

SERUM PROTEIN AND ALBUMIN PARAMETERS DURING PREGNANCY ALERT ABOUT THE NUTRITIONAL STATUS OF THE PREGNANT WOMAN. NARRATIVE REVIEW

Mercedes de Dios-Aguado

Servicio de Salud Pública Castilla- La Mancha

<https://orcid.org/0000-0002-0991-7558>

Alba Martín Forero-Santacruz

Servicio de Salud Pública Castilla-La Mancha

<https://orcid.org/0000-0002-9229-6934>

Eva Moncunill-Martínez

Universidad de Castilla-La Mancha- UCLM

<https://orcid.org/0000-0002-6885-530X>

Irene Soto-Fernández

Escuela Pública Ciudad de Nara

<https://orcid.org/0000-0002-1140-9544>

Sagrario Gómez-Cantarino

Universidad de Castilla-La Mancha- UCLM

<https://orcid.org/0000-0002-9640-0409>

All content in this magazine is licensed under a Creative Commons Attribution License. Attribution-Non-Commercial-Non-Derivatives 4.0 International (CC BY-NC-ND 4.0).



Abstract: The protein needs in pregnant women increase throughout pregnancy, due mainly to the growth of maternal and fetal tissues. Thus, the diet of pregnant women must be balanced, complete, and sufficient to cover the nutritional requirement in this stage of life. Unfortunately, certain social conditions prevent women from eating a proper diet, with undesirable consequences. Our study of integrative review has been undertaken with the intent to evaluate the nutritional status of pregnant women, and to identify indicators of nutritional quality. Most studies confirm that the diet of the pregnant woman is of low quality and inadequate, and they reveal that women do not have an adequate intake of macronutrients. Moreover, some articles describe that women during pregnancy, puerperium and lactation do not make the nutritional recommendations prescribed by the health professional. After analysing the articles narrative, the researchers detected the need to include the determination of serum albumin and total protein levels in the pregnancy and puerperium protocol, as indicators of nutritional quality. These parameters can alert and guide to health professional for the early detection of a possible malnutrition in the mother. It would also be very important promote dietary recommendations, even in countries with optimal socio-sanitary conditions.

Keywords: Review, pregnancy, maternal nutrition, biochemistry, socioeconomic status.

INTRODUCTION

Pregnancy is a complex stage for both women and the new life that is being generated, because harmoniously merge three concepts: the development of the fetus, the increase of its cellular mass, and the morphological changes that will allow it to acquire progressive functional capabilities.

That is because the physical structure, metabolism, and emotional stability of women during pregnancy and the puerperium undergo major changes, which implies an adaptation to these changes and an increase in the demand for nutrients, producing in some cases the alteration of nutritional status. A balanced diet at this stage of life provides adequate nutrients, favours the quality of the placenta and achieves optimal intrauterine fetal development [1]. Knowing the nutrients present in the food that is ingested, allows the woman to make a diet with nutritional quality and adequate to their needs. For this reason, the purpose should not be to design a special diet during pregnancy, puerperium or breastfeeding, but rather a personalized diet for each woman during the different stages of pregnancy and puerperium [1,2], but paying a special attention to women from socially disadvantaged groups, because very often do not have the resources to make a balanced diet during pregnancy [3].

Physiologically, gestation causes an increase in women blood volume up to 40-45%, causing the depletion of 25% of serum metabolites (such as total proteins and albumin), and being associated with a reduction in colloidal osmotic pressure and transport capacity of insoluble substances (bilirubin and fatty acids) [4,5]. Protein synthesis is increased by glucocorticoids and thyroid hormones, although their electrophoretic pattern shows decreased albumin by hemodilution. Transferrin and α -macroglobulin also increase as a result of increased estrogens and ferric deficit associated to pregnancy [6,7]. In summary, throughout pregnancy the protein needs increase due to the growth of maternal and fetal tissues, being more demanding from the second month of gestation [8]. Thus, in the pregnant woman diet, proteins must represent between 15 and 25% of the total caloric intake [9,10]. To maintain this extra quota of proteins,

women must consume daily meat, eggs, milk and their derivatives. However, in pregnant vegan women, such needs are met exclusively through the consumption of vegetables and legumes that contain adequate concentrations of essential amino acids [11,12], therefore, the quality of a woman's diet may be the product of her culture, local community and family [3].

The World Health Organization (WHO), as well as National Health Systems of several countries, have developed manuals that clearly explain the recommendations on the amount and quality of proteins that women should consume during pregnancy, puerperium and breastfeeding [1,13, 14]. All of them advise on the need to identify possible changes in the nutritional behaviour of women, with the aim of knowing if the food is balanced, complete and sufficient to cover the nutritional requirements at this stage of their life, or conversely [14], because a pregnant woman with macro or micronutrient deficiencies may be at greater risk of adverse pregnancy outcomes and fetal development [15].

Social conditions during pregnancy influence the failure or success of the new life development [16]. Thus, political tensions, natural disasters, active armed conflicts, difficulty in accessing basic health resources, educational deficiencies and other causes, are facts that force people to leave their country of origin or residence, and to find another place in the world where they can safely develop their life project. In this sense, it is possible to think that, depending on the context where the gestation takes place, it will present or not pathologies derived from poverty [17]. That is why, in neighbourhoods with a high density of ethnic minorities and a deficit of socio-sanitary services, the perinatal morbidity rate is high. Therefore, the elimination of the discriminatory factors experienced by some women from socially disadvantaged ethnic

groups reduces their perceived stress and the prevalence of prematurity [17,18].

