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## **Validation and reproducibility of a short food frequency questionnaire for cardiovascular prevention**

**Abbreviated title:** Validation and reproducibility of Cardiovascular Diet Questionnaire-2

**Tweet:** Diet is pivotal to cardiovascular risk. CDQ-2 is a new, simple, validated food-frequency questionnaire. It is a valuable tool for diet evaluation in cardiovascular disease prevention

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## **Summary**

*Background.* – Diet strongly influences cardiovascular risk. Dietary evaluation is a major issue in cardiovascular prevention, but few simple tools are available. Our team previously validated a short food frequency questionnaire; a new version of this questionnaire (Cardiovascular Dietary Questionnaire 2 [CDQ-2]) is easier to complete and more reliable.

*Aims.* – To validate CDQ-2 in comparison with the original version, and to test its reproducibility.

*Methods.* – CDQ-2 has 17 closed-ended questions; it provides a global dietary score that is a combination of specific scores for saturated, monounsaturated and omega-3 fatty acids, and fruit and vegetables. CDQ-2 was validated against the original version in two groups, who completed both questionnaires: 99 patients with cardiovascular risk factors and 50 healthy subjects. Reproducibility was assessed with 27 health professionals who completed the questionnaire twice, with a 1-month interval.

*Results.* – The correlation coefficients of the scores between the two questionnaires ranged from 0.65 (monounsaturated fatty acids) to 0.93 (fruit and vegetables) (all  $P < 0.001$ ). The percentage of subjects classified in the same quartile by both questionnaires ranged from 56% (omega-3 fatty acids) to 78% (fruit and vegetables). The percentage of subjects classified in the same or adjacent quartile ranged from 91% to 99%. The intraclass correlation coefficients, which assessed reproducibility, ranged from 0.61 (fruit and vegetables) to 0.88 (saturated fatty acids) ( $P < 0.001$ ).

*Conclusions.* – This new version of the short dietary questionnaire shows good reproducibility and correlations with the original version; use and reliability are improved, which makes CDQ-2 a valuable tool for cardiovascular prevention.

## **Résumé**

*Contexte.* – L'alimentation influence fortement le risque cardiovasculaire. L'évaluation nutritionnelle représente un enjeu majeur en prévention cardiovasculaire mais peu d'outils simples sont disponibles. Nous avons élaboré un questionnaire court de fréquence alimentaire, CDQ-2, simple à remplir et fiable.

*Objectifs.* – Valider le questionnaire CDQ-2 par rapport à la première version et évaluer sa reproductibilité.

*Méthodes.* – Le CDQ-2 comporte 17 questions fermées ; il fournit un score alimentaire global, combinaison de scores spécifiques pour les acides gras saturés, monoinsaturés, polyinsaturés oméga-3, fruits and légumes. Il a été validé par rapport à la première version dans 2 groupes qui ont rempli les 2 questionnaires : 99 patients à risque cardiovasculaire majoré et 50 sujets en bonne santé. La reproductibilité a été évaluée chez 27 professionnels de santé qui ont rempli 2 fois le questionnaire à 1 mois d'intervalle.

*Resultats.* – Les coefficients de corrélation des scores entre les 2 questionnaires sont compris entre 0,65 (acides gras monoinsaturés) et 0,93 (fruits et légumes) ( $P < 0,001$ ). Les pourcentages de sujets classifiés dans le même quartile par les 2 questionnaires vont de 56 % (oméga-3) à 78 % (fruits et légumes) ; les pourcentages de sujets dans le quartile identique ou adjacent de 91 % à 99 %. Les coefficients de corrélation intraclasse, évaluant la reproductibilité, sont compris entre 0,61 (fruits et légumes) et 0,88 (acides gras saturés) ( $P < 0,001$ ).

*Conclusions.* – La nouvelle version du questionnaire alimentaire CDQ-2 est bien corrélée à la version initiale. Son utilisation et sa fiabilité sont améliorées ce qui en fait un outil très utile en prévention cardiovasculaire.

## **KEYWORDS**

Cardiovascular diseases;

Diet;

Questionnaire;

Validity;

Reproducibility

## **MOTS CLÉS**

Maladies cardiovasculaires ;

Alimentation ;

Questionnaire ;

Validité ;

Reproductibilité

*Abbreviations:* CDQ-1, Cardiovascular Diet Questionnaire 1; CDQ-2, Cardiovascular Diet Questionnaire 2; CPAM, Caisse Primaire d'Assurance Maladie; CVD, cardiovascular disease; FV, fruit and vegetables; INCA 2, Individual and National Food Consumption Survey 2; MUFA, monounsaturated fatty acids;  $\omega$ -3 FA, omega-3 fatty acids; PUFA, polyunsaturated fatty acids; SFA, saturated fatty acids.

