

Evaluation of Interventions for Primary Prevention of Type 2 Diabetes in At-Risk Subjects in Africa : A Systematic Review

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Abstract

The objective of this systematic review is to provide an up-to-date review of research on primary prevention interventions for type 2 diabetes in adults in Africa. An electronic search for literature (PubMed, Scopus, Cochrane, African journal on line and ProQuestCentral) was conducted. A total of nine articles were selected. Primary prevention interventions were rare. Although the recent results of primary prevention interventions for type 2 diabetes in at-risk adults are not systematically measured, primary prevention is an important avenue in the management of type 2 diabetes because of the potential for improved glucose metabolism, altered insulin sensitivity, and reduced inflammatory markers. The research question for this study was: In at-risk or prediabetic or type 2 diabetic individuals, is adoption of a healthy diet and/or regular physical activity more beneficial in delaying the onset of biologically modifiable risk factors or reducing the incidence of type 2 diabetes? Interventions were based on nutrition or physical activity education or diet modification sessions. Results showed an improvement in physical activity level and dietary restriction with $p = 0.03$, followed by a decrease in systolic blood pressure OR = - 4.65 mmHg (-9.18; - 0.12) with $p = 0.04$ and a decrease in diastolic blood pressure OR = -3.30 mmHg (- 5.35; 61, 26) with $p = 0.002$. In addition, maximum walking speed had increased by 15% compared to the control group. The results also showed a decreased risk of developing abnormal glucose metabolism OR = 0.52 (0.27; 0.99).

This systematic review could help to better guide type 2 diabetes prevention interventions in Africa.

Keywords: Type 2 Diabetes; Primary Prevention; Africa

Introduction

Type 2 diabetes is one of the fastest growing diseases in the world and the number of people affected is estimated to reach 700.2 million by 2045 [IDF 2019] with an increasing number of complications and deaths; 84.5% of these people live in low- and middle-income countries. The link between environmental factors (inadequate diet, physical inactivity, tobacco use and harmful alcohol consumption) and the occurrence of type 2 diabetes is well known [1]. Several interventions for people at risk for type 2 diabetes or with diabetes have shown encouraging results in reducing the time to onset of the disease or limiting complications [2-4]. In developed countries, interven-

tions in people at risk are based on dietary modification and/or physical activity [5,6]. In Africa these interventions are very little implemented. The purpose of this article is to review the results of the evaluation of the implementation of primary prevention interventions for type 2 diabetes in people at risk of type 2 diabetes in Africa in order to better guide interventions.

Methods

Data sources and research strategies

We conducted an electronic literature search in the PubMed, Scopus, Cochrane, African journal on line and ProQuest databases, limited to articles written in English or French and published within the last ten years. The process of selecting potential articles for this review was completed on June 15, 2020; the search question was stated using the PICO criteria (P for population, I for intervention, C for comparison group and O for expected outcome) (Figure 1). Table 1 shows the research equations used. The bibliography of studies included in this review was reviewed to identify any additional relevant articles.

Selection of studies

Original studies comparing the effects of a nutrition and/or physical activity intervention at the beginning and end of the intervention or including a control group were included in this review when they met the selection criteria detailed in table 2. Two authors (M-A C. M.

