Relative validation of a short food frequency questionnaire to assess calcium intake in older adults

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Abstract

Objective: To develop and validate a food frequency questionnaire (FFQ) for estimating calcium intake in community-dwelling older adults using a food record as the reference method.

Method: A validation study involving 102 subjects (67 females) aged ≥65 years and residing independently in Adelaide, Australia, between 2002-06 was performed. Estimates of calcium intake over the last year were calculated from two versions (35 and 15 items) of the FFQ and compared with average intake from four days of non-consecutive food records (4DFR).

Results: Mean calcium intake from the 4DFR was 987 mg/day (95% CI 922-1051). The 35 and 15-item questionnaires gave mean intakes of 992 mg/day (95% CI 913-1,071) and 1017 mg/day (95% CI 927-1,106) respectively. Mean difference (95% limits of agreement) between the food record and the 35 and 15-item questionnaires was 5 mg (-739 – 729) and 28 mg (-936 – 879) respectively. The 15-item questionnaire demonstrated 82% sensitivity for classifying subjects with calcium intake below the estimated average requirement (EAR, 840 mg for males 51-70 years; 1,100 mg for females >51 years and males >70 years of age) and 46% specificity for classifying subjects with intake above the EAR.

Conclusion: The FFQ evaluated as part of this study is one of very few that has been tested across both genders and in older adults specifically. The 15-item version has demonstrated a level of sensitivity and specificity comparable with other FFQs for evaluating calcium intake.

Implications: The 15-item FFQ can be confidently used for measuring group mean calcium intake in older Australians or as a screening tool to allow health professionals to identify those who are most at risk of inadequate dietary calcium intake.

Keywords: ageing, dietary intake, calcium, osteoporosis.

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Osteoporosis is a disease characterised by low bone mass and is a major cause of both acute and chronic disability, particularly in older adults.[1] The impact of certain osteoporotic fractures can be severe and includes acute and long-term pain, activity restriction, and a reduced quality of life.[2] Furthermore, the health expenditure for treatment of osteoporotic fractures, associated complications and ongoing care is large.[3,4] Adequate calcium intake is central to the prevention and treatment of osteoporosis.[5-8] The 1995 Australian National Nutrition Survey (NNS) revealed that as many as 61% of females and 36% of males aged 65 years and over did not meet their recommended daily intake (RDI) for calcium (800 mg for males and 1,000 mg for females).[9] This suggests that for a significant portion of older adults in Australia there is an opportunity for preventive intervention if those with inadequate intakes can be identified.

A food frequency questionnaire (FFQ) is a recognised means of estimating nutrient intake and imposes less burden on the subject than other methods such as a food record.[10] The FFQ is easy to administer in large numbers of subjects and can be analysed in a relatively short period of time. This makes it a useful tool for determining those at risk of deficiency.[10,11] Ideally, every food intake method should be validated against a true external or biological reference.[12] As there is no appropriate biological measure for assessing calcium intake, the alternative is relative validation against a more comprehensive and precise dietary assessment tool, such as the food record.[11]

While FFQs assessing calcium intake have been validated in adult and postmenopausal women both in Australia and elsewhere,[13-23] relative validation studies that include men are scarce.[24] Both calcium-specific FFQs validated in Australian populations did not include men in their study sample.[14,19] It could also be assumed that consumption patterns in the older Australian population have changed significantly since the study by Angus et al.[14] in 1989. In addition, recommended calcium intakes have increased in recent revisions of the Nutrient Reference Values (NRV) for Australia and New Zealand, such that they are now in excess of 840 mg/day (up

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to 1,300 mg/day) for adults ≥65 years of age.[25] Thus, if a FFQ is to be used as a means of identifying older Australians with inadequate calcium intake, it should be assessed for its ability to classify individuals' calcium intake according to these higher requirement values.

The aims of the present study were to:

- Develop and validate a calcium-specific FFQ against average calcium intake from four non-consecutive days of food records in a sample of Australians aged 65 years and over.
- Assess the specificity and sensitivity of the FFQ in identifying those with calcium intake below the estimated average requirement (EAR) of the new Australian and New Zealand NRV (840 mg for males 51-70 years; 1,100 mg for females >51 years of age and males >70 years of age).[25]
- Examine whether use of fewer items in the FFQ could produce a similar rate of sensitivity and specificity.

