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Risk perception of developing diabetes among Spanish-speaking foreign-born Latinos

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Risk perception of developing diabetes among Spanish-speaking foreign-born Latinos

by

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DISSERTATION

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Dedication and Acknowledgements

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Abstract

The Diabetes Prevention Program (DPP) trial demonstrated that lifestyle interventions could reduce the incidence of type 2 diabetes mellitus (T2DM) in adults at high-risk. Only a small percentage of adults at high-risk are aware of their T2DM risk status and implementation of lifestyle interventions modeled on the DPP intervention has not been achieved.

The aims of the research presented in these three manuscripts address areas of needed action and research to speed up primary prevention efforts recommended by a Centers for Disease Control and Prevention, Division of Diabetes Translation advisory group: the need to effectively communicate T2DM risk, use mobile interactive technologies, and focus on vulnerable populations disproportionately impacted by T2DM.

The first two manuscripts describe a 2-phase clinical research project in a sample of foreign-born Latino adults living in California and speaking predominately Spanish at home to describe risk perceptions of developing diabetes and associated risk factors. A new Spanish-language adaptation of a published risk perception questionnaire was developed and tested. The results supported validity and reliability of the instrument and validation of inferences in Latino, foreign-born, Spanish-speaking at-risk populations. Of the 135 participants with complete data, 31% had higher risk perceptions of developing diabetes. In univariate logistic regression analyses, 9 of 18 potential variables tested were significant predictors of risk perception of developing diabetes. In the multiple logistic regression model, 5 variables were significant predictors of risk perception: optimistic bias, worry, perceived personal disease risk, educational attainment of ≥ high school graduate, and history of gestational diabetes. The results contribute to knowledge of risk perception of developing T2DM in this at-risk population and suggest further need for culturally accessible T2DM primary prevention research.

The final manuscript presents the results of a systematic review of DPP modeled T2DM preventive lifestyle interventions delivered via distance learning technologies. The evidence of efficacy is mixed and inconclusive due to heterogeneity of study designs, lack of targeted participant samples, variable intervention components, and inconsistent measures of weight loss outcome. Further, ethnic/racial minority groups were underrepresented in the samples. No trials tested Spanish-language interventions delivered via distance learning technologies and none tested mobile interventions.

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CHAPTER 3

Introduction

In the United States (US) an estimated 86 million adults have prediabetes, a high-risk state for developing type 2 diabetes mellitus (T2DM), one of the most prominent health threats in the 21st century. The landmark Diabetes Prevention Program (DPP) research trial demonstrated that a preventive lifestyle intervention could reduce the incidence of T2DM by 58% in adults with prediabetes, regardless of racial/ethnic background. Yet only a small percentage of US adults with prediabetes are aware of their T2DM risk status and implementation of large scale preventive lifestyle interventions modeled on the DPP intervention has not been achieved.

To speed up primary preventive T2DM efforts the US Centers for Disease Control and Prevention, Division of Diabetes Translation issued a number of action and research priorities based on the Clinic-Community Partnership Model. Key themes in the recommendations include the need to effectively communicate T2DM risk, use mobile interactive technologies, and focus on vulnerable populations disproportionately impacted by T2DM. The aims of the dissertation research presented in these three manuscripts address these three areas of needed action and research.

The first two manuscripts describe a 2-phase clinical research project in a sample of foreign-born Latino adults living in California and speaking predominately Spanish at home. The first phase of the clinical research project was to develop and test a Spanish-language cross-cultural adaptation of the Risk Perception Survey for Developing Diabetes (RPS-DD), a published validated questionnaire that measures diabetes perceived risk. The second phase of the clinical research project was to describe risk perception for developing diabetes and associated risk factors, including sociodemographic factors, body mass index, A1c level, fruit/vegetable intake, and level of physical activity. The final manuscript presents the results of a systematic

review of DPP modeled T2DM preventive lifestyle interventions delivered via distance learning technologies, the characteristics of the study samples that were tested, and the effectiveness of these T2DM preventive lifestyle interventions on weight loss.

Risk Perception Survey for Developing Diabetes for Foreign-Born US Adults from Mexico and Central America: Factor Analysis and Psychometric Properties

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Abstract

Background

Validated measures are needed to describe risk perception for developing diabetes and modifying factors among US Latino foreign-born adults from Mexico and Central America that speak predominately Spanish.

Research design and methods

The Risk Perception Survey for Developing Diabetes (RPS-DD) was translated into Spanish and cross-culturally adapted through harmonization of two independent English-to-Spanish translations, conduction of a focus group (n=11), and presentation of the findings to the author of the original questionnaire. The new Spanish-language adaptation of the RPS-DD was administered to a foreign-born Latino adult sample (n=146): age 39.5 ($\pm$9.9) years old, 74% women, 93% from Mexico and Central America, 61% < high school graduate, and 80% ≤ $20,000 annual household income. To evaluate psychometric measurement properties exploratory factor analyses were performed.

Results

The multi-item Likert scales and subscales did not cluster together as hypothesized in initial exploratory factor analyses. A clean solution was obtained after 2 reversed items were removed, from the Personal Control, Optimistic Bias, and Worry subscale responses. Neither the Personal Disease Risk scale responses nor the Environmental Health Risk scale responses loaded onto a single factor suggesting that in this population these scales should be treated as indexes rather than scales that measure unidimensional constructs. The scale reliabilities ranged from

0.54 to 0.89. Performance on the test of knowledge of risk factors for developing diabetes varied by item, and many participants routinely selected “don’t know”.

Conclusion

The findings of this study contribute evidence of validation of inferences made using a new Spanish-language adaptation of the RPS-DD in US adults foreign-born from Mexico and other Central American countries that speak predominately Spanish at home.

Risk Perception Survey for Developing Diabetes for Foreign-Born US Adults from Mexico and Central America: Factor Analysis and Psychometric Properties

Background

Estimates are that 29 million adults in the United States (US) have diabetes, and another 86 million have prediabetes, a high-risk state for developing diabetes (Centers for Disease Control and Prevention, 2014). Diabetes can lead to devastating health complications for individuals, and the costs associated with diabetes are unsustainable for society (Dall et al., 2014). Type 2 diabetes mellitus (T2DM), comprising 90-95% of all diabetes, can be delayed or prevented in adults at high-risk for developing diabetes, irrespective of ethnic/racial background (Knowler et al., 2002). Public health leaders recommend evaluation of status of risk for developing T2DM of all US adults by healthcare providers in clinical settings, and referral of adults found to be at high-risk for developing T2DM to community-based T2DM prevention programs (Green, Brancati, Albright, & Primary Prevention of Diabetes Working, 2012). Deployment of public health T2DM prevention campaigns and programs into communities is underway nationwide (Albright & Gregg, 2013). Special attention is needed to promote uptake of strategies for primary prevention of T2DM in adults belonging to groups vulnerable to receiving inadequate preventative health services (Green et al., 2012). Perception of risk for developing diabetes is believed to be a key factor in the engagement of adults at increased risk in T2DM primary prevention efforts (Downs, de Bruin, Fischhoff, & Walker, 2010; Fisher et al., 2002; Harwell et al., 2001). Perception of risk for developing diabetes and factors modifying perception of risk are measurable using a published questionnaire titled the Risk Perception Survey for Developing Diabetes (RPS-DD) (E. A. Walker, Mertz, Kalten, & Flynn, 2003).

Hispanic/Latino adults (henceforth referred to as Latino adults) in the US are

disproportionately impacted by diabetes. Compared to non-Latino white adults, Latino adults in the US are more likely to be diagnosed with diabetes, diagnosed with end-stage renal disease (a severe chronic complication of diabetes), and die from diabetes (US Department of Health and Human Services Office of Minority Health, 2014). Low levels of English proficiency, a factor associated with vulnerability to receiving inadequate preventative health services (Derose, Escarce, & Lurie, 2007), are common in Latino adults in the U.S. who are foreign-born (Ryan, 2014). The largest group of US Latino adults with lower levels of English-language proficiency, are foreign-born from Mexico and other Central American countries that speak predominately Spanish at home (Brown & Patten, 2014; Ryan, 2014).

To our knowledge there is no published evidence of the validation of inferences made with a Spanish-language RPS-DD. A Spanish-language RPS-DD is available, that was cross-culturally adapted for native-born adults from Puerto Rico and foreign-born adults from the Caribbean residing in New York City and other large metropolitan areas on the East Coast of the US (E.A. Walker, 2014). However, research has shown that health beliefs about the development of diabetes differ among subgroups of Latinos in the US (Caban & Walker, 2006). Based on these considerations, the development and the evaluation of psychometric measurement properties of a Spanish-language RPS-DD adapted for US Latino adults foreign-born from Mexico or Central American countries that speak predominately Spanish at home is warranted.

The aims of this study were to 1) develop a Spanish-language RPS-DD cross-culturally adapted for US adults foreign-born from Mexico and other Central American countries that speak Spanish at home (henceforth referred to as the target population); 2) assess the psychometric measurement properties of the developed Spanish-language RPS-DD multi-item Likert scales and subscales in the target population; and 3) evaluate the performance of the

developed Spanish-language RPS-DD diabetes risk factor knowledge test in the target population.

Design and Methods

This study consisted of 2 phases (Spanish-language translation/cross-cultural adaption and psychometric testing). The Institutional Review Board at the University of California, San Francisco, approved this study. All participants provided written consent prior to study enrollment. In the initial phase the published English-language RPS-DD was translated and cross-culturally adapted to develop a Spanish-language RPS-DD for US adults foreign-born from Mexico and other Central American countries that speak Spanish at home. In the second phase, evidence of the psychometric measurement performance of the developed Spanish-language RPS-DD was evaluated with a cross-sectional survey of 146 Spanish-speaking Latino adults. Permission was granted by the author of the published English-language RPS-DD to use the final Spanish-language RPS-DD in a cross-sectional survey of the target population (personal communication). The team that developed the Spanish-language RPS-DD for the target population was led by a Spanish-speaking non-Latino white nurse researcher born in the U.S. (KJ), and included a Spanish-speaking Latino nurse researcher foreign-born from Chile (RS), and a Spanish-speaking Latino experienced translator foreign-born from Mexico (EB). The first step in the cross-cultural adaptation process was the harmonization (Wild et al., 2005) of two English to Spanish forward-translations of the RPS-DD, the Spanish-language RPS-DD currently available (E.A. Walker, 2014), and a new Spanish-language forward-translation by one of the members of the current team (EB). Completion of the first step resulted in a pre-final Spanish-language RPS-DD adapted for the target population.

Next a focus group was conducted to elicit feedback on the pre-final Spanish-language RPS-DD with a group of Latino Spanish-speaking Promotores (N=11) who were experienced in delivering preventative health services in the target population. The focus group feedback was then incorporated into a final Spanish-language RPS-DD. The final Spanish-language RPS-DD was then back-translated from Spanish into English (DE). The last step was a review by the research team, with consultation by the author of the published English-language RPS-DD, of the entire Spanish-translation cross-cultural adaptation process. Presented in the review were: the final Spanish-language RPS-DD, the English-language back-translation of the final Spanish-language RPS-DD, the findings of the focus group, and a summary of the decisions and rationale of the changes made in the translation and cross-cultural adaptation process.

The focus group sample (n=11) was recruited from Promotores that volunteered at a community-based organization in Contra-Costa County, California. The focus group session took place in May 2014. The average age of the focus group participants was 48 (SD 2.6) years. Six of the participants were women and five, men. Eight of the participants reported speaking predominately Spanish at home. Nine of the participants were US adults foreign-born from Mexico, one, foreign-born from another Central American country, and one, foreign-born from a South American country. All but one of the participants, were high school graduates, five had attended some college, and three were college graduates or had advanced college degrees. Family incomes reported by participants ranged from less than $10,000/year, to between $50,000/year and $75,000/year. Four of the participants reported a medical history of diabetes.

In the second phase of the study, the final adapted Spanish-language RPS-DD was tested in a convenience sample of 146 Spanish-speaking Latino adults who were recruited from adults attending food pantry distribution and health promotion events and free health clinics in Marin

County, California in August and September 2014. The inclusion criteria were: age ≥ 20 years; Latino ethnicity; foreign-born, and speak predominantly Spanish at home. The exclusion criteria were known medical history of diabetes (other than history of gestational diabetes), and current pregnancy. Research staff (DG, EO, and KJ) distributed written one-page flyers containing a description of the study in Spanish and English to adults arriving at recruitment sites. Once flyers were distributed, research staff members (DG, EO, and KJ) were present and available to supply further information about the study in Spanish and English to potential participants expressing interest in the study.

The Spanish-language RPS-DD was administered as a paper-based questionnaire, with assistance for comprehension needs available if needed from Spanish-speaking research staff members (DG, EO, and KJ). Included in the paper-based survey were additional measures of demographics. Also measured were, height (portable stadiometer) and weight (AND UC-300 Precision Health Scale), with participants wearing light clothing and shoes. Glycosylated hemoglobin (A1c) level was measured with a finger-stick procedure using a CLIA-waived point-of-care A1c testing device (Siemens Vantage DCA Analyzer). The A1c test results, available in 6 minutes, were communicated to participants verbally and in writing, along with their weight, height, a brief written interpretation of the results, and a list of resources for follow-up if needed. Participants also received a 10 dollar gift card for their time.

The characteristics of the sample are shown in Table 1. The average age of participants was 39.5 (SD 9.9) years old, 74% were women, and 92% were foreign-born from Mexico or other Central American countries. Sixty percent had an educational attainment level of less than high school graduate. Annual household income was reported as less than $20,000 by 79% of the sample and less than $10,000 by 48%. A family history of diabetes was reported by 35%, a

history of gestational diabetes by 14%, and a history of prediabetes by 11%. The majority (83%) was overweight or obese. A1c level was 5.7% - 6.4% in 12 % of participants and, 6.5% or greater in 2% of participants.

Perception of risk for developing diabetes and modifying factors

English-language RPS-DD properties

There are four separate sections in the published four page paper-based English-language RPS-DD questionnaire (E. A. Walker et al., 2003) (see Appendix A). The first section, contained on the first page, consists of one multi-item Likert scale containing three subscales. Intended to measure unique general attitudes that may modify perception of risk for developing diabetes, the three subscales included in the first section are titled: *Personal Control* (4 items), *Optimistic Bias* (2 items), and *Worry* (2 items). In this section of the questionnaire, a set of instructions is presented at the top of the page, and the items are presented as statements of general attitudes. The Likert response options in this section are levels of agreement with the statements of general attitudes, presented from the highest level of agreement, to the lowest: “Strongly Agree”, “Agree”, “Disagree”, and “Strongly Disagree”. Notably, the *Personal Control* subscale contains two non-reversed and two reversed items.

The second and third sections of the questionnaire contained on the second and third pages of the questionnaire, are made up of two multi-item Likert scales intended to measure the global context of perceived risk to health that participants are theorized to have, among which exists perceived risk for developing diabetes. In section two, on page two, there is a multi-item Likert scale, identified as the *Personal Disease Risks* scale, that contains fifteen-items intended to measure perception of risk to health of 15 separate chronic health conditions and diseases. The instructions for completion of this section are presented at the top of the page, and the items in

the scale are listed below. The Likert response options are levels of perceived risk to health, presented from the lowest level, to the highest: “Almost No Risk”, “Slight Risk”, “Moderate Risk”, and “High Risk”. Notably, perceived risk for developing diabetes is measured using a single Likert item embedded within the *Personal Disease Risks* multi-item Likert scale. Also included in the *Personal Disease Risks* scale are items measuring perception of risk to health of other chronic health conditions and diseases including: chronic complications of diabetes, chronic diseases associated with diabetes, and other diseases not associated with diabetes. Formatted in a similar manner, the third section, on the third page of the questionnaire, identified as the *Environmental Health Risks* scale, measures perceptions of risk to health of nine environmental health hazards. The *Environmental Health Risks* scale covers perceptions of health to risk over a wide range of hazards including: medical x-rays, violent crime, extreme weather, driving/riding in an automobile, illegal drugs, air pollution, pesticides, household chemicals, and second-hand smoke.

The response options of the individual items in the first three sections of the RPS-DD questionnaire are assigned a numerical value from 1 to 4. The multi-item Likert scales and subscales are scored as averages of the individual item numerical values associated with the response options selected by the respondent within each scale or subscale. The scoring is reversed for 2 of the 4 items in the *Personal Control* subscale, the 2 items in the *Optimistic Bias* subscale, and the 2 items in the *Worry* subscale prior to interpretation to account for the conceptual direction of the items. The scores of the subscales can then be interpreted with higher scores indicating a higher level of the assessed construct, more personal control, more optimistic bias, and more worry, respectfully. Interpretation of the scale and subscale scores is similar for the *Personal Disease Risks* scale and the *Environmental Health Risks* scale, with higher scale

scores reflecting greater degrees of perceived comparative personal disease risks, and perceived comparative environmental risks, respectively.

The fourth section, on the fourth page, of the RPS-DD, is a test of knowledge of risk factors for developing diabetes. In the test, instructions are presented as a brief statement, and items, as a list. The responses options in the test are: “Increases the Risk”, “Has NO Effect on Risk”, and “Decreases the Risk”. Respondents are also given the option of answering, “Don’t Know”. Of the 11 items in the knowledge test, three items assess knowledge of the benefits of modifiable lifestyle factors: healthful diet, physical activity, and control of body weight. The remaining seven items assess non-modifiable risk factors. Four of the items that assess non-modifiable risk factors assess knowledge of the effect on risk of developing diabetes of different races and ethnicities including: being African American, being American Indian, being Asian American, being Caucasian, and being Hispanic. The items are dichotomously scored, correct/incorrect, and the number of correct responses is tallied with a possible score of 1-11. A higher score is interpreted as being more knowledgeable of risk factors for developing diabetes.

Newly adapted Spanish-language RPS-DD

The team that cross-culturally adapted the published English-language RPS-DD into Spanish for use in the target population made a number of changes. One notable formatting change intended to decrease the number of cognitive operations required to formulate responses to items was the development of two versions of the questionnaire, one for men and one for women. The two versions differed in the wording of two of the items in the *Optimistic Bias* subscale. In the English-language RPS-DD respondents are asked to compare their risk for developing diabetes to that of other individuals of the same “sex” in the statements in these

items. These statements were changed so that in the version for men, male respondents were asked to compare their risk for developing diabetes to that of other men, and in the version for women, female respondents were asked to compare their risk for developing diabetes to that of other women. Another formatting change made, based on reported findings from an unpublished study by a member of the translation team (RS), was the reordering of the Likert response options in the *Personal Disease Risk* scale and the *Environmental Health Risk* scale so that throughout the questionnaire the multi-item Likert scale and subscale response options were presented from highest to lowest. As a result of this change, the Likert response options in the *Personal Disease Risk* scale and the *Environmental Health Risk* scale were presented from the highest to the lowest levels of perceived risk: "High Risk", "Moderate Risk", "Slight Risk", and "Almost No Risk". In addition to formatting changes, alternative wording was substituted for a number of English-language idioms that were identified in the English-language RPS-DD that could not be translated literally into Spanish.