Database	Search equations
Pubmed	<p>(("Primary Prevention"[Mesh] OR "prevention and control"[MeSH Subheading] OR preventive[Text Word] OR prevention[Text Word]) AND ("Diabetes Mellitus, Type 2"[Mesh] OR "Ketosis-Resistant Diabetes Mellitus"[Text Word] OR "Non-Insulin-Dependent Diabetes Mellitus"[Text Word] OR "Stable Diabetes Mellitus"[Text Word] OR "Maturity Onset Diabetes Mellitus"[Text Word] OR "Noninsulin Dependent Diabetes Mellitus"[Text Word] OR "Maturity Onset Diabetes"[Text Word] OR "Type 2 Diabetes"[Text Word] OR "Adult- Onset Diabetes Mellitus"[Text Word]) AND ("Africa"[Mesh] OR Africa[Text Word] OR Algeria[Text Word] OR Angola[Text Word] OR Benin[Text Word] OR Botswana[Text Word] OR "Burkina Faso"[Text Word] OR Burundi[Text Word] OR Cameroon[Text Word] OR "Cape Verde"[Text Word] OR "Central African Republic"[Text Word] OR Comoros[Text Word] OR Congo[Text Word] OR "Ivory Coast"[Text Word] OR Djibouti[Text Word] OR Egypt[Text Word] OR Eritrea[Text Word] OR Eswatini[Text Word] OR Ethiopia[Text Word] OR Gabon[Text Word] OR Gambia[Text Word] OR Ghana[Text Word] OR Guinea[Text Word] OR Kenya[Text Word] OR Lesotho[Text Word] OR Liberia[Text Word] OR Libya[Text Word] OR Madagascar[Text Word] OR Malawi[Text Word] OR Mali[Text Word] OR Morocco[Text Word] OR Mauritius[Text Word] OR Mauritania[Text Word] OR Mozambique[Text Word] OR Namibia[Text Word] OR Niger[Text Word] OR Nigeria[Text Word] OR Uganda[Text Word] OR Rwanda[Text Word] OR "São Tomé and Príncipe"[Text Word] OR Senegal[Text Word] OR Seychelles[Text Word] OR "Sierra Leone"[Text Word] OR Somalia[Text Word] OR Sudan[Text Word] OR Tanzania[Text Word] OR Chad[Text Word] OR Togo[Text Word] OR Tunisia[Text Word] OR Zambia[Text Word] OR Zimbabwe[Text Word]) AND ("Adult"[Mesh] OR adult[Text Word] OR adults[Text Word])) AND filtres 10 ans.</p>
Scopus	<p>TITLE-ABS-KEY ((preventive* OR prevention OR preventif*) AND ("Ketosis-Resistant Diabetes Mellitus" OR "Non-Insulin-Dependent Diabetes Mellitus" OR "Stable Diabetes Mellitus" OR "Maturity Onset Diabetes Mellitus" OR "Noninsulin Dependent Diabetes Mellitus" OR "Maturity Onset Diabetes" OR "Type 2 Diabetes" OR "Adult- OR "Diabetes mellitus type 2" OR "Diabetes mellitus type II") AND (Africa OR Afrique OR Algeria OR Angola OR Benin OR Botswana OR "Burkina Faso" OR Burundi OR Cameroon OR "Cape Verde" OR "Central African Republic" OR Comoros OR Congo OR "Ivory Coast" OR Djibouti OR Egypt OR Eritrea OR Eswatini OR Ethiopia OR Gabon OR Gambia OR Ghana OR Guinea OR Kenya OR Lesotho OR Liberia OR Libya OR Madagascar OR Malawi OR Mali OR Morocco OR Mauritius OR Mauritania OR Mozambique OR Namibia OR Niger OR Nigeria OR Uganda OR Rwanda OR "São Tomé and Príncipe" OR Senegal OR Seychelles OR "Sierra Leone" OR Somalia OR Sudan OR Tanzania OR Chad OR Togo OR Tunisia OR Zambia OR Zimbabwe) AND (adult OR adults OR adults)) AND PUBYEAR > 2009.</p>

