HEALTH EDUCATION RESEARCH Vol.22 no.5 2007
Pages 691–702
Advance Access publication 30 November 2006

Validating the theoretical structure of the Treatment Self-Regulation Questionnaire (TSRQ) across three different health behaviors

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Abstract

Nearly 40% of mortality in the United States is linked to social and behavioral factors such as smoking, diet and sedentary lifestyle. Autonomous self-regulation of health-related behaviors is thus an important aspect of human behavior to assess. In 1997, the Behavior Change Consortium (BCC) was formed. Within the BCC, seven health behaviors, 18 theoretical models, five intervention settings and 26 mediating variables were studied across diverse populations. One of the measures included across settings and health behaviors was the Treatment Self-Regulation Questionnaire (TSRQ). The purpose of the present study was to examine the validity of the TSRQ across settings and health behaviors (tobacco, diet and exercise). The TSRQ is composed of subscales assessing different forms of motivation: amotivation, external, introjection, identification and integration. Data were obtained from four different sites and a total of 2731 participants completed the TSRQ. Invariance analyses support the validity of the TSRQ across all four sites and all three health behaviors. Overall, the internal consistency of each subscale was acceptable (most α values >0.73). The present study provides further evidence of the validity of the TSRQ and its usefulness as an assessment tool across various settings and for different health behaviors.

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Introduction

Nearly 40% of mortality in the United States is linked to social and behavioral factors such as smoking, diet and sedentary lifestyle [1–3]. A similar pattern is present worldwide suggesting that if humans were able to regulate their health risk behaviors 2.4 million cancer deaths (35% of the world's 7 million annual cancer deaths) could be avoided [4]. Self-determination theory (SDT) [5–7] proposes that autonomy is an essential factor for achieving durable change. SDT is the only theory of motivation and behavior in which the importance of autonomous self-regulation, including methods for assessing it, is emphasized.

Supporting patient autonomy is also a central tenet of clinical ethics [8] and professionalism [9]. The current US Preventive Services Guidelines on Behavioral Counseling [10] and the Public Health Service Guideline for Treating Tobacco Dependence identify supporting autonomy as an important aspect of working with patients to facilitate healthy behavior [11]. Thus, assessment of the autonomous self-regulation of health behaviors may be important for improving the health of North Americans.

In October of 1997, National Institutes of Health (NIH) Office of Behavioral and Social Sciences

doi:10.1093/her/cyl148

announced a Request for Applications focusing on 'Innovative Approaches to Disease Prevention Through Behavior Change'. Investigators were challenged to advance the science of health behavior change. Subsequently, 15 sites were funded by the NIH, with additional support from the American Heart Association and the Robert Wood Johnson Foundation and formed the Behavior Change Consortium (BCC) [12, 13]. The Treatment Self-Regulation Questionnaire (TSRQ) is a theoretically derived scale which assesses the degree of autonomous self-regulation regarding why people engage or would engage in healthy behavior, enter medical treatment, follow a treatment regimen or participate in a screening procedure to prevent disease. The BCC investigators were offered versions of the TSRQ to assess self-regulation for abstaining from tobacco, eating a healthier diet and getting regular physical activity, and four sites used the TSRQ in their studies. The goal of this paper is to describe the validation of the TSRQ across these four sites and three health behaviors.

Self-determination theory

The TSRQ is designed to assess the different forms of motivation within SDT [5, 14]. According to SDT, different types of motivation underlie people's behavior and fall along a continuum of self-determination or autonomy in the following order from least to most self-determined: amotivation, external, introjected, identified, integrated and intrinsic.

Amotivation

'Amotivation' represents the absence of motivation and thus is not self-determined. Amotivated individuals do not behave in a purposeful manner. They experience no meaningful relation between what they are doing and themselves.

Controlled regulation

According to SDT, two forms of extrinsic motivation are considered controlled. 'External regulation' refers to behavior that is performed in order to obtain a reward or to avoid negative consequences. Thus, the behavior is maintained by the presence of external contingencies in the environment. 'Introjected regulation' refers to behaviors that have been partially taken in by the person, and are performed to avoid feeling guilty or ego involved. Introjected behavior is internally controlled by the person himself although it is not self-determined.

