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Change in physical activity, food choices and hemoglobin A1c among American Indians and Alaska Natives with type 2 diabetes

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ABSTRACT

The prevalence of diabetes among American Indian and Alaska Native (AI/AN) adults is the highest of all United States racial/ethnic groups. Health behaviors, including regular physical activity and healthy food choices, are important components in the management of diabetes. We estimated the cross-sectional association between physical activity and healthy food scores, separately, and combined (PAHF) with hemoglobin A1c (HbA1c) over three years of the Special Diabetes Program for Indians-Healthy Heart demonstration project (SDPI-HH) intervention. The relationship between physical activity and food choices was also examined. Among 3,039 SDPI-HH participants at baseline, those reporting being physically active and having high healthy food scores had statistically significant lower HbA1c (mean = 7.67 ± 2.01) compared to inactive participants with low healthy food scores (7.90 ± 1.92). Among the 1,150 SDPI-HH participants who attended the three-year follow-up visit, participants who increased physical activity, consumption of healthy foods, or both had a larger decrease in HbA1c (β = -0.29, P = 0.03) over the study period compared to participants with no improvement in physical activity or increase in consuming healthy foods. This association was statistically significant among women (β = -0.35, P = 0.04) but not among men (β = -0.08, P = 0.70). Our findings indicated that an increase in healthier behaviors, including physical activity and healthy food choices, was associated with a small improvement in HbA1c in the subset of women who participated in the SDPI-HH through the three-year follow up. Although the decrease in HbA1c was small, physical activity and healthy food choices are important behaviors to incorporate into everyday life among AI/AN adults, particularly those with diabetes.

1. Introduction

The prevalence of type 2 diabetes mellitus among American Indian/ Alaska Native (AI/AN) adults is>15 %, the highest of all United States racial/ethnic groups (Centers for Disease Control and Prevention, 2017). Among AI/ANs, prevalence of diabetes ranges from 6 % among Alaska Natives to over 24 % among individuals in the southwest region of the United States (Centers for Disease Control and Prevention, 2017). Among people with diabetes, glucose control can reduce the risk of secondary complications, such as cardiovascular disease, retinopathy, neuropathy, renal failure, premature death, and improve health and quality of life (American Diabetes Association, 2015; Stratton et al., 2000).

Lifestyle interventions, specifically low fat, high fiber food choices and regular physical activity, are especially effective for preventing diabetes (Hu et al., 1999; Jiang et al., 2013; Knowler et al., 2002; Norris et al., 2005; Tuomilehto et al., 2001) and reducing cardiovascular disease morbidity and mortality among individuals with diabetes, including AI/AN patients (Gregg et al., 2003; Koivula et al., 2013; Moore et al., 2014). Regular physical activity has been consistently associated with improved glycemic control in people with diabetes (American Diabetes Association, 2003; Boulé et al., 2001; Sigal et al., 2006; Toledo et al., 2007). Similarly, dietary management is also a cornerstone of glycemic control and reduces risk factors for cardiovascular disease

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Table 1
Baseline characteristics among American Indians and Alaska Natives with type 2 diabetes participating in the Special Diabetes Program for Indians - Healthy Heart demonstration project (SDPI-HH), 2006–2009.

Characteristic	All Participants (N = 3,039)		Women (N = 2,005)		Men (N = 1,034)	
	N	%	N	%	N	%
Age						
18–39	354	11.6 %	236	11.8 %	118	11.4 %
40–49	667	21.9 %	421	21.0 %	246	23.8 %
50–59	1006	33.1 %	700	34.9 %	306	29.6 %
≥60	1012	33.3 %	648	32.3 %	364	35.2 %
Education						
< High School	546	19.1 %	356	18.8 %	190	19.6 %
High School Graduate	725	25.3 %	443	23.4 %	282	29.1 %
Some College	1164	40.7 %	802	42.4 %	362	37.3 %
≥College Graduate	427	14.9 %	291	15.4 %	136	14.0 %
Employment Status						
Employed	1399	51.8 %	942	52.8 %	457	49.8 %
Retired	499	18.5 %	308	17.3 %	191	20.8 %
Unemployed or student	803	29.7 %	533	29.9 %	270	29.4 %
Marital status						
Married or living together	1459	57.3 %	899	53.2 %	560	65.3 %
Separated/divorced or widowed	721	28.3 %	566	33.5 %	155	18.1 %
Never married	367	14.4 %	225	13.3 %	142	16.6 %
Annual household income ($US)						
0–14,999	761	31.1 %	533	33.2 %	228	27.2 %
15,000–29,999	690	28.2 %	467	29.1 %	223	26.6 %
30,000–49,999	601	24.6 %	389	24.2 %	212	25.3 %
≥50,000	392	16.0 %	218	13.6 %	174	20.8 %
BMI (Kg/m^2)						
Normal weight	117	3.9 %	75	3.7 %	42	4.1 %
Overweight	483	15.9 %	286	14.3 %	197	19.1 %
Obese	2436	80.2 %	1642	82.0 %	794	76.9 %
Smoking status						
Non-smoker	1360	47.4 %	1004	53.1 %	356	36.4 %
Current or former smoker	1509	52.6 %	888	46.9 %	621	63.6 %
Site location						
Urban	414	13.6 %	293	14.6 %	121	11.7 %
Rural	2625	86.4 %	1712	85.4 %	913	88.3 %
	Mean ± SD		Mean ± SD		Mean ± SD	
Years of diabetes duration	4.57 ± 6.45		4.70 ± 6.53		4.33 ± 6.28	
Comorbidity index [a]	4.25 ± 3.54		4.29 ± 3.58		4.17 ± 3.47	

Abbreviations: Body mass index (BMI); Standard deviation (SD).
[a] From self-administered comorbidity questionnaires without including diabetes.

Table 2
Baseline and follow-up physical activity levels and food scores among American Indians and Alaska Natives with type 2 diabetes participating in the Special Diabetes Program for Indians - Healthy Heart demonstration project (SDPI-HH), 2006–2009.