Cochrane	(preventive OR prevention) AND (“Ketosis-Resistant Diabetes Mellitus” OR “Non-Insulin-Dependent Diabetes Mellitus” OR “Stable Diabetes Mellitus” OR “Maturity Onset Diabetes Mellitus” OR “Non insulin Dependent Diabetes Mellitus” OR “Maturity Onset Diabetes” OR “Type 2 Diabetes” OR “Adult-Onset Diabetes Mellitus”) AND (Africa OR Algeria OR Angola OR Benin OR Botswana OR “Burkina Faso” OR Burundi OR Cameroon OR “Cape Verde” OR “Central African Republic” OR Comoros OR Congo OR “Ivory Coast” OR Djibouti OR Egypt OR Eritrea OR Eswatini OR Ethiopia OR Gabon OR Gambia OR Ghana OR Guinea OR Kenya OR Lesotho OR Liberia OR Libya OR Madagascar OR Malawi OR Mali OR Morocco OR Mauritius OR Mauritania OR Mozambique OR Namibia OR Niger OR Nigeria OR Uganda OR Rwanda OR “São Tomé and Príncipe” OR Senegal OR Seychelles OR “Sierra Leone” OR Somalia OR Sudan OR Tanzania OR Chad OR Togo OR Tunisia OR Zambia OR Zimbabwe) AND (adult OR adults)
ProQuest Central	(preventive OR prevention) AND (“Ketosis-Resistant Diabetes Mellitus” OR “Non-Insulin-Dependent Diabetes Mellitus” OR “Stable Diabetes Mellitus” OR “Maturity Onset Diabetes Mellitus” OR “Non insulin Dependent Diabetes Mellitus” OR “Maturity Onset Diabetes” OR “Type 2 Diabetes” OR “Adult-Onset Diabetes Mellitus”) AND (Africa OR Algeria OR Angola OR Benin OR Botswana OR “Burkina Faso” OR Burundi OR Cameroon OR “Cape Verde” OR “Central African Republic” OR Comoros OR Congo OR “Ivory Coast” OR Djibouti OR Egypt OR Eritrea OR Eswatini OR Ethiopia OR Gabon OR Gambia OR Ghana OR Guinea OR Kenya OR Lesotho OR Liberia OR Libya OR Madagascar OR Malawi OR Mali OR Morocco OR Mauritius OR Mauritania OR Mozambique OR Namibia OR Niger OR Nigeria OR Uganda OR Rwanda OR “São Tomé and Príncipe” OR Senegal OR Seychelles OR “Sierra Leone” OR Somalia OR Sudan OR Tanzania OR Chad OR Togo OR Tunisia OR Zambia OR Zimbabwe) AND (adult OR adults)
African Journal on Line	(preventive OR prevention) AND (“Ketosis-Resistant Diabetes Mellitus” OR “Non-Insulin-Dependent Diabetes Mellitus” OR “Stable Diabetes Mellitus” OR “Maturity Onset Diabetes Mellitus” OR “Non insulin Dependent Diabetes Mellitus” OR “Maturity Onset Diabetes” OR “Type 2 Diabetes” OR “Adult-Onset Diabetes Mellitus”) AND (Africa OR Algeria OR Angola OR Benin OR Botswana OR “Burkina Faso” OR Burundi OR Cameroon OR “Cape Verde” OR “Central African Republic” OR Comoros OR Congo OR “Ivory Coast” OR Djibouti OR Egypt OR Eritrea OR Eswatini OR Ethiopia OR Gabon OR Gambia OR Ghana OR Guinea OR Kenya OR Lesotho OR Liberia OR Libya OR Madagascar OR Malawi OR Mali OR Morocco OR Mauritius OR Mauritania OR Mozambique OR Namibia OR Niger OR Nigeria OR Uganda OR Rwanda OR “São Tomé and Príncipe” OR Senegal OR Seychelles OR “Sierra Leone” OR Somalia OR Sudan OR Tanzania OR Chad OR Togo OR Tunisia OR Zambia OR Zimbabwe) AND (adult OR adults)

Table 1: The search equations used in each database.

and S.C.) screened the studies and made the selection decision independently. The third author reviewed for discrepancies (A.C.S.) No discrepancies were reported.

Criteria for inclusion	Exclusion Criteria
Original article in English or French	Cross-sectional or clinical studies
Studies that provide explicit implementation of nutrition and/or physical activity intervention with human study population and control group.	Studies involving laboratory animals
Study population are African subjects at risk of type 2 diabetes or prediabetic or diabetic	Studies involving type 1 diabetics

Table 2: Study selection criteria.

Data extraction, evaluation and analyses of bias risks

Data were collected based on the study population, type of study, location of data collection, type of intervention, duration of the intervention and results obtained. These criteria for assessing study quality are detailed in table 3. The evaluation took into account selection bias, performance bias and attrition bias. A narrative synthesis was carried out on all the studies included and reported the key points on each of the elements studied in table 4.

Criteria for assessment	Methods adopted
Type of study	<ul style="list-style-type: none"> • Before and after (on the same population) • Here and elsewhere (one intervention group and one control group) • Before, after and here with an intervention group and a control group
Location of data collection	Africa
Study population	<ul style="list-style-type: none"> • People at risk for type 2 diabetes • Prediabetics • Diabetic subjects
Interventions	<ul style="list-style-type: none"> • Dietary changes • Cooking demonstration • Physical activity part
Results	<ul style="list-style-type: none"> • Measurement of behavioural risk factors • Measurement of biological risk factors • Measuring the Incidence of Type 2 Diabetes
Languages	French or English

Table 3: Criteria for assessing the quality of the selected studies.