In the elimination of social inequalities, the "social capital" (residents' resilience of a neighbourhood, which is measured by the willingness of neighbours to help each other in times of need, by the ability of residents to carry out collective action that generates mutual benefits, and interpersonal social connections and relationships of trust between different members of the community) play a decisive role [19], because although access to a healthy diet for pregnant women with a medium socioeconomic level is easy, on the contrary, a pregnant woman of low socioeconomic level and without social capital, is more exposed to an inadequate diet [20]. Scenario that the global economic crisis has magnified, because it is often observed that the pregnant woman of low socioeconomic status is on the verge of social exclusion and/or in a situation of poverty, a fact that prevents them from following the recommendations of dietary intake recommended by health professionals, being these suggestions a utopia, because they can only eat foods poor in protein, vitamins and minerals, achieving the necessary caloric intake every day through a diet with low nutrient density foods, which implies a lack of macro and micronutrients in your diet. [21]. The risk of poverty or social exclusion rate in Spain in 2020 (AROPE indicator), in the age range between 16 to 29 years was 29.3, while in the range of 30 to 44 years old it was 27.7(for both sexes), which represents an increase in the younger population. Considering only the female sex, in the age range of 16 to 29 years, the rate was 29.3, while in the age range of 30 to 44 years old, it was 27.7; therefore, there was a greater increase of risk of poverty or social exclusion in the stage of maximum fertility of women [22]. In this sense, the social determinants of

health can also have a negative impact on a woman's pre-conceptional health status, her diet during pregnancy and her gestational checks [23].

Given the evidence of the role played by nutrition during pregnancy and, with the purpose of advancing in the knowledge of the nutritional status of pregnant and puerperal women, an integrative review has been carried out with the aim of: 1) assess the latest studies on malnutrition in pregnant women, 2) describe the causes of maternal malnutrition during pregnancy, and 3) identify specific indicators of nutritional quality that serve to alert health professionals on malnutrition in the mother during pregnancy.

MATERIALS AND METHODS

INFORMATION SOURCE AND SEARCH STRATEGY

The search was performed through the following databases: PubMed, Medline, Scielo, Dialnet, and the integrative metasearch Google Scholar. The keywords used followed the CINAHL thesaurus, and were: Pregnancy, Preeclampsia, Serum Albumin, Blood Proteins, Maternal Nutritional Physiological and Supplementary Feeding, Emigrants and Immigrants, Vulnerable Populations, Poverty, Working Poor. A review of the scientific publications whose content was on gestation, albumin and proteins, was carried out. Selected papers were published between 1 January 2000 and 31 December 2021.

INCLUSION AND EXCLUSION CRITERIA

The articles chosen for the narrative review should be written in English, French or Spanish, being also original publications available online or through interlibrary loan. The articles were selected with relevant information about: (1) the nutritional status of the pregnant or puerperal woman, (2) the

feeding patterns of women in preconception, pregnancy and lactation, (3) supplementation with multiple macronutrients during pregnancy, and (4) the importance of nutrition in women during this stage of life.

Articles were excluded when: (1) the full text was not available, (2) texts written in a language other than those selected, (3) they were studies related to carbohydrates or they only adhered to micronutrient supplementation, (4) the socio-economic level of the country where the study of the pregnant woman was carried out, at the time of the development of the research, was different from the socio-economic level of Europe and / or (5) the studies were carried out in countries suffering from famine or war, and (6) sanitary conditions were not suitable for women.

Researchers reviewed the titles, abstracts and complete articles independently, and their bibliographical references manually to add them to the review if they were selected. When discrepancies arose among researchers, an attempt was made to reach a consensus, and if not possible, an external reviewer resolved the conflict.

DATA COLLECTION PROCESS

The data includes: (1) year of publication, (2) country of study, (3) sample type, (4) study design, (5) number of participants, (6) characteristics of the participants, (7) follow-up period and method, (8) intervention or exposure, and (9) main results and observed events.

We included a quality score of 3 points (2 = well described, 1 = poorly described, 0 = not described), for the following eight attributes: (1) description of the study site; (2) description of the study participants; (3) definitions of all variables; (4) description of data sources and measurement tools; (5) justification of sample size; (6) description

of statistical methods; (7) Description of results; (8) discussion and interpretation of results. Therefore, the maximum quality score was 16.

RESULTS

A total of 1430 potentially relevant titles were identified. After applying the inclusion and exclusion criteria and removing the duplicates, 167 abstracts were read. Of these, 88 full text articles were analysed, of which 26 were review articles and 31 (qualitative and quantitative) studies. However, 9 of them were not published within the time period investigated, although their inclusion

was chosen due to the relevance of their information, 5 Manuals or Guides related to the study topic were also reviewed, and 1 Doctoral Theses were identified. Finally, only 74 documents were used because 14 articles did not fit the characteristics of the narrative review. The selection of studies is illustrated in the flow chart made in accordance with the PRISMA statement (Figure 1).

Dietary recommendation to women during their gestation, puerperium and lactation period, has undergone multiple modifications over time, even generating controversy the extra amount of proteins that the woman should ingest during her