Autonomous regulation

Three forms of motivation, including two forms or extrinsic motivation, are considered autonomous or self-determined. Commonly assessed autonomous forms of extrinsic motivation are identification and integration. 'Identification' occurs when a behavior is positively endorsed and valued by the individual. 'Integration' occurs when a behavior is perceived as being part of the larger self, as being connected to other values and behaviors that may or may not be health related (e.g. family). In autonomy supportive environments, individuals begin to identify with the contingencies and through the process of internalization are able to move beyond introjection toward identification and integration. Finally, 'intrinsic motivation' is the prototype of self-determination and underlies behaviors that are engaged for their own sake, simply for the pleasure, interest and satisfaction derived from performing them.

The different types of motivation assessed with the TSRQ have been found to relate differently to various outcomes. Autonomous forms of extrinsic motivation (e.g. identification, integration) have been found to be associated with positive health, behavioral and psychological outcomes, such as adherence to medication regimens [15, 16] and a stringent weight-loss program for morbidly obese patients [17]. In contrast, controlled forms of motivation and amotivation have been linked to non-adherence to treatment and poorer health and well-being (see [18, 19] for reviews). Furthermore, change in autonomous motivation for quitting smoking was associated with increased cessation rates [20].

Previous versions of the TSRQ

The TSRQ was first developed by Ryan and Connell [21] and has been modified and adapted to assess various health behaviors. For example,

some versions of the TSRQ examined the regulation of behaviors for patients with diabetes [22, 15], morbidly obese patients in a very low-calorie, medically supervised weight-loss program [17] or the regulation of smoking behaviors [23, 24]. The amotivation subscale has been included in only a few versions of the TSRQ. For example, it has been used in a recent study of tobacco dependence treatment [20], in a study designed to assess why patients enter treatment [25], and has been adapted to examine patients' motivation for psychotherapy [26]. The different versions of the TSRQ have included between 15 and 19 items. Intrinsic motivation is rarely assessed in the TSRQ since intrinsic motivation applies to situations in which behaviors are performed because they are interesting and enjoyable and most people do not find health-promoting behaviors to be interesting and enjoyable. Although the orienting question and the items slightly change from one version to the other, each version was comprised of items written by experts in the field to assess the different forms of motivation proposed by Deci and Ryan [5] including amotivation.

Validation strategy

In the present study, we used the 15-item TSRQ, which is part of the Health-Care, SDT Questionnaire Packet (consult www.psych.rochester.edu/SDT) and used by the BCC investigators. In previous studies [15, 17, 22], the responses on the autonomous, controlled and amotivation items have simply been averaged to reflect those three motivational constructs. Typically, identification and integration tend to cluster well together, while external and introjection tend to separate. In the present study, a formal hypothesized model, based on theory and previous research, was tested. We hypothesized that a four-factor structure would emerge with distinguishable autonomous motivation, introjection, external and amotivation factors. The validity of the TSRQ factorial structure was tested using exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) with data collected from four different sites across three health behaviors (tobacco, diet and exercise). We expected the factorial structure to be confirmed in all data sets as evidenced by strong indices of fit [e.g. confirmatory fit index (CFI) > 0.90]. We also expected the factorial structure of the TSRQ to be found equivalent across sites and health behaviors which we tested with invariance analyses. Again, we expected strong model fit to support this hypothesis (e.g. CFI > 0.90). The pattern of correlations between the TSRQ subscales was also examined to support the construct validity of the scale. We expected the subscales theoretically closer to each other on the continuum of self-determination (e.g. autonomous and introjection) to be more positively correlated than those theoretically farther apart (e.g. autonomous and amotivation), thus forming a simplex pattern. In addition, correlations between the different subscales and relevant motivational correlates were examined to support the construct and convergent validity of the four-factor structure of the TSRQ.

Methods

Participants and procedure

We obtained data on the TSRQ from University of Rochester (U of R; smoking and diet), Oregon Health and Science University (OHSU; exercise), Emory University (diet and exercise) and Stanford University (exercise).

A total of 2731 participants completed the TSRQ across the four different sites (U of R: $n = 1006$, 643 females, 360 males and 3 people who did not provide gender information; OHSU: $n = 599$, 20 females, 579 males; Emory University: $n = 909$, 698 females, 211 males; Stanford: $n = 218$, 146 females, 71 males and 1 person who did not report gender. The demographics are summarized in Table I. (Although the population for the Emory site was African American adults, ~6% of the sample did not indicate their ethnicity. That is why the reported percentage of participants who indicated being African American is ~94%.)

