

## Research Article

# Pre-Diabetes in the Hispanic Population: Adolescents to Adulthood

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**Background:** Preventing prediabetes from developing into diabetes has led to successful programs like the Diabetes Prevention Program, although translation to minority populations is not readily available. Since minorities endure a disproportionate effect from diabetes and its complications, finding tailored interventions that work for minorities to prevent prediabetes is crucial. This review sought to understand successful interventions to prevent prediabetes in Hispanics across the lifespan.

**Methods:** Searching four electronic databases yielded 1,606 articles relating to prediabetes interventions in Hispanics. This was narrowed to 21 studies for full review.

**Results:** Cultural tailoring of programs has included promotoras, bilingual presenters, and specific focus on cuisine/recipe modification for adults. In adolescents, fewer applications are noted, though success has been seen using social media and by with mixed approaches of diet/activity.

**Discussion:** Culturally tailoring programs to the Hispanic population can effectively reduce risks by reducing weight and A1C. Further study, especially relating to interventions for adolescents, needs to be done to affect their risk for diabetes.

**Keywords:** Prediabetes; Hispanic or Latino; Adolescents; Adult; Intervention

## Introduction

The need to focus on those with prediabetes and start preventative measures to stop disease progression is accentuated by an increased prevalence across the lifespan and an overrepresentation of minority populations being affected.

Prediabetes is usually an asymptomatic condition that is diagnosed with an A1C of 5.7% to 6.4% or a fasting blood sugar of 100mg/dl to 125mg/dl [1]. This condition affects 84.1 million adults in the United States, equating to 33.9% of the adult population [2]. Nearly half (48.3%) of adults aged 65 or older have prediabetes [3]. Lack of intervention via lifestyle changes, medication, or both increases the chance of progression from prediabetes to Type 2 Diabetes Mellitus (T2DM) each year by 5% to 10% compared to 2% of those with normoglycemia [4]. The trajectory for T2DM is expected to continue climbing in the United States with a projected increase of 198% between 2005 and 2050 generally and a 481% increase in Hispanic populations [5].

Part of the risk of developing T2DM is linked to increased weight. Projections estimate that more than half of today's youth will be obese by the age of 35 if trends continue [6]. In minority youth, the percent of youth who have obesity are increased in minorities. For example, 22.5% of black youth, 20.6% of Hispanic youth, and 6.4% of Asian youth are obese [6].

These youth with overweight and obesity status have a greater risk for T2DM. If prediabetes transitions into T2DM, it can equate to a high cost. Total costs associated with diagnosed diabetes mellitus was

\$327 billion in the United States in 2017 [7]. This cost is comprised of \$237 billion in direct medical cost and \$90 billion in reduced productivity [7].

As those diagnosed with prediabetes have an increased risk of up to 70% of developing T2DM [8], it is imperative to intervene. Prediabetes interventions have been identified in the general population based on whether a person has Impaired Fasting Glucose (IFG) versus Impaired Glucose Tolerance (IGT) [9]. Engaging in diet and exercise was shown to reduce the risk of T2DM by 58% in those with IFG and IGT in a United States sample, while the use of metformin 850mg twice daily can lower risk 31% [9]. The 58% held steady in a Finnish study examining the effect of diet and exercise relating to IGT, though dropped to 28.5% in an Indian population [9].

While general studies have shown the positive effects associated with diet and lifestyle changes, specific barriers to change and the burden of socioeconomic inequalities that can affect the success of interventions need to be better understood, especially in high-risk minority groups [9]. This is especially true for youth who experience a 15-year reduction in their life expectancy when they are diagnosed with T2DM, thus having a ripple effect and burden on the workforce, healthcare, and the economy [10].

The risk of developing T2DM has been linked to escalating obesity rates and inactivity [11]. In fact, obesity and diabetes have been called the twin epidemic as eating, physical activity, and weight control are linked to both diagnoses [12]. Increasing diabetes

prevalence is concurrent with increasing obesity with projections that 42% of Americans could be obese by 2030 and 33% of adults could have diabetes by 2050 [12].

Intervention using the National Diabetes Prevention Program (NDPP) most notably have been found to be successful in adults, though there is limited study on what impact intervention can have specifically for the Hispanic population in adolescents [10]. By 2011, only six interventions had translated the successful NDPP lifestyle intervention to minority populations with three looking at African American populations and zero focusing on Hispanic populations [13].

This review sought to answer three questions. First, are specific interventions being created for the Hispanic population to reduce the progression of prediabetes in adolescence or adulthood? Second, are the interventions effective? Third, what still needs to be answered regarding the Hispanic population and prediabetes?

## Materials and Methods

Four electronic databases were searched between August and October 2018: CINAHL, EBSCOhost, PubMed, and One search. One search is an engine that simultaneously searches the library database, then ranks results by relevance to search terms. In addition to these searches, references of included articles were also searched, which yielded another 26 articles for examination. Figure 1 shows how article selection and rejection occurred.

### Search strategy

The search was limited to articles published between 2008 and 2018. This date range was identified to include the most recent research relating to this subject. Search terms included variations on “prediabetes,” “intervention,” and “Hispanic” or “Latino.”

