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Do lifestyle interventions affect dietary diversity score in the general population?

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Abstract

Objective: The dietary diversity score (DDS) is a good indicator of diet quality as well as of diet–disease relationships; therefore, the present study was undertaken to reveal the effect of a lifestyle intervention on this index.

Design: A baseline and three evaluation studies were conducted in two intervention districts (Isfahan and Najaf-Abad) and a reference area (Arak), all located in central Iran. The Isfahan Healthy Hearth Programme (IHHP) targeted the entire population of nearly 2 million in urban and rural areas of the intervention communities. One of the main strategies of the lifestyle intervention phase in the IHHP was healthy nutrition. Usual dietary intake was assessed using a forty-nine-item FFQ. A diversity score for each food group was calculated and the DDS was considered the sum of the diversity scores of the food groups.

Results: There were significant increases in DDS in both intervention areas ($P = 0{\cdot}0001$) after controlling for confounding factors. There was a significant interaction between area and evaluation stage with regard to DDS ($P = 0{\cdot}0001$). The effect of the intervention on the diversity scores of all food groups was also significant ($P = 0{\cdot}0001$ for all) after adjusting for socio-economic status.

Conclusion: The community-based lifestyle intervention in the IHHP was successful in improving DDS which might be related to an increase of diet quality of the population that in turn might decrease the risks of chronic diseases.

Keywords
Dietary diversity score
Intervention
Dietary variety

Moving from a monotonous diet to a more diverse diet has been shown to increase energy and micronutrient intakes in developing countries[1–5]. Intake of a diverse range of foods has been a recommendation for achieving adequate nutrient intake and such advice appears in the dietary guidelines of many countries[6]. The most recent dietary guidelines recommend using a variety of whole grains, fruits and vegetables[7]. There is an increasing trend towards assessing the nutrient quality of the diet[7]. Especially in developing countries, methods for evaluating nutrient adequacy should be simple and practical[8]. Previous studies in Iran have shown that a dietary diversity score (DDS), as well as the diversity score of each separate food group, is associated with diet quality in adult men, women and adolescents[4,5,9].

Furthermore, assessing overall diet is more informative than looking at only one single nutrient. According to previous studies, higher DDS is associated with greater intakes of fibre[2,4] as well as vitamin C[2] and Ca[4]. These nutrients have a negative association with CVD, hypertension and obesity[10–12]. There are several studies that show a relationship between diet variety and mortality[13], cancer[14], cardiovascular health[15–17] and metabolic syndrome[18].

The intervention phase in the Isfahan Healthy Heart Programme (IHHP) was conducted to improve lifestyle behaviours including dietary habits, physical activity level, tobacco control and stress management at community level[19]. Along with improving nutritional status, we wondered if we could assess the whole diet by determining the DDS before and after the intervention. As the DDS is a good indicator of diet quality as well as diet–disease relationships, the present study was undertaken to reveal whether or not the DDS was changed by the lifestyle intervention.

Methods

Population

The study design and rationale of the IHHP and intervention methods have been described elsewhere[20].

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Briefly, two intervention districts (Isfahan and Najaf-Abad) and a reference area (Arak), all located in central Iran, were included in the study. According to the 2000 National Census, the population was 1 895 856 in Isfahan and 275 084 in Najaf-Abad, a small district neighbouring Isfahan. Arak, located 375 km north-west of Isfahan with a population of 668 531, was selected as reference area because of similarities to the intervention areas in terms of socio-economic, demographic and health profile and good cooperation[20]. The intervention programme targeted the whole population in urban and rural areas of the intervention communities. Arak was monitored for evaluation purposes but did not receive interventions. Measurements were done at baseline and annually for four years in the intervention areas and three years in the reference area. Surveys were performed in the same years in both the intervention and control areas. A given number of individuals (independent sample surveys) from among the residents of the whole community were randomly selected by a multistage cluster sampling method in each annual evaluation. The sample studied in every survey was different because this was a population-based study and the sample size for each survey was calculated by a statistician in order that this sample would be a representative sample of the society. Informed written consent was provided by each participant. The study was approved by the research council and the ethical committee of the Isfahan Cardiovascular Research Center of Isfahan University of Medical Sciences.