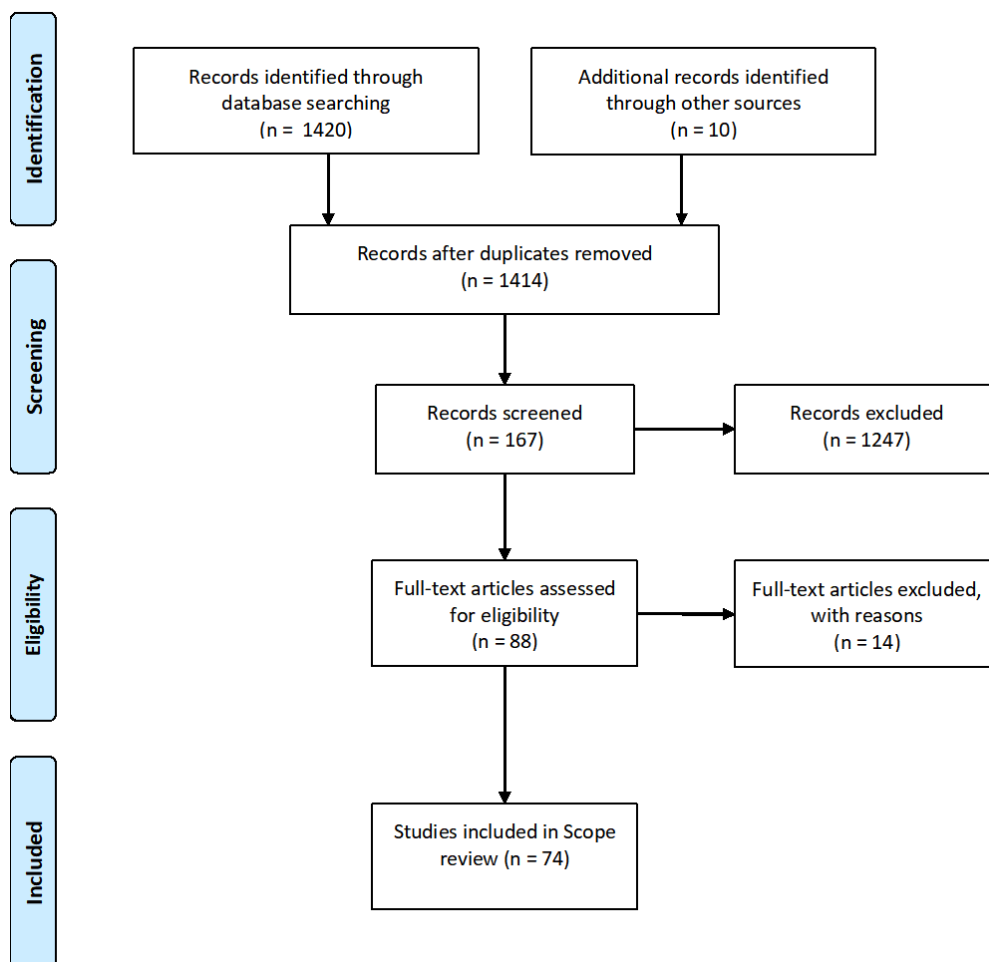


Figure 1. PRISMA statement flow chart.

pregnancy [24]. That is why women have gone from being stimulated to low-calorie diets, to obtain modest increases in weight during pregnancy, to be motivated to “eat for two”, which once led to excessive weight gain and it resulted in an increase in the prevalence of maternal and fetal morbidity [25]. Moreover, such recommendation has been mystified until today, and popular wisdom encourages pregnant women to “eat for two”.

At present, the pregnant woman diet is considered adequate when the feeding provides her with enough energy to maintain an optimal nutritional status; it supplies the amount of energy and nutrients that the cells of the different tissues and organs of her body require during pregnancy, puerperium and lactation; and provides a quantity and variety of foods that cover all her needs for protein, iron, calcium, folic acid, minerals and vitamins, avoiding deficiency states of macro and / or micronutrients [26,27].

To clarify this premise, it is necessary to differentiate between pregnant women with low weight (needs a diet with greater energy and nutrients, in order to improve their nutritional status), and pregnant women with overweight or obesity (her diet does not present energy restriction, being necessary a learning in the acquisition of nutritional habits and healthy lifestyle) [28]. Therefore, women during pregnancy, puerperium and breastfeeding should perform a personalized diet that provides her adequate food to promote fetal development [29,30].

The WHO and the National Governmental Organizations of different countries, insist on the need to identify the nutritional behaviour of women, with the aim of detecting whether the diet is balanced, complete and sufficient to cover the nutritional requirements at this stage of life; or conversely, it is deficient in macro or micronutrients, which could alter fetal development [13, 14,15,21]. In this sense,

it is essential to pay attention to the vegetarian (lacto-ovo-vegetarian, fish-vegetarian, etc.) and vegan diet, given that they are increasingly introduced in the population. Diets devoid of any food of animal origin, including eggs and milk, deserve special vigilance, since they have a lower consumption of energy and protein content, being greater the supply of fiber and unsaturated fats [30].

The studies carried out by Correa and Madden show that the diet performed by pregnant women included in their studies is of low quality and inadequate, and they reveal that most of participants do not have an adequate intake of macronutrients [31,32]. Moreover, authors show that the diets were insufficient in energy, proteins, vitamins and minerals, and those that reached a higher value of caloric intake was obtained from products with low nutrient density, which it does not imply a substantial improvement in the quality of the diet [31]. In general, the dietary pattern and lifestyle of the Spanish pregnant woman is not healthy, due to the excessive intake of foods with a high content of saturated fatty acids or sugars, being scarce the consumption of dairy and protein foods, and inadequate consumption of cereals and vegetables [33]. In this regard, only studies conducted in Australia and New Zealand recorded a decrease in carbohydrate consumption, protein consumption within the prescribed range, and adequate consumption of fruits and vegetables during pregnancy [34,35].

Some of the articles reviewed show that, in general, women during pregnancy, puerperium and lactation do not make the nutritional recommendations prescribed by the health professional, regardless of the country where they live, and show that the diet they perform does not meet the demand for nutrients and energy necessary for intrauterine fetal development [36,37], even

reaching maternal-child malnutrition [38,39]. Therefore, insufficient weight gains during pregnancy and a maternal diet with inadequate protein intake can cause intrauterine growth restriction, low birth weight, premature birth, congenital defects, cognitive and behavioural defects, postpartum complications, anaemia, maternal haemorrhage, preeclampsia and/or eclampsia [40,41,42]. On the other hand, these facts have been related to epigenetic changes in the fetus [43,44]. Because of the relevance of this information, maintaining an adequate macronutrient intake during pregnancy is essential to ensure healthy fetal development [42]. Therefore, knowing the diet carried out by pregnant woman, and especially of those women who live in conditions of poverty and / or vulnerability, to prevent malnutrition and possible undernourishment [45]. The social determinants of health, such as poverty, access to education and domestic violence, have a negative impact on the pregnant woman's health status, both because of a lack of resources to eat a balanced diet and because of the absence of scheduled check-ups during the three trimesters of pregnancy, which can affect the development of the pregnancy [23].

Researches confirms that a good protein intake during pregnancy favours the puerperal recovery of the mother and facilitates breastfeeding [13, 46]. In addition to the above, we must not forget the importance that the authors attach to the pre-gestational anthropometric measurements of the mother, the serum glucose levels during the pregnancy period, as well as the weight increase throughout pregnancy, factors influencing the development of the fetus and warn about malnutrition, gestational diabetes, decreased placenta weight, aged placenta, intrauterine mortality, premature birth, perinatal mortality, and without forgetting the risk of maternal mortality [42,46,47].

