

Slowing the diabetes epidemic in the World Health Organization South-East Asia Region: the role of diet and physical activity

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ABSTRACT

The nutrition transition occurring in the World Health Organization South-East Asia Region, as a result of rapid urbanization and economic development, has perhaps made this region one of the epicentres of the diabetes epidemic. This review attempts to evaluate the role of diet and physical inactivity in the South-East Asia Region in promoting this epidemic and points to strategies to slow it down by lifestyle modification. The emerging new food-production technologies and supermarkets have made energy-dense foods more easily available. This includes refined carbohydrate foods like those with added sugars, and refined grains and unhealthy fats. In addition, increased availability of modern technology and motorized transport has led to decreased physical activity. South Asian diets tend to be based on high-carbohydrate foods, with a predominance of refined grains. All of these accentuate the risk of diabetes in people of this region, who already have a unique "south Asian phenotype". However, there is increasing evidence that altering diet by replacing refined cereals like white rice with whole grains (e.g. brown rice) and increasing physical activity can help to prevent diabetes in high-risk individuals. An urgent, concerted effort is now needed to improve diet quality and encourage physical activity, by introducing changes in policies related to food and built environments, and improving health systems to tackle noncommunicable diseases like diabetes.

Key words: diabetes, diet, epidemic, physical activity, south Asians

BACKGROUND

One of the visions of the World Health Organization (WHO) is to reduce the avoidable burden due to noncommunicable diseases (NCDs),¹ with a specific target to halt the rise in the rates of obesity and diabetes globally. Almost two thirds of the world's population with diabetes currently resides in low- and middle-income regions. South Asia is one of the epicentres of the diabetes epidemic and diabetes rates vary from 3.3% in Nepal to 10% in India.²

The so-called "south Asian" or "Asian-Indian" phenotype makes this ethnic group more susceptible to both type 2 diabetes and premature coronary artery disease, compared to white Caucasians.^{3,4} This phenotype is characterized by increased insulin resistance; high diabetes rates, despite lower generalized obesity; central adiposity; and dyslipidaemia, with raised serum triglycerides and low levels of high-density lipoprotein (HDL) cholesterol. While genetic factors might

contribute a little to the south Asian phenotype, the current diabetes epidemic is fuelled predominantly by lifestyle, which is related to environmental factors. The two most important of these are unhealthy diet and physical inactivity. This article will therefore focus primarily on these two factors and examine how they are linked to the diabetes epidemic. It will also look at evidence and suggest how modifying these factors may help to prevent type 2 diabetes, or at least slow the rise in prevalence in this population.

Rapid globalization and urbanization have led to a rapid nutrition transition. This has affected food cultures and brought about drastic changes in the diets and physical activity of populations. This is very much pronounced in countries of the WHO South-East Asia Region, which are experiencing high increases in the prevalence of diabetes. Some of the changes in diet include increased consumption of packaged and processed foods – mainly as refined carbohydrates like white rice, added sugars, edible refined oils and fats, and decreased consumption

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of whole grains, nuts, fruits and vegetables.⁵⁻⁹ Today, people in low- and middle-income countries opt for energy-dense foods, as they are cheaper and more easily available than the alternatives.¹⁰

Physical inactivity is an independent risk factor for type 2 diabetes and current evidence suggests that adequate levels of physical activity may reduce the risk of type 2 diabetes by 27%.¹¹ Modern technical gadgets and use of motorized transport have reduced physical activity among children and young adults.¹² In 2013, Ranasinghe et al. reported that the overall prevalence of physical inactivity among the population of India was 19–88%, followed by Pakistan (60%) and Sri Lanka (11–32%).¹³ The recent Indian Council of Medical Research–India Diabetes (ICMR–INDIAB) study also reported that levels of physical inactivity were high (~55%) among Asian-Indians.⁸ This article will first deal with diet and then discuss the role of physical inactivity in the context of NCDs like type 2 diabetes in south Asians, with a focus on India, where a lot of recent data have emerged.

DIETARY PROFILE OF SOUTH ASIANS IN RELATION TO THE DIABETES EPIDEMIC

South Asian diets are high in carbohydrates.¹⁴ These carbohydrates are mainly derived from refined cereals like white rice and refined flour. There is also a high intake of fat, especially saturated fatty acid (SFA) and polyunsaturated fatty acid (PUFA), mainly in the forms of *n*-6 (omega-6) PUFA, and trans fatty acid (TFA), and a low intake of monounsaturated fatty acid (MUFA) and *n*-3 PUFA (resulting in a higher ratio of *n*-6/*n*-3). The diet is also low in dietary fibre and several micronutrients (e.g. magnesium, calcium, and vitamin D),^{8,15-18} all of which may contribute to the increased risk for NCDs like type 2 diabetes. This shift from ancestors' diets (high in animal protein, adequate in fibre, relatively low in carbohydrates and limited animal fat¹⁹) has resulted primarily from the changes in demography and socioeconomic status and "modernization". Urbanization and rising income levels have also led to an increase in consumption of milled and polished grains like rice and wheat, rather than unpolished brown rice, corn and millet.²⁰ Further, urbanization has led to increased employment for women. This has promoted a shift from home-cooked traditional foods to precooked convenience foods, as the mother has less time to cook.²¹