Members of the focus group repeatedly verbalized that one of the key considerations that should be taken into account in translating and cross-culturally adapting the RPS-DD was an anticipated high prevalence in target population of adults with low levels of educational attainment that may experience difficulty comprehending the meaning of items that require challenging cognitive operations to formulate responses. Particular concern was expressed by multiple members of the focus group regarding the number of challenging cognitive operations that may be required to respond to one of the items in the *Personal Control* subscale. The focus group members pointed out that the item required participants to conceptualize the concept of "control", which could mean a number of different things to different respondents leading to a high probability of misresponse. This item also differed from 2 of the other items in the subscale

in that it was one of the two reversed items, which added to the number of cognitive operations required to formulate a response, since this may require participants to choose a response option from the other end of the Likert scale, compared to their other responses in the multi-item scale.

Independent from the translation team, one of the focus group members expressed their satisfaction with the presentation of the multi-item Likert response options in consistent order throughout the questionnaire from highest to lowest. The rationale for the benefit of the presentation order from highest to lowest stated by the focus group member, and confirmed by other members, was that presentation in this order is what adults in the target population would expect when completing the questionnaire.

The final Spanish-language RPS-DD was approved for use in the second phase of the study by the author of the English-language RPS-DD (see Appendix B). Notably, it was decided that despite the concerns brought forward by the focus group regarding the possible performance of one of the reversed items in the *Personal Control* subscale, the item along with another reversed item in the *Personal Control* subscale were retained unchanged in the final Spanish-language RPS-DD.

Statistical Analysis

Univariate analyses were used to describe sample characteristics including: sociodemographics, medical history, and BMI. To evaluate the internal consistency reliability of the final Spanish-language RPS-DD adapted for the target population, Cronbach's alpha analyses were performed. Exploratory factor analyses of each of the multi-item Likert scales of the Spanish-language RPS-DD were used to determine whether the scale and subscale items clustered together, thus providing evidence of the measurement of underlying unidimensional constructs. All analyses were performed with STATA version 13.

Results

The focus of this report is on the psychometric measurement properties of the final Spanish-language RPS-DD developed in the first phase of this study. Exploratory factor analyses were performed to see if the Spanish-language RPS-DD multi-item Likert scales and subscales measured unidimensional constructs in the target population. When analyzed initially as a group of Likert items as presented in the questionnaire, the items from the *Personal Control*, *Optimistic Bias,* and *Worry* subscales did not cluster together as hypothesized. However, when the two reversed items in the *Personal Control* subscale were removed, a very clean solution was obtained establishing that the remaining six items in the multi-item Likert group containing three subscales do measure the three constructs as specified by the author of the published English-language RPS-DD (Table 2). Notably, one of the two reversed items removed was the item identified in the focus group as having a high potential for misresponse due to the perceived challenges of the cognitive operations needed to formulate accurate responses. In the sample, neither the *Personal Disease Risks* scale responses or the *Environmental Health Risks* scale responses loaded onto a single factor. The scale reliabilities ranged from 0.54 to 0.89 (Table 3).

In the sample, performance on the test of knowledge of risk factors for developing diabetes varied by the content of the test items (Table 4). The average number of correct items on the test was 4.36 (SD 2.18). More than 66% of the participants were able to correctly answer the item that asked if a healthful diet decreases the risk for developing diabetes. In addition, more than 75% were able to correctly answer the items that asked if exercising regularly and controlling weight gain decrease a person's risk for developing diabetes. However, more than 66% answered, "don't know", when asked about the effects on risk for developing diabetes of race and ethnicity including: Asian American, American Indian, African American and

Caucasian. And when asked about the effect on risk for developing diabetes of being Latino, only 40% of participants provided the correct answer, and 40% percent selected "don't know".

Discussion

This study was conducted to develop and test a Spanish-language cross-cultural adaptation of the RPS-DD questionnaire that measures of perceived risk for developing diabetes and modifying factors. The findings of this study contribute evidence of validation of inferences made using these measures in US adults foreign-born from Mexico and other Central American countries that speak predominately Spanish at home.

The factor analysis findings provided evidence for validation of inferences made from the *Personal Control*, *Optimistic Bias*, and *Worry* subscales of the Spanish-language RPS-DD in this population. It was confirmed that the *Optimistic Bias* and *Worry* subscales were unidimensional when measured using the Spanish-language RPS-DD and scored according to the published scoring guide for the RPS-DD (E. A. Walker, 2009). And the *Personal Control* subscale was unidimensional, when the two items that were reversed were removed. The internal consistency reliabilities of the Spanish-language RPS-DD multi-item Likert indices and subscales in our study are comparable to findings from studies using the published English-language RPS-DD. In non-Latino white patients of an academic hospital primary care practice, characterized by high levels of educational attainment, reliabilities reported ranged from 0.51 to 0.80 (Hivert, Grant, Warner, Meigs, & Shrader, 2009). In participants in the Diabetes Prevention Program research trial, the reliabilities ranged from 0.68 to 0.85 (E. A. Walker, Fisher, Marrero, McNabb, & Diabet Prevent Program Res, 2001). And in a sample of practicing physicians, reported reliabilities ranged from 0.64 to 0.83 (E. A. Walker et al., 2003).

Neither the *Personal Disease Risks* scale, nor the *Environmental Health Risks* scale, loaded onto a single factor. This suggests that in this population using the Spanish-language RPS-DD, the *Personal Disease Risks* and the *Environmental Health Risks* scales should be treated as indexes rather than scales that measure a unidimensional construct. The findings of the psychometric measurement properties of the *Personal Disease Risks* and *Environmental Health Risks* indices may differ from findings in previous studies in part due to the low educational attainment levels that characterized the sample. The *Personal Disease Risk* index encompasses a global range of diseases and health conditions. And the hazards included in *Environmental Health Risks* index vary greatly in dimensions that may affect perception of risk including: degree of familiarity, degree of dread, and the number of people exposed (World Health Organization, 2002). Individuals with higher levels of educational attainment may infer that items grouped together on the questionnaire are intended to measure underlying constructs, whereas such insights may not be readily apparent to individuals with lower levels of educational attainment. In addition, it is reasonable to assume that many of the people in the sample may not have previously reflected on the risks the items in the scales were intended to elicit. Thus requiring participants to formulate new judgments that may entail complex cognitive operations before selecting response options may be unwise (Krosnick, 1999).

The average number of correct responses on the test of knowledge of risk factors of developing diabetes in this sample, 4.36 of a total of 11 items, was lower than has been found in other samples characterized by higher levels of educational attainment (Hivert et al., 2009; E. A. Walker et al., 2003). This difference may be due in part to the inclusion in the test of 4 items that assess knowledge of the effects of belonging to certain racial/ethnic groups on risk for developing diabetes. The fact that “don’t know” was routinely selected by many participants on

the items in the test is consistent with survey research findings in samples characterized by low levels of educational attainment (Krosnick, 1999).

Limitations

Caution should be exercised in interpreting the findings of this study due to a number of considerations. Evidence supporting the validation of inferences made with the Spanish-language RPS-DD may have been stronger if this study's findings had demonstrated evidence of theoretical relationships between the constructs measured by the RPS-DD and related constructs measured by other means. Evidence of validation has been found by Walker et al. (2003) for the English-language RPS-DD in a sample of practicing physicians by demonstrating anticipated theoretical group relationships between physiological risk for diabetes measured using the ADA Diabetes Risk Test and scores of four of the scales and subscales of the RPS-DD: *Personal Disease Risks*, *Personal Control*, *Worry*, and *Optimistic Bias*. However, since markedly lower levels of educational attainment and knowledge of diabetes risk factors characterized our sample, the nature and direction of the theoretical relationships between the constructs could not be assumed. Exploratory factor analysis techniques were used in this study despite the limited numbers of items within the identified the subscales of the Spanish-language RPS-DD. And although internal consistency reliability levels 0.50 to 0.70 are considered acceptable when making group comparisons by some psychometric theorists (Switzer, Wisniewski, Belle, Dew, & Schultz, 1999), it is standard practice to exercise caution in interpreting measurements based on instruments scales with internal consistency reliabilities less 0.70.

Conclusions

This was the first evaluation of the unidimensionality of the scales and subscales of the RPS-DD. An attempt was made to see if there was a unidimensional construct measured by the

Spanish-language RPS-DD scales and subscales adapted for the target population. The sample in this study was characterized as having lower levels of educational attainment and yearly household income. Also, the sample was US adults foreign-born from Mexico and Central American countries and spoke predominately Spanish. All of these demographic characteristics have been associated with health gaps making this target sample important to study.

The findings of this study may lead to improvements in communication between patients and clinicians. Too often in clinical care, health prevention communication by clinicians is limited to brief patient education to correct myths and mistaken beliefs about health risks and preventative strategies. Rather, effective health prevention communication and persuasion principally rests on relationships developed over time between patients and their clinicians, based on genuine caring about concerns, respectfully listening to reasoning, and providing information in a non-judgmental manner. The measures in the RPS-DD have the potential to be used as tools in this communication to broaden the dialogue between clinicians and patients.

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Table 1: Characteristics of study participants (N=146)

Characteristic	n (%)
Mean age (years)*	39.5 (SD±9.9)
Sex	
Female	108 (74.0)
Country of origin*	
Mexico	60 (41.1)
Central American country (other than Mexico)	75 (51.4)
Other Latin American country	9 (6.2)
Educational attainment	
Less than 9th grade	68 (46.6)
9th to 12th grade	21 (14.4)
High school graduate	42 (28.8)
Some college, college graduate, or advanced degree	15 (10.3)
Yearly household income*	
Less than $10,000	70 (48.0)
$10,000 to $15,000	25 (17.1)
$15,000 to $20,000	21 (14.4)
$20,000 to $25,000	12 (8.2)
$25,000 to $35,000	14 (9.6)
$35,000 to $50,000	3 (2.1)
Medical History	
Family history of diabetes (mother, father, sister or brother)	51 (34.9)
History of gestational diabetes	21 (14.4)
History of prediabetes	16 (11.0)
BMI	
BMI Normal (18.5 - 24.9 Kg/m^2)	25 (17.1)
BMI Overweight (25.0 - 29.9 Kg/m^2)	62 (42.5)
BMI Obese (30.0 - 39.9 Kg/m^2)	54 (37.0)
BMI Extremely Obese (40.0 Kg/m^{2}or greater)	5 (3.4)
A1c	
6.4% or less	126 (86.3)
5.7% - 6.4%	17 (11.6)
6.5% or greater	3 (2.1)

*Due to missing responses percentages do not add to 100

Table 2: Factor loadings and unique variances based on a principal components analysis with oblique rotation for 6 items from the RPS-DD* cross-culturally adapted into Spanish (N=140)**

	Factor 1	Factor 2	Factor 3	Uniqueness
3. I think that my personal efforts will help control my risks of getting diabetes.	**0.9054**	0.0384	0.0975	0.2076
4. People who make a good effort to control the risks of getting diabetes are much less likely to get diabetes.	**0.7738**	0.0914	-0.0691	0.3234
5. I worry about getting diabetes.	-0.3104	0.1928	**0.7520**	0.2581
6. Compared to other people of my same age and sex (gender), I am *less* likely than they are to get diabetes.	0.0489	**0.8882**	0.0502	0.2096
7. Compared to other people of my same age and sex (gender), I am *less* likely than they are to get a serious disease.	0.0546	**0.8225**	-0.0990	0.2503
8. Worrying about getting diabetes is very upsetting.	0.2056	-0.1834	**0.8837**	0.1900

*Items 1 and 2 of the RRS-DD not included
**6 observations with missing values excluded

Table 3: Reliabilities of Spanish-language RPS-DD scales and subscales (N=146)

Scale or subscale	No. of items	Cronbach alpha
Personal control*	2	0.67
Optimistic bias**	2	0.72
Worry	2	0.54
Personal disease risk (global)	15	0.89
Environmental health risk	9	0.88

*Items 1 and 2 of personal control subscale not included
**2 observations with missing values excluded

Table 4: Knowledge of risk factors for type 2 diabetes (N=146)

Item	Answered correctly	Answered incorrectly	Answered "don't know" (or response missing)
33. Being Asian American	6 (4.1)	39 (26.7)	101 (69.2)
34. Being Caucasian	19 (13.0)	27 (18.5)	100 (68.5)
35. Eating a healthy diet	100 (68.5)	23 (15.8)	23 (15.8)
36. Being Black or African American	13 (8.9)	31 (21.2)	102 (69.9)
37. Being Hispanic	58 (39.7)	30 (20.5)	58 (39.7)
38. Having had diabetes during pregnancy	55 (37.7)	27 (18.5)	64 (43.8)
39. Having a blood relative with diabetes	90 (61.6)	16 (11.0)	40 (27.4)
40. Being 65 years of age or older	69 (47.3)	31 (21.2)	46 (31.5)
41. Exercising regularly	111 (76.0)	19 (13.0)	16 (11.0)
42. Being American Indian	7 (4.8)	40 (27.4)	99 (67.8)
43. Controlling weight gain	109 (74.7)	21 (14.4)	16 (11.0)

Presented as n (%)

Risk Perception of Developing Diabetes among Spanish-Speaking Foreign-Born Latinos

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Abstract

Background

Latinos in the U.S. are disproportionately impacted by diabetes. Foreign-born Latino adults that speak predominately Spanish at home are vulnerable to receiving inadequate type 2 diabetes (T2DM) prevention services. In this population, little is known about risk perception of developing diabetes, which is theoretically predictive of modifying T2DM lifestyle risk factors. The purpose of this study was to describe risk perception of developing diabetes in this population.

Design and Methods

Participants were surveyed using the validated Risk Perception Survey for Developing Diabetes (RPS-DD) in Spanish. T2DM risk factors measured included: BMI, A1c, and physical activity.

Results

Sample characteristics (N=146) were: age 39.5 (±9.9) yrs; 74% women; 61% education < high school graduate; 93% foreign-born from Mexico and Central America; and 65% annual household income < $15,000. Prevalence of T2DM risk factors was: 14% history of gestational diabetes; 35% family history of diabetes; 83% overweight or obese; 47% < 150 min/wk physical activity; and 12% prediabetic A1c.

Of the 135 participants with complete data, 31% had higher risk perceptions of developing diabetes. In univariate logistic regression analyses, 9 of 18 potential variables tested were significant ($p<0.05$) predictors of risk perception of developing diabetes. When these 9 variables were entered into a multiple logistic regression model, 5 were found to be significant predictors of risk perception: optimistic bias (OR 0.40), worry (OR 2.86), perceived personal

disease risk (OR 60.56), educational attainment of ≥ high school (OR 4.20), and history of gestational diabetes (OR 10.95).

Conclusion

This is the first study using a Spanish version RPS-DD in this population and reveals factors that influence perception of diabetes risk. The results from this study can be used to promote culturally acceptable T2DM primary prevention strategies and provide a useful comparison to risk perception of developing diabetes in other populations.

Risk Perception of Developing Diabetes among Spanish-Speaking Foreign-Born Latinos

Background

Type 2 diabetes mellitus (T2DM) has been identified as one of the most important preventable global health risks in the 21st century (World Health Organization, 2002). T2DM can lead to health consequences that threaten quality of life of individuals and families, and the economic costs associated with T2DM are unsustainable for society (Dall et al., 2010). The landmark Diabetes Prevention Program (DPP) Study demonstrated that delaying the onset, and in some cases preventing T2DM, is possible in adults at increased risk for development of T2DM, regardless of racial/ethnic background, through preventive interventions that facilitate positive modification of lifestyle risk factors including: diet, physical activity, and body weight (Hamman et al., 2006; Knowler et al., 2002). In the United States (US) public health campaigns are underway to translate the DPP research findings into practice deploying and promoting accessible community-based T2DM primary preventive lifestyle modification interventions nationwide (U.S. Department of Health and Human Services, 2014), particularly targeted toward engagement of adults with prediabetes, an asymptomatic condition of increased risk of developing diabetes, estimated to affect 86 million adults (Centers for Disease Control and Prevention, 2014b).

Clinicians working through clinic-community partnerships play a key role in these efforts by communicating with individuals in the general public regarding risk of developing diabetes and the benefits of participating in T2DM prevention lifestyle modification programs (Green, Brancati, Albright, & Primary Prevention of Diabetes Working, 2012). Health behavior of individuals is believed to be driven in part by perception of risk or vulnerability of developing diseases and health problems (Janz & Becker, 1984), and is modified by a number of

psychological factors including perceived control (Thompson & Spacapan, 1991), optimistic bias (Armor & Taylor, 1998), and worry (Portnoy, Ferrer, Bergman, & Klein, 2014). Understanding risk perception and modifying factors in diverse groups in the U.S. general public may help to optimize the effectiveness of this communication and influence engagement in T2DM primary preventive interventions.

In the U.S., Latino adults who are foreign-born and speak predominately Spanish at home are disproportionately impacted by T2DM, and vulnerable to receiving inadequate preventative health services. Compared to non-Latino White adults, Latinos have substantially higher rates of T2DM, higher rates of kidney failure (a chronic complication of T2DM), and higher rates of mortality related to T2DM (U.S. Department of Health & Human Services Office of Minority Health, 2014). Among foreign-born adults in the U.S., speaking predominately a language other than English at home is a factor associated with vulnerability to receiving inadequate preventive health services (Centers for Disease Control and Prevention, 2014a). While descriptions of risk perception of developing diabetes in U.S. Latino adults exist (Diaz, Mainous, Williamson, Johnson, & Knoll, 2012; Maty & Tippens, 2011; Walker, Fisher, Marrero, McNabb, & Diabet Prevent Program Res, 2001; Walker & Wylie-Rosett, 1998), there is limited literature on risk perception of developing diabetes and modifying psychological factors in U.S. Latino foreign-born adults that speak predominately Spanish at home. No studies exist that have used the validated instrument, the Risk Perception Survey for Developing Diabetes (RPS-DD) (Walker, Mertz, Kalten, & Flynn, 2003) in describing diabetes risk perception and modifying factors in this at-risk population.