Interventions

The intervention programme targeted the general population as well as specific target groups in urban and rural areas of the intervention communities. Key strategies for intervention activities included public education through mass media, inter-sectoral cooperation and collaboration, professional education and involvement, marketing and organizational development, legislation and coordination, and policy development, as well as research and evaluation. The main factors targeted by IHHP were healthy nutrition, increased physical activity, tobacco control and stress management. Interventions were targeted to individuals, populations and the environment based on results obtained from the baseline surveys and needs assessment, as well as existing health services. The programme comprised different projects on women, children, adolescents, high-risk groups and cardiac patients. An underlying principle in all ten projects was to develop and maintain close contact with representatives of relevant community organizations. The teams worked intensively and closely with representatives of mass media (television, newspapers, radio, etc.), health professionals (administrators, physicians, nurses, health workers and volunteers, social workers, school staff, etc.), business and market leaders (food industry, groceries, bakeries, fast-food shops), key staff in non-governmental organizations and local political decision makers (county, municipal and provincial leaders). Details of the interventions as well as IHHP organization are described elsewhere[21].

The 'Healthy Foods for Healthy Community Project' was one of the main projects of the IHHP. Many activities were performed for improving the food habits in society, including the training of kitchen staff in factories and improving the preparation and distribution of food in restaurants, sandwich sellers, pizzerias, and offices and organizations that serve food to their own personnel. Other activities were offering suitable strategies for the production of healthy food products, such as low-salt high-fibre bread, low-fat low-sugar candy and confections and low-fat dairy products; encouraging hydrogenated oil factories to produce oil with lower saturated and *trans* fatty acids; cooperating with the commerce organization to increase coupon-based distribution of liquid oil; and improving the labelling of food products. Educational materials such as books, compact disks, educational brochures and leaflets were also published and distributed in the intervention area[22].

Measurements

Measurements were done at baseline and annually for up to four years in the intervention areas and up to three years in the reference area. Measurements in the fourth year have not yet been done in the reference area because of budget insufficiency. Usual dietary intake was assessed using a forty-nine-item FFQ adapted from the validated Countrywide Integrated Non-communicable Disease Intervention (CINDI) programme. All questionnaires were administered by trained dietitians. The FFQ consists of a list of foods commonly consumed by Iranians (Appendix). Participants were asked to report their frequency of consumption and common portion sizes of each food item during the previous year on a daily (e.g. bread), weekly (e.g. rice, meat) or monthly (e.g. fish) basis. The reported frequency for each food item was then converted to a daily intake.

Other variables such as age, sex, smoking behaviour, place of residence, socio-economic status and educational level were collected by using validated questionnaires.

Dietary diversity score

First, we divided foods into six groups and then calculated the diversity score of each group. To be counted as a 'consumer' for any of the food group categories, a respondent needed to consume at least one-half serving per day as defined by the Food Guide Pyramid quantity criteria[2]; otherwise this score was considered zero. Finally, for calculating the diversity of each food group, we considered the sum of scores of the total subgroups divided by the number of subgroups in each food group and then multiplied by 2. So the diversity score of each food group could be between 0 and 2. For calculating the DDS, the sum of the diversity scores of the six food groups (grain diversity score, dairy diversity score, fruit

diversity score, vegetable diversity score, meat diversity score and oil diversity score) was considered. Hence, the DDS ranged between 0 and 12.

Statistical methods

Statistical analysis was performed using the SPSS for Windows statistical software package version 13·0 (SPSS Inc., Chicago, IL, USA). The trend of the DDS and the diversity score for each food group were analysed by two-way ANONA separately in the three areas and at the different evaluation stages. The effect of socio-economic status, age, residency and literacy was adjusted when the means are reported. In these analyses, the *P* values for area, evaluation stage and also the interaction between area and evaluation stage are presented separately.

