

## ORIGINAL PAPER

## PERFORMING AN ORAL GLUCOSE TOLERANCE TEST DURING PREGNANCY

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## Abstract

**Aim:** The goal of this study was to establish the level of awareness amongst pregnant women in terms of preparation for an oral glucose tolerance test (oGTT), compare the results of two waves of data collection, and identify the most frequent preanalytical mistakes made in connection to the oGTT. **Design:** Comparison of 2 cross-sectional studies. **Methods:** From 2013–2017 two independent questionnaire studies were performed on a total of 477 pregnant women in the Olomouc and Zlín regions. A total of 225 respondents took part in Study 1 (2013–2014), and a total of 252 in Study 2 (2016–2017). Acquired data was analysed using descriptive statistics focused on the substantive significance of the results, as well as inference statistics. **Results:** Based on the sum index, the overall level of awareness had increased slightly amongst the women in Study 2 (by 0.41 points out of 5), Cohen's  $d = 0.3$  suggests the effect was only mediocre. Fifteen erroneous processes were found. However, these had a decreasing trend once the guidelines had been unified. **Conclusion:** A more reliable performance of the oGTT in certified laboratories was declared by the respondents in Study 2. The level of awareness, and checking on their adherence to the regime before and during the course of measuring the oGTT in pregnant women was still inadequate. It is necessary to improve pregnant women's awareness of how to perform the oGTT correctly to ensure the least possible distortion of the results.

**Keywords:** oGTT, performance, preparation and awareness, recommended procedure.

## Introduction

Gestational diabetes mellitus (GDM) is a disorder in the metabolism of carbohydrates, fats, and proteins, which usually occurs between the second and third trimesters of pregnancy, resolves during the course of the postpartum period, and sometimes can recur (Anderlová et al., 2014a; Bakiner et al., 2013). GDM prevalence ranges from 9.6%–24% (American Diabetes Association, 2011; Anderlová et al., 2014b; Franeková & Jabor, 2010; Krejčí et al., 2019) and increases with the age of the pregnant woman. For women over 35 years of age, it reaches 19%–20% and copies the increase in numbers of those overweight and suffering obesity and diabetes in economically advanced countries (Krejčí et al., 2019; Metzger et al., 2008).

Timely treatment of GDM reduces the risk of pregnancy and perinatal complications. A mere lifestyle change can suffice in achieving good GDM compensation for up to 90% of women (Andělová et al., 2018; Landon et al., 2009; Negrato & Gomes, 2013). It is important, however, that women with

GDM are diagnosed early. The diagnostic criteria for GDM applied in the Czech Republic (CR) until 2015 were based on the criteria for glucose tolerance disorder in the general population (Andělová, 2013). GDM screening methods were inconsistent not just in the CR, but throughout the world. The IADPSG (International Association of Diabetes and Pregnancy Study Groups) only published new criteria for GDM diagnosis in 2010 on the basis of the results of the HAPO (Hyperglycemia and Adverse Pregnancy Outcome) multicentre study, and these were gradually adopted by professional organisations in many countries and by international institutions (the International Association of Diabetes and Pregnancy Study Groups, 2010; the HAPO Study Cooperative Research Group, 2008; the HAPO Study Cooperative Research Group, 2009; the World Health Organization, 2013). In the CR, the new diagnostic criteria were gradually adopted in 2014–2015, first by the Czech Medical Association of J. E. Purkyně ("CzMA JEP") Czech Diabetes Society and the CzMA JEP Czech Society of Clinical Biochemistry, then later also by the CzMA JEP Czech Gynecological and Obstetrical Society – CGOS (Andělová et al., 2018; Čechurová & Andělová, 2014; Friedecký et al., 2016). The most recent updated version was published as a summary document alongside recommended practice

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for gynaecological, diabetological, and neonatal care in 2018 and 2019 (Andělová et al., 2018; CGOS CzMA JEP, 2019; Krejčí et al., 2018). We have compared 2 cross-sectional studies (Study 1 was conducted prior to the unification of guidelines, Study 2 afterwards) aimed at finding whether the unification of guidelines in the Czech Republic had a positive influence on the performance of the oGTT (oral glucose tolerance test).

