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Calcium intake and knowledge among white adolescent girls in Gauteng, South Africa

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Objectives. To determine the knowledge and intake of calcium among white adolescent girls in Gauteng, South Africa.

Design. A quantitative study using a questionnaire interview conducted over 13 months (1 June 2000 - 31 July 2001).

Settings. Sixteen randomly selected private and state schools in the Gauteng area.

Subjects. Adolescent white girls aged between 15 and 17 years.

Outcome measures. Calcium intake and knowledge using a food frequency questionnaire (FFQ) and 7-day weighed records (WRS).

Results. Mean calcium intake according to the FFQ was 811 mg/day (adequate intake (AI) 1 300 mg/day). Fifty-one per cent of participants had not been given any information relating to calcium and its benefits. Teachers and parents are the most noted sources of information and 31% of the participants knew that adolescence was the most important period for calcium absorption and bone building.

Conclusions. Adolescents have low intakes of calcium compared with what is recommended. It is important to develop intervention programmes that target children, adolescents, teachers and mothers alike. It is also imperative to develop awareness of the importance of calcium consumption during childhood and adolescence in order to minimise the possibility of osteoporosis in later life.

Because of the high incidence of osteoporosis, calcium is a vital nutrient for adolescents. The adolescent growth spurt combined with the vulnerability of women to osteoporosis in later life, suggests an urgent need to emphasise calcium requirements. Adequate intakes (AIs) are currently estimated to be adequate to meet the known losses and needs for growth after adjusting for absorption. Although the AI for adolescent calcium intakes is 1 300 mg/day,[1] there is considerable uncertainty as to the optimal intake.[2,3] For example, the UK reference nutrient intake is 1 000 mg/day for adolescent girls,[4] while the World Health Organisation (WHO/FAO) recommends between 400 and 500 mg/day.[5]

While the need for calcium during growth has never been questioned, many researchers have debated the issue of how much calcium may be optimal. Results of recent research[6] indicate that optimal calcium intakes may be greater than the amounts consumed by most individuals. Calcium needs and retention are greater during pre-adolescence and puberty than in either childhood or adulthood. During the adolescent growth spurt 45% of adult skeletal volume is formed and bone mineral content is increased at a rate of 8.5% per year.[7-10]

Recent evidence suggests that adding 500 - 1 000 mg to current daily calcium intakes (to yield total intakes of 1 500 mg/day), will increase bone accretion rates in

adolescent girls by as much as 6%. In women, this would translate into optimal bone status at menopause and potentially act as a prophylaxis against osteoporosis.[11-14]

Some studies,[15-17] however, have failed to show sustainable benefits of calcium supplementation on bone mineral content after calcium supplement withdrawal, suggesting that calcium supplementation may reduce the remodelling space rather than increasing the overall mineralisation of bone.

The main purpose of this study was to determine whether adolescents had adequate calcium intake in relation to the AI and to determine their knowledge pertaining to calcium.

Methodology

Preliminary study

The study was undertaken in two phases. The food frequency questionnaire (FFQ) was validated in the preliminary phase, while its reproducibility was assessed in the main study. In the preliminary study an FFQ (a modification of the questionnaire used by MacIntyre[18]) and a 7-day weighed record (WR) (a modified version as used by MacIntyre[18]) were used and anthropometric data collected, while in the main study only an FFQ was undertaken, with anthropometric data collected.

Subjects and sample size

The research was undertaken on a sample of white adolescent girls aged between 15 and 17 years, from 16 schools throughout the Gauteng area. The sample size was calculated on the assumption that out of an average class of 50 pupils, 40% would volunteer.

Selection of schools

The Gauteng map was divided into four areas: north-east, north-west, south-east and south-west. Four schools were selected per area using random numbers to represent the participating area.

Inclusion criteria for schools

Only schools with a majority of white pupils, not less than 200 pupils in total, and that volunteered to participate were included.

Recruitment of schools and subjects

Each school was informed of its inclusion in the study via mail using supporting documentation. A liaison officer (grade 10 or 11 teacher) in each school arranged for the researcher to address the learners about the research.