### Inclusion criteria

Three key components were required for inclusion. First, articles had to be published in English. Second, the article had to be a primary study examining prediabetes in the Hispanic population. This meant that any review articles or those that addressed type 2 diabetes mellitus were excluded from the review. Also, the study needed to emphasize the Hispanic population or target minority populations including Hispanics. Twenty-one articles ultimately met the inclusion criteria.

## Results

The disproportionate effect of prediabetes and T2DM on ethnic minorities is well-documented [14]. Reliable prevention strategies including modifying lifestyle, physical activity, and diet have been noted as effective in those generally at risk with prominent programs including the National Diabetes Prevention Program (NDPP), which had high efficacy in 3,234 prediabetes adults in the United States [15]. A recent review [16] found that the NDPP program had only been translated into six ethnic populations, and only one study related specifically to the Hispanic population.

This current review found six studies relating to adolescents, two to pregnant Hispanic women, and 12 related to the adult Hispanic population. Table 1 describes the overall studies in more detail.

### Adolescents

The disproportionate impact of obesity-related, chronic

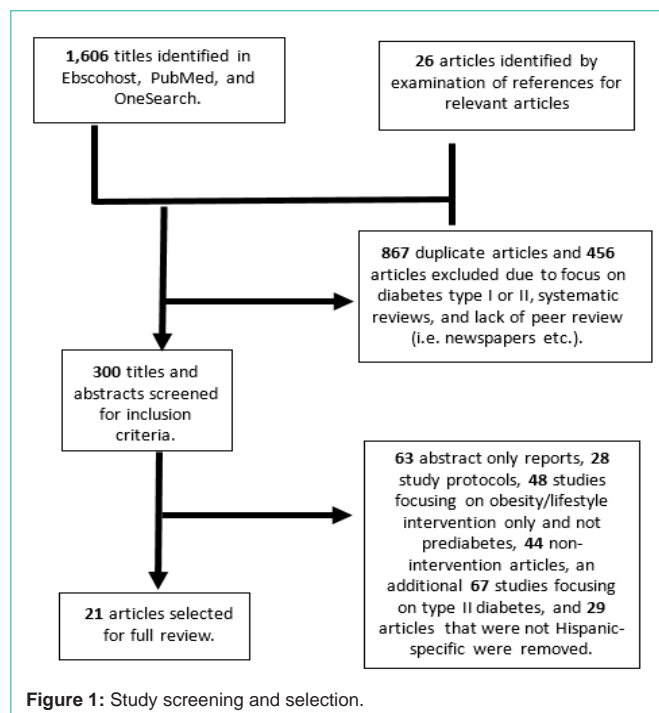


Figure 1: Study screening and selection.

conditions like type 2 diabetes, prediabetes, and insulin resistance is a problem noted in the literature [10]. A recent study protocol discussed the need to identify prevention programs in youth as 50% of Latino adolescents will develop T2DM in their lifetime [10].

Several identified studies focused on minority populations as a subgroup and not just on the Hispanic population [17-20]. Two of these studies [19,20] did include content in Spanish as a culturally specific strategy. Other included studies focused on minority populations and not exclusively Hispanic adolescents. In those studies, the percentage of included Hispanic adolescents ranged from 28% [19] to 49% [21] in non-Hispanic focused studies. The intent of the identified studies included describing risk factors in minority youth [20], examining acculturation [21], increasing awareness of prediabetes and risk [19], and performing an intervention [18,20,22].

Examining specific factors affecting minority group risk was looked at globally for minorities [17] and for the Hispanic-specific adolescent population [21]. Risk factors for metabolic issues included lower self-efficacy identified for physical activity and low perceived benefits of activity [17]. Meanwhile, acculturation effects on diet, which is a risk for issues with prediabetes as well as activity, was found to have some effect on adolescents. Specifically, the proportion of the Hispanic neighborhood was positively associated with fiber intake ( $\beta=0.205$ ,  $p<0.01$ ) and inversely associated to added and total sugar ( $\beta=-0.234$ ,  $p<0.01$ ;  $\beta=-0.229$ ,  $p<0.01$  respectively). There was also a finding that self-identified assimilation moderated the association between dietary fiber intake and % of Hispanic residents ( $\beta=-0.465$ ,  $p=0.036$ ). Identified interventions for the Hispanic population sought to improve nutrition and exercise as a prime focus, though the culture-specific measures were limited to bilingual content. Nonetheless, the results were favorable at varying degrees.

A 16-week randomized controlled trial found that those participants who increase their activity by 20 minutes more per

Table 1: Study characteristics by life period.