Since 2009, automatic GDM screening for all pregnant women has been indicated in the CR, except for women known to have a pre-gestational glucose metabolism disorder. The pregnant woman's own gynaecologist refers them for the examination, which is secured by a certified laboratory. The patients' blood sugar level is determined from venous blood (Friedecký et al., 2016). Screening is carried out in two phases. The first phase involves determining blood sugar level on an empty stomach from venous blood, and this should be done by the 14<sup>th</sup> week of pregnancy. The second phase – actual performance of the oGTT, takes place between the 24<sup>th</sup> and 28<sup>th</sup> week (Andělová et al., 2018; Čechurová & Andělová, 2014). The pregnant woman should observe her standard dietary regime (she should not limit carbohydrate intake), and the day before the oGTT she should avoid excess physical exertion and ensure she does not smoke. The actual oGTT is performed by determining three blood sugar level values from venous blood (glycaemia on an empty stomach, and at 60 and 120 min. after drinking 75 g of glucose). The first sample is taken in the morning after at least 8 hours of fasting (only water can be consumed). If a blood sugar level of  $\geq 5.1$  mmol/l is found, no further tests are made and following instruction, the woman is invited to return for another blood test on an empty stomach on another day. If normal blood sugar levels are ascertained, the woman drinks a solution of 75 g glucose dissolved in 300 ml water within a 5–10 minute period. The second venous blood sample is taken after 60 minutes, and the third after 120 minutes. Each blood sugar level must be ascertained by the standard method within 1 hour from collection at the latest. During the entire test period, the woman must remain at physical rest within the laboratory's waiting room. She must not smoke prior to or during the test. Regular doses of anti-insulin medication (in particular hydrocortisone, thyroxine, beta-sympathomimetic drugs) can only be used on the day of the test after it is completed. The test should not be performed during a period of acute illness (viral or other infectious disease, injury, etc.). If blood sugar level on an empty stomach is repeatedly  $\geq 5.1$  mmol/l, at 60 min.  $\geq 10.0$  mmol/l, at 120 min.  $\geq 8.5$  mmol/l – this means GDM is present and the woman is referred to diabetology.

Care for a pregnant woman with apparent diabetes is then the same as care for a pregnant woman with pregestational diabetes (Friedecký et al., 2016).

Determining blood sugar level by glucose tolerance (oGTT) may be affected by some level of imprecision in measuring. It is thus essential to observe the preanalytical and analytical conditions for measurement to ensure the results are reliable.

## Aim

- 1) To establish a level of awareness amongst pregnant women in terms of preparation for an oGTT, and compare the results of two waves of data collection.
- 2) To identify the most frequent preanalytical mistakes made in connection with performing the oGTT, and compare the results of two waves of data collection.

## Methods

### Design

Comparison of two cross-sectional studies. From 2013–2017, two independent questionnaire studies were performed in the Olomouc and Zlín regions on a total of 477 pregnant women focused on quality of oGTT performance, and awareness and verification of the regime kept before and during the course of oGTT measurement.

### Sample

The criteria determined for selecting respondents was: pregnant women in their  $38^{\text{th}} \pm 2$  week of pregnancy, who took oGTTs at selected sites in two regions of the Czech Republic who were willing to fill in a questionnaire.

### Data collection

Information was ascertained using a non-standardised anonymous questionnaire. Once the management from each site gave their consent to the study, data collection began. The information was found using an anonymous nonstandardized questionnaire. Data collection began once the management of the relevant workplaces had given their consent with the study. Midwives were involved in the data collection for both studies. They handed out the questionnaires to pregnant women prior to cardiography examination (this examination is normally performed in the last stage of pregnancy), and asked them to fill it out. The filled-out questionnaires were then cast into prepared boxes in waiting rooms, and were picked up once a day by an authorized worker.