During these visits the researcher emphasised that volunteers were needed to complete a dietary questionnaire and to have their height and weight measured. Volunteers were addressed by the researcher regarding when the research was to be conducted and each volunteer was given a sealed envelope to present to her parents. This envelope contained information on the researcher and the research project. Consent forms were attached for permission to participate in the study. The particulars of those participants who indicated willingness to participate were recorded and the school was requested to make a day available for the research.

Anthropometry

Height was measured to the nearest 5 mm with a tape measure placed against a perpendicular wall. Participants stood erect without shoes looking forward with the head in the Frankfurt plain, and heels perpendicular to the wall. All participants were weighed in light clothing without shoes to the nearest 0.5 kg on a portable electronic scale (Soehnle Digital, Germany). Body mass index (BMI) was calculated using the formula weight (kg)/height (m^2).

Interview schedule development

The FFQ made up the largest portion of the interview schedule (IS). Food items were listed together with their descriptions, with columns provided for the amount of food eaten and the frequency of consumption (number of times per day, per week, per month or seldom). The FFQ did not ask about the whole diet but only about calcium-rich foods, so the FFQ was not representative of the participants' whole diet. The questionnaire was pre-tested on 10 volunteers. Comments and problems with regard to the clarity and understanding of questions were addressed in a subsequent questionnaire. The questionnaire was also shortened because of time restraints. Fourth-year female students in food and beverage management were recruited as field workers to aid with the collection of data. The field workers were trained during a 3-day workshop.

The FFQ included additional questions to determine the participants' knowledge of calcium. There were 12 knowledge questions covering aspects such as the functions of calcium, preventive aspects of calcium intake and sources of calcium. These questions were both open- and closed-ended.

Content and face validity were ensured by basing questions on the literature (U MacIntyre — personal communication, 1999) and consulting with experts in the field (H Abrahamse —personal communication, 1999).

To ensure consistency the research team met after every fourth school had been evaluated in order to debate the completed research and future activities. Problems were discussed and techniques and methods revised and checked. Information was cross-checked

and recorded to ensure ongoing accuracy.

Validation of the FFQ

Validity of the FFQ was tested in the preliminary phase by the researcher and two field workers. The desired sample was estimated at 10% of the estimated sample size of 320, therefore a minimum of 32 participants was required. Volunteers were recruited to participate in the validation study, as this imposed a considerable burden on the participants.

The 3 schools selected were schools that showed interest in doing both the FFQ and the WR. This required the teacher to monitor the participants' progress throughout the 7 days on 2 occasions. All teachers involved in the research were presented with the research documentation sent to the schools before the researcher's visit. They were asked to read through it before the researcher liaised with them and to document any questions or concerns. An appointment was made with each of the teachers, during which time the researcher interviewed and informed them about the upcoming research. Their roles were clearly discussed and they were well equipped to assist in data collection.

The WR was conducted over a 7-day period, including a weekend. Consensus was obtained from all participants regarding the starting date. Each participant was given a WR diary that made specific provision for the record keeping of all foods consumed during the day. An example was presented to the participants, by the researcher, on how each entry was to be recorded. The researcher collected the WRs a week later and reviewed them for completeness.

Reproducibility of the FFQ

Reproducibility was tested in the main phase of the study and the desired sample size was estimated at 10% of the estimated sample size of 320, so a minimum of 32 participants were needed. Only volunteers were recruited and 2 schools were involved. At the end of the first interview the participants were asked if they would be willing to undergo the FFQ a second time, approximately 3 months later within the same season. Most of the participants in the first round of the FFQ complied with the reproducibility study and were present on the second visit. Teachers' encouragement and involvement ensured a positive turnout for the second questioning period.

Data collection

In the main study, the field workers assisted in completing the FFQ. As the research proceeded it became evident that the field workers were spending more time than was allocated per questionnaire. This resulted in long periods of absence by participants from classes. Although the interviews were timed during pre-testing (approximately 60 minutes), this was found to be unacceptably long by most of the schools and therefore additional amendments were needed to ensure participation by the schools. At the end of the first 6 months it was decided that in the next 6 months the field workers would work with groups of 3 - 5 participants. The field workers were thoroughly briefed on how to administer this new technique of data collecting, and possible problems that might arise were discussed. Each participant had a copy of the questionnaire and the field worker asked the group each question as it appeared on the questionnaire.