This article describes the findings of a descriptive cross-sectional study designed to explore perception of risk of developing diabetes and modifying factors in U.S. Latino foreign-

born adults that speak predominantly Spanish at home using a Spanish-language RPS-DD. Development and analysis of the psychometric performance of the Spanish-language RPS-DD used in this study are discussed in a separate article (Joiner, Sternberg, & Janson, 2015). The specific aims of the study were to: (1) describe perceived risk of developing diabetes and modifying factors, and (2) identify factors associated with risk perception of developing diabetes.

Design and Methods

In this descriptive cross-sectional study, 146 US Latino foreign-born adults, age 20 years or older, that reported speaking predominantly Spanish at home were enrolled in August and September 2014. Adults who were pregnant, or had a history of diabetes (other than a history of gestational diabetes) were not eligible to participate. Recruitment of participants took place in the San Francisco Bay Area of California among adults attending weekly food-pantry distribution and health services events, and among adults present in the waiting room of a weekly free clinic. The total attendance recorded by the community organizations directing the events and the clinic during the recruitment period was 1,265 adults.

Recruitment procedures consisted of announcements and distribution of informational study flyers by community organization staff members and study research team members (EO, DG, and KJ). Written consent was obtained in Spanish. Enrollment and completion of the study took place on-site. Enrolled participants underwent measurements of their height, body weight, and glycosylated hemoglobin (A1C) then self-administered a brief printed questionnaire, with assistance available for reading and comprehension from research team members (DG, EO, and KJ). The components of the questionnaire assessed: sociodemographics, health characteristics, physical activity, diet, risk perception of developing diabetes, and modifying psychosocial factors using validated instruments. Upon completion of the study, participants received a 10

dollar gift card. The study was approved by the Committee on Human Research of the University of California, San Francisco.

Measures

Height, Weight and BMI

Height and weight were measured, with participants wearing light clothing and shoes, by research team members (DG, EO, and KJ) using a portable stadiometer (Handi Stat; Perspective Enterprises, Portage, MI) and digital scale (UC-300 Precision Health Scale; A & N Engineering Inc., Milpitas, CA). Body Mass Index (BMI) was calculated based on the measured height and weight with a standard method.

A1C

A1C level was measured using a point of care CLIA-waived device (Siemens DCA 2000 Analyzer; Siemens Diagnostics, Tarrytown, NY), by research team members (DG, EO, and KJ). Participants were classified into one of 3 categories based on A1C result: normoglycemia (less than 5.7%), prediabetes (greater than or equal to 5.7% and less than 6.5%), and diabetes (6.5% or greater) (American Diabetes Association, 2014a). Participants with A1C levels consistent with prediabetes were considered to be at high risk of developing diabetes (American Diabetes Association, 2014a). Participants were provided, verbally and in writing, the results of their A1C measurement accompanied by a written statement that included a brief interpretation of the results and general advice to follow-up with a medical provider in the event that the A1C results were consistent with prediabetes or undiagnosed diabetes based on American Diabetes Association (ADA) standards for testing for prediabetes and diabetes in asymptomatic adults (American Diabetes Association, 2014a). The written information received by participants

included a list of primary care resources in the nearby area in case participants did not have a regular medical provider.

Sociodemographics and health characteristics

Sociodemographics and health characteristics assessed in the questionnaire included: age, sex, country of origin, education level, yearly household income, history of prediabetes, history of gestational diabetes, and family history of diabetes.

Physical activity and diet

Physical activity at the recommended level to reduce risk of developing T2DM of 150 minutes per week of aerobic activity of moderate-intensity or greater (Physical Activity Guidelines Advisory Committee, 2008), was assessed using a validated Spanish-language version (Chavez, Ainsworth, Farr, & Vega-Lopez, 2012) of the Stanford Brief Activity Survey (SBAS) (Taylor-Piliae et al., 2006). In the SBAS respondents read a brief introduction and chose one of five descriptions that best matched their own pattern of occupational and leisure-time physical activity over the past year. Using the SBAS scoring guide, overall physical activity level was determined: "inactive", "light-intensity activity", "moderate-intensity activity", "hard-intensity activity", or "very hard-intensity activity". Participants were considered to meet the recommended level of physical activity if their overall level of physical activity using the SBAS was 150 minutes per week and classified as "moderate-intensity activity", "hard-intensity activity", or "very hard-intensity activity" (Taylor-Piliae et al., 2006).

Diet was assessed using a Spanish-language Block Fruit and Vegetable Food Frequency Screener with evidence of reliability and validation in US Latino adults foreign-born from Mexico who speak Spanish (Wakimoto, Block, Mandel, & Medina, 2006). The items in this instrument assess the average portions per day of fruits and vegetables consumed over the past

month in 7 categories: fruit (fresh, frozen, and canned), fruit juice, green salad, tomatoes (and salsa), vegetable soup, potatoes, and other vegetables. For each item participant selected a response category: “Less than once per WEEK”, “About 1 time per WEEK”, “2-3 times per WEEK”, “4-6 times per WEEK”, “Once per DAY”, and “2 or more times per DAY”.

Indicators of risk of developing diabetes

The American Diabetes Association (ADA) Type 2 Diabetes Risk Test (American Diabetes Association, 2014b), was used to assess level of increased risk of developing diabetes based on the presence of risk factors: age, sex, history of gestational diabetes, family history of diabetes, history of high blood pressure, level of physical activity, and BMI. Participants that were scored as having 5 points or greater were considered at increased risk of developing diabetes as recommended by the ADA (American Diabetes Association, 2014b). The BMI used to score the ADA Type 2 Diabetes Risk Test was calculated based on body weight and height measurements. Physical activity was scored on the ADA Type 2 Diabetes Risk Test based on whether participants meet the recommended 150 minutes per week of aerobic activity at moderate-intensity or greater determined by the SBAS (Taylor-Piliae et al., 2006).

Risk perception of developing diabetes and modifying psychological factors

A Spanish-language cross-culturally adapted RPS-DD (sRPS-DD) developed by the research team was used in the current study to assess risk perception of developing diabetes and modifying factors (see Appendix B). Factor analysis and internal consistency reliabilities of the sRPS-DD subscales provided supporting evidence of the validation in the target population (Joiner et al., 2015).

A single ordinal four-point Likert-type response item in the sRPS-DD was used to assess risk perception of developing diabetes. The item was embedded in the *Personal Disease Risk*

subscale, a Likert-type 15-item index. Participants were asked to judge their own risk of developing diabetes and select one of 4 levels of risk: high risk (4 points), moderate risk (3 points), slight risk (2 points), or almost no risk (1 point).

For contextual comparison and to assess global perception of disease risk, the remaining 14 items in the sRPS-DD *Personal Disease Risk* subscale were used to separately assess risk perception of developing 14 other diseases and health problems on the same four-point Likert-type scale. Included in the diseases and health problems assessed were complications associated with uncontrolled diabetes, other chronic diseases associated with obesity and physical inactivity, and diseases not directly related to diabetes or obesity and physical inactivity that adults in the general public might be concerned about developing. Participants were also asked if they currently have or have had the diseases and health problems in the past. A global index of risk perception of developing the diseases and health problems for each participant was then derived as the mean of the 14 subscale items, excluding any items of diseases and health conditions participants indicated they already had.

Risk perceptions of environmental health hazards were assessed using a similar 9-item Likert-type subscale in the sRPS-DD, the *Comparative Environmental Risk* subscale. The items in this subscale assess risk perceptions of impacts of 9 separate chemicals and physical agents that may cause health damage or harm. An index score reflecting overall risk perception of environmental hazards to health was derived as the mean of the responses to the items.

General attitudes theorized to be potential modifiers of risk perception of developing diabetes were measured using three subscales in the sRPS-DD: *Personal Control*, *Optimistic Bias*, and *Worry*. The sRPS-DD *Personal Control* subscale was used to assess perception of influence of personal actions over modifiable diabetes risk factors. The sRPS-DD *Optimistic*

Bias subscale was used to assess confidence compared to peers, that diabetes would not be developed. The sRPS-DD *Worry* subscale was used to assess degree of concern and anxiety associated with risk perception of developing diabetes. Participants responded to each of the items in the subscales measuring these 3 general attitudes, by selecting a level of agreement or disagreement on a four-point Likert-type scale: strongly agree (1 point), agree (2 points), disagree (3 points), and strongly disagree (4 points). Averaging points associated with responses produced calculated summary scores for each of the subscales.

The sRPS-DD *Diabetes Risk Knowledge* test was used to measure level of knowledge of risk factors of developing diabetes. The 11 items in this test have the following response options: increases the risk, has no effect on risk, decreases the risk, and don't know. The test was scored as the number of correct responses and a higher score (ranging from 1 to 11) was interpreted as more knowledgeable of risk factors of developing diabetes.

Data Analysis

Descriptive statistics were used to analyze means and standard deviations of quantitative variables after normality of distribution was confirmed, while frequency and percentage were calculated to describe categorical variables.

A series of logistic regression analyses were used to explore the influence of modifying factors (independent variables) on risk perception of developing diabetes (dependent variable). Participants that perceived their own risk of developing diabetes as high or moderate were considered to belong to a group with moderate/high risk perceptions of developing diabetes, and participants that perceived their risk as slight or almost no risk, a group with lower risk perceptions. In order to account for the influence of other independent variables, variables found to be independently significantly associated with the dependent variable at the univariate level

($p < .05$) were entered together in a single multivariate logistic regression model. Only participants with complete data (n=135) were entered into the sample for the logistic regression analyses. To look for possible selection bias, comparisons were made between participants in the analyzed sample and the participants excluded due to incomplete data, using t-tests and fisher's exact tests. Correlations between potential predictors were analyzed in a correlation matrix, prior to entering the multivariate logistical regression, to check for multicollinearity. The statistical software package, STATA (version 13.0) (StataCorp, College Station, TX), was used for the data analysis.

Results

Characteristics of the participants that consented to participate in the study (N=146) were: mean age 39 (±10) years old, 74% female, 92% from Mexico or a Central American country, 61% with less than a high school graduate education, and 65% with family income < $15,000/year (see Table 1). Fourteen percent reported a history of gestational diabetes, 11% a history of prediabetes, and 35% a family history of diabetes. Eighty three percent were overweight or obese (BMI $\geq$ 25 kg/m^2). Twenty three percent had an ADA Type 2 Diabetes Risk Test score of 5 points or greater. Twelve percent had an A1C level consistent with prediabetes, and 2% consistent with undiagnosed diabetes. Forty seven percent were did not meet a level of physical activity recommended to prevent T2DM of 150 minutes of aerobic activity of moderate-intensity or greater. The average number of portions of fruit and vegetables consumed per day was 3.44 (±2.00).

The *Personal Disease Risk* subscale mean score was 1.73 (±0.67) indicating an overall slight perceived risk across the 15 diseases and health problems. Table 2 displays the mean scores of each of the 15 diseases and health problems in subscale ranked by mean perception of

risk score. Diabetes was the disease/health condition with the highest mean perception of risk score. Mean perception of risk scores of developing diabetes and other chronic diseases including high blood pressure, arthritis, heart disease and cancer, were greater than mean perception of risk scores of developing a number of chronic complications of diabetes. Also presented in table 2 are the proportions of study participants that reported a perception of high risk, and proportion of the sample that reported a perception of moderate or high risk. Sixteen percent of participants reported perception of high risk of developing diabetes, and 31.5% had a perception of moderate or high risk.

The *Comparative Environmental Risk* subscale mean score was 1.88 (±0.79) indicating overall slight perceived risk across the 9 potential health hazards assessed. The mean scores of each of the hazards are displayed in rank order in Table 2. The hazard with the highest mean perception of risk score was secondary cigarette smoke. The mean perception of risk scores of secondary cigarette smoke and other environmental chemicals and toxins including household chemicals, air pollution, and pesticides were greater than the mean perception of risk scores of a number of physical hazards to personal health including driving/riding in an automobile, violent crime, and extreme weather. Secondary cigarette smoke was perceived as high risk for personal health by 31% of the participants, and high or moderate risk by 46%.

The mean score on the *Personal Control* subscale was 3.34 (±0.76) indicating a tendency toward greater perceived personal control over risk of development of diabetes. The mean score on the *Worry* subscale was 2.96 (±0.80) indicating a slight to moderate concern regarding risk of developing diabetes. The mean *Optimistic Bias* subscale score was 2.96 (±0.92) indicating a tendency among the participants to perceive their risk of developing diabetes as less than that of

someone the same age and sex. The mean score on the *Diabetes Risk Knowledge* test was 4.36 (±2.18).

A sample of 135 of the study participants with complete data was selected to analyze the factors associated with moderate/high risk perception of developing diabetes. No statistically significant differences in assessed sociodemographics and health characteristics were found between 135 participants with complete data used in this analysis and the 11 participants who were excluded because of missing data (results not shown).

Of the 135 participants included in the statistical analyses, 42 (31.5%) were found to have moderate/high risk perception of developing diabetes, and 92 (68%) were found to have lower risk perceptions. Table 3 shows that the probability of being in the moderate/high risk perception of developing diabetes group was greater in adults with a history of prediabetes, a history of gestational diabetes, family history of diabetes, a high school diploma (or equivalent), and a family income of > $15,000/year. Participants with moderate/high diabetes risk perception were less optimistic about developing diabetes (more realistic), more worried, perceived more comparative disease risk, and perceived more comparative environmental risk. The comparative disease risk subscale score was the variable most strongly associated with risk perception of developing diabetes. History of prediabetes variable was not allowed to continue into the multivariate logistic regression model due to concerns that it would overwhelm the other predictors. Entering the remaining predictor variables with evidence of significance at the univariate analyses ($p < .05$) resulted in a multivariate logistic regression model with significant measures of fit (log likelihood = 38.582662, chi-square = 90.23 ($p < 0.0001$), pseudo R square = 0.5390).

Based on the lower bounds of the confidence intervals in the multivariate logistic regression model, the probability of being in the moderate/high risk perception group was at least 2.18 times greater if participants had a history of gestational diabetes, and 1.2 times greater if participants had a high school diploma (or equivalent). For every one unit increase in comparative disease risk subscale score, participants were at least 10.71 times more likely to be in the moderate/high risk perception group. For every one unit increase in worry subscale score, participants were at least 1.16 times more likely to be in the moderate/high risk perception group. For every one unit decrease in optimistic bias subscale score, adults were at least 1.22 times more likely to be in the lower risk perception group.

Discussion

The current study reveals a detailed description of risk perception of developing diabetes and modifying factors in a Latino, Spanish-speaking, lower educational attainment, at-risk population. The study addresses a gap in an emerging field of T2DM primary prevention research, as comparable studies performed among practicing physicians (Walker et al., 2003), primary care patients (Hivert, Grant, Warner, Meigs, & Shrader, 2009), and women with a history of gestational diabetes (Kim et al., 2007), have been in non-Latino White and/or Asian, English-speaking, and higher educational attainment populations.

The findings of the current study show that one third (31.5%) of the participants surveyed perceived themselves to be at moderate/high risk of developing diabetes. While this finding differs from a study of women with a history of gestational diabetes in which more than half of the participants (56.7%) had moderate/high diabetes risk perceptions (Kim et al., 2007), this finding did not differ markedly from findings in primary care patients (34.0%) ([25], and practicing physicians (27.7%) (Walker et al., 2003).

The factors found in the current study that predicted moderate/high vs. lower diabetes risk perception included: having a history of gestational diabetes, being a high-school graduate, having less optimistic bias (or a more realistic view of personal risk), having a greater degree of worry or concern, having greater perception of risk of developing comparative diseases and health conditions. These predictors of risk perception of developing diabetes may highlight factors that sensitize individuals to potential risk of developing the disease and merit further study.

The level of perceived personal control in the current study did not differ greatly from that found in other populations. However, there were higher levels of optimistic bias, and worry found in the current study. Of the four comparable studies, the lowest mean score on the knowledge of risk factors for developing diabetes was found in the current study and the highest in the sample of practicing physicians (Walker et al., 2003). It is conceivable that judgments of risk may be made differently in our Latino sample compared to the samples of the other studies (Hivert et al., 2009; Kim et al., 2007; Walker et al., 2003). In the other studies perception of personal risk of developing diseases and health conditions may be more in-line with objective statistical risk data obtained in formal education. In the current study sample, however, there may be more of a reliance on judging risk based on personal experience and exposure to information gleaned from the media. This reliance on personal experience in judgment of risk may also account for the difference observed between the current study sample and the sample practicing physicians (Walker et al., 2003) in the ranking of risk of diabetes in comparison to other chronic diseases. In the current study, diabetes was the top ranked disease and health condition in the *Personal Disease Risk* subscale, whereas in practicing physicians, diabetes was ranked fifth after heart disease, high blood pressure, arthritis, and cancer (Walker et al., 2003).

And in the Comparative Environmental Risk subscale, in the current study second hand smoke was the environmental health hazard perceived as posing the greatest risk, whereas in practicing physicians, driving/riding in a car was ranked as the greatest risk (Walker et al., 2003).

Strengths and limitations

This is the first study to describe risk perception of developing diabetes and modifying factors using a Spanish-language version of the validated Risk Perception Survey for Developing Diabetes among US Latino Spanish-speaking foreign-born adults a population characterized by factors linked to social disparities of diabetes-related health outcomes. The strengths of this study were that it was conducted entirely in Spanish in a homogenous sample using validated instruments in settings well known to the participants. Fluent Spanish-speaking research team members were available to answer questions and provide support in completing the research questionnaire. The results reveal important insight into the perception of diabetes risk in this vulnerable population of primarily Spanish-speaking Latino adults.

Limitations of the current study include reliance on recruitment of volunteers willing to complete the questionnaire and undergo measurement of weight, height and A1C, which may have resulted in a greater prevalence of adults concerned about their risk of developing diabetes in the sample, limiting the generalizability of the findings. The sample size was adequate but small and statistical analysis was limited to only those participants with complete data. A larger sample may have allowed for a number of subgroup comparisons to understand the effect of gender, ADA Type 2 Diabetes Risk Test score, and the influence of other independent variables on risk perception of developing diabetes.

Potentially modifiable factors that are linked to social disparities and diabetes outcomes were not assessed including: food security and health insurance. Assessment of these factors may

help explain the differences between the findings in the current study and other published studies. Food distribution events, where recruitment occurred are often attended by families that lack of sufficient means to eat balanced meals, eat sufficient quantities of food, and eat regular meals. Free clinics, another site where recruitment also occurred, tend to serve adults that lack health insurance, a risk factor for receiving inadequate health screening and health education.

