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1 ARTICLE ORIGINAL

2 Title: Evaluation of short food-frequency questionnaires to assess the dietary pattern
3 associated with atherosclerosis cardiovascular diseases.

4

5 Titre : Evaluation de questionnaires nutritionnels pour évaluer le profil alimentaire associé
6 aux maladies cardiovasculaires athéromateuses.

7

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14 Summary

15 Objectives: Cardiovascular diseases are strongly related to dietary habits. Diet can be assessed
16 using dedicated questionnaires that can be self-completed by subjects but with the risk of
17 errors. Aims: To compare the completion error rate of two questionnaires designed to assess
18 dietary pattern linked to cardiovascular diseases and to study the correlation between the two
19 questionnaires. Materials and Methods: Two questionnaires were used to assess dietary
20 patterns of students: the 14-item Food-Frequency-Questionnaire (FFQ) that was validated
21 against biomarkers, and the Cardiovascular-Dietary-Questionnaire 2 (CDQ2), which is a 19-
22 item-FFQ derived from the previous 14-item FFQ. Both questionnaires assessed the intake of
23 various food groups associated with either favourable or unfavourable effects on
24 cardiovascular risk. A global dietary score was calculated for each questionnaire. Results:
25 FFQ and CDQ2 were completed by 150 sport degree students. In the case of FFQ, 111
26 questionnaires out of 150 (74.0%) were incomplete compared to only 1 CDQ2 out of 150

27 (0.7%) ($p < 0.001$). The correlation coefficient between the overall CDQ2 score and the FFQ
28 dietary score was 0.53 ($p < 0.01$). Conclusion: The self-completion of CDQ2 compared to FFQ
29 was associated with far less errors. There was a significant correlation between CDQ2 and
30 FFQ. Preference should be given to CDQ2 in clinical practice and in studies where dietary
31 pattern are evaluated without any interviewer.

32 Key words: cardiovascular disease; questionnaire; diet; atherosclerosis

33 Résumé

34 Objectifs : Les maladies cardiovasculaires sont liées aux comportements alimentaires.
35 L'alimentation peut être évaluée par des questionnaires dédiés qui peuvent être remplis seuls
36 mais avec un risque d'erreurs. Les objectifs sont de comparer les erreurs lors du remplissage
37 de deux questionnaires développés pour évaluer l'alimentation liée aux maladies
38 cardiovasculaires athéromateuses et d'étudier la corrélation entre ces deux questionnaires.

39 Matériels et Méthodes : Deux questionnaires ont été utilisés pour évaluer l'alimentation
40 d'étudiants : un court questionnaire de 14 questions (FFQ) qui a été préalablement validé
41 contre des biomarqueurs et un second questionnaire (CDQ2) de 19 questions dérivées du
42 premier questionnaire (FFQ). Les deux questionnaires évaluent des groupes alimentaires qui
43 ont des effets favorables et défavorables sur le risque cardiovasculaire. Un score global
44 alimentaire était calculé pour chaque questionnaire.

45 Résultats : Les deux questionnaires ont été remplis par 150 étudiants en faculté de sport. Pour
46 le FFQ, 74 % ($n=111$) des questionnaires étaient incomplets comparativement à 0,7% ($n=1$)
47 pour le CDQ2 ($p < 0.001$). Le coefficient de corrélation entre les scores globaux du CDQ2 et
48 du FFQ était de 0,53 ($p < 0.01$). Conclusion : L'auto-remplissage du CDQ2 est associé à un
49 moindre nombre d'erreurs. Il existe une corrélation significative entre les deux questionnaires.
50 Le CDQ2 devrait être préféré en pratique clinique et dans les études où l'alimentation est
51 évaluée sans interviewer.

