CHAPTER 4 PREVENTION OF DIABETES IN WOMEN

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Effect of dietary pattern on incidence of diabetes in women

NCDs account for approximately 41 million deaths each year[1]. 85% of these deaths occur in low and middle-income countries[2]. In India, NCDs contribute to 62% of total deaths and 48% of these are preventable[3]. Also, the progression from prediabetes to diabetes occurs much faster in Asian Indians than in other ethnic groups[4].

Two major factors solely responsible for this rapid rise in the incidence of diabetes in developing countries are dietary habits and sedentary lifestyle[5]. There is substantial evidence that lifestyle modifications and/or pharmacological therapies can prevent or delay 25-40% of incident diabetes in high risk individuals[6-8].

Dietary interventions can prevent and control T2D by improving energy balance, IR and blood glucose control. There is evidence linking high calorie intake and high glycemic index diets to increased risk of T2D. The quality of diet components corresponds with T2D risk, progression and consequences[9]. In particular, a diet low in whole grains and high in glycemic load[10] and processed meats appears to increase the risk, especially in women[11]. In the Framingham Offspring Study, women with the "empty calorie" dietary pattern had higher and those with "wine and moderate eating" dietary habits had lower prevalence of the metabolic syndrome. In the Malmö Diet and Cancer Cohort, the metabolic syndrome was more prevalent in women with the "white-bread" dietary pattern and less prevalent in women with the "milk-fat" pattern[12].

A consensus report on nutrition therapy for diabetes concluded that people with diabetes consume same proportion of macronutrients as the general public, which is ~ 45% of their calories from carbohydrate, ~ 36-40% of calories from fat and the remainder (~ 16-18%) from protein[13].

A study on Japanese women found that eating white rice increased their risk of T2D by 1.65 times[14]. The prevention with mediterranean diet or PREDIMED trial showed that a Mediterranean style diet resulted in a 30% lower RR of T2D onset compared to a low fat eating pattern[15]. Another study on Caucasian women aged 40-60 years, found that a healthy diet pattern was related with decreased odds of IR and the metabolic syndrome, while a western diet pattern was associated with increased risks[16]. Many Indian studies have also highlighted that the dietary carbohydrates especially refined grains are positively associated with T2D. Polished white rice was noted to be the major contributor. Also, it was noticed that those who eat more rice, also eat less of virtually all other foods such as legumes, tubers, fruits and vegetables and dairy products[17].

A prospective cohort study of 35,988 older American women from Iowa State showed an inverse association between a healthy dietary pattern and metabolic syndrome. This was attributed to a diet that included whole grains, fiber, fruit and vegetables and high dietary magnesium[18]. Based on the DASH programme, the healthy dietary pattern helped to lower BP and improves symptoms of metabolic syndrome[19]. Higher intakes of these foods may also reduce insulin demand. A study from Chennai, India showed that a higher intake of fruit and vegetables contributed to 48% of the protective effect against CVD risk factors, including diabetes[20]. Furthermore, low glycemic load foods are associated with lower risk of IR.

An Indian study[21] sought to evaluate the contribution of various modifiable risk factors to the PARp for diabetes in an Asian Indian population. Of a cohort of 3,589 individuals, representative of Chennai, followed up after a period of 10 years, data from 1,376 individuals, who were free of diabetes at baseline, was analyzed.

The combination of risk factors like obesity, physical inactivity, unfavourable diet risk score, hypertriglyceridemia and low HDL cholesterol was found to explain 80.7% of all incident diabetes. Of these modifying diet and physical inactivity alone could (at least theoretically) prevent 50% of incident diabetes in the Asian Indian population[21] and this was more so in women (59.3% vs. 54% in men).

The PARp for the diet score was 29.8 (-2.0, 56.1) and 42.6 (10.7, 66.6) in males and females respectively. Thus, overall a low risk diet score could prevent 30% of cases of diabetes. The diet risk score in this study was computed incorporating intake of refined cereals, fruits and vegetables, dairy products and monounsaturated fatty acid[21]. Refined cereals showed the highest risk for diabetes (Figure 1).