Study 1 was undertaken in 2013–2014 (prior to unification of professional organisation guidelines),

and Study 2 was undertaken in 2016–2017 (following guidelines unification). Study 1 included 225 respondents, while Study 2 included 252. A total of 447 women were studied, with the remaining 80 questionnaires eliminated for not meeting criteria (i.e., not all questionnaire items being completed, or not undergoing an oGTT in the second phase of the test).

54% of those taking part in Study 1 were first-time mothers, 31% were second-time mothers and 15% third- or greater-time mothers. In Study 2, 58% of participants were first-time mothers, 30% were second-time mothers and 12% were third-time (or greater) mothers. More detailed information on respondents is given in Table 1.

**Table 1** Information on respondents (n = 477)

Items	Study 1: 2013–2014 (n <sub>1</sub> = 225)				Study 2: 2016–2017 (n <sub>2</sub> = 252)			
	min.	max.	mean	SD	min.	max.	mean	SD
<b>Descriptive statistics</b>								
<b>Mother's age</b>	16	43	31	5	14	44	31	5
<b>Week last oGTT performed</b>	14	39	25	3	20	39	25	2
<b>Current week of pregnancy when questionnaire was filled in</b>	34	40	38	2	32	42	38	2
<b>Weight gain (in kg) during pregnancy</b>	0	40	14	6	-9	30	13	5
<b>BMI at start of pregnancy</b>	16	42	23	3	16	41	25	5
<b>BMI at end of pregnancy</b>	18	43	27	4	18	43	28	4

BMI – Body Mass Index; oGTT – oral glucose tolerance test; n<sub>1</sub> – overall number of respondents in Study 1; n<sub>2</sub> – overall number of respondents in Study 2; min. – minimum; max. – maximum; SD – standard deviation

### Data analysis

The IBM SPSS Version 24 software was used for statistical processing. The data acquired was assessed using descriptive statistics. We assessed the data descriptively, focusing on the substantive significance of the results (Soukup & Rabušic, 2007). Besides that, statistical inference was applied too. Tables 2 and 4 show results of the chi-squared test, Table 3 then independent samples t-test results.

In Study 1, the average BMI value at the beginning of pregnancy was 23, while in the 38th week it was 27. In Study 2 the average value of BMI was 25, and in the 38th week 28.

## Results

### Objective 1

To establish a level of awareness in pregnant women of the regime prior to oGTT.

The results regarding pregnant women's awareness of the regime prior to performing oGTT are given in Table 2.

Numbers (n) correspond to the number of women who gave a positive answer to the particular answer. Differences in terms of individual items range in value (from -12 to + 46 p.p.). Of these 5 items, a sum index of the women's awareness was created from these five items ranging from 0–5 points – Table 3.

Comparing the awareness of pregnant women from 2013–2014 and 2016–2017, we can see that overall awareness had improved slightly by the second study, by a total of 8 percentage points. If we calculate the

substantive significance of the results, Cohen's  $d = 0.39$ , corresponding to a medium effect. Women are least aware of the reason for performing the oGTT, and the actual performance of the test in the laboratory. To a lesser extent, they lack information on possible side effects after taking the glucose solution, and have imprecise information on fasting.

### Objective 2

Most frequent preanalytical mistakes made in connection with performing the oGTT.

A summary of mistakes which respondents declared in oGTT testing is given in Table 4.

As the table shows, results in the two years differed significantly, with changes between the two waves of data collection ranging from -69 p.p. to + 6 p.p. The vast majority of items saw a fall, implying an improvement in the situation. In the second wave of data collection, respondents declare many fewer mistakes in not observing the fasting period (-69 p.p.), followed by not observing the number of three samples (-65 p.p.), insufficient information given on recommended period of fasting prior to test (-46 p.p.), and inadmissible forms of glucose administration (-40 p.p.).