Adolescents							
Study Author, year	Setting	Study type	Sample characteristics	Intervention design and length	Culture-specific strategies	Outcome measures	Findings
Alderete et al. (2012)	South Carolina United States	RCT	Age range: Mean age: 15.6 ± 1.1 years Mean BMI: 31.1 ± 3.9 kg/m <sup>2</sup> (decreasers) and 35.5 ± 6.4 (increasers) Hispanic: 49% (n=173)	Nutrition and/or exercise program (randomized to control, nutrition, or nutrition plus strength training group) 16 weeks	N/A	Participants categorized as PA increaser (n=41; 62%) if mean minutes of PA increased or PA decreasers (n=27, 40%) if they decreased minutes BMI Physical activity Fasting glucose Visceral fat	Weight, BMI, total fat mass, VAT, SAT, or HFF did not significantly change between PA increasers and decreasers (P>0.06) Increasers significantly decreased leptin levels by 18% compared to 4% in decreasers (p=0.02) Those who increased activity by 20 minutes more per day over 16 weeks reduced hepatic fat fraction, HOMA-IR, fasting insulin, and leptin levels (p values not reported)
Holl et al. (2011)	School New England City United States	Secondary analysis of RCT	Age range: 11-15 Mean age: 12.9 ± 0.7 Mean BMI: 31.6 ± 6.4 kg/m <sup>2</sup> Hispanic: 100% (n=66)	Gauge health behaviors, metabolic risk factors in minority youth	N/A	Health Behavior Questionnaire Oral glucose tolerance test to test insulin resistance Fasting A1C Lipid panel Body measurements	Compared to African American youth, Hispanic youth had higher triglycerides and lower HDL (p=0.05) Low self-efficacy for physical activity and perceived benefits for activity among all participants
Rogers et al. (2017)	School Social media San Francisco United States	Non-experimental pilot Youth participatory strategy	Age range: high school Mean age: 15.7 (CI 15.6, 15.8) Mean BMI: NA Hispanic: 28% (n=218)	Increase public health literacy with campaign <i>The Bigger Picture</i> . This uses social marketing to impact low-income, minority populations.	Use of poets to “re-story” information about diabetes into spoken-word narratives that were turned into PSAs (2, English and Spanish) Focus on disparities by race and SES Web site developed in English and Spanish Twitter, Facebook page, and toolkits/workshop books for educators made available	Web-based platform to gauge impact (reach) Knowledge change with pre and posttest at assemblies (effectiveness) Identification of public health or community group using/endorsing campaign (adoption)	<b>Reach:</b> PSA views: 1,049,187 times Facebook page: 1,388 likes Twitter: 874 followers Toolkit download: 890 times Workshop book download: 1,812 times <b>Effectiveness:</b> Student knowledge and attitudes improved. Ability to recognize environmental cause increased from 34% to 83% (OR 13.1, p<0.0001), agreed that Type II DM preventable changed from 70% to 92% (OR 5.3, p<0.001), and cared a lot about preventing Type II diabetes went from 29% to 59% (OR=9.1, p<0.001)
Savoie et al. (2014)	Parallel-group randomized trial to compare standard care versus Bright Bodies Connecticut United States	RCT	Age range: 10-16 Mean age: 12.7 ± 1.9 BB Group; 13.2 ± 1.8 in CC group Mean BMI: NA Hispanic: BB group 39.5% (n=15) and Control 32.4% (n=12)	Bright Bodies (BB) Healthy Lifestyle Program with two 50 minute exercise sessions a week, 40-minute nutrition/behavior class a week, and weekly weigh-in 6 months	Spanish-speaking class with bilingual instructors	OGTT for insulin sensitivity Homeostasis model assessment of insulin resistance (HOMA-IR) Whole body sensitivity index	Significant reductions from baseline in 2-h glucose were observed in both BB (227.2 mg/dL) and standard care (210.1 mg/dL) groups. Improvements significantly greater in BB (difference = 217 mg/dL; 95% CI 229 to 25; P = 0.005). Significantly greater improvements observed in the BB group for changes in fasting plasma insulin (P = 0.026), 2-h plasma insulin (P , 0.001), HOMA-IR (P = 0.03), and WBISI (P = 0.02). HbA1c, IGI, and DI showed nonsignificant changes Significantly greater improvements were observed in BB compared with CC with respect to changes in weight (difference = 23.1 kg; P = 0.006), BMI (21.1 kg/m <sup>2</sup> ; P = 0.005), BMI z score (20.10; P = .001), percentage body fat (23.8%; P = 0.003), and fat mass (25.0 kg; P = 0.002).
Shaibi et al. (2012)	Arizona United States	Community based intervention; nonrandomized pre-test and post-test design	Age range: 14-16 Mean age: 15 ± 0.9 Mean BMI (percentile): 96.3 ± 1.1 Hispanic: 100% (n=15)	Intervention with weekly lifestyle education classes and three 60-minute physical activity sessions. (Every Little Step Counts – Diabetes Prevention Program) 12 weeks	Education delivered in bilingual/bicultural promotoras	BMI z score BMI percentile Waist circumference Cardiorespiratory fitness Dietary fat consumption Insulin sensitivity 2-hour glucose levels	BMI percentile, BMI z score, and waist circumference significantly decreases (p<0.05). Decreased fasting insulin (p=0.06). Significant decrease in 2-hour glucose (10.8%), 2-hour insulin (23.6%), and AUC for glucose (16.2%), and insulin (25.5%), all p<0.01. These results correspond to 29.2% increase in insulin sensitivity (p=0.01).
Wen et al. (2017)	Los Angeles, California United States	Analysis of acculturation effect on dietary behavior in Hispanic youth	Age range: 7-18 Mean age: 13.5 ± 3.1 Mean BMI (percentile): 90.61 ± 16.29 Hispanic: 100% (n=124)	N/A	N/A	Acculturation, Habits, and Interests Multicultural Scale for Adolescents (AHIMSA) Neighborhood characteristics by geocoding addresses to determine percent of Hispanic population Local food access Dietary intake	Proportion of Hispanic population (neighborhood) positively associated with fiber intake (β= 0.205, p<0.01) and inversely associated to added and total sugar (β=-0.234, p<0.01; β=-0.229, p<0.01 respectively). Self-identified assimilation moderated association between dietary fiber intake and % of Hispanic residents (β=-0.465, p=0.036).

