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Appendix no 2

Summary of professional accomplishment

Warsaw, 2018

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Personal data

Dominika Maria Głąbska

1.1. EDUCATION AND SCIENTIFIC DEGREES

- **Doctor of Philosophy degree in agricultural sciences**, discipline: food technology and nutrition; field: human nutrition, Faculty of Human Nutrition and Consumer Sciences, Warsaw University of Life Sciences WULS-SGGW, 2012, thesis entitled: Analysis of the diet and nutritional status of individuals with colitis ulcerosa during remission
- **Bachelor degree in public health**, field: dietetics, Faculty of Health Sciences, Medical Academy in Warsaw (currently: Medical University of Warsaw), 2006, thesis entitled: Analysis of the association between nutrition and caries intensity in children and adolescents
- **Master of Science degree in agricultural sciences**, specialization: food technology and human nutrition, field: human nutrition and dietetics, Faculty of Human Nutrition and Consumer Sciences, Warsaw University of Life Sciences WULS-SGGW, 2005, thesis entitled: Evaluation of a diet of predialysis women with chronic renal failure receiving a supplement containing essential amino acid ketoanalogues

1.2. INFORMATION ON PREVIOUS EMPLOYMENT

- **Adjunct**, Chair of Dietetics, Department of Dietetics, Faculty of Human Nutrition and Consumer Sciences, Warsaw University of Life Sciences WULS-SGGW, since 01.10.2013
- **Assistant**, Chair of Dietetics, Department of Dietetics, Faculty of Human Nutrition and Consumer Sciences, Warsaw University of Life Sciences WULS-SGGW, 15.12.2009-30.09.2013

1.3. SCIENTIFIC ACHIEVEMENT BEING THE BASIS OF THE HABILITATION PROCEDURE

A. Title of the scientific achievement

The scientific achievement, in accordance with Article 16, Paragraph 2 of the Act of 14 March 2003 concerning the scientific degrees and titles (Journal of Laws 2016, item 88, as amended in Journal of Laws 2016, item 1311) is the series of 5 publications entitled: **„Applying food frequency questionnaires to assess the intake of micronutrients in a group of young women”**

B. The list of publications constituting the scientific achievement

(numbering according to appendix no 3, I.B.):

I.B.1. Głąbska D., Guzek D., Sidor P., Włodarek D. 2016. Vitamin D dietary intake questionnaire validation conducted in young Polish women. *Nutrients*. 5, 36. **(IF₂₀₁₆=3.550; MSaHE points: 35)**

I.B.2. Głąbska D., Guzek D., Ślęzak J., Włodarek D. 2017. Assessing the validity and reproducibility of an iron dietary intake questionnaire conducted in a group of young Polish women. *Nutrients*. 27, 199. **(IF₂₀₁₆=3.550; MSaHE points: 35)**

I.B.3. Głąbska D., Malowaniec E., Guzek D. 2017. Validity and reproducibility of the iodine dietary intake questionnaire assessment conducted for young Polish women. *International Journal of Environmental Research and Public Health*. 14(7), 700. **(IF₂₀₁₆=2.101; MSaHE points: 30)**

I.B.4. Głąbska D., Książek A., Guzek D. 2017. Development and validation of the brief folate-specific food frequency questionnaire for young women diet assessment. *Journal of Environmental Research and Public Health*. 14(12), 1574. **(IF₂₀₁₆=2.101; MSaHE points: 30)**

I.B.5. Głąbska D., Staniec A., Guzek D. 2018. Assessment of validity and reproducibility of the zinc-specific dietary intake questionnaire conducted for young Polish female respondents. *Nutrients*. 19, 104. (IF₂₀₁₆=3.550; MSaHE points: 35)

Accomplishment in total amounts: 165 MSaHE points, IF=14.852

In all publications, I am the first and the corresponding author. My contribution to the mentioned works is presented in Appendix no 3 and the statements of co-authors are presented are Appendix 4, while the full texts are presented in Appendix no 5

C. Presentation of the scientific aim of studies and their results accompanied by the possibilities of application of results of achievement

1. Introduction

Food frequency questionnaires (FFQ) are among the methods, that allow not only assessment of the intake of food products, but also assessment of the intake of nutrients. However, due to their specific data collecting procedure, type of data, as well as structured format, they differ significantly from the dietary record, or dietary recall.

Food frequency questionnaire is defined by the Food and Agriculture Organization of the United Nations (FAO) & World Health Organization (WHO) [1996] as a structured list of products, or groups of products (food items). For each of them, respondent is asked to estimate his usual frequency of consumption, while indicating number of servings consumed per day, week, month or year. The kind of included products, the number of products, as well as a way of frequency determining should be specific for the target group and assessed nutrients [FAO/ WHO, 1996].

Taking into account the characteristics of the food frequency questionnaires, the method is also called list-based diet history, but the period in which the history is recalled is strictly defined. It is also worth to be indicated, that in spite of the fact, that there are questionnaires designed to be recalled by the pollster, the majority of them is designed to be filled in by respondent, that simplifies and accelerates the procedure, as well as reduces the influence of pollster on the obtained answers [FAO/ WHO, 1996].

According to the classification of FAO/ WHO [1996], food frequency questionnaires are divided according to a way of expressing frequency and possibility to assess the nutrients intake into three groups: un-quantified food frequency questionnaires, semi-quantified food frequency questionnaires and completely quantified food frequency questionnaires, as well as are divided according to a number of questions and analyzed products into two groups: comprehensive food frequency questionnaires and brief food frequency questionnaires. The un-quantified food frequency questionnaires do not specify the size of serving, while the semi-quantified food frequency questionnaires indicate typical serving size for each product, and completely quantified food frequency questionnaires allow respondent to specify the arbitrary serving size. At the same time, comprehensive food frequency questionnaires allow to assess the intake of many nutrients, as a number of questions is considerable (most often – 50-150), while brief food frequency questionnaires allow to assess only one or few nutrients, as a number of questions is reduced [FAO/ WHO, 1996].

While comparing with a method of dietary record, or dietary recall, food frequency questionnaires allow to assess the diet in a quicker way, so they are an easier method, both for respondents and researchers. In spite of the fact, that a food frequency questionnaire does not allow to analyze all the aspects of diet associated with quality and quantity, a number of advantages is indicated for the method. The most important advantage of food frequency questionnaires is associated with a fact, that food frequency questionnaire allow to assess the typical intake of products and typical intake of nutrients, in a specific period of time, not only the intake during a days that are defined by respondent as typical ones. As the intake is variable, and commonly respondent is not aware of differences between specific days, the results obtained on the basis of a dietary record may be false, and the intake declared as a typical, may not be a typical one [Yang et al., 2010]. Moreover, a record is often conducted honestly only by the most motivated respondents, while the higher number of days of record causes lower honesty of data, so as a result, in some groups of respondents, the dietary recall allows to obtain more reliable data, that dietary record [Shim et al., 2014]. However, while assessing the dietary recall method, the problem associated with a remembrance of respondents must be indicated, that is an important factor, that may decrease the reliability of the obtained data, being is similar in the case of dietary recall and food frequency questionnaires [Armstrong et al., 2000].

Taking into account the difficulties in obtaining the reliable assessment of intake, as well as a need to obtain the data of intake in a quite simple way and being as reliable as possible, the simple questionnaires are needed to be easy for both respondent and researcher. In spite of the fact, that an assessment conducted using questionnaire is based on the recollection of data by respondents, it does not require the strong motivation of them and while the construction of questionnaire is proper, it allow to obtain reliable information about the intake. It is especially important in the case of nutrients that are in the typical diet derived from the specific sources, that are not consumed often, so are characterized by a high variability of intake [FAO/ WHO, 1996]. While the dietary recall or dietary record is used, in the case of such products, there is a high risk of overestimating (if a product was consumed during a day that is assessed) or of underestimation (if such product was not consumed during a specific day).

Taking into account indicated issues, food frequency questionnaires are an applicative tool to assess the important aspects of diet in research conducted in a large population groups. The various questionnaires were applied, among others, in European Prospective Investigation into Cancer and Nutrition (EPIC) Study [Kroke et al., 1999], Framingham Heart Study (Framingham Food Frequency Questionnaire) [Quatromoni et al., 2002], Nurses' Health Study (NHS) and Nurses' Health Study II (NHS II) [Hu et al., 2016], National Health and Nutrition Examination Survey (NHANES) [Ahluwalia et al., 2016], and other cohort studies conducted in various countries.

Taking into account the fact, that the methods that allow to conduct the quick and reliable assessment of diet are currently searched for, the National Institutes of Health – National Cancer Institute [2018] created the register of the short dietary assessment instruments, validated in a specific population groups, while the majority of them are the food frequency questionnaires¹. Among the most widely known and applied questionnaires (in the original version or modified), there are a comprehensive food frequency questionnaires of Willett (Harvard Food Frequency Questionnaire) [Willett et al., 1985] and of Block [Block et al., 1986], that allow to assess a number of nutrients at the same time. In

¹ In the register of National Institutes of Health – National Cancer Institute, there are ViDEO-FFQ, IRONIC-FFQ, IODINE-FFQ and FoL-IC-FFQ, which were validated in the studies, that are the basis of the presented achievement

Poland, among the quantified questionnaires, there are brief questionnaire to assess the intake of calcium ADOSCa [Szymelfejnik et al., 2006], comprehensive questionnaire FFQ [Wądołowska, 2005; Kowalkowska et al., 2013] and comprehensive questionnaire FFQ-6 (Food Frequency Questionnaire with 6 answers) [UWM, 2018], as well as un-quantified food frequency questionnaires, such as KomPAN [Gawęcki, 2014].

2. Scientific objective and hypothesis

The main aim of the presented achievement was to analyse the possibilities to apply the brief semi-quantified food frequency questionnaires in the assessment of dietary intake of chosen micronutrients in a group of young women.

Detailed objectives:

- assessment of an adequacy of intake of chosen micronutrients in a group of young women, conducted using developed brief semi-quantified food frequency questionnaires,
- comparison of the possibility to develop and apply brief semi-quantified food frequency questionnaires, depending on the sources of assessed nutrient – if it is derived from a lot of products or few, specific products,
- assessment of the possibility to apply various methods of the statistical analysis in the validation of the food frequency questionnaires,
- assessment of the influence of overestimation of the intake of products, observed for the food frequency questionnaires, on the results of the validation,
- assessment of the reproducibility and validity of the developed food frequency questionnaires and of the possibility to apply them in practice, during nutritional assessment and diet therapy.

On the basis of the above-mentioned objectives, the following hypotheses were specified:

- development of the brief semi-quantified food frequency questionnaires enables assessment of the dietary intake adequacy of nutrients for which the tool was developed,

- there is a possibility to develop brief semi-quantified food frequency questionnaires to assess the intake of particular nutrients, independently from the fact, that their sources are a lot of products or few, specific products,
- using, during a validation of the food frequency questionnaire, not only a recommended method of Bland-Altman, but also using other methods, allows to obtain a higher number of information,
- overestimation of intake by respondents, may influence the results of validation of the food frequency questionnaire,
- obtaining the high reproducibility, independently from the obtained lower validity of the validated food frequency questionnaires, allows to apply them in practice, during nutritional assessment and diet therapy

3. Discussion of publications

3.1. Adequacy of intake of chosen micronutrients, being important in nutrition of young women

Publications no I.B.1., I.B.2., I.B.3., I.B.4., I.B.5.

Głąbska D., Guzek D., Sidor P., Włodarek D. 2016. Vitamin D dietary intake questionnaire validation conducted in young Polish women. *Nutrients*. 8, 36.

Głąbska D., Guzek D., Ślęzak J., Włodarek D. 2017. Assessing the validity and reproducibility of an iron dietary intake questionnaire conducted in a group of young Polish women. *Nutrients*. 27, 199.

Głąbska D., Malowanec E., Guzek D. 2017. Validity and reproducibility of the iodine dietary intake questionnaire assessment conducted for young Polish women. *International Journal of Environmental Research and Public Health*. 14(7), 700.

Głąbska D., Książek A., Guzek D. 2017. Development and validation of the brief folate-specific food frequency questionnaire for young women diet assessment. *Journal of Environmental Research and Public Health*. 14(12), 1574.

Głąbska D., Staniec A., Guzek D. 2018. Assessment of validity and reproducibility of the zinc-specific dietary intake questionnaire conducted for young Polish female respondents. *Nutrients*. 10, 104.

The recommendations elaborated by Cade et al. [2004] present issues associated with developing, validating and applying food frequency questionnaires and indicate situations in which such questionnaires should be applied. Authors indicated, that analysis of intake conducted using questionnaires, that were validated in a specific population, should not be applied in such situations when in the clinical assessment, the precise information about intake is needed. In the other cases, while the information about specific intake of nutrient is not needed, and the information about estimated intake is sufficient, the food frequency questionnaires may be used. As a result, it may be concluded, that food frequency

questionnaires may be applied to categorize respondents into groups characterized by adequate and inadequate intake of a specific nutrient and to indicated the risk groups of the nutrient deficiency.

The studies conducted as an element of the EUROpean micronutrient RECommendations Aligned (EURRECA) Network of Excellence were among others associated with assessment of the possibility to apply food frequency questionnaires as a reliable method to assess the intake of minerals – iron, calcium, selenium, zinc and iodine [Serra-Majem et al., 2009], as well as vitamins – vitamin A, D, E, C, B₁, B₂, B₁₂, folate and niacin [Henríquez-Sánchez et al., 2009]. Assessment was conducted on the basis of the analysis of the food frequency questionnaires that allow the estimation of indicated nutrients intake, while validations were published before March 2008, and in the study of Serra-Majem et al. [2009] it was concluded, that questionnaires allow to conduct reliable assessment of minerals intake, especially calcium, but also iodine and zinc, and in the study of Henríquez-Sánchez et al. [2009] it was concluded, that questionnaires are acceptable method to assess the vitamins intake.