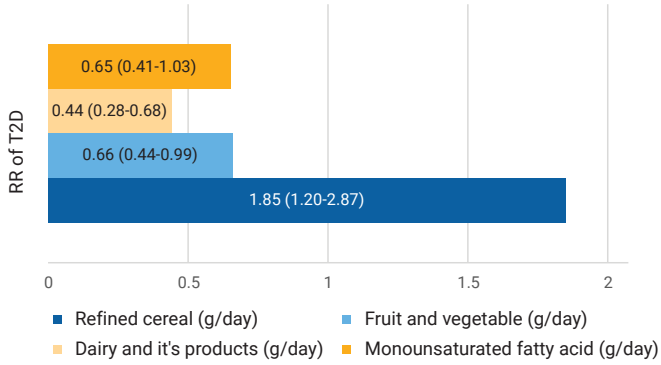

Figure 1: Diet risk score components and RR for T2D
Source: Anjana et al., 2015[21]

In another large nationwide trial, Indian dietary data collected from 12,500 individuals (46% females) was analyzed. The results showed that the consumption of milk, meat, junk food and less vegetables and fruits (Table 1) had a significant effect on the glycemic status and cholesterol levels of the participants[22].

A unique population-specific food-based diet score called the IDQS was developed with the aim to assess the independent association of diet with incidence of diabetes among Asian Indian adults. The association between diet score and the incidence of diabetes was prominent among both gender, older adults (> 30 years), overweight and obese individuals and those with higher physical activity. Higher IDQS was associated with a lower risk of T2D among South Indian adults[23].

Similarly, another Indian study highlighted the role of food choices and frequency of intake in diabetes prevention. The cross-sectional data of 99,574 women and 61,361 men aged 20-49 years, who participated in India's third National Family Health Survey conducted during 2005-2006 were used for this study. In women, daily or weekly consumption of pulses/beans and fruits was associated with a lower likelihood of diabetes[24]. The impact of a diabetes prevention intervention on diet and risk of diabetes in South Asians at high risk showed that decreasing total energy intake and increasing intakes of fruits and vegetables, could reduce the 1 year incidence of diabetes by half[25].

Table 1: Association between dietary factors with categories of diabetes, prediabetes and normoglycemia

Milk

	PPBG	FBG
Diabetes OR	17.19*	7.18*
Prediabetes OR	3.44	2.74*
Normoglycemia OR	2.56*	2.31

Meat

	PPBG	FBG
Diabetes OR	22.82*	6.81*
Prediabetes OR	3.90	2.63*
Normoglycemia OR	1.64	1.51*

Less fiber

	PPBG	FBG
Diabetes OR	17.77*	9.17*
Prediabetes OR	2.78	2.87*
Normoglycemia OR	2.80*	1.95*

Less fruit

	PPBG	FBG
Diabetes OR	14.71*	8.99*
Prediabetes OR	3.51*	1.95*
Normoglycemia OR	1.21*	1.18*

Skipping of breakfast

	PPBG	FBG
Diabetes OR	5.63	4.14
Prediabetes OR	1.33	1.69*
Normoglycemia OR	1.72*	1.45*

Note: There was a highly significant association between blood glucose (Fasting blood glucose and postprandial blood glucose) values and consumption of milk, meat, less fruits and less fiber, but not with skipping of breakfast in individuals with diabetes.*Significance p < 0.001. FBG: Fasting blood glucose, PPBG: Postprandial blood glucose

Source: Nagarathna et al., 2020[22]

Dietary intake was assessed in 133 women with GDM enrolled under the WINGS-MOC[26], from 6 maternity centers in Chennai, in South India. The WINGS-MOC dietary intervention included one-on-one monthly antenatal diet counselling, providing a dietary guideline booklet and healthy recipe demonstrations. A 'healthy diet score' was derived from the reported intake of whole grains, dairy products and dietary fiber. The effect of healthy diet score on neonatal outcomes (macrosomia, hyperbilirubinemia, congenital anomalies and neonatal ICU admissions) was evaluated. Higher consumption of whole grain, dairy products and dietary fiber was inversely associated with adverse neonatal outcomes. Those with the highest healthy diet score had lower risk for adverse neonatal outcomes even after adjusting for potential confounders[26].

Nutritional factors and approaches in diabetes

There may not be a single ideal percentage of carbohydrate, protein and fat for all people with or at risk of diabetes, therefore, macronutrient distribution should be based on existing eating patterns, preferences and metabolic goals. An assessment and review of current dietary intake should be followed by tailored advice on self-monitoring carbohydrate intake to optimizing meal timing and food choices as well as medication and physical activity[13,27].

The rapid nutritional transition in India has led to increased intake of calories, saturated fats, trans fatty acids, simple sugars, salt and low intake of fiber. Therefore, the consensus guidelines for Asian Indians recommends decrease in the overall intake of carbohydrates, increased intake of complex carbohydrates, fiber and low glycemic index foods, reduction in intake of saturated fats, maintaining ideal ratio of essential fatty acids, reduction in trans fatty acids, moderate increase in protein intake, decrease in salt intake and controlled intake of sugar[28,29](Table 2).