52

53 Mots clés : Alimentation, athérosclérose, questionnaire, maladies cardiovasculaires

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59 **ABBREVIATIONS**

60 14-item FFQ: 14-item Food Frequency Questionnaire

61 CDQ2: Cardiovascular dietary questionnaire 2

62 GS: Global score

63 MUFA: Mono Unsaturated Fatty Acids

64 PUFA: Poly unsaturated Fatty acids

65 SFA: Saturated fatty acids

66 VDS: Vascular dietary score

67

68 **INTRODUCTION**

69 Several studies have shown that diet is a risk factor in cardiovascular diseases[1–4].

70 Public policies adopted by high-income countries promoting healthier life styles and healthy

71 eating based on a Mediterranean diet should help to decrease the cardiovascular mortality[5].

72 Lifestyles are often acquired during the first part of subject's life and the effect of lifestyle is

73 related to exposure time. In this context, questionnaires could be used to assess the subjects'

74 dietary pattern.

75 Numerous tools with potential application to dietary assessment in clinical settings have been

76 reported[6]. All these tools do not report the same dietary information (fat intake, with or

77 without other nutrients, adherence to the Mediterranean diet, or fruit and vegetable intake).

78 The questionnaires used presented in this study has been developed specifically in France and

79 reports quality diet[7]. A short questionnaire on foods related to vascular risk, comprising 14
80 questions (14-item FFQ) was validated against biological markers and a 7-day food survey[7].
81 A connection between vascular diseases and a risk-related diet had already been highlighted
82 in cases of myocardial infarction, lower limb arterial disease and ischemic stroke[7–12].
83 Using this questionnaire, the scores for different food groups linked with cardiovascular
84 diseases can be calculated[7,9,13]. In previous studies, the food evaluation was carried out
85 with an interviewer, who ensured that all of the questions were answered. In fact, a missing
86 answer meant that the corresponding food score could not be calculated. The fact that an
87 interviewer was required precluded the widespread use of this questionnaire. Furthermore,
88 this questionnaire included several open questions that could raise issues. A new
89 questionnaire (Cardiovascular Dietary Questionnaire 2; CDQ2) based on the 14-item FFQ
90 was therefore developed to rule out open responses and includes only closed answers.
91 We assume that CDQ2 generates fewer errors than FFQ when self-completed and that there is
92 a satisfactory correlation between the two questionnaires. The primary objective of this study
93 was to compare the number of correctly completed questionnaires and the secondary objective
94 was to study the correlation between these two questionnaires.

95

96 **MATERIALS AND METHODS**

97 This is a transversal study carried out at the Catholic University of the West (UCO,
98 Angers, France) involving a student cohort studying Sports, Exercise Science and Technology
99 Degree (STAPS).

100 ***Study cohort***

101 All students were enrolled at the Institute of Physical Education and Sports Sciences
102 (IFEPSA-UCO, Angers) between 2014 and 2015. Students in the second and third year of
103 their licence studies (BSc/BA), aged 18 years old and over, with or without a disorder were

104 included. This study was approved by our institutional review board (CHU Angers). All of the
105 subjects signed an informed consent form in order to take part in the study. The study
106 protocol was conformed to the ethical guidelines of the 1975 Declaration of Helsinki.

107 *Study protocol*

108 The study was presented to the students in a lecture theatre. Two visits were then
109 organised: the first to obtain consent and to complete the FFQ and CDQ2 questionnaires, and
110 the second to correct any errors made on completing the questionnaires.

111

112 14-item FFQ: this questionnaire was used to assess the consumption of Saturated Fatty Acids
113 (SFA), Mono-Unsaturated Fatty Acids (MUFA), Polyunsaturated Fatty Acids (PUFA)
114 (omega 3 and omega 6), fruits and vegetables[7]. It was also used to calculate a global
115 vascular risk dietary score called the Vascular Dietary Score (VDS). This score was
116 calculated by adding up the beneficial elements (fruits and vegetables, MUFA, PUFA-n3) and
117 subtracting the SFA score. The latter ranged from -17 to +19. The higher the VDS, the higher
118 the cardiovascular protective diet and vice-versa. The FFQ had a good reproducibility
119 amongst the student population [14]. A $VDS \leq -1$ is considered as an unfavourable vascular
120 diet. The optimal dietary score is a $VDS \geq 8$ [11]. For more information about the scoring,
121 readers can refer to previous publications [7,10]

122

123 CDQ2 (Supplemental materials): This questionnaire was derived from the 14-item FFQ [7].
124 The 19 questions, including 2 on alcohol consumption, did not contain any open questions.
125 The CDQ2 was used to calculate a global score (GS). The GS ranges from -36 to +47. The
126 higher the GS, the higher the cardiovascular protective diet and vice-versa. The scoring
127 method is describe in the online supplemental materials.