Taking into account the indicated potential possibilities to apply the food frequency questionnaires, I analyzed the intake of chosen, important in the nutrition of young women, minerals, such as iron (**publication no I.B.2.**), iodine (**publication no I.B.3.**) and zinc (**publication no I.B.5.**), as well as vitamin D (**publication no I.B.1.**) and folate (**publication no I.B.4.**), that were assessed using developed original food frequency questionnaires. I made a choice of specific nutrients, for which I developed food frequency questionnaires, that were afterwards validated, taking into account the following criteria:

- minerals and vitamins indicated as important in the nutrition of young women, for which they are at risk of the deficiency, while I deliberately chose such nutrients for which deficiency is common and such nutrients for which deficiency is rare,
- minerals and vitamins characterized by significant variation of intake, depending on the day, that results from the sparse and specific sources (vitamin D, iodine) and characterized by a large number of sources (iron, folate).

As an element of the conducted studies, I conducted, in a groups of young women, an assessment of the adequacy of intake of chosen nutrients and, afterwards, the comparison of the share of individuals characterized by inadequate intake, depending on the method of assessment, while the developed food frequency questionnaires were applied and the 3-day

dietary record. I applied the 3-day dietary record as a reference method, as it is commonly applied in the validation of the food frequency questionnaires, being more reliable in presenting the intake of nutrient, than biomarkers do, while they present the nutritional status [Serra-Majem et al., 2009]. The nutritional status results from the intake, but also from physiological factors, associated with the nutrient absorption or loss, so the possibility, to apply biomarkers in the validation of the food frequency questionnaires, is limited [Bates et al., 1997].

Among assessed nutrients, there is folate, being the most commonly indicated as a nutrient for which deficiency in young women is especially important [WHO, 2015a]. The deficiency in the case of pregnant women is associated with a neural tube defects in their progeny, as well as with anemia in women, so the folic acid supplementation in the case of pregnant women should be applied as soon as possible, preferably before a conception [WHO, 2012]. At the same time, a number of young women do not apply the recommended supplements, that is especially alarming in countries in which the folate intake is inadequate. Among such countries, there is Poland, as in spite of the fact, that a number of products are fortified [Sicińska et al., 2018], the folic acid fortification is not obligatory [Meijer & de Walle, 2005].

In Canada, it is indicated, that 40% of women has a folate deficiency, that is stated on the basis of the blood folate level [Koren et al., 2008], in spite of the fact that the obligatory folic acid fortification applied [Food Fortification Initiative, 2017]. Moreover, in Canada, the necessity of nutritional education in a group of young women is emphasized, while the issue of the role of folic acid and the main dietary sources of folate are indicated as a most important [Wilson et al., 2003].

The study associated with a folate intake, that I conducted in a group of young women from Poland, aged 20-30 (**publication no I.B.4.**), indicated, that in comparison with the Estimated Average Requirement (EAR) level, the frequency of inadequate intake is quite high, as depending on the applied method, it was observed for 36.0% of individuals (dietary record) and 20.0-25.3% of them (the original food frequency questionnaire Fol-IC-FFQ² applied twice). On the basis of the obtained data, it may be stated, that a developed questionnaire indicates a little bit lower frequency of inadequate intake, than the reference method, as while using it, the inadequate intake was observed for each fourth or fifth, and

² Fol-IC-FFQ – Folate-Intake Calculation – Food Frequency Questionnaire

using dietary record – for each third analyzed individual. However, independently from the used method of assessment, in the conducted own study the frequency of inadequate folate intake was quite high.

The other important nutrient, for which the inadequate intake in young women is quite common, is iron. The anemia is indicted by WHO [2002] as one of the most important diet-related diseases and the iron deficiency contributes to the highest share of the incidences (50% of anemias result from the iron deficiency) [WHO, 2015b]. Taking into account the frequency of the anemia on the level of 23-27% of the general world population, it should be emphasized, that for the frequency higher than 20%, the iron deficiency of various intensity is estimated to occur in 50% of population [WHO, 2001; WHO, 2008].

The issue of iron deficiency and related anemia is reflected in the Global Targets 2025 by WHO [2014]. As one of the targets is indicated the necessity to reduce the frequency of anemia in a group of young women by 50%, that is the only target being not related to the population of children, but young women. In spite of the fact, that the highest frequency of anemia is stated for women of reproductive age and pre-school children [Stevens et al., 2013], women, not children, are indicated as a target group, as reducing the anemia frequency in the case of women, may reduce also the anemia frequency and the general condition in the case of their progeny, as was concluded by Black et al. [2013] on the basis of the meta-analysis. However, taking into account the lack of any success in achieving a indicated goal, some authors stated, that it will be impossible to achieve it until the year 2025 [Branca et al., 2014].

The study associated with an iron intake, that I conducted in a group of young women from Poland, aged 20-30 (**publication no I.B.2.**), is associated with an indicated issue of iron intake assessment. In the study, quite high frequency of inadequate iron intake was stated, while compared with the EAR level. Depending on the applied method, it was observed for 37.3% of individuals (dietary record) and 26.7% of them (the original food frequency questionnaire IRONIC-FFQ³). Similarly, as in the case of the previously mentioned questionnaire to assess the folate intake (Fol-IC-FFQ), the developed IRONIC-FFQ questionnaire indicates a little bit lower frequency of inadequate intake, than a reference method. However, independently from the applied method, in the conducted own study, quite high frequency of inadequate iron intake was observed in a group of young women.

³ IRONIC-FFQ – IRON Intake Calculation – Food Frequency Questionnaire

The other nutrient, for which the deficiency is common, both in Poland and other countries, is vitamin D [Calvo et al., 2005], that was emphasized for European countries, by the reports of European Food Safety Authority (EFSA) [2012]. Based on the data from the United States of America, from the NHANES 2003-2006 study, it may be supposed, that the problem of inadequate vitamin D intake is the most serious in the case of young women, as in a group of women, younger than 30 years, the lowest vitamin D intake is observed, while compared with other assessed population groups [Bailey et al., 2010]. The crucial issue is also associated with a fact, that until the age of 30, the peak bone mass and maximum bone density is obtained, that is influenced, among others, by vitamin D intake [Sadat-Ali et al., 2011]. After indicated age, the progressive bone mass loss is observed [Benjamin, 2010], that may cause the osteoporosis development, while the frequency of it in women is higher than in men [Cawthon, 2011].

The study associated with a vitamin D intake, that I conducted in a group of young women from Poland, aged 20-30 (**publication no I.B.1.**), revealed, in comparison with the Adequate Intake (AI) level of 5.0 µg of cholecalciferol, that was recommended during conducting the study [Jarosz, 2012], a very high frequency of inadequate vitamin D intake in the assessed group. It was stated, independently from the applied method (dietary record, the original food frequency questionnaire ViDEO-FFQ⁴) for majority of individuals (85-90%). It must be emphasized, that during conducting the study, the EAR level recommended by Institute of Medicine [2011] was higher (10.0 µg of cholecalciferol), as well as level recommended by the Polish National Food and Nutrition Institute in Warsaw since December 2017 is also higher (15.0 µg of cholecalciferol) [Jarosz, 2017]. While compared with the recommendations of Institute of Medicine [2011], as well as with a new Polish recommendations [Jarosz, 2017], in the studied group also the very high frequency of inadequate intake was stated, that was respectively 97-98% and 97-100% (depending on the applied method of assessment). In the case of vitamin D, not only a very high frequency of inadequate intake, observed in the conducted own study, in a group of young women, must be emphasized, but also the fact, that no differences of the inadequate intake frequency was stated, while assessment conducted using questionnaire and dietary record were compared.

The nutrient for which the deficiency is also quite high, is iodine. Its deficiency may contribute to inadequate production of thyroid hormones, while both iodine deficiency and

⁴ ViDEO-FFQ – Vitamin D Estimation Only – Food Frequency Questionnaire

its consequences may be stated for individuals in any age group. However, women of reproductive age, pregnant women and children are indicated as a risk groups, in the case of which, the higher iodine supply must be ensured, in order to reduce the risk of miscarriages, to reduce perinatal mortality and to improve the motor and cognitive functions of progeny [Zimmermann et al., 2008].

The analysis conducted by WHO, for ages indicate the same frequency of iodine deficiency [WHO, 2004; De Benoist et al., 2008, Andersson et al., 2012]. In the recent of the mentioned analysis [Andersson et al., 2012], it was indicated, that the iodine deficiency is stated for 28.5% of general population, while in Europe – for 44.2%. Poland is currently among 15 European countries in which the mild population iodine deficiency is observed [Andersson et al., 2012].

The study associated with an iodine intake, that I conducted in a group of young women from Poland, aged 20-35 (**publication no I.B.3.**), revealed, in comparison with the EAR level, various frequency of inadequate intake, depending on the applied method of assessment of intake. While dietary record was applied, it was observed for 90.0% of individuals, and while the original food frequency questionnaire IODINE-FFQ⁵ was applied – it was observed for 48.9-54.4% of them. Similarly, as in the case of previously indicated original questionnaires to assess the folate intake – Fol-IC-FFQ and to assess the iron intake – IRONIC-FFQ, it may be concluded, that for developed original questionnaire, the lower frequency of inadequate iodine intake is stated, than for the reference method. However, in the case of iodine, difference between frequency observed for two compared methods is higher, than for previously indicated questionnaires.

Probably, the observed situation results from the fact, that iodine in Polish diet is mainly derived from the salt, that since 1997 is obligatory iodine-fortified [Lewiński & Zygmunt, 2014] and is most commonly applied in the world, as a food product being iodine-fortified [WHO, 2004]. Taking into account the fact, that the salt intake assessment is challenging, in various countries, it is indicated, that iodine intake assessment is also challenging, while not only food frequency questionnaires are applied, but also – dietary record [Zhang et al., 2015].

In order to ensure that dietary record provides an information about actual salt intake, the respondent must be highly motivated, but also trained on the principles of recording

⁵ IODINE-FFQ – Iodine Dietary INTake Evaluation – Food Frequency Questionnaire

properly all products that are consumed, as an elements of dishes [Defagó & Perovic, 2015]. Moreover, the specifying properly the salt intake is hard to conduct, as both salt and species are commonly omitted by respondents [Shim et al., 2014], hence, it is indicated, that in the food frequency questionnaires, they should be specified as separate product items, or dishes that contribute a high share of them, should be specified [Shim et al., 1997; Yun et al., 2009].

The nutrient, for which deficiency is stated less often, than in the case of folate, iron, vitamin D, or iodine, is zinc. However, in the case of this nutrient, similarly as in the case of iodine, young women are indicated as a group, for which the adequate intake is especially important. It results from the necessity of providing progeny the adequate nutritional status, that in the case of zinc results from intake during the period of pregnancy and breastfeeding [Petry et al., 2016]. For children, the zinc level is especially important, as it results in, among others, reduced mortality due to gastrointestinal and respiratory disorders [Yakoob et al., 2011], while the deficiency causes worldwide 800 000 deaths each year [Caulfield & Black, 2004].

In the case of zinc, in spite of the fact, that a serious deficiencies are rarely diagnosed, WHO [2002] indicates, that mild and moderate deficiencies are commonly stated in all countries. Some researchers estimate, that zinc deficiency is stated in each third individual [Sandstead, 1991], while for eastern and central Europe, it is stated in 10% of population [Wessells & Brown, 2012].

The study associated with a zinc intake, that I conducted in a group of young women from Poland, aged 20-35 (**publication no I.B.5.**), revealed, in comparison with the EAR level, independently from applied method of intake assessment, similar frequency of inadequate intake. For dietary record, it was observed for 23.3% of individuals, while for the original food frequency questionnaire ZINC-FFQ⁶ – for 32.2% of them in the case of the first assessment and 26.7% in the case of the second assessment, conducted after 6 weeks. In this case, the lower frequency of inadequate intake, such as in the case of the Fol-IC-FFQ questionnaire to assess the folate intake, IRONIC-FFQ questionnaire to assess the iron intake and IODINE-FFQ questionnaire to assess the iodine intake, in comparison with the reference method, was not observed. At the same time, the opposite situation was stated – the frequency of inadequate intake was a little bit higher, while the data were obtained using questionnaire, in comparison with the reference method, but it was observed only in the

⁶ ZINC-FFQ – *Zinc Intake Calculation – Food Frequency Questionnaire*

case of the first contact with the questionnaire and it may result from lack of familiarity with the tool.

While the adequacy of intake of chosen nutrients, for which deficiency is observed, in the case of group of young women, is assessed, and while usefulness of the original questionnaires is analyzed, it must be emphasized, that categorizing respondents into groups characterized by adequate intake and inadequate intake, conducted using questionnaires, was properly performed, in the majority of cases. Only in the case of iodine, significant overestimation of intake observed for IODINE-FFQ questionnaire, contributed to concluded lower frequency of inadequate intake in the analyzed group, than for the reference method. However, it must be interpreted as resulting from a specific sources of nutrient, that in a Polish diet, in a significant share is derived from the iodine-fortified salt. Hence, while using the developer food frequency questionnaires, it is possible to indicate the risk groups of deficiency, but it must be taken into account, that due to the intake overestimation, some of individuals characterized by inadequate intake, will remain not identified.

3.2. Possibility to develop brief semi-quantitative food frequency questionnaires, depending on the sources of assessed nutrient – if it is derived from a lot of products or few, specific products

Publications no I.B.1., I.B.2., I.B.3., I.B.4.

