Contents lists available at [ScienceDirect](https://www.sciencedirect.com)

Primary Care Diabetes

journal homepage: <http://www.elsevier.com/locate/pcd>

Original research

Nutrition-related knowledge and its determinants in middle-aged and older patients with type 2 diabetes

Carlos Vasconcelos^{a,*}, António Almeida^b, Carla Sá^c, João Viana^c,
Maria Cabral^d, Elisabete Ramos^e, Romeu Mendes^f

^a University of Trás-os-Montes e Alto Douro, School of Education of Viseu, Polytechnic Institute of Viseu, Portugal

^b University of Trás-os-Montes e Alto Douro, Portugal

^c Research Center in Sports Sciences, Health Sciences and Human Development, CIDESD, University Institute of Maia, Portugal

^d EPIUnit – Instituto de Saúde Pública, Universidade do Porto, Portugal

^e EPIUnit – Instituto de Saúde Pública, Universidade do Porto, Faculdade de Medicina, Universidade do Porto, Portugal

^f EPIUnit – Instituto de Saúde Pública, Universidade do Porto, University of Trás-os-Montes e Alto Douro, Public Health Unit, ACES Douro I – Marão e Douro Norte, Northern Region Health Administration, Portugal

ARTICLE INFO

Article history:

Received 6 December 2018

Received in revised form

24 June 2019

Accepted 28 June 2019

Available online 24 July 2019

ABSTRACT

Aims: To analyse nutrition-related knowledge and its determinants in middle-aged and older patients with T2D.

Methods: In a cross sectional study, a total of 116 participants with T2D, aged 50–80 years, were recruited in primary health care. Data was collected by a self-reported questionnaire — the modified version of General Nutrition Knowledge Questionnaire (0–56 points). Sociodemographic data was also collected: gender, age, personal monthly income, living situation, education level, and marital status. One-way analysis of variance (ANOVA) was performed to assess differences in nutrition-related knowledge score among the different levels of sociodemographic characteristics.

Results: Questions on general dietary recommendations, dietary behaviors to reduce cardiovascular disease and cancer are the items with higher proportion of correct answers. On the other hand, health problems related with lower intake of fruit, vegetables and fiber and knowledge about antioxidants vitamins presented the lower proportion of correct answers.

Higher scores were found among those with lower age, higher personal monthly income, and higher education.

* Corresponding author.

E-mail address: cvasconcelos@esev.ipv.pt (C. Vasconcelos).

<https://doi.org/10.1016/j.pcd.2019.06.007>

1751-9918/© 2019 Primary Care Diabetes Europe. Published by Elsevier Ltd. All rights reserved.

Conclusions: Middle-aged and older patients with T2D showed alarming deficits on nutrition-related knowledge. Age, personal monthly income, and education level were observed as major determinants of nutrition-related knowledge.

Trial Registration: NCT02631902.

© 2019 Primary Care Diabetes Europe. Published by Elsevier Ltd. All rights reserved.

1. Introduction

Diabetes affects more than 425 million people worldwide, of which one-third are people older than 65 years. This number is expected to rise to 693 million in 2045 [1]. In Portugal, in 2015, the Portuguese Society of Diabetology reported a prevalence of diabetes of 13.3% (20–79 years old). The prevalence increases to 25% between the ages of 60 and 79 years old [2]. For 2030, the World Health Organization estimates diabetes as the 7th leading cause of death [3]. Besides mortality, diabetes has a huge impact on morbidity, with neuropathy, nephropathy, retinopathy, amputation and cardiovascular disease as major chronic consequences [2]. Type 2 diabetes (T2D) is the most common type of diabetes, accounting for 90–95% of all cases [4]. Dietary modification is considered a cornerstone of effective T2D self-management [5]. The goals of T2D dietary management are to attain ideal blood glucose and blood lipids levels, to prevent, delay, and control diabetes-related complications, and to improve health through a healthy diet [6]. While numerous factors potentially influence the adoption of a healthy diet, nutrition-related knowledge is necessary to achieve this goal [7].