Studies related to pregnant women who presented preeclampsia reveal that the electrophoretic pattern of their serum proteins is similar to that of patients with nephrotic syndrome [48]. In addition, pregnant women with preclampsia have a significantly lower serum albumin concentration than healthy pregnant women, but in serum concentrations of electrolytes (sodium, potassium and chlorine) no significant differences were observed. The plasma volume expansion during pregnancy leads to a decrease in the concentration of plasma proteins, and therefore is accompanied by an increase in the urinary excretion of amino acids [48,49]. However, it is important to note that pregnant women, even with an adequate nutritional status, have physiological and therefore specific modifications in their haematological and biochemical parameters. This fact should be taken with special consideration, since it would be a wrong interpretation to compare the serum values obtained in this period of life with the reference values of a woman who is not pregnant [50,42].

The main functions of the placenta, among others, are the passage of nutrients and water from the mother to the fetus, the excretion of fetal waste products into the maternal circulation, and the modification of the maternal metabolism by hormonal action during pregnancy. These functions are influenced by the woman nutritional status, since it is closely related to the growth of the placental tissue [51]. Thus, Julca et al. show that undernourished pregnant women present variations in chemical components and morphological differences in their placentas, which are more pronounced in women with low socioeconomic status [51]. In this sense, it is worth remembering the information provided by Schölmerich and Posthumus, where they related the perinatal morbidity rate and the prevalence of prematurity with the

social inequality experienced by the pregnant woman of some socially disadvantaged ethnic groups who lived in neighborhoods with little social capital [17,19]. On the other hand, it should be noted that stress alters the vaginal flora, as well as many other parameters, and so women are more exposed to infections of the vaginal tract, which results in an increase in the prevalence rate of prematurity [52,53]. Thereby, eliminating the factors of discrimination towards the mother is particularly interesting, since by reducing their stress, they will access to health services and will be able to carry out quarterly controls, which will decrease the perinatal morbidity rate and the prevalence of prematurity.

The studies reveal that socioeconomic status and living conditions of pregnant women warn of a possible food deficit, so it is necessary to insist on performing, throughout the pregnancy, a diet with foods rich in proteins that provide protein energy enough to face all the changes associated with its gravid status [54,55], without forgetting that people from disadvantaged social level, the consumption of fruits, vegetables, meats and fish is scarce [56,57]. These documents show the scientific evidence to recommend to the woman a protein rich diet to supply the necessary protein energy during her gestation, a circumstance that reduces by 44% all the causes of stillbirth [58]. In addition, nutrients and energy stored during pregnancy will facilitate the recovery of the mother in the puerperium and will be a great support for the establishment of breastfeeding. Once the adequate intake of macronutrients has been reached, there is no scientific evidence to justify its supplementation [59,60]. Regarding vegan women, supplementation would be justified because their diets are devoid of any food of animal origin, including eggs and milk, and they present a deficient intake of macronutrients [61].

At present, families with a lower socioeconomic status acquire foods that are poor in macronutrients, but sometimes consume a large amount of carbonated and sweetened beverages, facts that alert about malnutrition, since the “double burden” of nutrition must be considered: overweight, obesity and malnutrition “ [62]. In recent years, the nutritional status of the mother before and during pregnancy has been confirmed as one of the most influential environmental factors in fetal development with personalized nutrition gaining relevance [15,23,63]. Scientific evidence indicates that macro and micronutrients influence metabolic, cellular and molecular processes, including DNA structure and gene expression, which may contribute, directly or indirectly, to the prevention of numerous pathologies associated with nutrition [64].

Between 1970 and 2015, systematic literature reviews focused on the effect of protein energy supplementation during pregnancy, and they were performed on undernourished women from low- and middle-income countries [65]. In subsequent reviews conducted by Kramer or Ota, the authors conclude that “with nutritional advice”, the women have a lower relative risk of preterm birth; however, in those receiving balanced supplementation of energy and protein, the risk of fetal death was significantly reduced and the mean weight at birth increased in their children, there was also a significant reduction in the risk of prematurity, but no significant effect regarding neonatal death was detected. Pregnant women fed high-protein supplements had a significantly higher risk of having small babies for their gestational age, and women who received isocaloric protein supplementation did not have significant variations in their weekly gestational weight gain or on the weight of the child at birth. Therefore, it is encouraging to find that

women's prenatal nutritional counselling, with the aim of increasing the intake of energy and proteins during pregnancy, seems to be the most effective way to reduce the risk of premature birth [66,67].

Studies carried out on mothers who suffered from famine during the Second World War revealed that their fetuses suffered intra-uterine malnutrition, and that this phenomenon had long-term consequences. The fetus had to modify the functioning of some organs or systems to adapt to these extreme conditions, which in adulthood resulted in the degeneration of the state of health and some chronic pathologies related to these facts [68]. This is what has been called the phenomenon of "intrauterine programming" [69,70].

DISCUSSION

Draws attention to the authors of this work that, the few studies conducted in Europe related to malnutrition in pregnant women, were made about pregnancies after the end of World War II [68, 69]. Specifically, it was the famine suffered by the Dutch population during 1944, which has motivated the research production related to unfavourable conditions suffered by women during pregnancy [69,71,72]. This allows us to understand why the scientific literature that analyses the social variables of pregnant women comes mainly from that country [17,19].

It is also noteworthy that, in Europe, there are multiple studies performed on pregnant women related to excess nutrition [28, 33], but scarce those made around the malnutrition of women during this stage of life, especially when the economic crisis is very present today [21] and the migratory movements do not stop happening [20]. Then it will be necessary to take into account the health of migrants, since social, economic and cultural determinants affect the health of the pregnant woman,

therefore, in each quarter it is necessary to assess the nutritional status of women in order to adapt the protein requirements to their gestational state [73, 74], due to the existent of higher protein needs in the second and third quarter, as these are necessary to create new tissues [2,15,23,27]. All manuals and guides reviewed warn about the nutritional quantity and quality, providing recommendations on the intake of micro and macronutrients [1,13, 14]. But, although the lack of micronutrients in the diet of the pregnant woman has been extensively studied, no studies have been found regarding the lack of macronutrients in this group [59,60,61]. Unfortunately, while the health staff in each of the quarterly visits warns about the quality of the pregnant woman's diet [8], the woman does not make these recommendations [31,36,37,61].

