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Research article

Validity of a dietary calcium questionnaire modified to include supplement use in athletes

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Abstract

When conducting research in the area of bone health, accurate measurement of calcium intake is crucial. The rapid assessment method (RAM) is one technique that has frequently been used for its measurement of calcium intake. However, the RAM and other currently established questionnaires lack the assessment of dietary supplement use, which is common for athletes. Our objective was to evaluate the validity of a RAM questionnaire designed to assess daily calcium consumption which was further modified to meet the needs of athletes who frequently consume dietary supplements. Usefulness of the modified RAM for athletes and non-athletes was evaluated as well as utility among those who do and do not use supplements. The 47 volunteers (n = 31 women, 16 men) were between the ages of 18 and 25 including, 33 athletes and 14 controls. The population also contained 23 supplement users and 24 non-supplement users. Participants completed the modified RAM and were instructed to complete a three-day diet record (3DR), logging food intake for 2 weekdays and 1 weekend day. The data collected via the modified RAM was compared with the 3DR. Mean calcium intake was $935\text{mg} \pm 420\text{mg}$ and $1085\text{mg} \pm 573\text{mg}$, for the modified RAM and 3DR respectively. A strong positive correlation (r) was found between calcium intake measured with the modified RAM and 3DRs ($r(45) = 0.854$, $p < 0.01$). Intraclass correlation coefficients (ICC) revealed that agreement between the two instruments was good (ICC = 0.76, $df = 45$, $p < 0.01$) and much improved when compared to agreements without consideration of supplements (ICC = 0.05, $df = 21$, $p > 0.05$). We have found the modified RAM to be a valid tool which can be used to estimate calcium intake in the athletes and controls we strive to study. The accuracy of this instrument improved by including assessment of dietary supplement sources of calcium.

Key words: Sports nutrition, rapid assessment, athletic, bone health, osteoporosis.

Introduction

Dietary calcium intake is an important variable to measure accurately when investigating bone health. With an estimated 44 million Americans suffering from the debilitating effects of low bone mass, the amount of calcium individuals consume on a daily basis needs to be assessed and evaluated accurately (NIH Consensus, 2001). The Institute of Medicine (IOM) established the adequate intake (AI) levels of calcium for adults to be 1,000 mg, however research continually shows that most Americans do not reach these levels (Kunstel, 2005; Wright et al., 2003).

The rapid assessment method (RAM) for evaluating calcium intake was first established in 1989 as a food

frequency questionnaire (FFQ) by Angus et al. (1989). It was then further developed and titled the RAM by Hertzler and Frary (1994). The RAM has since been tested and modified to establish and improve its accuracy and validity. Much evidence demonstrates the RAM as accurate and reliable in quantifying calcium intake (Hertzler and Frary, 1994; Leachman Slawson et al., 2001; Ward et al., 2004). The main purposes of the RAM are to: 1) be user-friendly for the participants, 2) accurately evaluate daily calcium intake, and 3) be cost and time efficient.

We strive to evaluate bone health in college athletes in efforts to assess the most favorable mode of exercise and intensity that will optimize bone health and thereby prevent osteoporosis. In order to evaluate the effectiveness of exercise interventions on bone health in athletic populations, we need a questionnaire with established validity that would allow us to rapidly evaluate dietary intake of calcium in populations who frequently consume dietary supplements. Vitamin and mineral supplements represent a significant component of dietary intake in some individuals and therefore necessitate inclusion in questionnaires like the RAM in order to properly assess the diet (Satia-Abouta et al., 2003). Statistics, obtained from the Third National Health and Nutrition Examination Survey, indicate that the American consumption of dietary supplements is on the rise. Nearly 40% of the population takes a vitamin, mineral, or other type of dietary supplement, with women being more likely to use supplements than men (Ervin et al., 2004). Athletic populations may have particularly elevated consumption of supplements demonstrated by Roetert (2006), who found that 89% of 203 collegiate athletes surveyed had taken or were currently consuming dietary supplements. Data collected in our laboratory indicated that supplement use in Southern California, particularly in Los Angeles, and especially by athletes, is prevalent and therefore a necessary addition to the RAM in order to obtain accurate data. If we were to continue use of the previously validated RAM questionnaires, we would be missing a substantial source of bone nutrients in the diet because of the lack of evaluation of dietary supplements.

