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Knowledge of Risk Factors for Type 2 Diabetes Mellitus in Adolescents: Psychometric Analysis of Instrument

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The study evaluates the psychometric properties of the instrument Knowledge of Risk Factors for Type 2 Diabetes Mellitus in Adolescents. T2DM is on the increase among adolescents and there are no instruments to assess knowledge of risk factors in this population. The author revised parts of an adult instrument and reviewed the items for content validity. The final instrument, comprising 11 items, was administered to 225 high-school students 13 to 19 years of age in the New York City area. An exploratory factor analysis was conducted using maximum likelihood estimation and geomin rotation. Two factors were extracted. The overall reliability of the scale was found to be acceptable at .76. The instrument appears to be a promising tool for the evaluation of knowledge of risk factors for T2DM in adolescents.

Keywords: type 2 diabetes, risk factors, adolescents, instrument development

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Résumé

La connaissance des facteurs de risques en matière de diabète sucré de type 2 chez les adolescents : analyse psychométrique de l'instrument

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Cette étude évalue les propriétés psychométriques de l'instrument *Knowledge of Risk Factors for Type 2 Diabetes Mellitus in Adolescents* [Connaissance des facteurs de risques en matière de diabète sucré de type 2 chez les adolescents]. Le taux de diabète sucré est à la hausse chez les adolescents et il n'existe aucun instrument pour évaluer la connaissance des facteurs de risques chez cette population. L'auteure a étudié et évalué certaines composantes d'un instrument pour adulte pour déterminer la validité du contenu. L'instrument final, qui compte 11 composantes, a été testé auprès de 225 étudiants du secondaire âgés de 13 à 19 ans, dans la région de la ville de New York. Une analyse exploratoire des facteurs a été réalisée selon une approche d'estimation du maximum de vraisemblance avec rotation Geomin. Deux facteurs ont été extraits. La fiabilité générale de l'échelle jugée acceptable a été établie à 0,76. Cet instrument semble être un outil prometteur pour évaluer la connaissance des facteurs de risques en matière de diabète de type 2 chez les adolescents.

Mots clés : diabète de type 2, diabète sucré, facteurs de risques, adolescents

In the past two decades, the incidence of type 2 diabetes mellitus (T2DM) among US and Canadian children and adolescents has risen (Panagiotopoulos, Riddell, & Sellers, 2013; Writing Group for the SEARCH for Diabetes in Youth Study Group, 2007). The SEARCH for Diabetes Study Group estimates that types 1 and 2 diabetes are diagnosed in as many as 1.84 per 1,000 youths, in comparison to cancer, which is diagnosed in 1.24 per 1,000 youths (SEARCH for Diabetes in Youth Study Group, 2006). In Canada, the incidence of T2DM is 1.54 per 100,000 children and adolescents (Panagiotopoulos et al., 2013). In addition, the magnitude of the T2DM epidemic in this population is underestimated because youths may have few if any symptoms and the blood tests needed for diagnosis are often not ordered. According to the Canadian Diabetes Association, family history of T2DM, ethnic minority status, inadequate physical activity, and obesity are risk factors for the development of T2DM (Panagiotopoulos et al., 2013). In adults, knowledge of these and other risk factors for T2DM has been linked to health-promoting behaviours that can reduce the development of T2DM (Janz & Becker, 1984). Thus, in adolescents, knowledge of the risk factors for T2DM may also be linked to health-promoting behaviours and reduced incidence of T2DM. Empirical data on adolescents' knowledge of T2DM risk factors is needed so that nurses can formulate evidenced-based educational programs in order to possibly delay or prevent T2DM in this population. The author developed this instrument for a larger study in order to explore knowledge of risk factors for T2DM in adolescents. The purpose of the study was to test the psychometric properties of the new instrument in the adolescent population in order to evaluate their knowledge of risk factors for T2DM.

Background and Conceptual Framework

Risk factors for T2DM in adults, adolescents, and younger children include ethnic minority status, obesity, sedentary lifestyle, and family history of T2DM (American Diabetes Association [ADA], 2014; Panagiotopoulos et al., 2013). Omolafe, Mouttapa, McMahan, and Tanjasri (2010) conducted a cross-sectional study to examine the relationship between knowledge of risk factors for T2DM in African Americans. They administered a self-report questionnaire, which included risk factors for T2DM, to 133 African Americans between the ages of 18 and 65 who did not have a diagnosis of T2DM. They found that 55 participants (41.4%) had a family history of T2DM while 78 (58.6%) did not. Those with a family history were more knowledgeable about the health benefits of a balanced diet ($\chi^2 = 4.35$, $p = .03$) and engaged in

more physical activity (M = 3021.8 MET-minutes/wk, SD = 1623.0 Mann-Whitney U = 1056.5, $p < .001$).

