INC22-001

Effectiveness of Different Physical Activities Toward Glycemic Control in Prediabetes Mellitus Clients in Semarang Municipality

Arwani[1], Budi Widiyanto[2], Sri Widiyati[3]
[123]) Diploma IV of Nursing - Semarang
Department of Nursing – Politeknik Kesehatan Kemenkes Semarang
Jl. Tirto Agung Pedalangan Banyumanik Semarang
Corresponding author: arwani_arwani@ymail.com

ABSTRACT

Introduction – Currently, the prevalence rate of diabetes mellitus in Indonesia based on relevant diagnoses or symptoms reaches 2.1%, and it is estimated that by 2030 the number of people suffering from diabetes mellitus will reach 21.3 million. The case of diabetes mellitus in Central Java ranks second for non-communicable diseases after hypertension with the number of cases which tends to increase every year. On the other hand, the number of people with prediabetes also shows a number that tends to increase. The proportion of people with prediabetes is 2-4 times higher than the proportion of people with diabetes. One of the prevention efforts is through physical activity. Several studies have shown that physical activity has a significant effect on glycemic control. The study aimed to determine the effectiveness of giving different physical activities to glycemic control in prediabetic clients in Semarang municipality.
Methods – A randomized control trial (RCT) with a pretest-posttest design was conducted on 60 prediabetic clients using different treatments (healthy / slow walking, brisk walking, combination of both slowly and brisk walking). Random allocation was conducted to determine the research sample in each group. An initial measurement (pretest) of glycemic control was carried out using an indicator of HbA1c levels and was remeasured (posttest) after treatment for 3 months. Research Data were analyzed using univariate, bivariate, and multivariate analysis.
Results – The average level of glycemic control (HbA1c levels) before the intervention in the healthy walking group was 5.57% and decreased to 5.46% after the intervention; the combination group decreased from 5.93% to 5.78%, and in the slowly walking group decreased from 5.74% to 5.71%. However, there was no significant effect of slowly walking on glycemic control (HbA1c levels). Meanwhile, brisk walking and combination of slowly walking and brisk walking had a significant effect on glycemic control (HbA1c levels) ($p<0.05$).
Conclusion – The combination of physical activity group (brisk walking and slowly walking) has a better effect on glycemic control (HbA1c levels), compared to the slowly walking group, and brisk walking group.

Keywords: physical activity, slow walking, speed walking, combination, prediabetes, glycemic control

Introduction

Nowadays, diabetes mellitus becomes global health problem. Epidemiologically, the prevalence of people with diabetes mellitus at all ages in 2000 was 2.8% and is estimated to increase to 4.4% in 2030 (Wild et al., 2004). People with diabetes mellitus in 2035 are estimated to increase almost twice from 2030, which is as many as 592 million cases (Malik, et al., 2006). According to the WHO report there were 422 million people worldwide suffering from diabetes mellitus, and a prevalence of 8.5% occurred in the adult age group (WHO, 2016).

In Indonesia, the prevalence rate of diabetes mellitus based on relevant diagnoses or symptoms is 2.1% (Kemenkes RI, 2014), and it is estimated that in 2030 the number of people with diabetes mellitus will increase to 21.3 million (Kemenkes RI, 2014). In Central Java, based on the report of the 3rd quarter of 2015 of the Provincial Health Office of Central Java, diabetes mellitus ranks second to non-communicable diseases after hypertension with the number of cases which tends to increase every year, which is 110,860 cases in 2013 and increasing to 121,203 cases in 2014 (Semarang Municipality Health Office, 2015). On the other hand, the number of people with prediabetes also shows a number that tends to increase. There was an increase in the prediabetes population from 11.6% in 2003 to 35.3% in 2011.

Prediabetes is an important factor related to metabolic conditions that predispose individuals to a high probability of developing diabetes. Individuals with prediabetes have a high risk for pathological disorders such as diabetic retinopathy, neuropathy, nephropathy, and macrovascular complications (Tabak, et al. 2012). The results showed that the prevalence of diabetic retinopathy was 7.9% (Diabetes Prevention Program

Research Group, 2007), and the prevalence of peripheral neuropathy was higher in individuals with prediabetes than in individuals based on normal glucose tolerance (Lee et al. 2015). Prediabetes also increases the risk of chronic kidney disease (CKD) cardiovascular disease, coronary heart disease, and stroke (Hostalek, 2019).