DIETARY CARBOHYDRATES (QUANTITY AND QUALITY) AND DIABETES RISK

Carbohydrate-rich cereals account for 60% of daily caloric intake among Asian nations, which is one of the highest levels in the world.²⁰ Owing to rapid industrialization and to the green revolution, there has been a large increase in the consumption of refined grains (polished rice, white flour, semolina) in last few decades.^{22,23} Of the various refined grains, white rice in particular has a high glycaemic index (GI) and accounts for almost 50% of the total calories in the diet of the south Indian urban population,⁵ and 73% of the daily calorie intake of the

rural Indian population.²⁴ Data from Sri Lanka showed that white rice accounted for about 73% of caloric intake,²⁵ while in Bangladesh, rice and other cereals contributed to 80% of the total calories.²⁶

In 2009, Mohan et al. showed that dietary carbohydrates, and specifically the dietary glycaemic load, were associated with risk for type 2 diabetes among urban south Indians.²⁷ Refining of grains results in loss of fibre, vitamins, minerals and phytonutrients, which predispose to diabetes and cardiovascular disease. Another epidemiological study carried out in southern India showed that consumption of highly refined grain was significantly associated with insulin resistance, higher serum triglycerides and increased waist circumference.⁵

As south Asians traditionally consume a high-carbohydrate diet, it is difficult to alter the total carbohydrate content of their diets.^{27,28} Thus, it is important to encourage the consumption of low-GI and high-fibre foods in this population, in order to reduce the dietary glycaemic load. Making a simple change in diet, such as substituting brown rice as an alternative to polished white rice, may help to reduce the burden of type 2 diabetes in India and south Asia.²⁷ However, there are several challenges faced in promoting brown rice as a staple, as shown by a focus group study and a consumer perception study, where brown rice was associated with a poorer appeal and texture and increased cooking time.^{29,30} This underscored the need to find a healthier white-rice opportunity.

SUGAR AND SUGAR-SWEETENED BEVERAGES

In south Asia, the energy obtained from sugar and sweeteners has considerably increased in recent times. In Nepal, it increased from 4 g/capita/day in 1970 to 57 g/capita/day in 2010.³¹ A report in 2009 found that sugar intake among urban south Indians was mainly in the form of added sugar in hot beverages (tea and coffee), and contributed about 3.6% of the total glycaemic load compared to refined cereal (white rice), which provided 66% of the glycaemic load.⁷ However, recent data suggest an increase in intake of sugar from sugar-sweetened beverages among Indians. Further, the intake of "total" sugar (traditional sugar + sugars from sugar-sweetened beverages) among Indians (25.0 kg/capita in 2011) exceeds the average global annual per capita consumption of 23.7 kg.³²⁻³⁴

DIETARY FATS (QUANTITY AND QUALITY) AND DIABETES RISK: EVIDENCE

Next to refined grains, visible fats and oils are the main contributor to daily calorie intake in Indians. However, the total intake of dietary fat among Indian urban adults (24% total calories) and rural Indians (13% total calories) appears to be within the recommended intake of 30% of total calories.^{16,24,35} Visible fats and oils contribute almost half of the total calories derived from fat in Indian diets.³⁶ There has been a sharp increase in the intake of dietary fat in the last three decades, from 29 g/capita/day in 1970 to 45 g/capita/day in 1999 in the south Asian population.³⁷

More worrying is the fact that the quality of dietary fat in the south Asian population comprises a low intake of MUFA and *n*-3 PUFA and high intake of fats such as SFA, and TFA (mostly related to the widespread use of vanaspati, a hydrogenated vegetable oil), showing an imbalance and association with increased risk for NCDs especially type 2 diabetes.^{38,39} Several studies have reported that consumption of SFA or TFA contributes to an increase risk of NCDs like type 2 diabetes.^{40,41} The global mean intake of SFA ranged from 2.9% to 20.9% of total calories, with the lowest percentage reported in Bangladesh followed by India (7–8% of total calories).⁴²

Fat-rich animal foods are the primary source of SFA in diets. The total meat consumption has increased significantly in all south Asian countries in the past two decades. Countries like India have doubled their intake of meat and poultry since 2000, but the actual quantity is still low (50 g/capita/day),¹⁶ compared with diets in, for example, the United States of America (USA; 128 g/capita/day).⁴³ Meat consumption in Pakistan has increased by 130%. Sri Lanka has also gradually increased the trend in meat consumption from 1992 to 2007.²⁵