Since 2008, the incidence of malnutrition in Spain has increased, mainly of a protein-energy nature, especially in people with a disadvantaged and / or vulnerable social situation, due to the economic crisis [21]. It should be noted that malnutrition includes both obesity and undernourishment, being pathologies widely studied in the first years of life [25,43,62]. However, in the battery of tests performed to woman in each trimester of pregnancy, only obesity has specific markers that alert health professional about the potential risk it entails for women [2]. In general, pregnancy and puerperium medical protocols are aimed at identifying pathologies associated with obesity or deficiencies of micronutrients, pathologies monitored from pregnancy uptake, forgetting malnutrition in women, since it is not evaluated. Our review has only found studies in the United States, Spain and Venezuela where the serum proteins and albumin values are analysed throughout the gestation, as nutritional biomarkers [2,7, 73, 74]. Currently, the clinical protocol of pregnancy and puerperium carried out by

researchers at their workplace (Health Area No. 1, urban and rural level; Toledo, Spain), it only has the glycosylated haemoglobin determination and the maternal weight gain, as nutritional indicators. Aspects that are corroborated by the research carried out in Spain [73, 74].

It is convenient to reflect on the information provided by a Dutch study [17], which shows that inequality in the use of obstetric care, the use of health centres, as well as the difficulty in putting practice health advice prescribed by professionals, are events that may be motivated by a lack of knowledge of the health system, a cultural background that influences people in their health preferences, or due to ignorance of the cultural and ethnic reality of a specific area of health, both by the health professional who provides services there, and by the pregnant woman who demands health care. In addition, low levels of health education and poor command of the language of the country where they reside can exacerbate the inequalities of obstetric care [19].

After analysing the articles reviewed, the researchers detected the need to include the determination of serum albumin and total protein levels in the pregnancy and puerperium protocol, as indicators of nutritional quality. These parameters can provide nutritional information of the pregnant woman, alerting and guiding to health professional for the early detection of a possible malnutrition in the mother [2,27,49, 73,74].

Pregnancy is a time of change, and therefore it is the best time to carry out health education in women, this will allow her to empower themselves and not feel fragile, which will reduce the stress, a factor that negatively affects the development of the gestation [28,73,74].

CONCLUSIONS

In the scheduled reviews for each trimester of pregnancy, it is essential to assess the real nutritional status of women, promote dietary recommendations, and encourage the consumption of foods rich in calcium, iron, folic acid and protein, which will be of paramount importance for the women and her future son. This health intervention should be applied equally in all women who come to the control of pregnancy, and not only in cases of gestational diabetes, alteration of the body mass index or endocrinopathologies.

At present, the controls that are performed on the mother during the three trimesters of pregnancy, as well as the battery of analytical tests requested throughout pregnancy, whatever the socioeconomic level of the woman, can become incomplete by not disclosing their real nutritional status; it is necessary to incorporate the serum albumin and total proteins levels into the analytical tests, as effective biomarkers of nutritional quality. These data would provide health personnel with valuable and essential information to prevent possible maternal malnutrition during pregnancy, even in countries with optimal socio-sanitary conditions.

Participating in health education groups allows women of different ethnicities to share feelings, feel heard, increase their abilities, and participate in health programs designed for them, developing skills that achieve a healthy Mediterranean diet during pregnancy.

AUTHOR CONTRIBUTIONS

Conceptualization, Mercedes de Dios-Aguado; methodology, Sagrario Gómez-Cantarino; software, Alba Martín Forero-Santacruz. and Irene Soto-Fernández; validation, Mercedes de Dios-Aguado, Sagrario Gómez-Cantarino and Eva Moncunill-Martínez.; formal analysis, Alba Martín Forero-Santacruz.; investigation,

Mercedes de Dios-Aguado; resources, Eva Moncunill-Martínez.; data curation, Sagrario Gómez-Cantarino; writing—original draft preparation, Mercedes de Dios-Aguado, Alba Martín Forero-Santacruz and Irene Soto-Fernández.; writing—review and editing, Sagrario Gómez-Cantarino and Eva Moncunill-Martínez.; visualization, Alba Martín Forero-Santacruz. and Irene Soto-Fernández.; supervision, Mercedes de Dios-Aguado, and Eva Moncunill-Martínez.; project administration, Mercedes de Dios-Aguado, Sagrario Gómez-Cantarino. All authors have read and agreed to the published version of the manuscript.”

FUNDING

This research received no external funding.

ACKNOWLEDGMENTS

The PrePan study is grateful for the help of the staff of the library of the University of Castilla-La Mancha, Toledo Campus, and the library of the Toledo Hospital Complex (SESCAM), for their collaboration in the search scientific documentation used in this research.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

REFERENCES

1. Illana Álvarez, A.; Lara Leiva, L. F.; Rodríguez Garvín, J., **Alimentación durante el embarazo y la lactancia**. Revista Rol de Enfermería 2018, 41, 617-624. [Google scholar]
2. Rached de Paol i I, Azuaje Sánchez A, Henríquez Pérez G. **Cambios en las variables hematológicas y bioquímicas durante la gestación en mujeres eutróficas**. An Venez Nutr. 2002, 15, 11-7. [SciELO]
3. Barker M, Baird J, Tinati T, Vogel C, Strömmer S, Rose T, et al. **Translating Developmental Origins: Improving the Health of Women and Their Children Using a Sustainable Approach to Behaviour Change**. Healthcare. 2017, 5, 17. [Google scholar] [PubMed]
4. Bach-Ngohou, K, Schmitt, S. S, Le Carrer, D D, Masson, D. D, Denis, M M. **Les dysalbuminémies**. *Dysalbuminémies*. 2005, 63, 127-34. [Google scholar] [PubMed]
5. Inga Esteban, JJ I. **Prevalencia de malnutrición protéico-energético en gestantes mediante análisis de albúmina sérica en el I.N.M.P., en el periodo octubre – noviembre del 2010**. Universidad Nacional Mayor de San Marcos; 2011 [Google scholar]
6. Cidoncha A. Utilización del laboratorio: **el proteinograma en la práctica clínica**. Med Integral Med Prev Asist En Aten Primaria Salud. 2001, 38, 127-32. [Google scholar]
7. Kalhan SC. **Protein metabolism in pregnancy**. The American Journal of Clinical Nutrition. 2000, 71, 1249-1255. [PubMed]
8. Marini, JC. **Protein Requirements: Are We Ready for New Recommendations**. J Nutr. 2015, 145, 5-6. [Google Sholar] [PubMed]
9. Cereceda Bujaico M del P.; Quintana Salinas MR. **Consideraciones para una adecuada alimentación durante el embarazo**. Rev Peru Ginecol Obstet. 2014, 60, 153-60. [Google Scholar] [SciELO]
10. Sharlin, J.; Edelstein, S. **Essentials of life cycle nutrition**. Sudbury, Mass. Jones & Bartlett Publishers. London 2010, 295-308.
11. Barretto L, Mackinnon MJ, Poy MS, Wiedemann A, López LB. **Estado actual del conocimiento sobre el cuidado nutricional de la mujer embarazada**. Rev Esp Nutr Humana Dietética. 2014, 18, 226-37. [Dialnet] [Google Scholar]
12. Butte NF; King JC. **Energy requirements during pregnancy and lactation**. Public Health Nutr. 2005. 8, 1010-27. [Google Scholar] [PubMed]