Table 2: Currently available recommendations for medical nutrition therapy for the management of DM

Carbohydrates		
Indian guidelines		**ADA guidelines**
RSSDI	**Recommended intake:** 45-65% of total daily calories (minimum intake 130 g/day)	No specified recommended intake
	High fiber diet: Increased intake of soluble and insoluble fibers	High fiber and low glycemic index diet
	Preferred sources: Pulses, legumes, coarse grains, sprouted grams, unprocessed vegetables and fruits	**Preferred sources:** Fruits, vegetables, whole, grains, legumes and dairy products (milk and yoghurt)
	Substitution of polished white rice with millets and brown rice	
ICMR	**Recommended intake:** 55-60% of total daily calories	
	Intake of fiber-rich foods	
	Preferred sources: Cereals, mixed coarse grains, whole grains (e.g. ragi, oats, barley, jowar), whole pulses, whole fruits, salads and soybeans, leafy vegetables, fenugreek seeds	
	Restricted intake of all-purpose flour (maida)-based products	

Proteins		
Indian guidelines		**ADA guidelines**
RSSDI	**Recommended intake:** 10-15% of total daily calories	Typically 15-20% of total energy in individuals without diabetic kidney disease
		Recommended daily allowance in individuals with T2D and compromised renal function: 0.8 g/kg body weight/day
	Preferred sources: Not mentioned	**Preferred sources:** Not mentioned
ICMR	**Recommended intake:** 10-15% of total daily calories	
	Preferred sources: Vegetable sources, low-fat milk and milk products, fish and lean meat	

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For Indians who currently consume about 65-75% of calories from carbohydrates, reducing this to 50-55% and adding enough protein (20-25%), especially from vegetable sources and deriving the remaining calories from fat (20-30%) by including monounsaturated fats (e.g. groundnut or mustard oil, nuts and seeds) along with plenty of green leafy vegetables, would be the best diet prescription for the prevention and management of NCDs such as T2D and CVD[30].

Also, studies have shown that substituting brown rice for white rice has potential benefit on glycemic control among individuals with metabolic syndrome[31,32]. Regular consumption of dietary fiber is associated with decrease in all-cause mortality in diabetes. Therefore, people with diabetes should consume at least 25-40 g of dietary fiber/day. Daily consumption of 3 g of soluble fiber from 70 g of oats lead to beneficial effects on the lipid parameters, specifically total cholesterol and LDL cholesterol in hypercholesterolemic Asian Indians[33].

A large epidemiological study found that consumption of polyunsaturated fat is associated with lower risk of T2D[34]. Supplementation with Omega-3 fatty acids in individuals with prediabetes has demonstrated some efficacy in surrogate outcomes beyond serum triglyceride levels[35]. The PREDIMED study found that a Mediterranean style eating pattern supplemented either with extra virgin olive oil or with nuts, reduced incidence of T2D among people without diabetes with high cardiovascular risk at baseline[15]. Hence, it may be prudent to advocate these healthy dietary habits to help prevent and/or delay onset of diabetes.

Weight management, physical activity and glycemic control

The risk for diabetes significantly increases with age, obesity and physical inactivity[36]. Physical inactivity has been shown to be a major risk factor leading to NCDs like diabetes[37]. Globally women are physically less active than men[38]. This holds true for India as well. ICMR-INDIAB study showed that physical inactivity was higher in Indian women (67.2%) than in men (54.9%)[39] (Figure 2).

Fats		
Indian guidelines		**ADA guidelines**
RSSDI	**Recommended calorie intake:** No specified ideal intake	**Recommended calorie intake:** No specified ideal intake
	Restricted intake of saturated fats: <10% of total daily calories	**Restricted intake of saturated fats:** <10% total daily calories
	Minimal intake of trans fats	Minimal intake of trans fats
	Restricted intake of dietary cholesterol: < 300 mg/day	**Restricted intake of dietary cholesterol:** < 300 mg/day
	Preferred sources of MUFA/PUFA: Moderate intake of fish/seafood, chicken without skin and red meat as a source of PUFA	**Preferred sources of MUFA/PUFA:** Fatty fish, nuts and seeds
	Not recommended: Sunflower oil	
ICMR	**Recommended calorie intake:** 20–25% total daily calories	
	Restricted intake of saturated fats: < 7% total daily calories	
	Minimal intake of trans fats (hydrogenated vegetable fats)	
	Restricted intake of dietary cholesterol: < 300 mg/day	
	Preferred sources of MUFA/PUFA: Groundnut, sesame, cotton seed, rice bran or safflower along with soybean, mustard, canola, etc. as preferred choices for edible oils containing MUFA and PUFA	