## Background

Cardiovascular diseases (CVDs) are the leading cause of mortality among non-communicable diseases worldwide [1]. CVDs are largely accessible to prevention, in which lifestyle plays a major role. An optimal lifestyle could prevent up to 4 of 5 cases of myocardial infarction (MI), and a healthy diet is a key feature [2]. Diet can modulate CVD risk through various pathways: blood lipids, blood pressure, inflammation, insulin resistance, oxidative stress, endothelial function and arrhythmias [3].

Dietary patterns combine various nutrients that may influence CVD risk favourably or unfavourably [4]. The assessment of global dietary pattern is therefore pivotal in CVD risk evaluation. Compelling evidence from prospective cohort [5-9] and randomized [10, 11] studies show cardiovascular benefit from a combination of lower consumption of saturated fatty acids (SFA) and increased consumption of fruit and vegetables (FV), monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA), especially omega-3 fatty acids ( $\omega$ -3 FA). Recommended diets for cardiovascular prevention combine these characteristics [11, 12].

Compliance with dietary advice is of major importance for primary and secondary CVD prevention [13, 14], and it should be monitored as well as medication compliance. However, diet is more difficult to assess, and many physicians are not comfortable with doing so. A validated short food frequency questionnaire is therefore a valuable tool in patient care. The need for rapid diet assessment screening tools was underlined recently by the American Heart Association [15]. Our team has developed such a cardiovascular diet questionnaire, adapted to the French population, which has been validated against a reference method (7-day dietary history) as well as biomarkers [16]. Our team and others have faced a few difficulties in its clinical use because of some open-ended questions and the need to make secondary calculations to generate scores [17]. This was a limiting factor for its widespread use. Therefore, we have developed a new version, to make the questionnaire easier to complete and to simplify score calculation. This easy tool can help clinicians significantly in the provision of better patient care. This paper reports the validation of this new Cardiovascular Dietary Questionnaire (CDQ-2) against the original version (CDQ-1).

## Methods

### Study populations

The validity of CDQ-2 was assessed in two groups of volunteers aged between 30 and 70 years. Group I comprised 99 outpatient participants consulting with various CVD risk factors at the Cardiovascular Prevention Centre of Rennes University Hospital. These subjects had received dietary advice. Group II comprised 50 healthy participants recruited at a health appraisal centre (Caisse Primaire d'Assurance Maladie [CPAM], Rennes), without any known metabolic or cardiovascular disorder that would justify specific dietary attention. Participants from Groups I and II self-completed both questionnaires (CDQ-1 and CDQ-2) in a random sequence. The average completion time for CDQ-2 was about 5 minutes. The reproducibility of CDQ-2 was evaluated with 27 healthy volunteers (Group III) from Rennes University Hospital staff, who had declared regular food habits. These participants self-completed CDQ-2 twice, 1 month apart. The study was approved by Rennes University Hospital Ethics Committee. All participants gave their informed consent.

### **Food frequency questionnaires (Table 1)**

CDQ-1 contained 14 questions, three of which were open-ended, to take into account the complex composition of oils and margarines [16]. These questions made questionnaire completion and the scoring system complicated, with potential errors. Therefore, in CDQ-2, we chose to include only closed-ended questions (Appendix A and Appendix B). The 17 questions were designed to capture the main sources of the relevant nutrients. For each of the nine questions related to SFA intake, the associated score was weighted according to its contribution to the total intake of SFA in the second French Individual and National Food Consumption Survey (INCA 2) [18]; the SFA score ranges from 0 to 36. The fatty acid content was calculated from the answers to specific questions by using the CIQUAL database [19]. MUFA intake is explored with one question (score range 0–8).  $\omega$ -3 FA intake is explored with three questions (score range 0–21), and differentiates vegetable source (alpha-linolenic acid, 9 points) and marine source (12 points), mainly eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). There are four questions for FV consumption (score range 0–14). The global dietary score is calculated as  $(FV + MUFA + \omega\text{-3 FA}) - SFA$ , with a range from –36 to +43; higher scores indicate a better diet (Table 1).