Characteristic	All Participants		Women		Men		P-value [a]
	N (%) or mean ± SD						
Mean RAPA Score							
Baseline	3.89 ± 1.08		3.76 ± 1.10		4.15 ± 1.01		<0.001
Follow-up year one (n = 1,575)	4.08 ± 0.99		4.01 ± 1.02		4.25 ± 0.91		<0.001
Change of RAPA (time point one-baseline)	0.15 ± 1.15		0.20 ± 1.21		0.04 ± 0.99		0.01
Follow-up year three (n = 1,222)	3.94 ± 1.14		3.87 ± 1.15		4.08 ± 1.12		0.002
Change of RAPA (time point three-baseline)	−0.01 ± 1.25		0.05 ± 1.28		−0.14 ± 1.19		0.01
RAPA1 Category at baseline [b]							<0.001
Not Active	1817	62.3 %	1304	67.7 %	513	51.8 %	
Active	1099	37.7 %	621	32.3 %	478	48.2 %	
Mean Healthy food score [c]							
Baseline	3.52 ± 0.81		3.53 ± 0.82		3.49 ± 0.79		0.2
Follow-up year one (n = 1,575)	3.64 ± 0.78		3.65 ± 0.79		3.61 ± 0.76		0.4
Change of healthy food score (time point one-baseline)	0.08 ± 0.73		0.08 ± 0.73		0.08 ± 0.75		0.9
Follow-up year three (n = 1,222)	3.69 ± 0.80		3.74 ± 0.79		3.58 ± 0.80		0.002
Change of healthy food score (time point three-baseline)	0.11 ± 0.81		0.13 ± 0.80		0.06 ± 0.81		0.2
Healthy food score at baseline							0.1
Low healthy food score (≤median)	1492	50.3 %	964	49.3 %	528	52.1 %	
High healthy food score (>median)	1477	49.7 %	992	50.7 %	485	47.9 %	
Physical activity and healthy food score (PAHF) categories							
Baseline							
Non-active and low healthy food score	963	33.6 %	686	36.3 %	277	28.5 %	<0.001
Active and low healthy food score	477	16.7 %	248	13.1 %	229	23.5 %	
Non-active and high healthy food score	825	28.8 %	598	31.7 %	227	23.3 %	
Active and high healthy food score	597	20.9 %	357	18.9 %	240	24.7 %	
Follow-up year one							
No increase in physical activity or healthy food score	511	35.1 %	340	33.9 %	171	37.7 %	0.003
Increase in physical activity and no increase in healthy food score	240	16.5 %	179	17.9 %	61	13.4 %	
	470		305		165		

(continued on next page)

Table 2 (*continued*)

Characteristic	All Participants		Women		Men		P-value [a]
	N (%) or mean ± SD						
No increase in physical activity and increase in healthy food score		32.3 %		30.4 %		36.3 %	
Increase in physical activity and healthy food score	235	16.1 %	178	17.8 %	57	12.6 %	
Follow-up year three							
No increase in physical activity or healthy food score	383	33.2 %	235	30.5 %	148	38.8 %	<0.001
Increase in physical activity and no increase in healthy food score	160	13.9 %	125	16.2 %	35	9.2 %	
No increase in physical activity and increase in healthy food score	415	36.0 %	271	35.1 %	144	37.8 %	
Increase in physical activity and healthy food score	194	16.8 %	140	18.2 %	54	14.2 %	

Abbreviations: Body mass index (BMI); Rapid Assessment of Physical Activity (RAPA); Standard deviation (SD).
Physical activity measured using Rapid Assessment of Physical Activity.

[a] P-value for X^2 tests comparing male and female participants in the proportion of each category for each characteristic variable or two sample *t*-test comparing distribution of each continuous variable in two gender groups.

[b] Active is defined as a RAPA1 value of 5 is active, not active is defined as a RAPA1 value of 1–4.

[c] Healthy Food score was constructed by averaging the intake frequency of six healthy goods (whole grain bread; fruit; green leafy salad; cooked dried beans; fish, chicken, game; vegetables). The frequency for each type of food was reported as: (1) less than once a month, (2) 1–3 times a month, (3) about once a week, (4) 2–3 times per week, (5) about once a day, and (6) more than once a day.

(CVD) among individuals with diabetes (Brand-Miller et al., 2003; Choudhary, 2004; Jenkins et al., 2011).

Case management is frequently used to promote lifestyle change (Krein et al., 2004; Moore et al., 2014) and has been shown to improve glycemic control and reduce risk of heart disease risk among individuals with diabetes, including AI/ANs (Krein et al., 2004; Moore et al., 2014; Shojania et al., 2006). Indeed, Moore et al. documented improvements in blood glucose control, as measured by HbA1c, from baseline to year one in AI/AN patients with type 2 diabetes who participated in case management through the Special Diabetes Program for Indians-Healthy Heart demonstration project (SDPI-HH) (Moore et al., 2014). SDPI-HH participants were also shown to have increased use of aspirin and other antiplatelet therapies (Moore et al., 2014). The present study considered other potential impacts of SDPI-HH case management–specifically, the relationship between physical activity and food choices and the association between physical activity and food choices with HbA1c, both cross-sectionally and longitudinally.

2. Methods

2.1. SDPI-Hh

Beginning in fiscal year (FY) 2004, SDPI-HH was designed and funded to reduce cardiovascular risk factors among AI/AN people with diabetes by translating knowledge regarding improving CVD risk factors for implementation in geographically and organizationally diverse clinical settings. Complete details of the SDPI-HH project are described elsewhere (Manson et al., 2011; Moore et al., 2014). Briefly, 30 health-care programs serving predominantly AI/AN participants received funds to implement SDPI-HH. These programs, located in each of the 12 Indian Health Service (IHS) administrative service areas, included 7 IHS hospitals/clinics, 21 tribal health-care programs, and 2 urban Indian organization programs, serving a total of 138 tribes in 13 states. The University of Colorado Anschutz Medical Campus served as the Coordinating Center. Under the guidance of the IHS Division of Diabetes Treatment and Prevention, the Coordinating Center provided technical assistance to the programs and collected, managed, and analyzed process and outcome data. SDPI-HH participants attended individual case management meetings at which their progress toward cardiovascular risk reduction was evaluated. Nurses, pharmacists, and other ancillary health professionals served as case managers and worked with participants to introduce and explain clinical measures, to coordinate care

Table 3
Adjusted [a] association between physical activity and healthy food score at baseline and change in healthy food score at follow-up among American Indians and Alaska Natives with type 2 diabetes participating in the Special Diabetes Program for Indians - Healthy Heart demonstration project (SDPI-HH), 2006–2009.