Although some studies conducted in T2D patients had found deficits in nutrition-related knowledge [5,8–15], most of them were conducted in countries outside Europe [8–10,12,14,15] and only two were conducted in Western Europe [5,13]. Furthermore, few studies have analyzed the determinants of nutrition-related knowledge in T2D patients [9,11,14,15] and most of them only focused on educational level. To our knowledge, this is the first study in Portugal that focused on these two issues.

The aim of the present study was to analyze nutrition-related knowledge and its determinants in Portuguese middle-aged and older patients with T2D.

2. Methods

2.1. Study design

This was a cross-sectional study conducted in the cities of Vila Real and Maia, Portugal. Study protocol was approved by the local health ethics committee in accordance with the Declaration of Helsinki. All patients gave written informed consent before participation. Appropriate standard procedures were implemented to guarantee data confidentiality and protection.

2.2. Participants

A total of 116 middle-aged and older patients with T2D were recruited from primary health care centers by their family doctors in a consecutive basis according to the following inclusion criteria: aged between 50–80 years old; T2D diagnosed for at least six months; non-smokers; independent living in the community; without major changes in gait or balance; diabetes comorbidities under control; willingness to participate in this study.

2.3. Nutrition-related knowledge assessment

Nutrition-related knowledge was assessed using the Portuguese modified short version [16] of General Nutrition Knowledge Questionnaire (GNKQ) [17]. In order to adapt the GNKQ to the Portuguese population, the Translation into Portuguese, Cultural Adaptation and Linguistic Adaptation was performed [16]. The final version of the questionnaire consists of three sections, each one addressing a different area of knowledge: dietary recommendations (DR; 1 multiple choice question; 0–6 points); sources of nutrients (SN; 8 multiple choice questions; 0–34 points); and diet-disease relationship (DDR, 5 multiple choice and 4 open-ended questions; 0–16 points). Differences between original questionnaire and the one used in our study are presented in Table 1. The participants answered on a range of different scales such as ‘more, equal, less, don’t know’, ‘yes, no, don’t know’, ‘rich, poor, don’t know’, ‘agree, disagree, don’t know’. Some questions related to diet-disease relationships are open-ended and require participants to list diseases related with diet-related lifestyle factors. Correct responses from each section were added giving an overall score out of 56 points. A higher score reflects a higher knowledge level.

2.4. Sociodemographic characteristics

Sociodemographic characteristics were obtained through a set of questions at the end of the questionnaire: gender (male; female), age (<65; ≥65 years), personal monthly (net) income (<500 €; 500–1000 €; >1000 €), living situation (living alone; living with others), education level (years of school; ≤4 years; 5–9 years; >9 years), marital status (married or with domestic partner; single, divorced or widowed).

2.5. Data analysis

Categorical variables are presented as proportions (number and percentage) and continuous variables as means and standard deviations (SD). One-way analysis of variance (ANOVA) was performed to assess differences in nutrition-related

Table 1 – Differences between General Nutrition Knowledge Questionnaire (GNKQ) and Portuguese modified short version of GNKQ.

	GNKQ	Portuguese modified short version of GNKQ
Section 1	3 multiple choice and 1 open-ended question	1 multiple choice question
Section 2	21 multiple choice questions	8 multiple choice questions
Section 3	10 multiple choice questions	No questions — lack of internal consistency and item validation
Section 4	5 multiple choice and 5 open-ended questions	5 multiple choice and 4 open-ended questions

Table 2 – Participant's characteristics.

Characteristics	Mean (SD)
Age (years)	65.1 (6.7)
Duration of diabetes (years)	7.4 (6.6)
Glycated hemoglobin (%)	6.7 (1.1)
Body mass index (kg/m ²)	30.0 (4.6)

Table 3 – Nutrition-related knowledge scores (total and by section).

