

## **EFFECT OF WALKING EXERCISE ON CONTROLLING BLOOD GLUCOSE LEVEL AND BODY MASS INDEX AMONG GESTATIONAL DIABETIC WOMEN**

**Enas Sabry Fathy Elbeltagy, Nahed Fikry Hassan khedr, Nadia Youssef Ahmed Abd-Ella**

*Woman's Health and Midwifery Nursing Dep. Faculty of Nursing, Mansoura University, Egypt*

*Corresponding author: prof. Dr. NahedFikryKhedr*

*Email: [dr.nahid2020@hotmail.com](mailto:dr.nahid2020@hotmail.com)*

### **Abstract:**

**Background:** Gestational Diabetes Mellitus (GDM) is one of the most common medical health problems that may occur during pregnancy and may lead to a range of short and long-term maternal, fetal as well as neonatal complications. However, recent researches have revealed that, walking exercise has been considered as a 'gold standard' in controlling blood glucose level and body mass index among gestational diabetic women. **Aim:** The study was conducted to evaluate the effect of walking exercise on controlling blood glucose level and body mass index among gestational diabetic women. **Subjects and method:** A quasi-experimental study design was utilized at Antenatal Clinic of Obstetric and Gynecological Specialty Center at Mansoura University Hospitals, Mansoura city. A purposive sample conducted on 126 pregnant women diagnosed with gestational diabetes mellitus, The study sample was divided into two groups, intervention group (n= 63): practiced walking exercise in addition to routine antenatal care and control group (n= 63): followed routine antenatal care only. **Tools:** Two tools were used to collect data from participants as a structured interview schedule and maternal assessment record. **Results:** The current study results indicated that, there was a highly statistical significant reduction of body mass index and the mean random blood glucose levels at 34 & 37 weeks' of pregnancy after intervention in the walking exercise group than control group ( $p < 0.001$ ). **Conclusion and Recommendations:** This study showed that, pregnant women with gestational diabetes mellitus who practiced walking exercise had improved blood glucose level and body mass index than those who did not. It is recommended that, pregnant women with gestational diabetes mellitus should practice walking exercise during pregnancy as one of the significant modalities to improve blood glucose level and body mass index.

**Keywords:** Gestational Diabetes Mellitus, Walking Exercise, Blood Glucose Level, Body Mass Index

### **I. Introduction**

Pregnancy and childbirth are considered as a normal physiological condition that occurs in all women. Approximately, about 10% of pregnant women are at risk to develop maternal and fetal health problems during pregnancy such as pregnancy induced hypertension (PIH), eclampsia, hyperemesis gravidarum and gestational

diabetes mellitus. Thus, requires serious life modification as well as special care during pregnancy and childbirth (*Elbeltagy, Hassan & Khedr, 2017*).

Gestational Diabetes Mellitus (GDM) is a diabetes type which defined as any degree of glucose intolerance or abnormal glucose metabolism with the onset or first recognition during

pregnancy and usually resolves after birth. This definition can include women with previously undiagnosed diabetes as well as those who become transiently hyperglycemic because of pregnancy-induced insulin resistance (**Mukerji, Bacon & Feig, 2020**).

The prevalence of GDM increases rapidly especially among women over the age of 35 years. There were an estimated 204 million women worldwide had GDM. This number is predictable to increase to 308 million by 2045. Furthermore, there were about 21.3 million or 16.2% of live births suffering from hyperglycemia during pregnancy due to gestational diabetes, about one to seven of them are affected by GDM (**Wang & Tingting, 2019; Khanpaye et al., 2019**).

The exact causes of GDM are still unclear but there are several risk factors that lead to the GDM among pregnant women as maternal age over 30 years, high parity, family history of diabetes in a first degree relatives, previous GDM, obesity, prior macrosomic baby (<4.5 kg), malformed & unexplained fetal/perinatal loss, recurrent vaginal candidiasis and repeated miscarriage (**Craig, Sims, Glasziou & Thomas, 2020**).

Gestational diabetes mellitus does not cause any noticeable signs or symptoms, but some women with GDM rarely demonstrate increased thirst, increased urination, fatigue, nausea and vomiting, bladder infection, yeast infections and blurred vision (**Nasiri-Amiri et al, 2019**). It is associated with both short and long term adverse outcomes for mothers and their offspring as pregnant women with GDM are more predisposed to developing pregnancy-induced hypertension syndrome, polyhydramnios, premature rupture of

membranes, infection and macrosomia. (**Hull, 2020**).

