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Reliability and Validity of a Brief Questionnaire to Assess Calcium Intake in Female Collegiate Athletes

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Abstract

Calcium intake often is inadequate in female collegiate athletes, increasing the risk for training injuries and future osteoporosis. Thus, a brief and accurate assessment tool to quickly measure calcium intake in athletes is needed. We evaluated the reliability and validity, compared to 6 days of diet records (DRs), of the Rapid Assessment Method (RAM), a self-administered calcium checklist (14). Seventy-six female collegiate athletes (mean age = 18.8 yrs, range = 17–21; 97% Caucasian) were recruited from basketball, cross-country, field hockey, soccer, and volleyball teams. Athletes completed a RAM at the start of the training season to assess calcium intake during the past week. Two weeks later, a second RAM was completed to assess reliability, and athletes began 6 days of diet records (DRs) collection. At completion of DRs, athletes completed a final RAM, corresponding to the same time period as DRs, to assess agreement between the 2 instruments. The RAM demonstrated adequate test-retest reliability over 2 weeks ($n = 56$; Intraclass correlation [ICC] = .54, $p < .0001$) and adequate agreement with DRs ($n = 34$; ICC = .41, $p = .0067$). Calcium intake was below recommended levels, and mean estimates did not differ significantly on the RAM (823 ± 387 mg/d) and DRs (822 ± 330 mg/d; $p = .988$). Adequacy of calcium intake from both DRs and the RAM was classified as “inadequate” (<1000 mg/d) and “adequate” (≥ 1000 mg/d). Agreement between the RAM and DRs for adequacy classification was fair (ICC = .30, $p = .042$), with the RAM identifying 84% of athletes judged to have inadequate calcium intake based on DRs. The RAM briefly and accurately estimates calcium intake in female collegiate athletes compared to DRs.

Keywords

calcium intake; collegiate athletes; Rapid Assessment Method

Introduction

The adequacy of calcium intake is an important determinant of bone health. During adolescence and young adulthood, calcium intake is positively correlated with the achievement of peak bone mass (6, 30, 33), which is an important determinant of future osteoporosis risk (29). Likewise, calcium intake during adulthood is related positively to bone mass (9, 15) and negatively to bone fracture risk (16). Calcium supplementation increases bone mass in younger individuals (e.g., pre-menopausal) and slows loss in older individuals (2, 9, 17, 26).

Among young, physically active individuals, calcium intake is related to bone mass and risk of musculoskeletal injuries. Myburgh et al. (25) reported that elite female athletes with stress fractures had lower calcium intakes than those athletes without stress fractures, matched for age, height, and weight. Exercisers with shin soreness were found to have significantly lower calcium intake compared to uninjured exercisers, controlled for age, sex, and activity level (24).

Several case-control studies have reported that low bone mass (which, as shown above, is influenced by calcium intake) is associated with stress fractures in young adults. For example, Bennell et al. (5) found that female track and field athletes with stress fractures had lower total-body bone mineral content, and lower lumbar spine and foot bone mineral density than those female athletes without stress fractures, matched for age, weight, and height. Likewise, military recruits who developed stress fractures during basic training had lower bone mass at several sites compared to age-, height-, and weight-matched recruits (27), although conflicting findings exist (8). Adequate calcium intake appears to be important for preventing low bone mass and some musculoskeletal injuries in physically active populations.

The Food and Nutrition Board, Institute of Medicine recommends calcium intake of 1300 mg/d for 14–18-year-old males and females, and 1000 mg/d for men and women 19–30 years of age (37). However, calcium intake among adolescent and young adult females in the U.S. is below recommended levels (1, 11). Calcium needs are likely to be greater among athletes than the general population (7, 19), but average intake levels among female athletes appears to be inadequate and similar to that of same-age individuals in the general population (31). For example, Moffatt (22) demonstrated that high school female gymnasts had deficits in calcium intake (706.7 ± 355.50 mg) as well as other nutrients. Additionally, another study confirmed the low calcium intake (683 ± 58 mg) of collegiate female gymnasts (18). Across five women's collegiate athletic teams (basketball, golf, tennis, track/cross-country, and volleyball), calcium intake was well below recommended levels (31), averaging 900 mg/d.

Given these concerns about the adequacy of calcium intake in athletes, a calcium intake assessment instrument is needed for this population. To be useful, such an instrument needs to have adequate reliability and validity, and be brief, inexpensive, and easy to administer in field settings. Several dietary assessment instruments are available, which meet some, but not all, of these requirements for assessment of calcium intake. The most popular instruments include diet records (DRs), 24-hour dietary recalls, and food frequency questionnaires (FFQs).

