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VITAMIN AND MINERAL NUTRITIONAL STATUS OF HEALTHY PREGNANT WOMEN IMPROVED BY NUTRIENT SUPPLEMENTS

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Vitamin and mineral nutritional status of healthy pregnant women improved by nutrient supplements

Including varied and healthy food in daily diet that contains adequate amounts of nutrients is vital during pregnancy, especially when there is an increased requirement for several micronutrients. The aim of this study was to evaluate vitamin and mineral status of healthy pregnant women (N = 69) and to determine whether nutrient supplements improve their nutritional status. The evaluation of nutritional status was done by Prodi 5.7 Expert Plus computer programme and IBM SPSS Statistics 20.0 for statistical analysis. Nutrient intake of vitamins C, D, E, folic acid and minerals iron, iodine, calcium and sodium were compared with Reference values for nutrient intake (2004). Results of our study show that the most problematic nutrients are folate, iron and vitamin D. Intake of vitamins and minerals with food is of concern, as 46.4 % of all participants are indicated as women with poor nutritional status (sufficient in two or less nutrients), moreover none of them met the demand for six out of seven studied nutrients. Taking supplementation into account, 27.5 % of participants covered the need for six or more nutrients, however almost a quarter of studied subjects still remain in the group with poor nutritional status. In conclusion among participants who decided to take supplements, the vast majority of them improved their vitamin-mineral status moreover few of them improved their status significantly. Therefore the use of nutrient supplements could on average improve vitamin-mineral status as intake with a diet is obviously inadequate.

Key words: human nutrition / nutritional status / pregnant women / micronutrient intake / nutrient supplements

Izboljšanje vitaminsko mineralnega prehranskega statusa zdravih nosečnic z vnosom prehranskih dopolnil

Uravnotežena in raznovrstna prehrana, ki vsebuje zadostno količino hranil je med nosečnostjo zelo pomembna, še posebej ker so potrebe za številna hranila povišane. Namen naše raziskave je bila ocena zauživanja vitaminov in mineralov zdravih nosečnic (N = 69) in ugotoviti ali zaužita prehranska dopolnila izboljšajo njihov prehranski status. Za obdelavo prehranskih dnevnikov smo uporabili računalniški program Prodi 5.7 Expert Plus in IBM SPSS Statistics 20.0. Prehranski vnos vitaminov C, D, E, folne kisline in mineralov železo, jod, kalcij in natrij smo primerjali z Referenčnimi vrednostmi za vnos hranil (2004). Rezultati raziskave kažejo, da je najbolj problematičen vnos folne kisline, železa in vitamina D. Vnos vitaminov in mineralov s hrano je zaskrbljujoč, saj smo 46.4 % preiskovank uvrstili v skupino z revnim prehranskim statusom (zadovoljiv vnos dveh ali manj preiskovanih hranil). Poleg tega nobena od preiskovank ni dosegla priporočenega vnosa šestih ali več preiskovanih hranil. S prehranskimi dopolnili je 27.5 % udeleženk pokrilo potrebe po vseh ali šestih od sedmih vitaminov in mineralov, medtem ko je skoraj četrtina ostala v skupini z revnim prehranskim statusom. Zaključimo lahko, da se je prehranski status pri večini posameznic, ki so uživale prehranska dopolnila izboljšal, nekaterim statistično značilno. Uživanje prehranskih dodatkov je tako priporočljivo, saj je vnos vitaminov in mineralov s hrano nezadosten.

Ključne besede: prehrana ljudi / prehranski status / nosečnice / vnos mikrohranil / prehranski dodatki

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1 INTRODUCTION

A healthy and varied diet is important through the entire life, but particularly during pregnancy. The maternal diet must provide sufficient energy and nutrients to meet the mother's usual requirements, as well as the needs of the growing fetus, and enable the mother to accumulate stores of nutrients required for fetal development as well as for lactation. The dietary recommendations for pregnant women are actually very similar to those for other adults, but with a few notable exceptions (Williamson, 2006). Physiological and metabolic adaptations in pregnancy have no or small effects on needs for energy and macronutrients, but for several micronutrients increased absorption rates have been found in pregnancy. To estimate energy and nutrient needs during pregnancy the factorial approach is commonly used. This means that the extra energy and nutrient needs imposed by pregnancy are added to the baseline estimates for non-pregnant women (Raaij van and Groot de, 2003). The total energy cost of pregnancy has been estimated at around 300 MJ (71700 kcal). This is based on data from longitudinal studies and factorial calculations of the extra energy required during this period (Reference values…, 2004). The main recommendation is to eat a healthy, balanced diet. In particular, pregnant women should try to consume plenty of iron- and folate-rich foods, and a daily supplement of vitamin D is recommended throughout pregnancy (Williamson, 2006). Some nutrient requirements, particularly iron and folic acid, are more difficult to achieve than others through food sources. For this reason, supplements with these nutrients are recommended in addition to improved diets (LINKAGES, 2004).