128

129 Error types: different types of errors were considered: no response, double or triple response
130 or confused response indicating the subject's inability to answer the question independently
131 (problem about the type of oil chosen, type of margarine, etc.).

132

133 *Statistical analyses*

134 A "Shapiro Wilk" normality test was checked to confirm normal data distribution. It
135 showed that variables in the vascular dietary score (VDS), the global score and global score
136 without alcohol followed a normal distribution. The number of errors in the two
137 questionnaires was compared using the "McNemar Test". In order to investigate the
138 relationship between the two questionnaires, correlation tests were carried out between VDS
139 obtained with the 14-item FFQ and the GS obtained with the CDQ2. The level of significance
140 was set at $p < 0.05$.

141 **RESULTS**

142 *Study cohort characteristics*

143 Overall, 150 subjects were enrolled in our study (Table 1). The students had a mean
144 VDS of $-0.93 (\pm 3.33)$ and a GS of $0.89 (\pm 5.97)$.

145

146 *FFQ error types*

147

148 In Table 2, the types of errors made by the students are presented according to six
149 categories: omitted answers, problems with the type of oil, chips, margarine, responses in
150 duplicate or triplicate and questions about nut consumption. This type of error recurred
151 regularly for the same questions, namely 6, 7, 9, 12, 13 and 14. Frequent errors were made
152 when answering questions 13 and 14 on oil and margarine consumption on the 14-item FFQ.

153 ***Results of incorrectly completed questionnaires***

154 Over 70% of the FFQ were incorrectly completed on the first occasion (111/150).
155 Over 99% of CDQ2 were correctly completed except for 1 student who forgot to complete
156 half of the questionnaire.

157 ***Relations between the questionnaires***

158 A significant relationship was found between the VDS obtained with the FFQ and the
159 GS obtained with CDQ2 ($r=0.53$) ($p<0.01$). The removal of the 2 questions related to alcohol
160 did not change significantly the correlation: $r=0.54$ ($p<0.01$).

161 **DISCUSSION**

162 This study reports a great improvement in correct answers to questions and exploitable
163 self-completed questionnaires with a rate close to 100% in this student population with the
164 CDQ2. Furthermore, there is a good correlation of this questionnaire with the original 14-item
165 FFQ that generates too much errors or missing answers due to the relative complexity for
166 several subjects to answer correctly the questions related to the choice of fat and oils.
167 However that information is a major one to calculate an informative global dietary score.
168 Indeed the type of fat used for cooking or seasoning is one of the major nutritional
169 determinants to influence the cardiovascular risk. A high intake of saturated and trans fatty
170 acids increases the risk whereas mono and polyunsaturated fatty acids, in particular olive oil
171 and omega-3 fatty acids reduce the risk [15,16].

172 Fewer errors were made on completing the CDQ2 compared to the 14-item FFQ. The CDQ2
173 also had several advantages: first, it contained only closed questions – hence the questions
174 were answered more quickly. The time taken to answer the question seemed to facilitate the
175 students' decision [17]. Secondly, although CDQ2 had five additional questions, there were