Studies and years	Country	Duration of the intervention	Study population	Sample size	Intervention	The effects obtained
Pengpid, et al. 2014	Pretoria (South Africa)	36 months	Pre-diabetic church members with pre-hypertension	300 (150 per intervention and control group)	Since this study is a protocol, it was planned: - Formation of sub-groups of 6 to 8 people - 6 Two-hour counselling sessions led by health promoters for two weeks at intervals using manuals based on South African dietary guidelines and physical activity recommendations. - After each session home exercises are given to the participants so that each participant monitors their own behaviour and is expected to complete the food journal and record recommended physical activity schedules.	As this study is a protocol, the results will be based on baseline measurements prior to the intervention. Every 12 months of the intervention, a questionnaire is administered followed by anthropometric measurements, biological measurements (blood glucose and blood lipids) and clinical measurements (blood pressure).

R.W. Evans., <i>et al.</i>	South Africa (Cape Town)	12 weeks	Participants in this study are people selected from the community (people with a physical deformity and with two risk factors (based on the American College of Sport and Health stratification of CVD) are excluded.	25	27 two-hour physical activity sessions, two sessions per week.	<ul style="list-style-type: none"> -Increase in overall physical activity questionnaire score - Significant decrease in waist circumference (p = 0.001) - An improvement was also noted in the dietary restriction (p = 0.03).
M.A Siddiqui., <i>et al.</i> 2018	South Africa	Three months	Diabetic subjects in the hospital environment	95	Climbing 7,000 stairs per day while subjects in the control group should perform their usual activities.	Increased activity level with a mean of 7244.8 ± 1419.4 in the intervention group versus 3431.2 ± 1251.7 in the control group and a significant decrease in glycated hemoglobin level of 1.04% after three months of intervention
R.J. Mash., <i>et al.</i> 2014	South Africa	Four months	Randomly selected diabetics	866	Four 60-minute monthly nutrition education sessions for diabetic subject.	<ul style="list-style-type: none"> -Improving physical activity levels -Significant reduction in systolic OR = 4.65mmHg (-9.18; -0.12) and diastolic OR = -3.30 mmHg (-5.35; -1.26) blood pressure in diabetic patients in the intervention group compared to the control group at 12 months.
Porra-ta-Maury., <i>et al.</i> 2014	Ghana	21 days	Adults with diabetes in hospitals	23	Administration of "Ma-Pi 2" diet at breakfast, lunch, dinner and during snacks. The diet consists of: - 40-50% whole grains (whole grain rice, millet, barley) - 30 to 40% vegetables (carrots, chicory, red radish, onions, parsley, kale or broccoli, lettuce and chives°. 8 - 10% legumes (adzuki beans, chickpeas, lentils and black beans)	Blood sugar reduction, Lipid reduction, Urea reduction, Risk reduction, Cardiovascular, Increased urinary Ph.

Mvitu., <i>et al.</i>	Congo	6 months	Diabetic Patients	244	Administration of a WHO-adapted food frequency questionnaire with the STEPwise approach to inform patients about the number of vegetables and fruits rich in antioxidants, alcohol consumption and the use of cigarettes.	Consumption of red beans and antioxidant-rich vegetables was associated with a reduced risk of developing cataracts in diabetics. OR = 7.1(2.3; 22.2) with p = 0.001
T.J. Rambau., <i>et al.</i> 2015	Tanzania	12 weeks	Diabetic patients who should undergo total knee replacement surgery for their unilateral knee.	55	A progressive water resistance training program twice a week for 12 weeks.	Increase of the maximum running speed by 15% compared to the control unit. with P = 0.001 the power of the knee extensors and flexors on the osteoarthritis side has increased
N. Wennberg., <i>et al.</i> 2015	Mauritius	Six years	Diabetic Patients	804	High consumption of legumes	Decreased risk of abnormal glucose metabolism OR = 0.52 (0.27; 0.99)
Joan I.A. Comptbell-Toft., <i>et al.</i> 2010	Nigeria	Four months	Diabetic patients	23	Tea Consumption: Rauvolfia-Citrus	The reduction of fasting blood glucose by 10% and postprandial blood glucose by 11% and glycated hemoglobin by 6%.