	All Participants				Women				Men			
	Healthy food score (above the median)											
	OR	95 % CI		p value	OR	95 % CI		p value	OR	95 % CI		p value
Baseline												
RAPA1 Score [b]	**1.29**	**1.17**	**1.43**	**<0.001**	**1.35**	**1.20**	**1.52**	**<0.001**	1.16	0.96	1.40	0.1
RAPA1 Category [b]												
RAPA1 Category Active (Not active is ref)	**1.58**	**1.27**	**1.97**	**<0.001**	**1.77**	**1.34**	**2.33**	**<0.001**	1.31	0.91	1.89	0.1
	Change in healthy food score											
	β	SE		p value	β	SE		p value	β	SE		p value
Change in RAPA1 Score												
Follow-up year 1 [c]	0.03	0.02		0.2	0.04	0.03		0.1	−0.02	0.05		0.7
Follow-up year 3 [d]	0.02	0.03		0.6	−0.03	0.03		0.4	**0.10**	**0.05**		**0.03**

Abbreviations: Rapid Assessment of Physical Activity (RAPA); Confidence interval (CI); Standard error (SE).

[a] Multivariate regression models controlled for age, education, employment, marital status, income, body mass index, smoking, rural/urban site, years of diabetes, and comorbidity score. Models for all participants also included gender.

[b] Outcome is healthy food score above the median.

[c] Outcome is change of healthy food score follow-up year 1.

[d] Outcome is change of healthy food score follow-up year 3.

Table 4
Hemoglobin A1C (%) among American Indians and Alaska Natives with type 2 diabetes participating in the Special Diabetes Program for Indians - Healthy Heart demonstration project (SDPI-HH) by physical activity and healthy diet groups, 2006–2009.

Physical active and healthy food score (PAHF) group	Hemoglobin A1C (%)					
	All Participants		Women		Men	
	Mean ± SD	p value [a]	Mean ± SD	p value [a]	Mean ± SD	p value [a]
Hemoglobin A1c						
Baseline	N = 3,039	N = 2,005	N = 1,034			
Non-active and low healthy food score	**7.90 ± 1.92**	**0.03**	**7.89 ± 1.93**	**0.02**	7.94 ± 1.90	0.3
Active and low healthy food score	**7.89 ± 2.11**		**7.77 ± 2.03**		8.03 ± 2.18	
Non-active and high healthy food score	**7.69 ± 1.86**		**7.58 ± 1.75**		7.97 ± 2.10	
Active and high healthy food score	**7.67 ± 2.01**		**7.64 ± 1.89**		7.70 ± 2.18	
Change in Hemoglobin A1c						
Change from baseline to follow-up year 1 (year 1 – baseline)	N = 1,448	N = 998	N = 450			
No increase in physical activity or healthy food score	−0.26 ± 1.73	0.5	−0.13 ± 1.58	0.6	−0.51 ± 1.97	0.6
Increase in physical activity and no increase in healthy food score	−0.30 ± 1.62		−0.27 ± 1.46		−0.39 ± 2.01	
No increase in physical activity and increase in healthy food score	−0.15 ± 1.69		−0.11 ± 1.70		−0.22 ± 1.69	
Increase in physical activity and healthy food score	−0.12 ± 1.55		−0.04 ± 1.59		−0.36 ± 1.40	
No increase in physical activity or healthy food score	−0.26 ± 1.73	0.4	−0.13 ± 1.58	>0.9	−0.51 ± 1.97	0.2
Increase in physical activity and/or healthy food score	−0.18 ± 1.64		−0.14 ± 1.61		−0.28 ± 1.71	
Change from baseline to follow-up year 3 (year 3 – baseline)	N = 1,150	N = 769	N = 381			
No increase in physical activity or healthy food score	0.19 ± 1.87	0.1	0.29 ± 1.70	0.1	0.05 ± 2.11	0.7
Increase in physical activity and no increase in healthy food score	−0.04 ± 1.95		−0.03 ± 1.95		−0.07 ± 1.99	
No increase in physical activity and increase in healthy food score	−0.11 ± 1.76		−0.07 ± 1.79		−0.17 ± 1.70	
Increase in physical activity and healthy food score	0.04 ± 1.44		0.16 ± 1.40		−0.26 ± 1.49	
No increase in physical activity or healthy food score	**0.19 ± 1.87**	**0.03**	**0.29 ± 1.70**	**0.03**	0.05 ± 2.11	0.3
Increase in physical activity and/or healthy food score	**−0.05 ± 1.72**		**0.00 ± 1.74**		−0.17 ± 1.69	

Abbreviations: Standard deviation (SD).
[a] P value for ANOVA test for difference of A1c among physical activity and diet combination categories.

consistent with practice standards, to encourage adherence to treatment, and to set goals for behavior change.

2.2. Study population

To be eligible to participate in SDPI-HH participants had to be AI/AN, at least 18 years of age, and have diabetes as identified through electronic medical records and diabetes registries. Individuals with diabetes were also recruited through community- and clinic-based activities including health fairs and provider referrals and confirmed to have diabetes based on evidence of confirmed previous diagnosis from medical records or an Oral Glucose Tolerance Test result. Individuals were excluded if they were pregnant, receiving dialysis for end-stage renal disease, undergoing cancer treatment, suffering active alcohol or substance abuse, or had any other condition that might prohibit successful participation. A history of CVD was not a criterion for exclusion. Potential participants were identified by program staff through electronic medical records or type 2 diabetes registries and recruited through community and clinical activities, such as health fairs and provider referrals.

At baseline and annually for up to three years, participants underwent a medical examination and completed a questionnaire that covered sociodemographic characteristics, co-morbid health conditions, self-reported physical activity, food intake frequency, alcohol consumption and smoking status. From January 2006 to July 2009, 3,039 individuals were recruited and completed baseline questionnaires and physical examinations. At one and three years after baseline, 1,575 and 1,222 individuals, respectively, completed questionnaires and physical examinations.

The Colorado Multiple Institutional Review Board (IRB) at the

Table 5
The association between physical activity and healthy food score at baseline and follow-up with baseline or change in Hemoglobin A1C among American Indians and Alaska Natives with type 2 diabetes participating in the Special Diabetes Program for Indians - Healthy Heart demonstration project (SDPI-HH), 2006–2009.