Głabaska D., Guzek D., Sidor P., Włodarek D. 2016. Vitamin D dietary intake questionnaire validation conducted in young Polish women. *Nutrients*. 8, 36.

Głabaska D., Guzek D., Ślęzak J., Włodarek D. 2017. Assessing the validity and reproducibility of an iron dietary intake questionnaire conducted in a group of young Polish women. *Nutrients*. 27, 199.

Głabaska D., Malowanec E., Guzek D. 2017. Validity and reproducibility of the iodine dietary intake questionnaire assessment conducted for young Polish women. *International Journal of Environmental Research and Public Health*. 14(7), 700.

Głabaska D., Książek A., Guzek D. 2017. Development and validation of the brief folate-specific food frequency questionnaire for young women diet assessment. *Journal of Environmental Research and Public Health*. 14(12), 1574.

The brief food frequency questionnaires do not allow to assess simultaneously the intake of many nutrients, that is possible while the comprehensive questionnaires are applied, but due to a large number of questions, such questionnaires often lead to intake overestimation [Barrett & Gibson, 2010]. At the same time, brief food frequency questionnaires are indicated as especially valuable, as they allow to obtain, directly after

filling them out, by respondent, an information about the intake of nutrient, and afterwards, it is possible to give patient an information about it and to indicate the necessary changes of the nutritional behaviors [Martínez-González et al., 2012]. It is possible, due to the fact, that they are shorter than comprehensive questionnaires and less complicated, that results from the fact, that they are developed to assess the intake of one or a couple of nutrients, instead of a large amount of them, so the general number of questions does not exceed 50 [FAO/WHO, 1996]. At the same time, as was indicated by Serra-Majem et al. [2009], a lower number of questions in the questionnaire results not only in the fact, that it is easier for respondent to fill out, but also in the higher reliability, that may be a consequence of a higher level of concentration of respondent, during filling out the shorter form.

Developing the brief food frequency questionnaire, that contains a small number of questions associated with intake of products is possible especially when a nutrient is derived from a small number of specific products. Taking into account the characteristics of the Polish diet, I analyzed the original questionnaires that allow the assessment of the intake of vitamin D – ViDEO-FFQ questionnaire (**publication no I.B.1.**) and iodine – IODINE-FFQ questionnaire (**publication no I.B.3.**), as examples of nutrients, that in a diet of Polish respondents are derived from a limited number of sources. The choice of nutrients that were assessed was made in order to choose such nutrients which has either a typical food product sources (as in the case of vitamin D), or sources that are more challenging in assessment (as salt, being one of the major sources of iodine).

The most important sources of vitamin D are fish and fish products, while other products are characterized by lower share of vitamin D [Kunachowicz et al., 2005; Kunachowicz et al., 2017]. Due to a specific sources, in the European Nutrition and Health Report, vitamin D was indicated as a nutrient for which the intake is in Europe low, in all the population groups [Elmadfa et al., 2009], and in the EURRECA Network of Excellence project, it was stated, that the vitamin D deficiency is observed for 40% of population [Roman Viñas et al., 2011]. It results from the fact, that vitamin D intake is higher only in the case of countries, in which the higher fish intake is observed, such as Finland [Paturi et al., 2008] and Sweden [Becker & Pearson, 2002], for which the vitamin D intake is the highest from all the European countries.

In the case of a positively validated ViDEO-FFQ food frequency questionnaire to assess the vitamin D intake (**publication no I.B.1.**), in the questionnaire, there are 21 questions

about the intake of the groups of products, that are combined into 8 larger groups, to make it easier for respondents (fish, fish products, dairy products, eggs, meat, meat products, fats, cereal products – including products that contain vitamin D derived from eggs). In the case of the fish group, there are 3 questions included, while in the case of fish products – 2 questions. However, taking into account the fact, that the fish and fish products are the most important sources of vitamin D, in the case of questions about them, the higher number of species and types were indicated and grouped into subgroups characterized by a similar vitamin D content, as due to such procedure, in the questionnaire, 17 species of fish were included. Additionally, to obtain the higher level of precision in the vitamin D intake estimation, in the questionnaire was added a question about the most commonly consumed fish species for each subgroup included.

While the ViDEO-FFQ questionnaire was being developed, only the products that are sources of vitamin D in Poland were included. As a result, some products that are included in vitamin D questionnaires in other countries, were not asked about, that may be observed for such products as enriched soymilk, algae, kimchi, or ramen, included in Korean Calcium Assessment Tool (KCAT) to assess the calcium and vitamin D intake [Park et al., 2013]. Also other enriched products, that are available only in other countries (so included in the questionnaires for them) [Taylor et al., 2009], but not in Poland, were not included, as well as cod-liver oil, that in Poland is perceived as a supplement, not as a food product.

The other nutrient, that is derived from a specific food products, is iodine, in the case of which, similarly as for vitamin D, the main natural sources are fish and fish products, but also dairy products. As a result, in countries characterized by a high fish intake – Norway [Birgisdottir et al., 2013] and Iceland [Gunnarsdottir et al., 2010], the fish and fish products are the main dietary source of iodine. At the same time, in other countries, due to the higher intake, dairy products commonly are the main iodine source [Rasmussen et al., 2008]. The other products are less important as the sources of iodine, as they contribute to the lower share – in the case of Denmark, fish, dairy products and beverages combined, contribute to the 86% of the total iodine intake [Rasmussen et al., 2002]. Different situation is observed in some Asian countries – for example, in the case of Japan, among the main sources of iodine are except for fish and shellfish, also algae products [Fuse et al., 2013], that in western countries are not consumed in such amount that would be able to contribute to the significant share of the iodine intake. Hence, in order to satisfy the iodine needs, it is

recommended to consume at least two servings of fish a week and at least two servings of dairy products a day [Gunnarsdottir et al., 2013].

In the case of a positively validated IODINE-FFQ food frequency questionnaire to assess the iodine intake (**publication no I.B.3.**), in the questionnaire, there are 44 questions about the intake of the groups of products, that are combined into 13 larger groups, to make it easier for respondents (dairy products, eggs, meat products, fish and fish products, fats, cereal products, vegetables, legumes, potatoes, fruits, nuts and seeds, beverages, others – for which salt was included).

In the case of food frequency questionnaires to assess the iodine intake, in each country, crucial are the products that are iodine-enriched. In the case of a majority of countries, it is salt [WHO, 2004], but for some of them, also bread [Rasmussen et al., 2014], milk [Phillips, 1997], or water [Foo et al., 1996]. While the IODINE-FFQ questionnaire to assess the iodine intake was developed, the iodine-enriched salt was included, as in Poland it is the only products that is obligatory iodine-fortified. Taking into account the fat, that a salt was the most important product in the questionnaire, it was intentional to place the question about this product at the end of the form. It was planned to contribute to the situation in which respondent does not concentrate inordinately on this product and does not suppose, that this products is very important, that would cause that he does declare on purpose higher intake than it really is (as he perceives it as a source of iodine), or lower intake than it really is (as he perceives it as a source of sodium). Moreover, it was assumed, that at the end of the questionnaire, respondent has the highest skills in estimating the frequency of intake and most commonly chosen serving sizes, so the most important product, due to the iodine content, was placed at the end of the form.

It must be added, that estimating the intake of iodine-enriched salt, in order to assess the typical daily intake of nutrient, is indicated by authors of the questionnaires, as a quite challenging issue. On the one hand, if in a country, there is not one established level of the iodine added to the salt, some types of salt must be included in the questionnaire, that was applied, in the case of Slovenia, by Štimec et al. [2007]. On the other hand, the way in which the question is formulated, arouses a great deal of controversy, as authors commonly ask about it in very simplified way. Such simplified question was applied by Zhang et al. [2015], as in their questionnaire, they included a question about saltiness of dishes that respondents consume (low, average, high level) and on the basis of the answers, they estimated intake of

salt and iodine, but afterwards authors noticed that the way of asking the question was probably the reason of the low reliability of the assessed questionnaire [Zhang et al., 2015]. In the own study, in the case of a IODINE-FFQ food frequency questionnaire, the applied question allowed to obtain a specific answer (a mean number of teaspoons of salt consumed during a week, while the salt added to prepared and consumed dishes was also to be included), and teaspoon was chosen as a typical way to measure the intake, as it is more specific, than a pinch. Such approach allowed to obtain the better results of validation than in the case of the study of Zhang et al. [2015].

Developing the brief food frequency questionnaire with a limited number of questions, may be more challenging in the case of a product which is in a lot of products and, as a consequence, in a typical diet has a lot of sources. Moreover, it is commonly indicated, that number of questions in the questionnaire is very important factor during developing it, as too long questionnaires may cause weariness of respondents and, as a result, may cause uniformed answers for the following questions or other unreliable answers, that result in lower reliability of the obtained results [Choi & Pak, 2005]. Taking it into account, it is indicated, that questionnaires should be short and simple, to be a practical tool to be applied in a large population groups, as well as to cause no burden on the respondents and on researchers. This issue is especially important when a nutrient that is to be assessed is derived from many food products from a lot of groups.

Taking into account the characteristics of the Polish diet, I analyzed the original questionnaires that allow the assessment of the intake of iron – IRONIC-FFQ questionnaire (**publication no I.B.2.**) and folate – Fol-IC-FFQ questionnaire (**publication no I.B.4.**), that in a Polish diet are derived from more sources than vitamin D and iodine. The choice of the nutrients was conducted in such a way to choose a nutrients available from both plant and animal sources.

If the nutrient, that is to be assessed in the questionnaire, is derived from a large number of food products and questionnaire is to be a brief one (number of questions 50 or lower), to avoid the excessive number of questions, authors sometimes include only the most important sources of the nutrient. Such procedure was applied in the case of Block Dietary Folate Equivalent (DFE) Screener to assess the folate intake, while only the most important products that contribute 60% of intake were included [Clifford et al., 2005] and of questionnaire to assess the zinc intake, that was validated by Samman et al. [2010], while

products that contribute 80% of dietary intake were included. In the case of applying described strategy, it is important to consider the potential error associated with intake of nutrient for the other products, that are not included in the questionnaire, being not high for the population, but high in the case of individuals that are characterized by untypical intake of the products being eliminated from the questionnaire. As a result, it is indicated, that in the case of nutrients that are derived from a large number of plant and animal products, the risk of error is quite high and the list of food items must be specific for the group in which the assessment of intake is conducted [Ishihara et al., 2005].

Taking it into account, in order to obtain more universal tool, while the original Fol-IC-FFQ questionnaire to assess the folate intake and original IRONIC-FFQ questionnaire to assess the iron intake were developed, the other strategy was chosen. In indicated questionnaires, all food products being the sources of nutrient were included, not only the most important ones, but at the same time, the clustering procedure was applied and the products were grouped, taking into account the type of product, frequency of consumption in typical diet and the amount of assessed nutrient, that enabled reduction of the number of questions.

In the case of a positively validated Fol-IC-FFQ food frequency questionnaire to assess the folate intake (**publication no I.B.4.**), in the questionnaire, there are 25 questions about the intake of the groups of products. In order to obtain the higher accuracy of estimation of the folate intake, vegetables, as the most important source of folate were divided into 3 separate groups, depending on the average folate amount in a serving. The applied procedure of dividing vegetables into subgroups was quite important, as in various groups of respondents, various vegetables may be consumed with a various frequency, so total elimination of some of them from a questionnaire could contribute to high error of the obtained results. At the same time, in the questionnaire were not included the products, that are a typical sources of folate in other countries, but in Poland are rarely, or very rarely consumed, such as green tea, natto, miso and soy sauce, included in the questionnaire applied in Japan [Ishihara et al., 2005], or Bovril and Marmite, included in the questionnaire applied in Great Britain [Pufulete et al., 2002].

In the case of a positively validated IRONIC-FFQ food frequency questionnaire to assess the iron intake (**publication no I.B.2.**) in the questionnaire, there are 32 questions about the intake of the groups of products, that are combined into 12 larger groups, to make it easier

for respondents (meat, meat products, eggs, fish, dairy products, cereal products, fruits, vegetables, potatoes, fats, nuts and seeds, cocoa and chocolate). In the case of meat and meat products, taking into account the fact, that they are the most important sources of the heme iron, in order to obtain the higher precision of the iron intake estimation, in the questionnaire were added questions about the most commonly chosen types of meat and meat products. The applied procedure, similarly as the additional questions about the consumption of fish and fish products, in the case of the ViDEO-FFQ questionnaire to assess the vitamin D intake, was applied to obtain the more precise information about the intake of nutrient, while answering the additional questions is useful to calculate precisely the intake, but it is not necessary to estimate it.

While analyzing the possibility to develop the brief food frequency questionnaire, depending on the fact that assessed nutrient is derived from a lot of sources, or limited and specific sources, it must be emphasized, that a strategies of questionnaire construction applied in the own studies turned out to be effective ones to obtain the reliable tools. However, for other populations, than assessed in the own studies, and other nutrients, than assessed, it may be needed to apply the other strategies of questionnaire construction. It results from the fact, that questionnaires, with their specific characteristics and characteristics of the intake, should be developed for a specific country, or region, or even ethnic group [Williams & Innis, 2005], while the validation should be conducted in the target group [Heath et al., 2000]. Hence, the observations associated with possibilities to apply the questionnaire to assess the intake of specific nutrient intake in a specific group should not be extrapolated to the other nutrients and other population groups.

Independently from the assessed nutrient, in the own study, it was proven, that the type of sources of nutrient is not a barrier foreclosing the assessment of intake of nutrient conducted using the brief semi-quantified food frequency questionnaire. Moreover, while the result of studies of other authors are analyzed, it may be concluded, that in the case of nutrients, that are derived from rarely consumed products, the food frequency questionnaire may be better method to predict the nutritional status, than dietary assessment conducted during the random days [You et al., 2014]. In the study of You et al. [2014] it was concluded for the mercury from fish, but it may be supposed also for other fish-derived nutrients, that indicates not only the possibility to apply the food frequency questionnaire in such situation, but in such case – also its superiority over other methods.