Methods

Subjects

Subjects were recruited during three phases of data collection between 2002 and 2006. Recruitment occurred via advertisements posted at two large public hospitals in metropolitan Adelaide, South Australia, in addition to bowling clubs and retirement villages in the vicinity of these facilities. Subjects were also recruited from concurrent studies being conducted by the authors. None of the subjects were hospitalised at the time of data collection. Inclusion criteria were: male or female aged 65 years and over, living independently, and able to record their food and beverage intake over four non-consecutive days. The present study aimed to recruit a sample of approximately 100 subjects. This number is recommended as it provides a confidence interval for the limits of agreement that are approximately one-third the size of the standard deviation of the difference.[26] Willet indicates that a sample of 100 to 200 subjects is ideal for validation studies.[12]

Interested subjects were invited to attend an information and enrolment session with the investigator. Sessions were conducted in small groups of up to 10. Individual sessions were negotiated for subjects who could not attend a group session. On the day of enrolment, subjects providing informed consent were required to:

- Provide a brief medical history.
- List current medications including usage of vitamin and mineral supplements.
- Indicate their alcohol intake and smoking habits.
- Have their weight (nearest kg) and height (nearest 0.5cm) measured using calibrated digital bathroom scales (GlaxoSmithKline, China) and a stadiometer (CMS Weighing Equipment Ltd, London, England).
- Complete a self-administered FFQ (see Appendix 1).

Subjects also received comprehensive written and verbal instructions on how to keep a 24-hour food record. Ethical approval for this study was granted by the Repatriation General Hospital Ethics Committee, Adelaide, Australia.

Self-administered Food Frequency Questionnaire

The FFQ (see Appendix 1) consisted of questions relating to food and beverage items identified as major contributors to the calcium intake of the 1,960 Australians aged 65 years and over participating in the 1995 NNS.[9] Details of these items are included in Table 1. Questions referred to usual intake over the past year. For each food and drink item, a standard serve size was included to assist subjects in quantifying their usual consumption. However, subjects had the opportunity to specify their usual serve size if it differed from this amount. An additional question asked for an estimate of overall daily milk intake. This provided an alternative means of estimating daily milk consumption, which could reduce the number of items in the FFQ (see Table 1). All subjects were provided with standard verbal and written instructions on how to complete the FFQ. Once completed, each FFQ was reviewed by the investigator for clarity and completeness.

Calcium-fortified foods

In response to a recent amendment to the National Food Standards Code (Food Standards Australia New Zealand), which allows a greater range of food and beverage items to be fortified with calcium,[27] subjects recruited in 2006 (n=29) completed an additional set of questions to establish whether they regularly used any of the calcium-fortified milks, breads, breakfast cereals and orange juices available in Australian supermarkets, and if so which brand/s. This information was then used in conjunction

Table 1: Two-stage analysis of a food frequency questionnaire (FFQ) to estimate calcium intake[a] in Australians aged 65 years and over and the mean bias value[b] (±SE) added to the FFQ at each stage of analysis.

	Categories of items included (number of items in this category)	Bias value[b] (mg)	
		Males	Females
1. 35-item FFQ	Milk-based beverages (7); dairy foods including cheese, yoghurt and dairy-based desserts (13); bread and breakfast cereals (8); volume of milk added to beverages, breakfast cereals and porridge (5); type of milk used (1); type of bread used (1)	221 **(4.4)**	183 **(4.0)**
2. 15-item FFQ	As for 35 item, excluding bread, breakfast cereals and porridge (8), type of bread used (1) and replacing milk-based beverages (7) and volume of milk added to beverages, breakfast cereals and porridge (5) with single-item estimate of daily milk consumption (1)	326 **(6.0)**	261 **(4.6)**

Notes:

(a) Estimated calcium intake does not include calcium obtained from a vitamin or mineral supplement.

(b) Estimated calcium intake from each FFQ had a bias value added to it to compensate for the degree to which each FFQ was expected to under-estimate calcium intake. The bias value represents the mean difference between calcium intake calculated from the 1995 Australian National Nutrition Survey (NNS)[9] using all food and beverage items in the FFQ and total calcium intake from all food and beverage items in the 1995 Australian NNS.[9]

with the FFQ to estimate the proportion of subjects' calcium obtained from fortified foods. As orange juice is not included in the FFQ, subjects who regularly used calcium-fortified orange juice were asked to quantify how much they consumed and to identify the brand/s.

Four-day food record

Validation of the FFQ was achieved using four non-consecutive days of food records (4DFR). Subjects were instructed to use the metric spoon and cup measures provided to quantify their food and beverage intake. The food records were kept on four different days of the week specified by the investigator (including one weekend day) over a two to three-week period. All subjects completed their first food record the day after enrolment and returned it to the investigator via reply-paid post to allow checking for detail and clarity. The researcher notified subjects by telephone the day before each of the remaining three food records was to be kept.