Healthy behavior for people with diabetes mellitus who require long-term care is important. The health behavior recommended by WHO to manage diabetes mellitus effectively is the behavior of controlling sugar levels (glycemic control) to keep it stable (WHO, 2016). Long-term control of glucose concentration which is relatively stable is carried out through examination of HbA1c levels which can be used as material for treatment planning. Good glycemic control (A1c < 7%) provides benefits for people with type 2 diabetes mellitus. heart disease by 78% (Skyler, 2004; Clement, Bhattacharyya, & Conway, 2009). On the other hand, poor glycemic control can cause death in elderly people with type 2 diabetes mellitus.

Stability of sugar levels in people with type 2 diabetes mellitus can be performed in various ways, including through physical activity. Several research results show that there is a relation between physical activity and type 2 diabetes mellitus. Patients with type 2 diabetes mellitus who participate in self-management training for type 2 diabetes mellitus have an impact on the level of knowledge, frequency and accuracy of self-monitoring of blood sugar, and self-reporting behavior eating habits (diet) (Colberg, et al., 2010). Other studies have shown that people with type 2 diabetes mellitus who engage in regular physical activity have a positive impact on preventing the development of Impaired Glucose Tolerance (IGT) into type 2

diabetes mellitus (Sigal, et al., 2006). Similar studies also concluded that people with type 2 diabetes mellitus who perform physical activity in the form of aerobic (aerobic exercise) and resistance training (resistance training), both increase insulin sensitivity (Burr, et al., 2015). Increased insulin sensitivity will have an impact on decreasing the concentration of blood glucose levels in people with type 2 diabetes mellitus (Borghouts & Keizer, 1999).

Lack of physical activity, especially for people with type 2 diabetes mellitus, will have a negative impact on the health status of people with diabetes mellitus. Physical activity that is carried out irregularly will increase the risk of diabetes mellitus, and if this continues for a long time it will lead to unwanted complications of diabetes mellitus such as increased heart disease and stroke, neuropathy in the legs which can lead to gangrene of diabetes mellitus and amputation, diabetic retinopathy which leads to blindness and kidney failure. Conversely, if physical activity is carried out regularly, it will generally have a positive impact on blood sugar levels (glycemic control) and can prevent diabetes mellitus (Kemenkes RI, 2014). The impact of regular physical activity or exercise can also be seen from the level of Hemoglobin A1c (HbA1c) which is below the value of 48 mmol/mol (6.5%) (d'Emden, et al., 2015). This is understandable because HbA1c is formed by glycation of the N-terminal valine in the beta chain in hemoglobin, a non-enzymatic reaction occurring in red blood cells. So that the more glucose in the bloodstream, the higher the HbA1c value (Mahajan & Mishra, 2011).

Physical activity can be performed in various ways. In general, physical activity can be implemented in 3 ways: light-intensity physical activity, moderate-intensity physical activity, and vigorous-intensity physical activity (WHO, 2010). Light-intensity

physical activity is physical activity that requires light effort, such as walking slowly, sitting, standing, fishing, and playing music. Moderate-intensity physical activity is physical activity that requires sufficient effort and significantly increases the heart rate. Examples of this type of physical activity are brisk walking, dancing, gardening, housework, painting the walls of the house, installing tiles, moving items < 20 kg. Meanwhile, vigorous-intensity physical activity is physical activity that requires more effort and causes breathing and heart rate to increase significantly. This type of activity can be done by running, walking on an incline, cycling quickly, aerobics, swimming, and carrying / moving objects > 20 kg.

Methods

This study was a randomized control trial (RCT) using a pretest – posttest design, conducted on 60 prediabetic clients with different treatments (slowly walking, brisk walking, combination of both slowly and brisk walking). Random allocation was conducted to determine the research sample in each group. An initial measurement (pretest) of glycemic control was carried out using an indicator of HbA1c levels and was measured for the second measurement (posttest) after treatment for 3 months. The total sample was prediabetes clients who is literate, lived with their families, became active participants in PROLANIS program, and participated in the entire series of studies. Clients who suffer from chronic kidney failure, suffer from anemia (Hb levels below normal values), and refuse to participate were excluded from the study. Data analysis was performed by univariate, bivariate, and multivariate analysis.

