (i.e., age, income, education level, weight) and cancer treatments-related factors (i.e., surgery, radiotherapy, chemotherapy, fatigue) (Hart et al., 2016; Hou & Lam, 2014; Petrick et al., 2014; Phillips & McAuley, 2013).

In sum, the available evidence on temporal interrelationship between various HBs after a cancer diagnosis is mixed. Most studies have used a cross-sectional design or a longitudinal design with two time points only, separated by several years. Additional limitations of prior research include a focus on specific cancer types and the dichotomization of HB variables into “at risk” or “not at risk” categories using specific cutpoints (e.g., with or without an alcohol use disorder). Better understanding the interrelationships between diverse HBs is important to eventually design more effective interventions aiming at promoting a better lifestyle in cancer patients.

This study aimed at investigating longitudinally the interrelationships between smoking, physical activity, alcohol intake and caffeine consumption among cancer patients with mixed cancer sites at six time points within the 18 months following the perioperative period: baseline (T1), 2 (T2), 6 (T3), 10 (T4), 14 (T5), and 18 (T6) months. It was hypothesized that each HB (e.g., T1) would predict the same HB at the subsequent time point (e.g., T2) and that these associations would remain even after adjusting for concurrent and previous levels of other HBs. In addition, cross-lagged associations were expected for all HBs, that is, each HB would predict several other HBs at the following time point.

Methods

Participants

Procedure

The current study is an ancillary analysis of a prospective cohort study on the epidemiology of cancer-related insomnia. As previously described (Savard, Villa, Ivers, Simard, & Morin, 2009), patients were recruited at L'Hôtel-Dieu de Québec and the Hôpital du St-Sacrement (CHU de Québec – Université Laval) in Québec, Canada. The study was approved by the ethic’s review boards of both hospitals. All patients meeting the initial inclusion criteria (i.e., first diagnosis of nonmetastatic cancer; scheduled to receive curative surgery; between 18 and 80 years of age) were approached by a research assistant on the day of their preoperative visit. This study used a prospective longitudinal design comprising six time assessments:

baseline (T1), 2 (T2), 6 (T3), 10 (T4), 14 (T5), and 18 (T6) months. The first two time points were separated by a 2-month interval to capture the many changes that typically occur in the first few months following a cancer surgery. Although patients were recruited before surgery, 81.2% of them completed baseline measures afterward (20 days after on average). At each time point, participants were given or mailed a battery of self-report scales that they had to complete within the next week and to mail back. Then, a phone interview was conducted to complete missing data. The demographics (e.g., age, sex, education, income) were collected using a questionnaire. Cancer-related data (e.g., cancer site and stage, adjuvant treatments received) were taken from the patient's medical record. More details on the procedure are available elsewhere (Savard et al., 2009).

Measures

Health Behaviors Questionnaire. Alcohol consumption was assessed by asking the respondent about his/her average weekly intake (number of drinks) within the previous month. A score of 0 was attributed when a patient had not consumed any alcoholic beverage. Examples were given to help them assess this quantity (e.g., one ounce of 40% alcohol = one consumption). To measure physical activity, participants were asked to report the frequency with which they engaged in moderate to vigorous aerobic activity for ≥ 20 minutes each time within the previous month. Tobacco use was measured by the daily number of cigarettes smoked. Individuals who identified themselves as non-smokers received a score of 0. Caffeine intake was determined by the number of daily caffeinated beverages drunk in the previous week, including coffee, colas and other caffeinated beverages. These items were previously used in the Canadian Health Measures Survey (Tremblay & Connor Gorber, 2007). HBs were considered as ordinal variables in the analyses because it provides estimates that are more sensitive to change over time (deRuiter et al., 2014).