Calculating calcium intake

Calcium intakes (mg/day) from the FFQ were calculated using *Nutritional Values of Australian Foods*[28] (2002 data) and *Foodworks* (Foodworks Professional Edition 1998-2005 Xyris Software Australia) (2004 and 2006 data). Calcium intakes from the 4DFR were calculated using *SERVE* (SERVE Nutrition Management System for Microsoft Windows, M & H Williams, St Ives, NSW) (2002 and 2004 data) and *Foodworks* (2006 data). Recipes provided by subjects that were not already in *Foodworks* or *SERVE* were entered according to their individual ingredients for the reported serve size. The choice of software program was determined by the licensing arrangements between Flinders University and the software manufacturers at the time of data collection and analysis. However, regardless of software program used, the nutrient composition obtained for a selected food in one program is identical to that obtained using the alternate program. The *Nutritional Values of Australian Foods*[28] contains >1,500 foods published in the first five volumes of *The Composition of Foods, Australia*.[29] *Foodworks* and *SERVE* both use AUSNUT,[30] a compilation of Australian food composition data including the *Nutritional Values of Australian Foods*.

Calcium intake calculated from the FFQ and the 4DFR did not include calcium obtained from vitamin and mineral supplements; this was calculated as a separate value. For subjects who consumed a multi-vitamin and mineral supplement for which the calcium content was unavailable, a value representing the average calcium content of the four most commonly taken multi-vitamin and mineral supplements in the subject population (73 mg) was used.

Data analysis

Calcium intake from the FFQ was estimated in two stages resulting in a 35 and 15-item FFQ (see Table 1). It was expected that both versions of the FFQ would under-estimate calcium intake as not all dietary sources of calcium were included in the FFQ. To compensate for this difference, a gender-specific bias value was obtained for each FFQ by calculating the mean difference between calcium intake from food and beverage items in the FFQ, according to the 1995 NNS,[9] and total calcium intake from all food and beverage items in the 1995 NNS.[9] The estimated bias value (see Table 1) was added to calcium intake from each FFQ to give a corrected FFQ (cFFQ). Given the small margin of error (<5%), use of the mean rather than application of a range was deemed appropriate.

Means (95% CI) were calculated for age, weight, body mass index (BMI; weight in kg/height in metres squared), and calcium intake measured by the uncorrected FFQ, each corrected version (35 and 15-item cFFQ) and the 4DFR. Mean difference (bias), SD and 95% limits of agreement were calculated to assess the agreement between each version of the cFFQ and the 4DFR as recommended by Bland and Altman.[31] Agreement between calcium intakes calculated from estimated milk versus that calculated from 12 items in the FFQ was assessed in the same manner. For the subgroup of subjects who consumed calcium-fortified foods and beverages, the mean (95% CI) was calculated for calcium intake from fortified foods.

The EAR (840 mg for males 51-70 years; 1,100 mg for females >51 years and males >70 years) was used as the cut-point to identify those most at risk of inadequate calcium intake.[25] Each subject was classified as having calcium intake above or below the EAR based on calcium intake from the 4DFR and corrected intake from each cFFQ. Classification according to both cFFQs and the 4DFR was used to calculate the percentage of subjects correctly classified and misclassified, as well as the sensitivity and specificity of each FFQ. Sensitivity was defined as the proportion of subjects with daily intake below the EAR according to the 4DFR

Table 2: Estimated calcium intake[a] according to the uncorrected FFQ, each version of the corrected food frequency questionnaire (cFFQ)[b] and four-day food records (4DFR) in a group of Australians aged 65 years and over. Data expressed as mean (95% CI).

Estimated calcium intake (mg)	Total sample (n=102)	Males (n=35)	Females (n=67)
4DFR	987 (922-1,051)	975 (847-1,103)	993 (919-1,067)
Uncorrected 35-item FFQ	796 (716-875)	717 (610-824)	837 (729-944)
35-item cFFQ	992 (913-1,071)	938 (831-1,045)	1,019 (912-1,127)
15-item cFFQ[c]	1,017 (927-1,106)	1,053 (865-1,241)	998 (899-1,096)

Notes:
(a) Estimated calcium intake does not include calcium obtained from a vitamin or mineral supplement.
(b) Estimated calcium intake from each FFQ plus the mean difference between calcium intake calculated from the 1995 Australian National Nutrition Survey (NNS)[9] using all food and beverage items in the FFQ and total calcium intake from all food and beverage items in the 1995 Australian NNS.[9]
(c) n=96 (61 females). No significant differences across gender according to independent samples t-test (p<0.05).

who also fell below the EAR according to the relevant cFFQ. Specificity was defined as the proportion of subjects with daily intake above the EAR according to the 4DFR who also fell above the EAR according to the relevant cFFQ. All statistical analysis was performed using SPSS (SPSS Inc., Chicago, Illinois, version 11.5 for Windows, 2002). A significance level was set at $p<0.05$.