Implications for Care and Public Health

A major focus of US public health T2DM primary prevention efforts is engagement of adults with prediabetes in preventive lifestyle modification programs. Optimizing T2DM primary preventive initiatives in vulnerable populations is a priority in national public health efforts. Public health T2DM primary prevention efforts stand to benefit from the detailed description of risk perception and modifying factors in this at-risk population and further research in this emerging area. More immediately, understanding risk perception of developing diabetes and modifying factors in diverse populations may serve to inform patient/clinician interactions which are seen as a key opportunities for engaging individuals at high risk of developing diabetes in T2DM primary preventive behavioral modification programs. Future studies are needed to further elicit the social, cultural, and economic factors that influence perception of risk of developing T2DM. Ultimately the goal of this research is to develop interventions targeting risk perception to positively influence preventive health behaviors to alter the course of development of T2DM.

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Table 1. Participant characteristics (N=146)

	Mean (SD)	n (%)
Age (years)	39.5 (9.9)	
Female		108 (74.0)
Country of origin*		
Mexico		60 (41.1)
Guatemala		60 (41.1)
El Salvador		15 (10.3)
Other Latin American country		9 (6.2)
Education level		
Never went to school or only went to kindergarten		4 (2.7)
1st to 8th grade education		64 (46.6)
9th to 11th grade education		21 (14.4)
12th grade education or GED diploma		42 (28.8)
1 to 3 years of university education		13 (8.9)
4 years or more of university education		2(1.4)
Yearly household income*		
Less than $10,000		70 (48.0)
$10,000 to $15,000		25 (17.1)
$15,000 to $20,000		21 (14.4)
$20,000 to $25,000		12 (8.2)
$25,000 to $35,000		14 (9.6)
$35,000 to $50,000		3 (2.1)
Medical history		
History of gestational diabetes		21 (14.4)
History of prediabetes		16 (11.0)
Family history of diabetes (mother, father, sister or brother)		51 (34.9)
Body mass index		
Overweight (BMI 25.0-29.9 Kg/m^2)		62 (42.5)
Obese (BMI 30.0-39.9 Kg/m^2)		54 (37.0)
Extremely Obese (BMI $\geq$ 40.0 Kg/m^2)		5 (3.4)
American Diabetes Association type 2 diabetes risk test		
Increased risk of type 2 diabetes ($\geq$ 5 points)		34 (23.3)
A1C		
Prediabetes (5.7-6.4%)		17 (11.6)
Undiagnosed diabetes (6.5% and greater)		3 (2.1)
Physical activity		
< 150 min/week moderate and vigorous physical activity		69 (47.3)
Diet		
Fruit and vegetable intake (average portions/day)	3.4 (2.0)	

* Sum of percentages not 100 due to missing data

Table 2 Results of sRPS-DD Personal Disease Risk and Comparative Environmental Risk subscales (N=146)

	Have or have had disease/ health condition	Mean* risk perception	**"High"** risk perception	**"High"** or **"Moderate"** risk perception
	n (%)	Mean	n (%)	n (%)
Personal Disease Risk subscale				
Diabetes	0 (0.00)	2.08	24 (16.44)	46 (31.51)
High blood pressure	10 (6.85)	1.88	13 (8.90)	33 (22.60)
Arthritis	8 (5.48)	1.82	11 (7.53)	32 (21.92)
Impotence (men only)	0 (0.00)	1.76	5 (13.16)	8 (21.05)
Heart disease	1 (0.68)	1.75	12 (8.22)	33 (22.60)
Cancer	2 (1.37)	1.67	11 (7.53)	27 (18.49)
Blindness	3 (2.05)	1.56	10 (6.85)	23 (15.75)
Osteoporosis	1 (0.68)	1.53	6 (4.11)	19 (13.01)
Kidney failure	5 (3.42)	1.47	5 (3.42)	17 (11.64)
Stroke	1 (0.68)	1.49	8 (5.48)	18 (12.33)
Hearing loss	5 (3.42)	1.42	6 (4.11)	14 (9.59)
Infections needing treatment by a doctor	6 (4.11)	1.38	7 (4.79)	13 (8.90)
Asthma	6 (4.11)	1.34	5 (3.42)	10 (6.85)
Foot amputation	0 (0.00)	1.19	3 (2.05)	4 (2.74)
AIDS	0 (0.00)	1.10	1 (0.69)	2 (1.37)
Comparative Environmental Risk subscale				
Secondary cigarette smoke		2.39	45 (30.82)	67 (45.89)
Household chemicals		2.19	31 (21.23)	55 (37.67)
Air pollution		2.02	26 (17.81)	47 (32.19)
Pesticides		2.01	30 (20.55)	48 (32.88)
Extreme weather (hot or cold)		1.81	16 (10.96)	31 (21.23)
Medical X-rays/radiation		1.75	11 (7.53)	31 (21.23)
Driving/riding in an automobile		1.70	13 (8.90)	13 (8.90)
Violent crime		1.58	14 (9.59)	26 (17.81)
"Street"/illegal drugs		1.49	16 (10.96)	23 (15.75)

*Means calculated based only on responses of participants that indicated not having the disease/health condition and responded to item

Table 3: Comparisons between participants with lower vs. higher risk perception of developing diabetes (N=135)

Variables	**Lower diabetes** risk perception* (n=93)	**Higher diabetes** risk perception* (n=42)	**Unadjusted OR**	**P-value**
Risk factors for developing diabetes				
Age	38.73 (±10.03)	41.69(±9.54)	1.03	0.111
Male	27 (29.03%)	7 (16.67%)	0.49	0.130
History of prediabetes	2 (2.15%)	11 (26.19%)	16.15	< 0.001
History of gestational diabetes	7 (7.53%)	11 (26.19%)	4.36	0.005
Family history of diabetes	24 (25.81%)	21 (50.00%)	2.875	0.007
History of high blood pressure	7 (7.53%)	2 (4.76%)	0.61	0.554
Insufficient physical activity*	45 (48.39%)	20 (47.62%)	0.97	0.934
BMI (Kg/m^2)	29.07 (±4.15)	29.90(±5.89)	1.04	0.347
Indicators of risk of developing diabetes				
ADA risk score ≥ 5	19 (20.43%)	13(30.95%)	1.75	0.186
Prediabetic A1C	11 (11.83%)	4(9.52%)	0.78	0.694
Socio-demographic variables				
High school graduate	28 (30.11%)	24 (57.14%)	3.10	0.003
Family income ≥$15,000/year	28 (30.11%)	20 (47.62%)	2.11	0.051
Modifying psychosocial factors (possible range 1 to 4)				
Personal control	3.32 (±0.74)	3.34(±0.77)	1.04	0.869
Optimistic bias	2.67 (±0.86)	2.23(±0.95)	0.57	0.010
Worry	2.82 (±0.83)	3.17(±0.70)	1.82	0.022
Personal disease risk	1.28 (±0.34)	2.04(±0.64)	20.62	< 0.001
Comparative environmental risk	1.76 (±0.82)	2.18(±0.70)	1.91	0.006
Knowledge of risk factors of developing diabetes (possible range 0 to 11)				
Risk factor knowledge	3.82 (±2.11)	5.36(±1.99)	1.44	< 0.001

Note: OR= Odds Ratio

*Results presented as mean (±SD) or frequency (%), *based on SBAS

Table 4: Multivariate logistic regression model of variables predicting higher risk perception of developing diabetes (N=135)

Variables	Adjusted OR	95% CI	P-value
Risk factors for developing diabetes			
History of gestational diabetes	10.95	(2.18, 53.99)	0.004
Family history of diabetes	2.07	(0.59, 7.18)	0.254
Socio-demographic variables			
High school graduate or more	4.20	(1.20, 14.66)	0.024
Family income ≥ $15,000/year	0.84	(0.24, 2.94)	0.790
Modifying psychosocial factors			
Optimistic bias	0.40	(0.20, 0.82)	0.011
Worry	2.86	(1.16, 7.04)	0.022
Comparative disease risk	60.56	(10.71, 342.58)	< 0.001
Comparative environmental risk	0.67	(0.25, 1.76)	0.413
Knowledge of risk factors of developing diabetes			
Diabetes risk knowledge	1.21	(0.89, 1.64)	0.224

Note: OR= Odds Ratio; CI = confidence interval

Systematic Review of Type 2 Diabetes Preventive Lifestyle Interventions Delivered via Distance Learning Technologies

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Abstract

Background

Moderate weight loss through lifestyle modification can delay or prevent type 2 diabetes in adults at high risk for developing the disease. Distance learning technologies may decrease cost and increase availability of high-quality type 2 diabetes prevention lifestyle programs.

Objectives

The aims of this systematic review were to 1) describe type 2 diabetes prevention lifestyle studies testing interventions delivered via distance learning technologies, 2) describe the characteristics of the samples in these studies, and 3) assess the effectiveness of the interventions delivered via distance learning technologies for reduction of body weight.

Methods

Published studies were included that tested type 2 diabetes prevention lifestyle interventions delivered via distance learning technologies; were randomized controlled trials, non-randomized controlled trials, or before-and-after studies without a control group; and reported outcomes of weight loss. Two databases, PubMed and EMBASE were searched for reports of trials published in English, Japanese, Korean, or Spanish languages between January 1980 and September 2014. The identified trials were analyzed with a focus on study design, sample characteristics, features of interventions, and outcomes of weight reduction.

Results

Nine studies were identified that met the inclusion criteria. Five were randomized controlled trials, and the remaining studies were non-randomized controlled trials and before-and-after single group studies. The samples in 6 of the 9 identified studies were characterized by a broad range of risk factors for type 2 diabetes, and not limited to adults at high risk for

developing type 2 diabetes. Two of the studies were limited to adults with diagnosed prediabetes, defined by provider referral and self-report. One of the studies was limited to postpartum women with a history of gestational diabetes, defined by clinical diagnosis. Racial/ethnic minority groups were under represented in the samples, and no non-English speaking adults were included. The distance learning modes used to deliver interventions were: Web-based/Internet-based technologies, social media, DVDs, interactive voice response calls, telehealth video conferencing, and on-demand programing via television. In 7 of the 9 trials, components delivered via distance learning technologies were blended in interventions with components delivered face-to-face. The interventions were delivered only via distance learning technologies in two of trials. The weight loss outcomes were measured differently across studies and were not uniformly consistent with U.S. Center's for Disease Control and Prevention, Diabetes Prevention Recognition Program outcome measures.

Conclusions

Evidence of the effect of distance learning technologies in type 2 diabetes prevention lifestyle interventions is mixed and inconclusive due to the heterogeneity of study designs, sample characteristics, intervention components and modes of delivery, and variability in assessing weight loss. Although a wide variety of distance learning technologies are currently commercially available for delivering lifestyle interventions, only a limited number of clinical trials have been performed. Given the burden of type 2 diabetes in certain racial/ethnic minority groups and among individuals with disadvantaged socioeconomic status, focused research needs to be conducted in samples of adults at high risk for developing type 2 diabetes of prevention lifestyle interventions delivered via distance learning technologies that are tailored to vulnerable subpopulations and accessible with limited resources.

Keywords

Distance learning technologies; type 2 diabetes prevention

Systematic Review of Type 2 Diabetes Preventive Lifestyle Interventions Delivered via Distance Learning Technologies

Background

Threat of diabetes has emerged worldwide as a dominant public health concern. Estimated to affect more than 8.3% of the global adult population (International Diabetes Federation [IDF], 2012), diabetes is a major risk factor for cardiovascular disease and stroke, and a primary cause of chronic kidney failure, non-traumatic lower-extremity amputations, and blindness (Centers for Disease Prevention and Control [CDC], 2011). Internationally, the costs of diabetes to society are unsustainable; diabetes healthcare expenditures alone have been estimated at $471 billion for 2012 (IDF, 2012). If no action is taken, forecasts expect globally the number of persons with diabetes to nearly double from 285 million in 2010 to 439 million by 2030 (Shaw, Sicree, & Zimmet, 2010).

Type 2 diabetes (T2DM), accounting for 90 to 95% of all diabetes, can be delayed or in some cases prevented, through modification of lifestyle, diet and physical activity, that effectively reduces body weight. The landmark Diabetes Prevention Program (DPP) research trial demonstrated a decrease in incidence of T2DM of 58% among overweight individuals at high risk of developing T2DM that through lifestyle modification achieved a reduction of body weight in the range of 5-7%, regardless of racial/ethnic background (Knowler et al., 2002). T2DM prevention benefits of this level of modest weight loss have been shown to last in the DPP up to 10 years (Knowler et al., 2009).

However, provision of T2DM prevention lifestyle interventions similar to the intervention in the DPP to all people in the U.S. at high risk of developing T2DM has not yet been actualized or achieved. Cost is a limiting factor to widespread dissemination of

interventions. The DPP intervention was estimated to cost $1,399 per participant (Hernan et al., 2003). Translation studies of the DPP have controlled T2DM costs. However, low-cost high-quality scalable T2DM prevention lifestyle programs are not yet available. A common theme in proposals to deliver T2DM prevention lifestyle interventions (Atienza & Patrick, 2011; Green, Brancati, Albright, & Primary Prevention of Diabetes Working, 2012; Ockene, Schneider, Lemon, & Ockene, 2011; Wolfenden, Brennan, & Britton, 2010), is the incorporation of distance learning technologies (eg. web-based/Internet-based), which have become common channels for receiving information and communication for a growing number of people in the U.S. and around the world. In addition to lowering costs of delivery, potential benefits of incorporating distance learning technologies in T2DM prevention lifestyle intervention delivery include, reducing barriers to access, and improving engagement (Ali, Echouffo-Tcheugui, & Williamson, 2012; Whittemore, 2011).

A number of reviews of T2DM prevention lifestyle programs have been published (Ali et al., 2012; Cardona-Morrell, Rychetnik, Morrell, Espinel, & Bauman, 2010; Gillies et al., 2007; L. Jackson, 2009; Madden, Loeb, & Smith, 2008; Nield, Summerbell, Hooper, Whittaker, & Moore, 2008; Norris et al., 2005; Orozco et al., 2008; Satterfield et al., 2003; Whittemore, 2011; Yamaoka & Tango, 2005). However, no systematic review has been published that examined DPP modeled T2DM prevention lifestyle interventions delivered via distance learning technologies. It is important to learn whether interventions delivered remotely through technology are efficacious. If so, they have the potential to reach a larger part of the population at risk for developing T2DM. Therefore, the aims of this systematic review were to: 1) describe DPP modeled T2DM prevention lifestyle interventions delivered via distance learning technologies, 2) describe the characteristics of the study samples that were tested, and 3) assess

the effectiveness of T2DM prevention lifestyle interventions delivered via distance learning technologies on weight loss.

Methods

Studies were considered relevant for this systematic review if they met all the following inclusion criteria: 1) randomized controlled trials or non-randomized controlled trials or before-and-after single group studies without control groups; 2) studies that tested DPP modeled T2DM prevention lifestyle interventions intended to delay or prevent the onset of type 2 diabetes; 3) inclusion of participants that were ≥18 years of age; 4) inclusion of at least one distance learning technology in the delivery of the intervention. Distance learning modes of delivery include: web-based/Internet-based interventions, social media, serious games, DVDs, mobile applications, and certain telehealth applications (Eysenbach, 2011).

Search Strategy

Systematic search strategies were used to search the PubMed and EMBASE databases for records published from January 1, 1980 to September 19, 2014 to identify trials of T2DM prevention lifestyle interventions delivered via distance learning technologies. Table 1 includes a full description of the electronic search strategy for PubMed, from which the search of the other database was modeled. The search was limited to articles published in English, Korean, Japanese, and Spanish for which English translations of the titles were available.

Data Extraction and Review Methods

One reviewer (KJ) screened the citation titles and abstracts to identify articles that met the search criteria. The full-text of identified articles was retrieved and screened by one reviewer (KJ). In the case that the full-text of identified articles was only available in Japanese or Korean, the articles were reviewed by bilingual language-proficient associate researchers (EK and JC).

Questions about whether an article should be included were resolved through discussion with a second reviewer (SJ). One reviewer (KJ) extracted data from the articles that met the inclusion criteria.

Risk of Bias Assessment

Because studies of distance learning technologies are often reported as feasibility trials (Bennett & Glasgow, 2009), in addition to RCTs, non-randomized controlled trials and before-and-after studies were included in this review to represent emerging trends in distance learning technologies. Non-randomized controlled trials were studies in which the method of participant allocation was not random. Before-and-after studies were studies in which there was only one group, an intervention introduced by the investigators, and pre-post measurement performed. A risk of bias assessment (JPT & S, 2011) was made using a quality assessment tool (Thomas, Ciliska, Dobbins, & Micucci, 2004) appropriate for systematic reviews that include RCTs, non-randomized trials, and before-and-after studies (Deeks et al., 2003). In addition, the integrity of the interventions was assessed based on reported measures of engagement with the tested interventions (Eysenbach, 2011; N. Jackson & Waters, 2005).

Data Synthesis

To align with U.S. national T2DM prevention efforts, the text summary data synthesis of this review was framed using the Standards and Operating Procedures of the Centers for Disease Control and Prevention, Diabetes Prevention Recognition Program (DPRP) (CDC, 2015). Established under the Affordable Care Act, the DPRP is an initiative to faciliate quality and performance benchmarking of T2DM prevention lifestyle programs against the demonstrated efficacy and effectiveness of T2DM prevention lifestyle interventions in the DPP research trial, subsequent translational research studies, and other best practices.

Study samples were assessed in three key areas of focus in the DPRP standards and operating procedures: limitation of participant eligibility to adults at high risk for development of T2DM, use of evidence-based behavioral modification approaches for achieving modest sustainable weight loss, and weight outcomes. Participant assessment focused on evidence that enrolled participants were at high risk for developing T2DM. In alignment with DPRP standards, high-risk states of developing diabetes was limited to prediabetes and gestational diabetes mellitus (GDM). Prediabetes was defined as having a blood test consistent with elevated: fasting plasma glucose (100-125 mg/dL), 2-hour post-load plasma glucose (140-199 mg/dL), and/or hemoglobin A_{1c} (5.7-6.4%). Also considered high risk for developing T2DM were adults that were scored as having a high risk of having prediabetes or diabetes on screening tests for prediabetes or diabetes including: the CDC Prediabetes Screening Test, and the American Diabetes Association Type 2 Diabetes Risk Test. Interventions were assessed for duration, intensity, and components of interventions were classified by cognitive-behavioral strategies. Cognitive-behavioral strategy classifications included: 1) providing informational; 2) prompting of goal setting; 3) prompting and providing tools for self-monitoring; 4) providing feedback and support to promote development of problem-solving skills; and 5) facilitating social support (The Diabetes Prevention Program Research Group, 1999; Wing, 2004. pp. 147–62.). The effects of interventions in the identified trials were compared based on weight loss outcomes, and proportion of enrolled participants that experienced weight loss in the range of 5-10%. Due to the varied distance learning technologies and study designs direct comparisons of findings were not attempted. Results from trials with higher methodological quality were emphasized.