Chilton, Hu, and Wallace (2006) examined 40 Hispanic-American adults for knowledge levels regarding diabetes, including knowledge that a person who has a family member with diabetes is at greater risk for developing diabetes. The mean age of participants was 32.9 years. While participants had a low level of general knowledge regarding diabetes, more than half knew that if they had diabetes their children were at risk for developing T2DM.

Since family history of T2DM is a risk factor for developing diabetes, it is important to examine adolescents' knowledge of their own predisposition for T2DM. A family history in a first- or second-degree relative increases an adolescent's predisposition to diabetes (ADA, 2014).

Previous studies exploring adolescents' knowledge of risk factors for other diseases, including osteoporosis (Anderson, Chad, & Spink, 2005) and heart disease (Vale, 2000), found that adolescents and young adults have some knowledge of risk factors for specific diseases. In contrast, a study exploring knowledge of risk factors for cancer among Mexican adolescents found a low level of knowledge (Perez-Contreras et al., 2004).

The findings from the Child and Adolescent Trial for Cardiovascular Health (CATCH), a randomized controlled field trial of 5,106 schoolchildren in grade 3, demonstrated a significant relation between knowledge of risks for cardiac diseases and the risk-reducing benefits of a balanced diet (Luepker et al., 1996). This study was conducted in 96 public elementary schools in the United States. The schools were chosen based on ethnic diversity, willingness of food service departments to participate in the study, and proximity to one of the four field study centres. The intervention and control groups were randomized by school, for a total of 56 intervention schools and 40 control schools. The intervention groups were provided with information about cardiac risk (CATCH curricula) and healthier choices in terms of the food services program and the physical education curriculum. The control group received the health education and food service programs already in place. Adjusted means from repeated measures of analysis were done. When compared with the control group, the intervention group demonstrated a significant increase in dietary knowledge ($p < .001$) and a decrease in intake of total fat ($p = .001$), saturated fat ($p = .005$), and cholesterol ($p = .05$). A 5-year follow-up found that the total number of calories from both total and saturated fats had decreased from 31% to 10.4% (Osganian et al., 2003). These findings suggest that adolescents who are knowledgeable about the risk factors for T2DM may adopt or increase health-promoting behaviours.

The Knowledge of Risk Factors for Type 2 Diabetes Mellitus in Adolescents instrument was based conceptually on portions of the Children's Health Belief Model (CHBM) (Bush & Iannotti, 1990), which incorporates elements of the Health Belief Model (Becker, 1974) and Cognitive Developmental Theory (CDT). When individuals are knowledgeable about risk factors, they are more likely to believe that they can reduce their own risk factors for disease. CDT "has influenced studies of children's understanding of illness related processes" (Bush & Iannotti, 1990, p. 70). The CHBM, meanwhile, posits that a cognitive attribute such as knowledge can influence children's understanding of their health and their health decisions.

Procedures for Instrument Development

An extensive literature review identified a number of studies that have developed instruments for other chronic diseases but no studies that have developed instruments to measure knowledge of risk factors for T2DM in adolescents. It identified one promising tool for adults, the Risk Perception Survey for Developing Diabetes (RPS-DD) (Walker, Kalton, Mertz, & Flynn, 2003), which measures personal risk perception and actual risk for developing diabetes. The RPS-DD is a large, 53-item scale consisting of four subscales that examine multiple dimensions of health risks. The Environmental Health Risk subscale contains questions about air pollution, pesticides, and second-hand smoke. The Comparative Disease Risk subscale asks about high blood pressure, cancer, stroke, and diabetes. The Optimistic Bias subscale asks about perceived risks for developing diabetes. The Personal Control subscale addresses personal control over developing diabetes. In addition to these subscales, the Diabetes Knowledge Risk scale asks about personal risk factors for diabetes. Several of the questions were adapted from the American Diabetes Association Diabetic Risk Test (Walker et al., 2003).