Results

A total of 102 (67 female) subjects completed all components of the present study. The mean age of subjects was 75 years (95% CI 74-77). Subjects had a mean weight of 72 kg (95% CI 70-75) and a mean BMI of 27 kg/m^2 (95% CI 26-28). Thirty-one subjects reported no illness, with 35 subjects reporting just one illness. The four most common reported illnesses were categorised as hypertension (n=23), cardiovascular disease (n=18), arthritis (n=16), and osteoporosis (n=9). Fifty-four subjects consumed alcohol regularly (at least once a week) and two subjects were regular smokers. Fifty-seven subjects were married, 34 widowed, seven divorced or separated, and the remaining subjects (n=4) had never been married. Twenty subjects reported regularly taking a calcium supplement (200-600 mg calcium per tablet). Fifty reported regular intake of other vitamin and mineral supplements, 14 of which contained some calcium (18-200 mg calcium per tablet). Four subjects obtained calcium from both a calcium supplement and another vitamin and mineral supplement (total calcium from supplement 573-1,265 mg).

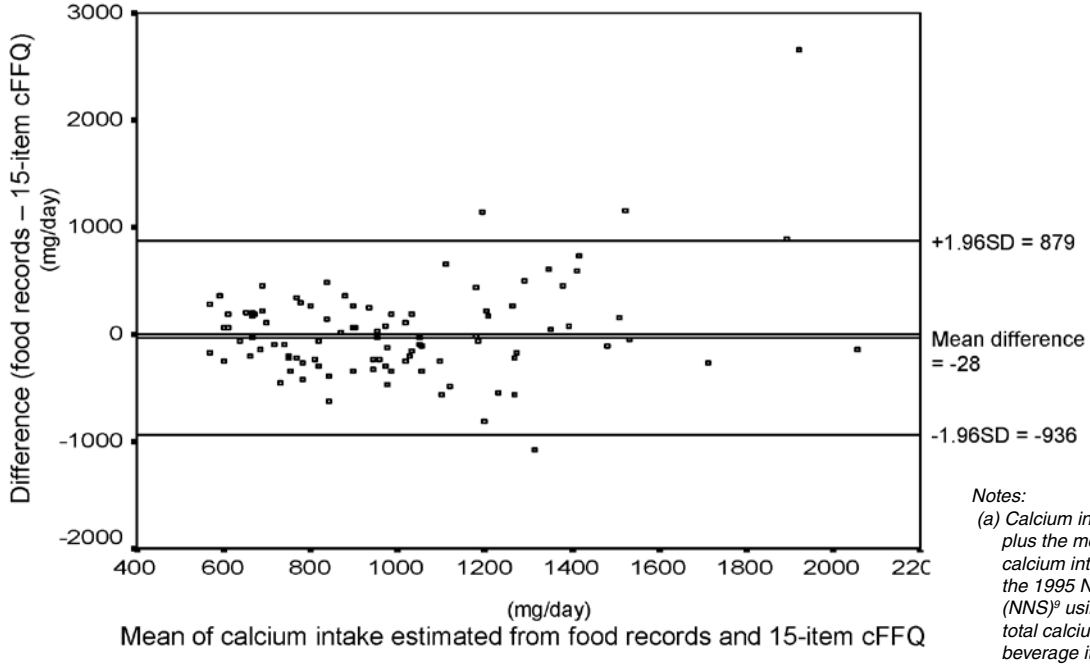
Estimated calcium intake according to each method

The results of the estimated calcium intakes from food and beverage items (supplements not included) according to the uncorrected 35-item FFQ, the 35 and 15-item cFFQ and the 4DFR are presented in Table 2. Estimated calcium intake did not differ between genders for any of these methods (see Table 2), therefore males and females have not been separated for subsequent analysis. The proportion of calcium intake from milk alone according to the uncorrected FFQ was 60% (95% CI 57-65), while dairy items (milk, cheese, yoghurt and milk-based desserts) contributed to 89% (95% CI 87-90) of estimated calcium intake. Data relating to the intake of calcium-fortified foods was available for 27 of the 102 subjects, eight of which reported regularly consuming foods or beverages fortified with calcium. Intake of calcium from fortified foods contributed an average 65 mg per day (95% CI 12-250) for this subset of subjects (n=8). Calcium obtained from subjects' estimated daily milk intake was compared with calcium intake calculated according to items in the FFQ. Estimated milk was only available for 96 subjects in the sample. The bias between these two methods was 28 mg (95% limits of agreement -744 – 801).