Results and Discussion

1. Univariat Analysis

1) Characteristics of samples

Tabel 1 Characteristics of samples

Characteristics	Physical Activity															*p*
	Brisk Walking					Combination					Slowly Walking					
	n	Min	Max	Mean	SD	n	Min	Max	Mean	SD	n	Min	Max	Mean	SD	
Age	20	21	52	39,4	9.93	20	23	52	40.1	7.19	20	48	41.2	5.24		0.756*
HbA1c	20	4.3	6.2	5.6	0.54	20	5.7	6.3	5.9	0.20	20	6.2	5.7	0.52		0.045*
Education																
Elementary School	2	10%				4	20%				4	20%				0.045**
Primary School	3	15%				5	25%				2	10%				
Secondary School	9	45%				9	45%				12	60%				
Tertiary School	6	30%				2	10%				2	10%				

*one-way Anova **Fisher Exact

Table 1 illustrates that in general the characteristics of the study samples in the three study groups were comparable (homogeneous), except for the HbA1c level.

2. Bivariat Analysis

1) HbA1c development (before and after doing activities)

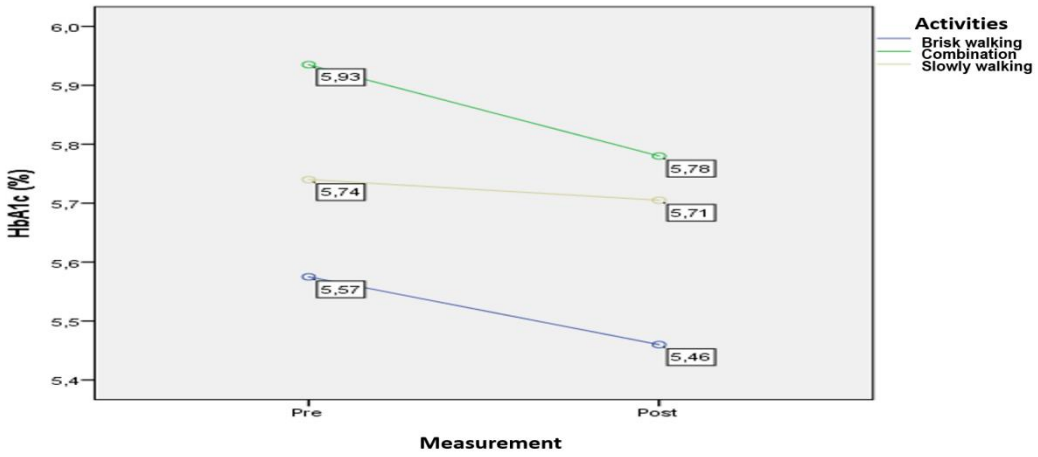

Figure 3. HbA1c development (before and after doing activities)

Figure 3 shows that the three groups had different initial HbA1c levels (pretest), and this situation affected the post-test HbA1c levels. In such circumstances, in measuring the effect of brisk walking activity and the combination of slowly walking and Brisk walking compared to slowly walking, there will be an overestimation. Therefore, to measure the exact effect, it is necessary to control the initial HbA1c data.

2) Effectiveness of Physical Activity in Lowering HbA1c

Table 3. Effectiveness of Physical Activity in Lowering HbA1c

Activities	B	Std. Error	t	p	95% Confidence Interval		Partial Eta Squared
					Lower Bound	Upper Bound	
Brisk walking	-0,25	0,14	-1,76	0,084	-,524	,034	5%
Combination	0,07	0,14	0,54	0,593	-,204	,354	1%
Slowly walking	Reference Group						

Activities	B	td. Error	t	*p*	95% Confidence Interval		'artial Eta Squared
					Lower Bound	Upper Bound	
:isk Walking	-0.25	0.14	-1.76	0.084	-.524	.034	5%
ombination	0.07	0.14	0.54	0.593	-.204	.354	1%
owly Walking	eference group						

The results of this analysis are provisional, because the magnitude of the effect is still disturbed by the pre HBA1c data. Therefore, the effect analysis must be controlled by pre HbA1c data with multivariate tests, in order to obtain the right amount of activity effect.

3. Multivariat analysis

1) HbA1c development before and after doing activities

The development of HbA1c levels in patients with Type 2 Diabetes Mellitus (DM) before and after carrying out activities in the three groups after controlling for pre HbA1c data can be seen in Figure 4.