In addition to the recommendation to take a folic acid supplement prior to conception and in the early stages of pregnancy, extra folate is also needed throughout pregnancy in order to prevent megaloblastic anaemia. An increment of 200 µg per day (to a total of 600 µg per day) was set by Reference values for nutrient intake (2004) for the duration of pregnancy. The increment in vitamin C intake of 10 mg per day (to a total of 110 mg per day) during the last trimester of pregnancy is to ensure that maternal stores are maintained, particularly towards the final stages of pregnancy (Williamson, 2006). Vitamin C also has an important role in enhancing the absorption of non-haem sources of iron. Pregnant women are therefore encouraged to consume foods or drinks containing vitamin C, together with iron-rich meals, in order to help with iron absorption (FSA, 2005). Vitamin D is important for the absorption and utilisation of calcium, needed for the calcification of the fetal skeleton, particularly during the later stages of pregnancy, and low vitamin D status can be detrimental to both the mother and the fetus. Pregnant women therefore need a good supply of vitamin D and supplements of 5 µg per day for all pregnant women were currently recommended by Reference values for nutrient intake (2004). Since different factors modulate the extent of endogenous vitamin D formation, quantification is hardly possible. Therefore the new reference values for vitamin D intake are specified for a situation in which endogenous synthesis is completely missing. Adequate vitamin D intake is estimated as 20 µg per day for children, adolescents and adults. Dietary vitamin D intake from habitual diet is not sufficient to achieve this value. This gap has to be covered by endogenous vitamin D synthesis and/or additional intake of vitamin D (German Nutrition Society, 2012). Pregnant women do not have a higher need for vitamin E, compared to other adults. In fact, most pregnant women will have no problem getting enough vitamin E through their diet. Since many prenatal vitamin supplements contain some vitamin E, there is no reason to take them additionally. The recommended dietary allowance of vitamin E for pregnant women is 13 mg per day, the same as is recommended for all adults.

Although calcium demands on the mother are high, particularly during the latter stages of pregnancy, physiological adaptations take place to enable more efficient uptake and utilisation of calcium, so an increased intake from the diet is not usually necessary (Williamson, 2006). Iron requirements are increased during pregnancy to supply the growing fetus and placenta and for the production of increased numbers of maternal red blood cells. In practice, many women are prescribed iron supplements during pregnancy and may also be given dietary advice to help them increase their iron intake (FSA, 2005). Although the increase in sodium requirement is not dramatic, it is important. Restricting sodium during pregnancy can cause problems for mother and her fetus, by disrupting this delicate fluid balance. The increment in sodium intake of 69 mg per day (to a total of 619 mg per day) was set by Reference values for nutrient intake (2004) for the duration of pregnancy. These needs can be easily covered with salt content in food. Iodine is particularly important in relation to pregnancy because of the risk of mental impairment in the offspring of iodine-deficient mothers (Fraser, 2005). Iodine intake is increased during pregnancy due to increased renal blood flow and the associated increase in iodine excretion in urine. Pregnant women should therefore need to pay attention to consume enough iodine; 200 (Reference values…, 2004) or 250 µg (WHO, 2007) per day are currently recommended.

The aim of this study was to evaluate vitamin and mineral status of healthy pregnant women and to determine whether nutrient supplements improve their status.