Hemoglobin A1c Physical activity and healthy food score (PAHF) group	All Participants β	SE	p value	Women β	SE	p value	Men β	SE	p value
Baseline [b]	N = 3,039			N = 2,005			N = 1,034		
Non-active and low healthy food score (ref)	0			0			0		
Active and low healthy food score	−0.04	0.15	0.8	−0.24	0.19	0.2	0.29	0.26	0.3
Non-active and high healthy food score	0.03	0.12	0.8	−0.17	0.13	0.2	**0.55**	**0.26**	**0.04**
Active and high healthy food score	−0.03	0.14	0.8	−0.06	0.16	0.7	0.09	0.26	0.7
Change in Hemoglobin A1c									
Change from baseline to follow-up year 1 (year 1 – baseline) [c]	N = 1,448			N = 998			N = 450		
No increase in physical activity or healthy food score (ref)	0			0			0		
Increase in physical activity and no increase in healthy food score	−0.13	0.16	0.4	−0.18	0.20	0.4	0.03	0.25	0.9
No increase in physical activity and increase in healthy food score	0.18	0.13	0.2	0.16	0.17	0.3	0.20	0.19	0.3
Increase in physical activity and healthy food score	0.01	0.16	0.9	−0.07	0.19	0.7	0.31	0.27	0.3
No increase in physical activity or healthy food score (ref)	0			0			0		
Increase in physical activity and/or healthy food score	0.06	0.11	0.6	0.00	0.14	>0.9	0.18	0.17	0.3
Change from baseline to follow-up year 3 (year 3 – baseline) [d]	N = 1,150			N = 769			N = 381		
No increase in physical activity or healthy food score (ref)	0			0			0		
Increase in physical activity and no increase in healthy food score	−0.26	0.19	0.2	−0.36	0.24	0.1	0.06	0.36	0.9
No increase in physical activity and increase in healthy food score	**−0.30**	**0.15**	**0.04**	−0.32	0.19	0.1	−0.22	0.24	0.3
Increase in physical activity and healthy food score	−0.28	0.19	0.1	−0.43	0.24	0.07	0.24	0.32	0.5
No increase in physical activity or healthy food score (ref)	0			0			0		
Increase in physical activity and/or healthy food score	**−0.29**	**0.13**	**0.03**	**−0.35**	**0.17**	**0.04**	−0.08	0.21	0.7

Abbreviations; Standard error (SE).
[a]Multivariate regression models include baseline characteristics, including age, education, employment, marital status, income, Body Mass Index category, smoking, rural/urban site, years of diabetes and comorbidity. Models for all participants also controlled for gender. Models for change of A1C also adjusted for baseline A1C value.
[b] Outcome is baseline Hemoglobin A1C (%).
[c] Outcome is change of Hemoglobin A1C (%) follow-up year 1.
[d] Outcome is change of Hemoglobin A1C (%) follow-up year 3.

University of Colorado Denver and the National IHS IRB approved the protocol. As required, grantees obtained approval from other entities charged with overseeing research in their program (e.g., tribal research review boards, tribal council, and regional IHS IRBs). All participants provided written informed consent and Health Insurance Portability and Accountability Act authorization. SDPI-HH grantees and the IHS reviewed and approved this article in advance of publication.

2.3. Physical activity

Physical activity was measured at baseline and at each of three annual follow-up visits by the Rapid Assessment of Physical Activity (RAPA) questionnaire (Topolski et al., 2006). RAPA is a short, self-administered instrument assessing weekly physical activity levels. Participants were presented examples of “light”, “moderate”, and “vigorous” physical activities. Participants were then asked how physically active they were by checking “yes” or “no” for each of the following:

(1) I rarely or never do any physical activities.

(2) I do some light or moderate physical activities, but not every week.

(3) I do some light physical activity every week.

(4) I do moderate physical activities every week, but<30 min a day or 5 days a week.

(5) I do vigorous physical activities every week, but<20 min a day or 3 days a week.

(6) I do 30 min or more a day of moderate physical activity, 5 or more days a week.

(7) I do 20 min or more a day of vigorous physical activities, 3 or more days a week.

Among “yes” responses, the response indicating the highest activity level was used to categorize the participants into one of five overall levels of physical activity: 1 = sedentary, 2 = underactive, 3 = regular underactive (light activities), 4 = regular underactive, and 5 = regular active (P.A.G.A. Committee, 2008, 2018).

2.4. Food choices

The operationalization and scoring of food choices are described elsewhere (Teufel-Shone et al., 2015). Briefly, participants were annually asked to recall the intake of 27 types of foods over the 30 days prior to data collection using a self-administered Food Frequency Questionnaire. The Food Frequency Questionnaire was adapted from the Multifactor Screener, evaluated at the National Cancer Institute and validated by other studies (Thompson et al., 2004). Some questions were culturally adapted for the AI/AN population. The frequency of each type of food was reported as: (1) less than once a month; (2) 1–3 times a month; (3) about once a week; (4) 2–3 times per week; (5) about once a day; and (6) more than once a day. The 27 food types were categorized as ‘healthy’, ‘unhealthy’, or ‘undetermined’ based on survey results from program staff members who led the nutrition education at the program sites. The healthy food score (range = 1 to 6) was constructed by averaging the intake of six healthy foods (wholegrain bread, fruit, green leafy salad, cooked dried beans, fish/chicken/game, and vegetables) and had a Cronbach’s α of 0.70. The healthy food score has been shown to be a reliable and valid indicator of dietary outcomes in related analyses of SDPI program outcomes (Teufel-Shone et al., 2015; Teufel-Shone et al., 2018).

2.5. Hemoglobin A1c (HbA1c)

Blood was drawn after a 12-hour fast to measure HbA1c (%). HbA1c was assessed by cite. Although assays varied by study cite, local or regional laboratories with standard available assays were used.

Table 6
Characteristics among American Indians and Alaska Natives with type 2 diabetes participating in the Special Diabetes Program for Indians - Healthy Heart demonstration project (SDPI-HH), by whether a participant completed year 1 or was lost to follow-up at year 1, 2006–2009.