176 fewer possible answers (maximum of 19 items). The FFQ contained only 14 questions but 27
177 items had to be completed [7]. Several partial responses were required for the same question.
178 The results of a meta-analysis of controlled, randomised studies suggest that preference
179 should be given to shorter questionnaires[18]. Shorter questionnaires can be completed more
180 quickly, probably increasing the rate of correct responses[19]. Thirdly, CDQ2 includes
181 alcohol consumption, which was not assessed in the FFQ. The effect of alcohol on
182 cardiovascular disease is debated [20,21]. But numerous epidemiologic studies have shown
183 results in support of a protective effect of a small to moderate alcohol consumption and a
184 deleterious effect of a high consumption and/or binge drinking[22–24]. Many epidemiologic
185 studies have reported that a small to moderate alcohol consumption can be considered as a
186 favourable lifestyle characteristic. Thus the inclusion of alcohol in a dietary questionnaire is
187 important especially for cardiovascular diseases. It could be criticised that alcohol
188 consumption was not considered in the original FFQ and thus the correlation between the 2
189 questionnaires could be weakened. However this was not the case.

190 A significant, albeit moderate, correlation ($r=0.53$) was observed between the two global
191 scores derived from the 2 questionnaires. This moderate correlation may be explained by the
192 homogeneity of the population with few extreme dietary scores being recorded. Another sub-
193 study carried out by our team in a more heterogeneous population ($n=56$) of 31 ± 17 years
194 revealed a VDS of 1.04 ± 5.08 and a GS score of 3.59 ± 7.92 with a higher correlation between
195 the two questionnaires: $r=0.78$ ($p<0.001$). Moreover the errors in FFQ answers represent the
196 main explanation for the alteration of the correlation, which is a strong argument in favour of
197 the preferential use of the CDQ2.

198

199 Limitations

200 It may be questioned whether the small number of errors made by this population on
201 completing CDQ2 can be extrapolated to older populations. However, the use of closed
202 answers has facilitated the responses and we can assume this will be the case also for other
203 populations. To date, it has not yet been shown that patients with cardiovascular diseases have
204 an unfavourable GS obtained with CDQ2 whereas it has been reported that a low SDV score
205 (14-item FFQ) is associated with myocardial infarction, PAD and ischemic stroke. There are
206 ongoing studies to check that the CDQ2 global score is as well associated with these diseases.

207 To conclude, this study shows that CDQ2 is well correlated with the original validated 14-
208 item FFQ and generates far more correctly self-completed questionnaires, which could
209 facilitate its widespread use especially in clinical practice.

210

211 **CONFLICT OF INTEREST:** The authors declare that they have no conflict of interest.

212 **DECLARATIONS:**

213 Ethics approval and consent to participate: This study was approved by our institutional
214 review board (CHU Angers Ethical Committee). All of the subjects signed an informed
215 consent form in order to take part in the study.

216 Funding: This study was funded by Université Catholique de l'Ouest.

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Table 1: Students Cohort Characteristics.

Characteristics	Population (n=150)
Age (years old), m +/- sd	20+/-1
Weight (kg), m +/- sd	67.2+/-8.9
Height (m), m +/- sd	1.76+/-0.08
Men, n (%)	111 (74)
Smokers, n (%)	28 (19)

Legend : m means mean and sd means standard deviation

Table 2: Type of errors found in the 14-item FFQ (n=150 participants)

Questions	Missing answer	Multiple answers	Confusion
Fries consumption	7	22	63
Bread and derived products	1		
Nuts consumption			4
Raw butter or cream consumption		2	
Margarin consumption	12		31
Oil consumption	64		47

Online supplemental material: CARDIOVASCULAR DIETARY QUESTIONNAIRE 2

1. How many portions of cheese do you eat on average? (1 portion = 1/8th of camembert = 30 g)

- | | |
|--|-------------------|
| <input type="checkbox"/> less than 1 portion per day | SFA score = 0 pt |
| <input type="checkbox"/> 1 portion per day | SFA score = 2 pts |
| <input type="checkbox"/> 2 portions per day | SFA score = 4 pts |
| <input type="checkbox"/> 3 or more portions per day | SFA score = 6 pts |

2. Do you eat dairy products?

(1 dairy product = 1 yoghurt or 100 g of white cheese or 1 glass of milk (15 cl) or 1 cream or desserts containing milk)