	Mean (SD)	Percentage of correct answers
Total score (0–56 points)	28.6 (7.5)	51.1%
Dietary recommendations (0–6 points)	4.8 (0.9)	80.0%
Sources of nutrients (0–34 points)	17.2 (5.8)	50.6%
Diet-disease relationship (0–16 points)	6.6 (2.0)	41.3%

knowledge score among the different levels of sociodemographic characteristics. All statistical analysis were performed using Statistical Package for the Social Sciences, version 20. The level of statistical significance was set at $p < 0.05$.

3. Results

3.1. Participant's characteristics

All patients were polymedicated, including for diabetes. Participants' characteristics are presented in [Table 2](#).

3.2. Nutrition-related knowledge

Nutrition-related knowledge total score and by section is presented in [Table 3](#).

Results from each question are presented in [Fig. 1](#). Questions on general dietary recommendations, dietary behaviors to reduce cardiovascular disease and cancer are the items with higher proportion of correct answers. On the other hand, health problems related with lower intake of fruit, vegetables and fiber and knowledge about antioxidants vitamins presented the lower proportion of correct answers.

3.3. Determinants of nutrition-related knowledge

Results of the analysis between sociodemographic characteristics and nutrition-related knowledge are presented in [Table 4](#).

4. Discussion

Our results showed important deficits regarding nutrition-related knowledge in this population, with 41% of participants scoring below 28 points. Age, years of school and personal monthly income were observed as determinants of nutrition-related knowledge.

Higher nutrition-related knowledge enables individuals with T2D to make healthier food choices [5]. According to our search, this is the first study conducted in Portugal that specifically evaluated nutrition-related knowledge in T2D patients. Studies conducted in T2D patients in other countries focused on other issues beyond nutrition-related knowledge (for example: glycemic control, diabetes complications, physical activity, etc.) and used different evaluation methods: group interviews [8,12] and questionnaires evaluating diabetes knowledge [5,10,11,13–15]. We just found one study that specifically assessed nutrition-related knowledge in T2D patients, using a 25-item nutrition knowledge scale designed for a community of Hispanics living in United States [9]. Despite the different methodological approaches, these studies also revealed nutrition-related knowledge deficits in this population.

We did not find studies in T2D patients that used GNKQ. However, studies conducted in other populations, in community setting, using GNKQ [18,19] found a better performance in DR section and lower in DDR as in our study. Increasing availability of nutrition information in the media can justify the awareness on DR section [20], which leads participants to be closer from dietary guidelines [7]. Regarding DDR, according to Rolstad et al. [21], the length of the questionnaire can increase response burden. Since DDR is the final section of our instrument, it may have influenced its score. Furthermore, results may have been conditioned by type of questions design, since there are some open-ended questions that required participants to report one or more diseases instead of choosing multiple choice answers [22]. Effectively, our participants were best able to give a correct response to multiple choice questions than open-ended ones. Despite the lower score in DDR, our participants had a higher proportion of correct answers in two questions from this section: dietary behaviors to reduce cardiovascular disease and cancer. Although the association between a balanced diet and cancer and cardiovascular diseases had been well recognized worldwide since 1950 [23], opposite findings to our study had been found in previous

Fig. 1 – Percentage of correct answers in each question of the Portuguese modified short version of General Nutrition Knowledge Questionnaire.

studies conducted with general population [24,25], where participants had poor knowledge about the link between fruit and vegetable intake and cancer.

On the other hand, throughout our questionnaire, the link of health problems with lower intake of fruit, vegetables and fiber and the knowledge about antioxidants vitamins presented the lower proportion of correct answers.

Fruits and vegetables are recommended mainly due to their high concentration of dietary fiber, vitamins (especially vitamins C and A) minerals (especially electrolytes) and phytochemicals (especially antioxidants) [26]. Low intake of fruits and vegetables are associated with cardiovascular diseases, high blood pressure, hypercholesterolemia, osteoporosis, many types of cancers, chronic obstructive pulmonary diseases, respiratory problems as well as mental health [27]. Consistent with our findings, Doherty et al. [8] revealed that the knowledge about the health effects of fruits was not clear, after interviewing 30 patients with T2D. Also Ranasinghe et al. [12] illustrated that individuals with T2D considered fruits unhealthy thanks to its sweet taste, in a cohort of 50 patients.