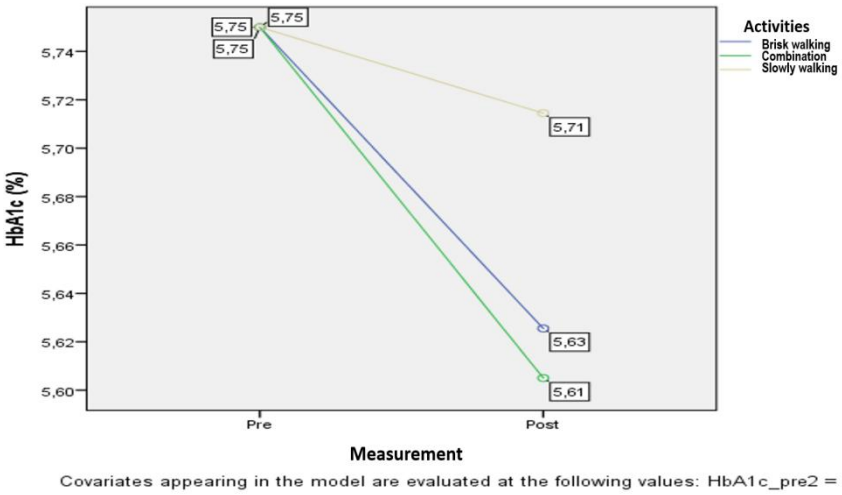

Figure 4. HbA1c development before and after doing activities

Figure 4 shows that after the control was carried out through analysis of the pre HbA1c data, the initial HbA1c data appeared to be in the same condition at the position of the HbA1c level of 5.75. In the brisk walking group, HbA1c was reduced to 5.61; Likewise, the combination group (brisk walking and slowly walking) can reduce HbA1c to 5.63; while in the slowly group it can only decrease by 5.71. From the three treatments, it appears that the brisk walking group and the combination group (brisk walking and slowly walking) were able to lower HbA1c which was greater than that of the leisurely walking group.

2) The Effectiveness of Physical Activity in Lowering HbA1c

Table 4. Effectiveness of Physical Activity in Lowering HbA1c

Activities	B	Std. Error	t	p	95% Confidence Interval		Partial Eta Squared
					Lower Bound	Upper Bound	
Brisk walking	-0,09	0,04	-2,09	0,041	-,174	-,004	7%
Combination	-0,11	0,04	-2,56	0,013	-,195	-,024	11%
Slowly walking	Reference group						

Activities	B	Std. Error	t	*p*	95% Confidence Interval		Partial Eta Squared
					Lower Bound	Upper Bound	
risk Walking	-0.09	0.04	-2.09	0.041	-.174	-.004	7%

ombination lowly Walking	0.11 eference group	0.04	-2.56	0.013	-.195	-.024	11%

Table 4 shows that patients with pre-diabetes mellitus (DM) type 2 who did brisk walking were able to lower their HbA1c by 0.09 compared to patients with Diabetes Mellitus (DM) type 2 who took a slowly walking, and the decrease was statistically significant (p=0.041). Doing brisk walking can reduce HbA1c by 7%. Even type 2 Diabetes Mellitus (DM) patients who did a combination of brisk walking and slowly walking were able to lower their HbA1c by 11% compared to Type 2 Diabetes Mellitus (DM) patients who took a slowly walking alone, and the decrease was statistically significant (p=0.013).

A. Discussion

1. Effect of Physical Activity on HbA1c Levels

The results showed that in the three study groups there was a decrease in HbA1c levels after physical activity. In the brisk walking group, the HbA1c can be reduced to 5.61, as well as the combination walking and brisk walking group can reduce the HbA1c to 5.63. while in slowly walking alone group can only decrease by 5.71. From the three treatments, it appears that the brisk walking group and the combination group (brisk walking and slowly walking) were able to lower HbA1c which was greater than that of the slowly walking group.

The results showed that physical activity was able to have a significant effect on glycemic control or HbA1c levels (Sigal, et al., 2006). Regular physical activity or exercise will reduce the level of HbA1c formed by the glycation of N-terminal valine in the beta chain in hemoglobin which will become more normal in

levels due to the decrease in blood glucose levels as a result of using it for energy when doing physical activity (Mahajan and Mishra, 2011).