DDS was divided into three categories (<50% of the maximum score of DDS; between 50% and 75% of the maximum score of DDS; >75% of the maximum score of the DDS), thus DDS was categorized as a score of <6, 6–9 or >9. Besides this category, the quartiles of DDS were also determined. The χ^2 test was used to compare the prevalence of the population in different quartiles of DDS and the three categories of DDS at baseline and after intervention in all three areas.

Results

General characteristics of the study participants are shown in Table 1. There were no significant differences in mean age, sex distribution or response rate between the intervention and reference areas. Table 2 shows the results of the multivariate-adjusted mean DDS across the different evaluation stages of the intervention and different areas of

Table 1 General characteristics of the study populations participating in the annual evaluations: Isfahan Healthy Heart Programme, Iran

			Annual evaluation								
	Baseline		First		Second		Third		Fourth		*P*
No. of intervention/control subjects	6175/6339		2994/2897		2400/2393		3012/3070		3011/–		
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Age (years)											
Intervention area*	38·6	14·7	40·4	15·4	40·7	15·6	45·1	17·3	45·6	17·3	<0·01
Reference area†	39·1	15·1	40·5	15·3	40·5	15·9	45·0	17·3	–		<0·01
	%		%		%		%		%		
Females											
Intervention area	51·3		50·0		50·3		50·6		51·4		>0·05
Reference area	50·8		51·0		50·5		51·1		–		>0·05
Response rate											
Intervention area	98		99		100		100		100		–
Reference area	100		97		99		100		–		–
Place of residence (% rural)											
Intervention area	21·0		18·5		18·7		20·3		11·9		<0·01
Reference area	33·4		33·3		35·0		31·0		–		<0·05
Illiterate											
Intervention area	13·8		16·7		16·1		21·0		21·0		<0·01
Reference area	26·3		24·9		20·9		30·9		–		<0·01
Income level											
Intervention area											
Low income‡	86·6		65·7		50·3		31·0		21·1		<0·01
Moderate income§	13·0		33·8		49·1		67·7		76·8		<0·01
High income‖	0·5		0·5		0·6		1·3		2·1		<0·01
Reference area											
Low income	83·0		55·7		27·8		31·0		–		<0·01
Moderate income	16·8		44·1		71·1		67·1		–		<0·01
High income	0·1		0·3		1·1		1·8		–		<0·01
Marital status											
Intervention area											
Married	80·0		79·5		77·8		78·2		77·7		<0·01
Single	14·9		16·5		16·0		13·3		12·7		<0·01
Divorced	0·4		0·2		0·5		0·5		0·6		<0·01
Reference area											
Married	80·0		80·6		76·7		78·7		–		<0·01
Single	15·2		14·3		16·3		12·8		–		<0·01
Divorced	0·5		0·5		0·8		0·4		–		<0·01

*Najafabad and Isfahan were the intervention areas.
†Arak was the reference (control) area.
‡Low income: <1 000 000R.
§Moderate income: 1 000 000–<5 000 000R.
‖High income: >5 000 000R.

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Table 2 Multivariate-adjusted mean dietary diversity score (DDS) across the different evaluation stages of the intervention and different areas of the study: Isfahan Healthy Heart Programme, Iran

	Najafabad*		Isfahan†		Najafabad and Isfahan		Arak‡		*P*§		
	Mean¶	SD¶	Mean	SD	Mean	SD	Mean	SD	Area	Evaluation stage	Area × evaluation stage
DDS‖									0·0001	0·0001	0·0001
Baseline	1·09	0·02	1·34	0·01	1·22	0·02	1·45	0·01			
First evaluation**	1·11	0·03	1·47	0·02	1·30	0·02	1·31	0·61			
Second evaluation††	1·30	0·03	1·55	0·02	1·42	0·03	1·31	0·01			
Third evaluation‡‡	2·74	0·02	2·55	0·02	2·65	0·03	1·31	0·01			