- | | |
|---|-------------------|
| <input type="checkbox"/> I only eat skimmed or semi-skimmed dairy products | SFA score = 0 pt |
| <input type="checkbox"/> I do not eat dairy products or I eat less than 1 per day | SFA score = 0 pt |
| <input type="checkbox"/> I eat 1 to 2 dairy products every day | SFA score = 1 pt |
| <input type="checkbox"/> I eat 3 dairy products every day | SFA score = 2 pts |
| <input type="checkbox"/> I eat 4 or more dairy products per day | SFA score = 3 pts |

3. Do you eat pork, beef, veal, mutton or lamb?

- | | |
|---|-------------------|
| <input type="checkbox"/> 0 to once a week | SFA score = 0 pt |
| <input type="checkbox"/> 2 to 3 times a week | SFA score = 1 pt |
| <input type="checkbox"/> 4 to 6 times a week. | SFA score = 2 pts |
| <input type="checkbox"/> once a day, or more | SFA score = 3 pts |

4. Do you eat fresh, tinned or frozen fish (including tuna, mackerel, sardines and herring)?

- | | |
|---|--------------------|
| <input type="checkbox"/> at least once a week | UFA Score = 0 pt |
| <input type="checkbox"/> once a week | UFA Score = 3 pts |
| <input type="checkbox"/> twice a week | UFA Score = 6 pts |
| <input type="checkbox"/> 3 times a week | UFA Score = 9 pts |
| <input type="checkbox"/> 4 times a week or more | UFA Score = 12 pts |

5. Do you eat processed and deli meats (except lean ham) i.e. ham, pâté, salami, rillettes, bacon, sausages (also in stews/casserole dishes, sauerkraut, etc.)?

- | | |
|---|-------------------|
| <input type="checkbox"/> 0 to once a week | SFA score = 0 pt |
| <input type="checkbox"/> 2 to 3 times a week | SFA score = 1 pt |
| <input type="checkbox"/> 4 to 6 times a week | SFA score = 2 pts |
| <input type="checkbox"/> once a day | SFA score = 3 pts |
| <input type="checkbox"/> more than once a day | SFA score = 4 pts |

6. Do you eat quiches, tarts and savoury snacks (toasted sandwiches, quiches, tarts, pizza, fried foods, hamburgers, sandwiches with butter, etc.)?

- | | |
|--|-------------------|
| <input type="checkbox"/> 0 to once a week | SFA score = 0 pt |
| <input type="checkbox"/> 2 to 3 times a week | SFA score = 2 pts |
| <input type="checkbox"/> 4 to 6 times a week | SFA score = 3 pts |
| once a day or more | SFA score = 4 pts |

7. Do you eat shop cake, gateaux and biscuits made from butter (including “home-made” produce)?

- | | |
|---|-------------------|
| <input type="checkbox"/> 0 to 1 portion per week | SFA score = 0 pt |
| <input type="checkbox"/> 2 to 4 portions per week | SFA score = 2 pts |

- 5 portions or more per week SFA score = 4 pts

8. Do you eat viennoiseries (croissant, brioche, pain au chocolat, pain au lait, etc.)?

- 0 to 1 per week SFA score = 0 pt
- 2 to 3 per week SFA score = 1 pt
- 4 to 6 per week SFA score = 2 pts
- 1 per day SFA score = 3 pts
- more than 1 per day SFA score = 4 pts

9. Do you eat fresh fruit?

(1 portion = 1 average-sized fruit, for example 1 apple or 2 clementines or a small dish of berries/small fruit)

- Never or rarely FV Score = 0 pt
- 1 to 2 portions per week FV Score = 1 pt
- 3 to 6 portions per week FV Score = 2 pts
- 7 to 13 portions per week (at least 1 fruit per day) FV Score = 3 pts
- 14 portions or more per week (at least 2 pieces of fruit per day) FV Score = 4 pts