With the permission of E. A. Walker (personal communication, November 5, 2007) the RPS-DD was used as a model for this new instrument for adolescents. As with the RPS-DD, all questions developed for the new instrument, Knowledge of Risk Factors for Type 2 Diabetes Mellitus in Adolescents, reflected the adolescent's knowledge of risk factors for T2DM. The Walker et al. (2003) instrument was reviewed and the subscale that had items related to knowledge of T2DM was chosen. Of the 10 items in the Walker et al. (2003) scale, nine were retained. The item "having had diabetes during pregnancy" was removed, since the instrument was intended for healthy adolescents who were not pregnant.

To estimate content validity, a draft of all the items in the new instrument was submitted to four experts: a researcher with expertise in pediatrics, a well-known expert in the field of psychological risk, a diabetes educator, and a physician with expertise in diabetes. These experts were asked to review each question for relevance, content, clarity, and age appropriateness. They suggested several modifications. The title of the instrument was changed to contain the phrase "type 2 diabetes" instead of "diabetes" alone, because two experts thought that failure to differentiate between type 1 and type 2 diabetes could substantially alter an adolescent's response. One expert recommended the addition of four questions related to metabolic syndrome: "having high blood pressure," "having high cholesterol," "having acanthosis nigrans," and "having polycystic ovarian syndrome." Changes suggested by the four content experts were made prior to testing of the instrument with high-school students. The final instrument for pilot testing consisted of 15 items.

Description, Administration, and Scoring of Instrument

The Knowledge of Risk Factors for Type 2 Diabetes Mellitus in Adolescents scale was developed in English and is a 15-item pen and paper self-report questionnaire that takes approximately 5 to 10 minutes to complete. Each item was selected based on the CHBM, a review of the RPS-DD tool, and the American Diabetes Association's risk assessment for T2DM (Bang et al., 2009). Additional items addressing metabolic syndrome were added following a review of content validity by four content experts. The questionnaire includes a list of items that are considered risk factors for T2DM. The items are short, from two to six words, with the exception of those concerning acanthosis nigrans and polycystic ovarian syndrome; I believe that these two conditions require a definition for adolescent respondents. Following are three sample questions: "having most of your fat around your abdomen," "being Asian," "having acanthosis nigrans, a dark leathery area under your neck." For each item, the respondent was asked to choose one answer from among the following: "increases the risk," "has no effect on the risk," "decreases the risk," "don't know if it's a risk factor," "unfamiliar with the term used," "not applicable." An example of a "not applicable" item is "Polycystic Ovary Syndrome (PCOS)" if answered by a male, because the syndrome is found only in females. The answers were scored "1" for correct and "0" for incorrect. The possible range of scores was 0–15. The higher the summated score, the more knowledge the participant demonstrated about T2DM.

Sample

High-school students aged 13 to 19 were eligible to participate. Inclusion criteria were male or female adolescent between the ages of 13 and 19. Exclusion criteria were history of type 1 or type 2 diabetes, history of any chronic disease, and pregnancy.

The participants were recruited from two private, independent college-preparatory parochial high schools in the New York City area (one all-female with an enrolment of approximately 400 and one all-male with an enrolment of approximately 1,000). The participants self-selected using a recruitment letter describing the study to each student. Initially, 300 of the 1,400 students indicated an interest in participating. The final convenience sample consisted of 225 students enrolled in the two schools who volunteered to take part. This sample size is satisfactory for exploratory analysis (Polit & Beck, 2011). The sample included students from all four grades, 9 (n = 72), 10 (n = 65), 11 (n = 30), and 12 (n = 58), and consisted of 48 girls (21.3%) and 177 boys (78.7%) ranging in age from 14 to 19. The mean age was 15.65 years (SD = 1.278) (Table 1). Given the disproportionately large number of boys in the sample, an independent sample t test was conducted to evaluate whether there were significant gender differences. No significant differences were observed t (-.57) =17, $p < .32$; the data were combined and an exploratory factor analysis was conducted using maximum likelihood estimation and geomin rotation, to accommodate binary data.

Table 1 ***Demographic Characteristics***

Variable		Frequency	%
Sex	Male	177	78.7
	Female	48	21.3
	Missing	0	0
Grade	9	72	32.0
	10	65	28.9
	11	30	13.3
	12	58	25.8
Age	14	47	20.9
	15	68	30.2
	16	46	20.4
	17	40	17.8
	18	21	9.3
	19	1	0.4
	Missing	2	0.9

Methods

Institutional cooperation was secured from each high school and the study was approved by the Institutional Review Boards of Rutgers University, the State University of New Jersey, and City University of New York, College of Staten Island. Several hundred letters with assent and consent forms were delivered by the students in the two high schools to their parents describing the study and requesting parental consent and student assent. Participation was voluntary and anonymous. The instrument, Knowledge of Risk Factors for Type 2 Diabetes Mellitus in Adolescents, and a demographic data sheet requesting information on the participant's age, sex, and grade were administered during homeroom period. Completion of the surveys took less than 10 minutes. Students who chose not to participate engaged in their usual activities. If students had questions, the researcher was available in the main office for consultation. The completed surveys were placed in a manila envelope by the homeroom teacher and the envelope was handed directly to the researcher.