*Najafabad was an intervention area; number of subjects in Najafabad at baseline, first evaluation, second evaluation and third evaluation was 1988, 896, 720 and 1008, respectively.
†Isfahan was an intervention area; number of subjects in Isfahan at baseline, first evaluation, second evaluation and third evaluation was 4187, 2098, 1680 and 2004, respectively.
‡Arak was the reference area; number of subjects in Arak at baseline, first evaluation, second evaluation and third evaluation was 6339, 2897, 2393 and 3071, respectively.
§*P* values from two-way ANOVA.
‖DDS is the sum of the diversity scores of six food groups (grain diversity score, dairy diversity score, fruit diversity score, vegetable diversity score, meat diversity score and oil diversity score).
¶Estimated marginal means and standard deviations adjusted for socio-economic status, age, residency and literacy (all such values).
**The first evaluation was conducted after 1 year of the study.
††The second evaluation was conducted after 2 years of the study.
‡‡The third evaluation was conducted after 3 years of the study.

the study. There was a jump in DDS between the second and third evaluation time points. After controlling for socio-economic status, there were significant increases in DDS in Najafabad and Isfahan (intervention areas) during the intervention (area main effect: $P = 0{\cdot}0001$ for all, two-way ANOVA; evaluation stage main effect: $P = 0{\cdot}0001$ for all, two-way ANOVA). There was a significant interaction between area and evaluation stage with regard to DDS ($P = 0{\cdot}0001$, two-way ANOVA). Table 3 shows multivariate-adjusted mean diversity scores of food groups across the different evaluation stages of the intervention and different areas of the study. The diversity scores of all food groups changed significantly during the different evaluation stages of the intervention. There was a very large increase in the dairy diversity score in the intervention areas between the second and third evaluation. A significant interaction between area and evaluation stage with regard to each diversity score of food groups was seen ($P = 0{\cdot}0001$, two-way ANOVA).

At baseline, all of the population in the three areas under study had a DDS of <6 (50% of the maximum score of DDS). Even after 3 years of intervention, this prevalence reduced to 98% and only 2% of the population had DDS score of 6–9 (between 50% and 75% of the maximum score of DDS). When we looked at the DDS quartiles, almost all of the population before and after the intervention was in the first and second quartiles (data not shown).

Discussion

The results of the present study show that community-based lifestyle interventions in the IHHP were successful in increasing the DDS as well as the diversity score of each food group. This increasing trend in DDS and diversity scores of food groups was significant for both area and evaluation stage, separately. While the DDS and all diversity scores of food groups were increased in the intervention areas (Najafabad and Isfahan), the DDS, diversity score of grain, diversity score of fruit and diversity score of vegetables decreased significantly in the reference area (Arak). We do not have any logical interpretation for this reduction but may be that the increasing price of food items is the reason, which did not affect the intervention area because of nutritional intervention.

Recently, researchers have shifted their focus from a nutrient-based approach to the whole dietary intake. By analysing the dietary intake of the population, the potential effect of known and unknown interactions among foods and nutrients may be taken into account. Furthermore, from a public health perspective, indices of the whole diet assessment such as the DDS may present a more precise judgement than looking at the nutrient intake per se[23]. The present study provided an opportunity to evaluate the diet by using a whole dietary assessment index before and after a lifestyle intervention. In this case, we were able to evaluate the impact of the intervention not only on nutrient consumption but also on dietary intake. Most previous nutritional interventions have focused on the effect of intervention on the intake of specific nutrients or the prevalence of chronic diseases and their risk factors[24–27]. To the best of our knowledge, the present study is the first one reporting the effect of lifestyle intervention on DDS.

