ISSN 2379-6391

SPORTS AND EXERCISE MEDICINE
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*Systematic Review*

# Type 2 Diabetes Mellitus Prevention Benefits of Physical Activity: Consequences for Sub-Saharan Africa

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***Article information***
**Accepted:** May 29th, 2025; **Published:** June 11th, 2025

***Cite this article***
Azeez T, Lawal A, Ogundiran O. Type 2 diabetes mellitus prevention benefits of physical activity: Consequences for Sub-Saharan Africa. *Sport Exerc Med Open J.* 2025; 11(1): 21-26.

## ABSTRACT

**Background**

Diabetes mellitus is a chronic metabolic disorder characterized by hyperglycaemia which is due to reduced insulin secretion and/or action. It has 6 sub-classes but type 2 is the most common. The prevalence of type 2 diabetes is rising at a very high rate in the sub-Saharan Africa region. Prevention is however better than cure and there are multiple pieces of evidence of the highest level that type 2 diabetes is preventable. Prevention of type 2 diabetes is looked at from the perspectives of primary, secondary, tertiary and quaternary prevention.

**Methods**

Measures that have been documented in the literature that can be adopted in the prevention of diabetes include lifestyle modification, pharmacotherapy and surgical interventions. Lifestyle modification is the most commonly reported measure and physical activity is a central focus in lifestyle modification. Physical activity refers to all body movements that lead to expenditure of energy above the resting level. Exercise is a structured and monitored subset of physical activity. Physical activity has been documented to help in the primordial prevention of type 2 diabetes for children born to a woman with gestational diabetes. It helps in modifying risk factors for diabetes such as obesity, dyslipidaemia and high blood pressure.

**Conclusion**

It is also valuable for secondary prevention of diabetes by modifying risk factors such as obesity, hypertension, excess calorie intake and lipids. Physical activity plays a central role in the management of a patient diagnosed with diabetes at the level of secondary prevention. Effective rehabilitation of patients with type 2 diabetes who have suffered macrovascular complications would constitute a tertiary level of prevention. Since physical activity is an effective, affordable and available form of preventing type 2 diabetes sub-Saharan Africa where the population has limited resources can leverage on its cost-effectiveness. This will help to improve longevity and improve the quality of life of people and save scarce resources in the region.

**Keywords**
Physical activity; Type 2 diabetes; Prevention; Sub-Saharan Africa.

## BACKGROUND

Diabetes mellitus is a chronic metabolic disorder where the central theme is hyperglycaemia due to a defect in insulin secretion and/or action.[1] It is a condition characterized by abnormalities of metabolism of carbohydrates, lipids and proteins. In the latest World Health Organization (WHO) classification, diabetes mellitus is categorized into type 1 diabetes, type 2 diabetes, hybrid type of diabetes, hyperglycaemia first detected in pregnancy, other specific types of diabetes and the unclassified type.[2]

According to recent statistics from the International Diabetes Federation (IDF), over 400 million individuals are living with diabetes and about 90% of this is accounted for by type 2 diabetes, thereby making it the most common type of diabetes.[3] There is an upsurge in the prevalence of type 2 diabetes mellitus due to the

rising prevalence of obesity, adoption of western lifestyles and increased life expectancy due to the benefits of intensified efforts to combat infectious diseases in the region.[4] The sub-Saharan African region was predicted to witness the highest percentage increase in diabetes incidence than any other region in the world.[3] Therefore, all hands must be on deck to prevent the situation from becoming worse.

Lifestyle modification is the most commonly documented modality of preventing progression of impaired glucose tolerance to type 2 diabetes.[5] Although, pharmacological and surgical therapies have also been documented as means of preventing progression of prediabetes to diabetes but lifestyle modifications remain a key approach.[5] These lifestyle modifications include weight loss, physical activity, dietary modification, consumption of fruits and vegetables and avoidance of excessive alcohol intake.[5] Physical activity remains a central focus in preventing diabetes, especially in sub-Saharan Africa where the prevalence of diabetes is expected to rise dramatically.

Physical activity involves to all forms of bodily movement that increases energy expenditure higher than the resting state. Exercise, on the other hand, is said to take place when physical activity has been prescribed by exercise experts in a structured manner and efficiently monitored.[6] So, exercise is a subtype of physical activity. Physical activity improves cardiovascular risk profile, assists in weight loss and enhances general well-being.[7] Studies have found out that regular physical activity may prevent or delay type 2 diabetes.[8] WHO categorizes physical activities into work-related, leisure-related and transport-related physical activities.[9] Despite the fact that the prevalence of diabetes is rising rapidly in sub-Saharan Africa, the level of physical activities among adults is decreasing and this may portend a great danger in terms of the burden of diabetes and is complications in the region.[10]

## AIM

The aim of this review article is to emphasize the role of physical activity and exercise in preventing diabetes mellitus and to highlight the implications of this preventive measure in sub-Saharan Africa, where the resources to treat are lacking and diabetes prevalence is projected to increase at a dramatic rate in the region.