Respondents also declared fewer errors in terms of performing the oGTT outside the period of the 24<sup>th</sup>–28<sup>th</sup> week of pregnancy (-15 p.p.), not verifying the period of fasting and not smoking (-9 p.p.), performing the oGTT outside the sampling laboratory (-8 p.p.), not receiving results on site (-7 p.p.), not checking use of medication (-5 p.p.), taking sample

**Table 2** Awareness of pregnant women of the regime prior to performing oGTT

Items	Study				Difference (p.p.)	Sig.
	1: 2013–2014 (n <sub>1</sub> = 225)		2: 2016–2017 (n <sub>2</sub> = 252)			
	n	%	n	%		
<b>Awareness of diet prior to oGTT:</b> 3 days prior to test keep standard dietary habits (no limitation to carbohydrate intake)	70	31	86	34	3	0.495
<b>Awareness of fasting:</b> period of 8–12 hours, no smoking	40	18	161	64	46	< 0.001
<b>Awareness of medication:</b> regularly taken medication can only be taken after the test	18	8	8	3	-5	0.026
<b>Awareness of reasons for performing oGTT</b>	155	69	141	56	-12	0.005
<b>The woman subjectively has not missed any information on performing oGTT</b>	149	66	174	69	3	0.556

*oGTT* – oral glucose tolerance test; *n*<sub>1</sub> – overall number of respondents in Study 1; *n*<sub>2</sub> – overall number of respondents in Study 2; *n* – number of responses; *p.p.* – percentage points; *Sig.* – statistical significance

**Table 3** Women's awareness (sum index, 0–5 points)

Items		Women's awareness, sum index 0–5 points				Sig.
		n	mean	min.	max.	
<b>Study 1</b>	2013–2014	225	1.94	0	4	< 0.001
<b>Study 2</b>	2016–2017	252	2.35	0	5	

*n* – number of respondents; *min.* – minimum; *max.* – maximum; *SD* – standard deviation; *Sig.* – statistical significance

**Table 4** Mistakes which respondents listed in performing the oGTT

Faulty practices declared by respondents	Study				Difference (p.p.)	Sig.
	1: 2013–2014 (n <sub>1</sub> = 225)		2: 2016–2017 (n <sub>2</sub> = 252)			
	n	%	n	%		
Insufficiently informed about diet before undertaking the oGTT	155	69	166	66	-3	0.495
Insufficiently informed about recommended fasting period before the oGTT	185	82	91	36	-46	< 0.001
Insufficiently informed about use of medication before the oGTT	207	92	244	97	5	0.026
Respondent did not observe fasting period	182	81	30	12	-69	< 0.001
oGTT performed outside sampling laboratory	38	17	23	9	-8	0.013
Blood samples taken from capillary blood (from finger)	19	8	11	4	-4	0.088
Number of 3 samples not observed (on empty stomach, after 1 h, after 2 h)	180	80	38	15	-65	< 0.001
Inadmissible form of glucose administration	122	54	35	14	-40	< 0.001
Woman allowed free movement (outside laboratory) while undergoing oGTT	45	20	66	26	6	0.129
Exercise regime prior to oGTT not verified (question in laboratory)	149	66	169	67	1	0.846
Possibility of intercurrent disease not ascertained (question in laboratory)	191	85	204	81	-3	0.275
Period of fasting and not smoking not verified (question in laboratory)	205	91	207	82	-9	0.005
Use of medication not verified (question in laboratory)	200	89	212	84	-5	0.143
oGTT performed outside 24 <sup>th</sup> –28 <sup>th</sup> week	56	25	25	10	-15	< 0.001
oGTT results not received on site	41	18	27	11	-7	0.025

*n*<sub>1</sub> – overall number of respondents in Study 1; *n*<sub>2</sub> – overall number of respondents in Study 2; *n* – number of responses; *p.p.* – percentage points; *Sig.* – statistical significance

from capillary blood (-4 p.p.), being insufficiently informed of diet before undertaking oGTT (-3 p.p.), and not checking the possibility of intercurrent disease (-3 p.p.).