10. Do you drink fruit juice every day (pure juice without added sugar)

- no or less than 1 glass per day FV Score = 0 pt
- yes, 1 glass per day FV Score = 1 pt
- yes, 2 glasses or more per day FV Score = 2 pts

11. Do you eat cooked vegetables and vegetable soup (1 portion = 1 plate or 2 bowl)

- Never or rarely FV Score = 0 pt

- 1 to 2 portions per week FV Score = 1 pt
- 3 to 6 portions per week (less than 1 portion per day) FV Score = 2 pts
- 1 portion per day FV Score = 3 pts
- more than 1 portion per day FV Score = 4 pts

12. Do you eat raw vegetables and salads?

- Never or rarely FV Score = 0 pt
- 1 to 2 portions per week FV Score = 1 pt
- 3 to 6 portions per week (less than 1 portion per day) FV Score = 2 pts
- 1 portion per day on average FV Score = 3 pts
- more than 1 portion per day FV Score = 4 pts

13. Do you usually eat margarine with a high Omega 3 content such as Fruit d'or® or Primevère® or Saint-Hubert oméga 3®?

- No UFA Score = 0 pt
- yes, with 1 meal per day UFA Score = 1 pt
- yes, with 2 meals per day UFA Score = 2 pts
- yes, with 3 or more meals per day UFA Score = 3 pts

14. Do you use butter on your bread or in your food?

(1 portion = 1 individual portion of 10 g)

- never or rarely SFA score = 0 pt
- 1 portion per day SFA score = 2 pts
- 2 portions or more per day SFA score = 4 pts

15. Do you cook with butter or with hard margarine such as Astra® ?

- never or rarely SFA score = 0 pt
- yes, 1 meal per day SFA score = 2 pts
- yes, 2 meals per day SFA score = 4 pts

16. Do you usually use one of the following oils: rapeseed, soybean, nut, or Isio4® ? no

UFA Score = 0 pt

- yes, at least 1 soup spoonful per day UFA Score = 2 pts
- yes, 1 soup spoonful per day UFA Score = 4 pts
- yes, 2 soup spoonfuls or more per day UFA Score = 6 pts

17. Do you usually use olive oil ?

- no UFA Score = 0 pt
- yes, at least 1 soup spoonful per day UFA Score = 1 pt
- yes, 1 soup spoonful per day UFA Score = 2 pts
- yes, 2 soup spoonfuls per day UFA Score = 4 pts
- yes, 3 soup spoonfuls per day UFA Score = 6 pts
- yes, 4 or more soup spoonfuls per day UFA Score = 8 pts

18. How much alcohol do you consume Monday to Friday? – in terms of the number of glasses of alcoholic drinks per day (see the table on the right for equivalents)

- never or seldom OH score=0 pt
- at least 1 glass per day OH score=1 pt
- 1 glass per day OH score=2 pts
- 2 glasses per day OH score=4 pts

<p><i>1 glass of alcohol</i> = 10 cl of Wine (i.e. 7.5 glasses in a 75 cl bottle) = 10 cl of Champagne = 2 to 3 cl of strong aperitif (Whisky, Pernod, etc.) 7 cl of apéritif – Muscat, Port, Martini 25 ml of Beer (half) or 5° Cider</p>

- 3 glasses or more per day OH score=0 pt

19. How much alcohol do you consume at the weekend? – give the overall quantity for

Saturday and Sunday

- never or seldom OH score=0 pt
- 1 to 2 glasses OH score=0 pt
- 3 to 7 glasses OH score=0 pt
- 8 or more glasses OH score=0 pt ; and a positive answer to this question
cancels all points at qs 18.

CDQ 2 Scores:

- SFA (saturated fatty acid) Score: 0 to 36
- UFA (unsaturated fatty acid) Score: 0 to 29
- FV (fruits and vegetables) Score: 0 to 14
- OH (alcohol) Score: 0 to 4
- Global CDQ2 Score: $UFA + FV + OH - SFA$: -36 to + 47
(the higher, the better = more protective)