Statistical analyses

A six-wave cross-lagged design and structural equation modeling were used to analyze data. To examine the longitudinal relationships between all four HBs, path analyses with cross-lagged effects were conducted by means of structural equation modeling, using 'lavaan' package (20), run in R. The cross-lagged model included cross-lagged paths linking each time point with the following assessment (e.g., from physical activity at T1 to smoking at T2), autoregressive paths (e.g., smoking at baseline to smoking at T2), and correlations within waves. All variables in this model were ordinal or binary. A robust maximum likelihood estimation was used to take into account any non-normality in the sample. Missing data (approximately 25.7% missingness for the full sample) was handled using full information maximum likelihood. Moreover, a number of fit indices were used to evaluate the model. A comparative fit index (CFI) value of 0.90 or more, a root mean square error of approximation (RMSEA) value of 0.08 or less, a chi2/df Ratio of 2 or less, and standardized root mean squared residuals (SMSR) of 0.05 or less were interpreted as indicating an acceptable fit (Hu & Bentler, 1999).

To control for the confounding effects of age, sex, income, weight, cancer type, chemotherapy and radiotherapy, these variables were included in the models as covariates. Age, sex, income, cancer type were treated as time invariant variables, while weight, chemotherapy and radiotherapy received since the last time point were treated as time-variant variables at each time point. Age was analyzed as an ordinal measure. Sex and annual family income (≤ 30 000 or >30 000 Cdn$) were both treated as binary variables. Cancer type was treated as an ordinal variable using the following five groups: breast, prostate, gynecologic, urinary and gastrointestinal and other cancers.

Results

Table 1 presents the characteristics of the sample at baseline (*N* = 962). The most frequent cancer sites were breast (48.3%), prostate (27.3%) and gynaecologic (11.5%). Descriptive statistics obtained on HB parameters at each time point are shown in Table 2. Briefly, 13% of participants were smokers at inclusion, and smokers smoked 16 cigarettes per day on average at all time points. The cumulative attrition rate across the six time points was 25.7%. On average, between six and eight monthly sessions of moderate or vigorous physical activity, four alcohol drinks per week and two daily caffeinated beverages were reported across time. Interestingly, while HB parameters were generally fairly stable, physical activity tended to increase over time.

For all four HBs, continuity paths systemically indicated that each HB was significantly predicted by the same HB at the previous time point. β values shown in Figure 1 indicate that associations between a given HB and the same HB at the following time point, were of a medium to large magnitude. The lowest associations were found for physical activity (range from β = .42 to β = .59) and the highest for smoking (ranged from β = .77 to β = .98).

Although the model showed a good fit to the data, SRMR = 0.050, RMSEA = 0.060, and CFI = 0.85, no consistent cross-temporal paths emerged between the four HBs. Only six significant unidirectional associations were found. More precisely, a higher physical activity level at T1 was significantly associated with a higher alcohol intake at T2 (β = .04, *p* = .04) and a higher physical activity at T3 was associated with a greater caffeine intake at T4 (β = .008, *p* = .04). Additionally, a lower rate of cigarette smoking at T4 was associated with a higher level of physical activity (β = -.09, *p* = .04) and a lower caffeine intake (β = -.02, *p* = .003) at T5, while a lower alcohol intake (β = -.12, *p* = .01) and a greater caffeine use (β = .50, *p* = .001) at T5, significantly predicted greater physical activity at T6. These significant associations are presented in Figure 1.

Discussion

The main goal of this investigation was to examine the cross-lagged associations between various HBs in cancer patients over an 18-month period following the perioperative phase. This study revealed that the four HBs assessed following cancer surgery (physical activity, tobacco and alcohol use, caffeine consumption) were mostly independent. No consistent cross-lagged relationships were found. Only six unique unidirectional associations were found and physical activity was the HB most consistently involved either as a predictor or as a predicted variable. Moreover, significant relationships mainly occurred at the last three time points of the study, thus towards the end or after the cancer treatments.