Participants at the U of R site were recruited through newspaper ads and sign in physician offices.

Table I. *Summary of demographics characteristics of participants from the various data sites*

Sites	Population	Mean age	Ethnicity	Highest education	Average income
U of R	Adult smokers	45.5	81.6% Caucasian 13.3% African American 2.3% Hispanic	42.0% high school 34.0% some college 24.0% graduated college	$30 000–39 999
OHSU	Active duty professional firefighters	40.0	91% Caucasian	12.0% high school 63.0% some college 24.0% graduated college	>$50 000
Stanford	General community sedentary population San Francisco Bay area	60.6	86.6% Caucasian 6.5% Hispanic 4.6% Asian 1.8% African American	4.6% high school 26.4% some college 69.0% graduated college	$60 000–69 999
Emory	African American adults attending local Atlanta churches	46.3	93.7% African American	28.0% high school 24.2% some college 42.0% graduated college	$40 000–$49 999

The study was not presented as a smoking cessation study because the general population of smokers was targeted. People who smoked five or more cigarettes per day, were 18 years of age or older, read and spoke English and had no history of a psychotic illness (depression and anxiety were allowed) were eligible to participate. Of those eligible to participate, 49% showed up for their initial appointment and were randomized to conditions. Participants at the OHSU site were recruited through fire departments. Department chiefs and union representatives of five fire departments without wellness programs in close proximity to OHSU were asked to participate. Following department approval, study information was disseminated through personal contact and an informational video and participation was offered to all full time fit-for-duty professional firefighters. Of those eligible to participate, 88% were randomized to conditions. Participants at the Emory site were recruited from 16 local churches in the Atlanta metropolitan area. Local Atlanta churches were asked to participate and the churches were randomly assigned to intervention conditions. Participants were recruited at health fairs conducted at each church. Of those eligible to participate, 86% were randomized to conditions. Participants at the Stanford site were drawn from the general community population living in the San Francisco Bay area. They came primarily from the mid-peninsula area of San Francisco Bay. People responded primarily to newspaper ads and flyers describing the study. Of those eligible to participate, 59% were randomized to conditions.

Measures

A summary of the different measures used in the various sites along with the descriptive statistics for the outcome measures is presented in Table II. All data were collected at baseline through surveys, before any intervention.

Treatment Self-Regulation Questionnaire

Each of the 15 items represents a reason for engaging in or changing a health behavior. Responses are given using a seven-point Likert type scale ranging from 1 (not at all true) to 7 (very true). (One of the sites, the Emory site, used a slightly different procedure to collect the data on the TSRQ. Participants had an additional option to indicate that the item was not applicable to them [code of 0]. Although this did not affect model fit, we also presented correlations between the different subscales without the data for participants that selected this option. This reduced the sample size for that data set to 563. The correlations based on this reduced data set are presented in parenthesis in Tables VII and VIII.) These reasons represent the different

forms of motivation proposed by Deci and Ryan [5]. Examples of the TSRQ items for tobacco are presented in Table III. For the other health behaviors assessed, the stem of the item was kept constant, while the health behavior changed. For example, an introjection item for the exercise behavior would read 'Because I would feel guilty or ashamed of myself if I did not exercise'.

Table II. *Summary of the different measures used in the various sites included in the present study and descriptive statistics for outcome measures*

Sites	TSRQ measures	Outcome measures	Mean	Standard deviation
U of R	TSRQ tobacco	Competence tobacco	4.67	1.45
	TSRQ diet	Competence diet	5.57	1.24
		CES-D	0.73	0.52
OHSU	TSRQ exercise	VO2 Max	38.18	6.93
Stanford	TSRQ exercise	Stanford (PAR)	32.53	1.00
		CES-D	0.29	0.24
Emory	TSRQ diet	Emory fruit and vegetable intake	4.37	2.32
	TSRQ exercise	YAPS		
		Vigorous	12.07	14.54
		Leisure	8.31	10.17
		Moving	8.38	4.26

CES-D, Center for Epidemiologic Studies Depression Scale.