Table 4: Status of studies included in the review.

Results

Figure 1 describes the bibliographic search procedure. Initially 347 articles were selected, of which 65 duplicates were eliminated. 284 articles were excluded on the basis of titles that did not meet the inclusion criteria. Following the eligibility criteria nine articles were finally selected (Figure 2).

Research question:

In at-risk or pre-diabetic individuals or those with type 2 diabetes, is adopting a healthy diet and/or regular physical activity so much more beneficial in delaying the onset of biologically modifiable risk factors or reducing the incidence of type 2 diabetes?

P = People at risk of diabetes or pre-diabetic or type 2 diabetic exposed to the intervention.

I = Any specific approach to dietary modification and/or regular physical activity.

C = Individuals at risk of diabetes or pre-diabetic or type 2 diabetes who have not had any dietary changes or a sedentary lifestyle.

O = Delay in the appearance of biological modifiable risk factors.

Figure 1: Search question based on PICO criteria.

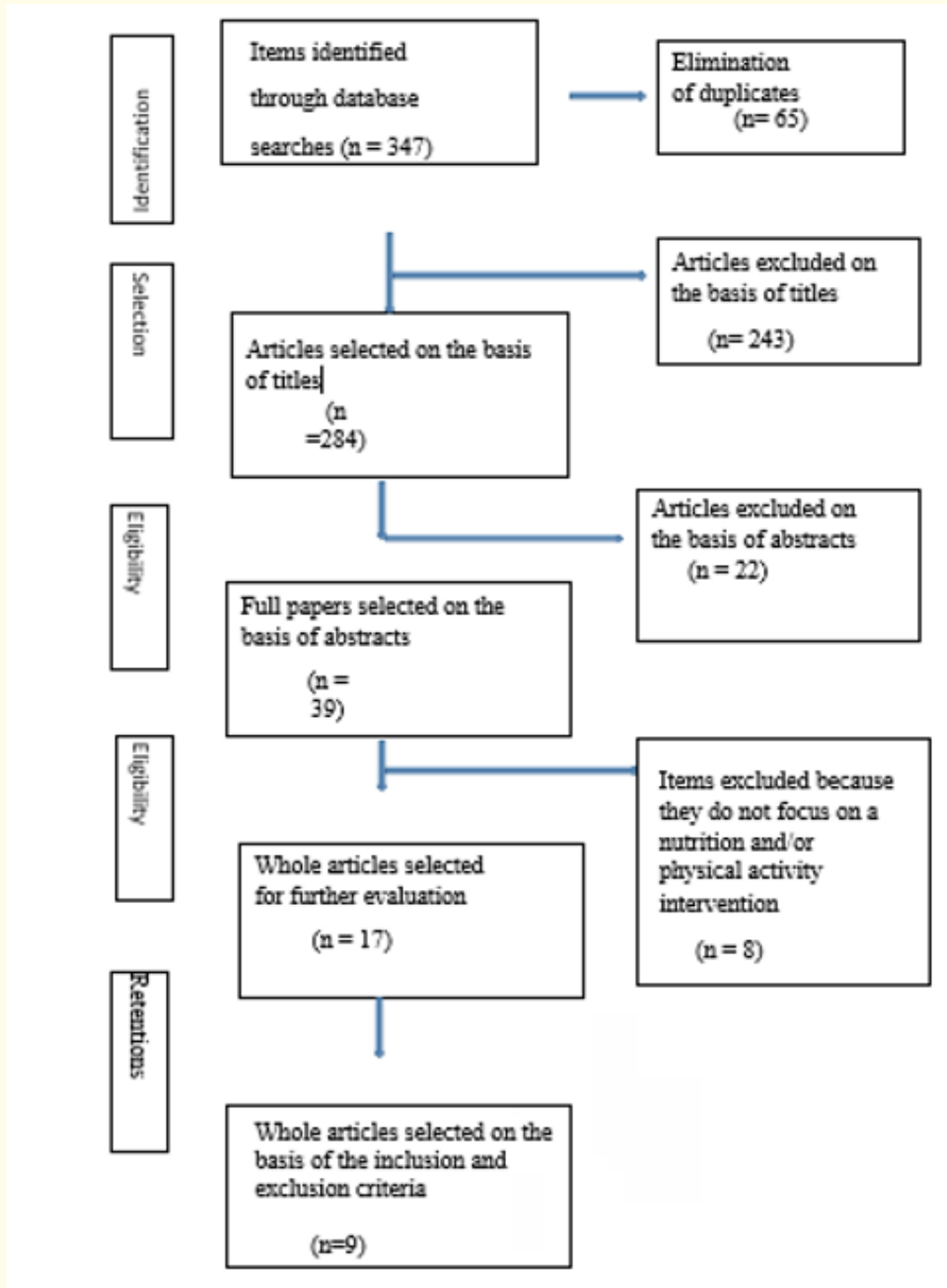


Figure 2: Flow chart for study selection.

Type of study

Three of the included studies were of the evaluative type here and elsewhere with two groups (intervention and control group), two are prospective before-after with the same group and four are prospective observational with two groups (one intervention and one control group).

Study population

Most of the studies (7 studies) involved diabetic subjects, only one study involved pre-diabetics. This study is a protocol so the study has not yet been carried out. Another study focused on subjects with a single risk factor, all the other studies focused on diabetics. All the subjects in this review are Africans.

Interventions carried out

The interventions can be summarized in three groups. The nutrition education group, the physical activity group and the diet modification group.

Nutrition education

The intervention in R.J. Mash's study consisted of four 60-minute monthly nutrition education sessions in diabetic subjects. These nutrition education sessions focused on the definition of diabetes, healthy lifestyle, medication and avoidance of complications.

In the Pengpid study, which is a published protocol, the planned intervention consisted of 6 two-hour counselling sessions every week. After each session, home exercises should be given to the participants so that each participant could monitor his or her own behaviour and complete the food diary and note the recommended physical activity schedules.

Physical activities

The R. W. Evans study conducted 27 60-minute physical activity sessions ranging from moderate to intense activity with some healthy lifestyle counseling poses.