There was a slight worsening in some mistakes. More respondents declared errors regarding not verifying their exercise regime before oGTT (+ 1 p.p.), being insufficiently informed on medication use prior to the oGTT (+ 5 p.p.) and free movement of the woman outside the laboratory being allowed while undergoing the oGTT (+ 6 p.p.). Although the vast majority of items (12 of 15) saw an improvement, many mistakes continued to be made, as declared by most respondents. Very common mistakes listed in the second wave of data collection are not checking medication use (84%), not checking the period of fasting and not smoking (82%), not checking the possibility of an intercurrent disease (81%), and also being insufficiently informed of what diet to observe prior to undertaking the oGTT (66%).

## Discussion

The inconsistent approach to GDM diagnosis around the world has led to intensive efforts to implement uniform rules. There have also been worries, however, that this would lead to a large increase in proven GDM cases (Krejčí et al., 2014; Visser & de Valk, 2013).

In a study by Franecková and Jabor (2010), GDM was ascertained at rates of 9.6%–24%, while a study by Anderlová et al. (2014a) found it amongst 16%–24.5% of pregnant women. The difference was whether blood sugar levels were also taken after 60 minutes. An epidemiological study by Krejčí et al. (2019) using the new criteria (2016–2018) recorded GDM amongst 14.5% of women. GDM rates increased significantly with an age of over 30 years. In Study 1, we found positive oGTT results (i.e. GDM) for 10% of pregnant women, and in Study 2 we found it for 12% of women. It is well known that around 70%–80% of women with GDM are overweight or obese (Andělová, 2013).

Delaying pregnancy to a later age, poor diet, being overweight and obese linked to insulin resistance are major risk factors, as is too much weight gain during pregnancy (Anderlová et al., 2014b; Krejčí, 2016; Krejčí et al., 2019). Both our studies found an average age of first-time mothers of 31 years. In Study 1, the BMI for women with GDM at the start of pregnancy was  $23.50 \pm 3.60$  (within the norm), while the figure in Study 2 was  $25.08 \pm 4.93$  (overweight). A large increase in the weight of mothers during pregnancy has also been shown to have an impact in terms of their children being overweight (Svačina, 2013). As such, it is recommended that overweight women carefully monitor their weight gain during pregnancy.

Although the quality of oGTT implementation has improved in recent years, we still encounter a number of faulty procedures in practice. We have summarised the faults we ascertained through the questionnaire in Table 4. oGTT performed outside 24<sup>th</sup>–28<sup>th</sup> week was found in 56 cases in Study 1 (i.e., 25%), and in 25 cases in Study 2 (i.e., 10%). Tests performed prior to the 24<sup>th</sup> week may lead to GDM being undiagnosed. An oGTT performed too late can result in late discovery, and thus late GDM treatment. In our study, 4% of respondents stated that their blood sample was taken from their finger, which is incorrect. While under normal circumstances, blood sugar level in capillary and venous blood will be the same, following glucose application the difference comes to 20%–25%. Determining blood sugar level using a glucometer is only suitable for general testing of glycaemic profile amongst diabetics, but not for diagnosing GDM. If venous blood samples are taken in the doctor's surgery and only then sent to the laboratory, there is a danger of an incorrect result due to the time delay involved. The correct procedure for performing and assessing an oGTT is given in the recommended procedure (Andělová et al., 2015, 2018).

On the basis of our investigation, we can say that implementation of the common guidelines has led to an improvement in oGTT performance. In terms of the quality of the information (Tables 2 and 3) and verification of the recommended regime for mothers prior to oGTT (Table 4), however, significant room for improvement was found. Workers in the sampling laboratory do not sufficiently check (in up to 80% of cases) whether the recommended regime prior to the test was observed, and they rely on the fact that the pregnant woman has been instructed by their referring gynaecologist.

Also frequently not observed was the physical inactivity of pregnant women during the course of the test. Physical activity can skew the results of the test, which can then be “falsely within the norm”.