3.3. Possibility to apply various methods of the statistical analysis in the validation of the food frequency questionnaires

Publications no I.B.2., I.B.3., I.B.4., I.B.5.

Głowska D., Guzek D., Ślęzak J., Włodarek D. 2017. Assessing the validity and reproducibility of an iron dietary intake questionnaire conducted in a group of young Polish women. *Nutrients*. 27, 199.

Głowska D., Malowanec E., Guzek D. 2017. Validity and reproducibility of the iodine dietary intake questionnaire assessment conducted for young Polish women. *International Journal of Environmental Research and Public Health*. 14(7), 700.

Głowska D., Książek A., Guzek D. 2017. Development and validation of the brief folate-specific food frequency questionnaire for young women diet assessment. *Journal of Environmental Research and Public Health*. 14(12), 1574.

Głowska D., Staniec A., Guzek D. 2018. Assessment of validity and reproducibility of the zinc-specific dietary intake questionnaire conducted for young Polish female respondents. *Nutrients*. 10, 104.

The recommendations that are elaborated by Cade et al. [2002; 2004] indicate the most important issues associated with development, validation and application of the food frequency questionnaires. Considering validation, the Bland-Altman method is recommended as a method that should be applied, both in the assessment of the validity and reproducibility of the questionnaire. At the same time, in a specific cases, if the type of data allows, it is possible to apply the kappa Cohen coefficient, that require the categorized data. Important is also, that in the recommendations, it was specified, that analysis of correlation may be applied in the validation of the food frequency questionnaires, but only as a supplementary method, while Bland-Altman method is at the same time applied [Cade et al., 2002; Cade et al., 2004].

It must be emphasized, that in the studies presenting the validations of the food frequency questionnaires, authors often apply other methods, than recommended. Not only, the Bland-Altman method often is not applied at all, but at the same time, authors do apply the alternative methods – analysis of the distribution of the results in the tertiles/ quartiles/ quintiles, analysis of the adequacy of intake in comparison with recommended value, or other coefficients, that were listed for example in the review paper by Serra-Majem et al. [2009].

Taking into account the indicated recommended methods of the food frequency questionnaire validation, as well as the fact, that commonly the other methods are applied instead, I analyzed the results of validation obtained for various methods of statistical analysis. In the case of the IRONIC-FFQ questionnaire to assess the iron intake (**publication no I.B.2.**), IODINE-FFQ questionnaire to assess the iodine intake (**publication no I.B.3.**), Fol-

IC-FFQ questionnaire to assess the folate intake (**publication no I.B.4.**) and ZINC-FFQ to assess the zinc intake (**publication no I.B.5.**), I applied, at the same time, the Bland-Altman method, kappa Cohen coefficient, analysis of correlation, analysis of the distribution of the results in the tertiles, analysis of the adequacy of intake in comparison with the recommended value, root mean square error of prediction (RMSEP) and median absolute percentage error (MdAPE). In order to enable comparison of the obtained results, I applied in the all constructed validations the same methods of the analysis of the data. Moreover, using the indicated methods, I conducted both the assessment of validity and reproducibility of the obtained questionnaires.

In spite of the fact, that the Bland-Altman method is recommended and some authors indicate it as a gold standard [Kowalkowska et al., 2013], it is not commonly applied in the validations, as well as some authors use this method, but with more concessionary criteria of concluding, than the most popular. Most often, it is defined, that a positive validation of the analysis conducted using the Bland-Altman method is concluded, while Bland-Altman index is lower than 5% [Myles & Cui, 2007], but some authors conclude, that the questionnaire was positively validated while Bland-Altman index is higher than 5%, that in a practice is commonly observed. For example, Bland-Altman indexes higher than 5% was observed in the following studies of other authors: 6.7% in the validation of the questionnaire to assess the vitamin D intake [Pritchard et al., 2010], 5.2% in the validation of the questionnaire to assess the iodine intake [Condo et al., 2015], 6.25% in the validation of the questionnaire to assess the folate intake [Galván-Portillo et al., 2011] and 9.1% in the validation of the questionnaire to assess the zinc intake [Samman et al., 2010].

In the own studies, also the higher than 5% values of the Bland-Altman index were observed, as in the assessment of the validity of the questionnaire, they were: 4.4-5.3% – for IODINE-FFQ questionnaire (**publication no I.B.3.**), 5.3% – for Fol-IC-FFQ questionnaire (**publication no I.B.4.**), 5.5-6.7% – for ZINC-FFQ questionnaire (**publication no I.B.5.**) and 6.7% – for IRONIC-FFQ questionnaire (**publication no I.B.2.**). The lower values of the Bland-Altman index were observed, in the own studies, in the assessment of the reproducibility of the questionnaire, as they were: 2.7% – for Fol-IC-FFQ questionnaire (**publication no I.B.4.**), 3.3% – for ZINC-FFQ questionnaire (**publication no I.B.5.**), 6.7% – for IRONIC-FFQ questionnaire (**publication no I.B.2.**) and 6.7% – for IODINE-FFQ questionnaire (**publication no I.B.3.**).

Obtaining, both in the own studies, and the studies of other authors, the borderline Bland-Altman index, being higher than 5%, but close to indicated value, is commonly interpreted as a positive validation of the questionnaire. It results from the fact, that some authors conclude, that it is not needed to observe such a strong association between assessed features, but it is needed just to observe such an association, that does not disturb the obtained data [Choi & Pak, 2005]. In spite of the fact, that such a level, that would not disturb the obtained data, is not defined, it is commonly indicated, that the Bland-Altman index lower than 10% allow to conclude, that the questionnaire is positively validated [Pritchard et al., 2010; Samman et al., 2010; Galván-Portillo et al., 2011; Condo et al., 2015].

In the case when the borderline Bland-Altman index is observed, especially valuable would be including into validation also the other methods of statistical analysis, that may enable concluding about the necessity to polish up the questionnaire or about the possibility to apply it in the form in which it was validated.

In the own studies, in order to validate the developed questionnaires, using the kappa Cohen coefficient, they were presented as the location of the obtained results in tertiles (categorized data) and afterwards they were interpreted, using the criteria by Landis and Koch [1977]. In the analysis of the validity, for the IODINE-FFQ questionnaire (**publication no I.B.3.**), Fol-IC-FFQ questionnaire (**publication no I.B.4.**) and ZINC-FFQ questionnaire (**publication no I.B.5.**) a slight agreement was observed, while for IRONIC-FFQ questionnaire (**publication no I.B.2.**) – a fair agreement. At the same time, in the analysis of reproducibility, for all the analyzed questionnaires, a substantial agreement was stated. In spite of the fact, that analysis of the kappa Cohen coefficient was conducted for the data transformed into categorized ones, it undoubtedly confirmed the previous observations, for the Bland-Altman method – higher reproducibility of all the questionnaires, than their validity.

Among supplementary methods, that allow to validate the elaborated questionnaires, the analysis of correlation was also applied, being indicated in the recommendations of Cade et al. [2002; 2004] as a method, that may be used, but only as a supplementary one while the Bland-Altman method is also applied. In the case of all the conducted analysis, the statistical significance of observed correlations was stated, but with various correlation coefficients. In the case of the analysis of validity, it was lower, than in the case of the analysis of reproducibility, as for reproducibility, independently from the validated

questionnaire, it was higher than 0.7, and it was 0.74 for ZINC-FFQ questionnaire (**publication no I.B.5.**), 0.80 – for Fol-IC-FFQ questionnaire (**publication no I.B.4.**), 0.81 – for IODINE-FFQ questionnaire (**publication no I.B.3.**) and 0.87 – for IRONIC-FFQ questionnaire (**publication no I.B.2.**). The average levels observed in the analysis of validity were similar as observed by other authors, that are indicated in the review by Serra-Majem et al. [2009].

In spite of the fact, that analysis of correlation is not the method of the questionnaire validation being recommended by Cade et al. [2002; 2004], as an exclusive one, and is only recommended as a supplementary one, Masson et al. [2003] indicated the values of the correlation coefficient that may indicate, that a questionnaire is positively validated. They stated, that necessary is to obtain the correlation coefficient higher than 0.5 [Masson et al., 2003]. Moreover, Willett [2001] defined the correlation coefficient of 0.7, as a level above which the correlation coefficients are very rarely observed in the validation of the food frequency questionnaires and he called it the ceiling of validity. He also stated, that it results from a fact, that an inherent complexity of a diet can not be fully captured in the structured questionnaire [Willett, 2001]. It corresponds with the result of the own studies, as the ceiling of validity was not obtained in a case of any assessment in the analysis of validity and was only observed in the assessment of reproducibility, that results from the fact, that for mentioned analysis the results obtained twice, using the same form, were compared.

Among the other supplementary methods, applied in the validation of the developed questionnaires, there is analysis of the distribution of results of nutrient intake in tertiles, that is commonly used by the other authors. Similarly, as an analysis of correlation, the indicated method is not recommended in the validation, but the formulated guidelines allow concluding on the basis of the observed results. Masson et al. [2003] indicated, that a positive validation may be concluded while over 50% of respondents are classified, using compared methods, to the same categories, while less than 10% are classified to the conflicting categories. In the own studies, in the assessment of validity, in the case of all the validated questionnaires, the agreement between methods was lower, than the indicated one, as either lower level of consistent results, or the higher level of conflicting ones was stated. At the same time, the required level of agreement was observed for all the validated questionnaires in the assessment of reproducibility, as the share of consistent results was 79% while conflicting – 3% for IRONIC-FFQ questionnaire (**publication no I.B.2.**), share of consistent results was 75% while conflicting – 4% for Fol-IC-FFQ questionnaire (**publication**

no I.B.4.), share of consistent results was 72% while conflicting – 3% for ZINC-FFQ questionnaire (**publication no I.B.5.**) and share of consistent results was 72% while conflicting – 1% for IODINE-FFQ questionnaire (**publication no I.B.3.**). Hence, similarly, as in the case of previously indicated results, the very high reproducibility, accompanied by lower validity, was confirmed.

Among the other supplementary methods of analysis, applied in the validation of the questionnaires, the RMSEP and MdAPE coefficients are characterized by a low practical value. At the same time, analysis of the adequacy of intake in comparison with the recommended value, as any other method, indicates the risk of improper concluding about the adequate or inadequate intake. In the case of mentioned method, also in the assessment of validity, the result of agreement were lower, than in the assessment of reproducibility, in the case of which, for all the questionnaires, very high level of agreement was stated. The share of the consistent results in the assessment of reproducibility of the questionnaires was 89% for IRONIC-FFQ (**publication no I.B.2.**), 87% – FoI-IC-FFQ (**publication no I.B.4.**), 86% – IODINE-FFQ (**publication no I.B.3.**) and 83% – ZINC-FFQ (**publication no I.B.5.**).

Assessing the possibility to apply the various methods of validation of the food frequency questionnaires, it must be emphasized, that independently from the results observed for various methods, in concluding, the results of the Bland-Altman method must be treated as the most important and dominant and must directly influence the general conclusion from the validation. Applying the kappa Cohen coefficient, due to the character of data applied during the validation of the questionnaire, requires the data transformation, that may contribute to the misinterpretation during concluding. It must be also indicated, that applying the other methods, as a supplementary ones, especially the analysis of correlation, analysis of distribution of the results in tertiles and analysis of the adequacy of intake in comparison with then recommended level, allows to observe the broader spectrum of dependencies.

While the supplementary methods are applied, in the own study, it was possible to indicate undoubtedly, that applied questionnaires are characterized by high or very high reproducibility of the results, accompanied by average or quite good validity. Applying other methods than the Bland-Altman method allowed also comparison of the own results with the results obtained by other authors, who applied other methods.

3.4. Influence of overestimation of the intake of products, observed for the food frequency questionnaires, on the results of the validation

Publications no I.B.1., I.B.2., I.B.4.

Głowska D., Guzek D., Sidor P., Włodarek D. 2016. Vitamin D dietary intake questionnaire validation conducted in young Polish women. *Nutrients*. 8, 36.

Głowska D., Guzek D., Ślęzak J., Włodarek D. 2017. Assessing the validity and reproducibility of an iron dietary intake questionnaire conducted in a group of young Polish women. *Nutrients*. 27, 199.

Głowska D., Książek A., Guzek D. 2017. Development and validation of the brief folate-specific food frequency questionnaire for young women diet assessment. *Journal of Environmental Research and Public Health*. 14(12), 1574.

The food frequency questionnaires are in general characterized by a tendency to overestimate the intake of products and nutrients, especially in comparison with the methods of dietary record and dietary recall, that at the same time have a tendency to underestimate the intake [Institute of Medicine, 2002]. However, as a methods of dietary record and dietary recall are commonly applied as a reference methods, the overestimation observed for the food frequency questionnaire method is in fact lower, than the observed one [Serra-Majem et al., 2009]. Hence, due to a lack of fully objective method to assess the intake, it is stated, that the observed overestimation level may be revalued.

Except for the general overestimation, observed in the case of food frequency questionnaires, the factors influencing it must be indicated. The accuracy of estimation is influenced by number of questions in the food frequency questionnaire. In general, it is indicated, that the higher number of questions about food items from various groups, causes higher risk of nutrients intake overestimation [van de Rest et al., 2007; Palmer & Morgan, 2012]. It results from the fact, that in the case of a long questionnaire, there is not only a risk of refusing filling it out [Kelley et al., 2003], but also a risk of unreliable answers, and even low overestimation of the intake of a lot of products, that respondent is asked about, in a consequence causes a significant overestimation of the final result [Choi & Pak, 2005]. The indicated problem is observed especially in the case of a comprehensive questionnaires, as a lot of questions is included and a lot of time is needed to complete, for example, the questionnaire validated by Fayet et al. [2011] consisted of 235 questions and to fill it out, the time of 45 minutes was needed.