Relevant search terms such as "*Physical activity to prevent diabetes*", "*type 2 diabetes*", "*prevention*", "*diabetes mellitus in sub-Saharan Africa*", "*prevention of diabete*s" and "*prevention of diabetes in sub-Saharan Africa*" were used to search the biomedical databases as well as the grey literature.

## METHODS

The biomedical databases explored were PubMed, Google Scholar, Science Direct and African Journals Online (AJOL). Over 80 *in vitro* studies, animal studies, expert reviews, epidemiologic studies, clinical trials, systematic reviews and meta-analyses were retrieved. The authors independently assessed the retrieved articles, and about 40 studies were selected to be the most relevant to the subject matter.

### Physical Activity and Health

Physical inactivity or being sedentary is an extensively documented risk factor for type 2 diabetes, cardiovascular disease, cancer, hypertension and depression.[11] Among the modifiable risk factors for diabetes and cardiovascular disease, physical inactivity has been reported to be the most prevalent.[12] The intensity of physical activity is described in terms of the metabolic equivalent of task (MET) defined as the rate of expending energy when performing a physical activity per body mass in comparison with the same rate of energy expenditure at rest.[13] On the basis of MET, physical activities are divided into three categories, light intensity activities (when MET<3) such as writing and typing, moderate intensity activities (when MET is 3-6) such as sweeping floor or walking at 3 mph and vigorous intensity activities (when MET is >6) such as jogging, bicycling and rope jumping.[13] Generally, physical activity leads to increased glucose uptake by active muscles balanced by hepatic glucose production, with a greater reliance on carbohydrate to fuel muscular activity as intensity increases.

In experimental studies that document the evidence of the benefit of physical activity, most moderate to vigorous physical activities were recreational in developed countries but in sub-Saharan Africa, most moderate to vigorous physical activities were non-recreational (work-related and transport-related physical activities).[14] Studies have shown that non-recreational physical activities do not give the same health benefit as recreational physical activities.[15] Additionally, it has been documented that less time is spent doing moderate to vigorous physical activities in low-income countries such as most of the counties of sub-Saharan Africa when compared with the developed countries.[14] All of these factors suggest that the benefit of physical activity in preventing diabetes may not be effectively utilized in sub-Saharan Africa.

The most common cause of death in diabetes is cardiovascular disease. It has been found that people who are physically active are less likely to die from cardiovascular disease.[16] This is crucial for the individuals in sub-Saharan Africa because the burden of cardiovascular disease is rising rapidly in the region.[17]

### Barriers to Physical Activity in Sub-Saharan Africa

Physical inactivity is now regarded as a major risk factor of death in developing countries such as found in sub-Saharan Africa.[18] Despite this fact, the prevalence of physical activity in the same region is low.[18] Rapid urbanization is reported to be partly responsible for dwindling level of physical activity among adults in sub-Saharan Africa.[19] The WHO has recommended moderate intensity physical activity of at least 150-minutes per week for adults but the degree of compliance with the recommendation varies widely in sub-Saharan Africa, with some areas observing compliance rate as low as 46% while in others, especially in the agrarian rural areas, the rate of compliance is as high as 95%.[10]

The most commonly reported barriers to physical activity in sub-Saharan Africa are internal barriers and external barriers[18] Internal barriers have to do with self-motivation, presence or lack of skills and energy, fear of injury, feeling of guilt with regards to

high calorie consumption and personal conviction on the need for physical activity. Many people in sub-Saharan Africa are not motivated to engage in leisure-related physical activity as they believe that work-related physical activity should suffice.[18] External barriers refer to the other factors such as environmental, lack of facilities for physical activity and exercise and poor socio-economic status. Interestingly, the higher the educational status in sub-Saharan Africa, the higher the risk of physical inactivity.[19] This is thought to be work-related as most people tend to reduce their physical activities once they get white-collar jobs. The implication of this for the sub-Saharan African population is that the cohort of urban-dwelling, white-collar employees who have lower physical activities are the same category with those with the highest risk of developing diabetes and cardiovascular disease due to their western lifestyles.[19]

### Concept of Prevention of Disease Using Diabetes Mellitus as an Illustration

'Prevention is better than cure' is a universal principle that is relevant also in the field of diabetology. Diseases have natural history and preventive measures can be undertaken at various phases of the disease. The aim of prevention is to reduce morbidity and mortality at individual level and reduce the burden of disease at the population level. The approaches to prevention can be categorized into primordial, primary, secondary, tertiary and quaternary.[20]

Primordial prevention aims at removing future hazards, determinants and risk factors for a disease. For example, optimal maternal health is considered as a primordial prevention of diabetes for the unborn child, later in life.