13. Ministerio de Sanidad, Servicios Sociales e Igualdad. **Guía de práctica clínica de atención en el embarazo y puerperio** 2014. Available online: https://www.mschs.gob.es/organizacion/sns/planCalidadSNS/pdf/Guia_practica_AEP (accessed on 10 February 2022).
14. WHO. **Protein and Amino Acid Requirements in Human Nutrition 2007**. Available online: https://www.who.int/nutrition/publications/nutrientrequirements/WHO_TRS_935 (accessed on 19 February 2022).
15. WHO. **Recommendations on Antenatal Care for a Positive Pregnancy Experience 2016**. Available online: https://www.who.int/reproductivehealth/publications/maternal_perinatal_health/anc-positive-pregnancy-experience (accessed on 01 April 2022).
16. Sánchez-Muniz, FJ.; Gesteiro, E.; Espárrago, M.; Rodríguez, B.; Bastida S. **La alimentación de la madre durante el embarazo condiciona el desarrollo pancreático, el estatus hormonal del feto y la concentración de biomarcadores al nacimiento de diabetes mellitus y síndrome metabólico**. *Nutrición Hospitalaria*. 2013, 28, 250-74. [Google Scholar] [SciELO].
17. Posthumus, AG.; Borsboom, GJ.; Poeran, J.; Steegers, EAP.; Bonsel, GJ. **Geographical, Ethnic and Socio-Economic Differences in Utilization of Obstetric Care in the Netherlands**. *PLOS ONE*. 2016, 11 e0156621. [Google Scholar] [PubMed]
18. Nair, M.; Kurinczuk, JJ.; Knight, M. **Ethnic Variations in Severe Maternal Morbidity in the UK– A Case Control Study**. *PLOS ONE*. 2014. 9, e95086. [Google Scholar] [PubMed]
19. Schömlerich, VL.; Erdem, Ö.; Borsboom, G.; Ghorashi, H.; Groenewegen, P.; Steegers, EA. et al. **The Association of Neighborhood Social Capital and Ethnic (Minority) Density with Pregnancy Outcomes in the Netherlands**. *PLOS ONE*. 2014, 9, e95873. [Google Scholar] [PubMed]
20. United Nations Development Programme Date: **Migration and Displacement 2019**. Available online: <https://www.undp.org/content/undp/en/home/2030-agenda-for-sustainable-development/prosperity/recovery-solutions-and-human-mobility/migration-and-displacement.html> (accessed on 10 February 2022).
21. Informe AROPE Date: **Estado de la Pobreza en España 2019**. Available online: <https://www.eapn.es/estadodepobreza/> (accessed on 2 April 2022).
22. Instituto Nacional de Estadística INE. **Población en riesgo de pobreza o exclusión social. Riesgo de pobreza y/o exclusión social (estrategia Europa 2020)**. Indicador AROPE. España y UE-28 (población de 18 y más años) 2020. Available online: https://www.ine.es/ss/Satellite?L=es_ES&c=INESeccion_C&cid=1259941637944&p=1254735110672&pagename=ProductosYServicios/PYSLayout (accessed on 2 April 2022).
23. Hil, I B.; Skouteris, H.; Teede, HJ.; Bailey, C.; Baxter, J-AB.; Bergmeier, HJ. et al. **Health in Preconception, Pregnancy and Postpartum Global Alliance: International Network Preconception Research Priorities for the Prevention of Maternal Obesity and Related Pregnancy and Long-Term Complications**. *Journal of Clinical Medicine* 2019. 8, 12. [Google Scholar] [PubMed]
24. Figueroa R. **Nutrición durante el embarazo y la lactancia**. *Rev Peru Ginecol Obstet*. 1996, 42, 14-6. [Google Scholar]
25. Pacora, P.; Ruíz, S. **Nutrición materna: Comer por dos para el bienestar del embarazo y la progenie?** *Revista Peruana Ginecología Obstetricia*. 1995. 41, 8-17. [Google Scholar]
26. Almaguer, C.; de la Caridad, C.; Cruz Sánchez, L.; López Menes, M.; González, J. D. **Nutrición y embarazo: algunos aspectos generales para su manejo en la atención primaria de salud**. *Revista Habanera Ciencias Médicas*. 2012. 11, 168-75. [Google Scholar]
27. Pacheco-Romero J. **Nutrición en el embarazo y lactancia**. *Revista Peruana Ginecología Obstétrica*. 2014. 60, 141-6. [Google Scholar] [SciELO]
28. Falen, J. **Necesidades nutricionales**. *Revista Peruana Ginecología Obstetricia*. 1995. 41, 14-20. [Google Scholar]
29. Falen, J.; Quiroz, J.; Figueroa, E. **Estado nutricional de la gestante adolescente y del recién nacido y consumo de alimentos y nutrientes**. *Revista Peruana Ginecología Obstetricia*. 1997. 43, 9-15. [Google Scholar]