Taking into account the potential significant overestimation in the case of the comprehensive questionnaires, it may be indicated, that if the assessment of intake of one nutrient or a couple of them is needed, it may be better to apply one or few brief

questionnaires, than a comprehensive one, as it may lead not only to quicker result obtaining, but also to lower overestimation.

Taking into account the potential overestimation of the intake of nutrients in the case of the food frequency questionnaires, as well as association between overestimation level and a number of questions included in a tool, I chosen the questionnaires, to analyze, using the Bland-Altman method, the influence of the overestimation, on the results of validation. I analyzed the overestimation level in the case of intake of respondents, observed in the validation of the ViDEO-FFQ questionnaire to assess the vitamin D intake (**publication no I.B.1.**), IRONIC-FFQ questionnaire to assess the iron intake (**publication no I.B.2.**) and Fol-IC-FFQ questionnaire to assess the folate intake (**publication no I.B.4.**). The indicated questionnaires were analyzed, due to various number of sources of nutrients, that are derived from a specific products (vitamin D) or from a large number of various food products (iron, folate). During the development of the questionnaires, the various techniques were applied in order to reduce the number of questions (including the clustering procedure), that as a result could had contributed to the overestimation level, as it influences the number of questions and accuracy of intake estimation by respondents. At the same time, the validation of the IODINE-FFQ questionnaire to assess the iodine intake, was deliberately not included to indicated analysis, as the significant share of iodine in a Polish diet is derived from the iodine-fortified salt. In the case of indicated product, due to challenging estimation of intake (possible overestimation or underestimation of the salt intake), observed associations may be untypical.

Both in the case of validation of the ViDEO-FFQ questionnaire to assess the vitamin D intake (**publication no I.B.1.**) and of validation of the IRONIC-FFQ questionnaire to assess the iron intake (**publication no I.B.2.**), it was observed, that in comparison with a results obtained using the dietary record, low level of overestimation was stated. Only in the case of Fol-IC-FFQ questionnaire to assess the folate intake, it was stated, that in the analysis of validity, conducted using Bland-Altman method, a minor underestimation of the folate intake was observed (**publication no I.B.4.**). It may result from the fact, that indicated questionnaire is characterized by a significantly reduced number of questions, while a large number of products are sources of folate in a typical diet. The questionnaire consists of 25 questions about the intake of food items, that were previously clustered, while in the case of IRONIC-FFQ questionnaire to assess the iron intake, that is also characterized by a large

number of food sources, the number of questions is higher, as 32 food items were included and combined into 12 larger groups of questions (**publication no I.B.2.**). It is associated with a fact, that in the case of a food frequency questionnaire, the number of included questions about food items from various food product groups and the kind of them is indicated as a main source of errors in the estimation of the intake of nutrients [Tucker, 2005].

At the same time, it must be indicated, that independently from a fact that nutrient was in a diet derived from a specific sources (vitamin D), or a lot of various sources (iron, folate), as well as independently from a fact that questionnaire overestimated the intake (VIDEO-FFQ, IRONIC-FFQ), or subtly underestimated (Fol-IC-FFQ), the indicated questionnaires were positively validated.

The fact, if for the questionnaire, the overestimation of the nutrients intake is indicated, or its underestimation, influences significantly the concluding based on the obtained results. If for the questionnaire, the overestimation of the results of intake is stated, individuals for which the inadequate intake was stated, using the form, may be really characterized by such inadequate intake, but it is also possible, that by inadequate intake are characterized also other individuals, for which, based on the questionnaire, the adequate intake was concluded (that results from the overestimation of their intake). In the population studies, it may result in lower frequency of inadequate intake observed, than in reality.

At the same time, if for the questionnaire, the underestimation of the results of intake is stated, individuals for which the inadequate intake was stated, using it, may be really characterized by such inadequate intake, but it is also possible, that their intake is adequate, but was underestimated. In the population studies, it may result in higher frequency of inadequate intake observed, than in reality. Taking into account the characteristics of the food frequency questionnaires, it is observed less often, than the other situation, but it must be taken into account during concluding.

Independently from the fact, if the food frequency questionnaires underestimates or overestimates the results of intake, they may be an especially valuable tool in the studies conducted in a large groups of respondents. If the intake of individual nutrients is assessed, the brief questionnaires may be a better tool, due to a lower risk of overestimation, that, due to a number of questions, is common especially in the case of a comprehensive

questionnaires [Kowalkowska et al., 2013], while the level of overestimation may be even 250% [Barrett & Gibson, 2010].

Considering the nutrients for which the influence of the potential overestimation on the results of validation was being analyzed, it must be indicated, that the assessment of the intake conducted using the brief food frequency questionnaires is especially needed in a large populations. It results from a fact, that monitoring of the nutrients intake in a risk groups of deficiency is an important aim of the public health improving actions, that in the case of a young women is indicated for vitamin D [Kennel et al., 2010] and iron [World Bank, 2003]. Such monitoring should be aimed at indicating individuals that are characterized by especially low intake and at enabling conducting in such groups the nutritional education, that in a consequence may contribute to lower frequency of deficiencies [Kaur et al., 2011; LeFevre, 2015].

At the same time, in the case of folate, there is a need to promote among women of reproductive age the knowledge about necessity to apply the supplementation of folic acid in the preconception period [WHO, 2012]. Taking it into account, in some countries, it is indicated to include into education also the information about main sources of folate [Wilson et al., 2003]. In the case of the mentioned nutrient, the intake monitoring should be applied in order to indicate the individuals characterized by especially low intake, but also to promote, in a group of women of reproductive age, the knowledge about recommended folate intake and necessary supplementation before pregnancy.

While assessing the influence of overestimation of intake, observed while the developed questionnaires were applied, on the results of validation, it must be emphasized, that overestimation of intake is not always observed while the food frequency questionnaires are applied. It is observed in the case of the majority of questionnaires, but not in the case of all of them, that was stated for the Fol-IC-FFQ questionnaire, for which the minor underestimation was observed. At the same time, it was stated, that existing overestimation or underestimation of the results of intake does not limit the possibility of the positive validation of the food frequency questionnaire, but it must be taken into account during concluding about the frequency of inadequate intake in the population.

3.5. Reproducibility and validity of the developed food frequency questionnaires and possibility to apply them in practice

Publications no I.B.1., I.B.2., I.B.3., I.B.4., I.B.5.

Głabska D., Guzek D., Sidor P., Włodarek D. 2016. Vitamin D dietary intake questionnaire validation conducted in young Polish women. *Nutrients*. 8, 36.

Głabska D., Guzek D., Ślęzak J., Włodarek D. 2017. Assessing the validity and reproducibility of an iron dietary intake questionnaire conducted in a group of young Polish women. *Nutrients*. 27, 199.

Głabska D., Malowaniec E., Guzek D. 2017. Validity and reproducibility of the iodine dietary intake questionnaire assessment conducted for young Polish women. *International Journal of Environmental Research and Public Health*. 14(7), 700.

Głabska D., Książek A., Guzek D. 2017. Development and validation of the brief folate-specific food frequency questionnaire for young women diet assessment. *Journal of Environmental Research and Public Health*. 14(12), 1574.

Głabska D., Staniec A., Guzek D. 2018. Assessment of validity and reproducibility of the zinc-specific dietary intake questionnaire conducted for young Polish female respondents. *Nutrients*. 10, 104.

The validation of the food frequency questionnaires is associated with two aspects – their validity (that is assessed while the results of nutrient intake obtained using the questionnaire are compared with the results obtained using the reference method) and reproducibility (that is assessed while the results of nutrient intake obtained twice using the same questionnaire are compared) [Cade et al., 2002; 2004].

It should be indicated, that obtained validity and reproducibility of the questionnaire are not always on the same level, while more often observed is a situation in which the reproducibility is higher than validity, than the other situation [Cade et al., 2004]. It results from the fact, that developing questionnaire, that is characterized at the same time by a high validity, high reproducibility, as well as is simple and easy to use for each respondent, is very challenging. Taking it into account, often a questionnaires that allow ideal assessment of a nutrient are not tried to be obtained (because such questionnaire would be very complicated), but rather are tried to be obtained a questionnaires, that are simple and additionally allow as valid and as reproducible assessment, as possible.

In the case of the questionnaires validated in the own studies, the observed reproducibility was higher than validity, that was stated for the ViDEO-FFQ questionnaire to assess the vitamin D intake (**publication no I.B.1.**), IRONIC-FFQ questionnaire to assess the iron intake (**publication no I.B.2.**), IODINE-FFQ questionnaire to assess the iodine intake (**publication no I.B.3.**), FoL-IC-FFQ questionnaire to assess the folate intake (**publication no I.B.4.**) and ZINC-FFQ questionnaire to assess the zinc intake (**publication no I.B.5.**).

Especially high reproducibility observed in the case of the food frequency questionnaire means, that it is a tool that may be used mainly to conduct the repeated assessments of the intake of a nutrient in the period of time [Owens et al., 2007]. It is associated, among others, with a situation when as an element of diet therapy, or nutritional education, the information about the role of nutrient and its sources are presented to respondents and, then in order to conduct monitoring of the results of dietary intervention, the intake of products or nutrients, is verified, after a period of time [McClelland et al., 2001].

While using the food frequency questionnaires, the assessment may be conducted even in a large population groups [Shim et al., 2014], as an element of programs promoting health and as an element of evaluation of effects of such programs, while applying other tools may be challenging, due to a large number of respondents [Wrieden et al., 2003]. Due to the fact, that food frequency questionnaires may be applied, it is possible to identify in a large population groups, individuals characterized by especially low intake of nutrient and, afterwards, to prepare for them dedicated educational actions.

Specific situation, while using the same tool a couple times, is needed, in the period of time, is assessment of the intake conducted for the pregnant women. The nutrition during pregnancy changes significantly, depending on the trimester, as well as depending on the day or well-being [Baer et al., 2005]. It results from the changes of the appetite, of the food product preferences, as well as changes of the energy needs [Zhang et al., 2015], or natural changes of diet depending on the season [Cheng et al., 2008]. Hence, the assessment of diet, based on the diet during random days, that is conducted using the dietary record or dietary recall method, in the case of pregnant women, may cause a high error of estimation. At the same time, the assessment of diet of pregnant women, should be conducted often, in order to analyze satisfying their nutritional needs. Taking it into account the fact, that in the own studies, questionnaires were validated in a group of young women, is especially important and it may enable conducting the diet assessment using them, also in a group of pregnant women.

The especially important aim, to apply the food frequency questionnaire, that is easy method to use, may be a quick obtaining of the information about the intake of nutrient, in the case of the individual respondents, that enables making a decision about a potential necessity of supplementation. Developed questionnaires allow to assess the dietary intake

of nutrients, as well as to ask respondents about applied supplementation and, afterwards, after estimating his total intake of nutrient, they allow not only to present respondent dietary recommendations, but also to indicate potential necessity to apply a supplementation [Rios-Avila et al., 2017].

The developer original questionnaires, that were validated during the own studies, were included into the register of the short dietary assessment instruments, validated in a specific population groups, of National Institutes of Health – National Cancer Institute [2018]. In the register, there are the ViDEO-FFQ questionnaire to assess the vitamin D intake (**publication no I.B.1.**), IRONIC-FFQ questionnaire to assess the iron intake (**publication no I.B.2.**), IODINE-FFQ questionnaire to assess the iodine intake (**publication no I.B.3.**) and Fol-IC-FFQ questionnaire to assess the folate intake (**publication no I.B.4.**).

Moreover, it should be emphasized, that the developed and validated questionnaires are currently used not only in Poland, but also in other countries. The ViDEO-FFQ questionnaire to assess the vitamin D intake (**publication no I.B.1.**) is applied during a study, that is conducted in cooperation with KBC Klinički Bolnički Centar Zagreb (University Hospital Centre Zagreb) in Croatia, as the questionnaire adjusting is conducted, in order to obtain the universal tool to assess the vitamin D intake in Croatia. It is an important aim, as in Croatia, there is no information about vitamin D content in the tables of the nutritional value of products, that causes, that vitamin D intake assessment on the basis of dietary record, or recall, is for dietitians challenging.

The ViDEO-FFQ questionnaire to assess the vitamin D intake (**publication no I.B.1.**) is also applied during studies conducted by:

- Gdański Uniwersytet Medyczny (Medical University of Gdańsk),
- Morsani College of Medicine in Tampa in United States,
- University of Wisconsin-Stout in United States,
- University of Alaska Anchorage in United States,
- Namik Kemal Üniversitesi (Namik Kemal University) in Turkey,
- Universidade Federal de Pernambuco (Federal University of Pernambuco) in Brasil.

At the same time, the IRONIC-FFQ questionnaire to assess the iron intake (**publication no I.B.2.**) is applied during studies conducted by:

- Universidad de Guadalajara (University of Guadalajara) in Mexico,

- Aspetar Orthopaedic and Sports Medicine Hospital in Qatar.

Using the indicated questionnaires not only in Poland, but also in the other countries results from the fact, that researchers commonly do not have the other brief validated tools, that would enable the assessment of the nutrient intake. However, it must be emphasized, that in order to use a questionnaire in the other country, the adjustment of the questionnaire is necessary, as it was done in the case of the ViDEO-FFQ and IRONIC-FFQ questionnaires, while changing them, to apply in other countries. It results from the differences of the typical diet in various countries, as well as from the various choices of products, including the fortified ones. Hence, including such products in the questionnaire is necessary, while it is to be applied in the other country, even if the raw products that are available in the countries are characterized by a similar content of nutrients [Schmid & Walther, 2013].