Characteristic	All Participants (N = 3039)		Completed year 1 (N = 2102)		Lost to follow-up at Year 1 (n = 937)		p-value
	n	Col %	n	Row %	n	Row %	
Age							<0.0001
18–39	354	11.6 %	193	54.5 %	161	45.5 %	
40–49	667	21.9 %	423	63.4 %	244	36.6 %	
50–59	1006	33.1 %	711	70.7 %	295	29.3 %	
≥60	1012	33.3 %	775	76.6 %	237	23.4 %	
Gender							0.01
Female	2005	66.0 %	1417	70.7 %	588	29.3 %	
Male	1034	34.0 %	685	66.2 %	349	33.8 %	
Education							0.1
< High School	546	19.1 %	374	68.5 %	172	31.5 %	
High School Graduate	725	25.3 %	509	70.2 %	216	29.8 %	
Some College	1164	40.7 %	779	66.9 %	385	33.1 %	
≥College Graduate	427	14.9 %	312	73.1 %	115	26.9 %	
Employment Status							0.0006
Employed	1399	51.8 %	929	66.4 %	470	33.6 %	
Retired	499	18.5 %	378	75.8 %	121	24.2 %	
Unemployed or student	803	29.7 %	553	68.9 %	250	31.1 %	
Marital status							0.4
Married or living together	1459	57.3 %	1004	68.8 %	455	31.2 %	
Separated/divorced or widowed	721	28.3 %	498	69.1 %	223	30.9 %	
Never married	367	14.4 %	240	65.4 %	127	34.6 %	
Annual household income ($US)							0.3
0–14,999	761	31.1 %	511	67.1 %	250	32.9 %	
15,000–29,999	690	28.2 %	474	68.7 %	216	31.3 %	
30,000–49,999	601	24.6 %	433	72.0 %	168	28.0 %	
≥50,000	392	16.0 %	268	68.4 %	124	31.6 %	
BMI (Kg/m^2)							0.4
Under or normal weight (<25)	117	3.9 %	75	64.1 %	42	35.9 %	
Overweight (25–30)	483	15.9 %	328	67.9 %	155	32.1 %	
Obese (>30)	2436	80.2 %	1698	69.7 %	738	30.3 %	
Smoker (% yes)							0.7
Non-smoker	1360	47.4 %	943	69.3 %	417	30.7 %	
Current or former smoker	1509	52.6 %	1036	68.7 %	473	31.3 %	
Site location							0.9
Urban	414	13.6 %	285	68.8 %	129	31.2 %	
Rural	2625	86.4 %	1817	69.2 %	808	30.8 %	
	Mean	SD	Mean	SD	Mean	SD	
Years of diabetes duration	4.57	6.45	4.64	6.7	4.42	5.81	0.4
Comorbidity	4.25	3.54	4.37	3.53	3.99	3.54	0.007
RAPA	3.89	1.08	3.93	1.05	3.82	1.15	0.02
Healthy Diet Score	3.52	0.81	3.54	0.8	3.48	0.82	0.08

Abbreviations: Rapid Assessment of Physical Activity (RAPA); Standard deviation (SD).

2.6. Covariates

Participants self-reported age, gender, educational attainment, employment status, marital status, and annual household income at baseline. Height was measured in centimeters. Weight was measured in kilograms or pounds with participants wearing light clothing and no shoes. Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared and categorized as under or normal weight (<25 kg/m^2), overweight (25–30 kg/m^2), or obese (>30 kg/m^2). Smoking was self-reported using items from the American Indian Service Utilization Psychiatric Epidemiology, Risk and Protective Factors Project (Nez Henderson et al., 2005) and participants were categorized as non-smokers, current smokers, or former smokers. Type 2 diabetes duration was self-reported and presented as years since diagnosis. Comorbidity burden was measured by an index of 12 conditions other than type 2 diabetes measured by the Self-Administered Comorbidity Questionnaire (Sangha et al., 2003). Program site location was categorized as urban or rural.

2.7. Statistical analyses

Baseline socio-demographic characteristics were examined for all participants and by gender. The mean RAPA score, healthy food score, and combined physical activity level and healthy food score (PAHF) at baseline and follow-up were calculated and compared between gender groups using two sample t-tests or chi-square tests. To assess the association between a participant's healthy food score and physical activity level, multivariate logistic regression models were fitted with dichotomized healthy food score (above the median = 1, at and below the median = 0) as the outcome variable and baseline RAPA score or physical activity category as the main independent variable. All multivariate models were controlled for baseline age, education, employment, marital status, income, BMI, smoking, rural/urban site, years of diabetes, and comorbidity score. In addition, multivariate linear regression models were fitted to examine the association between changes in healthy food scores and changes in RAPA scores during follow-up at year one and year three.

The distribution of HbA1c values at baseline and during follow-up were presented by physical activity level and dichotomized healthy food score and compared using ANOVA tests. Moreover, multivariate linear regression models were used to evaluate the association between HbA1c values and PAHF at baseline and follow-up controlling for other baseline social-demographic and participant characteristics. Results were statistically significant if the P-value was < 0.05. All analyses were performed using SAS 9.4 (SAS Institute Inc. Cary, NC).

3. Results

Among all SDPI-HH participants at baseline, the majority of the 3039 participants were 50 years or older (66 %), had completed some college or graduated from college (56 %), were employed (52 %), were married or living together with a partner (57 %), had an annual household income of less than $30,000 (59 %), and were from a rural SDPI-HH site (86 %) (Table 1). Eighty percent of participants were obese, 53 % were current or former smokers, and their mean comorbidity score was 4.3 ± 3.5. On average, participants had lived with diabetes for 4.6 ± 6.5 years. Compared to men, women were better educated and were more likely to be separated, divorced, or widowed; obese; never smokers; and live in urban areas (Table 1).

At baseline, SDPI-HH participants had a mean RAPA score of 3.89 ± 1.08; 62 % were categorized as "not active" and findings differed by gender (Table 2). Women reported, on average, statistically significantly lower RAPA scores (3.76 ± 1.10) and were more likely to be not active (68 %) compared to men (RAPA mean 4.15 ± 1.01, 52 % not active) at baseline. Compared to baseline, men and women reported statistically significantly more physical activity at follow-up year one (mean change of RAPA 0.15 ± 1.15). Women were more likely to increase their physical activity score (0.20 ± 1.21) compared to men (change of RAPA 0.04 ± 0.99) (Table 2). However, by follow-up year three, women appeared to have similar RAPA scores compared to baseline (mean change 0.05 ± 1.28) while men had lower RAPA scores (mean change −0.14 ± 1.19) compared to their respective baseline levels.

At baseline, SDPI-HH participants had a healthy food score of 3.52 ± 0.82 (Table 2). Differences between women and men were not statistically significant. From baseline to follow-up year one, there was a small increase in healthy food score (mean change 0.08 ± 0.73) that did not differ by gender. However, from baseline to follow-up year three, there was a larger increase in healthy food score among women (mean change 0.13 ± 0.80) compared to men (mean change 0.06 ± 0.81); however, the difference between men and women was not statistically significant.