It is good news that there has been a reduction in the prevalence of coronary heart disease with the replacement of energy from SFA or TFA with PUFA but this is restricted to high-income countries.⁴³ Studies have shown that south Asians consume an excess of *n*-6 PUFA. This has primarily occurred because traditional oils such as groundnut (a good source of MUFA) and sesame were replaced with oils that are high in *n*-6 PUFA, like sunflower and safflower oils, leading to an imbalance in the *n*-6/*n*-3 ratio. Studies have shown that this imbalance in *n*-6/*n*-3 ratio, owing to consumption of these high-*n*-6 PUFA oils, is associated with an increased risk for metabolic syndrome.³⁶ Similar findings were reported by Misra et al. in 2009.¹⁷

TFAs are even more deleterious to health than SFAs, owing to the hydrogenation process, which converts liquid oils to solid fats like vanaspati and margarine. The consumption of vanaspati accounts for 50% of TFA use and it is predominantly consumed in south Asian countries like India and Pakistan.^{44,45}

LOW CONSUMPTION OF FRUIT AND VEGETABLES

There is evidence to suggest that consumption of fruit and vegetables (≥ 5 servings or 400 g/day) is associated with a reduction in the risk of chronic disease like type 2 diabetes and coronary heart disease.^{17,46,47} However, the intake of fruit and vegetables is far below the recommended levels in almost all south Asian countries. The average per capita consumption of fruit and vegetables in India is around 3 servings/day,¹⁵ while it is 2.2 servings/day in Sri Lanka,⁴⁷ 1.8 servings/day in Nepal,⁴⁸ and 1 serving/day in Maldives.⁴⁹ A study in south Indians showed an inverse association between intake of fruit and vegetables and blood pressure, waist circumference, total cholesterol and low-density lipoprotein (LDL) cholesterol concentrations.⁶ Another study showed that total dietary fibre intake was inversely associated with total cholesterol and LDL cholesterol levels in people with diabetes.⁵⁰

DIETARY STEPS FOR PREVENTING OR SLOWING THE DIABETES EPIDEMIC IN SOUTH ASIA

A "healthy" diet, in terms of diabetes and prevention of cardiovascular disease, should include more whole grains, legumes, nuts, fish, fruit and vegetables and less refined carbohydrate, simple sugar and processed meat, and food that is high in sodium and TFA should be avoided as much as possible.⁵¹ Tables 1 and 2 summarize the nutrient recommendations for the prevention of NCDs such as diabetes and suggest healthier alternative dietary strategies. The two most important recommendations for south Asians would be to use whole-grain cereals and fats that are higher in *n*-3 fatty acid content. These two recommendations are discussed in greater detail in the subsequent sections.

Improving the quality of dietary carbohydrate foods

Whole grains consist of bran and germ constituents that are rich in dietary fibre, iron, magnesium, selenium, β -oryzanol and B vitamins. The bran protects the starchy endosperm from rapid digestion, thereby reducing the GI of the food. Prospective cohort studies in populations from high-income countries have shown that a high intake of whole grains lowers the risk of developing obesity, cardiovascular disease and type 2 diabetes.^{52–54} An intervention trial carried out on overweight Asian-Indians, using continuous glucose monitoring, showed a 20% reduction in their 24-h glycaemic responses and a 50% reduction in their fasting insulin levels when white rice was substituted with brown rice.⁵⁴ Unfortunately, the availability of brown rice and millets is still a challenge in most of south Asia, as most grains available in the market have undergone various degrees of polishing to improve their shelf-life and cooking quality.⁵⁵

However, as mentioned earlier, brown rice showed poor sensory attributes and acceptability among the south Asian population, which has become accustomed to white rice or other refined flour like wheat.^{29,30} Hence, the authors feel that the way forward would be to introduce health foods with lower glycaemic response, which would also have better consumer acceptability. In an effort to improve the quality of white rice, research work was carried out with agricultural scientists to develop a new hybrid rice variety. This helped to retain good amounts of non-digestible carbohydrate content even after polishing the rice and showed five times higher dietary fibre content compared to regular white rice, so it was introduced in the Indian market. This high-fibre white rice was shown to have a significantly lower GI (GI = 61.3 which is in the category of medium GI) compared to regular white rice (GI = 79.2, high-GI category).⁵⁶ However, although this work is promising, it is still only preliminary and randomized controlled trials need to be done to establish the usefulness of this rice.

Table 1: Recommended dietary guidelines for healthy living and prevention of noncommunicable diseases