Independently form a satisfying results of validation of the ViDEO-FFQ questionnaire to assess the vitamin D intake (**publication no I.B.1.**), IRONIC-FFQ questionnaire to assess the iron intake (**publication no I.B.2.**), IODINE-FFQ questionnaire to assess the iodine intake (**publication no I.B.3.**), FoI-IC-FFQ questionnaire to assess the folate intake (**publication no I.B.4.**) and ZINC-FFQ questionnaire to assess the zinc intake (**publication no I.B.5.**), the further studies on the possibility to improve them are needed. Such studies should include, among others, removing the redundant questions, in order to simplify the form, verifying the groups of products, as well as adding new fortified products [Huybrechts et al., 2009]. It results from the fact, that the tool, to be possible to be commonly applied, must be first of all up-to-date, as well as simple and understandable for respondents, to cause that the error of estimation is as low as possible.

Among strengths of the developed and validated food frequency questionnaires, the most important is the fact, that they are from the group of the brief questionnaires, so for respondents they are simple to fill out and they enable the quick assessment of the intake of a specific nutrients. At the same time, they are positively validated and a high reproducibility of the results was for them proven. Validation was conducted in a group of young women, that is especially prone for deficiencies, that is also the significant value of the developed questionnaires. They also allow to assess the intake of nutrients that are derived from products that in a typical diet are rarely consumed or from products in the case of which, the assessment of intake is challenging. As a result, they may allow more accurate assessment of

intake than methods that are based on the assessment on intake during the days that are defined by respondents as a typical ones. Among the weaknesses of the developed questionnaires, that are at the same time, the necessary directions to improve them, there is a lower validity than reproducibility of the questionnaires. Moreover, it must be mentioned, that the food frequency questionnaires, while compared with the other methods of intake assessment, are characterized by a tendency to overestimate the results, that was observed also for the validated ones.

Summarizing, it should be indicated, that while the possibility to apply the developed and validated food frequency questionnaires, is assessed, the high reproducibility is the main characteristics of them, that enables conducting the repeated measurements of intake in the same group of respondents in a specified period of time.

4. Summary

The obtained results let to verify the research hypothesis.

With a reference to hypothesis associated with a possibility to develop and apply the food frequency questionnaires in the assessment of the adequacy of intake of nutrients, it was concluded, that applying questionnaires to obtain the indicated aim is possible, if the nutrient is derived from a standard food products and the assessment of their intake is not especially challenging for respondents. Only in the case of the IODINE-FFQ questionnaire to assess the iodine intake, the significant overestimation of intake was observed while the assessment was conducted using the questionnaire, that contributed to indicating the lower frequency of inadequate intake in the analyzed group, than for a reference method. It resulted from the fact, that iodine is derived mainly from the iodine-fortified salt and the assessment of the intake of this product may be for consumers challenging.

With a reference to hypothesis associated with a possibility to develop and apply brief semi-quantified food frequency questionnaires, depending on the sources of assessed nutrient, it was concluded, that development of the reliable questionnaire is possible, independently from a character of a nutrient. At the same time, it was indicated, that the crucial issue is choosing the proper techniques, while the techniques applied in the case of the original questionnaires were: the products clustering, higher number of subgroups in the case of crucial products, including additional questions for the most important products and proper order of questions. Applying indicated techniques and the other ones, depending on

the nutrient and the population group, should allow, independently from the type of sources of nutrient, to obtain the reliable questionnaire.

With a reference to hypothesis associated with the possibility to apply various methods of the statistical analysis in the validation of the food frequency questionnaires, it was concluded, that in spite of the fact, that the Bland-Altman method should be the basis of the concluding, applying the additional methods, allow to obtain more information that are needed during concluding about possibility to apply the questionnaire in practice. As especially valuable methods, were indicated applying the analysis of correlation and analysis of the distribution of the results of intake in tertiles/ quartiles/ quintiles, due to existing recommended levels to be obtained in the validation of the questionnaires. Moreover, applying the analysis of adequacy of the intake of nutrient, in comparison with the recommendations, has a practice role during concluding.

With a reference to hypothesis associated with the influence of overestimation of the intake of products, by a respondent, observed for the food frequency questionnaires, on the results of the validation, it was concluded, that the influence of overestimation, in the case of a brief food frequency questionnaires, is minor. The low level of underestimation also, in the case of the brief food frequency questionnaires, does not influence the possibility to validate and apply the food frequency questionnaire. It should be also emphasized, that both overestimation, and underestimation, influences significantly the concluding about the frequency of inadequate intake in population, so information about the fact, that the questionnaire has a tendency to overestimate, or underestimate is necessary, during applying it.

With a reference to hypothesis associated with the possibility to apply in practice food frequency questionnaires, that are characterized by a high reproducibility level, the potential target groups, for which such questionnaires may be especially valuable, must be indicated. Among them, there are patients, participating in the nutritional education, that is aimed at increasing the intake of specific nutrients, including participants of the large health-promoting programs, as a number of participants may cause, that intake assessment, conducted using other methods of is impossible. The specific group are also pregnant women, due to their diet changing during pregnancy, that should be constantly monitored. The usefulness of the developed and validated food frequency questionnaires for indicated aims, may be confirmed by the fact, that they are already used in the studies conducted in

Poland and in other countries, and by the fact, that they were included into the register of the short dietary assessment instruments, validated in a specific population groups, of National Institutes of Health – National Cancer Institute [2018].

5. Conclusions

The conducted studies and the results presented in the achievement, associated with **applying food frequency questionnaires to assess the intake of micronutrients in a group of young women**, may contribute to broadening the knowledge in the field. They let to formulate the following conclusions:

- it is possible to develop and validate the brief semi-quantified food frequency questionnaires to assess the adequacy of intake of micronutrients, independently from their dietary sources, that enables the assessment of the intake in a group of young women, especially prone to deficiencies,
- applying at the same time the various methods of the statistical analysis in the validation of the food frequency questionnaires allows to obtain more information that are necessary during concluding about possibility to apply the questionnaires in practice
- knowledge about potential overestimation or underestimation of intake of nutrients, that are assessed using the food frequency questionnaire, should be taken into account in the studies conducted using them, during concluding
- the high reproducibility of the developed questionnaires allow to apply them in the studies, that require to conduct the repeated assessments in the period of time, including the analysis of the changes of the nutritional habits in assessment of the efficiency of diet therapy and nutritional education programs.

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1.4. DISCUSSION OF OTHER SCIENTIFIC AND RESEARCH ACHIEVEMENTS

I graduated Warsaw University of Life Sciences, Faculty of Human Nutrition and Consumer Sciences with a master engineer degree in 2005 year. My thesis entitled *Evaluation of a diet of predialysis women with chronic renal failure receiving a supplement containing essential amino acid ketoanalogues* and was well graded (5.0), as well as my master degree exam (5.0), so my final grade was also very good (5.0). Next year (2006), I graduated Medical University of Warsaw, Faculty of Health Sciences, with a bachelor degree

in the field of dietetics, while my thesis entitled *Analysis of associations between nutrition and dental caries intensity in children and adolescents*. The same year, I started my Ph.D. studies in Faculty of Human Nutrition and Consumer Sciences of Warsaw University of Life Sciences and in 2012 year, I presented my Ph.D. thesis entitled *Analysis of the diet and nutritional status of individuals with colitis ulcerosa during remission* to the Faculty Board of the Faculty of Human Nutrition and Consumer Sciences. My Ph.D. thesis was associated with the influence of diet of *colitis ulcerosa* individuals on their nutritional status, as well as possibility of satisfying their nutritional needs. After passing all the exams and public dissertation defense, it was very well graded (5.0) with distinction, so I obtained Ph.D. degree in agricultural sciences in the discipline of food technology. I started my professional work in December 2009, as assistant in the Chair of Dietetics, Department of Dietetics, Faculty of Human Nutrition and Consumer Sciences, Warsaw University of Life Sciences. My research work is associated with assessment of the nutritional status and nutrition, conducted using various methods, as an element of dietary prevention and diet therapy of diet-related diseases, as well as is associated with nutrition engineering.

Among my research interests, I may indicate following subject groups (numbering according to appendix no 3, II.A., II.D.):

- 1 **Subject group A.1.:** Low protein diet in chronic kidney disease during the pre-dialysis stage of the disease (publications no II.A.17., II.A.25., II.D.10., II.D.25., II.D.37., II.D.39., II.D.40., II.D.42., II.D.44., II.D.62.)
- 2 **Subject group A.2.:** Diet of elderly patients depending on their diet-related diseases (publications no II.A.24., II.D.1., II.D.3., II.D.6., II.D.7., II.D.8., II.D.11., II.D.14., II.D.15., II.D.24., II.D.35., II.D.36., II.D.38., II.D.41., II.D.45., II.D.46., II.D.61.)
- 3 **Subject group A.3.:** Dietary prevention of osteoporosis in young and post-menopausal women (publications no II.A.18., II.A.5., II.D.4., II.D.9., II.D.23.)
- 4 **Subject group A.4.:** Possibilities of diet-related diseases prevention in children (publications no II.A.2.; II.D.2.; II.D.43.; II.D.59.; II.D.60.; II.D.64.)
- 5 **Subject group A.5.:** Role of diet in inflammatory bowel disease (publications no II.A.1., II.A.3., II.A.6., II.A.8., II.A.10., II.D.5., II.D.47., II.D.51., II.D.56., II.D.57., II.D.65., II.D.66.)
- 6 **Subject group A.6.:** Possibilities of applying objective instrumental methods of measurement in nutrition and nutrition engineering research (publications no II.A.9.,

II.A.11., II.A.12., II.A.14., II.A.22., II.D.16., II.D.17., II.D.18., II.D.19., II.D.20., II.D.22., II.D.26., I.D.27., II.D.28., II.D.29., II.D.30., II.D.31., II.D.32., II.D.33., II.D.34., II.D.49., II.D.50., II.D.52., II.D.53., II.D.58.)

- 7 **Subject group A.7.:** Meat market directions, possibilities of development and consumer expectations (publications no II.A.4., II.A.7., II.A.13., II.A.15., II.A.16., II.A.18., II.A.20., II.A.21., II.A.23., II.D.12., II.D.13., II.D.21., II.D.48., II.D.54., II.D.55., II.D.63.)

A. Discussion of publications in the cycles of subjects

1. Low protein diet in chronic kidney disease during the pre-dialysis stage of the disease

(numbering according to appendix no 3, II.A., II.D.)

Among the main aims of therapy of chronic kidney disease during the pre-dialysis stage of the disease are reducing the unfavorable symptoms of uremia, delaying the renal-replacement therapy and improving the general quality of life, that may be obtained using the appropriate diet, that should be applied with other elements of therapy [Ayli et al., 2000]. Diet therapy should include the sufficient protein supply and energy value of diet, but it is indicated, that insufficient nutritional knowledge of patients and lack of understanding of necessary dietary restrictions, may negatively impact their status, including their body composition [Inaguma et al., 2006].

The indicated problem induced me to analyze the nutrition of chronic kidney disease patients during the pre-dialysis stage of the disease, that was the natural consequence of my previous research interest, as I analyzed the subject of diet of chronic kidney disease individuals as an element of the research included in my master thesis. I analyzed general quality of diet of pre-dialysis individuals (**publication no II.A.17.**), the protein content in diet and energy value of diet (**publication no II.D.62.**), as well as minerals content (**publication no II.D.44.**) and the role of physical activity influencing body composition of patients (**publication no II.A.25.**). The specific area of my interest were essential amino acid ketoanalogues, applied in order to deliver them for patients on low-protein diet. In groups of patients using essential amino acid ketoanalogues, I analysed general quality of diet (**publication no II.D.39.**), the protein content in diet and energy value of diet (**publication no II.D.42.**), but also the choice of food products (**publication no II.D.40.**).

In the studies conducted in the groups of chronic kidney disease pre-dialysis patients, I observed, that diet is improperly balanced, that was stated both in groups of individuals not applying essential amino acid ketoanalogues (**publication no II.A.17.**) and applying them (**publication no II.D.39.**). It was associated with protein intake decreasing that was accompanied by energy value of diet decreasing (**publication no II.D.62.**), that resulted in not satisfying other nutritional needs (**publication no II.D.44.**). Moreover, low level of physical activity was the other factor contributing to worsening body composition and decreasing muscle mass (**publication no II.A.25.**).

Especially in the case of individuals applying essential amino acid ketoanalogues, important is the fact, that the diet was not properly balanced, that was associated with too serious protein intake restrictions in some respondents and too high protein intake in others, that contributed to the fact, that supplementation was useless (**publication no II.D.42.**). The observed situation was the consequence of unfavorable changes of the composition of diet that were observed while disease progressed and, as I concluded, that were probably related to the lack of nutritional education in analyzed group (**publication no II.D.40.**).

As a result of improperly balanced diet following in a group of chronic kidney disease pre-dialysis patients and concluded lack of properly planned and conducted nutritional education, my further studies were associated with nutritional knowledge of pre-dialysis individuals and possibilities to conduct nutritional education for them. As it is indicated, that they commonly do not follow the diet properly [National Collaborating Centre for Chronic Conditions, 2008], I decided to assess, if they have the necessary nutritional knowledge. I analyzed their knowledge associated with protein content in food products (**publication no II.D.10.**) and with practical possibilities to apply low-protein diet (**publication no II.D.25.**), as well as I assessed changes of protein intake and of energy value of diet that were observed during nutritional education (**publication no II.D.37.**).