While DRs are sometimes considered the “gold standard” in diet assessment, burden is substantial in terms of effort required both to accurately record intake and to code the data (34). Twenty-four-hour dietary recalls have similar problems, and several repeated administrations are required because of daily variability in consumption (12, 34). Semi-quantitative food frequency questionnaires (FFQ) have been developed as a way to more accurately assess *usual* dietary intake, without the concomitant participant burden. Individuals report foods and beverages consumed, including portion sizes, from a comprehensive list of foods for a specified time period.

Several FFQs have been found to reliably and validly estimate calcium intake (e.g., 10, 12, 13, 28). Data collection and processing costs are low compared to other methods, but the length of a traditional FFQ (60–100 foods) prohibits its use as a screening tool. A few, shorter calcium-specific FFQs or checklists have been developed for populations other than the U.S., including Australia (3), Finland (35), and New Zealand (36). These instruments may not be appropriate for the American population, since the major food sources of calcium vary by country. Two such instruments have been developed in the U.S., but for peri-menopausal (23) and older adult women (10). However, the generalizability of these findings to populations with different dietary patterns, such as collegiate athletes, is unknown.

The Hertzler and Frary (14) Rapid Assessment Method (RAM) assesses calcium intake specifically, rather than total dietary intake, and was developed on several groups of Americans, including college students, making it pertinent to collegiate athletes. The RAM is brief, requires little time to complete, is inexpensive to administer and score, and requires literacy only at an eighth grade reading level. A limitation is that the instrument’s reliability and validity have not been sufficiently evaluated. The RAM was developed and initially evaluated in college students and their parents at a university health fair ($N=275$), Head Start teachers ($N=21$), and undergraduate students ($N=509$). Test-retest reliability over 3 weeks was excellent ($r=.80$), but the RAM’s validity, compared to 3-day DRs, was relatively weak ($r=.28$). At least three factors may have accounted for this weak validity. First, the RAM and DRs assessed different time intervals, with DRs being completed 1 week after the RAM was administered. Second, the validity sample contained many participants who were suspected of inaccurate reporting based on extremely low (<200 mg) or high (>5000 mg) calcium intakes, or unusually excessive differences in reporting between the two methods (>1500 mg). When these outliers were removed (15% of the sample), the validity coefficient increased to .68. Removal of observations in a validation study because of between-instrument inconsistency is methodologically problematic, however. A third possible contributor to the lack of between-methods agreement is their use of 3-day DRs.

According to Eck et al. (12), 3-day DRs showed poor reliability for calcium intake compared to 6-day DRs due to substantial day-to-day variability in intake. Therefore, 3-day DRs may not be the most appropriate standard of comparison.

Further research is needed to evaluate the RAM's reliability and validity. In particular, its usefulness in young adult athletic populations for young adult athletes has not been determined. In addition, the accuracy of the RAM has not been evaluated against an adequate "gold standard" dietary assessment method, which would be at least 6 days of DRs collected for the same time interval as the RAM. As such, the goals of the present study were to assess the test-retest reliability of the RAM over a 2-week period and its validity compared to 6-day DRs, among a sample of female collegiate athletes. This study also examined the RAM's utility as a screening instrument to identify athletes who have inadequate calcium intake. Last, the nature of reporting discrepancies between the RAM and DRs was investigated.

Methods

Participants

Participants were recruited from several women's sports teams at a Division III NCAA college ($n = 73$) and a Division I NCAA university ($n = 3$) in the Mid-South. These teams included basketball, cross-country, field hockey, soccer, and volleyball. Permission was obtained from the head strength and conditioning coach at each institution for the research team to attend a training session for each team at the start of the season to explain the study and recruit participants. The protocol and written informed consent document were approved by the University of Memphis Institutional Review Board and the Office of the Dean of Student Affairs, Rhodes College.

Instruments

Rapid Assessment Method (RAM)—The RAM (14) is a checklist of major food sources of calcium in the American diet, based on data from the Second National Health and Nutrition Examination Survey (1976–1980). To simplify reporting, foods are listed according to groups of similar items. These food groups include milk, yogurt, and cheese; fruits and vegetables; breads and cereals; meat, fish, poultry, and beans; and, fat, sugar, and alcohol. Extra foods that contain lower concentrations of calcium along with a fat-sugar-alcohol group also are included to provide a balanced framework of foods from which to select. The respondent indicates the number of servings of each food consumed over the past 7 days, which is a sufficiently long time period to ascertain usual calcium intake (12).