Recent studies have found that moderate physical exercise is an important part of management for women with GDM as it helps the women bodies' insulin work well, stimulates the body to move glucose into cells and increases the cells sensitivity to insulin which is an effective ways to control blood sugar levels (**Guelfi et al., 2016; da Silva et al., 2017**).

Also, exercise is great for relieving some of the aches and pains associated with pregnancy such as muscle cramps, back pain, constipation, swelling, trouble sleeping and can help the expectant mother to build endurance that is essential during delivery. Regular exercise reduces the risk of pregnancy related complications such as early pregnancy loss, decreases the risk of low birth weight, preterm delivery, hypertension, preeclampsia and polyhydramnios, modulates maternal weight gain in pregnancy and reduces the risk of large for gestational age newborns which are concerns with GDM (**Davenport et al., 2018**).

Walking exercise during pregnancy is simple and effective intervention to improve maternal health outcomes. For this reason, American College of Obstetrics and Gynecology (ACOG) recommends that pregnant women with GDM should engage in 45min of walking exercise at least 3 days per week (**Craig et al., 2020**).

### **1.1 Significance of the study**

Gestational diabetes mellitus is a major health problem in developing countries. The overall prevalence of GDM in Middle East and North Africa had the highest prevalence (12.9 %) compared to Europe which had the lowest prevalence (5.8%). It was the fifth

leading cause of maternal death (WHO, 2016; Zhu & Zhang, 2016). Regarding to the prevalence of GDM among pregnant women in Egypt is 2-14% of all pregnancies, this may be related to the lack of education and sociocultural factors in Egypt, thus lead to improper and substandard antenatal care, failure of screening high risk pregnancies and delaying of referral to the appropriate health facilities at appropriate time (Khalil, Fathy & Mahmoud, 2017).

Moreover, Gestational diabetes mellitus have serious adverse effect on mother's and fetal health which lead to increasing the rates of maternal and prenatal morbidity and mortality (Al-Nsour, 2017). However, the majority of studies using walking exercise as an interventional strategy to treat GDM were successful as it helps in controlling maternal blood sugar level and body mass index (Guelfi et al., 2016 ; Gilbert, Gross, Lanzi, Quansah, Puder & Horsch, 2019).

### 1.2 Aim of the study

The study was conducted to evaluate the effect of walking exercise on controlling blood glucose level and body mass index among gestational diabetic women.

### 1.3 Study Hypothesis

To achieve the present study aim, one hypothesis was tested "Pregnant women with gestational diabetes mellitus who practiced walking exercise have improved blood glucose level and body mass index than those who did not".

## II. Subjects and Method

### 2.1 Design

A quasi-experimental study design was utilized.

### 2.2 Setting

The current study was performed in the Antenatal Clinic of Obstetric and Gynecological Specialty Center at

Mansoura University Hospitals, Mansoura city, Dakahlia governorate, Egypt. The setting consists of one floor divided into six parts: reception part, sonar part, antenatal examination section, gynecological examination section, vesicular mole section and room for nursing staff. The official working hours at the antenatal clinic begins at 9 am and ends at 12 pm daily except Thursday, the routine antenatal care was provided by two nurses and 5 obstetricians (consultant, specialist assistant, specialist and two juniors). The flow rate of gestational diabetic women was 7-8 women per week.

### 2.3 Sampling

A purposive sample of 126 pregnant women diagnosed with GDM who were admitted to the previously described study setting between May 2019 to December 2019, enrolled in this study when fulfilled the following inclusion criteria: gestational age between 28-32 weeks, having single living fetus, regular follows up schedule of antenatal visits and can read and write. Exclusion criteria include the following: pregnant women suffering from other medical diseases as hypertension, diabetes mellitus or suffering from any obstetrical problems as pregnancy induced hypertension, preterm labor. Pregnant women who fulfilled the inclusion criteria were assigned to intervention group (who practiced walking exercise in addition to routine antenatal care) & control group (who followed routine antenatal care only).