Physical activity is all forms of body movement as carried out in this study (slowly walking, brisk walking, and a combination of both) produced from skeletal muscles that require energy expenditure. When a person does physical activity, there will be a process of hydrolysis of ATP to produce energy. Hydrolysis of 1 mole of ATP in muscle tissue will produce energy of 31kJ (7.3 kcal), and will produce other products in the form of ADP (Adenosine diphosphate) and Pi (inorganic phosphate). During physical activity, there are three energy metabolism pathways that can be used by the body to produce ATP, namely hydrolysis of phosphocreatine (PCr), anaerobic glycolysis of glucose, and burning of stored carbohydrates, fats and proteins (Irawan, 2007). This condition allows glucose reserves in the blood to be taken to meet the energy needed in the process of physical activity. The heavier the physical activity, the greater the use of energy reserves.

The results of this study indicate that the lowest ability to reduce HbA1c levels is in the group of leisurely walking physical activity. Casual walking is included in the category of light-intensity physical activity, namely physical activity that requires light effort that does not cause the respiratory and heart rates to increase significantly when compared to moderate-intensity physical activity and vigorous-intensity physical activity (WHO, 2010). 2010). While brisk walking physical activity and the combination of brisk walking and leisurely walking are physical activities that have a significant impact on the use of the body's energy stores, namely carbohydrate stores

(blood glucose, muscle and liver glycogen), and fat stores in the form of triglycerides to contribute to the rate of energy production in the body. in the body (Irawan, 2007). This condition has a direct impact on the use of energy sources including blood sugar levels so that it has an impact on the value or level of glycemic control, namely HbA1c levels.

2. The Most Effective Physical Activity in Lowering HbA1c Levels

The results of the study showed that the physical activity of a healthy walk and a combination of a healthy walk and a leisurely walk had a better effect on HbA1c levels than leisurely walking. In this study, it was found that patients with pre-diabetes mellitus (DM) type 2 who did brisk walking were able to significantly reduce HbA1c levels by 7% compared to patients with pre-diabetes mellitus (DM) type 2 who did a leisurely walk. Likewise, patients with pre-diabetes mellitus (DM) type 2 who did a combination of brisk walking and leisurely walking were able to significantly reduce HbA1c levels by 11% compared to patients with pre-diabetes mellitus (DM) type 2 who did a slowly walking alone.

The results of this study concluded that although brisk walking physical activity and a combination of brisk walking and leisurely walking both significantly affected HbA1c levels, combined physical activity gave a better effect because it was able to lower HbA1c levels higher than brisk walking.

Combination activities of brisk walking and slowly walking are carried out by combining physical activities of walking-slowly and brisk walking which are carried out for 4 weeks with details on day 1, 2, 3, and 4 with the duration of each -each day for a minimum of 25 minutes for normal/slowly walking and days 5, 6 and 7 with a minimum time duration of 25 minutes for each

day for brisk walking. This method has an impact on the process of burning carbohydrates as a process of energy metabolism from blood glucose or muscle glycogen from the consumption of carbohydrates consumed. The glucose formed is stored as energy reserves as glycogen in the liver and muscles and can be stored in the bloodstream as blood glucose or can also be carried into the body's cells that need it. Blood glucose or from muscle glycogen will undergo a glycolysis process that can produce ATP molecules, where as many as 2 ATP molecules can be produced if the source of glucose comes from blood glucose and as many as 3 ATP molecules if the glucose comes from muscle glycogen (Irawan, 2007). The process can be achieved well when a person performs regular physical activity such as brisk walking.

In the combination group, physical activity was also given a leisurely walk. This combination of physical activity will provide a comfortable feeling after the person concerned does physical activity that is sufficient to trigger heart and respiratory rates. This comfortable feeling allows a person to feel unburdened by physical activity so that it triggers stress which can affect blood sugar levels that rise. The accumulation of high blood sugar levels in the blood vessels will give an idea of higher HbA1c levels (Iemitsu et al., 2016).

B. Research Limitation

Many factors have an influence on glycemic control (HbA1c levels), but in this study it was not possible to completely control these factors, including: behavior in carrying out a special diet, drinking alcohol, and also body mass index (BMI). Another factor that was not controlled in this study is the forms of family support that may have an influence on the pattern of physical activity

carried out even though in this study it was controlled with SOPs for physical activity.