To assist respondents in their estimation of serving sizes, line drawings of two-dimensional portion sizes by ounces, cups, and slices were provided. Although nutritionists often provide food models and training to individuals completing dietary checklists, portion size drawings were provided instead of training to keep the assessment as brief as possible and to replicate "real world" usage of the instrument.

Slight modifications were made to the RAM. First, the instructions in the Hertzler and Frary (14) RAM asked the participant(s) to record the usual number of servings on a *typical* day in

the last week. On the modified RAM, the participant was asked to record the *actual* number of servings during the past week. This change was made to increase the accuracy of reporting. Second, calcium supplemented foods that had come on the market after the RAM was developed were added (orange juice, bread, and light bread). Third, bagels and potatoes were added, since they were found in our clinical work to be popular among college athletes. Fourth, quiche was deleted because it was rarely consumed in our previous work with college athletes (31). Finally, all major references to calcium were removed to reduce biased reporting.

Total calcium intake was estimated from the RAM by multiplying the total number of servings of each food by the corresponding calcium value (mg) in each food group. Then, the total number of servings and total milligrams of calcium within each food group were summed. Finally, each food group total was summed to derive the total calcium intake for the past week. To estimate average daily intake, total weekly calcium intake was divided by seven.

Six-day Diet Records (DRs)—For six consecutive 24-hour periods, participants were instructed to record the time that a food or beverage was consumed, the meal designation, the name of all foods eaten, the amount eaten, and the details of preparation. At the end of each day, the participant also reported whether the day's consumption was typical, if she was ill, and if she was on a diet. Prior to data collection, a registered dietitian and dietetics graduate student trained participants to complete the DRs, using standardized food models to demonstrate serving sizes.

Data obtained from DRs were analyzed using the DINE Nutrient Analysis Program for IBM-compatible computer systems (DINE Systems, Inc., Amherst, NY, USA). This analysis program includes a database of over 8000 food items, and features the capability of adding new foods and recipes as needed. DINE is capable of estimating a variety of nutrients but was used only to assess calcium intake in the present study. DRs were coded according to the same food groups listed on the RAM (e.g., milk, yogurt, cheese, fruits, and vegetables) to directly compare calcium intake for each group by the two instruments. An "extra food" grouping was used to include foods reported on the DRs that were not captured by any of the standard food groupings.

Procedure

Data were collected during three strength and conditioning training sessions.

Session 1—This session was conducted during the 1st week of the training season. Study procedures were explained, written informed consent was obtained, and the first of three RAMs (RAM I) was completed, which covered the previous week's dietary consumption. The RAM was administered by a trained graduate student who provided instructions and briefly checked completed forms for missing or questionable responses.

Session 2—Approximately 2 weeks after Session 1 ($M = 16.9$ days), a second RAM was completed (RAM II). After completing RAM II, participants were trained and practiced recording their dietary intake with DRs, using a standardized protocol developed by the

University of Memphis Center for Community Health. Participants were then instructed to record their dietary intake the next day and to continue for 5 additional days. A graduate student was available at strength and conditioning training sessions during this 6-day period to answer questions and collect completed DR.

Session 3—Approximately 1 week after Session 2 ($M = 8.4$ days), participants completed a third RAM (RAM III), which corresponded to the same data collection period as the DRs.

Approach to Data Analysis

Agreement coefficients, calculated as intraclass correlations (ICCs), were used to assess both test-retest reliability and validity. Following the methodology of Eck et al. (12), agreement coefficients were chosen over Pearson product-moment correlations because the former indicates the extent to which the methods are equivalent rather than merely proportional. Assessing equivalence is important, since we were interested in the extent to which the two instruments are interchangeable. To assess test-retest reliability, RAM I was compared to RAM II. To assess validity, the 6-day DRs were compared to RAM III.

The RAM's utility as a screening device to identify individuals with low calcium intake was assessed by categorizing calcium intake, as assessed by both the DRs and RAM III, as either "inadequate" (<1000 mg/d) or "adequate" (≥ 1000 mg/d), based on national dietary recommendations (37). The Food and Nutrition Board of the Institute of Medicine (37) has established 1000 mg/d as an adequate calcium intake for 19–30-year-old males and females, based on intake estimates derived from healthy individuals in this age group. Agreement between the two instruments was calculated by the percent agreement and ICC.

To determine the sources of discrepancies between reported calcium intake on the DRs and RAM III, we compared the mean calcium intake for each food category. For categories in which mean intakes differed by ≥ 1 SD (387 mg/d), we undertook a qualitative analysis, comparing each participant's responses on the DRs and RAM in terms of types of food, number of servings, and portion sizes reported.