Food components	Dietary guidelines for Asian-Indians 2011 ⁵⁵	WHO 2003 ^{54,66}
Energy		
Sedentary activity level	Normal weight: 30 kcal/kg of ideal body weight/day	
	Overweight: 20–25 kcal/kg of ideal body weight/day	
Moderate activity level	Normal weight: 35 kcal/kg of ideal body weight/day	
	Overweight: 30 kcal/kg of ideal body weight/day	
Heavy activity level	Normal weight: 40 kcal/kg of ideal body weight/day	
	Overweight: 35 kcal/kg of ideal body weight/day	
Carbohydrates ^b	50–60% of total energy	55–75% of total energy
Dietary fibre	25–40 g/day	20 g/day
Protein	1 g/kg body weight/day	10–15% of total energy
Fats		
Total	30% of total energy	15–30% of total energy
SFA	<10% of total energy	<10% of total energy
	<7% of total energy (if LDL >100 mg/dL)	<7% of total energy (for high-risk groups)
<i>n</i> -6 PUFA	5–8% of total energy	5–8% of total energy
<i>n</i> -3 PUFA	1–2% of total energy	1–2% of total energy
<i>n</i> -6/ <i>n</i> -3 ratio	5–10	—
MUFA	10–15% of total energy	By difference
TFA	<1% of total energy	<1% of total energy
Dietary cholesterol	200–300 mg/day	<300 mg/day
Fruit and vegetables	>400 g per day	>400 g per day
Salt	<5 g of added salt per day; prefer iodized salt in the diet	<5 g of added salt per day
Free sugars ^c	<10% of total energy	<10% of total energy

GI: glycaemic index; LDL: low-density lipoprotein; MUFA: monounsaturated fatty acid; PUFA: polyunsaturated fatty acid; SFA: saturated fatty acid; TFA: trans fatty acid; WHO: World Health Organization.

^aWHO 2003 recommendations are followed by Bangladesh, Sri Lanka and Pakistan.

^bInclude complex carbohydrates mainly whole grains, millets, legumes and pulses, fruit and vegetables and low-GI foods.

^cMost of the free sugars are sugars added in food preparation and sweetened beverages and natural free sugars are present in honey, syrups, fruit juices and fruit juice concentrates.

Improving the quality of dietary fat sources

The use of MUFAs in the diet has been shown to reduce the risk associated with type 2 diabetes.³⁸ However, MUFA intake is low in India, even compared to other south Asian countries.⁵⁷ Studies have shown that just one ounce of nuts a day, adjusted with the carbohydrate intake, can provide cardiometabolic benefits and also improve satiety.⁵⁸ It is also possible that use of oils that are rich in MUFA and higher in *n*-3 fatty acid may help to prevent diabetes by reducing insulin resistance.⁵⁹

THE ROLE OF PHYSICAL INACTIVITY IN THE DIABETES EPIDEMIC

Physical inactivity has been shown to be an important risk factor for most chronic diseases, including type 2 diabetes, and seems to increase the risk of type 2 diabetes independently of diet. A sedentary lifestyle over several years has been shown to be associated with increased risk for type 2 diabetes, cardiovascular disease and premature mortality.^{60,61}

Table 2: Dietary strategies for a healthy dietary pattern to slow the epidemic of diabetes

South Asian food habits leading to increased risk	Beneficial replacements
↑ Refined grains, starches, sugars	↑ Whole grains, millets
↑ High-GI foods (simple and easily digestible carbohydrates)	↑ Low-GI foods (complex carbohydrates rich in dietary fibre)
↑ Red meats	↑ Legumes and pulses, fatty fish (<i>n</i> -3 PUFA)
↑ Industrial trans fats/ready-to-eat processed foods	↑ Fruit and vegetables
↑ Saturated fats, ghee	↑ Low-fat dairy products; combination of vegetable oils (with appropriate <i>n</i> -6/ <i>n</i> -3 ratio and rich in MUFA)
↓ MUFA-rich foods	↑ Nuts and oilseeds and vegetable oils like mustard and canola
↑ Added-salt and added-sodium foods	↓ Added salt and salty products like pickles, chips etc.
↑ Sugar-sweetened beverages (e.g. fruit juices)	↑ Whole fruits

GI: glycaemic index; MUFA: monounsaturated fatty acid; PUFA: polyunsaturated fatty acid; ↑: increase; ↓: decrease.

According to the American Diabetes Association (ADA), “physical activity” is defined as bodily movement produced by the contraction of skeletal muscle that requires energy expenditure in excess of resting energy expenditure, while “exercise” is defined as a subset of physical activity that is planned and structured, and consists of repetitive bodily movement performed to improve or maintain one or more components of physical fitness.⁶² There is mounting epidemiological evidence that, in addition to reduced physical activity, “sedentary behaviour”, defined as engaging in activities at the resting level of energy expenditure, which includes sleeping, sitting, lying down, computer time and viewing television, also plays an important role in the etiology of type 2 diabetes.⁶³⁻⁶⁵

According to the American College of Sports Medicine (ACSM), individuals with type 2 diabetes generally have a lower level of fitness (VO_{2max}) than those without diabetes. Therefore, exercise intensity should be at a comfortable level in the initial periods of training and should progress cautiously as tolerance for activity improves. Resistance training has the potential to improve muscle strength and endurance, enhance flexibility and body composition, decrease risk factors for cardiovascular disease, and result in improved glucose tolerance and insulin sensitivity.⁶⁶ In order to prevent type 2 diabetes in high-risk individuals (e.g. those with impaired glucose tolerance), the ADA and ACSM recommend at least 150 min/week (2.5 h/week) of moderate to vigorous physical activity (see Table 3).^{62,66-68}