Agreement between the food records and the food frequency questionnaires

The 35-item cFFQ over-estimated calcium intake by an average of 5 mg/day (95% limits of agreement -739 – 729) when compared with the 4DFR. The agreement between the 15-item cFFQ and the 4DFR is illustrated in Figure 1. The 15-item cFFQ under-estimated calcium intake by an average of 28 mg (95% limits of

Figure 1: Mean vs. difference plot of estimated calcium intake from four-day food records compared with calcium intake from a 15-item corrected food frequency questionnaire (cFFQ)[a] in a group of Australians aged 65 years and over (n=96).



Notes:
(a) Calcium intake from the 15-item FFQ plus the mean difference between calcium intake (mg) calculated from the 1995 National Nutrition Survey (NNS)[9] using all items in the FFQ and total calcium intake from all food and beverage items in the 1995 NNS.[9]

agreement -936 – 879) when compared with the 4DFR. Figure 1 also illustrates an increasing bias (dispersion of data points) with increasing mean calcium intake.

Classification of subjects according to each method

The classification of subjects' calcium intake according to each cFFQ and the 4DFR is shown in Table 3. Seventy-five per cent (56+21/102) and 69% (50+16/96) of subjects were classified into the same category by both the 4DFR and the 35 and 15-item cFFQ respectively (see Table 3). The specificity error or rate of false positives (i.e. estimated calcium intake below the EAR according to the cFFQ but above according to the 4DFR) for the 35 and 15-item cFFQ was 16% (16/102) and 20% (19/96) respectively. The sensitivity error or rate of false negatives (i.e. estimated calcium intake above the EAR according to the cFFQ but below according to the 4DFR) was 9% (9/102) for the 35-item cFFQ and 11% (11/96) for the 15-item cFFQ. The sensitivity and specificity of both versions of the cFFQ are presented in Table 3.

The median percentage of the EAR met by the nine subjects misclassified as false negatives according to the 35-item cFFQ was 87% (95% CI 70-95) and the median percentage of the EAR met by the 11 subjects misclassified as false negatives according to the 15-item cFFQ was 86% (95% CI 56-95). According to the 4DFR, 18 out of the 30 subjects taking vitamin and mineral supplements containing calcium were found to have calcium intake below the EAR (without considering the calcium obtained from supplements).

Discussion

This is the first study to validate a calcium-specific FFQ suitable for screening for inadequate calcium intake in older Australians according to the recently published NRV.[25] Furthermore, it is one of the first to have included male subjects, which is important because of the increasing recognition of the presence and serious consequences of osteoporosis among men.[32] The findings of this study suggest that the FFQ developed by the authors, specifically for assessment of calcium intake in Australians aged 65 years and over, can provide an appropriate and clinically useful means for screening calcium intake in accordance with achievement of the EAR. Reducing the number of items analysed in the FFQ from 35 to 15 did not greatly affect its ability to correctly classify subjects according to the adequacy of their calcium intake.

Table 3: Sensitivity, specificity and classification of calcium intake according to both versions of the corrected food frequency questionnaire (cFFQ)[a] and four-day food records (4DFR) using the estimated average requirement (EAR)[b] to define inadequacy in a group of Australians aged 65 years and over (35-item cFFQ n=102; 15-item cFFQ n=96).

Estimated calcium intake according to:	Estimated calcium intake according to 4DFR		Sensitivity %	Specificity %
35-item cFFQ	<EAR	≥EAR		
<EAR	56	16	86	57
≥EAR	9	21		
15-item cFFQ				
<EAR	50	19	82	46
≥EAR	11	16		

Notes:
(a) Estimated calcium from each FFQ plus the mean difference between calcium intake calculated from the 1995 Australian National Nutrition Survey (NNS)[9] using all items in the FFQ and total calcium intake from all food and beverage items in the 1995 Australian NNS.[9]
(b) EAR= 840 mg for males 51-70 years; 1,100 mg for females >51 years and males >70 years of age.[26]