Results

Since ordinary factor analysis cannot be computed reliably on dichotomous data, the research used the MPlus 7 program, which also accommodates dichotomous data because it uses probit and loglinear analyses (Muthén, 1978; Muthén & Muthén, 2012). An exploratory factor analysis was conducted using maximum likelihood estimation and geomin rotation, which accommodates dichotomous data. Follow-up item analyses (including alpha coefficients) of the items loading on each factor were computed. Kuder-Richardson 20 statistics and split half reliabilities were computed to test internal consistency of the factors. Means and standard deviations are reported.

Factor Analysis

All 15 items were subjected to exploratory factor analysis using MPlus 7. This analysis found that item 1 (Asian) and item 15 (PCOS) produced an empty cell, invalidating the results of the analysis. Therefore, item 15 was removed and another factor analysis using the first 14 items was conducted. Weighted least squares estimation and geomin rotation were used because these are binary items. Four factors were selected based on both chi-square tests of the model fit (χ^2 (41) = 49.73, p = .16) and the number of eigenvalues greater than 1. Factor loadings are presented in Table 2. The solution did not present clearly defined factors that had high loadings on only one factor (see Table 2). Upon examination of the

Table 2 ***Factor Loadings for Four-Factor Solution***

Item	Factor			
	1	2	3	4
5. Hispanic	0.972			
9. Native American	0.922			
4. Black	0.906			
1. Asian	0.849			-0.549
7. 65 years old	0.499	0.497		
10. Controlling weight gain		0.950		
8. Exercise regularly		0.906		
3. Healthy diet		0.843		
6. Blood relative		0.564		
12. Cholesterol		0.589		0.797
11. Blood pressure		0.503		0.639
2. Caucasian		0.396		
14. Acanthosis nigrans			1.469	
13. Fat around abdomen			0.340	0.351
% variance explained	26.0	27.8	17.2	11.0
KR-20	.75	.69		
Split-half reliability	.82	.78		

Notes: Total % variance explained = 82.0. Geomin rotation. Factor loadings less than .3 have been removed. Factor loadings, which represent beta weights in this type of factor analysis, can exceed 1.00. Split-half reliability was computed using the Spearman-Brown prophecy formula.

"cleanly" loading items and removal of items that loaded on more than one factor — items 1 (Asian), 7 (age 65), 11 (controlling BP), 12 (cholesterol), and 13 (fat around the abdomen) — and the selection of factors with eigenvalues over 2 reduced the data to nine items that loaded on primarily two factors. Another factor analysis was then preformed with weighted least squares estimation and geomin rotation, now with two factors. This solution produced a much cleaner set of factor loadings (Table 3), and the two factors explained a total of 65.32% of the variability in the scores. Factor 1 included items 5, 9, 4, and 1, which all related to ethnicity. Factor 2 included items 11, 8, 10, 3, 6, 7, and 13, items that reflected modifiable factors and medical conditions related to diabetes.

Table 3 ***Factor Loadings for Two-Factor Solution***

Item	Factor	
	1	2
5. Hispanic	0.968	
9. Native American	0.899	
4. Black	0.866	
1. Asian	0.809	
12. Cholesterol	-0.411	0.965
14. Acanthosis nigrans	-0.413	0.491
11. Controlling blood pressure		0.908
8. Exercise regularly		0.884
10. Controlling weight gain		0.781
3. Healthy diet		0.757
6. Blood relative		0.630
7. 65 years old		0.628
13. Fat around abdomen		0.548
2. Caucasian	⋆	⋆
% variance explained	26.82	38.50
KR-20	.76	.76
Split-half reliability	.81	.80

Notes: Total % variance explained = 65.32. Geomin rotation. ⋆ Factor loadings less than .3 have been removed. Split-half reliability was computed using the Spearman-Brown prophecy formula.

Items 12 (cholesterol) and 14 (acanthosis nigrans) were removed, since they loaded on both factors. Chi-square tests of model fit, however, were statistically significant (χ^2 (52) = 70.57, p = .04), which is interpreted as a poor fit with the data. This demonstrates that there is not full validation of the two-factor solution, but the loadings and the interpretability of the factors lend support to the two-factor solution over the four-factor solution (see Tables 1 and 2).