Table 3: Recommended physical activity for individuals with type 2 diabetes

Organization	Type of physical activity	Frequency
American College of Sports Medicine (ACSM), 2000 ⁶⁶	Moderate to vigorous aerobic training	At least 3 nonconsecutive days/week
	Moderate to vigorous resistance training	At least 2 days/week
Canadian Diabetes Association (CDA), 2003 ⁶⁷	Moderate to vigorous aerobic training	At least 3 nonconsecutive days/week
	Moderate to vigorous resistance training	3 days/week
American Diabetes Association (ADA), 2004 ⁶²	Moderate to vigorous aerobic activity	150 min/week spread out over at least 3 days/week
	Moderate to vigorous resistance training	2-3 days/week
ADA and ACSM, 2010 ⁶⁸	Moderate to vigorous aerobic activity	150 min/week spread out over at least 3 days/week with no more than 2 consecutive days between bouts of aerobic activity
	Moderate to vigorous resistance training	2-3 days/week
	For additional health benefits:	
	<ul style="list-style-type: none"> • Combined aerobic and resistance training • Encouraged to increase total daily unstructured physical activity • Flexibility training may be included but should not be undertaken in place of other recommended types of physical activity 	

PATTERNS OF PHYSICAL ACTIVITY IN SOUTH ASIANS

Wide variations in the prevalence of physical activity have been reported in countries of south Asia, namely Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka.¹³ In 2004, Fischbacher et al. reported that the rates of physical activity were 50–75% less among South Asians compared to the general population living in the United Kingdom of Great Britain and Northern Ireland.⁶⁹

Table 4 shows the patterns of physical activity in countries of south Asia.^{8,70–86} The World Health Survey, a large cross-sectional study, was conducted by WHO in 51 countries in 2002 and 2003.⁷⁴ This included countries that had a large proportion of the world's population, with a wide geographical distribution across WHO regions, including several countries in the South-East Asia Region. Physical activity was assessed using the International Physical Activity Questionnaire (IPAQ). The prevalence of physical inactivity for men in south Asian countries, including Bangladesh, India, Nepal, Pakistan and Sri Lanka, ranged from 6.5% to 12.8%, while for women it ranged from 9.7% to 27.3%.⁷⁴

Three studies on physical activity have been reported from Sri Lanka: the WHO STEPS (STEPwise approach to Surveillance) survey,⁷² one in the western province of Sri Lanka,⁷⁵ and finally a nationally representative study.⁸³ The prevalence of inactivity was reported to be 25% in the WHO STEPS survey, 31.8% in the western province and 11% in the national sample. Men were more inactive than women and inactivity was reported to be 35.2% in urban adults and 27.6% in rural adults in the study from the western province of Sri Lanka.⁷⁵ A study on physical activity conducted in Pakistan by Khuwaja and Kadir in 2010 reported a high prevalence of inactivity (60.1%).⁷⁸ The WHO STEPS survey conducted in Bhutan in 2007, Maldives in 2011 and Nepal in 2013 reported inactivity levels of 58.6%, 45.9% and 3.5% in these populations, respectively.^{73,82,84}

Several studies have been done in India, and the prevalence of inactivity ranged widely, from 9.7% to 54.4%, probably reflecting the methodology used or the sample surveyed.^{8,74} The WHO STEPS survey done on 1359 males and 1469 females in a rural area in Faridabad district of Haryana reported a very high rate of physical inactivity.⁷⁶ Another study conducted by Sullivan et al. in 2011, which assessed the physical activity levels in migrant groups in India ($n = 6447$), showed that physical activity was highest in rural men, followed by migrants and then urban men.⁸⁰ Levels of sedentary behaviour and television viewing were lower in rural residents, whereas these were similar among migrant and urban residents.⁸¹ In 2014, Anjana et al. assessed the pattern of physical activity in a community-based national survey, the ICMR–INDIAB study, in four areas of India (Tamil Nadu, Maharashtra, Jharkhand and Chandigarh, representing the south, west, east and north of India respectively), using the Global Physical Activity Questionnaire (GPAQ).⁸ Of the 14 227 individuals studied, 54.4% were inactive. Subjects were more inactive in urban compared to rural areas (65.0% versus 50.0%).

Thus, epidemiological studies from south Asian countries show that a large percentage of people in this region are inactive, with very few engaging in recreational physical activity; the explosive increase in the prevalence of type 2 diabetes in these countries may be attributed to this high percentage of inactivity. A systematic review done by Horne and Tierney in 2012, on barriers to exercise and physical activity among older adults in south Asia, concluded that lack of understanding about benefits, a communication gap with health-care professionals, cultural beliefs, and lack of culturally sensitive facilities are some of the barriers for physical activity.⁸⁷ In a recent study conducted by Anjana and colleagues in 2015,⁸⁸ for the Diabetes Community Lifestyle Improvement Program (D-CLIP), the most frequent barriers to exercise perceived by men were “few places to exercise” and “tires me”, followed by “takes too much of my time” and “places to exercise are far away”. The reasons most frequently cited by women were “takes too much of my time”, followed by “few places to exercise” and “takes time away from my family”. Thus, it is clear that these barriers to physical activity must be overcome if levels of physical activity in the society are to be improved.