Results

Seventy-six participants were recruited for this study (22 cross country, 15 soccer, 3 basketball, 13 volleyball, and 23 field hockey). Ninety-seven percent of the sample (74 of 76) were European Americans; the remainder were African Americans. Participants' average age was 18.8 ± 1.1 years (range = 17–21). The average height, weight, and body mass index was 65.4 ± 2.4 in., 131.9 ± 15.6 lbs., and 21.7 ± 2.3 kg/m², respectively.

Initial data collection occurred during mandatory training sessions for all female athletes, and all who were present provided baseline data (RAM I). However, participation was voluntary, and not everyone completed the study due to scheduling conflicts or lack of interest. Of the 76 participants, 57 participants (75%) completed RAM I and RAM II for the reliability analysis; 35 participants (46%) completed RAM III and 6-day DRs for the validity analyses.

Study non-completers and completers were compared in terms of baseline calcium intake (based on RAM I) and team membership. Non-completers and completers did not differ significantly in terms of baseline calcium intake ($M = 1142.5 \pm 513.5$ mg/d vs. 1230.2 ± 625.5 mg/d, respectively; $t_{68} = -.64$, $p = .52$). Completion rate differed according to team ($\chi^2 [4, N = 75] = 14.74$, $p = .0053$), ranging from 28.6% for cross-country to 100% for basketball. However, calcium intake did not differ significantly across teams ($F_{4, 65} = 1.40$, $p = .24$).

One participant's calcium intake was substantially above the norm for this sample. This cross-country athlete's calcium intake was 5380.9 mg/d based on RAM I, which was 5.3 *SD* units above the mean. Her calcium intake based on subsequent RAMs and DRs was similarly high. Intake levels were confirmed with this participant who reported consuming large amounts of calcium-rich foods to help treat a bone fracture. Although her data were valid, she was excluded from subsequent analyses because she disproportionately influenced the magnitude of associations for both reproducibility and validity. For example, the association between RAM I and RAM II (2-week test-retest reliability), as indicated by the ICC, was .79 with this participant included and .41 with her excluded.

Test-retest Reliability

Two-week test-retest reliability was assessed by comparing calcium intake from RAM I and RAM II (see Table 1). On average, calcium intake measured on the RAM II was 269.4 mg/d ($SD = 455.6$) lower than RAM I ($t_{55} = -4.42$, $p < .0001$). Agreement between the RAM I and RAM II was moderate (ICC = .54, $df = 55$, $p < .0001$). The magnitude of association was slightly greater using the Pearson product-moment correlation ($r = 0.58$).

Validity

The validity of the RAM was assessed by comparing calcium intake estimates on RAM III and 6-day DRs (see Table 2). Agreement between the two instruments was moderate (ICC = .41, $df = 33$, $p = .0067$). Mean total calcium intakes did not differ significantly between RAM III (823 ± 387 mg/d) and DRs (822 ± 330 mg/d; $t_{33} = -.015$, $p = .988$). In terms of the specific food groups, the RAM overestimated calcium intake from fruits/vegetables and sugars/fats, and underestimated intake from meat/legumes (Table 3).

Identification of Athletes With Low Calcium Intake

In order to evaluate the usefulness of the RAM as a screening device to identify athletes with low calcium intake, each participant's calcium intake, from both the RAM III and DRs, was categorized as "adequate" (≥ 1000 mg/d) or "inadequate" (< 1000 mg/d) to meet the nutrient needs of individuals in this age group, according to national recommendations (37). As illustrated in Table 4, 21 of 34 participants (61.8%) were judged to have inadequate intake on both the RAM III and DR, and 4 of 34 participants (11.8%) were judged to have adequate intake on both instruments. Thus, exact agreement between the RAM and DRs was 73.5%. Of those participants who were categorized as having inadequate calcium intake based on DRs, the RAM similarly classified 84.0% of them (21 of 25 participants). Overall agreement between the two instruments for classification of intake as adequate versus inadequate was fair (ICC = .30, $df = 33$, $p = .042$).

Qualitative Analysis of Differences Between DRs and RAM

To identify sources of discrepancies in reported calcium intake, responses within each food group were evaluated for participants whose intakes differed by ± 1 *SD* between DRs and RAM. It was hypothesized that discrepancies would be due to high-calcium foods being reported on DRs that were not included on the RAM, or to differences in portion sizes or number of servings. Comparison of discrepant responses indicated that under- or over-reporting on the RAM tended to be consistent across food groups. No consistent errors or biases in under- or over-reporting number of servings or portion sizes were observed within any food groups.