When assessing PAHF at baseline, about one-third of SDPI-HH participants were both physically non-active and had a low healthy food score (34 %, Table 2). This was true of a statistically significantly higher proportion of women (36 %) than men (29 %). Conversely, a higher proportion of men were in both active and high healthy food score category (25 %) compared to women (19 %). At follow-up year one, 66 % of women increased their physical activity, healthy food score, or both, compared to 62 % of men. Similarly, at follow-up year three, 70 % of women increased their physical activity, healthy food score, or both compared to 61 % of men.

Participants who reported being physically active had statistically significantly higher odds of having a healthy food score above the median at baseline (OR = 1.58, 95 % CI: 1.27, 1.97, Table 3). Consistently, among women, those who reported being physically active had statistically significantly higher odds of having a healthy food score above the median (OR = 1.77, 95 % CI: 1.34, 2.33). Although not statistically significant, men who reported being physically active also had higher odds of having a healthy food score above the median (OR = 1.31, 95 % CI: 0.91, 1.89). Change in RAPA score from baseline to follow-up years one and three was not associated with change in healthy food score among women. Change in RAPA score from baseline to follow-up year three was associated with a change in healthy food score among men (β = 0.10, P = 0.03, Table 3).

At baseline, SDPI-HH participants who were active and had a high healthy food score had lower HbA1c levels (7.67 ± 2.01) compared to those who were not active and had low healthy food scores (7.90 ± 1.92) (Table 4). However, this association was mainly driven by women. Women who were active and had a high healthy food score had lower HbA1c levels (7.64 ± 1.89) compared to not active women with low healthy food scores (7.89 ± 1.93). At baseline, there were no statistically significant difference in HbA1c level by activity and healthy food score among men. From baseline to follow-up year one, all participants' HbA1c level decreased, regardless of PAHF changes (Table 4). However, at follow-up year three, HbA1c increased among participants with no improvement in physical activity or healthy food score (0.19 ± 1.87), while those with any increase in physical activity, healthy food score, or both experienced a small decrease in HbA1c (-0.05 ± 1.72).

In multivariate regression models, PAHF was not statistically significantly associated with baseline HbA1c level except those non-active men with high healthy food scores had marginally higher HbA1c than the non-active male group with low healthy food scores (β = 0.55, P = 0.04, Table 5). From baseline to year one, there were no statistically significant differences in change in HbA1c by PAHF groups (Table 5). However, at follow-up year three, participants with improvements in either or both behaviors had lower HbA1c compared to those who did not increase physical activity or healthy food score (β = -0.29, P = 0.03). This association was statistically significant among women (β = -0.35, P = 0.04) but not among men (β = -0.08, P = 0.70).

4. Discussion

The SDPI-HH Program engaged a large national sample of AI/AN participants diagnosed with diabetes in an intervention designed to promote diabetes self-management to improve CVD risk factors. At baseline, reported physical activity levels and heathy food choices among SDPI-HH participants were only associated with HbA1c among non-active men with high healthy food scores. At baseline, women and men had similar healthy food scores, yet men reported higher physical activity levels than women. From baseline to years one and three, men and women reported relatively small changes in physical activity levels and mean healthy food score.

At the one-year follow-up, SDPI-HH participants' HbA1c did not change significantly, regardless of PAHF. This outcome is comparable to the Strong Heart Study, in which a cohort of AIs enrolled in cardiovascular risk reduction study, did not exhibit an association between physical activity and a one-year change in HbA1c (Hu et al., 1999). Yet among the SDPI-HH participants who continued to the year three follow up, some change was noted further into the intervention phase, with women who increased their physical activity, healthy food scores, or both exhibiting a small statistically significant reduction in HbA1c by year three.

Regardless of change in HbA1c, at follow-up years one and three, more women, compared to men, increased their physical activity. Since more women than men enrolled in the SDPI-HH program and intervention staff were generally women (Manson et al., 2011; Moore et al., 2014), intervention events that supplemented the case management sessions, such as healthy cooking classes, weekly walks and dance-a-thons were often women focused. Thus, women may have been more attracted to planned activities and received a larger dose of education and behavior change reinforcement. However, we were unable to quantify specific doses of education and reinforcement by specific participants and, thus, by sex. Additionally, women had lower baseline physical activity levels compared to men and, consequently, had more room for improvement throughout the intervention.

Diabetes management differs between men and women (Legato et al., 2006). Hence, intervention strategies to improve diabetes self-management may be more effective if they differentiate by gender in design. Specifically, women and men in the general population and within AI/AN populations engage in physical activity differently (Azevedo et al., 2007; Coble and Rhodes, 2006; Harnack et al., 1999; Lee, 2005; Storti et al., 2009; Story et al., 2001) and have different eating habits (Fagerli and Wandel, 1999; Harnack et al., 1999; Story et al., 2001; Wardle et al., 2004). Targeting the differences in these behaviors to meet the needs of male and female participants separately may be a key to managing diabetes through effective changes in activity and dietary habits (Norris et al., 2001; Norris et al., 2002). SDPI-HH findings and associated literature suggests that if group education is one of the intervention strategies, gender specific sessions might hold promise for influencing behavior change. Men and women may be starting a program at different levels of physical activity and healthy food choices, different challenges to enacting behavior changes as dictated by their work and household responsibilities, and with different perspectives and readiness to change.

A primary limitation of this study was participant retention. About 50 % of participants did not complete the first annual questionnaire and 60 % did not complete the third. Men were more likely than women to be lost to follow-up, older adults were likely to participate more fully than younger adults, and higher socioeconomic status participants were more likely to be retained (Table 6, Manson et al., 2011). One predictor of retention of particular importance in SDPI-HH was higher levels of physical activity at baseline (Manson et al., 2011). This trend may have introduced selection bias into our study. Participants who stayed with the program, were particularly motivated and willing to comply with program visits, telephone follow-ups, and required laboratory testing. These participants are likely different from those who dropped out of the program, and more broadly, those seeking services from IHS, tribal, and urban programs, which limits the generalizability of this study. Also, women were better educated compared to men in the study, which may influence physical activity and healthy food choices. To take differences into account, we controlled for education in our multivariate models. In addition, given the focus on AI/AN people, the results may not be generalized to non-AI/AN populations. Although participants were found to have increased use in antiplatelet therapies that may affect HbA1c (Moore et al., 2014), we were unable to take medication use into account for the current study. Finally, physical activity and food choices were based on self-reported measures. Under-reporting of total food intake, over-reporting of fruit and vegetable intake (Paalanen et al., 2006), and over-reporting of physical activity is common when using self-report methods (Sallis and Saelens, 2000). Additionally, Food Frequency Questionnaires are not exceptionally sensitive to detecting dietary changes (Cade et al., 2002). However, we were able to detect small differences in healthy food scores among participants as well as an association between healthy food scores and a small decrease in HbA1c among women. Thus, associations may be stronger than the Food Frequency Questionnaire was able to detect in our study. Future interventions should include objective measures of physical activity and food choices such as accelerometers, direct observation, and biomarkers to complement self-reported behaviors. This methodological rigor could help determine granular changes in physical activity and food choices during an intervention.