EVIDENCE FOR THE ROLE OF PHYSICAL ACTIVITY IN REDUCING THE RISK OF TYPE 2 DIABETES

There is a large body of evidence supporting the hypothesis that physical activity may be useful in preventing or delaying the onset of type 2 diabetes. Studies have shown that physically active individuals have a 30–50% lower risk of developing type 2 diabetes compared to sedentary individuals.⁸⁹ Bassuk and Manson concluded that physical activity may prevent or delay the onset of type 2 diabetes and its cardiovascular sequelae, through beneficial effects on body weight, insulin sensitivity, glycaemic control, blood pressure, lipid profile, fibrinolysis, endothelial function and inflammatory defence systems.⁹⁰

Randomized controlled trials from populations in high-income countries and in Asia have demonstrated that supervised exercise programmes, with or without dietary modifications, significantly reduced the incidence of diabetes in high-risk groups, by up to 67%.^{91–97} In the non-randomized Malmö trial, 260 men with impaired glucose tolerance underwent a 6–12-month supervised exercise programme and diet counselling.⁹⁶ After 6 years of follow-up, the cumulative incidence of diabetes in the intervention group was found to be 11%, as compared to 21% in the control group.

The first of the randomized trials of lifestyle intervention for prevention of diabetes was the Da Qing trial conducted in China (1986–1992). In this study, after 6 years of active intervention, the risk for diabetes was reduced by 46% in an exercise-only group compared with a control group.⁹¹ In both the Finnish Diabetes Prevention Study (DPS)⁹² and the United States (US) Diabetes Prevention Program (DPP),⁹³ lifestyle intervention, which included both diet and exercise, significantly reduced the incidence of diabetes by 58%. The DPP, though not specifically

Table 4. Levels of physical activity in South Asian countries

Author, year	Country	Sample size	Assessment tool	Prevalence
Vazet et al., 2004, 2006 ^{70,71}	India	782	Physical Activity Level (PAL)	Men: PAL 1.22–1.64; women: PAL 1.30–1.56
World Health Organization, 2006 ⁷²	Sri Lanka	11 680	WHO STEPS Global Physical Activity Questionnaire (GPAQ)	Prevalence of inactivity 25.0% (men 17.9%, women 31.9%)
World Health Organization, 2007 ⁷³	Bhutan	2484	WHO STEPS Global Physical Activity Questionnaire (GPAQ)	Prevalence of inactivity 58.6% (men 49.8%, women 69.6%)
Guthold et al., 2008 ⁷⁴	Bangladesh	5166	International Physical Activity Questionnaire (IPAQ)	Prevalence of inactivity: men 6.5%, women 25.2%
	India	7945		Prevalence of inactivity: men 9.3%, women 15.2%
	Nepal	7945		Prevalence of inactivity: men 6.7%, women 9.7%
	Pakistan	5610		Prevalence of inactivity: men 12.8%, women 27.3%
	Sri Lanka	5464		Prevalence of inactivity: men 7.3%, women 13.8%
Arambepola et al., 2008 ⁷⁵	Sri Lanka	1400	International Physical Activity Questionnaire (IPAQ)	Prevalence of inactivity 31.8% (men 38.5%, women 24.7%)
Krishnan et al., 2008 ⁷⁶	India	2828	WHO STEPS Global Physical Activity Questionnaire (GPAQ)	Prevalence of inactivity 34.2% (men 22.2%, women 45.5%)
Haldiya et al., 2010 ⁷⁷	India	1825	Interviewer-administered questionnaire	Prevalence of inactivity 40.0% (men 40.8%, women 39.7%)
Khuwaja and Kadir, 2010 ⁷⁸	Pakistan	534	International Physical Activity Questionnaire (IPAQ)	Prevalence of inactivity 60.1%; women were significantly more inactive than men (OR: 2.1, $P < 0.001$)
World Health Organization, 2010 ⁷⁹	Bangladesh	9275	WHO STEPS Global Physical Activity Questionnaire (GPAQ)	Prevalence of inactivity 27.0% (men 10.5%, women 41.3%)
Sullivan et al., 2011 ⁸⁰	India	6447	Physical activity level (PAL)	Prevalence of extreme inactivity 9.7% (men 7.4%, women 12.9%)
Mittal et al., 2011 ⁸¹	India	520	Interviewer-administered questionnaire	Prevalence of inactivity 29.4% (men 12.7%, women 46.1%)
World Health Organization, 2011 ⁸²	Maldives	1780	WHO STEPS Global Physical Activity Questionnaire (GPAQ)	Prevalence of inactivity 45.9% (men 39.1%, women 52.4%)
Katulanda et al., 2013 ⁸³	Sri Lanka	4485	International Physical Activity Questionnaire (IPAQ) – short version	Prevalence of inactivity 11.0% (men 14.6%, women 8.7%)
World Health Organization, 2013 ⁸⁴	Nepal	4143	WHO STEPS Global Physical Activity Questionnaire (GPAQ)	Prevalence of inactivity 3.5% (men 4.5%, women 2.4%)
Vaidya and Krettek, 2014 ⁸⁵	Nepal	640	WHO STEPS Global Physical Activity Questionnaire (GPAQ)	Prevalence of low physical activity 43.3% (men 38.3%, women 45.1%)
Anjana et al., 2014 ⁸	India	14 227	WHO STEPS Global Physical Activity Questionnaire (GPAQ)	Prevalence of inactivity 54.4% (men 41.7%, women 58.3%)
Zaman et al., 2015 ⁸⁶	Bangladesh	4073	WHO STEPS Global Physical Activity Questionnaire (GPAQ)	Prevalence of inactivity 38.6% (men 34.2%, women 42.5%)