Results

Figure 1 illustrates the search and study selection process (Moher, Liberati, Tetzlaff, & Altman, 2010). The initial search yielded 2807 unique records. After excluding 604 duplicate records, and 2146 records on the basis of screening of titles and abstracts, 57 full-text records were assessed; 9 study reports (Ackermann et al., 2014; Estabrooks & Smith-Ray, 2008; Kramer et al., 2010; Ma et al., 2013; McTigue et al., 2009; Nicklas et al., 2014; Sepah, Jiang, & Peters, 2014; Tate, Jackvony, & Wing, 2003; Vadheim et al., 2010) met all the inclusion and exclusion criteria.

Description of Trials

Table 2 summarizes in chronological order from 2003 to 2014, the study designs and sample characteristics of the 9 studies in this review. All nine trials were conducted in the US. Five of the 9 trials used RCT designs (Ackermann et al., 2014; Estabrooks & Smith-Ray, 2008; Ma et al., 2013; Nicklas et al., 2014; Tate et al., 2003), two used non-randomized controlled trial designs (Kramer et al., 2010; Vadheim et al., 2010), and two trials used before-and-after study designs without control groups (McTigue et al., 2009; Sepah et al., 2014). Four of the five RCTs used two-armed designs (Ackermann et al., 2014; Estabrooks & Smith-Ray, 2008; Nicklas et al., 2014; Tate et al., 2003), the 5th used a three-arm design (Ma et al., 2013). In 3 of the trials that included two groups, interventions enhanced with additional component(s) were provided to one group and basic interventions provided to second group (Ackermann et al., 2014; Estabrooks & Smith-Ray, 2008; Tate et al., 2003). Control groups received standard care, in 2 of the trials (Ma et al., 2013; Nicklas et al., 2014). In one of the trials, the control group received an face-to-face treatment similar to the distance learning technology treatment being tested (Kramer et al., 2010). In the RCT that used a three-armed design, one group received standard care, and one group

received an face-to-face treatment similar to the distance learning technology treatment (Ma et al., 2013).

Sample Characteristics

The sample sizes of the studies varied from 27 (Vadheim et al., 2010) to 306 (Ackermann et al., 2014), with a total of 1,136 participants enrolled in the combined trials (see table 2). The baseline mean age of enrolled participants ranged from 33.4 years (Nicklas et al., 2014) to 59.7 years (Kramer et al., 2010). Most participants (84%) were women. The majority (72%) was non-Hispanic White. Detailed data on the ethnic/racial background of participants was reported in 6 of the 9 studies (Ackermann et al., 2014; Estabrooks & Smith-Ray, 2008; Ma et al., 2013; McTigue et al., 2009; Nicklas et al., 2014; Sepah et al., 2014). The percentage of participants identified as Black ranged from 4% (Estabrooks & Smith-Ray, 2008) to 29% (Nicklas et al., 2014; Sepah et al., 2014), Asian and/or Pacific Islander, 3% (Estabrooks & Smith-Ray, 2008) to 17% (Ma et al., 2013), and Hispanic/Latino, 3% (Ackermann et al., 2014) to 20% (Nicklas et al., 2014). All of the trials limited enrollment to English language proficient participants. Eight of the trials reported data on the educational attainment level of enrolled participants (Ackermann et al., 2014; Estabrooks & Smith-Ray, 2008; Kramer et al., 2010; Ma et al., 2013; McTigue et al., 2009; Nicklas et al., 2014; Sepah et al., 2014; Tate et al., 2003). Five trials reported income level data (Ackermann et al., 2014; Ma et al., 2013; McTigue et al., 2009; Nicklas et al., 2014; Sepah et al., 2014). Demographic data reported in the 9 trials is shown in Table 2.

The eligibility criteria of 8 trials included BMI requirements (Ackermann et al., 2014; Gabriele, Carpenter, Tate, & Fisher, 2011; Kramer et al., 2010; Ma et al., 2013; McTigue et al., 2009; Nicklas et al., 2014; Sepah et al., 2014; Vadheim et al., 2010). In five of the 8 trials, potential participants were considered eligible if they had a baseline BMI of 25 kg/m^2 or greater

(Ackermann et al., 2014; Kramer et al., 2010; Ma et al., 2013; McTigue et al., 2009; Vadheim et al., 2010). In one trial participants were required to have a BMI of 27 kg/m^2 or greater (Tate et al., 2003). In another trial participants were required to have a BMI of 24 kg/m^2 or greater, or 22 kg/m^2 or greater if participants were Asian (Sepah et al., 2014). In one trial participants were required prepregnancy to have a BMI of 24 kg/m^2 or greater, or 22 kg/m^2 or greater if Asian (Nicklas et al., 2014). One trial did not report a BMI eligibility requirement (Estabrooks & Smith-Ray, 2008). Among the 8 trials reporting baseline BMI data, the highest mean BMI was 36.6 kg/m^2 (Sepah et al., 2014), and the lowest was 30.4 kg/m^2 (Nicklas et al., 2014).

In two of the studies, eligibility was limited to adults with prediabetes defined by elevated blood glucose level or clinical diagnosis of prediabetes (Estabrooks & Smith-Ray, 2008), or by self-reported history of prediabetes (Sepah et al., 2014). In one trial, participation was limited to women that were clinically diagnosed with gestational diabetes during their pregnancy recruited during the course of their pregnancy care (Nicklas et al., 2014). The other six trials (Ackermann et al., 2014; Kramer et al., 2010; Ma et al., 2013; McTigue et al., 2009; Tate et al., 2003; Vadheim et al., 2010) based eligibility on a broader range of risk factors for metabolic or cardiovascular disease including: age greater than or equal to 45 years old, belonging to a minority ethnic/racial group, history of prediabetes, impaired glucose tolerance, impaired fasting glucose, a family history of diabetes (parent or sibling), diabetes, metabolic syndrome, hypertension, dyslipidemia, abdominal obesity, history of gestational diabetes, and history of giving birth to an infant weighing more than 9 lbs. In five of the 6 trials that based eligibility on a broader range of risk factors for metabolic or cardiovascular disease, the proportions of participants characterized by categories consistent with prediabetes were reported (Kramer et al., 2010; Ma et al., 2013; McTigue et al., 2009; Tate et al., 2003; Vadheim et al.,

2010). Tate et al. (2003) reported that 7% of participants had impaired glucose tolerance. Kramer et al. (2010) reported that 85% of the participants had prediabetes at baseline based on fasting blood glucose or hemoglobin A_{1c} level. In two trials, McTigue et al. (2009) and Vadheim et al. (2010), 16% and 33% of enrolled participants respectively, were reported to have one of three criteria: prediabetes, impaired fasting glucose, and/or impaired glucose tolerance. Ma et al. (2013) reported that 54.4% of participants had prediabetes. Characterization of glycemic status was not reported in Ackermann et al. (2014). None of the studies reported data reflective of risk status of prediabetes or diabetes based on screening test scores.

Intervention Characteristics

The duration and intensity that curriculum content was delivered in the interventions varied in the 9 identified trials. Five trials tested interventions with 12-month durations (Ackermann et al., 2014; McTigue et al., 2009; Nicklas et al., 2014; Sepah et al., 2014; Tate et al., 2003), one trial tested an intervention with a 15-month duration (Ma et al., 2013), and three trials tested interventions with 3-4 month durations (Estabrooks & Smith-Ray, 2008; Kramer et al., 2010; Vadheim et al., 2010). In 4 of the 5 trials that tested interventions with 12-month durations, the initial 3 – 4 months were core phases, and the remaining 8 – 9 months were maintenance phases (Ackermann et al., 2014; McTigue et al., 2009; Nicklas et al., 2014; Sepah et al., 2014). Three trials tested interventions that consisted only of only 3-4 month core phases (Estabrooks & Smith-Ray, 2008; Kramer et al., 2010; Vadheim et al., 2010). In the core phases of the interventions participants were exposed to a new curriculum topic each week. In the maintenance phases, new curriculum topics were offered monthly. In one trial of an intervention with a 12-month duration, details of the pacing and number of curriculum topics was not reported (Tate et al., 2003).

The trial interventions delivered curricular content via a variety of distance learning technologies. Estabrooks and Smith-Ray (2008) delivered content through interactive voice response automated telephone calls. Kramer et al. (2010) and Ma et al. (2013) provided participants with DVDs of pre-recorded staged group meetings. Vadheim et al. (2010) synchronously transmitted group meetings through telehealth video conferencing. Tate et al. (2003) delivered intervention content through an asynchronous web-based tutorial. Sepah et al. (2014) delivered content in a series of asynchronous lessons in a workbook format posted on a web page. McTigue et al. (2009) delivered content via web-based asynchronous auto-narrated lessons. Nicklas et al. (2014) delivered animated videos narrated by a physician via an asynchronous web-based program. Participants in Ackermann et al. (2014) were offered curriculum content via on-demand television programing. In four of the 9 trials, intervention participants received supplemental curricular content at face-to-face introductory/orientation sessions (Estabrooks & Smith-Ray, 2008; Ma et al., 2013; McTigue et al., 2009; Tate et al., 2003).

The interventions in eight of the nine trials included self-monitoring components and/or tools. Kramer et al. (2010) and Vadheim et al. (2010) included exclusively printed hard-copy diaries for participants receiving the distance learning technologies to self-monitor body weight, food intake, and physical activity. Exclusively web-based self-monitoring diaries were provided to intervention participants in Ma et al. (2013) and Sepah et al. (2014). And four trials provided intervention participants both printed and web-based diaries for self-monitoring (Ackermann et al., 2014; McTigue et al., 2009; Nicklas et al., 2014; Tate et al., 2003). Standard pedometers were supplied as part of the intervention in four trials (Kramer et al., 2010; Ma et al., 2013; McTigue et al., 2009; Nicklas et al., 2014). Sepah et al. (2014) provided participants with digital

pedometers. Standard body weight scales were provided as part of the intervention in two trials, (Ma et al., 2013; Nicklas et al., 2014). Sepah et al. (2014) and Ackermann et al. (2014) provided intervention participants wireless scales that passively transmitted data via the Internet. Self-monitoring components were not reported in the intervention in Estabrooks and Smith-Ray (2008).

In 8 of the 9 studies, support and guidance was delivered by lifestyle coaches with a range of backgrounds and training, via distance communication technologies (Ackermann et al., 2014; Kramer et al., 2010; Ma et al., 2013; McTigue et al., 2009; Nicklas et al., 2014; Sepah et al., 2014; Tate et al., 2003; Vadheim et al., 2010) In McTigue et al. (2009), registered nurses communicated with participants via electronic messaging and an on-line chat-room. In Nicklas et al. (2014), registered dietitians communicated with participants through the web-based portal and/or by telephone. In Tate et al. (2003), Ackermann et al. (2014), Sepah et al. (2014), and Ma et al. (2013) lifestyle coaches communicated with participants via web-portals. Social support was facilitated through an on-line chat room, telehealth videoconference group sessions, on-line discussion boards, social media.

The cost estimates were reported in 2 of the 9 trials. In Kramer et al. (2010), the cost of the in-person intervention received by the control group was estimated to be $300 per participant. The average cost per participant of the 10-month on-site group intervention received by the control group in Vadheim et al. (2010) was $560, and the telehealth intervention received by the intervention group, $470.

Effects of Interventions

The weight loss results reported in the 9 trials included in this review are displayed in Table 4. A number of key findings of the potential of lifestyle interventions delivered via

distance learning technologies to improve weight loss can be synthesized from the five RCTs that provide the highest quality of evidence. Improved weight loss due to interventions delivered via distance learning technologies was demonstrated in an RCT that evaluated effectiveness of a home-based self-directed DVD intervention, and a coach-led face-to-face group intervention. Compared to usual care and the self-directed DVD intervention, the face-to-face coach-led intervention was found to achieve the greatest improvements (Ma et al., 2013). The weight loss improvements achieved by the self-directed DVD intervention were greater than those achieved by usual care. The self-directed DVD and the coach-led face-to-face interventions both included self-monitoring aids and lifestyle coaching delivered via the Internet (Ma et al., 2013). In the only other RCT that compared interventions delivered via distance learning technologies to usual care, greater reduction in postpartum weight retention was achieved by an intervention that included web-based delivery of curriculum topics, self-monitoring aids, and lifestyle coaching (Nicklas et al., 2014). There were conflicting findings from the two RCTs that compared the effectiveness of basic and enhanced programs delivered via distance learning technologies. Tate et al. (2003) demonstrated that compared to weight loss achieved by a basic Internet-delivered program, greater weight loss could be achieved when the basic program was augmented with web-based self-monitoring aids and lifestyle coaching. However, a subsequent study by Ackermann et al. (2014), that delivered curricular content in on-demand video programing via television, found no improvement effect when web-based self-monitoring aids and lifestyle coaching were added. Estabrooks and Smith-Ray (2008) tested a series of interactive voice response telephone calls after a face-to-face group session. Compared to a no treatment control group, the interactive voice response telephone call group did not experience significantly greater alterations in body weight.

Findings can also be synthesized from the non-randomized controlled trials that provide a degree of preliminary evidence. Kramer et al. (2010) evaluated an intervention delivered via mail of pre-recorded group session DVDs accompanied by telephone delivered lifestyle coaching. At 3 months, both the intervention group and the in-person control group experienced significant within-group reductions in mean body weight but no between group differences were found. Vadheim et al. (2010) tested an intervention delivered via telehealth video conferencing and found no significant differences in mean weight loss at 4 months between the intervention group and the in-person control group. Findings from the 2 single-group pre-post studies provide preliminary evidence regarding the potential implications of distance learning DPP modeled lifestyle interventions. McTigue et al. (2009) and Sepah et al. (2014) demonstrated the feasibility of delivering an Internet program with self-monitoring aids and social support features in single group pre-post studies.

Methodological Quality Factors

Important to highlight are a number of methodological factors that may influence the findings in the 9 identified trials. In only 3 of the trials were potential participants referred in a systematic manner from clinical sources and the percentages that agreed to participate before randomization reported (Estabrooks & Smith-Ray, 2008; Ma et al., 2013; Nicklas et al., 2014). In the 6 other studies identified participants were self-referred. In 8 of the identified trials, eligibility screening was performed in-person. In one study, potential participants were screened only by telephone (Sepah et al., 2014). In all 5 of the RCTs identified in this review, adequate description of allocation processes that included concealment and appropriate methods were reported, with balanced intervention and control groups at baseline with respect to potential

confounders. The allocation process was not described in any of the identified non-randomized controlled trials.

Blinding of study staff involved in administering the interventions was not reported in any of the 9 identified trials. Measures of engagement (Eysenbach, 2011) in the intervention were reported in all of the identified trials. Measurements of engagement included: web-site analytic data, email messages, completed interactive voice response calls, telehealth video conference group attendance, on-demand programing viewing data, and web-based forms submitted after watching modules. Only one of the trials reported assessment of participant initiated co-interventions (eg. other weight loss programs) (Ma et al., 2013). In 2 of the trials, outcome assessors were blinded to treatment allocations (Ma et al., 2013; Nicklas et al., 2014). Blinding of the outcome assessors was not described in 5 of the identified studies. Outcome assessments in 2 of the 9 trials used self-obtained weight measures by participants using home-based wireless scales transmitted through cellular networks (Ackermann et al., 2014; Sepah et al., 2014). Only one of the two trials that used wireless scales reported estimates of the wireless scales accuracy from the manufacturer, and range and test-retest analyses to support reliability and validity of the measures (Ackermann et al., 2014). In only two of the studies that used traditional scales to assess outcome measures were calibration procedures described (Ma et al., 2013; Nicklas et al., 2014). Six trials of the 9 trials identified reported intention-to-treat analyses (Ackermann et al., 2014; Estabrooks & Smith-Ray, 2008; Kramer et al., 2010; Ma et al., 2013; Nicklas et al., 2014; Tate et al., 2003). Three reported per-protocol analyses (McTigue et al., 2009; Sepah et al., 2014; Vadheim et al., 2010). In one of the RCTs, simple imputation (eg. baseline) was used to handle missing data (Tate, 2003), and in one study multiple imputation (eg. Monte Carlo Method) was used (Ackermann, 2014). In two of the trials, there was mention that

authors/evaluators involved in the study were employees of the companies that developed and owned the investigated distance based learning interventions being tested (Ackermann et al., 2014; Sepah et al., 2014).

Discussion

The purpose of this systemic review was to describe research performed testing T2DM prevention lifestyle interventions delivered via distance learning technologies. In summary, from this review the evidence regarding the efficacy of distance learning technologies in the delivery of T2DM prevention lifestyle interventions for adults at high risk of developing diabetes is limited.

T2DM prevention lifestyle studies have tested various intervention distance delivery modes including: web-based/Internet-based interventions, social media, DVDs, interactive voice telephone calls, telehealth video conferencing, and on-demand programing delivered via television. This range of technologies is generally reflective of current commercially available distance learning technologies, with the notable exception that there were no studies identified in this review that tested interventions delivered by mobile applications. Computer mediated programs have been tested in which curriculum content has been delivered in a variety of formats including, workbooks, audio-narrated lessons, and short videos.

From the evidence distance learning technologies have the potential to be efficient platforms for T2DM prevention lifestyle programs. They are can be used for providing information, prompting goal setting, promoting and providing tools for self-monitoring, and providing feedback. Lifestyle coaches can use communication technologies to provide support and guidance to participants regarding progress toward goals. Based on the limited cost information available from 2 of the reviewed trials, preliminary evidence indicates that distance

learning technologies delivered T2DM prevention lifestyle interventions may be significantly less resource intensive than the original DPP study intervention.

The majority of the studies identified in this review tested hybrid interventions that required participants to attend at least one face-to-face group meeting with other study participants and lifestyle coaches. In only two of the trials were participants able to use the entire intervention at their own convenience from their own homes (Ackermann et al., 2014; Sepah et al., 2014). In light of this distinction between synchronous and asynchronous interventions, at this point in the research of the effectiveness of delivery via distance learning technologies further investigation is needed to fully evaluate potential effects of T2DM prevention lifestyle interventions that can be used entirely at the convenience of participating individuals.