### 2.4 Sample size calculation

Based on the data from literature (Azzam & El Sharkawy, 2015). Thinking about degree of essentialness of 5%, and intensity of investigation of 80%, the example size can be determined utilizing the accompanying equation:  $n = [2(Z\alpha/2$

$+ Z\beta)^2 \times p(1-p)/(p_1 - p_2)^2$ , Where  $n$  = sample size required in each group,  $p$  = pooled proportion (proportion of event in group 1 + proportion of event in group 2)/2,  $p_1-p_2$  = difference in proportion of events in both groups,  $Z\alpha/2$ : This depends on level of significance, for 5% this is 1.96,  $Z\beta$ : This depends on power, for 80% this is 0.84,  $n = [2(1.96 + 0.84)^2 \times 0.45(1-0.55)]/(0.25)^2=62.4$

**So, the required sample size per group was 63 pregnant women.**

#### **Group allocation**

All GDM pregnant women who attended antenatal clinic were invited to participate in the study. About 140 pregnant women with GDM were assessed for eligibility to participate in the current study, 12 women didn't met the inclusion criteria & 2 refused to participate in the study. Thus, excluded leaving 126 eligible women divided into equal numbers (63 women for each group). The first 63 pregnant women assigned to control group while the second 63 pregnant women assigned to exercise group till finishing the sample size.

#### **2.5 Data collection tools:**

Two tools were utilized for information collection; these tools were developed by the researcher as follows:

**Tool I: A structured Interview Schedule.** It was designed to collect data about the participant's general characteristics such as (age, educational level, occupation, telephone number, weight, height and Body Mass Index (BMI) and obstetrical history such as (gravidity, parity, gestational age ...etc).

**Tool II: Maternal Assessment Record.** It was designed to collect data about the

participant's blood glucose level through measuring the maternal random blood glucose level at 34 & 37 weeks of gestation.

#### **2.6 The validity of the tools**

The tools validity was confirmed by a panel of three experts in the specialty of the study: the first expert specialized in obstetric field of medicine and the other two experts specialized in maternity nursing. Based on the expert's recommendations minor modifications were performed.

#### **2.7 Reliability of the tools**

The reliability test and internal consistency for the questionnaire showed Cronbach's alpha value for tool II ( $\alpha=0.835$ ) and hence the questionnaire showed high reliability.

#### **2.8 Pilot Study:**

The pilot study was performed on 10% (13 pregnant women with GDM) of the study sample. The purpose of this pilot study was to test clarity of the questions and statements, feasibility, objectivity and consistency of tools and to detect ambiguity in the study tools. Based on finding of the pilot study, the necessary modifications were done on the study tools. The pilot sample was excluded from the total study sample.

#### **2.9 Ethical considerations**

Ethical approval was obtained from Research Ethics Committee at the Faculty of Nursing - Mansoura University. Participants were informed that participation in the study was voluntary. A written consent was obtained from all participants after clarifying the study purpose. The participants were reassured about the Anonymity, privacy & safety of the collected information throughout the whole study as the tool was given code number instead of taking woman's name. After finishing statistical analysis all

sheets were burned. The results were used as a component of the necessary research for doctoral study as well as for future publications and education.

#### **2.10 Research process**

This study was done through three phases: preparatory, implementation and evaluation of the outcomes.

##### **Preparatory phase**

In this phase, official agreements were taken from the Ethics Committee of Nursing Faculty and from the director of the Antenatal Clinic of Obstetric and Gynecological Specialty Center at Mansoura University Hospitals. After that, the study tools were prepared by the researcher after reviewing of the current national and international related literatures, its validity and reliability were tested and the required modifications were done.

Piloting was conducted on thirteen pregnant women with the pre-assigned criteria to test the feasibility of the intervention. The actual field work of the study was conducted for 8 month's period from May 2019 to December 2019.

##### **Implementation phase**

The researcher attended to the antenatal clinic of obstetric and gynecological specialty center three days / week from 9 Am till 12 Pm, firstly the researcher introduced herself to the subjects and their informed consent was taken after explaining the study aim. After that, the researcher checked if the subjects met the inclusion criteria of the study, accordingly, the researcher completed the data of structured interview schedule for the study groups.

Random Blood Glucose (RBG) sample was taken as well as anthropometric assessment were measured to each subject in both intervention and control groups, then,

the researcher calculated the subjects BMI through the following formula "woman's weight in Kilogram divided by height squared in meter  $BMI = \frac{\text{weight in kilogram}}{(\text{height})^2}$  (Azzam&El Sharkawy, 2015).