Table III. *Factor loadings from the EFA: U of R tobacco use*

	Factors			
	1	2	3	4
Autonomous motivation				
Because stopping smoking is very important for being as healthy as possible	0.87			
Because I personally believe it is the best thing for my health	0.76			
Because I feel that I want to take responsibility for my own health	0.67			
Because stopping smoking is an important choice I really want to make	0.64			
Because I have carefully thought about it and believe stopping smoking is very important for many aspects of my life	0.62			
Because stopping smoking is consistent with my life goals	0.55			
Introjected regulation				
Because I would feel guilty or ashamed of myself if I smoked		0.97		
Because I would feel bad about myself if I smoked		0.63		
External regulation				
Because I feel pressure from others to stop smoking permanently			0.82	
Because others would be upset with me if I smoked			0.76	
Because I want others to see I can do it			0.55	
Because I want others to approve of me			0.55	
Amotivation				
I really don't think about stopping smoking				0.55
I don't really know why				0.38
Because it is easier to do what I am told than think about stopping smoking				0.33

Center for Epidemiologic Studies Depression Scale

Center for Epidemiologic Studies Depression Scale [27] was used to assess self-reported depressive symptoms in the Rochester and Stanford data sets. Patients rate how much they have experienced each of 20 depressive symptoms on a four-point scale. Radloff [27] found high interitem and test–retest reliabilities in both clinical and non-clinical samples, and the measure has been widely used in research with primary care populations. It has also been found effective in differentiating whether smokers would be able to quit [28]. In the present study, the internal consistency of the scale was adequate ($\alpha = 0.76$).

Perceived competence

Five items were used by the U of R site to assess the degree to which patients feel able to stop smoking successfully or change their diet. Respondents indicated their agreement with each item on a 1 (strongly disagree) to 7 (strongly agree) scale. (Example item: I feel confident in my ability to stop smoking permanently.) In a previous study examining behavior change related to smoking, the items were found to have good internal consistency ($\alpha = 0.91$) [20]. In the present data sets, the internal consistency was also adequate ($\alpha = 0.86$ for smoking and 0.89 for diet).

Emory fruit and vegetable intake

Multiple measures of dietary intake were obtained to provide a converging (i.e. triangulated) estimate of true intake. These measures have been described in detail elsewhere [29]. All participants completed the recently developed National Cancer Institute 19-item fruit and vegetable food frequency questionnaire (FFQ) assessing intake in the past month [30]. A 2-item measure was used to assess usual fruit and vegetable intake; one item each for fruit and vegetable consumed 'each day' [31]. The third instrument used was a 36-item fruit and vegetable FFQ based on the Health Habits and History Questionnaire [31], originally developed for the Eat for Life study [29]. The three measures were averaged to yield a composite fruit and vegetable variable.

Emory physical activity

Emory physical activity was measured using the YALE Physical Activity Survey (YPAS) [32]. The YPAS is an interviewer-administered questionnaire divided into two sections from which a total of eight indices can be calculated. For the purpose of the present study, we focused on three activity dimensions: vigorous activity, leisurely walking and moving. Each individual index is created by multiplying a frequency score by a duration score for each specific activity (e.g. vigorous activity).

OHSU physical activity

Physical parameters assessed included aerobic capacity (peak oxygen uptake). Oxygen uptake was measured during Bruce protocol treadmill exercise to maximal exertion using a SensorMedics 2900 or a MedGraphics TEEM 100 metabolic cart, with the same instrument used for an individual's pre- and 1-year testing. Maximal exertion was defined as volitional exhaustion, a plateau in heart rate and a respiratory exchange ratio >1.05 [33]. VO2 Max testing was chosen because of a strong relation between improvement in maximal treadmill time and decreased risk in mortality [34].

Stanford physical activity recall

Stanford physical activity recall (PAR) was used by the Stanford site. Minutes spent in physical activities of moderate and higher intensities as well as general levels of physical activity and energy expenditure were assessed using the 7-day PAR, developed originally at the Stanford Center for Research in Disease Prevention for the Stanford Five-City Project [35]. This interviewer-administered recall has been used successfully in a variety of studies and its validity, reliability and sensitivity to change documented in a range of populations. Interrater and test–retest reliabilities have been reported in the 0.69–0.86 range [36] and concurrent validity coefficients in the 0.75–0.84 range [37, 38]. The PAR was selected as the principal outcome measure for the NIH multisite Activity Counseling Trial [39].