30. Marangoni, F.; Cetin, I.; Verduci, E.; Canzone, G.; Giovannini, M.; Scollo, P. et al. **Maternal Diet and Nutrient Requirements in Pregnancy and Breastfeeding**. An Italian Consensus Document. *Nutrients* 2016. [Google Scholar] [PubMed]
31. Manjarrés Correa, LM.; Díaz Cadavid, A.; Parra Sosa, BE.; Restrepo Mesa; SL.; Mancilla López, L. **Changes in energy and nutrients intake of pregnant women After nutritional intervention and educational program**. *Nutr Humana*. 2008, 10, 153-63. [Google Scholar] [SciELO]
32. Madden, Jamila M. **Nutrition and Diet Quality during Pregnancy**. 2015 Department of Nutrition. Florida state university college of human sciences. Florida. Available online: http://purl.flvc.org/fsu/fd/FSU_migr_etd-9391
33. Cuervo, M.; Sayon-Orea, C.; Santiago, S.; Martínez, JA. **Dietary and health profiles of Spanish women in preconception, pregnancy and lactation**. *Nutrients*. 2014, 6, 4434-51. [Google Scholar] [PubMed]
34. Blumfield, M.; Hure, A.; MacDonald-Wicks, L.; Smith, R.; Simpson, S.; Raubenheimer, D. et al. **The association between the macronutrient content of maternal diet and the adequacy of micronutrients during pregnancy in the Women and Their Children's Health (WATCH) study**. *Nutrients*. 2012. 4, 1958-76. [Google Scholar] [PubMed]
35. Watson, PE.; McDonald, BW. **The association of maternal diet and dietary supplement intake in pregnant New Zealand women with infant birthweight**. *European Journal of Clinical Nutrition*. 2010. 64, 184-93. [Google Scholar] [PubMed]
36. Laraia, BA.; Bodnar, LM.; Siega-Riz, AM. **Pregravid body mass index is negatively associated with diet quality during pregnancy**. *Public Health Nutrition*. 2007. 10, 920-6. [Google Scholar] [PubMed]
37. Li, N.; Liu, E.; Guo, J.; M, Pan.; L, Li.; B, Wang, P. et al. **Maternal prepregnancy body mass index and gestational weight gain on pregnancy outcomes**. *PloS One*. 2013. 8, e82310. [CrossRef] [Google Scholar]
38. Pita Rodríguez, G.; Pineda, D.; Martín, I.; Monterrey Gutiérrez, P.; Serrano Sintes, G.; Macías Matos, C. **Ingesta de macronutrientes y vitaminas en embarazadas durante un año**. *Revista Cubana Salud Pública*. 2003. 29, 220-7. [Google Scholar] [SciELO]
39. Restrepo Mesa, SL.; Parra Sossa, BE. **Implicaciones del estado nutricional materno en el peso al nacer del neonato**. *Perspectiva En Nutricion Humana*. 2009. 11, 179-86. [Google Scholar] [SciELO]
40. Endeshaw, M.; Ambaw, F.; Emiru, A.; Ayalew A. **Effect of Maternal Nutrition and Dietary Habits on Preeclampsia: A Case-Control Study**. *International Journal Clinical Medicine*. 2014. 5, 1405-16. [CrossRef] [Google Scholar]
41. Morrison, JL., Regnault, TRH. **Nutrition in Pregnancy: Optimising Maternal Diet and Fetal Adaptations to Altered Nutrient Supply**. *Nutrient* 2016. 8, 1-5. [CrossRef] [Google Scholar]
42. Stephens, TV.; Payne, M.; Ball, RO.; Pencharz, PB.; Elango, R. **Protein Requirements of Healthy Pregnant Women during Early and Late Gestation Are Higher than Current Recommendations**. *The Journal of Nutrition*. 2015. 145, 73-8. [CrossRef] [Google Scholar]
43. Martinez-Lopez, E.; García-García, MR.; Campos-Pérez, WY.; González-Becerra, K. **Nutritional Genomics: Concepts and expectations**. *Revista de Endocrinología Nutrición*. 2013, 21, 22-34. [Google Scholar]
44. Herring, CM.; Bazer, FW.; Johnson, GA.; Wu, G. **Impactos de la ingesta de proteínas de la dieta materna en la supervivencia, el crecimiento y el desarrollo fetales**. *Exp. Biol. Med*. 2018, 243, 525-33. [CrossRef] [Google Scholar]
45. Restrepo, SL.; Mancilla, LP.; Parra, BE.; Manjarrés, LM.; Zapata, NJ.; Restrepo, PA. et al. **Evaluación del estado nutricional de mujeres gestantes que participaron de un programa de alimentación y nutrición**. *Revista Chilena Nutrición*. 2010. 37, 18-30. [Google Scholar] [SciELO]
46. Castro M, Kac.; G.; Sichieri, R. **Assessment of protein intake during pregnancy using a food frequency questionnaire and the effect on postpartum body weight variation**. *Cad. Saúde Pública*. 2010. 26, 2112-20. [Google Scholar] [PubMed]
47. Grieger, JA.; Clifton, VL. **A review of the impact of dietary intakes in human pregnancy on infant birthweight**. *Nutrients*. 2014, 7, 153-78. [Google Scholar] [PubMed]