The 35-item cFFQ generally showed the best ability to classify subjects' calcium intake according to the EAR (sensitivity=86%, specificity=57%). However, sensitivity and specificity were fairly consistent for both versions of the cFFQ, demonstrating moderate to high sensitivity (82%-86%) and low to moderate specificity (46%-57%). These values are consistent with the literature, which reports sensitivity between 60-96% and specificity between 33-89% for calcium-specific FFQs.[16,20-21,24,33,34] Ideally, a screening tool will have both high sensitivity and specificity; however this is rare, and commonly an increase in one will compromise the other.[35] This is indeed what has been demonstrated in the present and other similar studies.[16,21,24,34]

Two studies reporting the greatest extremes in sensitivity and specificity[21,24] clearly demonstrated the difficulty in achieving both high sensitivity and high specificity. Both studies used cut-offs for calcium inadequacy that were far greater than the estimated calcium intake for the majority of participants. Hence, the very low proportion of participants in these studies being able to achieve an adequate calcium intake resulted in the low specificity and high sensitivity values reported. In contrast, Montomoli et al. (2002)[20] reported high sensitivity and specificity values (87% and 89% respectively), likely a result of a very comprehensive FFQ (19 food items with three questions per item) and a longer duration of recording for the reference method (14 days of estimated food records).

It is important to consider sensitivity and specificity in context with how a screening tool is to be used in the clinical setting. In this instance, an important purpose of the FFQ is to allow health professionals to identify and treat older adults who may be at an increased risk of osteoporosis because of inadequate dietary calcium intake. If the shortest 15-item cFFQ were used to detect those with inadequate calcium intake, the sensitivity error indicates 11% would miss out on receiving required intervention, and the higher specificity error means 20% of individuals would receive unnecessary intervention and resources may be wasted. It should be noted that the 11 subjects in the present study who were misclassified as false negatives by the 15-item FFQ had a median calcium intake that met 86% of the EAR, the majority (n=9) with intake above 70% of the EAR. This indicates the probability of nutritional risk for these individuals is very low.

While the corrected versions of the FFQ could be used to accurately assess group mean calcium intake, neither are suitable for assessing calcium intake at the individual level. For the 35-item

cFFQ, the inaccuracy could result in an over-estimation of up to 729 mg or under-estimation of up to 739 mg (range 1,468 mg), while for the 15-item cFFQ daily calcium intake for an individual could be over-estimated by as much as 879 mg or under-estimated by as much as 936 mg (range 1,814 mg). This potential range of inaccuracy is clearly unacceptable. The larger disagreement with the 4DFR between calcium intake found when using the 15-item cFFQ (1,814 mg) compared with the 35-item FFQ (1,468 mg) is due to the fact that calcium estimated from the single item of daily milk intake showed poor agreement with calcium estimated from the 12 items covering milk intake in the FFQ. However, the 35-item FFQ still had ranges of inaccuracy that were clinically significant and the benefits of the 15-item FFQ outweigh the benefits of a longer FFQ. The shorter questionnaire lends itself to be used as a screening tool for rapid assessment of calcium intake, is less complex for both the respondent and the assessor, and is considerably less resource intensive. Furthermore, it is the lower calcium intakes that are of primary interest here and the 15-item cFFQ seemed to show the greatest difficulty in accurately assessing individuals with higher mean calcium intakes, often under-estimating daily intake. These individuals may be obtaining a significant portion of their dietary calcium from sources that are not included in the 15-item FFQ.

The present study found that the use of calcium-fortified foods was not common. In addition, the contribution of calcium from fortified foods for the subgroup that regularly used them was not considered high enough to warrant the addition of these items to the FFQ. Including calcium-fortified foods in the FFQ would increase the complexity of the questionnaire for both the respondent and assessor. The need for their inclusion in the FFQ will require regular re-assessment, particularly if these products become more commonly available and consumed by older Australians.

Another complexity in this area is the use of vitamin and mineral supplements containing calcium. While the FFQ reported in this study does not explicitly capture the calcium content and use of these products, the use of vitamin and mineral supplements containing calcium does need to be routinely checked as part of a secondary assessment to prevent unnecessary intervention occurring. The results of the present study indicate that the use of supplements containing calcium is common in this age group and more than half the subjects using these supplements have inadequate calcium intake from food and beverage items alone.