During conducted studies, I stated, that chronic kidney disease pre-dialysis patients do not have the necessary knowledge associated with protein content in food products (**publication no II.D.10.**), that would enable low-protein diet following (**publication no II.D.25.**). While I concluded that nutritional education is needed for indicated group of patients, I proved, that it may be effective and may contribute to improving diet (**publication no II.D.37.**).

2. Diet of elderly patients depending on their diet-related diseases

(numbering according to appendix no 3, II.A., II.D.)

Nutritional recommendations for elderly should be formulated taking into account the specific needs of the group, including needs resulting from the malnutrition risk, as well as prevention and therapy of diseases, including diet-related ones [WHO, 2018]. Among diseases especially important for the indicated group, there are not only conditions resulting from the natural ageing process (osteoporosis, cognitive dysfunctions, digestive impairment, vision loss), but also diseases not distinctive for elderly, but observed for them more often, than for younger ones (hypertension, diabetes, dyslipidaemia) [Institute of Medicine, 2010].

Taking into account the fact, that majority of chronic kidney disease patients applying low-protein diet, analyzed in my studies (subject group A.1), were elderly ones, the natural consequence of indicated research interest, was my interest in diet of elderly patients, depending on their diet-related diseases. I participated in studies on the nutritional value of diets of elderly nursing homes residents (**publication no II.D.3.**) and the possibility to satisfy their nutritional needs (**publication no II.D.61.**), including the influence of season (**publication no II.D.6.**), as well as in studies comparing diets of nursing homes residents and elderly patients living with their families, that was conducted for Alzheimer's disease patients (**publication no II.D.15.**) and other elderly ones (**publication no II.D.14.**).

In the conducted studies, it was observed, that nursing home menus are improperly planned (**publication no II.D.3.**), so they do not satisfy nutritional and energy needs (**publication no II.D.61.**). Moreover, it was emphasized, that such problems are stated independently from the season (**publication no II.D.6.**). While diets of nursing homes residents and elderly patients living with their families were compared, it was observed, that diets of patients living with their families are in general more properly balanced (**publication no II.D.14.**), but fruits and vegetables intake was still insufficient (**publication no II.D.15.**). The completion of the presented research was my participation in the study on the possibilities to improve the sensory features of vegetable during their thermal treatment (**publication no II.A.24.**).

The further study in which I participated, included assessment of the dietary recommendations compliance in a group of elderly malnourished patients (**publication no II.D.8.**) and in a group of patients with Age-related Macular Degeneration (AMD) diagnosed, while for them I analyzed not only following the general recommendations (**publication no**

II.D.41.), but also following the lutein intake (**publication no II.D.35.**) and n-3 fatty acids intake recommendations (**publication no II.D.24.**).

In the study assessing diet of elderly malnourished patients, it was observed, that not only their nutritional status is worse, than in the case of the control group, but also their diet is not properly balanced and it does not provide sufficient minerals and vitamins intake (**publication no II.D.8.**). The similar results I observed in the case of individuals with AMD, as in the indicated group, in spite of declared following the general dietary recommendations more often (**publication no II.D.41.**), I observed lack of nutritional knowledge, that would contribute to choosing vegetables high in lutein (**publication no II.D.35.**) and to choosing fish high in n-3 fatty acids (**publication no II.D.24.**).

Taking into account the problem, indicated both in the studies conducted in the nursing homes and in groups of patients living with their families, associated with following improperly balanced diet, not adequate for patients with specific diseases, I planned study on nutritional knowledge and behaviors of medical staff and on the association with nutritional behaviors of their patients. I conducted indicated study in a groups of diabetology nurses (**publication no II.D.7.**) and they were combined with a study conducted in a group of diabetes type 2 patients (**publication no II.D.36.**), including assessment of fruit and vegetables intake (**publication no II.D.38.**) and analysis of the possibility of designing a new bakery product characterized by a low glycemic index (**publication no II.D.11.**).

The issue of nutritional knowledge of diabetology nurses is very important, as currently it is indicated, that nurses do not have the sufficient level of nutritional knowledge, while at the same time they often inform patients about nutritional recommendations [Heller et al., 2007]. Indicated observations were confirmed in the study conducted in a group of diabetology nurses, as I observed, that not only their nutritional behaviors are not proper (**publication no II.D.7.**), but also I observed, that nurses who educate diabetic patients do not follow the same recommendations, that diabetes type 2 patients do not follow (**publication no II.D.36.**), including too low vegetables intake (**publication no II.D.38.**).

As I observed, in the conducted studies in the groups of elderly, not following nutritional recommendations may, among other reasons, result from the lack of knowledge and of skills of incorporating recommendations into regular diet in the case of medical staff. As a result, I participated in preparing reports presenting current nutritional knowledge for dietitians and other medical staff educating patients. I participated in preparing manual of

diet therapy, that was published by PZWL State Publishing House for Medicine (**publication no II.D.1.**), as well as in preparing manuscripts presenting dietary recommendations for individuals with hypertension (**publication no II.D.45.**) and lactose intolerance (**publication no II.D.46.**), that were published in medical journals.

3. Dietary prevention of osteoporosis in young and post-menopausal women

(numbering according to appendix no 3, II.A., II.D.)

Due to extending lifespan expectancy, age-related diseases, including osteoporosis, are now becoming more serious challenges for the public health, than previously, that is observed both for Poland, and for other developed countries [Johnell & Kanis, 2006]. Simultaneously, the association between calcium intake and bone mineral density or bone mass [Wosje & Specker, 2000] and, as a result osteoporosis risk [Nieves et al., 2008], is commonly known. Also, it is indicated, that in the case of female individuals, the peak bone mass is reached at the age of 30, while afterwards, the progressive loss of bone mass is observed [Benjamin, 2010]. It allows to indicate the necessary nutritional recommendations exclusive for young women and exclusive for post-menopausal women. In the case of girls and young women, the primordial and primary dietary prevention is needed, to establish proper dietary patterns and to provide sufficient calcium intake during bone mass formation, while in the case of post-menopausal women, the secondary prevention is needed, to provide sufficient calcium intake in order to inhibit bone calcium loss [Prentice, 2004].

My research interest, associated with nutritional recommendations for elderly (subject group A.2), induced me to analyze also the possibilities to conduct dietary prevention of osteoporosis. I participated in the studies conducted in a groups of both young and post-menopausal women. As an element of the studies on primordial and primary prevention, I assessed dietary risk factors of osteoporosis (**publication no II.D.4.**) and association between choice of products and calcium intake in a groups of young women (**publication no II.D.9.**). At the same time, as an element of the studies on secondary prevention, I assessed minerals intake (**publication no II.A.5.**), including calcium intake (**publication no II.D.23.**), and I participated in analysis of association between calcium intake and bone mineral density (**publication no II.A.18.**).

During studies conducted in a groups of young women, too low intake of calcium and of other minerals influencing bone growth was observed (**publication no II.D.4.**).

Simultaneously, low dairy products intake, including low cheese intake, was indicated as a main reason of low calcium intake and a high osteoporosis risk (**publication no II.D.9.**).

In a studies conducted in a groups of post-menopausal women, similar low calcium intake was observed, as for young ones, that was stated independently from the energy value of diet (**publication no II.A.5.**) and that was associated with too low intake of dairy meals (**publication no II.D.23.**). Moreover, in the mentioned group, it was stated, that women characterized by low bone mineral density, have lower calcium intake, than the others (**publication no II.A.18.**). Similar observations were indicated while women with and without a history of osteoporotic fractures were compared, that confirms the necessity of nutritional education including sufficient calcium intake recommendation.

4. Possibilities of diet-related diseases prevention in children

(numbering according to appendix no 3, II.A., II.D.)

The increasing frequency of excessive body mass is, in the case of children, a serious public health problem, due to a number of possible health consequences, including the risk of diet-related diseases in the future [Sahoo et al., 2015]. At the same time, the significant association between nutritional behaviors and children body mass is commonly stated, that confirms the need for nutritional education in this specific population group [Toschke et al., 2005].

The indicated role of nutrition and dietary education, that should be implemented as soon as possible, induced me to analyze nutritional behaviors of children. The indicated research interest area was also the natural consequence of the fact, that I analyzed the subject of association between diet and dental caries incidence in children and adolescents as an element of the research included in my bachelor thesis. Hence, in the further studies, I analyzed association between calcium intake (**publication no II.D.64.**), as well as milk and dairy products intake (**publication no II.D.43.**) and dental caries intensity in young individuals. My other studies were associated with food products choice in a group of children (**publication no II.D.2.**) and influencing factors, including food neophobia (**publication no II.A.2.**), as well as I participated in assessment of diet of specific group of children with autism spectrum disorders (**publication no II.D.60.**).

In the studies conducted in a groups of children and adolescents with dental caries, I observed significant association between dairy products intake (**publication no II.D.64.**),

especially rennet cheese intake, and dental caries intensity (**publication no II.D.43.**). At the same time, the study on choice of food products conducted in a group of children revealed, that dairy products are quite rarely chosen and bought by them, similarly as fruits and vegetables (**publication no II.D.2.**).

Continuing previous studies of food products choice, I participated in analysis of the influence of food neophobia on choices in a group of children, while the significant influence of neophobia on the low intake of vegetables (but not of fruits), was observed, while the actual intake was compared with the recommended intake (**publication no II.A.2.**). Similarly, the studies conducted in a group of children with autism spectrum disorders, in which I participated, revealed association between body mass and vegetables intake (but not fruits intake) (**publication no II.D.60.**).

My interest in nutritional behaviors of children caused also my participation in preparing the publication presenting common problems of pediatric nutrition (**publication no II.D.59.**).

5. Role of diet in inflammatory bowel disease

(numbering according to appendix no 3, II.A., II.D.)

In spite of the fact, that diet therapy is indicated in the recommendation for inflammatory bowel disease individuals as an important element of therapy [Mowat et al., 2011], in practice only a small number of patients apply it [Cassinotti et al., 2009]. It results from a limited evidence of the role of diet in etiology of the disease [Carter et al., 2004], or the possibility to influence the natural course of the disease by a diet [Hou et al., 2014].

Indicated conditions induced me to analyze the possible dietary factors associated with the symptoms of ulcerative colitis during remission, while I concentrated on the anti-oxidative and anti-inflammatory compounds – carotenoids (**publication no II.A.6.**) and isoflavones (**publication no II.A.1.**). Indicated issue was in the area of my research interests and resulted from my literature review that I conducted during preparing my Ph.D. thesis in which I assessed the diet and body composition of ulcerative colitis individuals.

In the studies that I conducted, I observed, that higher lycopene, lutein and zeaxanthin intake in a group of ulcerative colitis patients, being during remission, may reduce the frequency of abdominal pain and faecal blood, mucus and pus (**publication no II.A.6.**). Simultaneously, I stated, that moderate daidzein, glycytein and total isoflavone intake may

reduce, in the same group of patients, the frequency of abdominal pain and constipations (**publication no II.A.1.**). As a result, I concluded, that there are prospective possibilities to optimize dietary treatment in analyzed group of patients, to reduce the frequency of unfavorable symptoms, but they require further studies, due to diverse course and symptoms of the ulcerative colitis.

Continuing my previous literature review, I analyzed recommendations for inflammatory bowel disease individuals during remission and I elaborated publications presenting most important recommendations formulated for patients in other countries (**publication no II.D.47.**). It is important, as in Poland, previously there was no such recommendations for patients.

I participated also in preparing reports presenting possible directions for modifying the content of functional food products (on the example of meat products) (**publication no II.D.65.**), in order to adjust them for the specific needs of consumers (**publication no II.D.51.**), and especially for the specific needs of inflammatory bowel disease individuals (**publication no II.D.56.**), as well as I participated in analysis of prospects (**publication no II.D.66.**) and model studies in the area (**publication no II.A.3.**). Moreover, I participated in elaborating the report that presents the role of perception (**publication no II.A.10.**) and consumer expectations in creating new products (**publication no II.D.57.**), as well as the report that presents consumer behaviors towards meat products characterized by enhanced health-promoting value (**publication no II.A.8.**), including their willingness to pay (**publication no II.D.5.**).

6. Possibilities of applying objective instrumental methods of measurement in nutrition and nutrition engineering research

(numbering according to appendix no 3, II.A., II.D.)

Possibility to apply instrumental methods of assessment in the conducted research is especially valuable, as they allow to obtain the objective measurement of assessed features. It may be stated for all the areas of research, including nutrition and nutrition engineering research. In the case of the nutrition research, it is necessary to assess properly the energy requirement, that may be estimated for individual patients, using the predictive equations, but in such case it is not precisely defined [FAO, 2001]. At the same time, it is possible to

measure the resting energy expenditure [Compher et al., 2006] and physical activity of individual [Sylvia et al., 2014], that enables obtaining more precise data.

Taking into account the fact, that my research interests were associated with individual dietary treatment for patients and analysis of their diets, the study that I conducted included among others assessment of the energy requirement. Hence, I interested also in the possibility to apply the objective instrumental methods of measurement, including indirect calorimetry, to assess the basal energy requirement (**publication no II.D.16.**) and including accelerometer-based physical activity assessment (**publication no II.D.49.**).

As an element of the studies in which I participated, the possibilities to apply indirect calorimetry to assess basal energy requirement were assessed in a groups of overweight and obese women and it was observed, that indicated method is effective and may allow to conduct body mass reduction programs more efficiently (**publication no II.D.16.**). At the same time, during analysis of the physical activity of patients, conducted using methods of objective measurement, it was proven, that such measurement is possible, effective and may simplify the diet therapy, as it enables estimating energy expenditure resulting from physical activity (**publication no II.D.49.**).