Sugars and sweeteners		
Indian guidelines		**ADA guidelines**
RSSDI	Reduced intake of refined sugars	Reduced intake of HFCS and sucrose
	Moderate intake of non-nutritive artificial sweeteners	Substitute nutritive sweeteners with non-nutritive sweetener
	Avoid consumption of HFCS	Natural fructose/free fructose from fruits (3–4% of energy intake and not < 12) is permissible
ICMR	Avoidance of sugar, honey, jaggery	
	Restricted use of artificial sweeteners and avoidance in pregnant/lactating women with diabetes	
	Avoidance of very sweet fruits and fruit juices	

Micronutrients and other dietary recommendations		
Indian guidelines		**ADA guidelines**
RSSDI	Inclusion of micronutrients (chromium, α-lipoic acid, magnesium and zinc) as adjunct to standard care[b]	Not recommended
	Restricted intake of dietary salt: < 5 g/day[c]	**Restricted sodium intake:** < 2300 mg/day[c]
	Avoidance of alcohol consumption	Moderate alcohol consumption
	Cessation of tobacco use	
ICMR	Not recommended	
	Restricted intake of dietary salt: < 6 g/day	
	Moderate of alcohol consumption	
	Cessation of any form of tobacco use	

Note: a Particularly in patients with established CVD
b Insufficient evidence available
c Further restriction in patients with diabetes and hypertension
MUFA Mono-unsaturated fatty acids, PUFA Poly-unsaturated fatty acids
Source: Viswanathan et al., 2019[29]

Recent studies have showed an extremely strong positive relation between level of BMI and the risk of diabetes in women[6]. Conversely, weight loss appears to be highly effective in preventing prediabetes progression to T2D and managing cardiometabolic health in T2D[6,8]. Regular physical activity contributes to both weight loss and prevention of weight regain. Structured weight loss programmes and meal replacements have been found to help weight loss in people with diabetes. Metabolic surgery, weight loss drugs and glucose lowering therapies can be used in conjunction with lifestyle modifications to achieve greater weight loss that is maintained for a longer period of time[40].

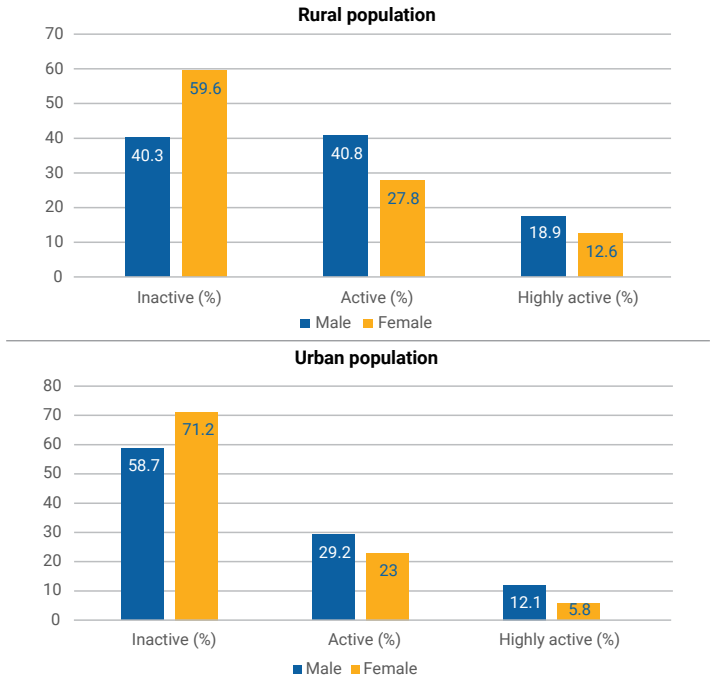


Figure 2: Physical activity levels in the study population
Source: Anjana et al., 2014[39]

In T2D, 5% weight loss is recommended to achieve clinical benefit and the benefits are progressive. The goal for optimal outcomes is loss of 15% or more weight when needed and whenever it can be feasibly and safely accomplished. In prediabetes, the goal is 7-10% weight loss for preventing progression to T2D[6,8].