##### **Control group**

Control group received the routine care of the antenatal clinic at the obstetric and gynecological specialty center which consisted of booking, history taking, physical examination and investigation for example, Complete Blood Count (CBC), liver, kidney tests and urine analysis.

##### **Intervention group**

At this phase, the subjects were given face-to-face instructions regarding healthy precautions before starting exercise as she should wear loose fitting comfortable clothes as well as a good support bra, choose shoes that are designed for the type of exercise, consume enough calories to meet the needs of pregnancy, finish eating at least one hour before exercising, drink water before, during and after workout and practice in a climate with reasonable temperature and dampness.

Additionally, testing blood sugar before doing any physical activity is mandatory. If the subject's blood glucose level is low, eating something and testing again to make sure that level is higher before starting an activity. If the subjects uncover manifestations, for example, dyspnea, amniotic liquid spilling or vaginal bleeding, they ought to quickly quit working out.

The subjects started the exercise session by performing an active warm-up of 5 minutes duration to relieve muscle stiffness. Exercise sessions include walking exercise for 35 minutes, the subjects initiate a 5-minute cool down period until the heart rate and breathing

are return to the baseline. An instructive brochure was given to the subjects in the intervention group.

The researcher instructed the subjects to demonstrate walking exercise at home and follow them by phone. It will be conducted three times per week with each session lasting 45 minutes. This will be conducted from GDM diagnosis (26th to 28th gestational week) to the end of the third trimester.

**Evaluation of the study outcomes**

Two post intervention evaluations were done at 34 & 37 weeks of pregnancy to measure the RBG &

anthropometric measurements for each subject in both groups.

**2.11 Statistical analysis**

All measurable analyses were performed utilizing SPSS for windows variant 20.0 (SPSS, Chicago, IL). All nonstop factors ordinarily dispersed and were communicated in mean  $\pm$ standard deviation (SD). Categorical information was communicated in number and rate. The correlations were resolved utilizing Student's t test for two factors with constant information of ordinary dispersion. Chi-square test was utilized for examination of factors with categorical data.

**III.Results**

**Table 1.**Frequency Distribution of the Intervention and the Control Groups According to Their Demographic Characteristics.

Demographic characteristics	Intervention group (n=63)		Control group (n=63)		Chi square test	
	No.	%	No.	%	X <sup>2</sup>	P
<b>Age (years)</b>						
18 – 23	2	3.1	6	9.5		
24 – 29	27	42.9	17	27.0		
30 – 35	19	30.2	27	42.9		
>35	15	23.8	13	20.6	5.807	0.121
Mean $\pm$ SD	30.9 $\pm$ 5.2		30.8 $\pm$ 5.6		0.066*	0.948
<b>Residence</b>						
Urban	28	44.4	25	39.7		
Rural	35	55.6	38	60.3	0.293	0.588
<b>Educational level</b>						
Read/Write	18	28.6	20	31.7		
Secondary education	24	38.1	25	39.7		
High education	21	33.3	18	28.6	0.356	0.837
<b>Occupational status</b>						
House wife	46	73.0	47	74.6		
Working	17	27.0	16	25.4	0.041	0.839

\* *t value, Student's t test*

**EFFECT OF WALKING EXERCISE ON CONTROLLING etc...**

**Table one** presents demographic characteristics of the intervention and the control groups. The mean age of studied groups was almost similar (30.9 vs. 30.8), respectively. The higher percentages of the intervention and

control groups had secondary education, were housewives and from the rural area. There was no statistical significant difference between the studied groups concerning age, level of education, occupation and place of residence.