Pregnancy							
Study Author, year	Setting	Study type	Sample characteristics	Intervention design and length	Culture-specific strategies	Outcome measures	Findings
Kieffer et al. (2014)	Detroit, Michigan United States	RCT		Culturally tailored, Spanish-language Healthy Mothers on the Move intervention with home visits, group classes, activities, and social support from trained community health workers (CHWs) and peers. 11 weeks	Spanish language Hispanic culture focus with community engagement	Dietary changes	Compared to minimal intervention group, experimental group had improved dietary behaviors like decreased added sugar consumption (p=.05), total fat (p<.05), saturated fat (p<.01), percentage of daily calories from saturated fat (p<.001), solid fats and added sugars (p<.001), and increased vegetable consumption (p<.01).
O'Brien et al. (2015)	United States	Single-arm pilot	Age range: Mean age: Mean BMI (percentile): 90.61 ± 16.29 Hispanic: 100% (n=20)	Lifestyle intervention with 24 sessions (14 weekly core sessions and 10-post core sessions either biweekly or monthly). 1 year	Promotora led sessions in Spanish	Weight change A1C Fasting plasma glucose Waist reduction	Mean weight loss of 10.8 pounds, equaling 5.6% loss on initial body weight. No significant change in A1c or fasting plasma glucose.
Adulthood							
Study Author, year	Setting	Study type	Sample characteristics	Intervention design and length	Culture-specific strategies	Outcome measures	Findings
Ahn et al. (2018)	Memphis United States	Longitudinal, retrospective comparison	Age range: 30-60+ Mean age: 51 ± 8.6 Mean BMI: 36.2 ± 5.5 Hispanic: 8.8% (n=13) African American: 81% (n=119)	Community-based intervention of health-coach visits, registered dietitian visits, and exercise consultations 12 months	N/A	Biometric measures of HbA1c, BMI, blood pressure, cholesterol, triglycerides	Treatment group reduced BMI (-2.1%, p<.001) and HbA1c (-0.6%, p<.001) and increased diabetes knowledge (+5.4%, p=.025) No improvement in biometric measures in comparison group Dietitian visits most effective treatment component in reducing HbA1c (coefficient = -0.08, p=.025)
Buckley et al. (2015)	Providence, Rhode Island United States Vida Sana/Healthy life intervention	Cross-sectional	Age range: 16-79 Mean age: 49.8 Mean BMI: 31.5 ± 7.7 Hispanic: (n=171)	Reduce risk factors for metabolic syndrome using an 8-week program.	English or Spanish materials with simple language at a fifth grade level. Trained peers to provide education and social engagement.	Weight loss BMI Waist circumference	Average person lost 3.7-pounds (a reduction of 2.0 % from baseline and had average BMI decrease of 0.7 kg/m2 , from 31.5 to 30.8. The average waist circumference decreased by nearly one inch (0.9 inches).
Chang et al. (2018)	New Haven, Connecticut United States	Cross-sectional study	Age range: 18-49 Mean age: 33.7 ± 8.58 Mean BMI: 31.56 ± 7.15 Hispanic: (n=160)	Describe perception of barriers to prediabetes prevention measures related to physical activity with women with a multigenerational prevalence of obesity and type 2 diabetes	English or Spanish survey availability	Barriers to engage in physical activity Demographic features	Lack of willpower (61.9%) and lack of energy (53.6%) are identified as barriers for physical activity in this population. Mean likelihood score for willpower 5.08 ± 2.5 and 4.52 ± 2.63 for lack of energy. Overweight and obese women more likely than normal weight women to cite social influence (OR=2.58, p=0.04) and lack of skill (p=0.05) as barriers.
O'Brien et al. (2017)		Three-arm comparative trial with parallel group design (randomized) Metformin 850 mg BID Regular medical care Promotora-Led Diabetes Prevention Program based on Group Lifestyle Balance Program or intensive lifestyle intervention (ILI)	Age range: Mean age: 45.1 ± 12.5 Mean BMI: 33.3 ± 6.5 Hispanic: (n=92)	Compare effectiveness of metformin trial, standard care, and a DPP-based program delivered by protoras with Latinas who have prediabetes.	Promotora-led lifestyle intervention in ILI group	Weight BMI Waist circumference Hemoglobin A1c, fasting glucose, fasting plasma insulin, HOMA-IR	12-month weight loss (ILI, -4.0 kg; metformin, -0.9 kg; standard care, +0.8 kg; p<.001) Post-hoc pairwise comparisons were significant for ILI versus standard care (-4.8 kg, p<0.001) and ILI versus metformin (-3.1 kg, p<0.013), but not for metformin versus standard care (-1.7 kg, p=0.276) ILI lost 5% of initial weight compared to 1.1% in metformin group and 0.9% weight gain in standard care (p<.001).
O'Brien et al. (2015)	Philadelphia, Pennsylvania United States	Trial with 1 experimental arm Promotora-Led Diabetes Prevention Program based on Group Lifestyle Balance Program	Age range: 35-64 Mean age: 44.5 ± 13 Mean BMI: 36.5 ± 7.6 Hispanic: (n=20)	Test feasibility and preliminary effectiveness of program in Hispanic women (pilot)	Promotora-led sessions in Spanish (24 sessions divided into 14 weekly core sessions and 10 post sessions)	Weight loss, waist circumference, A1C, fasting plasma glucose	Weight loss of 10.8 pounds (p<.001, effect size=-.23) and 5.6% loss of initial body weight as well -4.3 cm waist circumference (p<.001; effect size=-.25), at 12 months. Modest reductions seen in A1C (-0.1, p=.7, effect size=-.50) and fasting plasma glucose (-2.4 mg/dl, mmol/L, p=.43, effect size =-.19), though not significant.