Laboratory and clinical studies suggest that physical activity can enhance insulin sensitivity and glucose tolerance, thus reducing the risk of T2D. This effect can last up to 72 h after exercising even in people with T2D[41] (Figure 3). Exercise independently affects glucose metabolism by increasing both insulin-mediated and non-insulin mediated glucose disposal. A single exercise session increases insulin-mediated glucose uptake for more than 24 h. The increased insulin sensitivity occurs because of increased number and activity of glucose transport proteins (especially the glucose transporter 4 isoform), both in muscle and adipose tissue. Glycogen synthase activity leads to increased glycogen synthesis and non-oxidative glucose disposal[42]. Exercise also reduces adipose tissue mass and preserves or increases lean body mass, which increases insulin sensitivity[43].

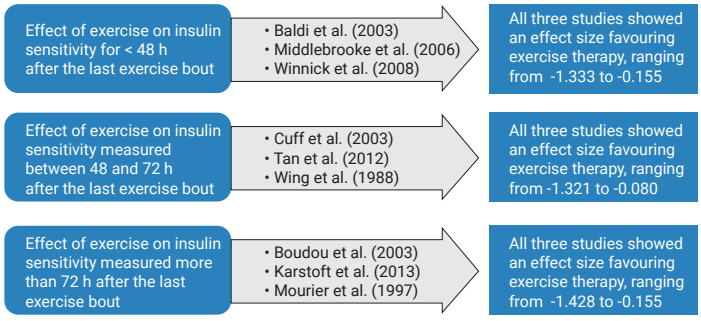


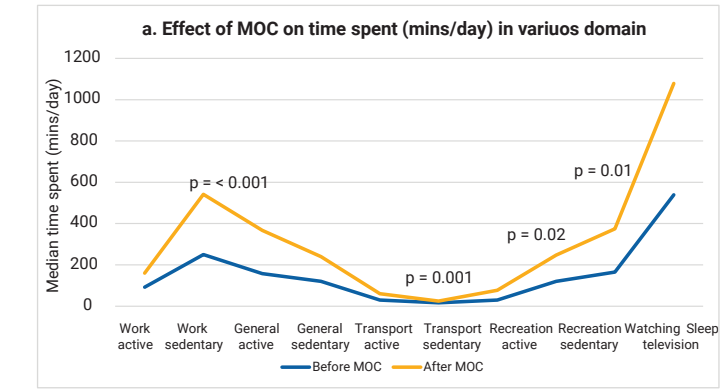
Figure 3: The effect of exercise on insulin sensitivity at < 48 h, at 48-72 h, and at > 72 h after the last bout of exercise. ES: Effect size

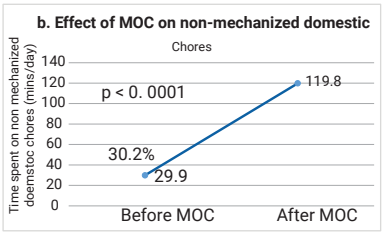
Source: Way et al., 2016[41]

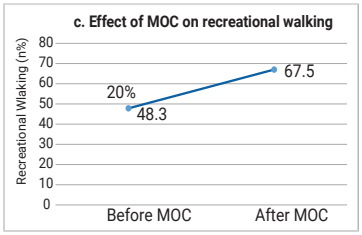
Among people who do not have diabetes, research show that strategically adding exercise to diet therapy facilitate and helps maintain weight loss, mediated by reducing the adipose tissue and increasing muscle mass and strength[10]. Thus, physical activity is important in the prevention of T2D in women through its independent effects on body weight, IR/sensitivity and glucose tolerance[44].

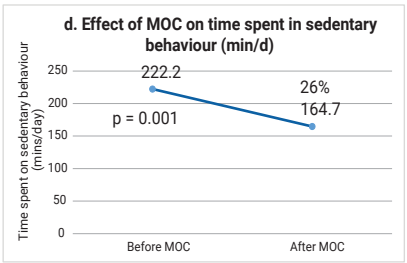
A prospective cohort study of women with diabetes showed that greater leisure-time physical activity was associated with substantially reduced risk for cardiovascular complications. Women with diabetes who exercised for at least 4 h/week had a 40% lower risk of CVD. The reduction in risk was similar for CHD and ischemic stroke and the dose-response relationship was consistent in subgroup analyses according to cardiovascular risk factors[45].

Indian studies have also shown that women with diabetes are at particularly high risk against CVDs and diabetes eliminates the usual female advantage for death from coronary disease[46,47].