Primary prevention seeks to address risk factors to a diseases and halt the onset of the disease. The aim is risk reduction either from avoiding the risk or cushioning the effect of the risk. Primary prevention of diabetes will include activities such as reducing caloric intake, weight loss, ensuring physical activity and stopping smoking. Prevention of prediabetes from becoming diabetes is also considered as a form of primary prevention.[12]

Secondary prevention is targeted at treating the disease at the early stage, preferably at the preclinical stage. It is about prevention of the complications of a full-blown disease and maintaining the health of the individual. Optimal glycemic control, lifestyle modification, good blood pressure control and control of dyslipidaemia are secondary prevention measures in a patient with diabetes.

Tertiary prevention refers to the cushioning of the impact of the diseases. It focuses on improving the quality of care and ensuring satisfactory longevity. Rehabilitation and adjustment to disability are the focus of tertiary prevention measures. In this instance, the attention is on post-amputation patients, patients with diabetic nephropathy and other complications to ensure they get the needed optimal care and to improve their quality of life.

Quaternary prevention is a relatively new concept and concerns medical ethics. It is derived from the principle of *'primum non nocere*' which translates as "*above all, do no harm*".[20] Medical interventions also have potential harmful ethics, quaternary prevention is to prevent unnecessary or unethical interventions that have a high-risk of causing harm rather than help. It also deals with taking responsibility for the limited public resources available for care. Actions must be taken to identify and avoid 'over medicalization' of patients. With this approach for example, a diabetic patient with limited life expectancy should not be a candidate for tight glycemic control with multiple daily insulin injection especially where medical care is out of pocket.

### Physical Activity and Primordial Prevention of Type 2 Diabetes

Primordial prevention of type 2 diabetes is well-represented in provision of optimal care for women with gestational diabetes mellitus (GDM) because both the mother and the baby are at increased risk of type 2 diabetes later.[21] Gestational diabetes mellitus is defined as any degree of glucose intolerance first detected at pregnancy.[2] Coincidentally, the prevalence of GDM is high and is still rising in sub-Saharan Africa.[22] So, this has tremendous implication in sub-Saharan Africa considering that the obstetric care is presently sub-optimal.

The treatment of GDM is lifestyle modification and central to lifestyle modification is physical activity and exercise. Physical activity has been found to improve insulin resistance and reduces the risk of both the mother and the baby of developing type 2 diabetes later in life.[23] Physical activity can increase energy expenditure thereby helping to control the weight. It can also reduce stress and stress-induced food intake.[24] Physical activities also regulate the secretion and activities of certain hormones such as ghrelin and leptin thereby regulating eating behaviours.[24]

Compared with other preventive measures, physical activity is cheap, easy to use and safe. The fact that physical activity is cheap and does not require any special education makes it an acceptable and potentially effective preventive measure for pregnant women in sub-Saharan Africa where the majority are living in rural areas and have low educational status and financial resources. However, a recent study done of physical activity among market women reported that pregnant women would rather wait for postnatal period because of the fear of having abortion in the first trimester and preterm labour in the third trimester.[25] This implies that adequate physical and health education will be required to promote the adoption of physical activity as a preventive measure.

Another approach to primordial prevention of type 2 diabetes using physical activity concerns children, adolescent and young adult health. A Nigerian study reported a high prevalence of type 2 diabetes among young adults. This has been reported in many other sub-Saharan African countries.[26] This is thought to be partly due to rising prevalence of childhood and adolescent obesity and physical inactivity in the region.[27] Promoting physical activity among children, adolescent and young adult is a cost-effective primordial prevention of type 2 diabetes mellitus.[28] A study conducted in South Africa identified some barriers to physical activity among adolescents namely poverty, perceived benefits of physical activity, lack of physical and health education, demographic factors and poor infrastructure.[28]

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### Physical Activity and Primary Prevention of Type 2 Diabetes

Primary prevention of type 2 diabetes concerns addressing the risk factors before the onset of the disease. Some of the modifiable risk factors include obesity, excessive calorie intake, physical inactivity, hypertension, dyslipidemia, smoking and excessive alcohol intake. Physical activity can be classified on the basis of the muscles involved and the aim of the activity.[29] In aerobic exercise, there is repeated movement of large muscle groups and examples include walking, jogging and swimming. Resistance exercise aims to develop the bulk and strength of specific muscle groups and a good example is weight lifting. Flexibility exercise targets movement across joints and balance exercise seeks to prevent falls.