Due to methodological limitations the findings of the studies identified in this review need to be interpreted with caution. Participant recruitment in the majority of the identified studies depended on self-referral, which increases the risk of selection bias, and may lead to over estimation of efficacy effects. Only one of the studies reported whether participants were participating in other weight loss programs. The possibility of co-interventions from participation in other studies or activities is a potential confounder that could have resulted in over estimation of efficacy of the tested interventions. In a number of the identified studies the validity and reliability of the scales used to assess body weight, a key outcome, were not reported. The simple imputation technique used to handle missing data in one of the studies increases the risk of over reporting efficacy since the data may not be reflective of unrecorded weight gain that may have occurred in some participants. Per-protocol analysis, used in a number of studies increases the risk of efficacy estimates that are not generalizable since analysis is limited to participants engaged with the intervention.

Sample characteristics of the 9 reviewed studies limit the generalizability of the findings. The majority of participants in the sample populations were female. Certain ethnic/racial minority groups including African-American/non-Hispanic black and Hispanic/Latino populations were underrepresented, and no T2DM prevention lifestyle interventions delivered via distance learning technologies were tested in U.S. adults unless they were proficient in English. There were no U.S.-based or international trials of DPP modeled T2DM prevention lifestyle interventions conducted in Spanish. The majority of the trials have been among samples of adults with college-level education. Participants from disadvantaged socioeconomic populations were under-represented. Only two of the trials met the standards for participant eligibility in the DPRP, having prediabetes or having a history of gestational diabetes. In 7 of the 9 trials, large proportions of the samples were characterized by broader T2DM risk factors, which is not in alignment with national implementation efforts of T2DM prevention lifestyle programs that are targeted to people at high risk for developing diabetes.

This review has a few limitations to consider. Only trials that tested DPP modeled T2DM prevention lifestyle interventions delivered via distance learning technologies were included. Due to the paucity of randomized controlled trials testing these interventions, meta-analysis was not possible. The inclusion of non-randomized controlled trials and single group pre-post studies provides information limited to feasibility and promise but not definitive results. The interventions in the identified trials were complex, often with multiple components that precluded evaluation of the effectiveness of single components. Despite these limitations, the findings of this review have important implications. Distance based learning technologies exist capable of delivering T2DM prevention lifestyle programs in a variety of formats with features that leverage important behavioral change techniques. Engagement of adults with risk factors for

developing T2DM in prevention programs delivered via distance learning technologies can result in achievement of modest weight loss at levels that are clinically significant for prevention of development of T2DM.

Future Directions

Future research is needed to more fully evaluate T2DM prevention lifestyle interventions delivered via distance learning technologies. The small number of studies identified demonstrates the promise of these delivery platforms, but more research needs to be done to adequately describe the target populations, the characteristics of the interventions, and the efficacy of these interventions. Furthermore, without using commonly accepted and consistent outcome measures, comparisons of the effectiveness of these interventions in findings across studies are difficult to adequately evaluate.

More research is needed to test T2DM prevention lifestyle interventions delivered via distance learning technologies among adults at high risk of developing diabetes belonging to minority ethnic/racial groups especially Latino/Hispanic, and non-Hispanic black populations. Special considerations to expand recruitment of participants from certain at risk ethnic/racial minority groups or socioeconomically disadvantaged populations in future trials of interventions delivered via distance learning technologies should include sensitivity to cultural diversity, literacy level, and language. Future trials need to also include outcome measures consistent with DPRP standards and cost evaluations of the interventions.

Wired web-based/Internet-based platforms, the distance learning technologies used in many of the identified trials, may not reach adults of diverse racial/ethnic backgrounds due to different devices used to access the Internet and the digital divide; that is not all persons have equivalent access and skills. Mobile communication devices present opportunities to engage U.S.

adults in T2DM prevention lifestyle programs. Particularly programs accessible on Smartphones have the potential in the US to reach racial/ethnic minority populations that are disproportionately affected by prediabetes and T2DM. Today, 85% of adults in the U.S. use the Internet (Fox, 2011). An equal proportion of US adults own a mobile phone, and 45% own a Smartphone (Fox & Duggan, 2012). Individuals belonging to ethnic/racial groups or socioeconomically disadvantaged populations are particularly likely to access the Internet via mobile communication devices. Recent survey data shows high penetration of Smartphone ownership among racial and ethnic minority populations. While 42% of non-Hispanic white adults own a Smartphone, 47% of non-Hispanic black adults and 49% of Hispanic adults report Smartphone ownership (Fox & Duggan, 2012). Compared to non-Hispanics White adults, Smartphone owners who identify themselves as belonging to a racial/ethnic minority group, engage in more non-voice calling mobile phone activities, including: sending and receiving text messages, accessing the Internet, sending or receiving email, downloading an app, or watching a video (Zickuhr & Smith, 2012).

Conclusion

The evidence of the effectiveness of T2DM prevention lifestyle programs is mixed due to the heterogeneity of study designs, sample eligibility criteria, and outcome measures. Although a wide variety of distance learning technologies is commercially available, only a limited number have been rigorously tested in research trials. Given the burden of T2DM in certain racial/ethnic minority groups and among individuals with disadvantaged socioeconomic status, T2DM prevention lifestyle interventions delivered via distance learning technologies that are sensitive to cultural differences and accessible for adults with limited resources need to be developed and tested in the near future.

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Abbreviations

A1C = hemoglobin A_{1c}
App = mobile communication technology application
BMI = body mass index
BP = blood pressure
DM = diabetes mellitus
GDM = gestational diabetes mellitus
HDL = high-density lipoprotein
HTN = hypertension
IFG = impaired fasting glucose
IGT = impaired glucose tolerance
IVR = interactive voice response
LDL = low-density lipoprotein
MS = metabolic syndrome
RCT = randomized controlled trial
T2DM = type 2 diabetes mellitus
TG = triglycerides
US = United States
WC = waist circumference

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Table 1: PubMed strategy

PubMed strategy
1. "Prediabetic State"[mh]
2. prediabet* OR pre-diabet*
3. Diabetes Mellitus, Type 2/pc[mh:noexp]
4. Diabetes Mellitus/pc[mh:noexp]
5. Glucose Intolerance[majr] OR "impaired fasting glucose"
6. Insulin Resistance[majr]
7. (Blood Glucose[majr] OR Glucose/metabolism[majr]) AND (diabetes OR diabetic*)
8. Metabolic Syndrome x/pc[mh] OR "metabolic syndrome"[ti]
9. Obesity/pc[mh] OR obesity[ti]
10. ("metabolic syndrome" OR obese OR obesity OR weight) AND (diabetes OR diabetic*)
11. 1-10/OR
12. avatar*
13. blog*
14. Bluetooth*
15. cell phone* OR cellular phone* OR cellular telephone*
16. chatroom*
17. Computers[mh]
18. "computer based" OR "computer tailored"
19. computer*[ti] NOT tomograp*
20. DVD*
21. Educational Technology[mh]
22. ehealth OR "e-health"
23. "electronic mail" OR email*[tw] OR e-mail*[tw]
24. exergam*
25. facebook
26. fitbit
27. gaming
28. information communication technolog*
29. Information Dissemination[mh]
30. instant messag*
31. internet
32. ipad*
33. iphone*
34. ipod*
35. mhealth[tw] OR "m-health"
36. mobile communication*
37. mobile device
38. "mobile health" NOT (mobile health clinic* OR mobile health unit*)
39. mobile phone* OR mobile telephone*
40. "personal digital assistant" OR "personal digital assistants"
41. smart phone* OR smartphone*

42. "social media"
43. (social support[mh] OR social network*) AND (online[tw] OR Online Systems[mh] OR Technology[mh:noexp])
44. technolog*[ti]
45. telehealth OR tele-health
46. telemonitor*
47. Telemedicine[mh:noexp]
48. Telenursing
49. Telephone[mh]
50. telephone* NOT (telephone interview* OR telephone survey*)
51. text messag*
52. texting[tw]
53. tweet
54. twitter
55. video game* OR videogam*
56. Videodisc Recording[mh]
57. videodis*
58. "virtual community"
59. “virtual reality”
60. “web-based” OR webpage* OR web page* OR web survey* OR web application* OR “web access”
61. “world wide web” OR “worldwide web”
62. “web resource” OR “web resources”
63. 12-62/OR
64. 11 AND 63
65. 11 AND 63
    a. NOT ("type 1" NOT "type 2")
    b. NOT (Diabetes Mellitus/therapy OR Diabetes Mellitus/diagnosis OR Diabetes Mellitus/pathology OR Diabetes Mellitus/physiopathology NOT prevent*)
    c. NOT (Adolescent[mh] OR Child[mh] NOT Adults[mh])
    d. NOT (adolescen*[ti] OR child*[ti] OR high school*[ti] OR infant*[ti] OR neonat*[ti] OR newborn*[ti] OR preschool*[ti] OR school age*[ti] OR youth*[ti] NOT (adult*[ti] OR men[ti] OR women[ti]))
    e. NOT (Animals[mh] NOT Humans[mh])
    f. NOT (Letter[pt] OR Editorial[pt] OR News[pt] OR Case Reports[pt] OR Review[pt] OR Dental Journals[sb])
66. 65 AND (Eng[la] OR Jpn[la] OR Kor[la] OR Spa[la])

Figure 1: Flow chart of the literature search

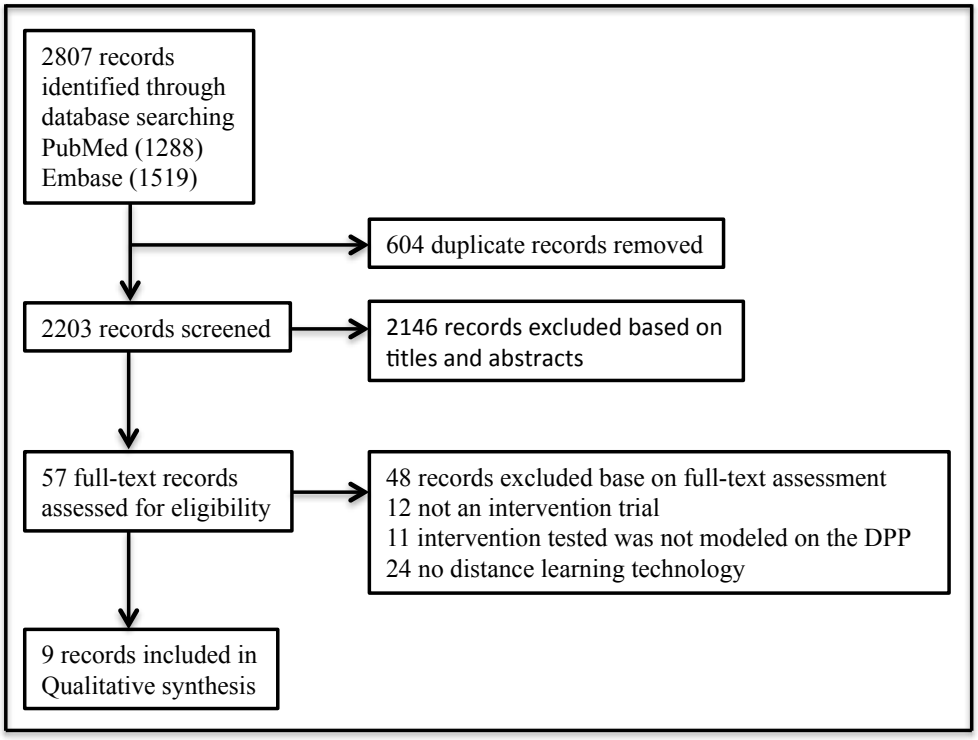

Table 2: Description of trials

First Author/ Year/ Country/ Duration of intervention	Design/Completed assessment/Measures of engagement/Dependent measures/ Methodological quality[a]	Eligibility screening procedure and criteria (BMI and T2DM risk)/participant cost or compensation	Sample characteristics	Mean BMI/ Percentage with prediabetes/hx of GDM/high risk test score
Tate 2003 U.S. 12 months	RCT 2 groups (N=92) • Intervention (n=46): Internet delivered program enhanced with self monitoring aids + lifestyle coaching via internet • Control (n=46): Basic internet delivered program Completed 12 mo assessment: Intervention 83% Control 85% Website login frequency Weight: in clinic in a hospital gown without shoes on a calibrated scale Height: in clinic using a wall-mounted stadiometer WC: in clinic at the umbilicus Venous blood glucose: analyzed at an independent lab Quality: Moderate	Screened: in-person BMI: ≥27 and ≤40 kg/m^2 T2DM risk: ≥1 risk factor • Age ≥45yrs • A family hx of DM • High chol • High BP • IGT • Hx of GDM • Hx of delivery of neonate ≥4kg • Racial/ethnic minority	Age: 48.5 (9.4) years Female: 89% White: 89% High school: 15% Some college: 37% College degree: 31% Graduate degree: 17% Income: NR	BMI: 33.1 (3.8) kg/m^2 Prediabetes: 7% (IGT) Hx of GDM: 9%
Estabrooks 2008 U.S. 3 months	RCT 2 groups (N = 77) • Intervention (n=39): In-person program + interactive voice response calls • Control (n=38): In-person program Completed 3 mo assessment: Intervention 82% Control 72% IVR call completion	Screened: in-person BMI: NR T2DM risk: elevated BG level and/or clinical dx of prediabetes (provider referral)	Age: 58.8 years Female: 71.4% White: 68% Asian: 3% Black: 4% Hispanic: 18% Other: 3% Unknown: 4% Grade school: 3% High school: 32%	BMI: NR Prediabetes: 100% (provider referral)

	Weight: in clinic clothed without shoes on a calibrated scale Height: in clinic using a wall-mounted tape measure Quality: Moderate		College: 35% 31% Graduate school: 14% Unknown: 16% Income: NR	
McTigue 2009 U.S. 12 months	Single group pre-post study 1 group (N=50) • Internet delivered program with self-monitoring aids and social support features Completed 12 mo assessment: Single group 90% Website login frequency Weight: in clinic (by study staff or at clinic appt) on a calibrated scale Quality: Weak	Screened: in-person BMI: ≥25 kg/m^2 T2DM Risk: ≥1 risk factor • HTN • Dyslipidemia • DM • IFG	Age: 51.94 (10.82) years Female: 76% White: 86% African American: 8% Asian: 4% Other: 2% ≥ Some college: 96% Income: Reported as ability to pay for basics	BMI: 36.43 (6.78) kg/m^2 Prediabetes: 16% (IFG)
Kramer 2010 U.S. 3 months	Nonrandomized controlled study 2 groups (N = 48) • Intervention (n=22): DVD self-directed program + lifestyle coaching via telephone • Control (n=26): In-person coach-led program 3 mo assessment: Intervention 64% completed Control 92% completed Telephone call completion Weight, height, WC, fasting glucose and A1C: at center (details not reported) Quality: Weak	Screened: in-person BMI≥25 kg/m^2 T2DM Risk: • IFG • MS (NCEP ATP III criteria)[c]	Age: 59.7 yrs Female: 71% White: 83% ≥ some college: 73% Income: NR	BMI: 34.1(6.6) kg/m^2 Prediabetes: 83%[d] (IFG and/or A1C 5.7–6.4%)

Vadheim 2010 U.S. 4 months	Nonrandomized controlled study 2 groups (N = 29) • Intervention (n=16): Group program via telehealth video conferencing (with lifestyle coaching sent by mail) • Control (n=13): In-person group program (with in-person lifestyle coaching) Completed 4 mo assessment: Intervention 88% Control 100% Telehealth group attendance Weight: at sites (details not reported) Height: details not reported Quality: Weak	Screened: in-person BMI: >25kg/m^2 T2DM Risk: ≥1 risk factor • dx of prediabetes • dx of IGT • dx of IFG • BP≥130/85 • TG>150 • LDL>130 • HDL<40 (women) and <50 (men) • hx of GDM • hx of neonate >9lbs(4.1kg) $150 was paid by participants, employers or insurance companies	Age: 51(11) years Female: 81% Ethnicity/race: NR Education: NR Income: NR	BMI: 36.4(7.3) kg/m^2 Prediabetes: 33% (dx of IFG or IGT) Hx of GDM: 7%
Ma 2013 U.S. 15 months	RCT 3 groups (N = 241) • Intervention (n=81): DVD self-directed program + internet delivered program (self-monitoring aids) + email delivered lifestyle coaching • Control (n=79): in-person program (lifestyle coaching) + internet delivered program (self-monitoring aids) • Control (n=81): usual care Email messages Had weight data at 15 mo: DVD self-directed 92% Coach-led in-person 91% Standard care 91% Quality: Moderate	Screened: in-person BMI: >25 kg/m2 T2DM Risk: • IFG • MS (2005 joint criteria of the AHA and NHLBI)	Age: 52.9 (10.6) years Female: 47% White: 78% Asian/Pacific Islander: 17% Hispanic: 4.1% College level or above: 97.2% <$75,000: 12%	BMI: 32.0 (5.4) kg/m^2 Pre-DM: 54.4%
Ackermann 2014	RCT 2 groups (N = 306)	Screened: in-person	Age: 46.7(11.3) years	BMI: 35.6(5.9) kg/m^2

U.S. 12 months	• Intervention (n=153): Program via Video On-Demand + Internet delivered program (self-monitoring aids, social support platform, lifestyle coaching) • Control (n=153): Program via Video On-Demand Completed 12 mo assessment: Intervention 77% Control 83% Video On-Demand viewing, log-in, and use of web portal Weight: data wirelessly transmitted from participants self-measurements on BodyTrace eScales (manufacture reported accuracy ±0.1kg) (Range and variation checks performed) Height: in clinic using a wall-mounted stadiometer Quality: Moderate	BMI: ≥25kg/m^2 (and <140 kg) T2DM Risk: Has or had ≥1 risk factor • dx of prediabetes • high BP • Abnormal blood chol • hx of GDM • a parent or sibling who has/had T2DM	Female: 82% White: 77% Black: 18% Hispanic: 3% ≥Some college: 86.7% <$25,000/yr: 7.8% $25-75,000/yr: 54.5% >$75,000/yr:37.7%	Prediabetes: NR Hx of GDM: NR
Sepah 2014 U.S. 12 months	Single group pre-post study 1 group (N = 220) • Internet delivered program (self-monitoring aids, social support platform, lifestyle coaching) Had weight data at 12 mo: NR Weight: data transmitted from wireless scale that was mailed to participants (details not provided) A1C: self-administered (AccuBase A1C kits by DTI Laboratories, Thomasville, GA) that were mailed to participants to return	Screened: telephone BMI: ≥24 kg/m2 (≥22 kg/m2 if Asian) T2DM Risk: • Self-reported dx of prediabetes in previous year No cost or compensation	Age: 43.6 (12.4) years Female: 82.7% White: 50.2% Black: 29.3% Hispanic: 10.7% Other: 9.8 ≥ college graduate: 51.7% <$50,000/yr: 48.3%	BMI: 36.6 kg/m2 Prediabetes: 100% (self-reported)