One pattern was identified that contributed to discrepancies of calcium reported on the fruits and vegetables section was that participants were unaware of which vegetables qualified as “dark green.” Participants consistently classified lettuce as a dark green vegetable on the RAM. As dark green vegetables contain a substantial amount of calcium, and lettuce does not, this error contributed to larger calcium intakes from vegetables on the RAM than on the diet records.

The only foods that were not included on the RAM but contributed a significant amount of calcium, based on the DRs, were Powerbars® and quiche. Quiche was included on the original RAM developed by Hertzler and Frary (14), but was removed from the modified version of the instrument used in this study because it was expected that this food would not be commonly consumed by this population. The total amount of calcium contributed by the extra foods was substantial for some participants (range = 99–414 mg). However, except for quiche and Powerbars®, all of the foods in the “extra foods” section contained only small amounts of calcium, if any.

Discussion

The results of the present study indicate that the RAM, a brief checklist that can be completed in less than 10 min, provides similar estimates of calcium intake compared to DRs. The RAM was shown to have adequate test-retest reliability over a 2-week period. In addition, the RAM demonstrated adequate agreement with calcium intake assessed by DRs, considered the “gold standard” in self-report dietary assessments. Furthermore, the RAM was shown to be a useful screening device to identify athletes with inadequate calcium intake. These results are encouraging given the inadequacy of calcium intake in this age group and the important role that calcium plays in bone health.

Consistent with previous findings in female athletes, calcium intake in this study was below recommended levels. Average calcium intake during athletic training, based on both the RAM and DRs, was approximately 822 mg/d. Recent recommendations have called for calcium intakes of 1300 mg/d for 14–18-year-old males and females, and 1000 mg/d for 19–30 year olds (Institute of Medicine, Food and Nutrition Board; 37). Calcium needs may be even higher in competitive athletes (7, 19). Our findings highlight the need for routine assessment of calcium intake in female athletes.

Test-retest reliability of the RAM over a 2-week period was adequate but far from perfect. Mean calcium intake differed by 269.4 mg/d across two administrations of the RAM, and the agreement coefficient was moderate ($ICC = .54$). The difference in mean intake may partly represent true variation in calcium intake. The time periods assessed differed by 2 weeks, and there is considerable day-to-day variability in calcium intake among young adults (12). The degree of reproducibility observed in the present study is similar to several other studies. For example, Eck et al. (12) reported ICCs of .59 and .63 for repeated administrations of two 1-week FFQs. In an earlier study, Eck et al. (13) reported a reliability coefficient (Pearson product-moment) of .57 for calcium intake assessed twice by a 1-week FFQ. In the only previous study to evaluate the reproducibility of the RAM, Hertzler and Frary (14) reported a reliability coefficient (Pearson product-moment) of .80 for two administrations over a 3-week period. The greater reliability observed by Hertzler and Frary (14) compared to the current study may be related to the larger sample size in the former. With only 56 participants in the test-retest reliability component of the present study, some restriction in the range of true calcium intake values is likely to have occurred, which would be expected to reduce the magnitude of association between the instruments. In support of this, the current study achieved a much greater reliability coefficient when a participant with very high calcium intake was included. When data for this participant was included, the reliability coefficient (using Pearson product-moment) was .81, which is virtually identical to that reported by Hertzler and Frary (14).

Agreement between the RAM and DRs was adequate ($ICC = .42$) and is generally in the range found by other validity studies of calcium intake comparing FFQs to DRs. Across 10 studies that compared calcium intake from FFQs and DRs, validity coefficients ranged from .24 to .88 and averaged 0.56 (3, 10, 12–14, 20, 28, 32). In the only previous study to compare the RAM to DRs, Hertzler and Frary (14) reported a validity coefficient (Pearson product-moment) of .28 using 3-day DRs among 119 college students. The validity coefficient in this previous study was significantly improved when statistical outliers were removed who were suspected of under- or over-reporting food intake ($r = .68$). Several studies, assessing calcium intake with FFQs other than the RAM, have reported much higher validity coefficients than observed in the current study. For example, Eck et al. (12) compared 6-day DRs to two versions of a 7-day FFQ. ICCs of .65 and .84 were reported. Similarly, Cummings et al. (10) reported a validity coefficient (Pearson product-moment) of .76 comparing usual calcium intake on FFQ to 7-day DRs.