5. Conclusion

The prevalence of diabetes among AI/AN adults is the highest among all United States racial/ethnic groups (Centers for Disease Control and Prevention, 2017). Health behaviors, including regular physical activity and healthy food choices are important components in the management of diabetes. A key outcome of this analysis revealed that an increase in healthier behaviors, including physical activity, healthy food choices, and the combination of both were associated with a small improvement in HbA1c in SDPI-HH women who may have already been predisposed to physical activity and health food choices. If participants are receptive to only changes in physical activity or food choices, this singular propensity should be encouraged as altering just one side of the energy balance scale and may have a positive impact on HbA1c.

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CRediT authorship contribution statement

Ricky Camplain: Conceptualization, Methodology, Writing – original draft, Writing – review & editing, Visualization. **Nicolette I. Teufel-Shone:** Conceptualization, Writing – review & editing, Supervision. **Luohua Jiang:** Methodology, Formal analysis, Data curation, Writing – review & editing. **Jennifer Chang:** Methodology, Formal analysis, Data curation, Writing – review & editing. **Spero M Manson:** Resources, Writing – review & editing, Supervision, Funding acquisition.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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References

American Diabetes Association, 2003. Physical activity/exercise and diabetes mellitus. Diabetes care 26:s73-s77.

American Diabetes Association, 2015. 4. Foundations of care: education, nutrition, physical activity, smoking cessation, psychosocial care, and immunization. Diabetes Care 38, S20–S30.

Azevedo, M.R., Araújo, C.L.P., Reichert, F.F., Siqueira, F.V., da Silva, M.C., Hallal, P.C., 2007. Gender differences in leisure-time physical activity. International Journal Public Health 52, 8.

Boulé, N.G., Haddad, E., Kenny, G.P., Wells, G.A., Sigal, R.J., 2001. Effects of exercise on glycemic control and body mass in type 2 diabetes mellitus: a meta-analysis of controlled clinical trials. JAMA 286, 1218–1227.

Brand-Miller, J., Hayne, S., Petocz, P., Colagiuri, S., 2003. Low–glycemic index diets in the management of diabetes: A meta-analysis of randomized controlled trials. Diabetes Care 26, 2261–3227.

Cade, J., Thompson, R., Burley, V., Warm, D., 2002. Development, validation and utilisation of food-frequency questionnaires–a review. Public Health Nutr. 5, 567–587.

Centers for Disease Control and Prevention, 2017. National diabetes statistics report, 2017. Centers for Disease Control and Prevention, Atlanta, GA.

Choudhary, P., 2004. Review of dietary recommendations for diabetes mellitus. Diabetes Res. Clin. Pract. 65, S9–S15.

Coble, J.D., Rhodes, R.E., 2006. Physical activity and Native Americans: a review. Am. J. Prev. Med. 31, 36–46.

Committee, P.A.G.A., 2018. Physical activity guidelines advisory committee scientific report. US Department of Health and Human Services, Washington, DC.

Committee, P.A.G.A., 2008. Physical activity guidelines advisory committee report, 2008. Washington, DC: US Department of Health and Human Services 2008:A1-H14.

Fagerli, R.A., Wandel, M., 1999. Gender differences in opinions and practices with regard to a" healthy diet". Appetite 32, 171–190.

Gregg, E.W., Gerzoff, R.B., Caspersen, C.J., Williamson, D.F., Narayan, K.V., 2003. Relationship of walking to mortality among US adults with diabetes. Arch. Intern. Med. 163, 1440–2147.

Harnack, L., Story, M., Rock, B.H., 1999. Diet and physical activity patterns of Lakota Indian adults. J. Am. Diet. Assoc. 99, 829–835.

Hu, D., Henderson, J.A., Welty, T.K., Lee, E.T., Jablonski, K.A., Magee, M.F., Robbins, D. C., Howard, B.V., 1999. Glycemic control in diabetic american indians. longitudinal data from the strong heart study. Diabetes Care 22, 1802–2187.

Jenkins, D., Srichaikul, K., Kendall, C., Sievenpiper, J., Abdulnour, S., Mirrahimi, A., Meneses, C., Nishi, S., He, X., et al., 2011. The relation of low glycaemic index fruit consumption to glycaemic control and risk factors for coronary heart disease in type 2 diabetes. Diabetologia 54, 271–329.

Jiang, L., Manson, S.M., Beals, J., Henderson, W.G., Huang, H., Acton, K.J., Roubideaux, Y., Project, S.D.P.f.I.D.P.D., 2013. Translating the diabetes prevention program into American Indian and Alaska native communities: results from the special diabetes program for Indians diabetes prevention demonstration project. Diabetes care 36: 2027-34.

Knowler, W.C., Barrett-Connor, E., Fowler, S.E., Hamman, R.F., Lachin, J.M., Walker, E. A., Nathan, D.M., 2002. Reduction in the incidence of type 2 diabetes with lifestyle intervention or metformin. The New England journal of medicine 346, 393–403.

Koivula, R.W., Tornberg, Å.B., Franks, P.W., 2013. Exercise and diabetes-related cardiovascular disease: systematic review of published evidence from observational studies and clinical trials. Curr. Diab.Rep. 13, 372–380.

Krein, S.L., Klamerus, M.L., Vijan, S., Lee, J.L., Fitzgerald, J.T., Pawlow, A., Reeves, P., Hayward, R.A., 2004. Case management for patients with poorly controlled diabetes: a randomized trial. The American journal of medicine 116, 732–779.