	Quality: Weak			
Nicklas 2014 U.S. 12 months	RCT 2 groups (N = 75) • Intervention (n=36): Internet delivered program (self-monitoring aids) + lifestyle coaching via telephone or email • Control (n=39): Usual care Online forms submitted after watching modules, report of watching modules to lifestyle coach, website analytic data Had weight data at 12 mo: Intervention 92% Control 90% Prepregnancy weight: self-reported Weight, Height, Glucose, and A1C: measured at hospital (details not reported) Quality: Moderate	Screened: in-person BMI: ≥24 kg/m2 (>22 kg/m2 if Asian) T2DM Risk: • Recent dx of gestational diabetes	Age: 33.4 (5.3) years Female: 100% White: 57% Black: 29% Hispanic: 20% Asian: 15% College graduate: 59% 175% or less of federal poverty level: 34%	Prepregnancy BMI: 30.4 (6.0) kg/m^2 Hx of GDM: 100%

Abbreviations:
A1C = hemoglobin A_{1c}, BMI = body mass index, BP = blood pressure, DM = diabetes mellitus, DPP = the Diabetes Prevention Program, dx= diagnosis of, GDM = gestational diabetes mellitus, HDL = high-density lipoprotein, HTN = hypertension, Hx = history of, IFG = impaired fasting glucose, IGT = impaired glucose tolerance, IVR = interactive voice response, LDL = low-density lipoprotein, NCS = nonrandomized controlled study,
MS = metabolic syndrome, RCT = randomized controlled trial, SD = standard deviation, T2DM = type 2 diabetes mellitus, TG = triglycerides, WC = waist circumference
Footnotes:
[a] Methodological quality rating assessed using the Quality Assessment Tool for Quantitative Studies [33]

Table 3: Description of interventions

Lead author/ year/ duration of intervention	**Components delivered in-person or by telephone, and paper-based materials**	**Components delivered via distance learning technologies**	**Duration and intensity**	
			Intervention	**Control**
Tate (2003) Intervention: 12 months	**a.** Group orientation - Internet navigation and study website procedures (*PI*) - Information on diet, PA and behavior change (*PI*) - Standard DPP goals *(GS)* **b.** Printed materials - Program manual *(PI)* - Calorie books *(PI)* - Daily diet and PA diaries *(SM)*	**c.** Website-based tutorial (on weight loss) *(PI*) **d.** Website-based tips and links *(PI*) **e.** Website-based directory of resources *(PI*) **f.** Web-based forms for reporting BW *(SM)* **f.** Automated e-mails - Information on diet, exercise and behavior change *(PI)* - Reminder to report BW (*SM)* **g.** Email - Status of weight loss *(PF)* **h.** Web-based diaries - Calorie intake, fat intake, and PA energy expenditure, and comments/questions for behavioral counselor *(SM*) **i.** Behavioral counselor e-mails (MS/MA or PhD in health education, nutrition, or psychology) *(PF*)	**a.** 1 session (1 hr) **b.** 1 set **c.** 1 tutorial **d.** 1 tip and link/week for 12 months **e.** 1 directory **f.** 1 entry/week **g.** 1 email/week **h.** 1 diary **i.** 5 emails/week for 1st month then 1x/week for remaining 11 months	**a.** 1 session (1 hr) **b.** 1 set **c.** 1 tutorial **d.** 1 tip and link/week for 12 months **e.** 1 directory **f.** 1 entry/week **g.** NP **h.** NP **i.** NP
Estabrooks (2008) Intervention: 3 months	**a**. Group session - Information on behavior change, self-regulatory skill development, diet and PA *(PI)* - Standard DPP goals; personal action plan developed *(GS)*	**b.** IVR calls - Counseling reinforcing information delivered in the class *(PI)* - Tips on diet, exercise, and behavior change *(PI)*	**a.** 1 session (90 min) **b.** 12 weekly calls total • 7 counseling calls (5-10 min/call) • 5 tip calls (<1 min/call)	**a.** 1 session (90 min) **b.** NP
McTigue (2009) Intervention:	**a.** Group orientation - Usage of software *(PI)* - Information on	**d.** Website - Audio-narrated lessons, information on diet, exercise and	**a.** 1 session (2 hrs) **b.** 1 set **c.** 1 pedometer **d.** 24 lessons	NA

12 months	diet, PA and behavior change *(PI)* - Standard goals of DPP *(GS)* **b.** Paper-based materials - Fat and calorie content of foods *(PI)* - Forms for tracking food intake *(SM)* **c.** Pedometer (*SM)*	behavior change, quizzes, workbook pages, links *(PI*) - Forms to develop action plans *(GS)* - Tool to develop PA action plans *(GS)* **e.** Web-based diary - BW, daily fat intake, daily calorie intake, daily steps, and PA (*SM*) - Tool to convert PA into step equivalents *(SM)* - Link to paper-based diet tracking forms *(SM)* - Display of BW, totals of fat and calories, and PA *(SM)* **f.** Automated e-mail prompts *(SM)* **g.** Electronic messaging (nurse-educator) *(PF)* **h.** On-line chat-room (nurse- educator) (*SS)* **g.** EHR progress reports sent to referring providers	(30-45 min/lesson) • 16 core lessons (1 lesson/week for initial 16 weeks) • 8 maintenance lessons (1 lesson/month for final 8 months) **e.** 1x/day (diary) and 1x/week (progress report) **f.** 1x/week **g.** 1x/week for initial 4 months then 2x/month for remaining 8 months **h.** 1-2x/week **g.** 4x during the 12 months	
Kramer (2010) (Kramer et al., 2010)(Kramer et al., 2010)(Kramer et al., 2010)(Kramer et al., 2010)(Kramer et al., 2010) Intervention: 3 months	**a.** Group sessions - Information on diet, PA and behavior change *(PI)* - Standard goals of DPP (*GS*) - Review of progress towards goals, and questions/concerns *(PF)* **b.** Paper-based materials - Workbook, fat and calorie counter *(PI)* - Books for self-tracking food intake and PA *(SM)* **c.** Pedometer (*SM)* **d.** Telephone calls	**e.** DVDs (delivered by mail) Series of taped sessions of staged group lifestyle modification program *(PI)*	**a.** NP **b.** 1 set **c.** 1 pedometer **d.** 1x/week **e.** 1 DVD mailed/week for 12 weeks	**a.** 12 sessions 1x/week **b.** 1 set **c.** 1 pedometer **d.** Not provided **e.** Not provided

	Review progress towards goals (BW and PA) and questions/concerns *(PF)* (prevention professional)			
Vadheim (2010) Intervention: 10 months	**a.** Group sessions - Information on diet and PA (*PI)* - Standard goals of DPP *(GS)* - Reviewed logs and provided feedback *(PF*) (Registered dietitian certified diabetes educator and lifestyle coach with training in exercise sciences) **b.** Paper-based materials - Manual of sessions *(PI)* - Book with fat and caloric content of foods *(PI)* - Diary for BW, Fat and caloric intake, and PA *(SM)* **c.** Supervised PA sessions - Aerobics, strength training, yoga, dance classes, Pilates, water aerobics (lifestyle coaches) **d.** Assistance Initiating and maintaining PA (*PI)* (local recreation center staff) **e.** Mailed feedback from lifestyle coaches relayed to participants (telehealth coordinators) *(PF*)	**f.** Group meetings via telehealth video conferencing - Simultaneous group sessions lead by telehealth coordinator at distant site (*PI)* - Standard DPP goals *(GS)*	**a.** NP **b.** 1 set **c.** NP **d.** As needed **e.** 1x/week **f.** 22 sessions total (1 hr/session) • 16 sessions 1x/week for 16 weeks • 6 sessions 1x/month for final 6 months	**a.** 1 session/week for 16 weeks then 1 session/month for 6 months (session duration 1 hr) **b.** same **c.** 2–4/wk **d.** NP **e.** NP **f.** NP

Ma (2013) Intervention: 15 months	**a.** Orientation - 1st session of Group Lifestyle Balance program (PI) - Training to use AHA free Heart360 web portal (PI) **b**. In-person program (Group Lifestyle Balance program) (PI) - Food tastings (PI) - 30-40 min of guided PA (Registered dietitian and a fitness instructor) **c.** Weight scale (SM) **d.** Pedometer (SM)	**e.** DVD program (Group Lifestyle Balance) (PI) **f.** AHA free Heart360 web portal - Weight and PA goal setting (GS) - Self-monitoring tools (SM) **g.** Standardized reminder email messages - About self-monitoring **h.** Standardized motivational email messages (SS) **i.** Personalized email messages - Progress feedback and lifestyle coaching based on Heart360 self-monitoring records (PF) (Lifestyle coach)	**a.** 1 class **b.** NP **c.** 1 scale **d.** 1 pedometer **e.** 11 sessions on DVD (self-directed) **f.** Free access **g.** Not provided **h.** 1 email/month for months 4-15) **i.** 1 email/month for months 4-15)	**a.** 1 class **b.** Remaining 11 sessions (1 class/week) **c.** 1 scale **d.** 1 pedometer **e.** NP **f.** Free access **g.** 2 emails/week for 15 months **h.** 1 email/month for months 4-15) **i.** NP
Ackermann (2014) Intervention: 12 months	**a.** Welcome kit - Program instructions (PI) **b.** Instructions for accessing interactive web portal **c.** Paper-based materials - Calorie counting guides (PI) - Paper booklets for tracking weight and PA (SM)	**d.** Video series via Video On-Demand - Lifestyle education (PI) - Problem solving strategies (PI) - Standard DPP goals (GS) (Presented in a reality TV format following experiences of 6 men and women with prediabetes participating in lifestyle intervention) **e.** Interactive web portal - Educational content (PI) - Electronic self tracking tools (SM) - Social media platforms (SS) - Interaction with virtual lifestyle coach (PF) **f.** Automated phone calls - Reinforcement of	**a.** 1 set **b.** 1 set **c.** NP (provided only to those without internet access) **d.** 16 episodes (schedule of sessions not reported) **e.** 1 portal **f.** 1 call/week for 12 months **g.** 1 scale	**a.** 1 set **b.** NP **c.** 2–4/week **d.** 16 episodes (duration not reported) **e.** NP **f.** 1x/week for 12 months **g.** 1 scale

		content from Video On-Demand sessions **g.** Weight scale (cellular enabled) (SM)		
Sepah (2014) Intervention: 12 months	**a.** Digital pedometer **b.** Photo frame **c.** Informational kit - Describing maintenance phase program	**d.** Online asynchronous lessons - DPP core curriculum formatted as a workbook with written curriculum with questions that are answered by free response (PI) **e.** Private online social network (small group, 10 to 15 participants) - Online asynchronous discussion board where comments and replies can be posted. Comments and responses can also responded to with "like", and "understand" (SS) **f.** Online health coaching in small group social network - Guided discussion board - Provided feedback on food logs and PA progress (PF) - Provided individualized counseling (Training of lifestyle coaches consistent with CDC DPRP standards) **g.** Wireless weight scale **h.** Private online social network (entire sample) - Online asynchronous discussion board where comments	**a.** 1 pedometer **b.** 1 photo frame **c.** 1 kit **d.** 16 lessons (1 lesson/week posted for initial 16 weeks) **e.** 1 social network **f.** Access (initial 4 months) **g.** 1 scale **h.** Access (final 8 months)	NA

		and replies were posted. Comments and responses also could be responded to with "like", and "understand" (SS)		
Nicklas (2014) Intervention: 12 months	**a.** Informational handout - General recommendations regarding weight loss (PI) **b.** Log books - To track diet and PA (SM) **c.** Weight scale (SM) **d.** Measuring cups and spoons (SM) **e.** Pedometer (SM) **f.** Complimentary membership to YMCA	**g.** Web-based program - Animated videos narrated by physician (PI) - Goal (return to prepregnancy weight over 12 month study period) (if this goal met and still overweight, then goal of 7% weight loss from 6 week post partum weight) (GS) - Forms to enter goals, weekly weight and PA (SM) - Shopping lists, recipes, menu planning tips, exchange lists, and PA education (PI) - A breastfeeding section with 4 additional modules and a mechanism for contacting a lactation consultant (PI) **h.** Lifestyle coaching via website or telephone (Licensed registered dietitian)	**a.** 1 handout **b.** 1 set **c.** 1 scale **d.** 1 set **e.** 1 pedometer **f.** 1 gym membership **g.** 22 modules • 12 core modules (1 lesson/week initial 12 weeks) • 6 optional modules • 4 optional modules on breastfeeding **h.** Individual coaching	**a.** 1 handout **b.** NP **c.** NP **d.** NP **e.** NP **f.** NP **g.** NP **h.** NP

Cognitive behavioral strategy components: PI = provided information, GS = provided goal setting, SM = provided self-monitoring tools, PF = provided feedback, SS = facilitated social support
Abbreviations and Acronyms: BG = blood glucose, BP = blood pressure, BW = body weight, DPP = the Diabetes Prevention Program, NA = not applicable, NP = not provided, NR = not reported, PA= physical activity, WC = waist circumference, wk = week

Table 4: Trial results and conclusions

Author(s)	Group Treatment	Statistical method of quantitative analysis/ Results	Significant results reported
Tate	Intervention (n=46): Internet delivered program enhanced with self monitoring aids + lifestyle coaching via internet Control (n=46): Basic internet delivered program	Intent-to-treat analysis (Simple imputation method: assumed no change from baseline for missing data) Weight change, kg • At 12 months -4.4(6.2) vs. -2.0(5.7) (P=0.04) Weight change, % • At 12 months 4.8 vs. 2.2 (P=0.03) Change in BMI, kg/m^2 • At 12 months -1.6(2.2) vs -0.8(2.1) (P=0.03) Change in WC, cm • At 12 months -7.2(7.5) vs. -4.4(5.7) (P=0.05)	Within group differences NR Between group differences Change in BW (kg) Percent of BW loss Change in BMI Change in WC
Estabrooks	Intervention (n=39): In-person program + interactive voice response calls Control (n=38): In-person program	Intent-to-treat analysis (Method for handling missing data NR) Weight change, lb • At 3 months -5.0 vs. -3.2 lb (p=NR) Weight change, % • At 3 months -2.63 (3.08) vs. -1.64 (1.78) (p=0.13)	Within group differences NR Between group differences NR
McTigue	Intervention (N=50): Internet delivered program with self-monitoring aids and social support features	Per-protocol analysis (n=45) (completed 12 month weight assessment) Weight change, kg • At 12 months -4.79 (95% CI: -7.36 to -2.22) Achieved > 5% weight loss, % • At 12 months 31 Achieved 7% weight loss, % • At 12 months 18	Within group differences NR
Kramer	Intervention (n=22): DVD self-directed program + lifestyle coaching via telephone Control (n=26): In-person coach-led program)	Intent-to-treat analysis (Method for handling missing data NR) Weight change, lb • At 3 months -11.83 (11.41)[b] vs -13.89(14.34)[b] (p=NR) Weight change, % • At 3 months 5.6[b] vs 6.6 [b] (p=NR)	Within group differences Intervention group: Change in BW Percent of BW loss Change in BMI Change in WC Change in FPG Change in A1C Control group: Change in BW

		Change in BMI, kg/m^2 • At 3 months -1.81(1.70)[b] vs -2.25(2.11)[b] (p=NR) Change in WC, in • At 3 months -1.87(1.98)[b] vs -2.49(2.08)[b] (p=NR) Change in FPG, mg/dl • At 3 months -4.71(6.66)[b] vs. +1.15(10.52) (p=NR) Change in A1C, % • At 3 months -0.16 (0.23)[b] vs. -0.31(0.25)[b] (p=NR)	Percent of BW loss Change in A1C Between group differences NR
Vadheim	Intervention (n=16): Group program via telehealth video conferencing (with lifestyle coaching sent by mail) Control (n=13): In-person group program (with in-person lifestyle coaching)	Per-protocol analysis (n=14 and n=13) Weight change, kg • At 4 months -6.7 (3.7) vs -6.5 (3.1) (p=0.85) Change in BMI, kg/m^2 • At 4 months -2.7 (1.3) vs. -2.5 (1.0) (p=0.62) Achieved > 7% weight loss, % • At 4 months 50 vs. 46 (p=0.84)	Within group differences NA Between group differences NR
Ma	Intervention (n=81): DVD self-directed program + internet delivered program (self-monitoring aids) + email delivered lifestyle coaching Control (n=79): In-person program (lifestyle coaching) + internet delivered program (self-monitoring aids) Control (n=81): usual care	Intent-to-treat analysis (Multiple imputation method for handling missing data) Weight change, kg** • At 3 months -4.5(0.8) vs. -5.4(0.7) vs. -0.7(0.8) (P<0.001 vs usual care; P=0.09 vs coach-led) • At 6 months -4.3 (0.8) vs. -6.6(0.8) vs. -0.7(0.9) (P<0.001 vs usual care; P<0.001 vs coach-led) • At 15 months -4.5(0.9) vs. -6.3(0.9) vs. -2.4(0.9) (P=0.02 vs usual care; P=0.04 vs coach-led) Weight change, %** • At 3 months -4.9(0.8) vs. -5.8(0.8) vs. -0.7(0.8) (P<0.001 vs usual care; P=0.09 vs coach-led) • At 6 months -4.7(0.9) vs. -7.2(0.9) vs. -0.9(0.9) (P<0.001 vs usual care; P<0.001 vs coach-led) • At 15 months -5.0(0.9) vs. -6.6(0.9) vs. -2.6(0.9) (P=0.02 vs usual care; P=0.03 vs coach-led)	Within group differences NR Between group differences (DVD vs. usual care) Weight change (kg and %) at 3 months, 6 months, and 15 months Change in BMI (%) at 15 months Achieved 7% weight loss Between group differences (DVD vs. coach-led) Weight change (kg) at 6 months and 15 months Change in BMI (%) at 15 months Achieved 7% weight loss