2 MATERIAL AND METHODS

Our study was conducted as a part of the research project "The role of human milk in development of breast fed child's intestinal microbiota" (J4 – 3606). Participants were recruited from January to May 2011 at the University medical Centre Ljubljana, Gynaecological clinic, while attending parents' school. 150 healthy pregnant women received the written instructions and attended the lecture about the study protocol. Sixty nine women were willing to participate and signed the consent forms. The study protocol was approved by the Ethical Committee of the Republic of Slovenia. Assessment of dietary intake was used to determine the nutritional status of pregnant women. Participants were asked to record the intake of all foods, drinks and vitamin-mineral supplements consumed throughout the 4 consecutive days including one weekend day. Study participants were also instructed not to make any dietary changes during the trial. 4-day food diary was completed in accordance with household survey method. Completed paper based food diaries were sent to the Biotechnical faculty and entered into computer programme Prodi 5.7 Expert, which is based on SFK 2005, BLS II.3 extract nutritional database, user defined food and commercial products (Kluthe, 2010). The results were compared to Reference values for nutrient intake (2004). One sample t-test (IBM SPSS Statistics 20.0) was used for statistical evaluation.

3 RESULTS

Sixty nine pregnant women who participated in this study were healthy with an average age of 30.6 ± 3.8 years. They were in 30.5 ± 3.7 week of pregnancy with normal pregnant weight (71.8 ± 12.0 kg) and 166.7 ± 5.3 cm high. Their average weigh before pregnancy was 64.1 ± 11.8 kg. Our sample (N = 69) represents 2.32 % of all live births (N = 2971) in Ljubljana in the year 2011 (SURS, 2012).

Table 1 represents average daily dietary intake of vitamins and minerals among 69 pregnant women. Average 4-day dietary intake of micronutrients was compared to Reference values for nutrient intake (2004). Results show that on average vitamin C and E intake was 184.8 and 14.4 mg, respectively. Intake was statistically higher than reference values, therefore in compliance with recommendations (Reference values…, 2004). However detailed review shows that 8 participants (11.6 %) did not meet the demand for vitamin C intake. Moreover, surprisingly 46.4 % participants were below recommended value for vitamin E intake.

Intake of folic acid, as one of the most important nutrient in fetus development, is of serious concern. On average with 299.4 µg per day is statistically significantly lower than reference values (Table 1). Actually none of the participants achieved the recommended 600 µg per day, moreover only 35 subjects (50.7 %) covered 50 % of the recommendation (Fig. 1d). Similarly, average vitamin D intake is also statistically lower than Reference values

Table 1: *Average daily dietary intake of vitamins and minerals among 69 pregnant women in comparison to Reference values for nutrient intake (2004)*
Preglednica 1: *Povprečno dnevno zauživanje vitaminov in rudninskih snovi pri 69 nosečnicah in primerjava z referenčnimi vrednostmi za zauživanje hranil (2004)*

N = 69	Mean	Standard Deviation	CV %	Reference value for nutrient intake (2004)	P-value
Vitamin C (mg/day)	184.8	76.7	41.5	110	0.000*
Vitamin D (µg/day)	2.6	2.8	107.7	5[a]	0.000*
				20[b]	0.000*
Vitamin E (mg/day)	14.4	5.7	39.6	13	0.043*
Folic acid (µg/day)	299.4	83.4	27.9	600	0.000*
Ca (mg/day)	1159.6	301.6	26	1000	0.000*
Fe (mg/day)	14.5	4.1	28.3	30	0.000*
I (µg/day)	181.8	56.2	30.9	200[a]	0.009*
				250[c]	0.000*
Na (mg/day)	2473.1	872.1	35.3	619	0.000*
NaCl (g/day)	6.3	2.2	34.9	5	0.000*

[a] Reference value for nutrient intake (2004); [b] Reference value recommended by German Nutrition Society (2012);
[c] Reference value recommended by WHO (2007); * designate significance P ≤ 0.01 for one-sample t test

for nutrient intake (2004) and only 6 participants (8.7 %) met the demand (5μg/day) for vitamin D intake. Moreover none of the participants met the demand for vitamin D intake recommended by WHO (2007) (Fig. 1b).