Lack of knowledge in the link between fiber intake and health is alarming as dietary fibers are known to have a protective effect against stroke, diabetes, obesity and several gastrointestinal diseases such as: constipation, hemorrhoids, colon cancer, gastroesophageal reflux disease, duodenal ulcer, diverticulitis [28]. They are also associated with lower all-cause mortality in individuals with T2D [29].

Regarding the connection between antioxidant vitamins intake and health, our results are in keeping with the study of Parmenter et al. [19], where only 22% of participants have heard about antioxidant vitamins. Scientific findings relating to this term are recent [19] and the mean age of our sample is 65.1 (6.7) years old. Higher dietary intake of antioxidant vitamins was inversely associated with pancreatic cancer risk [30] and may decrease the risk of all-cause mortality [31].

Studies evaluating the determinants of nutrition-related knowledge in individuals with T2D are scarce [9,11,14,15] and mostly centered in educational level [9,14,15]. In our study it was observed higher nutrition-related knowledge scores with lower age, more years of school, and higher personal monthly income.

Regarding age, we did not find any study in T2D patients. However, other studies conducted in people without T2D also reported that older people had a lower nutrition-related knowledge [32,33]. In our study, higher knowledge scores of younger age groups probably reflects the fact that the Portuguese current dietary recommendations are relatively recent [34] and older people have more implemented ideas regarding food, being less receptive to change [19]. Older adults have more difficulties in the use of new technologies that are, increasingly, a major information source [35]. Another possible reason could be the rise of cognitive impairment as population ages [36].

In what concerns education level, our results are consistent with other findings in individuals with [9,14,15] and without diabetes [18,32,37–39]. School is a stimulus for more knowledge and for a better understanding of information from different sources such as newspaper, TV, radio, internet, etc.

[19]. The importance of educational status is highlighted in a study carried out by Nilsson et al. [40] in which T2D patients with less education had 40% excess mortality compared with those who were highly educated.

The association of nutrition-related knowledge and personal monthly income needs to be analyzed with care, since it is common the use of different methodologies [38]. In many studies, personal monthly income is included in socioeconomic status (SES) that is defined by Adler et al. [41] as a complex construct including economic status (income), social status (education) and work status (occupation). Our findings confirm the conclusion of Parmenter et al. [19] that people with a lower SES (determined by occupational status) seemed to have a lower nutrition-related knowledge. Also, De Vriendt et al. [38] found a similar result, with a higher SES (composed by a higher educational level, non-smoking behavior, and higher occupation status) related to higher nutrition-related

Table 4 – Analysis between sociodemographic characteristics and nutrition-related knowledge.

Characteristics	Sample		Total nutrition-related knowledge score (0–56 points)	Dietary recommendations section (0–6 points)	Sources of nutrient section (0–34 points)	Diet-disease Section (0–16 points)
	n	%	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Age			^a		^b	
<65 years	55	47.4	30.15 (7.50)	4.87 (0.88)	18.60 (5.85)	6.71 (2.05)
≥65 years	61	52.6	27.28 (7.30)	4.77 (0.92)	16.02 (5.55)	6.49 (1.96)
Gender						
Male	61	52.6	28.82 (6.68)	4.95 (0.76)	17.21 (5.30)	6.69 (1.79)
Female	55	47.4	28.44 (8.40)	4.67 (1.02)	17.27 (6.39)	6.49 (2.23)
Education level			^c		^d	^e
≤4 years	61	52.6	25.39 (6.76)	4.66 (0.91)	14.70 (5.08)	6.03 (1.85)
5 to 9 years	29	25.0	31.21 (6.83)	5.07 (0.96)	19.21 (5.10)	6.93 (2.07)
>9 years	26	22.4	33.38 (6.39)	4.92 (0.74)	21.00 (5.45)	7.54 (1.88)
Marital status						
Single, divorced or widowed	19	16.4	27.42 (7.79)	4.63 (1.42)	16.79 (5.63)	6.00 (2.16)
Married or with domestic partner	97	83.6	28.88 (7.47)	4.86 (0.76)	17.33 (5.87)	6.71 (1.96)
Living situation						
Living alone	9	7.8	28.50 (5.33)	4.80 (1.23)	17.14 (4.22)	6.58 (2.28)
Living with others	107	97.2	30.22 (7.67)	5.00 (0.87)	18.44 (5.93)	6.78 (1.99)
Personal monthly income			^f		^g	
<500 €	53	45.7	27.53 (7.24)	4.81 (0.88)	16.34 (5.55)	6.38 (2.14)
500–1000 €	36	31.0	27.64 (7.21)	4.72 (1.03)	16.31 (5.22)	6.61 (2.04)
>1000 €	27	23.3	32.15 (7.61)	4.96 (0.76)	20.26 (6.24)	7.00 (2.00)