Several possible reasons exist for the lower validity coefficient observed in the present study compared to previous ones. First, our sample size ($n = 34$) was smaller than several previous studies. A small sample size may deflate the validity coefficient if it does not represent the full range of values (21). Second, FFQs used in some other studies have included a larger number of items, which may provide a more accurate assessment of calcium intake. The RAM included 54 items compared to other FFQs that have included more than 100 items (e.g., 13). Despite this disclaimer, the RAM did include all the major sources of calcium intake in the American diet. It should also be noted that high validity coefficients have been reported for some FFQs that included a relatively small number of items (e.g., 3). Also, Cummings et al. (10) demonstrated that validity coefficients remained similar across FFQs varying in length from 5 to 34 items.

This study demonstrates the utility of the RAM as a screening device to detect low calcium intake. Overall agreement between the RAM and DRs, correcting for chance agreement, was fair ($ICC = .30$). In terms of identifying those individuals with low calcium intake as measured by DRs, the RAM correctly identified 84%. Therefore, the RAM can reasonably identify those with low calcium intake and who may be in need of intervention to reduce their risk of training-related bone injuries and future osteoporosis.

Our qualitative comparison of responses on the DRs and RAMs, for food categories in which average intake differed substantially on the two instruments, indicated some reasons for discrepant reporting that should be addressed. Respondents should be reminded that lettuce does not qualify as a dark green vegetable. Although the amount of calcium in each of the extra foods was small, when added together the total amount from extra foods did contribute to the daily calcium totals. Powerbars® and other similar calcium-fortified “energy” bars, as well as quiche, should be included on the RAM. In addition, including sections for extra foods and oral calcium supplements would allow other important sources of calcium to be properly considered.

This study included several positive features. First, it sampled athletes from several sports teams. Because inadequate calcium intake is pervasive among women athletes, the RAM must be able to validly assess intake across many types of athletes. Another important feature is that *agreement* rather than mere *association* between the RAM and DRs was assessed. Other studies have used the Pearson product moment correlation, which is not an appropriate measure of agreement or interchangeability between measures. In the present study, ICCs were used to assess agreement, as has been recommended (4, 12). Finally, this study used 6 days of DRs for comparison to the RAM. This is important, since fewer days of DRs generally produce lower reliability coefficients, due to substantial day-to-day variation in calcium intake (12).

Despite these strengths, several limitations of the study should be noted. First, the relatively small sample size may have led to an underestimation of the true validity coefficient due to range restriction in calcium intake. Second, neither the RAM nor the “gold standard” instrument to which it was compared in this study (diet records) may adequately capture the use of calcium-fortified foods unless the respondents purchase their own food and are cognizant of nutrient labels. This limitation may be especially applicable to college athletes who eat in campus dining facilities. However, use of calcium-supplemented foods is thought to be uncommon in college food service due to the relatively high cost of these products and, in fact, neither university in our study provided calcium-fortified foods in their dining facilities. Another weakness is the lack of heterogeneity in our sample. Virtually all participants were Caucasian females from a Division III NCAA college. Future research should determine whether these results can be replicated in other groups (African Americans, male athletes, and Division I NCAA schools).

In summary, this study demonstrates that a simple, inexpensive self-report checklist can estimate calcium intake reliably and accurately in female collegiate athletes. The RAM is likely to be a helpful and cost-effective screening device to identify athletes with inadequate

calcium intake who could benefit from interventions to reduce the risk of bone injuries and future osteoporosis.