Due to fetus and placenta growth during pregnancy (FSA, 2005) recommendation for iron intake is 100 % higher than for non-pregnant women. Results show that on average daily iron intake meets the demand for non-pregnant women, but is significantly lower than recommended value for pregnant women (30 mg/day) (Table 1). In addition 39.1 % of subjects covered or exceeded the recommended value for iron among non-pregnant women, but none of the participants reached the higher demand for iron during pregnancy (Fig. 2a). Risking the mental impairment in the offspring of iodine-deficient mothers (Fraser, 2005) iodine is particularly important in relation to pregnancy. On average daily iodine intake was significantly lower than both recommended values as indicated in Table 1. 47 and 59 participants did not meet the demand for 200 μg and 250 μg per day, respectively (Fig. 2b). Intake of macro elements sodium and calcium were statistically higher than recommended values (Reference values…, 2004). Therefore average daily calcium intake was in accordance with recommended value, while average sodium intake with 2.5 g per day was higher than amount referenced. Moreover average daily salt intake was higher than recommended daily intake (5 g/day). It is evident (Fig. 2d) that 66.7 % of women in studied group were above the recommended daily salt intake.

Among 69 pregnant women in our study 60.9 % decided on taking nutrient supplements. 20 different nutrient supplements were documented and classified into five groups (count N): vitamin-mineral supplements (10), calcium (3), iron (2), vitamin C (3) and vitamin supplements (2). The vast majority of subjects took one (N = 26) or two (N = 8) nutritional supplements. On the other hand there were 3 subjects recorded with 4 or more different supplements in their daily diet.

Average daily intake of vitamins with food in comparison with food + supplements is presented in figure 1. It was not surprising that on average daily vitamin C intake with food + supplements was statistically higher (Table 2) than recommended value as daily vitamin C intake with food already exceeded recommended 110 mg per day (Reference values..., 2004). The same trend can be seen in daily vitamin E intake. The number of participants not meeting the demand for vitamin E intake with food and food + supplements dropped from 32 to 17, respectively (Fig. 1c). Average daily intake of vitamin

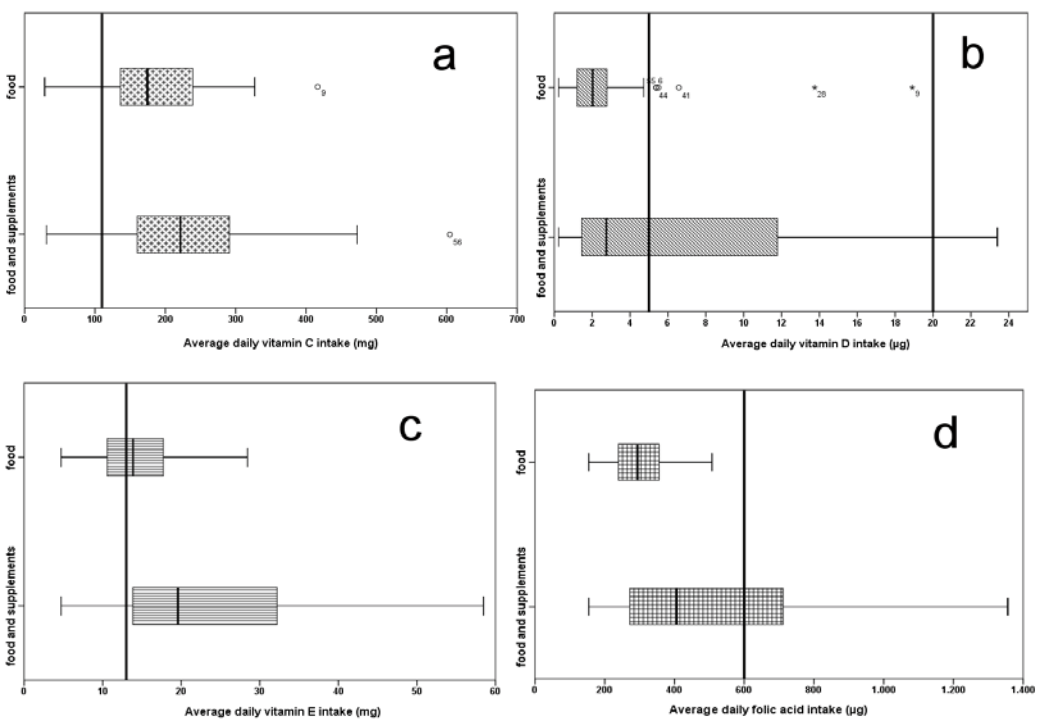

Figure 1: *Daily intake of vitamin C (a), vitamin D (b), vitamin E (c) and folic acid (d) among pregnant women in comparison with Reference values for nutrient intake (2004)*
Slika 1: *Dnevno zauživanje vitamina C (a), vitamina D (b), vitamina E (c) in folne kisline (d) pri nosečnicah in primerjava z referenčnimi vrednostmi za zauživanje hranil (2004)*