There was a jump in DDS between the second and third evaluation which may be due to passing two phases of intervention and increasing the duration of nutritional intervention after two intervention phases. It seems that people got more familiar with the concepts of the intervention after the passage of more time. In particular, there was a large increase in the dairy diversity score in the intervention areas between the second and third evaluation which may be due to nutritional education

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Table 3 Multivariate-adjusted mean diversity scores of food groups across the different evaluation stages of the intervention and different areas of the study: Isfahan Healthy Heart Programme, Iran

	Najafabad*		Isfahan†		Najafabad and Isfahan		Arak‡		*P*§		
Variable	Mean‖	SD‖	Mean	SD	Mean	SD	Mean	SD	Area	Evaluation stage	Area×evaluation stage
Diversity score of grain									0·0001	0·0001	0·0001
Evaluation stage¶											
Baseline	0·98	0·02	1·25	0·02	1·11	0·02	1·56	0·01			
First evaluation**	1·05	0·04	1·20	0·03	1·13	0·03	1·41	0·02			
Second evaluation††	1·15	0·04	1·18	0·03	1·16	0·03	1·38	0·02			
Third evaluation‡‡	1·55	0·03	1·53	0·02	1·55	0·03	1·37	0·02			
Diversity score of dairy products									0·0001	0·0001	0·0001
Evaluation stage											
Baseline	0·001	0·006	0·02	0·004	0·01	0·004	0·001	0·003			
First evaluation	0·01	0·008	0·02	0·006	0·01	0·007	0·03	0·005			
Second evaluation	0·01	0·010	0·02	0·006	0·01	0·007	0·01	0·005			
Third evaluation	0·78	0·007	0·40	0·005	0·60	0·007	0·08	0·004			
Diversity score of fruits									0·0001	0·0001	0·0001
Evaluation stage											
Baseline	0·36	0·007	0·38	0·005	0·37	0·006	0·43	0·003			
First evaluation	0·36	0·010	0·42	0·007	0·39	0·009	0·39	0·005			
Second evaluation	0·43	0·010	0·38	0·008	0·41	0·009	0·40	0·005			
Third evaluation	0·41	0·009	0·43	0·006	0·43	0·008	0·38	0·004			
Diversity score of vegetables									0·0001	0·0001	0·0001
Evaluation stage											
Baseline	0·27	0·006	0·27	0·005	0·27	0·005	0·40	0·004			
First evaluation	0·25	0·010	0·29	0·007	0·27	0·008	0·34	0·005			
Second evaluation	0·26	0·010	0·26	0·007	0·26	0·008	0·26	0·006			
Third evaluation	0·30	0·008	0·24	0·006	0·27	0·007	0·29	0·005			
Diversity score of meat									0·0001	0·0001	0·0001
Evaluation stage											
Baseline	0·10	0·003	0·10	0·002	0·10	0·002	0·14	0·002			
First evaluation	0·11	0·005	0·12	0·004	0·11	0·005	0·16	0·003			
Second evaluation	0·12	0·006	0·12	0·006	0·12	0·006	0·14	0·003			
Third evaluation	0·13	0·004	0·17	0·006	0·16	0·006	0·17	0·003			
Diversity score of oil									0·0001	0·0001	0·0001
Evaluation stage											
Baseline	0·16	0·010	0·32	0·008	0·24	0·008	0·16	0·006			
First evaluation	0·17	0·010	0·40	0·010	0·27	0·010	0·12	0·010			
Second evaluation	0·24	0·010	0·41	0·010	0·32	0·010	0·21	0·010			
Third evaluation	0·43	0·010	0·54	0·010	0·48	0·010	0·24	0·008			

*Najafabad was an intervention area; number of subjects in Najafabad at baseline, first evaluation, second evaluation and third evaluation was 1988, 896, 720 and 1008, respectively.
†Isfahan was an intervention area; number of subjects in Isfahan at baseline, first evaluation, second evaluation and third evaluation was 4187, 2098, 1680 and 2004, respectively.
‡Arak was the reference area; number of subjects in Arak at baseline, first evaluation, second evaluation and third evaluation was 6339, 2897, 2393 and 3071, respectively.
§*P* values from two-way ANOVA.
‖Estimated marginal means and standard deviations adjusted for socio-economic status, age, residency and literacy (all such values).
¶Evaluation stage is the time of evaluation.
**The first evaluation was conducted after 1 year of the study.
††The second evaluation was conducted after 2 years of the study.
‡‡The third evaluation was conducted after 3 years of the study.

of the public through television and industry producing more kinds of dairy products, especially the low-fat versions.