^a Significant differences between participants with <65 years and ≥65 years ($p = 0.040$).

^b Significant differences between participants with <65 years and ≥65 years ($p = 0.016$).

^c Significant differences between participants with ≤4 years of school and >9 years of school ($p < 0.001$) and between ≤4 years of school and 5–9 years of school ($p = 0.001$).

^d Significant differences between participants with ≤4 years of school and >9 years of school ($p < 0.001$) and between ≤4 years of school and 5–9 years of school ($p = 0.001$).

^e Significant differences between participants with ≤4 years of school and >9 years of school ($p = 0.003$).

^f Significant differences between participants with a personal monthly income <500 € and >1000 € ($p = 0.026$).

^g Significant differences between participants with a personal monthly income >1000 € and <500 € ($p = 0.012$) and between >1000 € and 500–1000 € ($p = 0.020$).

knowledge. The fact that less educated people may have lack of resources and difficulties to access to some sources of nutrition information [42] may justify the differences in nutrition-related knowledge according to personal monthly income and years of school.

Regarding gender, and contrary to our results, most studies observed that women had higher nutrition-related knowledge than men [19,32,33,39,43]. Our finding is not unique [37], and may be related with changes in family structure, with more men cooking and having interest about food contents [19]. It also appears that marital status and living situation are not significant determinants of nutrition-related knowledge as it was shown in the systematic review of Barbosa et al. [44].

Considering the importance of nutrition-related knowledge in glycemic control [45] and weight management [46], the current findings suggest a need for nutrition education intervention in this population. Primary health care system could be a successful context for the implementation of these interventions [47].

This study has few limitations. Analysis were based on cross-sectional data and therefore cannot demonstrate cause-effect relationships. Further research should extend this work by using intervention-design data, preferably from a randomized controlled trial to determine how nutrition-related knowledge influence dietary behaviors over time. The instrument that we used to measure nutrition-related knowledge differ from those used by other studies in T2D and only evaluate declarative knowledge (do not evaluate procedural knowledge). Our sample may not be representative of the wider Portuguese population with T2D, since our data collection was made only in the north of Portugal. Therefore extrapolation of the results beyond this sample needs to be treated with caution.

Despite the limitations, our study also has strengths. The questionnaire used covered three main areas of nutrition-related knowledge (DR, SN and DDR). Besides, through our search, it seems the first study evaluating nutrition-related knowledge in T2D Portuguese patients. We believe that our data are of high clinical importance as it indicates the need for practical dietary education.

5. Conclusions

Middle-aged and older patients with T2D showed alarming nutrition-related knowledge deficits, especially related to the link between health problems and lower intake of fruit, vegetables and fiber and knowledge about antioxidants vitamins. Age, personal monthly income, and years of school were observed as determinants of nutrition-related knowledge. Participants with lower age, higher personal monthly income, and more years of school showed better scores.