Okene et al. (2012)	Lawrence, Massachusetts United States	RCT	Age range: 25-79 Mean age: 52 Mean BMI: Hispanic: (n=312)	Test effectiveness of community-based intervention for weight loss and diabetes risk reduction using a literacy-sensitive and culturally-focused lifestyle approach	Trained Spanish-speaking community members as intervention leaders, dietary advice based on Latino foods, modification of Latino recipes, a videotape novella that targeted cultural beliefs and attitudes, bicultural and bilingual individuals from the community to perform interventions, and hands-on activities like walking with pedometers, use of a visual food guide in a supermarket session, and demonstrations of components like healthy cooking methods and portion sizes.	Weight loss HbA1c	Control group lost more weight than usual care group (-2.5 pound, $p=.004$ ) and had more reduction in HbA1c (-0.10%, $p=.009$ ). Significant correlation between weight loss and HbA1C change ( $r=0.41$ ; $P<.001$ ).
Pagialunga et al. (2018)	Phoenix, Arizona United States	Descriptive study in convenience sample	Age range: Mean age: 46.3 $\pm$ 13.5 Mean BMI: N/A Hispanic: (n=391)	Provide HbA1c information/screening to raise awareness and assess interest in medical research participation	Spanish-speaking staff (nurses, recruiters, and metabolic specialists)	Site of recruitment: two health fairs, church open-house, cultural street party, and county exposition HbA1c	HbA1c 6.0 $\pm$ 1.4% HbA1c screening was an effective recruitment tool with 1 new registration for research in every 13 screened participants. Further, providing service like HbA1c could give valuable service in underserved population and raise awareness of DM.
Ritchie et al. (2018)	Denver, Colorado United States	Cohort study comparing Latino and NHW enrollees	Age range: Mean age: 45.94 $\pm$ 12.44 (Latino) and 52.78 $\pm$ 10.66 (NHW) Mean BMI: 34.62 $\pm$ 7.48 (Latino) and 35.98 $\pm$ 8 (NHW) Hispanic: (n=567)	National Diabetes Prevention Program (NDPP) curriculum with 16 weekly to bi-weekly sessions for six months to achieve weight loss. Followed by 6 months of monthly sessions to support weight loss maintenance. 1 year	Classes offered in English or Spanish Three trained Latina paraprofessionals worked as full-time NDPP coaches and conducted support calls between sessions	BMI Session attendance Weight loss	Latinos were approximately half as likely to attend as NHWs with an odds ratio of 0.52 ( $P < .01$ ; 95% confidence interval: 0.36-0.77). Latino participants attended 2.67 + 0.63 ( $P < .001$ ) fewer sessions than NHWs. Concluded attendance issues need resolved to improve risk outcomes in Latino population.
Ruggiero et al. (2011)	Illinois United States	Non-randomized prospective study with single group design Healthy Living Program (HLP) based on the DPP	Age range: 18-65 Mean age: 37.86 $\pm$ 8.52 Mean BMI: 31.19 $\pm$ 4.34 Hispanic: (n=69)	Target a high-risk group and provide community-based program based on DPP to change lifestyles.	Intervention offered in Spanish	Weight BMI Waist circumference	Weight changes at six months of -4.82 ( $p=.0016$ ) and 12 months -2.79 ( $p=.065$ ), BMI at 6 months -0.91 ( $p=.0015$ ) and 12 months -0.50 ( $p=0.067$ ), waist circumference (inches) at 6 months -1.56 ( $p<.0001$ ) and 12 months -1.38 ( $p=.0001$ )
Van Name et al. (2016)	New Haven, Connecticut United States	RCT with usual care and intervention 14-week program based on DPP	Age range: $\geq$ 25 Mean age: 43.8 $\pm$ 10.8 Mean BMI: 35.4 $\pm$ 8.5 Hispanic: (n=61)	Perform a modified DPP intervention in inner-city, Hispanic women who have high risk for type 2 diabetes.	Family-centered intervention Classes in English and Spanish and bilingual handouts/ presentation materials Bilingual facilitator Educational fotonovela (story with photographs and dialogue bubbles) Material in English/ Spanish Culturally acceptable exercise strategies like dance and walking Cooking demonstrations of low-fat traditional Mexican foods Group meal sharing Inclusion of family or support person (1) to intervention Promotora	Metabolic parameters: fasting glucose, 2-hour glucose, fasting insulin, HOMA-IR, HbA1C Weight BMI Waist circumference	After one year, the intervention group lost 3.8 kg (4.4%) versus usual care group gain of 1.4 kg (1.6%, $p<.0001$ ), two-hour glucose excursion decreased 15 mg/dl (0.85 mmol/L) versus 1 mg/dl (0.07; $p=0.03$ ).
Vincent et al. (2014)	Arizona United States	RCT 5-month program Un Estilo De Vida Saludable (EVS)	Age range: $\geq$ 25 Mean age: 50.9 $\pm$ 12.05 Mean BMI: 34.32 $\pm$ 5.78 Hispanic: (n=58)	Perform an intervention based on content from the Diabetes Prevention Program that is culturally tailored to Spanish-speaking adults of Mexican descent.	Educational fotonovela (story with photographs and dialogue bubbles) Material in English/ Spanish Culturally acceptable exercise strategies like dance and walking Cooking demonstrations of low-fat traditional Mexican foods Group meal sharing Inclusion of family or support person (1) to intervention Promotora	Weight loss Waist circumference BMI Diet and physical activity self-efficacy	significant group main effects for weight, $F(1, 30) = 4.39$ , $P = .045$ ; waist circumference, $F(1, 30) = 4.67$ , $P = .039$ ; BMI, $F(1, 30) = 4.97$ , $P = .033$ ; and diet self-efficacy, $F(1, 30) = 5.58$ , $P = .025$ Intervention group having lower weight (188.23 vs 194.49), smaller waist circumference (41.34 vs 43.39), lower BMI (32.84 vs 34.04), and greater diet self-efficacy (7.78 vs 5.87) than the attention control group.