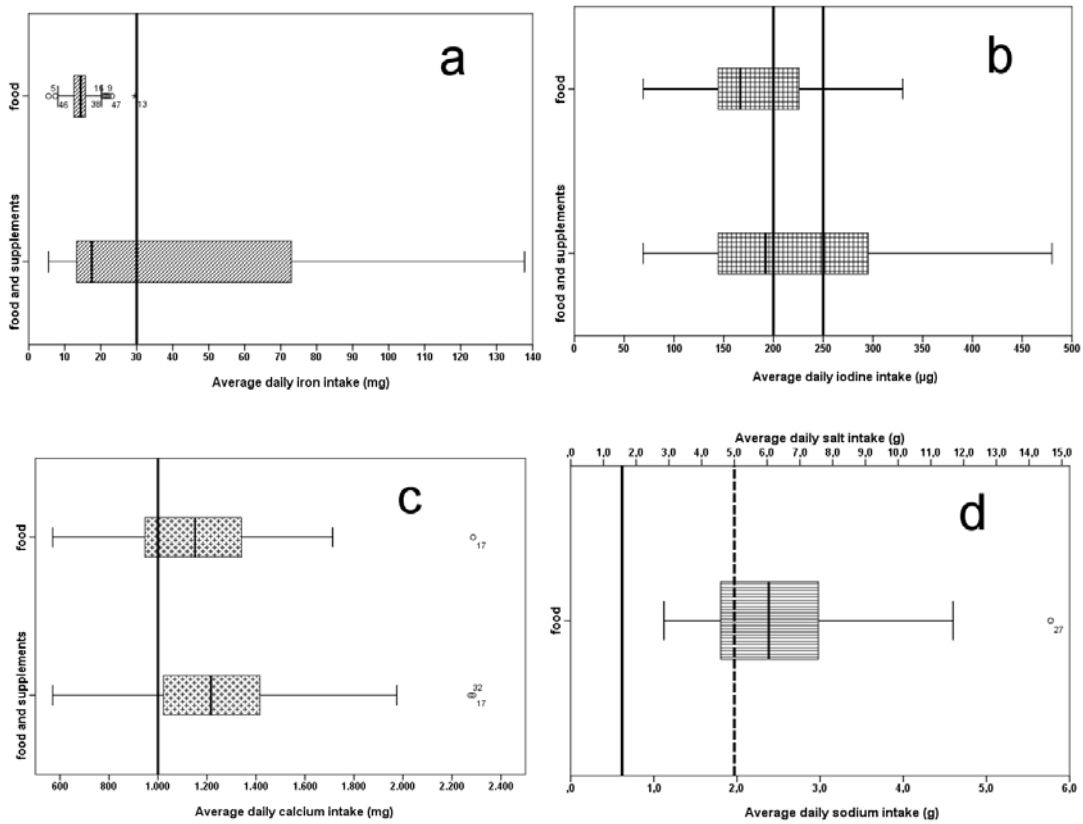

Figure 2: *Daily intake of minerals iron (a), iodine (b), calcium (c) and sodium (d) among pregnant women in comparison with Reference values for nutrient intake (2004)*
Slika 2: *Dnevno zauživanje rudninskih snovi, železa (a), joda (b), kalcija (c) in natrija (d) pri nosečnicah in primerjava z referenčnimi vrednostmi za zauživanje hranil (2004)*

D rose from 2.6 to 6.1 µg per day between food and food + supplements. Taking supplements into consideration average daily intake of vitamin D among participants met the demand for recommended dietary value (Reference values..., 2004). Nevertheless still astonishing high percentage (63.8 %) of participants did not cover the need for daily vitamin D intake (Fig. 1b). On the other hand only one participant reached the reference value recommended by WHO (2007) and therefore average daily vitamin D intake with food + supplements was statistically lower (Table 2) than recommended 20 µg per day (WHO, 2007). Taking supplements into account the folic acid status of studied group improved significantly. Average folic acid intake increased from 299.4 to 538.2 µg per day for intake by food and by food + supplements, respectively. Although average folic acid intake by food + supplements was in accordance with Reference values for nutrient intake (2004) (Table 2), there were still 49 participants (71 %) who did not meet the demand (Fig. 1d).