Results

Phase I: EFAs

A series of EFAs with oblimin rotation were conducted to examine the viability of the proposed four-factor structure. One EFA was performed for each data set obtained, thus a total of six EFAs were conducted. Overall, the four-factor structure was supported in all six data sets. As expected, integration and identification items formed one factor, the autonomous motivation factor. For example, Table III presents the factor loadings for U of R for tobacco use. The internal consistency of the four subscales was also assessed for the six different data sets analyzed using Cronbach's alpha. The internal consistency for three of the four factors was acceptable ranging from 0.85 to 0.93 for autonomous motivation, from 0.74 to 0.86 for introjection and from 0.73 to 0.91 for external regulation. For amotivation, one value was found to be unacceptable (0.41), but the rest were acceptable ranging from 0.73 to 0.79. Overall, internal consistencies were adequate. The descriptive statistics for the TSRQ subscales for all sites and health behaviors assessed are presented in Table IV.

Phase II: CFAs

A series of CFA using LISREL 8 were conducted to confirm the hypothesized factorial structure of the TSRQ and its invariance across sites and health behaviors (tobacco use, diet and exercise), thus testing whether the TSRQ provided equivalent information across data sets. The following logic was followed. A CFA was conducted for each of the six data sets available in order to confirm the factorial structure of the TSRQ for each data set individually. Second, the invariance analyses were conducted, and assessed the equivalence of the TSRQ within each site measuring more than one health behavior and then assessed the equivalence of the TSRQ within each health behavior across the different sites. In each set of invariance analyses, a baseline model was first tested in which the validity of the factorial structure of the TSRQ was simultaneously examined across data sets without imposing any constraints on the various estimated parameters (factor loadings, error variances, covariances). Then, the factor loadings were specified to be the same across data sets allowing a test of the equivalence of the factorial structure.

Table IV. *Summary of the descriptive statistics for the TSRQ subscales for all sites and health behaviors assessed*

Sites	Autonomy	Introjection	External regulation	Amotivation
U of R				
Tobacco	6.08 (1.09)	3.14 (1.95)	3.05 (1.67)	1.85 (1.11)
Diet	5.85 (1.29)	2.99 (1.83)	2.05 (1.30)	2.15 (1.28)
OHSU				
Exercise	5.79 (1.01)	4.28 (1.64)	2.56 (1.21)	2.12 (1.04)
Stanford				
Exercise	6.20 (0.88)	3.52 (1.64)	2.38 (1.15)	2.08 (1.04)
Emory				
Exercise	4.06 (1.21)	1.89 (2.31)	1.17 (2.44)	1.41 (2.42)
Diet	4.07 (1.14)	1.96 (2.28)	1.00 (2.31)	1.48 (2.15)

Standard deviations are presented in parentheses.

Individual confirmatory factor analyses

Results of the CFA for all data sets were acceptable. The factor loadings were all significant for all models tested ($z > 1.96$). As expected, the χ^2 values were also found to be significant as this index of fit is highly sensitive when the sample size is large. In addition, the CFI and incremental fit index (IFI) were excellent ranging from 0.94 to 0.97 across the six models tested. The goodness of fit (0.89–0.94) and the root mean square error of approximation (RMSEA; 0.6–0.09) were also good across all models. For example, Fig. 1 displays the CFA for OHSU for exercise.

Invariance analyses within sites and across health behaviors

The U of R site assessed behaviors related to tobacco and diet. The initial model with all factor loadings freely estimated was excellent. Although the χ^2 value was significant [χ^2 (168, n = 1006) = 1333.90, $P < 0.05$], the CFI and IFI were 0.95, and the RMSEA was 0.08, indicating that the hypothesized four-factor structure of the TSRQ was representing the data accurately for tobacco and