**Table (2):** Frequency Distribution of the Anthropometric Measures for the Intervention and the Control Groups.

Body Mass Index status	Intervention group		Control group		Chi square test	
	No.	%	No.	%	X <sup>2</sup>	P
<b>Before intervention (At 28-32 weeks of pregnancy)</b>	<b>(n=63)</b>		<b>(n=63)</b>			
Height (cm)	165.9 ±4.5		165.7 ±4.5		0.217	0.829
Body weight (kg)	79.3 ±12.9		81.8 ±13.8		1.050	0.296
BMI (kg/m <sup>2</sup> )						
Normal	15	23.8	12	19.1		
Overweight	24	38.1	21	33.3		
Obese	20	31.7	24	38.1		
Morbidly obese	4	6.4	6	9.5	1.297	0.730
Mean ±SD	28.8 ±4.4		29.8 ±4.6		1.214*	0.227
<b>After intervention (At 37 weeks of pregnancy)</b>	<b>(n=59)</b>		<b>(n=51)</b>			
Height (cm)	164.3 ±4.4		165.6 ±5.0		1.484	0.141
Body weight (kg)	82.6 ±13.4		92.1 ±13.3		3.721	<0.001**
BMI (kg/m <sup>2</sup> )						
Normal	6	10.2	2	3.9		
Overweight	20	33.9	8	15.7		
Obese	27	45.7	21	41.2		
Morbidly obese	6	10.2	20	39.2	14.928	0.002
Mean ±SD	30.6 ±4.5		33.6 ±4.4		3.572*	<0.001**

\* *t value, Student's t test*

\*\**Highly Statistical Significant at P<0.001*

**Table two** presents the anthropometric measures of the intervention and the control groups. There was no statistical significant difference between the studied groups concerning the categories of body mass

index at baseline assessment (28-32 weeks of gestation). While, there was highly statistical significant difference between two groups concerning the categories of body mass index at 37 weeks of gestation (P<0.001).

**Table (3)** Frequency Distribution of the Intervention and the Control Groups According to Their Random Blood Glucose Levels.

Maternal RBG* levels	Intervention group		Control group		Chi square test	
	No.	%	No.	%	X <sup>2</sup>	P
<b>Before intervention (At 28 – 32 wks)</b>	<b>(n=63)</b>		<b>(n=63)</b>			
Normal (80 – 140 mg/dl)	11	17.5	7	11.1		
High (>140 mg/dl)	52	82.5	56	88.9	1.307	0.309
Mean ±SD	168.2	±37.7	177.1	±37.9	1.321	0.189
<b>After intervention (At 34wks)</b>	<b>(n=63)</b>		<b>(n=57)</b>			
Normal	59	93.7	0	0.0		
High	4	6.3	57	100.0	105.012	<0.001**
Mean ±SD	113.2	±14.0	193.6	±38.8	15.395	<0.001**
<b>At 37 weeks</b>	<b>(n=59)</b>		<b>(n=51)</b>			
Normal	59	100.0	0	0.0		
High	0	0.0	51	100.0	110.000	<0.001**
Mean ±SD	102.3	±10.1	202.4	±37.2	19.856	<0.001**

\*Random Blood Glucose Level

(\*\*) P is highly statistically significant if < 0.001

Table three shows that the mean of maternal random blood glucose levels at baseline assessment was (168.2±37.7 & 177.1±37.9), respectively with no statistical significant difference among the studied groups. While, there was highly statistical significant difference between both groups in relation to maternal random blood glucose levels at both 34 & 37 weeks of pregnancy.

#### IV. Discussion

Gestational Diabetes Mellitus (GDM) substantially increases the risk of adverse health effects on both women and their offspring, thus create highly medical costs for prenatal, intranatal as well as postnatal care. Therefore, pregnancy is an ideal time for providing health education to women with GDM, because health education is the first step of diabetes management and providing women with accurate knowledge, skills

and actions to cope with the practical aspects of self-care measures regarding GDM to improve fetal and maternal outcomes (Osugwu, Fuka, Agho, Khan & Simmons, 2020).

The current research aimed to evaluate the effect of walking exercise on controlling blood glucose level and body mass index among gestational diabetic women. The study hypothesis was supported by the study results as there was a highly statistical significant difference among the intervention and the control groups regarding blood glucose level and body mass index.

Guo, Zhang, Li, Zhou, Chen & Li, (2019) reported that, educational intervention regarding exercise has a positive impact on healthy weight gain in pregnant women with GDM which is consistent with the current study findings as there was no statistical



significant difference among the studied groups in relation to body mass index at baseline assessment (28-32 weeks of gestation). On the contrary, there was a highly statistical significant difference at 37 weeks of gestation.

Such findings are supported by *Azzam & El Sharkawy (2015)* who studied the effect of GDM educational intervention on pregnancy outcomes and reported that, there was a significant difference among the intervention and control groups regarding to the mean body weight & mean BMI at baseline assessment compared to at 37 weeks' of pregnancy after intervention. In the same line *Muktabhant, Lawrie, Lumbiganon & Laopaiboon, (2015)* who conducted a randomized controlled trial to evaluate the efficacy of exercise on preventing excessive weight gain during pregnancy, found that, women who received exercise education were more likely to experience low weight gain than those who did not.