*p < 0.05 considered as significant using Wilcoxon signed rank test

Figure 4: Effect of WINGS MOC on physical activity patterns of GDM women (n = 151). (a) Effect of WINGS MOC on time spent (mins/day) in various domains, (b) Effect of WINGS MOC on non-mechanized domestic chores, (c) Effect of WINGS MOC on recreational walking, (d) Effect of WINGS MOC on the time spent in sedentary behaviour (mins/day)

Source: Anjana et al., 2016[48]

A randomized controlled translation trial D-CLIP of 578 overweight/obese Asian Indian adults with prediabetes, compared standard care to a culturally tailored lifestyle education curriculum, based on the US diabetes prevention programme plus stepwise addition of metformin (500 mg, twice daily). Three year follow-up showed that the RR reduction in diabetes incidence was 9.8 (34.9% in the control group and 25.7% in the intervention group developed diabetes)[8]. The D-CLIP-step-wise diabetes prevention programme besides resulting in a 32% lower 3 year diabetes risk, also showed an almost 50% reduction of diabetes incidence in participants who had a BMI of ≥ 27 at baseline, thus showing weight loss is an important risk factor in diabetes prevention.

In the WINGS study, physical activity patterns were studied in 795 pregnant women with and without GDM, and WINGS-MOC intervention was evaluated. It was found that physical activity levels were inadequate amongst this group of pregnant women studied. However, a low-cost, culturally appropriate MOC could bring about significant improvements in physical activity in women with GDM. These changes were associated with improved glycemic control and reduction in adverse neonatal outcomes[48] (Figure 4).

However, as this chapter specifically addresses diabetes prevention in women it also imperative to recognise the challenges to making lifestyle changes especially exercise among women. Low level physical activity is known to contribute to poor health outcomes for women, with cultural barriers being a major factor in discouraging women from participation.

Reasons for higher physical inactivity in women include time constraints, self-consciousness, lack of confidence, physical inability, lack of encouragement from family members, discomfort with the attire, expensive club and gym memberships, inability to access exercise facilities, unfavourable weather conditions and exercise not being considered 'culturally acceptable'[49,50].

The D-CLIP study data revealed gender differences in the perceived barriers to exercise showing women having many socio-cultural barriers compared to their male counterparts[51] (Figure 5).

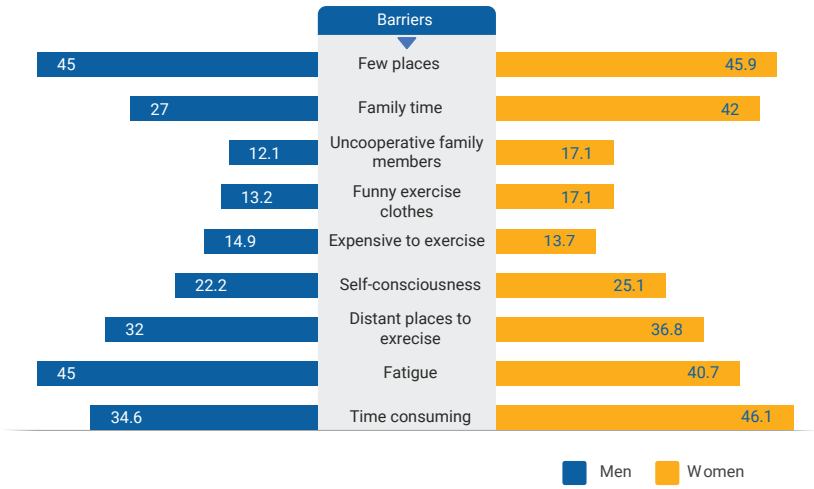


Figure 5: Perceived barriers to exercise among the non-exercisers

Source: Anjana et al., 2015[51]

Future research should therefore devise and test lifestyle interventions specific for women. One such novel intervention called THANDAV (over NCDs) was designed specifically for adolescent girls and women and a pilot study testing the intervention showed that THANDAV, which fused HIIT with a culturally accepted form of physical activity namely dance helped improve the fitness of adolescent girls[52]. We need more such targeted interventions that focus on improving both dietary habits and physical activity behaviour specifically among women, thereby helping to prevent diabetes and improve metabolic outcomes.

Conclusion

To prevent diabetes in women, interventions should target the two main modifiable risk factors namely diet and exercise that cause the disease. However, these lifestyle behaviours are the most difficult to change and hence designing gender specific strategies that promote healthy eating and regular physical activity is of considerable public health importance.

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