day also reduced their hepatic fat fraction, Homeostatic Model Assessment of Insulin Resistance (HOMA-IR), fasting insulin, and leptin levels, though p-values were not reported [18]. Another study [20] employing a randomized control trial intervention over a six-month period examined how the use of the Bright Bodies (BB) Healthy Lifestyle Program with 40-minute weekly nutrition/behavior classes, a weekly weigh in, and two 50-minute exercise sessions with bilingual instructors and Spanish-speaking instruction versus usual care. The BB program was found to have significant improvements over the standard care groups. This included improved fasting plasma insulin ( $p=0.026$ ) and two-hour plasma insulin ( $p=0.001$ ).

The last intervention study focused solely on the Hispanic population and delivering culturally-specific content. The use of bilingual and bicultural promotoras was implemented to deliver content of Every Little Step Counts Diabetes Prevention Program. This included lifestyle classes weekly and three-times weekly 50-minute physical activity sessions during a 12-week period [22]. Positive changes were seen in the examined outcomes, including significant decreases in BMI percentile, BMI z score, and waist circumference ( $p<0.05$ ) and lowering of glucose markers like 2-hour glucose (10.8%), 2-hour insulin (23.6%), Area Under the Curve (AUC) for glucose (16.2%), and insulin (25.5%), all  $p<0.01$ . Insulin sensitivity also increased 29.2% ( $p=0.01$ ).

Increasing awareness and understanding of diabetes risk was also the focus of a youth participatory campaign that relied on social media, public service announcements, and assemblies [19]. While the overall focus was on all minority populations, information was made available in English and Spanish to increase the reach. Biometric outcomes were not used, and instead, the focus of the intervention was on reaching a wide audience and improve knowledge and attitudes. Findings showed increased ability to recognize environmental cause (34% to 83%, OR 13.1,  $p<0.0001$ ), realization that T2DM is preventable (70% to 92%, OR 5.3,  $p<0.001$ ), and more concern about prevention of T2DM (29% to 59%, OR=9.1,  $p<0.001$ ).

### Pregnancy

As weight and development of T2DM and gestational diabetes are linked, several interventions focused on improving lifestyles in pregnancy to prevent issues that can affect both maternal and child health [23-25]. Changing lifestyle risk factors like the amount of exercise, dietary quality, and weight gain in pregnant Latina mothers is posited to reduce obesity and impaired glucose tolerance [25].