Due to supplementation iron intake on average rose from 14.5 to 38 mg per day, therefore was in accordance with Reference values for nutrient intake (2004). To put things into perspective, 45 participants (65.2 %) were still under recommendation, while 6 participants exceeded 100 mg per day. Daily iodine intake with food + supplements was on average 221.8 µg, therefore in accordance with Reference values for nutrient intake (2004) and statistically lowers than WHO (2007) recommendation (Table 2). More than half of the participants and almost 67 % did not reach 200 and 250 µg per day respectively (Fig. 2b). As a result of supplement intake 7 participants improved their calcium status, consequently 79.7 % of studied women exceeded the Reference values for nutrient intake (2004) (Fig. 2c).

In general, none of the participants reached the recommended values for all studied nutrients (vitamin C, D, E, folic acid, calcium, iron and iodine) with food as indicated in Table 3. One participant achieved the recommendation for five out of seven nutrients. 17.4 % of the participants reached the recommendation for four nutrients. Vitamin C, E, Ca and I were nutrients covered most often. Unfortunately there were four participants, who did not meet the recommendation for all studied nutrients (Table 3). Two of them improved their vitamin C, E and iodine

Table 2: *Average daily intake of vitamins and minerals with food and supplements among 69 pregnant women in comparison to Reference values for nutrient intake (2004)*
Preglednica 2: *Povprečno dnevno zauživanje vitaminov in rudninskih snovi s prehranskimi dopolnili pri 69 nosečnicah in primerjava z referenčnimi vrednostmi za zauživanje hranil (2004)*

N = 69	Mean	Standard Deviation	CV %	Reference value for nutrient intake (2004)	P-value
Vitamin C (mg/day)	240.4	107.3	44.6	110	0.000*
Vitamin D (μg/day)	6.1	6.2	101.6	5[a]	0.160
				20[b]	0.000*
Vitamin E (mg/day)	23.9	13.3	55.6	13	0.000*
Folic acid (μg/day)	538.2	337.9	62.8	600	0.133
Ca (mg/day)	1239.5	355.6	28.7	1000	0.000*
Fe (mg/day)	38	35.1	92.4	30	0.063
I (μg/day)	221.8	95.2	42.9	200[a]	0.061
				250[c]	0.016*

[a] Reference value for nutrient intake (2004); [b] Reference value recommended by German Nutrition Society (2012);
[c] Reference value recommended by WHO (2007); * designate significance $P \leq 0.01$ for one-sample t test

status with vitamin-mineral supplements. Seven participants reached the recommendation for one nutrient, most often vitamin C. Approximately half of the participants (46.4 %) met the recommendation for two or less nutrients and were indicated as women with poor nutritional status. Taking the supplements 15 participants improved their nutrient status, however there were still 24.6 % of studied women with poor vitamin-mineral status.

Table 3: *Count of participants that reached the recommended nutrient intake for studied nutrients (vitamin C, D, E, folic acid, calcium, iron and iodine) with food and food + supplements in accordance to Reference values for nutrient intake (2004)*
Preglednica 3: *Število udeleženk, ki so dosegle priporočene vrednosti za proučevana hranila (vitamin C, D, E, folna kislina, kalcij, železo in jod) s hrano in hrano s prehranskimi dopolnili in primerjava z referenčnimi vrednostmi za zauživanje hranil (2004)*

	Food		food + supplements	
N*	Frequency	Percent	Frequency	Percent
0	4	5.8	2	2.9
1	7	10.1	3	4.3
2	21	30.4	12	17.4
3	24	34.8	9	13.0
4	12	17.4	21	30.4
5	1	1.4	3	4.3
6	0	0.0	11	15.9
7	0	0.0	8	11.6

*Count of nutrients in accordance to Reference values for nutrient intake (2004)

Taking the supplementation into account, 8 and 11 participants covered the need for seven and six studied nutrients, respectively (Table 3). Interestingly using the vitamin-mineral supplementation 6 participants improved their nutrient intake and covered six or seven nutrients as opposed to poor nutrient intake with food (sufficient in two or less nutrients).