More specifically, greater alcohol intake at 2 months and greater caffeine consumption at 6 months were significantly associated with higher physical activity at the previous time point. These findings support the positive association between alcohol consumption and physical activity found in adults without cancer (Piazza-Gardner & Barry, 2012) but are inconsistent with the lack of association previously observed in two studies conducted in cancer patients (Duffy et al., 2008; Kanera et al., 2016). Besides, a higher level of physical activity at 14 months was significantly predicted by a lower nicotine consumption at the previous time point. This result suggests that smoking negatively affects the physical activity behavior, thus corroborating previous findings in adults with and without a history of cancer (deRuiter et al., 2014; Mason et al., 2013). Moreover, a lower alcohol intake at 14 months was associated with a higher physical activity level at 18 months. This finding is inconsistent with those of previous investigations that revealed no significant association between alcohol use and physical activity in individuals with (Duffy et al., 2008) or without (deRuiter et al., 2014) cancer. This contradictory result may be due to the different timeframes investigated and alcohol intake characterization. Another interesting result was the important association found between a greater caffeine intake at 14 months and a higher level of physical activity at 18 months. To our knowledge, this is the first study to identify caffeine use as a predictor of physical activity. This result is in line with results of a recent investigation which showed that the consumption of caffeine (versus placebo) 1 h before exercising induced improvements in exercise capacity and muscular strength in prostate cancer survivors (Cornish, Bolam, & Skinner, 2015). Hence, together, these results suggest that caffeine could increase exercise capacity.

Overall, these findings suggest that interventions promoting HB changes during the cancer treatment trajectory should target each HB separately. The relative independence between HBs observed in this study may be explained by psychological mechanisms that are known to underlie HB change and that were unsolicited during cancer treatment. One of these mechanisms is the coactivation phenomenon, which consists of an increased probability that if individuals take effective action on changing one behavior they are more likely to take action on changing a secondary behavior (Johnson et al., 2014; Prochaska, Prochaska, & Prochaska, 2014). Coactivation may not have occurred in this observational study because of the typical low level of motivation to change during and after cancer treatment. Indeed, precontemplation and contemplation stages for changing physical activity and smoking behaviors have been found in approximately 70% of breast and prostate cancer patients during the first year post-diagnosis (12). A low desire to change physical activity (13%) and smoking (11%) was also found in a mixed sample of cancer survivors (Mayer et al., 2007).

Another mechanism that may not have been active during our observational study, particularly in the first few months, is the compensatory health beliefs effect, which postulates that unhealthy behaviors can be compensated for by engaging in other health-related behaviors (Rabia, Knäuper, & Miquelon, 2006). This mechanism is especially likely to be altered in the presence of cancer-related distress and overuse of avoidance coping skills during cancer treatment (Hawkins et al., 2010; Parelkar, Thompson, Kaw, Miner, & Stein, 2013). The end of cancer treatment can stimulate the compensatory health beliefs. Consistent with this hypothesis, a study of breast, prostate and colorectal cancer survivors showed that participants who had been diagnosed between 12 and 24 months earlier reported more HB changes than those who had received their diagnosis within the last year (Bluethmann et al., 2015).

The current study attempted to circumvent limitations of previous research by using a large sample of patients with mixed cancer sites to assess the longitudinal interrelationships between four HBs. Another major strength of this study was its longitudinal design with repeated measures of HBs. Moreover, several time-dependent covariates (i.e., weight, chemotherapy and radiotherapy) were included in the analyses, which increased the validity of these results. However, this investigation also had several limitations that should be noted. Participants with unhealthy behaviors are more inclined to drop out from studies (Groeneveld, Proper, van der Beek, Hildebrandt, & van Mechelen, 2009). Hence, results obtained may not generalize to patients who have poorer HBs. The temporal associations between HBs may also had been affected by advice or conselling that patients received from their cancer care providers during and following treatment. For instance, in a Canadian study, 28% of the oncologists reported recommending PA to their patients (Jones, Courneya, Peddle, & Mackey, 2005). Several marginally significant associations were found and multiple associations were tested in our model, thus possibly inflating the Type I error rate (Cribbie, 2007). The relatively crude measures of HBs that were available in this secondary analysis of a larger study provided a less accurate quantification in comparison to specific validated tools. Additionally, self-report measures of HBs are likely to be influenced by social desirability (Adams et al., 2005). The temporal associations examined in this study may have been affected by the different intervals between time points (ranged from 2 to 4 months). Finally, nutrition, an important HB that is likely to change during and after cancer treatment (Barrera & Demark-Wahnefried, 2009), was not measured in this study.