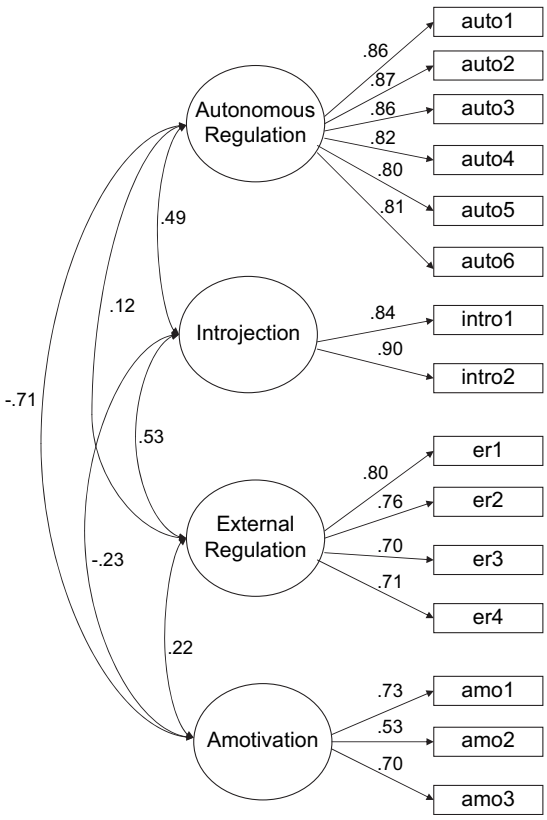

Fig. 1. CFA model for the OHSU site for exercise.

diet. Next, in the invariance model, all the factor loadings were specified to be of equal values for both health behaviors. Overall, the fit indices were adequate and indicated that the TSRQ was equivalent across the two health behaviors [χ^2 (179, n = 1006) = 2028.86, $P < 0.05$; CFI and IFI were 0.92, and the RMSEA was 0.11].

Emory provided data on the TSRQ for exercise and diet behaviors. The initial model with all factor loadings freely estimated was excellent. As expected, the χ^2 value was significant [χ^2 (168, n = 909) = 974.98, $P < 0.05$]. The CFI and IFI were 0.97, and the RMSEA was 0.07, supporting the validity of the hypothesized structure. In the invariance model, all the factor loadings were fixed to be equal for both health behaviors. Overall, the fit indices were excellent and indicated that the TSRQ was equivalent across diet and physical activity [χ^2 (179, n = 909) = 1017.29, $P < 0.05$; CFI and IFI were 0.97, and the RMSEA was 0.07].

Invariance analyses within health behaviors and across sites

Three sites administered the TSRQ for exercise behaviors: OHSU, Emory and Stanford. The initial model fit was excellent with all factor loadings freely estimated [χ^2 (252) = 1291.29, $P < 0.05$]. The CFI and IFI were 0.97, and the RMSEA was 0.08, indicating that the hypothesized four-factor structure of the TSRQ adequately represented the exercise data across those three sites. In the invariance model, the factor loadings were constrained to be equal across the three exercise sites. Overall, the fit indices were very good and indicated that the TSRQ for exercise was similar across the sites [χ^2 (274) = 1885.84, $P < 0.05$; CFI and IFI were 0.95, and the RMSEA was 0.11].

Two sites administered the TSRQ for diet: U of R and Emory. The initial model was good. The χ^2 value was significant [χ^2 (168) = 2763.38, $P < 0.05$], the CFI and IFI were 0.90, and the RMSEA was 0.13, suggesting that the hypothesized four-factor structure was valid. In the invariance model, all the factor loadings were constrained to be equal for the TSRQ model for diet tested across the two different sites. The findings for diet were not as strong in support of the equivalence of the TSRQ; the resultant fit indices suggested that the model was moderately adequate [χ^2 (179) = 3336.35, $P < 0.05$; CFI and IFI were 0.87, and the RMSEA was 0.15].

Correlations between the subscales of the TSRQ and the health outcomes assessed were used to further examine the validity of the TSRQ. Tables V through X present these correlations for the different sites. Autonomous motivation tended to be significantly and positively associated with positive health outcomes (e.g. composite fruit and vegetable consumption, greater levels of physical activity, higher VO2 Max values) and not associated or negatively associated with negative health outcomes (e.g. depression). In contrast, non-self-determined forms of motivation (e.g. introjection,

Table V. *Correlations between TSRQ subscales and motivational correlates for the U of R site: tobacco use*

	1	2	3	4	5	6
1. Autonomous	1.00					
2. Introjection	0.30**	1.00				
3. External	0.13**	0.59**	1.00			
4. Amotivation	−0.30**	0.04	0.13**	1.00		
5. Competence	0.44**	0.09**	−0.01	−0.15**	1.00	
6. Depression	−0.05	0.12**	0.14**	0.07*	−0.12*	1.00

*$P < 0.05$; **$P < 0.01$.