OR: odds ratio; STEPS: World Health Organization STEPwise approach to Surveillance; WHO: World Health Organization.

aimed at Asians, had a small Asian subpopulation, and reported that Asians had a greater risk reduction for diabetes (70%) with lifestyle intervention (diet and physical activity) as compared to the white population (51%).⁹³ In a Japanese trial conducted in 2005 involving 458 men with impaired glucose tolerance, intensive lifestyle modification reduced the risk of diabetes by 67%.⁹⁴ A follow-up of the Finnish DPS in 2006 showed a 43% reduction in diabetes risk over a median of 7 years after discontinuation of active counselling.⁹⁷

In India, few trials have been conducted to assess the benefit of physical activity in type 2 diabetes. The Indian Diabetes Prevention Programme (IDPP) reported that, after 3 years of follow-up, the relative risk reduction for diabetes was 28.5% with lifestyle management, 26.4% with metformin, and 28.2% with the combined interventions, compared with the control group.⁹⁵ The same group conducted the IDPP-3, which was a randomized clinical trial that studied 10 sites to assess whether mobile phone messaging that encouraged lifestyle changes could reduce incident type 2 diabetes in Indian men with impaired glucose tolerance.⁹⁸ A total of 537 participants were randomly assigned to a mobile phone messaging intervention ($n = 271$) with frequent SMS text messages, or standard care ($n = 266$, control group receiving standard lifestyle advice at baseline). The cumulative incidence of diabetes was significantly lower in those who received mobile phone messages (18%) than in controls (27%).

D-CLIP, a randomized controlled trial of diabetes prevention in adults with prediabetes (impaired glucose tolerance or impaired fasting glucose or both) compared standard care to a culturally tailored lifestyle education curriculum based on the US DPP, plus stepwise addition of metformin when needed.⁹⁹ During 3 years of follow-up, 34.9% in the control group and 25.7% in the intervention group developed diabetes; the relative reduction in diabetes incidence was 32%.¹⁰⁰

Together, these trials demonstrate that modification of diet and physical activity is highly effective in preventing type 2 diabetes in different ethnic and racial groups. However, there is now emerging data on the long-term benefits of such interventions. The median 7-year follow-up of the DPS showed that not only was the marked reduction in the risk of type 2 diabetes in the intervention group sustained, but the absolute risk difference between the groups in fact increased during the post-intervention period.¹⁰¹ Similarly, the 20-year follow-up of the Da Qing cohort showed that the lifestyle-modification group continued to have a lower incidence of type 2 diabetes compared to control participants.¹⁰² These data suggest that intensive lifestyle modification, even for a limited time, can have long-term benefits as far as the risk of type 2 diabetes is concerned.

A number of studies have shown that individuals who are active have a lower risk of developing type 2 diabetes compared to those who are sedentary. Among more than 70 000 initially healthy women from the USA participating in the Nurses' Health Study, walking briskly for at least 30 min/day for 5 days/week was associated with a 25% reduction in diabetes over 8 years of follow-up among those reporting no vigorous exercise, after adjustment for age, body mass index, and other risk factors for diabetes.¹⁰³

In a community-based study conducted in Chennai, south India (Chennai Urban Population Study), standard lifestyle advice (e.g. increasing physical activity and improving diet) was provided to the participants at baseline. After a 10-year follow-up, a 277% increase in the exercise levels of residents of a middle-income colony (the Asiad Colony) was reported, following the construction of a park by the residents of the colony themselves.¹⁰⁴ During the follow-up period, in a colony of individuals from a lower income group, where no built intervention was given, the prevalence of diabetes increased from 6.5% to 15.3% (a 135% increase). However, in the Asiad Colony, a middle-income group where the park was available, the prevalence only increased modestly from 12.4% to 15.4% (i.e. a 24% increase).¹⁰⁵ This indicates that a moderate investment of time and effort might slow the rise in the prevalence of diabetes. This phenomenon is referred to as "prevention of excess gain".¹⁰⁶ This study has been cited as a potential model for prevention of diabetes through community action.¹⁰⁷