For the participants of the intervention group of the T.J. Rambau study, coaching of water resistance exercises of two sessions per week for 12 weeks was carried out while the control group performed the usual activities.

For the M. A. Siddiqui study, subjects in the intervention group were expected to climb 7,000 stairs per day while subjects in the control group performed their usual activities.

Diet modification

The Porrata-Maury Study had administered the "Ma-Pi 2" diet at breakfast, lunch, dinner and snacks. The diet consists of 40 - 50% whole grains, 30 - 40% vegetables, 8 - 10% legumes, ground sesame seeds roasted with sea salt and fermented products, seaweed and caffeine-free worm tea.

Mvitu's study had shown that consumption of vegetables rich in antioxidants protected against cataract formation in diabetics.

In Wennberg's study in Mauritius, the intervention consisted of high consumption of legumes which reduced the risk of abnormal glucose metabolism.

In addition, taking tea: *Rauvolfia-Citrus* on a regular basis in Nigeria, has shown in obese people with type 2 diabetes, a significant improvement of the glycemic and lipid profile after four months of intervention.

Results obtained after the different interventions of the included studies

Among the studies reviewed, nutrition education significantly reduced systolic and diastolic blood pressure in diabetic patients in the intervention group compared to the control group at 12 months. The odds ratios were 4.65 mmHg (-9.18; 0.12) with $p = 0.04$ and -3.30 mmHg (-5.35; -1.26) with $p = 0.002$ [7]. With regard to physical activity, systolic and diastolic blood pressure was significantly reduced in the intervention group and the level in the three studies that included physical activity [8-10]. In addition, the activity level increased by 7244.8 ± 1419.4 in the intervention group compared to 3431.2 ± 1251.7 in the control group [8,10] and the glycated hemoglobin level was significantly reduced by 1.04% with $p = 0.001$ after four months of intervention [10]. As for the modification of the diet, a reduction in blood glucose, lipidemia, urea and cardiovascular risk, then an increase in urinary Ph $p < 0.001$ after 21 days of intervention on the same diabetic subjects [11]. In addition, a decrease in the risk of abnormal glucose metabolism was observed after six years in the OR = 0.52 (0.27; 0.99) study [12]. Similarly in diabetic subjects, after four months of intervention, there was a 6% reduction in glycated hemoglobin levels, an improvement in the lipid profile and insulin sensitivity on the one hand, and a 10% reduction in fasting and 11% reduction in post-meal blood glucose levels on the other hand [13].