Table VI. *Correlations between TSRQ subscales and motivational correlates for the U of R site: diet*

	1	2	3	4	5	6
1. Autonomous	1.00					
2. Introjection	0.25**	1.00				
3. External	0.14**	0.53**	1.00			
4. Amotivation	−0.38**	0.02	0.16**	1.00		
5. Competence	0.54**	0.09**	0.02	−0.22**	1.00	
6. Depression	−0.01	0.16**	0.19**	0.08**	−0.14**	1.00

**$P < 0.01$.

Table VII. *Correlations between TSRQ subscales and motivational correlates for the Emory site: diet*

	1	2	3	4	5
1. Autonomous	1.00				
2. Introjection	0.33**	1.00			
	(0.33**)				
3. External	0.23**	0.56**	1.00		
	(0.12**)	(0.49**)			
4. Amotivation	0.09**	0.40**	0.67**	1.00	
	(−0.16**)	(0.24**)	(0.56**)		
5. Composite Fruit and Vegetable	0.28**	0.08*	0.07*	−0.01	1.00
	(0.28**)	(0.15**)	(0.12**)	(−0.04)	

Correlations in parentheses are based on the reduced data set ($n = 563$). Although the population for the Emory site was African American adults, ~6% of the sample did not indicate their ethnicity. That is why the reported percentage of participants who indicated being African American is about 94%.
*$P < 0.05$; **$P < 0.01$.

external regulation and amotivation) tended to be significantly and positively associated with negative health outcomes (e.g. depression and amount of calories from fat) and weakly or significantly negatively associated with positive health outcomes [e.g. perceived competence (PC) to change a health behavior, total fruits and vegetables consumed and physical activity]. However, introjection was significantly associated with greater levels of physical activity and higher VO2 Max values at OHSU. This is consistent with findings from other studies, which found a significant relationship between introjection and increases in positive health outcomes [24, 39].

In addition, the hypothesized simplex pattern of relations between the TSRQ subscales was found at all sites [5]. That is, the subscales closer to each other on the continuum of self-determination (e.g. autonomous and introjection) were more positively correlated than those theoretically farther apart (e.g. autonomous and amotivation).

Discussion

Overall, the results of the present study support the construct validity of the 15-item TSRQ, the hypothesized four-factor structure representing different forms of motivation and the equivalence across three different health behaviors (tobacco, diet and exercise) and across four different research sites.

Specifically, results of the CFA supported the validity of the four-factor structure hypothesized and tested in the six different data sets examined. When the hypothesized models were constrained to be equivalent across health behaviors and then across sites, results of the invariance analyses again supported the validity of the TSRQ. The internal consistency of the different TSRQ subscales was acceptable across the different sites, except for one low value for the amotivation subscale in one data set.

The pattern of relations among the TSRQ motivation subscales and between the TSRQ motivation subscales and various health outcomes supported the validity of the four-factor structure. Importantly, the simplex pattern was observed in each data set examined. The pattern of relations between the subscales of the TSRQ and a mental health indicator

Table VIII. *Correlations between TSRQ subscales and motivational correlates for the Emory site: exercise*

	1	2	3	4	5	6	7
1. Autonomous	1.00						
2. Introjection	0.41** (0.41**)	1.00					
3. External	0.28** (0.26**)	0.65** (0.64**)	1.00				
4. Amotivation	0.22** (0.15**)	0.51** (0.46**)	0.77** (0.76**)	1.00			
5. Vigorous	0.07 (0.08)	0.02 (0.06)	−0.09* (−0.03)	−0.14** (−0.14**)	1.00		
6. Leisure	0.12** (0.14**)	0.05 (0.05)	0.01 (−0.01)	−0.07 (−0.11*)	0.43** (0.45**)	1.00	
7. Moving	0.11** (0.14**)	0.01 (0.02)	0.03 (−0.02)	−0.03 (−0.05)	0.11** (0.13**)	0.23** (0.25**)	1.00

Correlations in parentheses are based on the reduced data set (n = 563). Although the population for the Emory site was African American adults, ~6% of the sample did not indicate their ethnicity. That is why the reported percentage of participants who indicated being African American is about 94%.
*P < 0.05; **P < 0.01.