To ensure that there was quality control and standardisation of interviewers the main researcher was present at all schools during data collection periods, and with the aid of the field workers ensured that all questionnaires were as complete as possible.

Statistical analyses

For the validation process, Spearman's rank correlation coefficients were applied to the calcium intakes of the FFQ and those from the WR. Mean difference in calcium intake was tested using the ***t***-test for paired samples. For reproducibility, correlations between the first and second administration of the FFQ were calculated using Spearman's rank correlation coefficients.

Statistical analyses of the data from the main study included the calculation mean, median and standard deviation. Categorical data were expressed as frequencies. Dietary data were analysed using a computer programme based on the South African food composition tables.[19] The statistical programme used was Statistical Package for the Social Sciences, 1995 (SPSS).[20]

The completed WR was first analysed to estimate energy intake, then analysed for calcium-rich foods for comparison with the FFQ.

Knowledge questions were analysed to establish the frequency of the correct answers and then calculated to a percentage.

Ethical considerations

The Ethics Committee of the Technikon Witwatersrand approved the study. Written consent was granted by the Department of Education for the research to be conducted in schools in the Gauteng area. All parents signed a consent form granting permission for their daughters to participate in the research.

Results

Validity

A total of 40 participants were recruited to complete the 7-day WR, of which only 34 (85%) returned usable

records. Reasons for records not being used were that they were incomplete (N = 3) and that dietary energy intakes exceeded the sample mean of the WR ± 2 SD (6 592.5 kJ and 943.7 kJ) (N = 3).

The mean calcium intake according to the WR was 518.7 mg/d (SD 226.4/mg/d), while for the FFQ it was 1 074 mg/d (665.1 mg/d). The mean intake recorded on the FFQ for calcium was significantly higher than that recorded on the WR ($p < 0.05$). There was no correlation ($r = 0.11$) ($p = 0.520$) between calcium intakes estimated on the FFQ and those on the WR.

Reproducibility

To ensure that the FFQ was reproducible 40 participants were recruited. Owing to energy values exceeding the sample mean ± 2 SD (11 064 kJ and 1 525.9 kJ), 3 subjects (7.5%) were eliminated, so only 37 participated.

The mean for the first administration of the FFQ (FFQ1) was 835.3 mg/d (SD 279.8 mg/d), and for the second administration (FFQ2) 804.2 mg/d (230.1 mg/d) ($p < 0.05$).

The Spearman's rank correlation coefficient ($r = 0.7$) shows that there was a significant correlation coefficient ($p < 0.001$).

Main study

Subjects and sample size

A total of 282 participants was used in this section of the study from the sample population of 320 in the main study. Exclusion from the analyses was based on energy intake exceeding the sample mean ± 2 SD.

Anthropometry

Table I indicates that 74% of the subjects were within the normal BMI range, 21.5% were underweight and 4.5% were obese. Chronic energy deficiency existed in 16 participants with BMI levels below 18.5 kg/m^2, resulting in moderate to severe thinness in 6% of the participants.

Table I. Body mass index results and analysis (N = 282)

BMI	N	%	Criteria
< 16.0	8	2.3	CED grade III — severe thinness
16.0 - 16.99	8	2.3	CED grade II — moderate thinness
17.0 - 18.49	44	15.6	Underweight — mild thinness
18.5 - 26.9	209	73.7	Normal weight
27 - 29.9	6	2.1	Obesity grade I
30 - 39.9	6	2.1	Obesity grade II
≥ 40	1	0.3	Obesity grade III

BMI = body mass index (kg/m^2); CED = chronic energy deficiency.[37]

Calcium intake

The mean reported calcium intake was 811 mg/day (SD 322 mg/d), 68% of AI. Table II reflects the distribution of calcium intakes. The majority (58%) had intakes below two-thirds of AI (866 mg/d), 34% had adequate intakes, while 7% had intakes higher than the recommended amount of 1 300 mg/day. According to the WHO's recommendations,[5] intakes below 400 mg/day result in far fewer individuals (10%) being at risk.

Dietary calcium knowledge

In response to the question on the function of calcium in the body, 91% of the participants stated that calcium was used to strengthen and build bones and teeth. Only a small minority (6%), did not know the function of calcium, while 3% stated other functions such as heartbeat and growth.