48. Joseph, J.C.; Baker, C.; Sprang, M.L.; Bermes, E.W. **Changes in plasma proteins during pregnancy.** *Annals Clinical Laboratory Science*. 1978, 8, 130-41. [Google Scholar]
49. Knight E, Spurlock B, Edwards C, Johnson A, Oyemade U, Cole O, et al. **Biochemical profile of African American women during three trimesters of pregnancy and at delivery.** *Nutritión*. 1994. 124, 943S-953S. [Google Scholar] [PubMed]
50. Al Ghazali, B.; Al-Taie, A.A.H.; Hameed, R.L. **Study of the clinical significance of serum albumin level in Preeclampsia and in the detection of its severity.** *Am J Biomed*. 2014, 2, 899-902. [Google Scholar]
51. Julca, R. V.; Salgado, G.; Carranza, E.; Gonzalez, E. **Composición química de placentas de dos grupos poblacionales.** *Ciencia e Investigación*. 1999, 2, 111-7. [Google Scholar]
52. Kramer, M. S.; Goulet, L.; Lydon, J.; Séguin, L.; McNamara, H.; Dassa C.; et al. **Socio-economic disparities in preterm birth: causal pathways and mechanisms.** *Paediatric and perinatal epidemiology*. 2001, 15, 104-23. [Google Scholar] [PubMed]
53. Pouchieu, C.; Lévy, R.; Faure, C.; Andreeva, V. A.; Galan, P.; Hercberg, S.; et al. **Socioeconomic, lifestyle and dietary factors associated with dietary supplement use during pregnancy.** *PloS One*. 2013, 8, e70733. [Google Scholar] [PubMed]
54. Picciano, M. F. **Pregnancy and Lactation: Physiological Adjustments, Nutritional Requirements and the Role of Dietary Supplements.** *The Journal of nutrition*. 2003, 133, 1997S-2002S. [Google Scholar] [PubMed]
55. Elango, R.; Ball, R. O. **Protein and Amino Acid Requirements during Pregnancy.** *Advances in Nutrition*. 2016, 7, 839S-844S. [Google Scholar] [PubMed]
56. Imdad, A.; Yakoob, M. Y.; Bhutta, Z. A. **The effect of folic acid, protein energy and multiple micronutrient supplements in pregnancy on stillbirths.** *BMC Public Health*. 2011, 1, (Suppl 3): S4. [Google Scholar] [PubMed]
57. Imdad, A., Bhutta, Z. A. **Maternal nutrition and birth outcomes: effect of balanced protein-energy supplementation.** *Paediatric and perinatal epidemiology*. 2012, 26, 178-90. [Google Scholar] [PubMed]
58. Imdad, A.; Bhutta, Z. A. **Effect of balanced protein energy supplementation during pregnancy on birth outcomes.** *BMC Public Health*. 2011, 11, 17. [Google Scholar] [PubMed]
59. Liberato, S. C.; Singh, G.; Mulholland, K., **Effects of protein energy supplementation during pregnancy on fetal growth: a review of the literature focusing on contextual factors.** *Food & nutrition research*. 2013, 57, 20499. [Google Scholar] [PubMed]
60. Wang, F.; Wang, L.; Xu, Z.; Liang, G., **Identification and analysis of multi-protein complexes in placenta.** *PloS one*. 2013, 8, e62988. [Google Scholar] [PubMed]
61. Rodríguez, M. L., Méndez, J. S., Martínez, M. S., & Domínguez, M. C. **Suplementos en embarazadas: controversias, evidencias y recomendaciones.** *Información Terapéutica del Sistema Nacional de Salud*. 2010, 34, 117-28. [Google Scholar] [Dialnet]
62. López de Blanco, M.; Landaeta-Jiménez, M.; Herrera Cuenca, M.; Sifontes, Y. **La doble carga de desnutrición y obesidad en Venezuela.** *Fundación Bengoa*. 2014, pp 77-87. [Google Scholar]
63. Fernández-Molina, L.; Soriano, J. M., & Blesa-Jarque, J. **La nutrición en el periodo preconcepcional y los resultados del embarazo: revisión bibliográfica y propuesta de intervención del Dietista-Nutricionista.** *Revista Española de Nutrición Humana y Dietética*. 2016, 20, 48-60. [Google Scholar] [SciELO]
64. Yoldi, F. I. M., & Hernández, J. A. M. **La nutrición personalizada a través de la epigenómica.** *Mediterráneo Económico*. 2015, 27, 345-61. [Google Scholar] [Dialnet]
65. Stevens, B.; Buettner, P.; Watt, K.; Clough, A.; Brimblecombe, J.; Judd, J., **The effect of balanced protein energy supplementation in undernourished pregnant women and child physical growth in low-and middle-income countries: A systematic review and meta-analysis.** *Maternal & child nutrition*. 2015, 11, 415-432. [Google Scholar] [PubMed]
66. Kramer, M. S., & Kakuma, R. **Energy and protein intake in pregnancy.** *Cochrane Database of systematic reviews*. 2003, 4. [Google Scholar] [PubMed]

67. Ota, E., Hori, H.; Mori, R.; Tobe-Gai, R.; Farrar, D. **Antenatal dietary education and supplementation to increase energy and protein intake.** Cochrane database of systematic reviews. 2012, 6. [Google Scholar] [PubMed]
68. Barker, D. J. P.; Forsén, T.; Uutela, A.; Osmond, C.; Eriksson, J. G. **Size at birth and resilience to effects of poor living conditions in adult life: longitudinal study.** BMJ (Clinical research ed.). 2001, 323, 1273-1276. [Google Scholar] [PubMed]
69. Maldonado-Durán, J. M.; Lartigue, T. **Fenómenos de la “programación” in útero: efectos del alto nivel de estrés y de la desnutrición durante el embarazo.** Perinatol Reprod Humana. 2008, 22, 26-35. [Google Scholar]
70. Casanello, P., Krause, B. J., Castro-Rodríguez, J. A., & Uauy, R. **Epigenética y obesidad.** Revista chilena de pediatría. 2016, 87, 335-42. [Google Scholar] [CrossRef]
71. Dunger, D. B.; Ong, K. K. **Endocrine and Metabolic Consequences of Intrauterine Growth Retardation.** Annals of the New York Academy of Sciences. 2005, 34, 597-615. [Google Scholar] [PubMed]
72. Huizink, A. C.; Robles de Medina, P. G.; Mulder, E. J. H.; Visser, G. H. A.; Buitelaar, J. K. **Stress during pregnancy is associated with developmental outcome in infancy.** Journal of Child Psychology and Psychiatry. 2003, 44, 810-818. [Google Scholar] [PubMed]
73. Gómez-Cantarino, S.; Agulló-Ortuño, M. T.; de Dios-Aguado, M.; Ugarte-Gurrutxaga, M. I., & Bouzas-Mosquera, C. **Prevalence of Hypoproteinemia and Hypoalbuminemia in Pregnant Women from Three Different Socioeconomic Populations.** International Journal of Environmental Research and Public Health. 2020, 17, 6275. [Google Scholar]
74. de Dios-Aguado, M.; Agulló-Ortuño, M. T.; Ugarte-Gurrutxaga, M. I.; Yañez-Araque, B.; Molina-Gallego, B., & Gómez-Cantarino, S. **Nutritional Health Education in Pregnant Women in a Rural Health Centre: Results in Spanish and Foreign Women.** In Healthcare. 2021, 9, 1293. [Google Scholar]