### **Statistical analysis**

Statistical analysis was performed with SAS statistical software, version 8.02 (SAS Institute, Cary, NC, USA). We first calculated the Spearman correlation coefficients between the scores given by both questionnaires. In addition to correlations based on continuous variables, we cross-classified the scores into quartiles to evaluate the ability of both questionnaires to classify individuals similarly in broad categories of intake. Percentages of concordant classification for the same quartile are given, together with concordant classification in the same or adjacent quartile. The intraclass correlation coefficient was also assessed for each score, to test the reproducibility of CDQ-2. A *P* value < 0.05 was considered as significant. To evaluate the consistency between the two measurements, the difference between the two scores obtained for each subject was plotted against the mean score, and limits of agreement were defined as means  $\pm$  1.96 standard deviations, according to the Bland and Altman method [20].

## Results

Participants were mainly middle aged, with a higher proportion of men in Group I and women in Group III (health professionals) (Table 2). In Group I, 19% of the subjects had a history of documented atherosclerotic CVD. As a result of the selection criteria, Group I participants had several risk factors and a higher mean body mass index than those in Groups II and III. The mean dietary scores were rather similar between Group I (who had received dietary advice) and Group III (Table 3), and were better in these two groups than in Group II.

The correlation coefficients between CDQ-1 and CDQ-2 ranged from 0.65 to 0.93 (all *P* < 0.001), with lower values for the fatty acid scores, for which the questions were modified most (Table 4). The percentage of subjects classified in the same quartile by both questionnaires ranged from 56% ( $\omega$ -3 FA consumption) to 78% (FV), and averaged 63%. The percentage of subjects classified in the same or adjacent quartile ranged from 91% (unsaturated FA) to 99% (FV and global scores), averaging 97%.

Reproducibility was checked for each score between the two administrations of CDQ-2. The intraclass correlation coefficients were 0.70 (global score), 0.88 (SFA), 0.61 (FV), 0.73 (MUFA), 0.75 ( $\omega$ -3 FA) and 0.64 (marine  $\omega$ -3 FA), and averaged 0.72 (all *P* < 0.001). Finally, the Bland and Altman representation for the different scores (Fig. 1 for the global score) indicated minimal mean differences:



0.26 (global score), 0.07 (SFA), 0.37 (FV), -0.15 (MUFA), -0.11 ( $\omega$ -3 FA) and 0.04 (marine  $\omega$ -3 FA).

There was no systematic difference between the two administrations of the questionnaire.

## **Discussion**

This new version of the Cardiovascular Dietary Questionnaire, CDQ-2, has good correlations with CDQ-1 and good reproducibility; use and reliability are improved and its diet information has been updated. Therefore, CDQ-2 can help clinicians significantly in the provision of better patient care.

### **Diet quality and cardiovascular risk**

Survivors of myocardial infarction who consume a higher-quality diet have lower subsequent all-cause and cardiovascular mortality, especially when there is a greater improvement in diet from before to after the myocardial infarction [8, 13, 21]. Conversely, ignoring a healthy lifestyle is associated with an unfavourable prognosis [22]. Above all, randomized studies have proved that a Mediterranean diet significantly reduces cardiovascular events in high-risk patients [10, 11]. Therefore, long-term assessment of dietary advice compliance is at least as important as medication observance in clinical practice [14, 15]; however, it is clearly deficient. The few published studies report a marked deterioration in compliance especially after the first 1 or 2 years [23, 24]. A major pitfall for diet assessment is that many physicians are not comfortable with doing it, as there are few simple tools available.

### **Food frequency questionnaires**

Many studies have documented the strong relationship between diet and cardiovascular risk with various questionnaires [6, 9, 25], but the questionnaires used in those studies included a hundred items, which makes them unsuitable for clinical practice. Only a few short questionnaires have been proposed [26], sometimes limited to nutrients that are likely to influence a specific risk factor, such as cholesterol [27]. However, it has been shown that a short questionnaire can be an effective method of assessing diet quality [28], and is associated with changes in biomarkers [29].

For cardiovascular prevention, such a questionnaire needs to include foods associated with beneficial effects (unsaturated fatty acids and FV) and deleterious effects (SFA) on CVD risk, as well as a comprehensive diet score, as individual food groups may not be significant separately [9]. The 14

questions of our initial CDQ-1 were designed to take into account the major sources of nutrients in the French population: SFA, MUFA, PUFA and FV [16]. CDQ-1 has been used to assess diet in various populations with coronary artery disease [23, 30], stroke [31], peripheral artery disease [32] and in healthy students [33]. Our team and others have faced a few difficulties in its clinical use, because of some open-response questions and the need to make secondary calculations to generate scores [16]. This was a limiting factor for widespread use, especially for self-completed use. Therefore, we have restructured the questions in CDQ-2 to make it easier to self-complete and to calculate the scores.