Table IX. *Correlations between TSRQ subscales and motivational correlates for the OHSU site: exercise*

	1	2	3	4	5	6
1. Autonomous	1.00					
2. Introjection	0.43**	1.00				
3. External	0.10*	0.46**	1.00			
4. Amotivation	−0.56**	−0.15**	0.22**	1.00		
5. VO2 Max	0.23**	0.21**	−0.03	−0.19**	1.00	
6. Physical activity	0.30**	0.23**	0.04	−0.16**	0.39**	1.00

**P < 0.05; **P < 0.01.

Table X. *Correlations between TSRQ subscales and motivational correlates for the Stanford site: exercise*

	1	2	3	4	5	6
1. Autonomous	1.00					
2. Introjection	0.31**	1.00				
3. External	0.10	0.46**	1.00			
4. Amotivation	−0.47**	−0.16*	−0.01	1.00		
5. Depression	−0.01	0.21**	0.12	0.08	1.00	
6. Physical activity	0.16*	0.22**	0.04	−0.15*	0.08	1.00

*P < 0.05; **P < 0.01.

(depressive symptoms) and physical health indicators (fruit and vegetable intake, fat intake, physical activity and VO2 Max) provided strong construct validity evidence. Overall, autonomous motivation was found to be positively associated with positive health outcomes such as PC and total fruit and vegetable consumption, and greater levels of physical activity, including improved VO2 Max. In contrast, introjection, external regulation and amotivation were generally found to be positively associated with a negative health outcome like depression. This pattern of results was also observed in the recent Rochester's tobacco use study reported elsewhere [20].

Notably, the modest but consistent simplex pattern of relations found between VO2 Max and the TSRQ subscales are striking because of the strong relation between VO2 Max and mortality. Blair *et al*. [34] identified a 7.9% reduction in risk of mortality for each minute increase in maximal treadmill time, and showed a 44% reduction in mortality for men who improved or maintained physical fitness compared with those who remained unfit over a span of 5 years. In addition, these relations are important because the VO2 Max is a physiological measure, and thus not subject to error related to self-reported variables. Thus, the

various levels of self-regulation for physical activity related as hypothesized to physical fitness.

Previous research has shown that maintenance of glycemic control measured on HbA1c [15], long-term maintenance of abstinence from tobacco [40] and reduction in low density lipoprotein cholesterol are also predicted by autonomous self-regulation measured with the TSRQ [41]. Taken together, these results provide further construct validity supporting the relation between self-regulation measured with the TSRQ and overall physical health.

One of these clinical trials demonstrated that autonomous self-regulation can be facilitated by a clinical intervention intended to increase patients' willingness to participate in treatment [20]. Not only does this demonstrate that health can be improved by facilitating the process of internalization of autonomy but also it is consistent with the tenets of clinical ethics and professionalism in medicine.

Although the results of the present study are very encouraging, the data remain cross-sectional in nature. However, it is important to note that the measure's sensitivity to change has been assessed and established for the target behavior of smoking [20]. The sensitivity to change of the TSRQ for diet and exercise and the test–retest reliability remain to be explored in future studies. While the present analyses involved thousands of participants, from diverse populations, generalization of these conclusions to all populations needs to be further established. Nonetheless, the results of the present study provide very good evidence of the stability of the TSRQ and its generalizability to various health domains.

In summary, analyses across the four BCC sites that utilized the TSRQ to measure self-regulation for behavior change have provided reasonable evidence for the validity and reliability of this measure and for its consistency across studies of tobacco use, diet and physical activity. Health researchers now have a reliable and valid scale that can be used to assess motivation across a variety of health behaviors which account for a high percentage of morbidity and mortality in the United States [3] and the world [4]. Establishing measures that relate to important health behaviors and their change represent an important step in determining how interventions improve health for those at risk. As autonomy is also a fundamental aspect of clinical medicine and ethical care, assessing the self-regulation continuum in medical care may provide insight into a variety of clinical domains, and has potential broad implications for reliably assessing the quality and effectiveness of health care.

Acknowledgements

This study was supported by grant R01-MH59594, cofunded by the National Institute of Mental Health and the National Cancer Institute. We also want to acknowledge the supplemental funds that were provided for cross-site activities. We want to thank the other sites that provided data for this cross-site analysis: OHSU, Emory University and Stanford University.

Conflict of interest statement

None declared.

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Received on February 23, 2006; accepted on September 18, 2006