THE SYNERGISTIC EFFECT OF DIET AND PHYSICAL ACTIVITY IN SLOWING THE EPIDEMIC OF DIABETES

Nutrition transition and increasingly sedentary lifestyles, which could have a synergistic effect on diabetes risk, are observed in south Asian populations. This underscores the need for policy changes and effective education programmes related to lifestyle modifications in low- and middle-income countries. Thus, prioritizing prevention strategies to curtail the epidemic of diabetes requires an understanding of the relative importance of various modifiable risk factors. Recently, in an urban south Indian population, the contribution of various modifiable risk factors to the partial population-attributable risk for diabetes was evaluated in a cohort of 1376 individuals who were free of diabetes at baseline and followed up for 10 years.³⁸ Abdominal obesity was found to contribute the most to incident diabetes (relative risk [RR]: 1.63). The risk for diabetes increased with increasing quartiles of the diet risk score (computed incorporating intake of refined cereals, fruits and vegetables, dairy products and MUFA; highest quartile RR: 2.14) and time spent viewing television (RR: 1.84) and sitting (RR: 2.09). The combination of five risk factors (obesity, physical inactivity, unfavourable diet risk score, hypertriglyceridaemia and low HDL cholesterol) could explain 80.7% of all incident diabetes. However, improvement in diet and levels of physical activity alone could reduce the prevalence of diabetes by 50%.³⁸ This suggests that modifying these easily identifiable risk factors could prevent the majority of cases of incident diabetes in the Asian-Indian population. Translation of these findings into public health practice will go a long way in arresting the progress of the diabetes epidemic in this region.

NATIONAL-LEVEL POLICY RECOMMENDATIONS

Prevention and management of NCDs like type 2 diabetes across the globe is crucial and will be an uphill task in south Asia, owing to a multitude of barriers. WHO has taken initiatives to combat the risk associated with morbidity, mortality and

disability due to NCDs, through multisectoral collaboration and cooperation at national, regional and global levels. As a result, the population can benefit by achieving the highest attainable standards of health and productivity throughout their lifespan. The goals set by WHO in 2013 include (i) a 25% reduction in overall mortality; (ii) a 10% reduction in the prevalence of physical inactivity; (iii) a 10% reduction in excess alcohol consumption; (iv) a 30% reduction in tobacco usage; (v) a 30% reduction in salt/sodium intake; and (vi) a 25% reduction in high blood pressure.¹

Hence, when planning prevention programmes at national level, a multifaceted approach is essential for success. Some of the policies listed next may help to slow down the epidemic of NCDs such as type 2 diabetes among the countries of south Asia.

- National food policies must target and improve the availability and accessibility of healthy and nutritious foods. Coordination between the public and private sectors needs to be improved to make the policies function properly.
- The government should make efforts to ensure that the food industry strictly complies with norms of food safety and standards.
- Nutrition and agricultural policies that support production and distribution of healthy foods are critical, such as introducing agricultural subsidies that increase the accessibility and affordability of whole grains, fruit, vegetables, legumes and nuts.
- Collaboration between health, education, information and agriculture ministries is essential to create awareness and to facilitate a healthy lifestyle among the population.
- Nutrition and physical activity programmes targeting schoolchildren should be developed to reduce childhood obesity. The sale of unhealthy processed foods like junk foods should be prohibited in schools and in nearby shops. Promoting sales of such products through advertisement must also be controlled.
- Creating awareness of the impact of unhealthy diets, and educating people that prevention is the best cure for NCDs like type 2 diabetes, through newspapers, national TV channels and radio channels, may help to promote healthy eating behaviours and thus promote good health.
- Encouraging physical activity by the creation of amenities such as public spaces (e.g. parks) for walking or cycling is needed to facilitate healthy living.
- It is important for health policy-makers to take the actions necessary to reduce harmful behaviours such as smoking, alcohol misuse, use of trans fat in restaurants and consumption of junk foods.
- As the burden of NCDs is now shifting towards the poor, reducing the cost of drugs and ensuring reasonable access to care remains a high priority. It is important to develop strategies to educate and motivate the public regarding the prevention of diabetes and other NCDs.

- Public and private-sector organizations across all countries of south Asia should work together, in order to measure the magnitude of the problem and design a holistic approach for preventing NCDs like type 2 diabetes, as lessons and good practices learnt from one country can easily be applied to another.

CONCLUSION

Healthy diet and regular physical activity have numerous beneficial effects on the prevention of type 2 diabetes. Economic policies related to agriculture, investment, trade and marketing could have an impact on what the population consumes. Policy-makers should consider these factors while formulating strategies to reduce the burden due to type 2 diabetes and other NCDs in this region. A multi-stakeholder approach is needed to slow down the epidemic of diabetes in South Asians. The time to act is now.

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