4 DISCUSSION AND CONCLUSIONS

4.1 DISCUSSION

Including varied and healthy food in daily diet that contains adequate amounts of nutrients is vital for optimum fetal growth and development and to maintain good maternal health. There is an increased requirement for several micronutrients during pregnancy (Williamson, 2006; Ladipo, 2000). In our study we evaluated the vitamin-mineral nutritional status of healthy pregnant women. For that reason the intake of vitamins C, D, E, folic acid and minerals iron, iodine, calcium and sodium was analysed. There is an increased requirement for all of studied nutrients during pregnancy except for calcium (Reference values..., 2004), as metabolic adaptations enable more efficient absorption and utilisation during this period (Williamson, 2006).

Results of our study showed that folic acid and iron were the most problematic nutrients in terms of meeting the recommended values. The fact that intake of both nutrients with food was below the recommendations for all the participants is alarming. The importance of good

dietary advice during pregnancy to encourage women to consume a healthy, balanced diet, in particular plenty of iron- and folate-rich foods, should therefore not be underestimated. In other words most cases of anaemia during pregnancy are caused by iron deficiency; however, it is also associated with folate deficiency (Williamson, 2006). For this reason, supplements with these nutrients are recommended in addition to improved diets (LINKAGES, 2004), a folic acid supplement (400 μg/day) is recommended prior to and up to the 12th week of pregnancy, and a vitamin D supplement (10 μg/day) is recommended throughout pregnancy (Williamson, 2006).

Taking into account supplements folate and iron intake was on average in accordance with recommendations however only around one third of all subjects met the demand for both nutrients. Vitamin D is the third most critical nutrient on average the intake with food was statistically lower than reference value, while with supplementation intake of vitamin D was in accordance with recommended value. The same trend can be seen in case of iodine intake. On average calcium, vitamin C and E were higher than or in compliance with recommendations.

In many women, intakes of a range of nutrients are below the recommended value, suggesting they are likely to be inadequate (Williamson, 2006). In our study almost half of all studied participants did not meet the recommendations for five or more nutrients with food and were indicated as women with poor nutritional status. Including supplementation less than a quarter of participants still remains in a group with poor vitamin-mineral status. On the other hand more than a quarter of subjects improved their status with supplementation, as none of the participants met the demand for six or more nutrients with food. Nevertheless women eating a good diet are more likely to take supplements than are those at greater risk for micronutrient deficiencies (Ladipo, 2000), in our case there were 6 subjects who significantly improved their vitamin-mineral status with taking supplementation.

One approach to increase the intake of essential nutrients is to increase their levels in specific target foods through fortification (Keen and Zidenberg-Cherr, 1994; Williamson, 2006). According to Ladipo (2000), discussion and agreement is needed about issues related to what motivates women of childbearing potential to change behaviour that can result in improved nutritional status, through improved dietary practices or the use of vitamin-mineral supplements linked in with the safety issues.

4.2 CONCLUSIONS

The outcomes of our study can be summarised in the following conclusions:

- The most problematic nutrients seem to be folate and iron as on average daily intake of these nutrients is below the recommendation for all the participants. Beside that only 6 participants (8.7 %) reached the recommended value for vitamin D.
- In general supplements intake improved folate, iron and vitamin D status of pregnant women, on the contrary intake of these nutrients is inadequate for at least 64 % of the participants.
- On average intake of calcium, vitamin C and E with food is higher than or in compliance with recommendations and therefore non-problematic.
- Overall intake of vitamins and minerals with food is of great concern, as 46.4 % of all participants are indicated as women with poor nutritional status, moreover none of them exceeded the recommended value for six or seven nutrients.
- In our study 42 participants (60.9 %) decided to take supplements, 6 (8.7 %) of them significantly improved their vitamin-mineral status, nevertheless taking supplements nutritional status of four participants (5.8 %) remained unchanged.
- Taking supplementation into account 27.5 % of participants met the demand for six out of seven nutrients, however almost a quarter of studied subjects still remain in the group with poor nutritional status (sufficient in two or less nutrients).
- Focusing only on individual-level dietary intake of healthy pregnant women, most of the participants in our study were deficient in three or more nutrients and indicated as subjects with poor nutritional status. Therefore other approaches, such as nutrient biomarkers in body fluids should be used to confirm these results of relatively poor intake of essential nutrients during pregnancy.

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