Several studies showed significantly lower Oral Glucose Tolerance Test (OGTT) in physically active women as exercise improves insulin affectability and diminishes both fasting and postprandial glucose fixations in ladies with GDM (*Barakat et al, 2018; Lantaff et al, 2019*).

The present study findings showed that, there was no statistical significant difference in the maternal random blood glucose levels baseline assessment among the studied groups. On contrary, there was a highly statistical significant difference among the studied groups at both 34 & 37 weeks of pregnancy. Such findings may be contributed to that physical exercise stimulates the body to move glucose into cells and increases the cells sensitivity to insulin.

This result is in concurrent with *El Toony, Khalifa & Ghazaly, (2018)* who stated that, the blood glucose level significantly controlled by medical nutritional therapy and exercise in their study about the effectiveness of an educational program for women with GDM. Another study by *Allehdan, Basha, Asali & Tayyem, (2019)* who studied the effect of dietary and exercise interventions on glycemic control, maternal and neonatal outcomes in women with GDM reported that, the combination of diet and exercise interventions controls fasting & postprandial blood glucose level.

#### **Conclusion**

Based on the current study findings, it was established that, pregnant women with GDM who practiced walking exercise had improved blood glucose level and body mass index than those who did not.

#### **Recommendations**

**Based on the current study findings, the following can be recommended:**

- 1-Pregnant women with GDM should practice walking exercise for 45min during pregnancy as one of the significant modalities to improve blood glucose level and body mass index.
- 2-Providing in-service training programs for maternity nurses concerning the benefits and how to merge woman's compliance to walking exercise during pregnancy.

#### **Acknowledgment**

We would like to thank the obstetricians, nurses, and women at antenatal clinic of obstetric and gynecological specialty center at Mansoura university hospital for their help in conducting the study and without whom the study could not have been achieved.

**Conflict of Interests**

The authors state that there is no conflict of interests regarding this study.

**References**

1. **Elbeltagy, E. S., Hassan, S. I., & Khedr, N. F. (2017).** Association of Cesarean Delivery with Occurrence of Placenta Previa. *IOSR Journal of Nursing and Health Science (IOSR-JNHS)* e-ISSN: 2320–1959.p- ISSN: 2320–1940, 6, (4 Ver. III), 1-9.
2. **Mukerji, G., Bacon, S., & Feig, D. S. (2020).** Gestational Diabetes and Type 2 Diabetes During Pregnancy. In *Maternal-Fetal and Neonatal Endocrinology* (pp. 371-388). Academic Press.
3. **Wang, X., & Tingting, D. (2019).** Women's experiences of gestational diabetes mellitus: A descriptive review.
4. **Khanpaye, A., Abdoullahi, A., Riahipour, B., Mohebifar, M., Mahmoodi, R., Shirmardi, S., & Madmoli, M. (2019).** Evaluation of Knowledge, Attitude and Performance Regarding Gestational Diabetes Mellitus in Southwest of Iran. *Journal of Pharmaceutical Research International*, 1-6
5. **Craig, L., Sims, R., Glasziou, P., & Thomas, R. (2020).** Women's experiences of a diagnosis of gestational diabetes mellitus: a systematic review. *BMC pregnancy and childbirth*, 20(1), 76.
6. **Nasiri-Amiri, F., Sepidarkish, M., Shirvani, M. A., Habibipour, P., & Tabari, N. S. M. (2019).** The effect of exercise on the prevention of gestational diabetes in obese and overweight pregnant women: a systematic review and meta-analysis. *Diabetology & metabolic syndrome*, 11(1), 72.
7. **Hull, B. (2020).** Comparison of Confidence in Diabetes Control Between Women Diagnosed with Gestational Diabetes and Women Diagnosed with Diabetes Outside of Pregnancy in California.
8. **Guelfi, K. J., Ong, M. J., Crisp, N. A., Fournier, P. A., Wallman, K. E., Grove, J. R., ... & Newnham, J. P. (2016).** Regular exercise to prevent the recurrence of gestational diabetes mellitus. *Obstetrics & Gynecology*, 128(4), 819-827.
9. **da Silva, S. G., Hallal, P. C., Domingues, M. R., Bertoldi, A. D., da Silveira, M. F., Bassani, D., ... & Evenson, K. (2017).** A randomized controlled trial of exercise during pregnancy on maternal and neonatal outcomes: results from the PAMELA study. *international journal of behavioral nutrition and physical activity*, 14(1), 175.
10. **Davenport, M. H., Ruchat, S. M., Poitras, V. J., Garcia, A. J., Gray, C. E., Barrowman, N., ... & James, M. (2018).** Prenatal exercise for the prevention of gestational diabetes mellitus and hypertensive disorders of pregnancy: a systematic review and meta-analysis. *British journal of sports medicine*, 52(21), 1367-1375.
11. **WHO Mortality Database [online database].** Geneva: World Health Organization; ([http://apps.who.int/health\\_info/statistics/mortality/cause\\_of\\_death\\_query/](http://apps.who.int/health_info/statistics/mortality/cause_of_death_query/), accessed 12 January 2016).
12. **Zhu, Y., & Zhang, C. (2016).** Prevalence of gestational diabetes and risk of progression to type 2 diabetes: a global perspective. *Current diabetes reports*, 16(1), 7.
13. **Khalil, N. A., Fathy, W. M., & Mahmoud, N. S. (2017).** Screening