The results of this investigation highlight that health behaviors are mainly independent in cancer patients in the 18-month period following the perioperative phase. An exception to this conclusion is physical activity which was the only HB identified as a predictor and a predicted factor. Overall, these findings suggest that interventions promoting HB changes during the cancer treatment trajectory should target each HB separately. This conclusion is in line with observations of a systematic review that include ten randomized controlled trials assessing the effects of multiple HB change interventions in cancer (Green, Hayman, & Cooley, 2015). Although quality of life and mental health outcomes were consistently enhanced, when a significant HB change occurred, it did not systematically prompt modification of another HB. For instance, Hawkes et al. assessed the efficacy of a telephone-delivered 6-month multiple HB change intervention versus usual care in colorectal cancer survivors (Hawkes et al., 2013). They observed a significant increase of moderate physical activity following the intervention, but no significant between-group differences were found on alcohol intake and smoking.

If the relative independence between HBs obtained in this study during and after cancer treatment is replicated, it would also suggest that each HB and its specific determinants should be targeted independently in an intervention (Hyman, Pavlik, Taylor, Goodrick, & Moye, 2007). Moreover, researchers investigating single HB change intervention should carrefully monitor other HBs. Indeed, cognitive or behavioral efforts that are invested to modify a specific HB decrease the ability to maintain other HBs (Martins, Morgan, & Truby, 2008; Sniehotta, Presseau, Allan, & Araújo-Soares, 2016).

More research is needed on the relationships between multiple health behaviors in the context of cancer. It would be valuable to confirm our results using objective measures of HBs (e.g., smoke analyzer, accelerometer). Future research should also be undertaken to investigate the psychological mechanisms associated with the initiation of multiple HB change during cancer treatments, such as autonomous motivation (Hagger et al., 2014), cognition transfer (Fleig, Küper, Lippke, Schwarzer, & Wiedemann, 2015), and coactivition (Prochaska et al., 2014).

Table 1
Participants' characteristics at baseline

Variable	*M* (*SD*)	*n* (%)
Age	57.0 (9.9)	
Sex (women)		619 (64.3)
Marital status		
Married/cohabiting		644 (67.4)
Single		100 (10.5)
Separated/divorced/widowed		211 (22.1)
Education (n = 948)		
Primary school or less		70 (7.4)
High school		392 (41.4)
College		237 (25.0)
University degree		249 (26.3)
Income (>30 000 CDN $) (*n* = 809)		407 (50.3)
Time since initial diagnosis (months; *n* = 938)	2.2 (1.9)	
Cancer site		
Breast		465 (48.3)
Prostate		263 (27.3)
Gynaecologic		111 (11.5)
Urinary and gastrointestinal		69 (7.2)
Other		32 (3.3)
Cancer stage [a]		
0		44 (4.6)
I		339 (35.2)
II		358 (37.2)
III		175 (18.2)
IV		25 (2.6)
Unspecified		21 (2.2)
Adjuvant treatments received (*n* = 872) [b]		
None (surgery only)		357 (37.1)
Radiation therapy		76 (7.9)
Chemotherapy		27 (2.8)
Hormone therapy		30 (3.1)
Radiation therapy and chemotherapy combined		76 (7.9)
Radiation and hormone therapies combined		142 (14.8)
Chemotherapy and hormone therapy combined		12 (1.2)
Radiation therapy, chemotherapy, and hormone therapy (all)		152 (15.8)

[a] All of the patients with stage IV cancer were included because they did not have distant metastases.
[b] Some patients did not receive any treatment while others received more than one treatment during the study