The results suggest the need for nutrition education in this population, as this can contribute to dietary changes and therefore to the improvement of health outcomes.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflict of interest

The authors state that they have no conflict of interest.

Acknowledgements

The authors acknowledge the support received from all participants of the *Diabetes em Movimento* Vila Real and *Diabetes em Movimento* Maia.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:<https://doi.org/10.1016/j.pcd.2019.06.007>.

REFERENCES

- [1] International Diabetes Federation, IDF Diabetes Atlas, IDF, Brussels, 2017.
- [2] Sociedade Portuguesa de Diabetologia, Diabetes: Factos e Números: o ano de 2015, Sociedade Portuguesa de Diabetologia, Lisboa, 2016.
- [3] C.D. Mathers, D. Loncar, Projections of global mortality and burden of disease from 2002 to 2030, *PLoS Med.* 3 (11) (2006) e442.
- [4] S. Chatterjee, K. Khunti, M.J. Davies, Type 2 diabetes, *Lancet* (London, England) 389 (10085) (2017) 2239–2251.
- [5] C. Breen, M. Ryan, M.J. Gibney, D. O'Shea, Diabetes-related nutrition knowledge and dietary intake among adults with type 2 diabetes, *Br. J. Nutr.* 114 (3) (2015) 439–447.
- [6] M. Asif, The prevention and control the type-2 diabetes by changing lifestyle and dietary pattern, *J. Educ. Health Promot.* 3 (2014) 1.
- [7] I. Spronk, C. Kullen, C. Burdon, H. O'Connor, Relationship between nutrition knowledge and dietary intake, *Br. J. Nutr.* 111 (10) (2014) 1713–1726.
- [8] M.L. Doherty, E. Owusu-Dabo, O.S. Kantanka, R.O. Brawer, J.D. Plumb, Type 2 diabetes in a rapidly urbanizing region of Ghana, West Africa: a qualitative study of dietary preferences, knowledge and practices, *BMC Public Health* 14 (2014) 1069.
- [9] N. Fitzgerald, G. Damio, S. Segura-Perez, R. Perez-Escamilla, Nutrition knowledge, food label use, and food intake patterns among Latinas with and without type 2 diabetes, *J. Am. Diet. Assoc.* 108 (6) (2008) 960–967.
- [10] H. Kessler, S.M. Wunderlich, Relationship between use of food labels and nutrition knowledge of people with diabetes, *Diab. Educ.* 25 (4) (1999) 549–559.
- [11] T. Klupa, M. Mozdzan, J. Kokoszka-Paszkot, M. Kubik, M. Masierek, M. Czerwinska, et al., Diet-related knowledge and physical activity in a large cohort of insulin-treated type 2 diabetes patients: PROGENS ARENA study, *Int. J. Endocrinol.* 2016 (2016) 2354956.