The question as to whether calcium can prevent cancer and high blood pressure resulted in 42% stating that it could not, and 58% stating that it could. Participants were asked if any person had discussed or given them information on calcium and its functions. Fifty-one per cent stated they had received no information, while 49% stated 'yes' to receiving some information.

With regard to who provided them with information on calcium, parents and family were mentioned by 46%,

Table II. Calcium frequency distribution (N = 282)

Calcium levels	N	%	Criteria
< 866 mg or $^2/_3$ of the AI (USA) (1 300 mg/d)	164	58.1	Inadequate intakes — group at risk
866 - 1 300 mg/d	97	34.4	Adequate intakes
> 1 300 mg/d	21	7	> AI
AI (UK) < 1 000 mg/d	82	29	Inadequate intakes —
LRNI < 450 mg/d	35	12.4	group at risk
AI (WHO/FAO) < 400 mg/d	27	10	Inadequate intakes — group at risk

AI (USA) = adequate intakes for the USA (excluding Canada);[1] AI (UK) = adequate intakes for the UK;[4]
LRNI (UK) = lower reference nutrient intake;[4] AI (WHO/FAO) = adequate intakes for the World Health Organization.[5]

teachers and health workers 43% while 5% had heard about it on the television, radio or in magazines. Other sources (6%) were of little significance.

When participants were asked to identify the most important age for calcium absorption to take place, infancy was mentioned by 31%, followed by adolescence (25%), childhood (19%) and throughout life (25%). Calcium needs and retention are in fact greatest during pre-adolescence and puberty, more so than in either childhood or adulthood.[7-10]

Discussion

Validity

In general, the WR showed significantly lower calcium intakes than those of the FFQ. A possible reason for the higher calcium values could be the fact that the FFQ focused on calcium-containing foods, thus obliging the participants to recall calcium-containing food intakes.[21] Overreporting in this area could be due to the sheer number of calcium- containing products asked about in the FFQ. The mean calcium result in this FFQ, namely 1 074 mg/d, was similar to the mean results (1 166 mg/d) obtained with the Youth/Adolescent Questionnaire (YAQ) used by Rockett and researchers[22] in the USA and very similar to the 1 094 mg/d found by Karvetti and Knuts.[23]

The WR method was selected for the validation study as it is a valid and reliable method of obtaining true daily intakes according to Montomoli and researchers.[24]

This method has proved successful in other studies,[21] but may not have been the best method to use in this adolescent population as the burden of keeping a WR could have resulted in changes in eating patterns. Respondents could have reduced the number of foods and snacks consumed and decreased the complexity of their diet by substituting foods that were simpler to record.[23,25-27]

The correlation of nutrients could improve with an increase in the number of days recorded in the WR, as found in a study by Potosky and co-workers[28] and Montomoli and researchers.[24] Research by Heaney *et al*.[29] confirms that this period of observation (7 days) may not be long enough to assess calcium intakes accurately.

The high food requirements of these participants in combination with unstructured eating patterns and a significant degree of out-of-home eating suggests that serious bias towards underestimation could have occurred with the WR.[26,27,30,31] This could be attributed to forgetfulness and lack of compliance caused by the irritation and tedium of having to record food intakes on an almost hourly basis. [32,33]

The fact that adolescents lack maturity with regard to this type of dietary investigation could have contributed to the validation results obtained in this study. Poor validation was obtained in spite of the voluntary participation in completion of the WR and FFQ.

Reproducibility

The positive reproducibility result could reflect the consistent manner in which the FFQ was administered.

Anthropometry

The fact that 21.3% of the participants had BMIs below 18.5 kg/m^2 could be detrimental since thin women are at greater risk of osteoporotic fractures.[29,34] Body weight is one of the most powerful determinants of bone mass and overweight women have been shown to absorb calcium with greater efficiency and to lose less bone at menopause. However, while obese women are known to be protected from osteoporotic fractures, trading one disease for another does not seem an attractive strategy in an effort to optimise bone strength.[34-36]

Table I illustrates that 60 participants (21%) were classified as underweight.[37] Of these 60 participants, 16 (5%) showed levels of moderate thinness (2.5%) and severe thinness (2.5%).[30] These results reflect low dietary intakes and could be linked to the low calcium intake historically experienced in adolescence. The high prevalence of underweight girls might also be reflective of a high occurrence of eating disorders in this adolescent population.