Discussion

This review is one of the first to take stock of nutritional and/or physical activity interventions implemented to prevent diabetes or reduce risk factors for the disease in African countries. Several studies have confirmed the protective effects of nutrition and/or physical activity interventions in people at risk [14] for diabetes or suffering from diabetes [15]. Therefore, it is important to take stock of interventions for better guidance in the control of type 2 diabetes given the significant increase in the number of cases and projections in the African region.

Study population

All studies were conducted in pre-diabetic or already diabetic adults, no studies included subjects at risk of diabetes with a screening score. Sample sizes ranged from 23 to 300 subjects randomly selected from hospitalized; or pre-diabetic church members. Studies on subjects at risk for diabetes are needed to better control the progression of the disease.

Intervention

Interventions are mostly based on dietary modification. The study in Ghana [11] changed the diet. The South African study was based on theory sessions based on South African dietary and physical activity recommendations [16]. In addition, only one study regularly monitored the activities of its intervention [11]. It would be desirable to provide practical support to people at risk of diabetes in nutrition education, cooking demonstrations and physical activity sessions on a sustained basis with a control group to evaluate the real effect of the intervention. In Northern countries where the projections of high prevalence of diabetes are lower than in the African Region [17], nutrition education interventions coupled with physical activity have shown an improvement in the risk factors for type 2 diabetes and even in the incidence of the disease.

The results obtained

Among the studies reviewed, dietary modification was beneficial in reducing venous blood glucose, blood lipids and increasing urinary pH [11]. These beneficial effects have been demonstrated in several studies in northern countries [18]. This is justified by the ingestion of carbohydrates is crucial in the management of type 2 diabetes as they are involved in the post-meal glycaemic response. In addition, the presence of certain micronutrients (magnesium, manganese, zinc, chromium) improves glucose metabolism and cell sensitivity to insulin [19]. As for physical activity, most of the appreciated studies showed an improvement in systolic and diastolic blood pressure. It would therefore be desirable to combine physical activity with diet in adult African populations in order to evaluate the effect. There is increasing evidence that physical activity improves metabolism, insulin sensitivity and reduces inflammatory markers in diabetics [20]. We found that no intervention had been performed in subjects at risk. Early intervention improves glycemic and lipid status more rapidly, thereby preventing the onset of the disease. It would then be desirable to undertake research in this direction.

Assessment of study biases

The evaluation took into account selection bias, performance bias and attrition bias.

Selection bias

Several studies were not randomized [8,10,11,21]. Participants were selected on the basis of inclusion and exclusion criteria. This non-randomized selection could bias the results and the representativeness of the participants.

Performance bias

The intervention is known by the participants and the investigator in several studies. Only one study used double-blinding [13]. The practice of new lifestyle approaches requires prior sensitization of participants to create a climate of trust. This may account for the fact that the majority of interventions are not masked.

Attrition bias

Studies have shown fewer participants after the intervention compared to the number of subjects selected at baseline. This constitutes a bias for the study, but the interventions took place over a longer or shorter period of time, which would have resulted in cases being lost to follow-up. In addition, family or professional constraints may slow down the rate of engagement or even lead to the abandonment of the interventions.

Limitations of the included studies

- The minimum sample size for drawing conclusive conclusions is at least 30 participants.
Three studies [8,11,21] had sample sizes below 30.
- No study actively followed up subjects during the interventions, and under these conditions it is easier to abandon newly acquired practices.
- It was difficult to hide the interventions as they were focused on changing eating habits and lifestyle.

Conclusion

In summary, improving the diet of people with diabetes is beneficial in the management of diabetes. This indicates that when the diet is more alkalinizing, it reduces triglycerides, LDL cholesterol and increases urine pH, thus decreasing the deleterious effects of the disease. This review has shown that for the last ten years no nutritional intervention studies have combined diet, culinary demonstrations and physical activity. Additional studies would be desirable to support this statement.

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