- [12] P. Ranasinghe, A.S. Pigera, M.H. Ishara, L.M. Jayasekara, R. Jayawardena, P. Katulanda, Knowledge and perceptions about diet and physical activity among Sri Lankan adults with diabetes mellitus: a qualitative study, *BMC Public Health* 15 (2015) 1160.
- [13] J. Speight, C. Bradley, The ADKNowl: identifying knowledge deficits in diabetes care, *Diab. Med.* 18 (8) (2001) 626–633.
- [14] H. Wang, Z. Song, Y. Ba, L. Zhu, Y. Wen, Nutritional and eating education improves knowledge and practice of patients with type 2 diabetes concerning dietary intake and blood glucose control in an outlying city of China, *Public Health Nutr.* 17 (10) (2014) 2351–2358.
- [15] J.F. Watson, S. DuFord, Perceived and actual knowledge of diet by individuals with non-insulin-dependent diabetes, *Diab. Educ.* 18 (5) (1992) 401–406.
- [16] J. Souza, *Conhecimentos Nutricionais: Reprodução e Validação do Questionário* [master's thesis], University of Porto, Porto, 2009 <https://repositorio-aberto.up.pt/bitstream/10216/22176/4/CONHECIMENTOS%20NUTRICIONAIS%20Reproducao%20e%20Validacao%20de%20Questio.pdf>.
- [17] K. Parmenter, J. Wardle, Development of a general nutrition knowledge questionnaire for adults, *Eur. J. Clin. Nutr.* 53 (4) (1999) 298–308.
- [18] G.A. Hendrie, J. Coveney, D. Cox, Exploring nutrition knowledge and the demographic variation in knowledge levels in an Australian community sample, *Public Health Nutr.* 11 (12) (2008) 1365–1371.
- [19] K. Parmenter, J. Waller, J. Wardle, Demographic variation in nutrition knowledge in England, *Health Educ. Res.* 15 (2) (2000) 163–174.
- [20] C.J. Kullen, J.L. Farrugia, T. Prvan, H.T. O'Connor, Relationship between general nutrition knowledge and diet quality in Australian military personnel, *Br. J. Nutr.* 115 (8) (2016) 1489–1497.
- [21] S. Rolstad, J. Adler, A. Ryden, Response burden and questionnaire length: is shorter better? A review and meta-analysis, *Value Health* 14 (8) (2011) 1101–1108.
- [22] C.J. Kullen, L. Iredale, T. Prvan, H.T. O'Connor, Evaluation of general nutrition knowledge in Australian military personnel, *J. Acad. Nutr. Diet.* 116 (2) (2016) 251–258.
- [23] WHO, Diet, nutrition and the prevention of chronic diseases, World Health Organ. Tech. Rep. Ser. 916 (i-viii) (2003) 1–149, backcover.
- [24] A.S. Anderson, D.N. Cox, S. McKellar, J. Reynolds, M.E. Lean, D.J. Mela, Take Five, a nutrition education intervention to increase fruit and vegetable intakes: impact on attitudes towards dietary change, *Br. J. Nutr.* 80 (2) (1998) 133–140.
- [25] S.M. Krebs-Smith, J. Heimendinger, B.H. Patterson, A.F. Subar, R. Kessler, E. Pivonka, Psychosocial factors associated with fruit and vegetable consumption, *Am. J. Health Promot.* 10 (2) (1995) 98–104.
- [26] J.L. Slavin, B. Lloyd, Health benefits of fruits and vegetables, *Adv. Nutr. (Bethesda, MD)* 3 (4) (2012) 506–516.
- [27] D. Pem, R. Jeewon, Fruit and vegetable intake: benefits and progress of nutrition education interventions-narrative review article, *Iranian journal of public health* 44 (10) (2015) 1309–1321.
- [28] S. Otles, S. Ozgoz, Health effects of dietary fiber, *Acta Sci. Pol. Technol. Aliment.* 13 (2) (2014) 191–202.
- [29] A.B. Evert, J.L. Boucher, M. Cypress, S.A. Dunbar, M.J. Franz, E.J. Mayer-Davis, et al., Nutrition therapy recommendations for the management of adults with diabetes, *Diab. Care* 37 (Suppl 1) (2014) S120–43.
- [30] J. Chen, W. Jiang, L. Shao, D. Zhong, Y. Wu, J. Cai, Association between intake of antioxidants and pancreatic cancer risk: a meta-analysis, *Int. J. Food Sci. Nutr.* 67 (7) (2016) 744–753.