		Change in BMI, kg/m^2** • At 15 months -1.6(0.3) vs. -2.2(0.3) vs. -0.9(0.3) (P=0.02 vs usual care; P=0.03 vs coach-led) Achieved 7% weight loss, %** • At 15 months 35.6 vs 37.0 vs 14.4 DVD vs usual care (P=0.004) Coach-led vs usual care (P=0.003)	
Ackermann	Intervention (n=153): Program via Video On-Demand + Internet delivered program (self-monitoring aids, social support platform, lifestyle coaching) Control (n=153): Program via Video On-Demand	Intention to treat analysis (Multiple imputation method for handling missing data) Weight change, % • At 5 months -2.9 vs -3.7 (p=0.19) • At 12 months NR (p=0.23)	Within group differences NR Between group differences NR
Sepah	Intervention (N=220): Internet delivered program (self-monitoring aids, social support platform, lifestyle coaching)	Per-protocol analysis for weight change (n=187 core completers) (Core completers completed ≥4 sessions in the initial 16 weeks) (n=144 post-core completers) (Post-core completers completed >4 sessions in the initial 16 weeks and >1 session in the following 8 months) Weight change, lb • At 4 months -11.1(0.7)[b] (Core completers) -11.9(0.7)[b] (Post-core completers) • At 12 months -10.7(1.2)[b] (Core completers) -11.3(1.2)[b] (Post-core completers) Weight change, % • At 4 months -5.0 (Core completers) -5.4 (Post-core completers) • At 12 months -4.8 (Core completers) -5.2 (Post-core completers) Per-protocol analysis for A1C change (n=159 core A1C completers) (Core A1C completers completed ≥4 sessions in the initial 16 weeks and ≥1 A1C measurement) (n=130 post-core completers) (Post-core A1C completers completed	Within group differences (Core completers and Post core completers) Change in BW (kg) at 4 months, and 12 months Within group differences (Core A1C completers and Post core A1C completers) Change in A1C at 12 months

		>4 sessions in the initial 16 weeks and >1 session in the following 8 months and ≥1 A1C measurement) Change in A1C, % • At 4 months +0.03(0.06) (Core A1C completers) +0.03(0.06) (Post-core A1C completers) • At 12 months -0.37(0.06) (Core A1C completers) -0.40(0.07) (Post-core A1C completers)	
Nicklas	Intervention (n=36): Internet delivered program (self-monitoring aids) + lifestyle coaching via telephone or email Control (n=39): Usual care	Intent-to-treat analysis (Multiple imputation method for handling missing data) Weight change, kg* • 6 weeks to 6 months postpartum -2.6 vs. +1.4 (P=0.002) • 6 weeks to 12 months postpartum -2.8 vs. +0.5 (P=0.022) • prepregnancy to 12 months postpartum -0.7 vs +4.0 (P=0.035)	Within group differences NR Between group differences Change in BW at 6 mo Change in BW at 12 mo Change in BW prepregnancy to 12 mo postpartum

A1C= hemoglobin A_{1c}, BMI=body mass index, BW=body weight, FBG=fasting blood glucose, FPG=fasting plasma glucose, NR=not reported, SD=standard deviation
Footnotes: [b] ($p<0.05$)

*Abstracted weight from medical record at 6-months for 4 intervention and 3 control participants, and at 12-months for 3 intervention and 2 control participants/self-reported weight at 6-months for 2 intervention participants and 5 control participants, and at 12-months 2 intervention and 2 control participants

**Abstracted weight from medical record at 3-months for 4 self-directed, 1 in-person, and 9 usual care participants, at 6-months 4 self-directed, 5 in-person and 9 usual care participants, and at 12-months 10 self-directed, 6 in-person and 8 usual care participants/self-reported weight at 6-months 3 self-directed, 1 in-person and 1 usual care participants, and at 12-months 1 self-directed, 2 in-person participants/

Table 5: Methodological quality ratings of the 11 trials

Author	Component quality ratings: 1(strong), 2(moderate), 3(weak)						Global quality rating
	Selection bias	Design	Con-founders	Blinding	Data collection methods	Withdrawals and drop-outs	
Tate	3	1	1	2	1	1	Moderate
Estabrooks	3	1	1	2	1	2	Moderate
McTigue	3	2	3	2	1	2	Weak
Kramer	3	1	3	2	1	1	Weak
Vadheim	3	1	3	2	1	2	Weak
Ma	3	1	1	2	1	1	Moderate
Ackermann	3	1	1	2	1	2	Moderate
Sepah	3	2	3	2	3	2	Weak
Nicklas	3	1	1	2	1	1	Moderate

Acronyms: NCS = non-randomized controlled study, RCT = randomized controlled trial
Global quality rating scores: strong (no weak ratings), moderate (1 weak rating), weak (≥2 weak ratings)
Adapted from the Quality Assessment Tool for Quantitative Studies [33]
Selection bias: Q1-1(randomly selected), 2(referred in a systematic manner), 3(self-referred), Q2-% of subjects that agreed to participate
Design: 1(RCT or NCS), 2(Single group pre-post study), 3(other)
Confounders: 1(≥ 80% of relevant cofounders controlled), 2(60%-79% of relevant cofounders controlled), 3(<60% of relevant cofounders controlled, or not described)
Blinding: 1(outcome assessor and participants blinded), 2(either outcome assessor or participants not blinded, or blinding not described), 3(outcome assessor aware of intervention status, and participants aware of study question)
Data collection methods: 1(tools valid and reliable), 2(tools valid but reliability of tools not described, 3(both validity and reliability of tools not described)
Withdrawals and drop-outs: 1(follow-up rate ≥ 80%), 2(follow-up rate 60-79%), 3(follow-up rate < 60% or not described)

Summary and Conclusions

The dissertation research presented in the 3 manuscripts has important implications for clinical care and future research. Primary care providers working through clinic-community partnerships play a key role in the promotion of awareness of patients' personal diabetes risk status and the encouragement of patients with prediabetes to engage in preventive T2DM lifestyle programs. The present research adds to current understanding of perception of diabetes risk among Spanish speaking Latino immigrants. Comparing the findings of the present research with previous reports using the same questionnaire highlights the variation between the samples tested. Slightly less than one third of our study participants considered themselves to be at moderate/high risk of developing diabetes, indicating that perceived vulnerability to diabetes exists to some extent in this sample, which is similar to the proportion reported in a group of non-Latino white primary care patients, lower than a reported in a group of women with a history of gestation diabetes mellitus, and higher than reported in a group of physicians (see manuscript number 2: Risk perception of developing diabetes among Spanish-speaking foreign-born Latinos). In our sample having a greater degree of worry or concern predicted moderate/high diabetes perceived risk. This finding suggests that in this sample greater general worry or concern leads to perceiving risk for developing diabetes. Further, in our sample the threat of diabetes was perceived to a greater degree than other comparable chronic diseases and health conditions. In contrast, diabetes was the fifth highest perceived threat after heart disease, high blood pressure, arthritis, and cancer reported in the sample of physicians. This difference may reflect a tendency in our sample to estimate potential risk of diseases based on personal experience rather than objective statistical data. One implication of these findings is that positive affective support may be a key element in empowering patients toward prevention in this

population. Instead of focusing on losses of function that may occur if a patient develops diabetes, it may be more productive for clinicians to deliver messages that emphasize potential benefits for the patient and their family linked to preventive health behaviors.

The findings of risk perception for developing diabetes and modifying factors in this Latino foreign-born Spanish speaking sample may be reflective of cultural variation, and therefore, future research in a larger sample and in other vulnerable populations for comparison is warranted. A number of studies, including a large ongoing trial of a DPP modeled program offered through a partnership between a health system and the YMCA, are measuring diabetes risk perception with the English-language version of the Risk Perception Survey for Developing Diabetes (RPS-DD). Future similar effectiveness trials in Spanish-speaking populations may benefit from the newly developed Spanish-language adaptation of the RPS-DD and the reliability and validation evidence in a Latino, foreign-born predominately from Mexico and Central America, Spanish-speaking, lower educational attainment, at-risk population.

Participative T2DM preventive lifestyle program recognition by the Centers for Disease Control and Prevention Diabetes Prevention Program requires that participant enrollment be limited to adults that have evidence of prediabetes or a history of gestational diabetes mellitus. It was found in the systematic review that the samples of trials were characterized by broad rather than specific risk factor recruitment criteria, which is not in alignment with national implementation efforts. Instead, participative T2DM preventive lifestyle programs should be targeted to people at high-risk. Also certain ethnic/racial minority groups, especially African-American/non-Hispanic black and Hispanic/Latino populations, were found to be underrepresented in the samples of the reviewed studies. No trials were found that tested Spanish-language interventions delivered via distance learning technologies. Future directions

for research include the development and testing of Spanish-language tailored participative T2DM preventive lifestyle interventions delivered via distance learning technologies that are sensitive to particular cultural preferences and accessible for adults with limited resources.

Appendix A

ATTITUDES ABOUT HEALTH

This survey will provide important information about how people feel about the risk of getting a chronic disease, like diabetes. There are no right or wrong answers. We are interested in *your* opinions and attitudes. Please answer each question as best as you can.

General Attitudes

For each item, please circle the number below the response that BEST DESCRIBES YOUR OPINION.

	Strongly Agree	**Agree**	**Disagree**	**Strongly disagree**
1. I feel that I have little control over risks to my health.	1	2	3	4
2. If I am going to get diabetes, there is not much I can do about it.	1	2	3	4
3. I think that my personal efforts will help control my risks of getting diabetes.	1	2	3	4
4. People who make a good effort to control the risks of getting diabetes are much less likely to get diabetes.	1	2	3	4
5. I worry about getting diabetes.	1	2	3	4
6. Compared to other people of my same age and sex (gender), I am *less* likely than they are to get diabetes.	1	2	3	4
7. Compared to other people of my same age and sex (gender), I am *less* likely than they are to get a serious disease.	1	2	3	4
8. Worrying about getting diabetes is very upsetting.	1	2	3	4

Your Attitudes about Health Risks

Below is a list of health problems and diseases. For each one, please circle the number below the words to tell us if you think **your own personal health** is at "almost no risk," "slight risk," "moderate risk" or "high risk" from these problems.

If you, or a family member, already have the disease (or had the disease in the past), please *also* check (√) the appropriate line on the right. ⇓

	Almost No Risk	**Slight Risk**	**Moderate Risk**	**High Risk**	**Have(or had) this disease:** ***myself***	***family member***
9. Arthritis	1	2	3	4	_____	_____
10. Heart Disease	1	2	3	4	_____	_____
11. Cancer	1	2	3	4	_____	_____
12. High blood pressure	1	2	3	4	_____	_____
13. Hearing loss	1	2	3	4	_____	_____
14. Asthma	1	2	3	4	_____	_____
15. Diabetes	1	2	3	4	_____	_____
16. Osteoporosis (bone disease)	1	2	3	4	_____	_____
17. Stroke	1	2	3	4	_____	_____
18. Blindness	1	2	3	4	_____	_____
19. Foot amputation	1	2	3	4	_____	_____
20. Infections needing treatment by a doctor	1	2	3	4	_____	_____
21. Impotence (only in men)	1	2	3	4	_____	_____
22. Kidney failure	1	2	3	4	_____	_____
23. AIDS	1	2	3	4	_____	_____

Environmental Health Risks

Below is a list of possible hazards or dangerous conditions in the environment around most of us.

For each one, please circle the number below the words to tell us if your **own personal health** is at "almost no risk," "slight risk," "moderate risk" or "high risk" from each of the following hazards or conditions.

	Almost No Risk	**Slight Risk**	**Moderate Risk**	**High Risk**
24. Medical X-rays (radiation)	1	2	3	4
25. Violent crime	1	2	3	4
26. Extreme weather (hot or cold)	1	2	3	4
27. Driving/riding in an automobile	1	2	3	4
28. "Street" drugs (illegal drugs)	1	2	3	4
29. Air pollution	1	2	3	4
30. Pesticides	1	2	3	4
31. Household chemicals	1	2	3	4
32. Cigarette smoke from people smoking around you	1	2	3	4

Risks of Getting Diabetes for People in the General Public

We would like you to **think about people in the general public** and NOT about your own personal risk of getting diabetes.

Circle the number below the words that best describe your opinion about whether each item listed below *increases (or raises) the risk* of someone getting diabetes, *has no effect on the risk*, or *decreases (or lowers) the risk* of someone getting diabetes.

	Increases the risk	**Has NO effect on risk**	**Decreases the risk**	**Don't Know**
33. Being Asian American	1	2	3	0
34. Being Caucasian (White)	1	2	3	0
35. Eating a healthy diet	1	2	3	0
36. Being Black or African-American	1	2	3	0
37. Being Hispanic	1	2	3	0
38. Having had diabetes during pregnancy	1	2	3	0
39. Having a blood relative with diabetes	1	2	3	0
40. Being 65 years of age or older	1	2	3	0
41. Exercising regularly	1	2	3	0
42. Being American Indian	1	2	3	0
43. Controlling weight gain	1	2	3	0

Thanks!

Appendix B

RPS-DD Spanish (for women)

IDEAS SOBRE LA SALUD

Esta encuesta nos ayudará a obtener información importante de lo que usted siente sobre el riesgo de tener una enfermedad, como la diabetes.

En este encuesta no hay respuestas correctas o incorrectas.

En cada pregunta, por favor marque en el recuadro ☒ bajo la opción que mejor expresa su opinión e ideas.

Ideas generales

	Estoy **totalmente de acuerdo**	Estoy **de acuerdo**	Estoy **en desacuerdo**	Estoy **totalmente en desacuerdo**
1. Siento que tengo poco control sobre los riesgos para mi salud.	☐1	☐2	☐3	☐4
2. Si voy a tener diabetes, no hay mucho que yo pueda hacer para evitarlo.	☐1	☐2	☐3	☐4
3. Creo que las cosas que yo haga me van a ayudar a controlar los riesgos de tener diabetes.	☐1	☐2	☐3	☐4
4. Las personas que hacen mucho esfuerzo por controlar los riesgos de tener diabetes tienen bastantes menos probabilidades de tener diabetes.	☐1	☐2	☐3	☐4
5. Me preocupa que vaya a tener diabetes.	☐1	☐2	☐3	☐4
6. En comparación con otras mujeres de mi misma edad, es menos probable que yo tenga diabetes.	☐1	☐2	☐3	☐4
7. En comparación con otras mujeres de mi misma edad, es menos probable que yo tenga una enfermedad grave.	☐1	☐2	☐3	☐4
8. El hecho de preocuparme de que yo pueda tener diabetes me estresa mucho.	☐1	☐2	☐3	☐4

Ideas sobre los riesgos para la salud

A continuación hay una lista de enfermedades. Para cada una, por favor marque en el recuadro ☒ bajo la opción que mejor exprese el riesgo que usted siente para su salud .

	Siento que **tengo alto riesgo** de tener	Siento que **tengo riesgo moderado** de tener	Siento que **tengo poco riesgo** de tener	Siento que **no tengo casi ningún riesgo** de tener	Si usted o algún familiar tiene o ha tenido alguna enfermedad de la lista, por favor *también* marque ✕ en la línea apropiada. ⇩ **Yo** tengo o he tenido	**Un familiar** tiene o ha tenido
9. Artritis	☐4	☐3	☐2	☐1	____	____
10. Enfermedad del corazón	☐4	☐3	☐2	☐1	____	____
11. Cáncer	☐4	☐3	☐2	☐1	____	____
12. Presión alta	☐4	☐3	☐2	☐1	____	____
13. Sordera	☐4	☐3	☐2	☐1	____	____
14. Asma	☐4	☐3	☐2	☐1	____	____
15. Diabetes	☐4	☐3	☐2	☐1	____	____
16. Osteoporosis	☐4	☐3	☐2	☐1	____	____
17. Derrame cerebral	☐4	☐3	☐2	☐1	____	____
18. Ceguera	☐4	☐3	☐2	☐1	____	____
19. Amputación del pie	☐4	☐3	☐2	☐1	____	____
20. Infecciones que necesitan tratamiento médico	☐4	☐3	☐2	☐1	____	____
21. Impotencia sexual (solo hombres)	☐4	☐3	☐2	☐1	____	____
22. Insuficiencia renal (problemas en los riñones)	☐4	☐3	☐2	☐1	____	____
23. SIDA	☐4	☐3	☐2	☐1	____	____

Ideas sobre los riesgos ambientales para la salud

A continuación hay una lista de peligros o condiciones que pueden ser riesgosas para la salud y que existen en nuestro medio ambiente.

Para cada una, por favor marque en el recuadro ☒ bajo la opción que exprese mejor el riesgo que usted siente para su salud.

	Siento que **tengo alto riesgo** para mi salud por	Siento que **tengo riesgo moderado** para mi salud por	Siento que **tengo poco riesgo** para mi salud por	Siento que **no tengo casi ningún riesgo** para mi salud por
24. Radiografías (radiación)	☐4	☐3	☐2	☐1
25. Crimen o violencia	☐4	☐3	☐2	☐1
26. Clima extremo (calor o frío)	☐4	☐3	☐2	☐1
27. Manejar o andar en automóvil (carro)	☐4	☐3	☐2	☐1
28. Drogas (drogas ilegales)	☐4	☐3	☐2	☐1
29. Contaminación del aire	☐4	☐3	☐2	☐1
30. Pesticidas	☐4	☐3	☐2	☐1
31. Productos químicos de limpieza	☐4	☐3	☐2	☐1
32. Humo de cigarro de personas fumando a su alrededor	☐4	☐3	☐2	☐1

Ideas sobre los riesgos de tener diabetes para las personas en general

Ahora nos gustaría que piense en el riesgo de tener diabetes de las personas en general y NO al nivel personal.

Por favor marque en el recuadro ☒ bajo la opción que mejor exprese su opinión e ideas.

	Aumenta el riesgo de tener diabetes	**No tiene ningún efecto en el riesgo** de tener diabetes	**Disminuye el riesgo** de tener diabetes	**No lo sé**
33. Ser asiático	☐1	☐2	☐3	☐0
34. Ser anglosajón	☐1	☐2	☐3	☐0
35. Comer saludable	☐1	☐2	☐3	☐0
36. Ser afroamericano	☐1	☐2	☐3	☐0
37. Ser hispano/latino	☐1	☐2	☐3	☐0
38. Haber tenido diabetes durante el embarazo	☐1	☐2	☐3	☐0
39. Tener un familiar con diabetes	☐1	☐2	☐3	☐0
40. Tener 65 o mas años	☐1	☐2	☐3	☐0
41. Hacer ejercicio regularmente	☐1	☐2	☐3	☐0
42. Ser nativoamericano (indígena americano)	☐1	☐2	☐3	☐0
43. Controlar o disminuir el sobrepeso	☐1	☐2	☐3	☐0

¡Muchas gracias!

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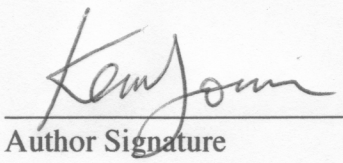

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