- for gestational diabetes among pregnant women attending a rural family health center-Menoufia governorate-Egypt. *Journal of Family Medicine and Health Care*, 3(1), 6-11.
14. **Al-Nsour, M. (2017)**. Consequences of gestational diabetes and risk factors in Jordan: results of the 2017 Jordan behavioral risk factor surveillance survey. *preventing chronic disease J*, 9(1), 25-87.
  15. **Gilbert, L., Gross, J., Lanzi, S., Quansah, D. Y., Puder, J., &Horsch, A. (2019)**. How diet, physical activity and psychosocial well-being interact in women with gestational diabetes mellitus: an integrative review. *BMC pregnancy and childbirth*, 19(1), 60.
  16. **Azzam, H. F., & El Sharkawy, N. B. (2015)**. Effect of Gestational Diabetes mellitus Health Education Module on Pregnancy Outcomes. *World Journal of Nursing Sciences*, 1 (3): 76-88.
  17. **Osugwu, U. L., Fuka, F., Agho, K., Khan, A., & Simmons, D. (2020)**. Adverse Maternal Outcomes of Fijian Women with Gestational Diabetes Mellitus and the Associated Risk Factors. *Reproductive Sciences*, 1-9.
  18. **Guo, H., Zhang, Y., Li, P., Zhou, P., Chen, L. M., & Li, S. Y. (2019)**. Evaluating the effects of mobile health intervention on weight management, glycemic control and pregnancy outcomes in patients with gestational diabetes mellitus. *Journal of endocrinological investigation*, 42(6), 709-714.
  19. **Muktabhant, B., Lawrie, T. A., Lumbiganon, P., &Laopaiboon, M. (2015)**. Diet or exercise, or both, for preventing excessive weight gain in pregnancy. *Cochrane database of systematic reviews*, (6).
  20. **Barakat, R., Refoyo, I., Coteron, J., & Franco, E. (2018)**. Exercise during pregnancy has a preventative effect on excessive maternal weight gain and gestational diabetes. *A randomized controlled trial. Brazilian journal of physical therapy*.
  21. **Lantaff, R., Ward, R., Griffin, S., & Usher-Smith, J. (2019)**. Women's views concerning lifestyle changes to reduce risk of developing type 2 diabetes after gestational diabetes: A systematic review, qualitative synthesis and recommendations for practice.
  22. **El Toony, L. F., Khalifa, W. A., &Ghazaly, O. M. (2018)**. Assessing the effectiveness of an educational program for patients with gestational diabetes in Assiut University. *Egyptian Journal of Obesity, Diabetes and Endocrinology*, 4(1), 17.
  23. **Allehdan, S. S., Basha, A. S., Asali, F. F., &Tayyem, R. F. (2019)**. Dietary and exercise interventions and glycemic control and maternal and newborn outcomes in women diagnosed with gestational diabetes: Systematic review. *Diabetes & Metabolic Syndrome: Clinical Research & Reviews*.