- [31] A. Ayedi, A. Rashidy-Pour, M. Parohan, M.S. Zargar, S. Shab-Bidar, Dietary antioxidants, circulating antioxidant concentrations, total antioxidant capacity, and risk of all-cause mortality: a systematic review and dose-response meta-analysis of prospective observational studies, *Adv. Nutr. (Bethesda, MD)* (2018).
- [32] M. Dickson-Spillmann, M. Siegrist, Consumers' knowledge of healthy diets and its correlation with dietary behaviour, *J. Human Nutr. Diet.* 24 (1) (2011) 54–60.
- [33] J. Wardle, K. Parmenter, J. Waller, Nutrition knowledge and food intake, *Appetite* 34 (3) (2000) 269–275.
- [34] S.S. Rodrigues, B. Franchini, P. Graca, M.D. de Almeida, A new food guide for the Portuguese population: development and technical considerations, *J. Nutr. Educ. Behav.* 38 (3) (2006) 189–195.
- [35] S.J. Czaja, N. Charness, A.D. Fisk, C. Hertzog, S.N. Nair, W.A. Rogers, et al., Factors predicting the use of technology: findings from the Center for Research and Education on Aging and Technology Enhancement (CREATE), *Psychol. Aging* 21 (2) (2006) 333–352.
- [36] M.N. Munshi, Cognitive dysfunction in older adults with diabetes: what a clinician needs to know, *Diab. Care* 40 (4) (2017) 461–467.
- [37] E. Carrillo, P. Varela, S. Fiszman, Influence of nutritional knowledge on the use and interpretation of Spanish nutritional food labels, *J. Food Sci.* 77 (1) (2012) H1–8.
- [38] T. De Vriendt, C. Matthys, W. Verbeke, I. Pynaert, S. De Henauw, Determinants of nutrition knowledge in young and middle-aged Belgian women and the association with their dietary behaviour, *Appetite* 52 (3) (2009) 788–792.
- [39] P. Mirmiran, F. Mohammadi-Nasrabadi, N. Omidvar, F. Hosseini-Esfahani, H. Hamayeli-Mehrabani, Y. Mehrabi, et al., Nutritional knowledge, attitude and practice of Tehranian adults and their relation to serum lipid and lipoproteins: Tehran lipid and glucose study, *Ann. Nutr. Metab.* 56 (3) (2010) 233–240.
- [40] P.M. Nilsson, S.E. Johansson, J. Sundquist, Low educational status is a risk factor for mortality among diabetic people, *Diab. Med.* 15 (3) (1998) 213–219.
- [41] N.E. Adler, T. Boyce, M.A. Chesney, S. Cohen, S. Folkman, R.L. Kahn, et al., Socioeconomic status and health. The challenge of the gradient, *Am. Psychol.* 49 (1) (1994) 15–24.
- [42] C.W. Kassahun, A.G. Mekonen, Knowledge, attitude, practices and their associated factors towards diabetes mellitus among non diabetes community members of Bale Zone administrative towns, South East Ethiopia. A cross-sectional study, *PLoS One* 12 (2) (2017) e0170040.
- [43] W. Lin, C.M. Hang, H.C. Yang, M.H. Hung, 2005–2008 Nutrition and Health Survey in Taiwan: the nutrition knowledge, attitude and behavior of 19–64 year old adults, *Asia Pac. J. Clin. Nutr.* 20 (2) (2011) 309–318.
- [44] L.B. Barbosa, S.M. Vasconcelos, L.O. Correia, R.C. Ferreira, Nutrition knowledge assessment studies in adults: a systematic review, *Cien. Saude Colet.* 21 (2) (2016) 449–462.
- [45] H.M. Tseng, S.F. Liao, Y.P. Wen, Y.J. Chuang, Stages of change concept of the transtheoretical model for healthy eating links health literacy and diabetes knowledge to glycemic control in people with type 2 diabetes, *Primary Care Diab.* 11 (1) (2017) 29–36.
- [46] D.M. Klohe-Lehman, J. Freeland-Graves, E.R. Anderson, T. McDowell, K.K. Clarke, H. Hanss-Nuss, et al., Nutrition knowledge is associated with greater weight loss in obese and overweight low-income mothers, *J. Am. Diet. Assoc.* 106 (1) (2006) 65–75, quiz 6–9.
- [47] M.J. Davies, S. Heller, T.C. Skinner, M.J. Campbell, M.E. Carey, S. Cradock, et al., Effectiveness of the diabetes education and self management for ongoing and newly diagnosed (DESMOND) programme for people with newly diagnosed type 2 diabetes: cluster randomised controlled trial, *BMJ (Clin. Res. ed)* 336 (7642) (2008) 491–495.