Reliability Analyses

Four-factor solution. Kuder Richardson-20 (KR-20) analyses were then computed for these groups of items for reliability. Factor 1: the KR-20 for items 4 (Black), 5 (Hispanic), and 9 (Native American) was .75, which

is an adequate range. This factor represents knowledge about ethnicity and diabetes. Factor 2: items 2 (Caucasian), 3 (healthy diet), 6 (blood relative), 8 (exercise regularly), and 10 (controlling weight gain) were used to compute a KR-20 of .69, almost adequate. Results indicated that removal of item 2 (Caucasian) would increase the value to .76, and therefore item 2 was eliminated. The final items included in factor 2 were 3, 6, 8, and 10, representing modifiable behavioural factors and medical conditions related to diabetes. Since only one item loaded on factor 3 and none remained on factor 4, further analysis was not computable for these factors (Table 2).

Two-factor solution. Kuder Richardson-20 analyses were conducted for the two-factor solution. Factor 1: the KR-20 for items 1, 4, 5, and 9 was in the acceptable range, .76. This factor represents ethnicity and diabetes, similar to the first factor in the four-factor solution. Factor 2: the KR-20 for items 3, 6, 7, 8, 10, 11, and 13 was also .76, indicating acceptable reliability (Table 3). This factor represents modifiable behavioural factors and medical conditions related to diabetes.

Split-half reliability. Split-half reliability using a Spearman-Brown correction formula was conducted for each reduced factor to further assess reliability of the factors. Alternating items were assigned to each half to mimic the traditional method of splitting a scale along odd- and even-numbered items. All split-half reliabilities for the four-factor solution were acceptable to good (factor 1: $r = .82$; factor 2: $r = .78$), and the split-half reliabilities of the two-factor solution were both in the good range (factor 1: $r = .81$; factor 2: $r = .80$). These results can be found in Tables 2 and 3.

Discussion

The psychometric properties of the new instrument to measure adolescents' knowledge of risk factors for T2DM indicate that it is a valid and reliable tool for use in research and clinical practice. The two-factor solution supported by factor analysis is consistent with the literature on T2DM (ADA, 2014). The reliability of the scale is acceptable, at .76 (Nunnally & Bernstein, 1994), and the split-half reliabilties are good for both factors, $r = .81$ and .80, respectively. Test-retest reliability was not assessed. Test-retest reliability examines the stability of characteristics over time. Knowledge acquisition is a cognitive measure that can change quickly; thus this test would not have been appropriate for the present study (Waltz, Strickland, & Lenz, 2005). With further refinement, the new instrument has the potential to become an even stronger and more useful instrument. Coefficient alphas for this study could not be compared to those for the RPS-DD study because that researcher did not report any coefficient alphas on the knowledge subscale for comparison.

Reading ease of the tool may also be a factor. The Flesch Kincaid grade level was determined to be at grade 10, which is considered a high grade level for instrument testing. Generally, it is recommended that multisyllabic words and long sentences be avoided (Polit & Beck, 2011). Most sentences were short but multisyllabic words were used for questions about medical conditions. Acanthosis nigrans, polycystic ovary syndrome, and cholesterol are all multisyllabic words and were removed during exploratory factor analysis. Since the sample consisted of high-school students, perhaps these participants did not identify with or understand the medical terms fully. These items could be replaced with words of fewer syllables. Further refinement of these questions is needed.

Limitations of the study include the fact that the sample came from two private, independent high schools, making the population homogeneous. The population was primarily Caucasian and the results may not be generalizable to all adolescent students. Further studies are needed to evaluate the instrument's psychometric properties with a more ethnically diverse population.

This instrument could be used by clinical nurses as a screening tool to assess the knowledge of adolescent patients regarding T2DM and then draw up a plan to inform and better educate them. It could also be used by school nurses as an assessment tool for knowledge of T2DM. Thereafter, an educational program could be developed based on the adolescents' level of understanding of T2DM.

Overall, the psychometric results demonstrate that Knowledge of Risk Factors for Type 2 Diabetes Mellitus in Adolescents is a promising short, easy-to-complete tool for evaluation of knowledge of risk factors. The instrument contributes to nursing science because it is the first to examine adolescents' knowledge of risk factors for T2DM. Further instrument studies are needed to improve the tool's psychometrics of medical conditions related to diabetes.

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