Dietary habits vary from country to country. The questionnaires need to be validated in specific populations according to their nutritional habits and culture [34]. The questions have therefore been chosen to capture the main sources of the nutrients of interest, and the score associated with each question has been weighted according to its contribution to the total intake of the nutrients in INCA-2 [18]. Despite its limited number of questions, CDQ-2 improves the evaluation of nutrients: for instance, 85% of SFA intake is covered with nine items in CDQ-2 versus 78% in CDQ-1, and marine  $\omega$ -3 FA intake can be separated from total  $\omega$ -3 FA intake.

To evaluate food frequency questionnaires, Spearman correlations must be preferred for continuous variables, and correlation coefficients are generally considered as good between 0.5 and 0.7 [34]. The correlation coefficients and cross-classification results are quite good between CDQ-2 and CDQ-1 for the different nutrients. They are somewhat weaker for MUFA, as only olive oil is taken into account for MUFA intake in CDQ-2, because it is the major source of vegetable MUFA and the best associated with cardiovascular prevention [11]. Rapeseed oil is another important source of MUFA, but its consumption is taken into account in questions assessing  $\omega$ -3 FA intake. Moreover, the cross-classification also gives very good results, as 91–99% of subjects are classified in the same or adjacent quartile, and no mismatching is observed. The good correlations and consistency between the two completions of the questionnaire, with an interval of 1 month, confirm the good reproducibility of CDQ-2. It is weaker for FV and marine  $\omega$ -3 FA, which may be explained because the intake of these foods is not steady over time.

## **Study limitations**

We did not repeat the validation against another reference tool, such as a 7-day diet record or biomarkers, which was done for the first version of our questionnaire (CDQ-1) [16]. In CDQ-2 we

aimed to build a questionnaire that was easier to answer and therefore more reliable. Despite their differences, the correlations between CDQ-1 and CDQ-2 are good. CDQ-2 was constructed with the INCA-2 data as reference for the scoring of each question in relation to its weight within the consumption of the concerned nutrients. That weight may vary between different countries because of different food habits. CDQ-2 use in other populations may need prior evaluation of the adequacy of the questions for the food habits in a different country. This is a common problem with questionnaire-based dietary assessment [34]. Dietary habits also vary over time, and new specific foods can appear (e.g. novel processed dishes), which may change the sources of nutrients. An update of the questionnaires may therefore be necessary. CDQ-2 therefore includes more complete information than CDQ-1. Finally, we have not included questions for the assessment of alcohol consumption. Many studies have reported a beneficial effect on cardiovascular risk of mild-to-moderate alcohol consumption [2, 5, 6], but the net effect of alcohol is a matter of debate [35]. In another version of CDQ-2 (not shown), we included two questions related to alcohol consumption that gave positive points only for regular and mild-to-moderate consumption, excluding important or binge drinking. The correlation between the global scores of this modified version of CDQ-2 and CDQ-1 (which did not include questions about alcohol) remains good [17].

## **Conclusions**

This new version of the food frequency questionnaire (CDQ-2) shows good correlations with the previous version and good reproducibility; use and reliability are improved, especially for self-completion. Given the importance of diet in CVD prevention, such a questionnaire is a very valuable tool for clinical practice and research.

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None.

### **Declaration of interest**

The authors declare that they have no conflicts of interest concerning this article.

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## Figure legend

**Figure 1.** Graphical representation of the difference between the two consecutive global scores versus the mean of the two scores for each individual. The differences between the two consecutive global scores, obtained to assess the reproducibility of the food frequency questionnaire Cardiovascular Dietary Questionnaire 2, are plotted versus the mean of the two scores for each individual, according to the Bland and Altman method [20]. Horizontal lines indicate the mean difference between the two scores ( $d = 0.26$ ) and the limits of agreement (corresponding to the 95% confidence interval,  $\text{mean} \pm 1.96$  standard deviations).

**Table 1** Characteristics of the two food frequency questionnaires.

	CDQ-1		CDQ-2	
	Number of questions	Score range	Number of questions	Score range
Saturated fatty acids (SFA)	6	0 to 17	9	0 to 36
Fruit and vegetables (FV)	3	0 to 7	4	0 to 14
Monounsaturated fatty acids (MUFA)	2	0 to 4	1	0 to 8
Omega-3 polyunsaturated fatty acids ( $\omega$ -3)	3	0 to 8	3	0 to 21
Marine $\omega$ -3 fatty acids	1	0 to 3	1	0 to 12
Global dietary score = (MUFA + $\omega$ -3 + FV) – SFA	14	–17 to 19	17	–36 to 43

CDQ-1: Cardiovascular Diet Questionnaire 1; CDQ-2: Cardiovascular Diet Questionnaire 2.