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References

1. Alaimo K, McDowell MA, Briefel RR, Bischof AM, Caughman CR, Loria CM, Johnson CL. Dietary intake of vitamins, minerals, and fiber of persons ages 2 months and over in the United States: Third National Health and Nutrition Examination Survey, Phase 1, 1988–1991. *Adv Data*. 1994; 14:1–28.
2. Aloia JF, Cohn SH, Vaswani A, Yeh JK, Yuen K, Ellis K. Risk factors for postmenopausal osteoporosis. *Am J Med*. 1985; 78:95–100.
3. Angus RM, Sambrook PN, Pocock NA, Eisman JA. A simple method for assessing calcium intake in Caucasian women. *J Am Diet Ass*. 1989; 89:209–214. [PubMed: 2915093]
4. Armstrong, BK.; White, E.; Saracci, R. Epidemiology. New York: Oxford University Press; 1994. Principles of Exposure Measurement in.
5. Bennell KL, Malcolm SA, Thomas SA, Reid SJ, Brukner PD, Ebeling PR, Wark JD. Risk factors for stress fractures in track and field athletes. *Am J Sports Med*. 1996; 24:810–818. [PubMed: 8947404]
6. Bronner F. Calcium and osteoporosis. *Am J Clin Nutr*. 1994; 60:831–836. [PubMed: 7985620]
7. Clarkson PM, Haymes EM. Exercise and mineral status of athletes: calcium, magnesium, phosphorus, and iron. *Med Sci Sports Exerc*. 1995; 27:831–843. [PubMed: 7658944]
8. Cline AD, Jansen GR, Melby CL. Stress fractures in female army recruits: implications of bone density, calcium intake, and exercise. *J Am Coll Nutr*. 1998; 17:128–135. [PubMed: 9550456]
9. Cumming RG. Calcium intake and bone mass: a quantitative review of the evidence. *Calcif Tissue Int*. 1990; 47:194–201. [PubMed: 2146986]
10. Cummings SR, Block G, McHenry K, Baron RB. Evaluation of two food frequency methods of measuring dietary calcium intake. *Am J Epidemiol*. 1987; 126:796–802. [PubMed: 3661527]
11. Eck LH, Hackett-Renner C. Calcium intake in youth: sex, age, and racial differences in NHANES II. *Prevent Med*. 1992; 21:473–482.
12. Eck LH, Klesges LM, Klesges RC. Precision and estimated accuracy of two short-term food frequency questionnaires compared with recalls and records. *J Clin Epidemiol*. 1996; 49:1195–1200. [PubMed: 8827001]
13. Eck LH, Klesges RC, Hanson CL, Slawson D, Portis L, Lavasque ME. Measuring short-term dietary intake: development and testing of a 1-week food frequency questionnaire. *J Am Diet Assoc*. 1991; 91:940–945. [PubMed: 1894902]
14. Hertzler AA, Frary RB. A dietary calcium rapid assessment method (RAM). *Topics Clin Nutr*. 1994; 9:76–85.
15. Holbrook TL, Barrett-Connor E. An 18-year prospective study of dietary calcium and bone mineral density in the hip. *Calcif Tissue Int*. 1995; 56:364–367. [PubMed: 7621342]
16. Holbrook TL, Barrett-Connor E, Wingard DL. Dietary calcium and risk of hip fracture: 14-year prospective population study. *Lancet*. 1988; ii:1046–1049.
17. Horowitz M, Wishart JM, Goh D, Morris HA, Need AG, Nordin BEC. Oral calcium suppresses biochemical markers of bone resorption in normal men. *Am J Clin Nutr*. 1994; 60:965–968. [PubMed: 7985641]
18. Kirchner EM, Lewis RD, O'Connor PJ. Bone mineral density and dietary intake of female college gymnasts. *Med Sci Sports Exerc*. 1995; 27:543–549. [PubMed: 7791585]