The findings of the present study provide an important contribution to the literature in this area. Unlike previous work, the findings are presented in accordance with the increased NRV for calcium[25] and have included older men in the sample. The design of the FFQ is strong as it was based on consumption patterns specific to the subject population and included items that contribute the most to calcium intake within this population. The four days of food records were non-consecutive and therefore likely to provide a better estimate of variance.[36] The present study also used the most relevant means of data analysis to validate the FFQ, examining 95% limits of agreement and calculating sensitivity and specificity. A large number of calcium-specific validation studies fail to examine all these parameters, using correlation values to represent agreement between two methods,[13-15,17,18,23] which is inappropriate in this situation.[31]

Compared with the present study, studies that have examined bias and limits of agreement[16,19,21,22,24,33,34] report greater mean difference (31-144 mg) between calcium estimated by a food record and calcium estimated by a FFQ in addition to a clinically unacceptable range for assessment of individual calcium intake (710 to 1,428 mg). One exception to this is the study performed by Montomoli et al. (2002),[20] with mean bias of only 11.3 mg and 95% limits of agreement from -244 to 222. Once again, the comprehensive FFQ developed by Montomoli et al. (2002)[20] performed better than most, but due to its length and origin it is unlikely to be suitable as a screening tool in Australia.

The sample of the present study had very similar rates of calcium inadequacy according to the 1991 RDI for calcium (1,000 mg females; 800 mg males) to those found in the 1995 Australian NNS,[9] indicating the sample was representative of the general older Australian population and further supports the evidence that inadequate calcium intake is common among this age group (57% vs. 61% females; 34% vs. 36% males). That said, as the subjects were volunteers they are likely to have been healthier than many older Australians. This was evident in the present study as the majority of subjects reported just one illness. A random selection of subjects would have improved the study design, but was beyond the scope of the study.

A limitation of the present study is that four days of food records may not be long enough to capture a subject's usual calcium intake or sufficiently represent the time period (previous 12 months) captured by the FFQ. Eight days of food records has been indicated as optimal for ranking individuals' calcium intake.[37] However, it has been reported that using four to five days of food records is sufficient to correctly classify individuals into extreme thirds of calcium intake.[11] Furthermore, Nelson and Bingham (1997)[11] concluded that using three to four days of food records provides minimal differences in the accuracy of the assessment of dietary nutrients compared with a longer recording period of seven days. A significant consideration for an ageing population is subject burden, which would increase with a longer recording period. Thus, this approach is likely to increase under-reporting, reduce compliance, or result in alterations to usual dietary habits.[38] Minimising respondent burden together with limited resources meant four days of estimated food records was a suitable compromise for the present study.

The food record is not a precise measure of calcium intake, but as mentioned previously there is no true external or biological reference method for assessing calcium intake. Relative validation using diet records represent the best comparison method as the key errors associated with these methods are mainly independent of each other.[10] Key errors associated with food records are the possibility of alterations in usual dietary habits and an inability to capture the variation of an individual's diet, while those associated with the FFQ relate to memory, estimating usual serve size and interpretation of questions.[10]

Another explanation for the inaccuracy of the FFQ in the present study may be the older subject population, who could have a reduced ability to accurately recall their usual food and beverage intake over the previous 12 months.[39] While this is a plausible explanation, a recent study validating a calcium-specific FFQ across different age groups (10-75 years), which required recall over the previous 12 months, indicated that the agreement between the FFQ and the reference method was not affected by age.[40] This length of recall allows seasonal variation in calcium intake to be considered, which is an advantage of the FFQ method over other methods such as 24-hour recall.[10] While the FFQ appears to be a useful instrument to screen for inadequate dietary calcium intake among older adults, its ability to be translated to a younger population with less stable dietary patterns[41] requires further evaluation.

In conclusion, the 15-item cFFQ (see Appendix 1) could be used for measuring group mean calcium intake in older Australians. It has good potential for use as a rapid clinical screening tool for identifying older Australians at risk of inadequate dietary calcium intake and could therefore guide preventive intervention strategies. The FFQ designed in the present study could also be used for measuring group mean calcium intake in older Australians. It should not, however, be used to assess calcium intake at the individual level. Further research is required to establish the repeatability of the FFQ before it can be used as a reliable dietary calcium screening tool.

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Appendix 1: The Food Frequency Questionnaire

How to answer

If you NEVER have a food ..... write N
If you RARELY have a food (less than once a month) ..... write R
If you usually eat a food:
About once a MONTH ..... write 1M
About twice a MONTH ..... write 2M
About three times a MONTH ..... write 3M
About once a WEEK ..... write 1W
About twice a WEEK ..... write 2W
About three times a WEEK ..... write 3W
And so on ..... (4W, 5W, 6W, etc)
About once a DAY ..... write 1D
About twice a DAY ..... write 2D
And so on ..... (3D, 4D, 5D, etc)

Standard serves

Alongside each food there is a 'standard' serve size. The standard serve is not necessarily a 'normal' serve, it is simply there to help us measure food intake. If you usually eat more or less than the standard serve size for a particular food, please indicate (on the space provided) how much more or less is eaten at a time.