Conclusion and Recommendation

The average picture of glycemic control (HbA1c levels) before the intervention in the healthy walking group was 5.57% and decreased to 5.46% after the intervention; the combination group from 5.93% to 5.78%, and in the leisurely walking group from 5.74% to 5.71%. There was no significant effect of leisurely walking physical activity on glycemic control (HbA1c levels), and there was a significant effect of both brisk walking physical activity or combined physical activity (fast walking and slowly walking) on glycemic control (HbA1c levels). The combination physical activity group (brisk walking and slowly walking) had a better effect on glycemic control (HbA1c levels), compared to the slowly walking group.

Acknowledgement

We would like to thank the Director of Politeknik Kesehatan Kemenkes Semarang, the Head of Nursing Department, the Head of Semarang Nursing D IV Study Program for the support, the head of Semarang City Srondol Health Center, and the head of Banyumanik Village, as well as all health cadres.

References

Borghouts LB, Keizer HA. (1999). Exercise and Insulin Sensitivity : A review. *Int J Sports Med*, *20*, 1–12.

Bonita R, Beaglehole R, Kjellstrom T. (2006). *Basic epidemiology*. 2nd Ed., World Health Organisation.

Burr JF, Rowan CP, Jamnik VK, Riddell MC. (2015). The role of physical activity in type 2 diabetes prevention: Physiological and practical perspectives. *The Physician and Sportmedicine*, *38*(1), 72–82. https://doi.org/10.3810/psm.2010.04.1764

Clement M, Bhattacharyya O, Conway JR. (2009). Is tight glycemic control in type 2 diabetes really worthwhile? Yes. *Canadian Family Physician Medecin de Famille Canadien*, *55*(6), 580–588.

Colberg SR, Sigal RJ, Fernhall B, Regensteiner JG, Blissmer BJ, Rubin RR, Chasan-Taber L, Albright AL, B. B. (2010). Exercise and type 2 diabetes. *Diabetes Care*, *33*(12), 2692–2696. https://doi.org/10.2337/dc10-1548

d'Emden MC, Shaw JE, Jones GR, Cheung NW. (2015). Guidance concerning the use of glycated haemoglobin (HbA1c) for the diagnosis of diabetes melitus. *MJA*, *203*(July), 89–91. https://doi.org/10.5694/mja15.00041

Dinas Kesehatan Kota Semarang. (2015). *Profil kesehatan kota Semarang*. Dinkes Kota Semarang.

Iemitsu K, Iizuka T, Takihata M, Takai M, Nakajima S, et al. (2016). Factors influencing changes in hemoglobin A1c and body weight during treatment of type 2 diabetes with ipragliflozin : Interim analysis of the ASSIGN-K study. *J Clin Med Res*, *8*(5), 373–378.

Irawan MA. (2007). Metabolisme energi tubuh & olehraga. *Sport Science Brief.* 01(07), 1-9.

Kementerian Kesehatan RI. (2014). *Waspada diabetes: Situasi dan analisis diabetes mellitus*. Jakarta.

Mahajan RD; Mishra B. (2011). Using glycated hemoglobin HbA1c for diagnosis of diabetes mellitus : An Indian perspective. *International Journal of Biological & Medical Research*, *2*(2), 508–512.

Malik S, Basit R, Naz S, Mawani M, Masood MQ, Akhte J. (2006). Adherence to lifestyle advice and treatments in Pakistani patients with type 2 diabetes mellitus. *Journal of Diabetes Mellitus*, 6, 49-57.

Sigal RJ, Kenny GP, Wasserman DH, Castaneda-Sceppa C. (2006). Physical activity / exercise and type 2 diabetes: A concensus statement from the American Diabetes Association. *Diabetes Care*, *6*, 1433–1438. https://doi.org/10.2337/dc06-9910

Skyler JS. (2004). Effects of Glycemic Control on Diabetes Complications and on the Prevention of Diabetes. *Clinical Diabetes: A Publication of the American Diabetes Association*, *22*(4), 162.

WHO. (2003). *Adherence to long-term theraphies*. Switzerland: WHO Library Catalouging-in-Publication Data.

WHO. (2010). *Global recommendations on physical activity for health*. Switzerland.

Wild S, Roglic G, Green A, Sicree R, King H. (2004). Global prevalence of diabetes: Estimates for the year 2000 and projections for 2030. Diabetes Care, 27(5), 1047-53.