19. Klesges RC, Ward KD, Shelton ML, Applegate WB, Cantler ED, Palmieri GMA, Harmon K, Davis J. Changes in bone mineral content in male athletes. *J Am Med Assoc.* 1996; 276:226–230.
20. Larkin FA, Metzner HL, Thompson FE, Flegal KM, Guire KE. Comparison of estimated nutrient intakes by food frequency and dietary records in adults. *J Am Diet Assoc.* 1989; 89:215–223. [PubMed: 2915094]
21. McCall, RB. *Fundamental Statistics for Psychology*. 3rd. New York: Harcourt Brace Jovanovich; 1980.
22. Moffatt RJ. Dietary status of elite female high school gymnasts: inadequacy of vitamin and mineral intake. *J Am Diet Assoc.* 1984; 84:1361–1363. [PubMed: 6491118]
23. Musgrave KO, Giambalvo L, Leclerc HL, Cook RA, Rosen CJ. Validation of a quantitative FFQ for rapid assessment of dietary calcium intake. *J Am Diet Assoc.* 1989; 89:1484–1488. [PubMed: 2794308]
24. Myburgh KH, Grobler N, Noakes TD. Factors associated with shin soreness in athletes. *Physic Sports Med.* 1988; 16:129–134.
25. Myburgh KH, Hutchins J, Fataar AB, Hough SF, Noakes TD. Low bone density is an etiologic factor for stress fractures in athletes. *Ann Int Med.* 1990; 113:754–759. [PubMed: 1978620]
26. Peterson BA, Klesges RC, Kaufman EM, Cooper TV, Vukadinovich CM. The effects of an educational intervention on calcium intake and bone mineral content in young women with low calcium intake. *Am J Health Promot.* 2000; 14:149–156. [PubMed: 10787766]
27. Pouilles JM, Bernard J, Tremollieres F, Louvet JP, Ribot C. Femoral bone density in young male adults with stress fractures. *Bone.* 1989; 10:105–108. [PubMed: 2765307]
28. Rimm EB, Giovannucci EL, Stampfer MJ, Colditz GA, Litin LB, Willett WC. Reproducibility and validity of an expanded self-administered semiquantitative food frequency questionnaire among male health professionals. *Am J Epidemiol.* 1992; 135:1114–1126. [PubMed: 1632423]
29. Ross PD. Osteoporosis: frequency, consequences, and risk factors. *Arch Intern Med.* 1996; 156:1399–1411. [PubMed: 8678708]
30. Sentipal JM, Wardlaw GM, Mahan J, Matkovic V. Influence of calcium intake and growth indexes on vertebral bone mineral density in young females. *Am J Clin Nutr.* 1991; 54:425–428. [PubMed: 1858707]
31. Slawson DL, McClanahan BS, Clemens LH, Ward KD, Klesges RC, Vukadinovich CM, Cantler ED. Food sources of calcium in a sample of African-American and Euro-American collegiate athletes. *Int J Sport Nutr.* 11:199–208.
32. Stuff JE, Garza C, Smith EO, Nicholds BL, Montandon CM. A comparison of dietary methods in nutritional studies. *Am J Clin Nutr.* 1983; 37:300–306. [PubMed: 6823893]
33. Teegarden D, Lyle RM, Proulx WR, Johnston CC, Weaver CM. Previous milk consumption is associated with greater bone density in young women. *Am J Clin Nutr.* 1999; 69:1014–1017. [PubMed: 10232644]
34. Thompson FE, Byers T. Dietary assessment resource manual. *J Nutr.* 1994; 124:2245S–2317S. [PubMed: 7965210]
35. Uusi-Rasi K, Salmi H, Fogelholm M. Estimation of calcium and riboflavin intake by a short diary. *Scand J Nutr.* 1994; 38:122–124.
36. Wilson P, Horwath C. Validation of a short food frequency questionnaire for assessment of dietary calcium intake in women. *Eur J Clin Nutr.* 1996; 50:220–228. [PubMed: 8730608]
37. Yates AA, Schlicker SA, Suitor CW. Dietary reference intakes: the new basis for recommendations for calcium and related nutrients, B vitamins, and choline. *J Am Diet Assoc.* 1998; 98:699–706. [PubMed: 9627630]

Table 1
Test-Retest Reliability of Average Calcium Intake (mg/d) From the RAM Over a 2-Week Period (*N* = 56)

RAM I		RAM II		Difference		Pearson *	ICC ⁺
<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>		
1195.5	555.8	925.8	373	269.4	455.6	0.58 ^a	0.54 ^a

* Pearson product-moment correlation coefficient;

⁺ Intraclass correlation coefficient;

^a *p* < .0001.

Table 2
Agreement Between the RAM and Diet Records for Average Calcium Intake (mg/d; $N = 34$)

RAM III		6-day diet records			Pearson [*]	ICC ⁺
<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>			
822.2	330.7	823.2	387.3	0.42 ^a	0.41 ^b	

^{*} Pearson product-moment correlation coefficient;

⁺ intraclass correlation coefficient;

^a $p = .0137$;

^b $p = .0067$.

Table 3Comparison of the Means ($\pm SD$) of Calcium Intakes (mg/d) From the RAM and Diet Records ($N = 34$)

Food group	RAM	Diet records	<i>p</i>
Dairy	556 $\pm$ 247	311 $\pm$ 333	.405
Fruits/vegetables	130 $\pm$ 137	46 $\pm$ 36	.001
Grains	94 $\pm$ 46	111 $\pm$ 46	.124
Meats/legumes	13 $\pm$ 13	36 $\pm$ 43	.001
Sugar/fats	29 $\pm$ 21	9 $\pm$ 11	.000
Extra foods		99 $\pm$ 87	
Total intake	822 $\pm$ 331	823 $\pm$ 387	.988

Note. Data from the third RAM to be administered (RAM III) were used in these analyses. Probability value from between-group *t* tests.

Table 4

Number and Percent of Participants Classified As Having “Adequate” or “Inadequate” Calcium Intake on the RAM and Diet Records

RAM	Diet records	
	Inadequate (<1000 mg/d)	Adequate (≥ 1000 mg/d)
Inadequate (<1000 mg/d)	N= 21, 61.8%	N= 5, 14.7%
Adequate (≥ 1000 mg/d)	N= 4, 11.8%	N= 4, 11.8%

Note. Calcium intakes of 1000 mg/d or more were classified as “adequate,” and intakes of < 1000 mg/d were classified as “inadequate,” based on national recommendations for 19–30 year olds (37). Percentages are of the total sample.