For example, if when you eat icecream you have one 'scoop' instead of our standard serve of two scoops, indicate how often icecream is eaten and then write 'one scoop'.

How to answer

NEVER	**RARELY**	**Times a MONTH**	**Times a WEEK**	**Times a DAY**
		1	**1**	**1**
N	**R**	**2 M**	**2 W**	**2 D**
		3	**3**	**3**
			and so on	**and so on**

Examples:

Custard	½ cup	3W	
Tea	1 cup	4D	
Icecream	2 scoops	3W	one scoop

The person above has on average:
A **standard** serve of custard **three times a week**
Four cups of tea **every day**
One scoop of ice cream **three times a week**

How often do you have these beverages?

1. Tea	1 cup	_____
2. Coffee	1 cup	_____
3. Glass of milk	1 cup	_____
4. Cocoa/Drinking choc/Milo/Aktavite	1 cup	_____
5. Flavoured milk (choc, coffee)	Small carton (375ml)	_____
6. Milkshake/thickshake	Medium size	_____
7. Sustagen	Small carton (250ml)	_____
Do you have milk: (circle where appropriate)		
8. In your tea:	Yes, qty per cup (ml)	_____
	No	_____
	Don't drink tea	_____
9. In your coffee	Yes, qty per cup (ml)	_____
	No	_____
	Don't drink coffee	_____

Continued next page

Continued from previous page

10. Do you make your drinking chocolate/cocoa/Milo/Aktavite with: (circle one)
(a) mostly milk (b) about half and half
(c) mostly water (d) I do not drink these

11. What type of milk do you usually have?[a]
(e.g. whole milk, Skimmer, Light choice, Skim choice ['Tone'], Take Care, powdered skim milk, Calcium choice, evaporated milk and Soy milk.)

Type of milk used: _____

How often do you eat these foods?

Cheese		
12. Prepacked slice[a]	1 (20 g)	_____
13. Hard/tasty[a]	1 slice (20 g)	_____
14. Cream[a]	1 tablespoon	_____
15. Cottage[a]	1 tablespoon	_____
Yoghurt		
16. Natural[a]	small carton (200 g)	
17. Fruit[a]	small carton (200 g)	
18. Fruche[a]	small carton (200 g)	
19. Le Rice[a]	small carton (180 g)	
20. Creamed Rice[a]	1 serve (150 g)	_____
21 Crème Caramel[a] (commercial)	1 (150g)	_____
22. Custard[a]	½ cup	_____
23. Rice pudding/sago/ semolina/tapioca[a]	½ cup	
24. Icecream[a]		
tub	2 scoops (summer)	
	(winter)	_____
on stick/cone	1 scoop (summer)	_____
	(winter)	_____
25. Weet-bix	2 biscuits	_____
26. Cornflakes	1 cup	_____
Muesli (specify brand)		
27. Homemade	½ cup	_____
28. Toasted	½ cup	_____
29. Untoasted	½ cup	_____
30. Cereal flakes (specify brand)		_____
Other (specify brand)		_____
31. Porridge	1 cup, cooked	
	(summer)	_____
	(winter)	_____

32. Do you make your drinking porridge with: (circle one)
(a) mostly milk
(b) mostly water
(c) about half and half
(d) I do not eat porridge

Please specify the amount of milk that you would usually use to make porridge
_____ml OR _____ cups

33. How much milk would you usually add to cereal? (circle the closest amount)
(a) none
(b) about half a cup
(c) about 1 cup
(d) about 2 cups or more (please state how much _____)

34. How much milk in all forms would you drink in a day?[b]
_____ml OR _____ cups

35. How many slices of bread do you usually eat? Remember the bread in sandwiches and toast (1 large roll = 3 slices of bread).
_____ slices/day OR _____ slices/week

36. What type of bread do you usually eat?
(a) white
(b) wholemeal
(c) mixed grain
(d) other (please specify) _____
(e) I do not eat bread

Thank you for completing the questionnaire

Notes:
(a) Item included in 15-item Food Frequency Questionnaire.
(b) Item included in 15-item Food Frequency Questionnaire but not in the 35-item questionaire.