Lee, Y.-S., 2005. Gender differences in physical activity and walking among older adults. Journal of women & aging 17, 55–70.

Legato, M.J., Gelzer, A., Goland, R., Ebner, S.A., Rajan, S., Villagra, V., Kosowski, M., 2006. Gender-specific care of the patient with diabetes: review and recommendations. Gend. Med. 3, 131–158.

Manson, S.M., Jiang, L., Zhang, L., Beals, J., Acton, K.J., Roubideaux, Y., Project, S.H.H. D., 2011. Special diabetes program for Indians: Retention in cardiovascular risk reduction. The Gerontologist 51:S21-S32.

Moore, K., Jiang, L., Manson, S.M., Beals, J., Henderson, W., Pratte, K., Acton, K.J., Roubideaux, Y., 2014. Case management to reduce cardiovascular disease risk in American Indians and Alaska Natives with diabetes: results from the Special Diabetes Program for Indians Healthy Heart Demonstration Project. American journal of public health 104:e158-e64.

Nez Henderson, P., Jacobsen, C., Beals, J., Team, A.-S., 2005. Correlates of cigarette smoking among selected Southwest and Northern plains tribal groups: the AI-SUPERPFP Study. American journal of public health 95:867-72.

Norris, S.L., Engelgau, M.M., Narayan, K.V., 2001. Effectiveness of self-management training in type 2 diabetes: a systematic review of randomized controlled trials. Diabetes Care 24, 561–587.

Norris, S.L., Nichols, P.J., Caspersen, C.J., Glasgow, R.E., Engelgau, M.M., Jack Jr, L., Isham, G., Snyder, S.R., Carande-Kulis, V.G., et al., 2002. The effectiveness of disease and case management for people with diabetes: a systematic review. Am. J. Prev. Med. 22, 15–38.

Norris, S.L., Zhang, X., Avenell, A., Gregg, E., Bowman, B., Schmid, C.H., Lau, J., 2005. Long-term effectiveness of weight-loss interventions in adults with pre-diabetes: a review. Am. J. Prev. Med. 28, 126–139.

Paalanen, L., Mannisto, S., Virtanen, M.J., Knekt, P., Rasanen, L., Montonen, J., Pietinen, P., 2006. Validity of a food frequency questionnaire varied by age and body mass index. J. Clin. Epidemiol. 59, 994–1001.

Sallis, J.F., Saelens, B.E., 2000. Assessment of physical activity by self-report: status, limitations, and future directions. Res. Q. Exerc. Sport 71, 1–14.

Sangha, O., Stucki, G., Liang, M.H., Fossel, A.H., Katz, J.N., 2003. The Self-Administered Comorbidity Questionnaire: a new method to assess comorbidity for clinical and health services research. Arthritis Care & Research 49, 156–163.

Shojania, K.G., Ranji, S.R., McDonald, K.M., Grimshaw, J.M., Sundaram, V., Rushakoff, R.J., Owens, D.K., 2006. Effects of quality improvement strategies for type 2 diabetes on glycemic control: a meta-regression analysis. JAMA 296, 427–440.

Sigal, R.J., Kenny, G.P., Wasserman, D.H., Castaneda-Sceppa, C., White, R.D., 2006. Physical activity/exercise and type 2 diabetes: a consensus statement from the American Diabetes Association. Diabetes Care 29, 1433–2148.

Storti, K.L., Arena, V.C., Barmada, M.M., Bunker, C.H., Hanson, R.L., Laston, S.L., Yeh, J.-L., Zmuda, J.M., Howard, B.V., et al., 2009. Physical activity levels in American-Indian adults: the strong Heart Family Study. Am. J. Prev. Med. 37, 481–547.

Story, M., Stevens, J., Evans, M., Cornell, C.E., Gittelsohn, J., Going, S.B., Clay, T.E., Murray, D.M., 2001. Weight loss attempts and attitudes toward body size, eating, and physical activity in American Indian children: relationship to weight status and gender. Obes. Res. 9, 356–363.

Stratton, I.M., Adler, A.I., Neil, H.A.W., Matthews, D.R., Manley, S.E., Cull, C.A., Hadden, D., Turner, R.C., Holman, R.R., 2000. Association of glycaemia with macrovascular and microvascular complications of type 2 diabetes (UKPDS 35): prospective observational study. BMJ 321, 405–412.

Teufel-Shone, N.I., Jiang, L., Beals, J., Henderson, W.G., Zhang, L., Acton, K.J., Roubideaux, Y., Manson, S.M., 2015. Demographic characteristics and food choices of participants in the special diabetes program for American Indians diabetes prevention demonstration project. Ethnicity & health 20, 327–340.

Teufel-Shone, N.I., Jiang, L., Rockell, J., Chang, J., Beals, J., Bullock, A., Manson, S.M., 2018. Food choices and distress in reservation-based American Indians and Alaska Natives with type 2 diabetes. Public health nutrition:1–9.

Thompson, F.E., Midthune, D., Subar, A.F., Kahle, L.L., Schatzkin, A., Kipnis, V., 2004. Performance of a short tool to assess dietary intakes of fruits and vegetables, percentage energy from fat and fibre. Public Health Nutr. 7, 1097–1106.

Toledo, F.G., Menshikova, E.V., Ritov, V.B., Azuma, K., Radikova, Z., DeLany, J., Kelley, D.E., 2007. Effects of physical activity and weight loss on skeletal muscle mitochondria and relationship with glucose control in type 2 diabetes. Diabetes 56, 2142–2217.

Topolski, T.D., LoGerfo, J., Patrick, D.L., Williams, B., Walwick, J., Patrick, M.M.B., 2006. Peer reviewed: the Rapid Assessment of Physical Activity (RAPA) among older adults. Preventing Chronic Disease 3.

Tuomilehto, J., Lindström, J., Eriksson, J.G., Valle, T.T., Hämäläinen, H., Ilanne-Parikka, P., Keinänen-Kiukaanniemi, S., Laakso, M., Louheranta, A., et al., 2001. Prevention of type 2 diabetes mellitus by changes in lifestyle among subjects with impaired glucose tolerance. N. Engl. J. Med. 344, 1343–1350.

Wardle, J., Haase, A.M., Steptoe, A., Nillapun, M., Jonwutiwes, K., Bellisie, F., 2004. Gender differences in food choice: the contribution of health beliefs and dieting. Ann. Behav. Med. 27, 107–116.