Only two studies were identified that discussed prediabetes relating to pre-pregnancy weight status and potential interventions. The first examined an 11-week RCT to improve dietary outcomes by engaging women in community-planned intervention with social support from trained community health workers [23]. Significant and improved changes in dietary quality were noted in the experimental group that was given a culturally tailored and Spanish-language specific program. Changes included decreased added sugar consumption ( $p=0.05$ ) and increased vegetable consumption ( $p<0.01$ ).

Meanwhile, the second study [26] focused on the post-gestational period for mothers who had gestational diabetes to prevent T2DM. The positive impact was found on weight with a mean loss of 10.8 pounds or 5.6% loss from initial body weight, though there were no

significant changes found in either the A1C or the fasting plasma glucose.

Each of these programs focused on improving healthy behaviors by using promotoras and incorporating the Spanish language.

### Adults

Twelve articles were found relating to adult prediabetes. Of these, 10 involved interventions for prediabetes in adulthood, one [27] focused on identifying barriers with prevention measures in the Hispanic population, and another [28] described the effect of a community health intervention to raise awareness of prediabetes.

Most of the interventions focused on translating the NDPP into a culturally-tailored approach. The NDPP has been proven as an effective intervention to target moderate weight loss and increased physical activity in high-risk patients and its effect of lowering diabetes incidence by 58% [15]. The NDPP initial trial while effective has also been noted as expensive with intervention cost of \$1,399 per participant in the year-long period [29] and as non-culturally specific as most participants were of non-Hispanic white populations [29,31]. However, since the NDPP initial trial, multiple researchers have attempted to modify this program to be more targeted to high-risk groups like the Hispanic population [29-32].

Nine interventions were patterned after the NDPP [25,29,33-38]. The first noted attempt to tailor the NDPP to adult, at-risk Hispanic groups was done in 2011 [29]. Participants ( $n=312$ ) in the intervention versus usual care had modest and significant weight loss (-2.5 versus 0.63 pounds,  $p=0.04$ ) as well as a decrease in hemoglobin A1c (-0.10% versus -0.04%,  $p=0.009$ ). Several other modifications of the NDPP also noted improved outcome measures with the interventions. Similar weight-loss was seen in 2011 using a participatory approach in Illinois with participants having weight changes at six months of -4.82 pounds ( $p=0.0016$ ) and -2.79 pounds at 12 months ( $p=0.065$ ). The other seven studies also proved effective at varying degrees to reduce weight in participants. Weight was a common parameter used to gauge success as it is linked to the development of T2DM.

Meanwhile, one of the most recent interventions expanded beyond examining the lifestyle intervention component to include other treatment components. This study compared usual care, an NDPP-based program, and use of metformin 850mg twice daily [26]. These results highlighted that the NDPP program had the highest amount of weight loss over a 12-month period with -4kg loss compared to -0.9kg in the metformin group and +0.8kg in usual care ( $p<0.001$ ).

This review highlights that while the modified NDPP interventions have been successful, they have had to be modified to make them more feasible and to add cultural tailoring. While the NDPP was a one-year intensive lifestyle program, the culturally tailored programs modified the intervention length. The original NDPP was intensive with multiple interventions. This included using individual case managers or lifestyle coaches and frequent contact with participants. The program was a structured, 16-week intervention instilling self-management strategies for weight loss and activity followed by a maintenance phase that included follow up, group sessions lasting four to eight weeks, and individual approaches [39]. This extensive program also used a well-developed network providing feedback,

support, and training [39].

Adaptations to this extensive program included using a shortened, eight-week program [32] to a 14-week core program with 10 weeks of follow up sessions [26,29]. These programs also used different methods to translate the program to the Hispanic population. While five [28,36,37,39,40] only provided material or sessions in English/Spanish, others had more extensive tailoring. Several studies trained Hispanic paraprofessionals or promotoras to serve as coaches, lead sessions, and perform support calls between sessions [26,29,33-36,38].

One study [29] employed multiple strategies to tailor a prevention program to Hispanics. This included giving culturally specific advice, including dietary advice based on Latino foods and modifying Hispanic recipes. They even created a videotape novella that targeted cultural beliefs and attitudes to provide content in an engaging and preferred format. This study also utilized traditional tailoring options like having bicultural and bilingual individuals from the community perform interventions, employ hands-on activities like walking with pedometers, use of a visual food guide in a supermarket session, and demonstrations of components like healthy cooking methods and portion sizes.

Using existing social networks in a low-income rural area, which are known as colonias, was used to create a participatory intervention that could target specific cultural and economic situations [6]. This study was unique also due to the recruitment method that involved using the promotores to recruit participants and provide the focus group teaching and activity sessions over an eight-week period. This small study only had 38 people in the intervention and 43 in the comparison group but showed an average BMI decrease was 0.19 in the intervention group and this was statistically significant over the comparison group ( $p=0.005$ ).