Previous studies showed that dietary variety can be a good indicator of nutrient adequacy[2–7]. Thus the trend in the present intervention, of increasing DDS after five years of nutritional intervention at community level, could be an indicator of increasing dietary adequacy in the intervention areas.

Two reports regarding the diversity score of food groups and special nutrient adequacy also showed how different food group varieties contribute to the probability of nutrient adequacy among a representative group of Tehranian adults[5,9]. It has been mentioned that variety of whole grains is associated with protein and vitamin B_2 intakes and the variety of whole grains may be used as a simple method for evaluating the adequacy of the mentioned nutrients[5,9]. Therefore, the increasing diversity score of grains during the intervention period in the present study may be an indicator of increasing protein and vitamin B_2 intakes among the people in the intervention areas. This might be due to increasing the consumption of whole grains, which was one of the aims in the IHHP nutrition project. Regarding the association between DDS and chronic diseases, previous studies have shown an inverse association between DDS and metabolic risks which may be attributed to the higher consumption of healthier food groups associated with higher DDS. Subjects who had higher DDS consumed more fibre, fruit, vegetables and vegetable oil[13–18]. Therefore, increased DDS after the lifestyle intervention in the present study indicates that this intervention might result in a lower prevalence of risk factors for chronic diseases. However, chronic diseases such as the metabolic syndrome and CVD are heterogeneous and besides dietary pattern, other factors such as hereditary factors may need to be considered. Additionally, most of the risk factors are interrelated and this could confound the relationship between DDS and metabolic risk factors.

Our findings need to be interpreted while considering some limitations. We used an FFQ to assess dietary intakes. So, misclassification is a major concern in our study, as it is in all epidemiological studies. When we categorized subjects according to DDS quartiles, all of the population was in the first and second quartiles. This could, to some extent, be explained by an inadequate number of food items in the FFQ to cover all the possible food items in each food group. In the present study, we adjusted for the effect of socio-economic status in reporting the mean values for DDS and diversity scores of food groups, which might be a strength point.

In conclusion, the lifestyle intervention in the IHHP, reported in the present study, was successful in improving DDS which might be related to an increase of diet quality of the population that in turn might decrease the risks of chronic diseases.

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Appendix

Foods and food groups in the FFQ

1.	Hydrogenated oil	26.	Chocolate
2.	Liquid oil	27.	Boiled potato
3.	Olive oil	28.	Fried potato
4.	Animal oil	29.	Fresh fruit
5.	Margarine	30.	Fresh juice
6.	Butter	31.	Dried fruit
7.	Tallow	32.	Fresh vegetables
8.	Cream	33.	Cooked vegetables
9.	Cheese	34.	Dried vegetables
10.	High-fat milk	35.	Pickled vegetables
11.	Low-fat milk	36.	Salted vegetables
12.	High-fat yoghurt	37.	Walnuts
13.	Low-fat yoghurt	38.	Pistachios, almonds
14.	Liver, kidney, heart	39.	Seeds
15.	Kalepache (a traditional Iranian food consisting of organ meats)	40.	Commercial fruit
16.	Sausages	41.	Eggs
17.	Red meat	42.	Pulses
18.	Poultry	43.	Soya
19.	Fish	44.	Canned foods
20.	Bread	45.	Fried meals
21.	Rice	46.	Hamburger
22.	Sweet cola	47.	Pizza
23.	Diet cola	48.	Mayonnaise
24.	Jam	49.	Garlic
25.	Cake, sweets, biscuits		