Moderate to vigorous intensity physical activity has been documented not only to prevent type 2 diabetes directly but to also prevent it indirectly by reducing other modifiable risk factors such as obesity, dyslipidaemia and hypertension.[6] The implication of this to the sub-Saharan Africa population is that the other modifiable factors that are improved by physical activity namely, obesity, dyslipidaemia and hypertension are highly prevalent in the subregion. Therefore, the effect of physical activity on the prevention of type 2 diabetes is likely to be greater in sub-Saharan Africa. Internet-based interventions to promote physical activity such as internet-based physical activity coaching, goal setting and feedback as well as conversations with the physical trainer *via* phone or e-mail have been found to be more effective than usual care.[30] This may be a challenge in sub-Saharan Africa, despite its documented effectiveness, because internet facilities are not readily available and where it is available, many uneducated people may not benefit and it may be unaffordable to many people.

### Physical Activity and Secondary Prevention of Diabetes

In a newly diagnosed type 2 diabetes patient, lifestyle modification is the backbone of management. There are meta-analyses and multiple randomized studies that point to the effectiveness and affordability of exercise in ensuring optimal glycemic control and preventing complications of diabetes.[31] Regular exercise has been shown to independently improve HbA1c, after adjusting for other factors.[31] Physical activity acts as a secondary prevention approach by reducing weight, improving insulin sensitivity and cardiorespiratory fitness, an independent predictor of mortality.[31] Even without any reduction in body weight, it is still effective in controlling blood glucose when taken with other measures.

For individuals in sub-Saharan Africa, physical activity is cheap and can be adopted as an effective mechanism in controlling blood glucose and other parameters such as lipid profile and blood pressure, hence a crucial role in secondary prevention of diabetes.

### Physical Activity and Tertiary Prevention of Diabetes

Physical activity and exercise plays a crucial role in the rehabilitation of diabetic patients who have suffered complications of the disease. Macrovascular complications include stroke, coronary heart disease and peripheral arterial disease while microvascular complications include neuropathy, nephropathy and retinopathy. Physical activity and exercise have been found to improve cardiorespiratory fitness, strength and stability in post-stroke patients. It has also been documented to improve cognitive function, mood and general well-being. It has also been shown to reduce mortality and improve the quality of life.[32] Ensuring adequate physical activity, post-myocardial infarction has been shown to be associated with reduced hospitalization, earlier mobilization and improved working capacity.[33] Cardiorespiratory fitness is enhanced and patient can return to work. The relevance to patients in sub-Sahara Africa is that the physical activity-based rehabilitation ensures early return to work so that they can earn a living, as patients often pay out of pocket and may already be in debt following treatment for the stroke or myocardial infarction.

Physical activity has also been found to be beneficial in diabetes patients with peripheral arterial disease. Physical activity improves the walk time before onset of pain, enhance muscular function and vascular supply.[34] It has also been associated with lower risk of limb amputation among patients with diabetes.[34] Amputation is associated with reduced employability so, in sub-Saharan Africa where the basal level of unemployment is high, any effort, including physical activity, to preserve the limb is of enormous importance.

## CONCLUSION

The prevalence of type 2 diabetes mellitus in sub-Sahara Africa is high and it keeps rising. However, there are multiple piec es of evidence that type 2 diabetes is preventable. Prevention is categorized into primordial, primary, secondary, tertiary and quaternary prevention. The documented measures of preventing type 2 diabetes are lifestyle modification, pharmacotherapy or surgery.

Central to the concept of lifestyle modification is physical activity which is any degree of body movement that leads to energy expenditure. A structured, prescribed and monitored subtype of physical activity is exercise. Physical activity have been shown extensively to have a role to play in the primordial, primary, secondary and tertiary prevention of type 2 diabetes. Physical activity is effective, affordable and available. The implication of this to the sub-Saharan Africa population is to focus more in adopting exercise and physical activity to reduce the incidence of type 2 diabetes and its burden on the population.

## CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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