Another study sought to compare Latino and non-white Hispanic populations using the same intervention. Using a no-control, cohort method, Latinos participants were compared to non-Latino participants to gauge the effectiveness of the NDPP curriculum with standard delivery. This intervention focused on achieving weight loss in the first six months with 16 weekly-to-biweekly sessions, followed by a six-month maintenance period with six monthly sessions. This program also included the use of three Latina paraprofessionals who were full-time coaches and who made between-session support calls to participants. Results showed that Latinos were roughly half as likely as non-Hispanic whites to attend sessions (OR = 0.52,  $p<0.01$ , 95% CI 0.36-0.77). The Latino participants were also less likely to achieve the goal of  $\geq 5\%$  weight loss in the first six months (15.6% versus 26.1%,  $p<0.05$ ). Attendance at sessions increase body weight loss by 0.3% ( $+0.02$ ,  $p<0.001$ ).

Overall, each of the studies showed success with the interventions. This review also showed social influences and a lack of skill can be barriers for Hispanic women to engage in prediabetes prevention measures [27]. However, another study showed that by providing bilingual staff to perform health screenings like HbA1c tests at community fairs can increase recruitment for study participation and serve to raise awareness about issues like prediabetes [28].

## Discussion

This current review provides evidence from 21 studies regarding the potential to culturally tailor interventions for the Hispanic population. Most studies have used variations of the NDPP program, especially for adults. Adolescent strategies have also included the use of social media to increase awareness of health issues in high school students. Tailoring programs to meet cultural needs have included minimal intervention like simply adding a bilingual facilitator or materials. Additional more extensive adjustments to programs have included using culturally popular fotonovelas, acceptable activity strategies like dance and walking, and food preparation demonstrations of cultural foods [35].

Among the reviewed articles, there is a consensus noted that lifestyle interventions have had significant effects on participant characteristics, including their weight, body mass index, and waist circumference. Reduction in parameters like a participant's weight was seen in every identified study to varying degrees and maintained it at follow up. This was seen with an adult population who engaged in a 14-week intervention. After a year, the intervention group had lost 3.8kg or 4.4% body weight compared to the control group who gained 1.4kg or 1.6% body weight ( $p<0.001$ ) [37]. Ability to continue changes after the intervention is important, and sustainability is described as more important than when intervention occurs [28].

Weight loss and changes to features like BMI or waist circumference were the most often reported and measured outcome for prediabetes intervention studies. Diabetes-specific measures were less commonly measured, though positive results have been noted. For example, two of the six studies involving youth had measures specific to diabetes, and both showed improvements. A significant reduction from baseline for two-hour glucose, fasting plasma insulin levels, and two-hour plasma insulin levels were noted after a six-month intervention involving diet and exercise in one youth study [20]. Meanwhile, six of the 12 adult studies reported diabetes-specific parameters with mixed results. A 12-month intervention [11] with education/coaching, dietary help, and exercise consultations showed a significant drop in HbA1c in participants (-0.6%,  $p<0.001$ ) while a study with a much smaller sample ( $n=20$ ) only found modest reductions in the HbA1c (-0.1,  $p=0.7$ ) [26].

There is also evidence that intervention can improve knowledge of prevention and disease complications. In a social marketing campaign targeted for low-income, minority populations, both student attitudes, and knowledge improved [19]. Youth were better able to realize T2DM is preventable (OR 5.3,  $p<0.001$ ), cared more about prevention (OR=9.1,  $p<0.001$ ), and better recognized environmental factors (OR 13.1,  $p<0.0001$ ). Similarly, an adult population expressed improved diet self-efficacy and lower BMI than the control group ( $p$  values not reported).

In the only study found that compared Hispanic and non-Hispanic participants, there was a noted difference in attendance. Hispanic/Latino participants were half as likely to attend sessions compared to their non-Hispanic white counterparts (OR=0.52,  $p<0.01$ ) [33]. Overall, Hispanic/Latino participants attended 2.63 fewer sessions ( $p<0.001$ ). Although this is only a single study, it does point to the need to resolve any attendance issues.

Overall, the findings of this review indicate that culturally tailoring programs to the Hispanic population can be effective in reducing risks, such as weight and lowering A1C. There is a need for further study especially relating to adolescents as very few interventions were targeted at improving adolescents' risk for T2DM.

## Conclusion

This review highlights the effectiveness of NDPP-based interventions for adults that employ culturally relevant strategies like providing intervention in Spanish/English, relating diet modification to foods used in the culture and modified recipes, and using promotoras to help support participants. Public intervention to halt the progression of prediabetes to T2DM can be used effectively, especially in high-risk populations [28]. If started early, the degree of intensity in the intervention can be lower and still have a maximal impact on disease progression [28]. There is more limited information about effective interventions for adolescents, though researchers are noting the positive effects of using social media campaigns to reach out to these populations [41]. However, this review highlights the overriding theme that interventions involving diet, exercise, and use bilingual/bicultural promotoras can have the best effect on the Hispanic population. More research is needed specific to the Hispanic population to identify what interventions have the best effect, especially on diabetes-specific parameters, and how sustainable results are.

## Compliance with Ethical Standards

This review study did not have IRB approval. No informed consent was needed as this was an analysis of existing research and did not involve participants or newly collected data.

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