Table 2

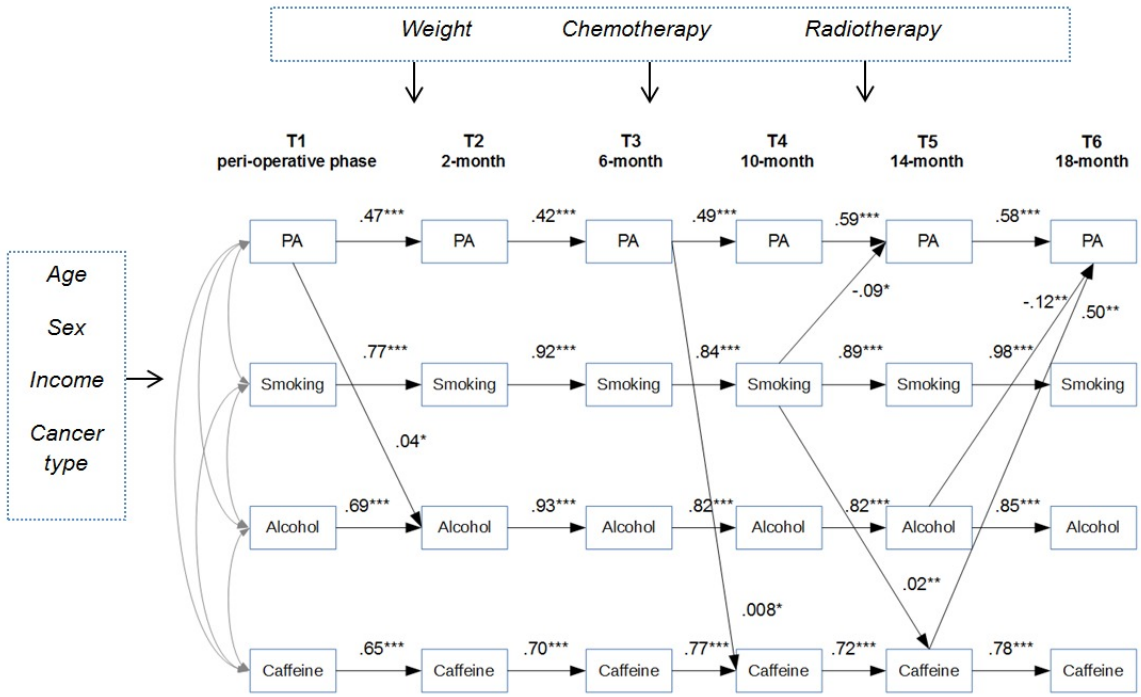
Characteristics of health behaviors

		T1	T2	T3	T4	T5	T6
Tobacco (daily number of cigarettes)	*M*	16.3	16.8	16.0	16.5	16.2	16.5
	SD	7.8	7.4	8.7	7.0	6.8	7
	min	1	1	1	1	1	1
	max	40	35	60	35	40	40
	median	15	15	15	15	15	15
	N	126	90	82	73	67	70
Physical activity (moderate to vigorous aerobic activity for ≥20min/month)	*M*	6.9	6.2	7.6	7.9	8.3	8.3
	SD	9.1	9.3	9.5	9.5	9.5	9.5
	min	0	0	0	0	0	0
	max	60	60	50	60	60	60
	median	3.0	1.0	3.0	4.0	5.0	5.0
	N	934	846	814	770	735	715
Alcohol (number of drinks/week)	*M*	4.0	3.4	4.0	4.1	4.2	4.2
	SD	5.5	5.4	6.3	6.3	6.3	6.4
	min	0.0	0.0	0.0	0.0	0.0	0.0
	max	56	50	60	60	50	56
	median	2.0	2.0	2.0	2.0	2.0	2.0
	N	946	848	813	768	735	715
Caffeine (caffeinated beverages/day)	*M*	2.4	2.1	2.1	2.2	2.1	2.1
	SD	1.6	1.5	1.5	1.5	1.4	1.4
	min	0	0	0	0	0	0
	max	12	15	14	15	10	16
	median	2.0	2.0	2.0	2.0	2.0	2.0
	N	946	847	812	771	736	715

Note. M = mean, SD = Standard deviation, min = minimum, max = maximum, N = available data for statistical analyses

Figure 1

Final model with significant relationships between health behaviors



Note. PA = Physical activity, * p <.05, ** p < .01, ** p <.001

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