If a standard oGTT cannot be performed due to vomiting, it is recommended that it be replaced at least with a blood sugar level test on an empty stomach, and determination of postprandial blood sugar level following a breakfast including at least 50 g of carbohydrates. This value should be lower than 7.8 mmol/l (Krejčí, 2016).

Krejčí stresses that in order to minimise errors in performing an oGTT, the pregnant woman must be given the correct information, samples should be taken directly in the laboratory, and blood sugar levels should be measured using the standard laboratory method (Krejčí, 2016).

Women should be informed of the recommended period of fasting (8–12 hours) prior to collection. Fasting for over 12 hours is inappropriate, and fasting for less than 8 hours is insufficient (Krejčí, 2016). In our study, we ascertained that women were often given imprecise, or even no, information. Study 2 saw an improvement in awareness of the period of fasting prior to the oGTT. Awareness increased from 18% to 64%, although this still means that the remaining 36% of pregnant women were given insufficient information. Also, 34% of respondents said that they were not informed of unrestricted sugar (carbohydrate) intake 3 days prior to the test.

In a short questionnaire survey undertaken by Bankovic Radovanovic and Kocijancic in 23 Croatian primary and secondary medical facilities of 343 respondents prior to an oGTT test, it was found that 42% of respondents had a high level of knowledge of how the oGTT was performed, and 38% had an appropriate level of knowledge. The level of knowledge was lower amongst pregnant women who received information from their gynaecologist compared to women who received information from laboratory staff (Bankovic Radovanovic & Kocijancic, 2015).

GDM treatment involves dietary regulation, lifestyle modification, and regular blood sugar level tests. Relatively few pregnant women with GDM require insulin therapy. Complications can be prevented by catching GDM early, correctly determining a diagnosis, and receiving optimal follow-up treatment (Calkins & Devaskar, 2011; Catalano et al., 2012; Marshall et al., 2014; Schneider et al., 2011).

### **Limitation of study**

Both comparative studies involve intentional selection of respondents on the basis of predetermined criteria, which regardless of its size cannot be considered representative considering the population investigated. As such, the results obtained cannot be generalised, although one can focus on the substantive significance of the results, which is no less important for practice. Statistical inference was applied within our analysis based on the request made by the editors of the magazine. However, we need to mention the fact that there are articles that warn of its limitations when applied in scientific discourse in both the Czech Republic (Soukup & Rabušic, 2007; Soukup, 2010; Soukup & Kočvarová, 2016) and abroad (Bernardi et al., 2017).

In the second study implemented in 2016–2017, the same respondents could not be involved, because during the period the investigation was implemented, they had to be pregnant women who had the oGTT ahead of them. The compared selections, however,

show very similar characteristics (see Table 1). At the same time, it was not possible to ensure that responses related to the same staff performing the test as had been the case in the previous study. From this perspective, too, one should consider a comparison of results as indicative, and results cannot be broadly generalised. Many identified differences are significant, and certainly tell us that we need to continue to focus on the issue investigated, which if overlooked could have unfortunate consequences in practice.

### **Conclusion**

The unified recommended GDM screening procedure in the Czech Republic has had a positive impact on the validity of investigations undertaken in certified laboratories. The awareness of pregnant women about preparing for the oGTT, however, has only improved a little. It is thus essential to increase women's awareness of how to prepare correctly prior to the performance of the laboratory test. We are therefore putting together educational materials for gynaecological surgeries and sampling laboratories. These comprise information leaflets which should improve pregnant women's awareness, thus helping improve the precision of oGTT results and ensure correct GDM diagnosis.

### **Ethical aspects and conflict of interest**

The authors declare that there was no conflict of interest involved in publishing this study. Respondents were informed of their voluntary participation in the study in an additional part of the questionnaire. The Tomas Bata University in Zlín ethics commission found no breach of current rules and regulations regarding research and publishing results.

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### **Author contributions**

Concept and design (PK), data collection (PK), data analysis and interpretation (IK, PK), preparation of draft manuscript (PK, VV, MK), manuscript critical



review (PK, IK, MK), article finalisation (PK, IK, VV).

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