However, the objective measurements in the nutrition research was not the only area of my research interest, as I also analyzed the possibility to use the objective measurements in the nutrition engineering. While I participated in two projects associated with food analysis, I assessed the possible objective methods as a part of my research. Food analysis enables obtaining information about physical, chemical and biological properties of food products and allows objective assessment of measurable features [Singham et al., 2015]. During my studies on the indicated area, I analyzed mainly physical properties of food products (color, texture), but also chemical properties (fat content, volatile compound contents) and biological properties (structure of meat).

While studying the possibilities to assess the color of food products, I participated in analysis conducted using instrumental methods, including computer image analysis. The studies were associated with influence of the thermal treatment on the color of beef cuts – striploin (**publication no II.D.20.**), blade (**publication no II.D.32.**), tenderloin (**publication no II.D.29.**) and inside (**publication no II.D.22.**), as well as possibilities to predict the color of inside (**publication no II.D.30.**) and blade (**publication no II.D.33.**). The studies included

influence of various factors on the color of meat and meat products, while analyzed factors were: applied packaging (**publication no II.D.27.**), among others modified atmosphere packaging containing carbon monoxide (**publication no II.A.9.**) and applied forage with selenium (**publication no II.D.28.**) and plant oils (**publication no II.A.22.**). The additional studies of physical properties of food products, in which I participated, were associated with possibilities to assess, using instrumental methods, texture of meat (**publication no II.D.50.**) and potatoes (**publication no II.D.31.**).

The other area of studies, in which I participated, was associated with possibilities to apply computer image analysis to assess visual features (**publication no II.D.58.**), in order to assess the quality of products (**publication no II.D.53.**). The conducted studies included assessment of the fat tissue and connective tissue share in beef (**publication no II.D.17.**), as well as association between beef classification and tissues share for striploin (**publication no II.D.18.**) and cube roll (**publication no II.D.19.**). Moreover, I participated in elaborating the recommendations for applying the computer image analysis in the food industry in order to improve production (**publication no II.D.52.**).

As an element of the studies associated with new methods of assessment of food products quality, I participated also in the analysis of the possibility to apply instrumental measurement of the volatile compounds in the assessment of the quality of pork (**publication no II.A.12.**), including pork after frozen storage (**publication no II.A.11.**).

The other area of my research interests was associated with a possibility of conducting the microscopic analysis of the properties of food products, that was conducted for meat products. The influence of type of meat (**publication no II.D.26.**) and cut (**publication no II.A.14.**) on the observed results of the microscopic analysis was assessed. Moreover, I participated in preparing the methodological study presenting the indicated scope (**publication no II.D.34.**).

7. Meat market directions, possibilities of development and consumer expectations

(numbering according to appendix no 3, II.A., II.D.)

Meat and meat products are commonly indicated as an elements of diet associated with a risk of diet-related diseases [Larsson & Orsini, 2014]. At the same time, it is emphasized, that they are important source of protein, so in diet of elderly the intake of meat should not be significantly reduced [Battaglia Richi et al., 2015]. A number of factors

influences the observed meat intake in Europe and contributes to it, while the intake is high, independently from the nutritional recommendations [Schmid et al., 2017].

Participating in the projects associated with the analysis of the pork and beef, I was among other activities analyzing factors contributing to the consumers perception of meat. The studies were associated with perception of grilled (**publication no II.A.7.**) and roasted meat (**publication no II.A.15.**), influence of a thermal treatment on the perception (**publication no II.A.16.**), as well as associations between features perceived by consumers (**publication no II.A.23.**) and the factors influencing the perceived general quality (**publication no II.A.20.**). The studies were also associated with influence of the packaging methods on the preferences (**publication no II.D.48.**) and oxidative processes (**publication no II.A.4.**), as well as with influence of the race (**publication no II.A.13.**), genetics (**publication no II.D.54.**), production system (**publication no II.D.21.**) and forage (**publication no II.D.63.**) on the chosen quality features of meat and meat products.

The other publications, in which I participated, presented systems of beef classification (**publication no II.D.55.**) and associations between meat classification and quality (**publication no II.A.18.**), while the type of muscle was also included (**publication no II.A.21.**). Moreover, I participated in the analysis of meat market in Poland and other countries (**publication no II.D.13.**), as well as analysis of factors influencing its development (**publication no II.D.12.**).

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B. Summary of the overview of the scientific-research work

My scientific achievements are **98** papers, including **30** published in the journals being indexed in the Journal Citation Report (JCR) list, **58** published in journals listed in Part B of the Ministry of Science and Higher Education list, **7** chapters in scientific monographs, **1** scientific monograph, **2** popular scientific publications (presented in Table 1) and **2** patents obtained.

Tabela 1. Total number of published scientific papers accompanied by the number of the MSaHE – Ministry of Science and Higher Education points and the Impact Factor points

No	Publication	Number of publications		MSaHE points*	Impact Factor by year	Total MSaHE points**
		Before Ph.D.	After Ph.D.			
A. Scientific papers published in journals with Impact Factor, indexed in Journal Citation Reports (JCR)						
1	Anais da Academia Brasileira de Ciências ⁷	-	1	25	0.861	25
2	Animal Science Journal ⁶	-	1	25	1.045	25
3	Animal Science Papers and Reports ⁷	-	1	25	0.725	25
4	Annals of Agricultural and Environmental Medicine: AAEM ³	-	1	10	1.126	10
5	Asian-Australasian Journal of Animal Sciences ⁴	-	1	25	0.563	25
6	Bulletin of the Veterinary Institute in Pulawy ⁴	-	1	20	0.365	20
7	International Journal of Environmental Research and Public Health ⁷	-	2	30	2x2.101	2x30
8	Italian Journal of Food Science ³	1	-	20	0.444	20
9	Journal of Food and Nutrition Research ³	1	-	20	0.600	20
10	Journal of Food and Nutrition Research ⁷	-	1	20	1.950	20
11	Journal of Food Composition and Analysis ⁷	-	1	35	2.752	35
12	Journal of Food Science and Technology ⁷	-	1	25	1.262	25

No	Publication	Number of publications		MSaHE points*	Impact Factor by year	Total MSaHE points**
		Before Ph.D.	After Ph.D.			
13	Journal of Health, Population and Nutrition ⁷	-	1	25	1.187	25
14	Journal of Sensory Studies ⁷	-	1	30	1.540	30
15	Journal of Sports Medicine and Physical Fitness ³	1	-	20	0.847	20
16	Journal of the Science of Food and Agriculture ⁷	-	1	35	2.463	35
17	LWT - Food Science and Technology ⁷	-	1	35	2.329	35
18	Meat Science ⁷	-	1	35	3.126	35
19	Nutrients ⁶	-	5	35	5x3.550	5x35
20	Pakistan Journal of Agricultural Sciences ⁶	-	1	30	0.597	30
21	Pesquisa Agropecuária Brasileira ⁶	-	1	30	0.661	30
22	Public Health Nutrition ⁵	-	1	30	2.679	30
23	Turkish Journal of Veterinary & Animal Sciences ⁵	-	1	20	0.242	20
24	Turkish Journal of Veterinary & Animal Sciences ⁶	-	1	15	0.352	15
25	World Journal of Gastroenterology ⁷	-	1	25	3.365	25
Total		3	27	-	53.033	815
B. Scientific papers published in journals without Impact Factor, listed in Part B of the MSaHE list						
1	Advances in Science and Technology – Research Journal ³	-	1	5	-	5
2	Advances in Science and Technology – Research Journal ⁴	-	3	5	-	3x5
3	Bromatologia i Chemia Toksykologiczna ¹	1	-	4	-	4
4	Bromatologia i Chemia Toksykologiczna ³	1	-	4	-	4
5	Bromatologia i Chemia Toksykologiczna ⁶	-	1	6	-	6
6	Bromatologia i Chemia Toksykologiczna ⁷	-	1	6	-	6

No	Publication	Number of publications		MSaHE points*	Impact Factor by year	Total MSaHE points**
		Before Ph.D.	After Ph.D.			
7	Diabetologia Praktyczna ²	2	-	6	-	2x6
8	Folia Pomeranae Universitatis Technologiae Stetinensis, Agricultura, Alimentaria, Piscaria et Zootechnica ⁴	-	1	5	-	5
9	Folia Pomeranae Universitatis Technologiae Stetinensis. Agricultura, Alimentaria, Piscaria et Zootechnica ³	1	-	4	-	4
10	Geriatrya ⁴	-	1	5	-	5
11	Inżynieria Rolnicza ³	1	-	4	-	4
12	Inżynieria Rolnicza ⁴	-	2	5	-	2x5
13	Journal of Research and Applications in Agricultural Engineering ³	3	-	5	-	3x5
14	Journal of Research and Applications in Agricultural Engineering ⁴	-	2	5	-	2x5
15	Kardiologia po Dyplomie ⁷	-	1	3	-	3
16	Klinika Oczna ³	1	-	9	-	9
17	Medical Tribune ⁶	-	1	4	-	4
18	Nauki Inżynierskie i Technologie ⁴	-	1	4	-	4
19	Nefrologia i Dializoterapia Polska ²	1	-	6	-	6
20	Nefrologia i Dializoterapia Polska ³	1	-	5	-	5
21	Nowa Klinika ⁵	-	1	6	-	6
22	Okulistyka ²	1	-	6	-	6
23	Okulistyka ³	1	-	4	-	4
24	Opakowania ³	-	1	4	-	4
25	Postępy Nauki i Techniki ³	2	1	4	-	3x4
26	Postępy Techniki Przetwórstwa Spożywczego ³	2	-	5	-	2x5
27	Postępy Techniki Przetwórstwa Spożywczego ⁴	-	1	4	-	4
28	Problemy Higieny i Epidemiologii ⁵	-	3	7	-	3x7
29	Roczniki Państwowego Zakładu Higieny ²	3	-	9	-	3x9
30	Roczniki Państwowego Zakładu Higieny ⁴	-	1	6	-	6

No	Publication	Number of publications		MSaHE points*	Impact Factor by year	Total MSaHE points**
		Before Ph.D.	After Ph.D.			
31	Roczniki Państwowego Zakładu Higieny ⁵	-	1	7	-	7
32	Roczniki Państwowego Zakładu Higieny ⁶	-	1	14	-	14
33	Roczniki Państwowego Zakładu Higieny ⁷	-	1	14	-	14
34	Roczniki Warszawskiej Szkoły Zdrowia ²	1	-	2	-	2
35	Zeszyty Naukowe Ochrony Zdrowia – Zdrowie Publiczne i Zarządzanie ³	-	1	9	-	9
36	Zeszyty Naukowe Ochrony Zdrowia – Zdrowie Publiczne i Zarządzanie ⁴	-	1	8	-	8
37	Zeszyty Naukowe SGGW w Warszawie. Ekonomia i Organizacja Gospodarki Żywnościowej ⁷	-	2	13	-	2x13
38	Zeszyty Naukowe Szkoły Głównej Gospodarstwa Wiejskiego w Warszawie. Problemy Rolnictwa Światowego ³	1	-	7	-	7
39	Zeszyty Naukowe Szkoły Głównej Gospodarstwa Wiejskiego w Warszawie. Problemy Rolnictwa Światowego ⁵	-	3	8	-	3x8
40	Życie Weterynaryjne ³	1	-	4	-	4
41	Żywnienie Człowieka i Metabolizm ²	1	-	2	-	2
Total		25	33	-	-	353
C. The chapters in scientific monographs						
1	Original research	-	5	5	-	5x5
2	Review papers	-	2	5	-	2x5
Total		-	7	-	-	35
D. The scientific monographs						
1	Scientific monograph	-	1	25	-	25
Total		-	1	-	-	25

No	Publication	Number of publications		MSaHE points*	Impact Factor by year	Total MSaHE points**
		Before Ph.D.	After Ph.D.			
E. Popular science publications						
1	Przegląd Mleczarski	2	-	-	-	-
Total		2	-	-	-	
All publications		30	68		53.033	1228

* The number of MSaHE – Ministry of Science and Higher Education points, attributed to the publication, according to the relevant list of journals

** The number of MSaHE – Ministry of Science and Higher Education points, attributed to the publication, according to the relevant list of journals, multiplied by number of attributed publications

¹ The Communication of the Minister of Science and Higher Education regarding the list of scientific journals of 21 October 2005

² The unified list from the website of the Ministry of Science and Higher Education (2007-2010)

³ The Communication of the Minister of Science and Higher Education regarding the list of scientific journals of 20 December 2012

⁴ The Communication of the Minister of Science and Higher Education regarding the list of scientific journals of 17 December 2013

⁵ The Communication of the Minister of Science and Higher Education regarding the list of scientific journals of 31 December 2014 (with amendments of 25 March 2015)

⁶ The Communication of the Minister of Science and Higher Education regarding the list of scientific journals of 23 December 2015

⁷ The Communication of the Minister of Science and Higher Education regarding the list of scientific journals of 9 December 2016

I am an author of **30** scientific papers published in the journals indexed in the *Journal Citation Report (JCR)* list, while all the mentioned works were published in the period of 2011-2018. The number of citations of my publications, according to the Web of Science database stands at **123**, while according to the Google Scholar it is **181**. The H-index (Hirsch Index), according to the Web of Science stands at **5**, while according to the Google Scholar it is **6**.

The Total Impact Factor of my publications (according to the JCR list, appropriate for the year of publication) is **53.033**, while the 5-year Impact Factor for them is **61.553**.

The total number of points attributed to my scientific papers stands at **1228** points (according to the MSaHE – Ministry of Science and Higher Education lists, appropriate for the year of publication). The number of points attributed to my scientific papers after achieving my Ph.D. degree is **1035** points (according to the MSaHE lists, appropriate for the year of publication).