**Table 2** Clinical characteristics of the participants in the three groups.

	Group I ( <i>n</i> = 99)	Group II ( <i>n</i> = 50)	Group III ( <i>n</i> = 27)
Age (years)	53 ± 10	56 ± 10	49 ± 9
Men	66 (67)	22 (44)	7 (26)
Women	33 (33)	28 (56)	20 (74)
ACD	19 (19)	0 (0)	0 (0)
CAD/PAD/TIA/stroke/AAA	13/8/7/3	0 (0)	0 (0)
Atherosclerotic risk factors			
Smoking	28 (28)	9 (18)	4 (15)
Hypertension	63 (64)	10 (20)	3 (11)
Type II diabetes	8 (8)	4 (8)	0 (0)
Hyperlipidaemia	76 (77)	9 (18)	0 (0)
Familial history of premature ACD	44 (44)	NA	5 (19)
BMI (kg/m <sup>2</sup> )	28.0 ± 4.8	25.5 ± 4.9	24.0 ± 2.7
Mean number of risk factors	2.94 ± 1.00	0.96 ± 0.90	0.81 ± 0.74

Data are expressed as mean ± standard deviation, number or number (%). AAA: abdominal aortic aneurysm; ACD: atherosclerotic cardiovascular disease; BMI: body mass index; CAD: coronary artery disease; NA: not available; PAD: peripheral artery disease; TIA: transient ischaemic attack.

**Table 3** Dietary scores with Cardiovascular Diet Questionnaire 2 in the three groups of participants.

	Score range	Group I	Group II	Group III-1 <sup>a</sup>	Group III-2 <sup>a</sup>
Dietary scores					
Global dietary score	-36 to 43	9.5 ± 9.3	7.0 ± 8.2	9.9 ± 5.9	9.6 ± 5.2
Saturated fatty acids	0 to -36	-6.9 ± 3.9	-7.1 ± 4.0	-6.0 ± 3.8	-6.0 ± 3.7
Fruit and vegetables	0 to 14	7.6 ± 2.8	6.8 ± 2.7	7.9 ± 2.2	7.4 ± 1.8
Unsaturated fatty acids	0 to 24	8.7 ± 4.9	7.3 ± 4.6	8.0 ± 3.4	8.3 ± 3.9
Monounsaturated fatty acids	0 to 3	1.3 ± 1.2	1.3 ± 1.0	1.5 ± 0.8	1.6 ± 1.0
Omega-3 polyunsaturated fatty acids	0 to 21	7.5 ± 4.5	6.1 ± 4.3	6.6 ± 3.2	6.7 ± 3.7
Marine omega-3 fatty acids	0 to 12	5.6 ± 3.8	4.7 ± 3.5	4.9 ± 2.7	4.7 ± 3.6

<sup>a</sup>For group III: Group III-1 = first completed questionnaire; Group III-2 = second completed questionnaire (1 month later).

**Table 4** Correlation and cross-classification between Cardiovascular Diet Questionnaire 1 and Cardiovascular Diet Questionnaire 2 in Group I participants.

	Correlation ( <i>n</i> = 99)		Cross classification		
	Spearman correlation coefficient	<i>P</i>	Same quartile	Same or adjacent quartile	Complete mismatching (extreme quartiles)
Global dietary score	0.91	< 0.001	61 (62)	98 (99)	0 (0)
Saturated fatty acids	0.86	< 0.001	62 (63)	96 (97)	0 (0)
Fruit and vegetables	0.93	< 0.001	77 (78)	98 (99)	0 (0)
Unsaturated fatty acids	0.78	< 0.001	51 (52)	90 (91)	0 (0)
Monounsaturated fatty acids	0.65	< 0.001	57 (58) <sup>a</sup>	a	a
Omega-3 polyunsaturated fatty acids	0.80	< 0.001	55 (56)	93 (94)	0 (0)
Marine omega-3 fatty acids	0.79	< 0.001	b	b	b

Data are expressed as number (%) unless otherwise indicated.

<sup>a</sup> For monounsaturated fatty acids the same “tertile” was used instead of the quartile because of a limited score range.

<sup>b</sup> A specific marine omega-3 fatty acid score was not available with Cardiovascular Diet Questionnaire 1.