Calcium intake

The mean calcium intake of 811 mg/d does not meet the 2000 AI quota of 1 300 mg/d for adolescence.[1] Dietary energy intake was not measured by the FFQ as it focused specifically on calcium-containing foods, and this could be looked upon as a shortcoming of the study. According to *The Nutritional Status of South Africans*,[38] a literature review done in 1997, the mean calcium intake of white women aged between 16 and 24.9 years was 803 mg/day. There does not seem to have been much change since then, even when using different methods of dietary analysis.

Unfortunately, relatively little information exists on the factors influencing a decrease in calcium intake. It is possible that there is increased concern with body size and shape, and milk intake may be cut because of the misconception that it is fattening.[33,39,40] Other reasons could be that many women do not know what the recommended intake of calcium is, and some may not feel personally at risk of developing a disease related to low calcium intake.[41-43]

The low intakes of calcium reported indicate a risk of calcium deficiency, as 58% (Table II) were classified as being in the at-risk[44] group according to the AI. However, the WHO's recommendation shows that there does not seem to be a great risk of inadequate calcium intake in our study group.[5]

Although many of the variables affecting calcium intake among adolescents are unexplained,

interventions focusing on taste appeal, peer and family education programmes may be effective. Adolescent studies have shown that taste is one of the most important influences in food choice.[45-47] Other important factors that could contribute to calcium intake are beliefs, attitudes and sensory evaluations.[41,48,49]

Dietary calcium knowledge

Most of the study group (91%) knew the functions of calcium. This suggests that adolescents are aware of the major health benefits of calcium, but lack specific information on daily requirements. Lack of information could contribute to adolescents' suboptimal intake of calcium[34,50] — only 49% of the participants had been given any formal or informal information related to calcium, leaving the rest of the subjects (51%) uninformed.

The majority of the adolescents (91%) were aware of the importance of calcium in bone formation, but only 58% knew of its role in the prevention of cancer and regulation of blood pressure.[34,51,52]

Limited knowledge could be one of the multiple factors leading to inadequate calcium intake during adolescence. If adolescents had more knowledge of calcium they might consume larger amounts of this mineral.[34,51]

Peer and family education programmes might be an effective means of providing nutritional education for adolescents.[45,49,53,54] Dietary habits of family members and peers, as well as advertisements, affect adolescents' dietary habits, therefore advertisers and families should be included in any calcium educational programme for adolescents. Parents and schoolteachers seem to be the best people to facilitate a calcium education programme as they have proved to be the best way for calcium-related information to reach the target group.[41]

Adolescents were not aware of the most important stage of bone development — only 25% gave adolescence as the period of greatest development. Adolescents grow at the greatest rate of any age group after infancy and the growth of the skeleton requires a positive calcium balance to reach optimal peak bone mass. Knowing that adequate calcium intake during adolescence is critical for the prevention of osteoporosis could ensure a higher consumption of calcium, and those adolescents who are aware of the daily calcium requirements could consume more of this essential mineral. Health concerns and food preferences are prominent motives that could trigger change in the eating habits and patterns of adolescents.[55]

Conclusion

Because of the maximum bone mass acquired during puberty, calcium deposits during these years may determine the risk of osteoporosis and fractures in adulthood.[34,56-58]

It is therefore conceivable that one approach to reducing the risk of osteoporosis may be provision of adequate calcium knowledge and intake during the formative years. By discovering what perceptions and concerns influence calcium consumption among adolescents, researchers can develop educational strategies that translate the benefits demonstrated in clinical trials to adolescents in general. The validation results could imply that there was an overestimation of calcium intake in the FFQ and therefore the number of subjects with low intake could have been under-estimated. This would mean that more girls have low intakes than was found, and that the problem is more severe than realised. Further research is needed to identify and change the attitudes and behaviours leading to low calcium intake, and to determine how best to communicate the important nutrient contribution of dairy products as part of a healthy diet.

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