There is currently a deficiency of measurement tools that quickly assess calcium intake which include evaluation of supplemental sources of calcium. Our newly modified LMU RAM is designed for young, athletic individuals who frequently consume supplements. Therefore, our aim was to evaluate the validity of the LMU RAM in assessing daily calcium intake compared with a three-day diet record (3DR) in college athletes and controls. Further

evaluation was also performed to evaluate whether the LMU RAM was valid for use in athlete and non-athletes, as well as those who do and do not use supplements.

Methods

Study population

Participants were recruited from multiple sources at Loyola Marymount University (LMU) by posting flyers around campus, contacting coaches in the athletic department, and making announcements in classes and at scheduled practices. The volunteers ranged in age from 18-25, were of a healthy body mass index (BMI 18-30), and were either Division I athletes in the National Collegiate Athletic Association (n=33) or normally active (n = 14). Normally active was defined as non-varsity athletes who participated in no more than 4 hours of physical activity per week. The group of 47 participants consisted of 16 males and 31 females (34% men, 66% women). The LMU Institutional Review Board approved the ethics of this study protocol and all subjects gave written, informed consent.

LMU RAM development

The modified LMU RAM was configured utilizing previous publications (Hertzler and Frary, 1994; Leachman Slawson et al., 2001; Ward et al., 2004). The modified LMU RAM asks students to quantify servings of food consumed in the previous 7 days. Considering age appropriateness, we altered our questionnaire by eliminating the foods that are not commonly consumed by athletic college students (items removed include: oysters, sardines with bones, and salmon with bones). In addition, we added "salmon" to the list of foods commonly consumed because college-age students more typically consume this food without bones. Therefore, we decreased the assigned calcium value for 3 oz of salmon to exclude consumption of bones (from 150 mg to 10 mg). Our LMU RAM included an additional food that is a typical source of calcium for college students, "Latte: iced or steamed" with an assigned calcium value of 250 mg for a 12 oz serving. In addition, we separated out items that had previously been grouped together to make the questions easier to answer and quantify. Lastly, a section on supplement use was included. The questionnaire read, "protein or diet bar, i.e. Balance Bar, Powerbar, etc." and "shake: protein or diet shake, i.e. Slim Fast, Myoplex shake". Participants were asked for the name brand and researchers looked up the calcium value for each product. If participants could not recall the name brand, they were asked to look it up once at home. The research team contacted them at a later time via phone or e-mail to confirm brand name. The LMU RAM also requested information on "multi-vitamin and or mineral supplement" use in the previous 7 days, including name brands.

Questionnaire administration

Participants visited the Human Performance Laboratory at LMU as part of a larger study investigating bone health. During their lab visit, many questionnaires were administered, including the LMU RAM. A physical activity questionnaire, previously established to be accurate and reli-

able, was used to quantify MET-hours per week of activity (Kohl et al., 1988). After completing the testing session, participants were instructed to complete a 3DR, recording all food and beverage consumption for 3 days: 2 weekdays and 1 weekend day. A brief introduction and visual reference was provided to assist participants in quantifying portion size. Detailed information regarding brand names, package size, preparation methods, condiments, and plate waste was requested. Upon return of diet records, researchers reviewed the food log confirming descriptions and quantities. Food models were used to help participants verify portion size. The 3DR was evaluated using Food Processor SQL Version 10.0. Total calcium intake with and without supplements was quantified from the LMU RAM for the whole week and divided by seven to quantify daily intake.

Data analysis

Agreement between participant's calcium intake as calculated from the LMU RAM and the 3DR was evaluated using Pearson correlations (r) and intraclass correlation coefficients (ICC). ICCs were chosen in addition to correlations to allow for evaluation of how interchangeable the LMU RAM is with 3DRs. ICCs, whose use is supported by others, allow for assessment of equivalency, unlike the Pearson correlations which simply evaluate proportionality (Eck et al., 1996; Ward et al., 2004). Data was analyzed using Statistical Package for Social Sciences (SPSS) Version 14.0 for Windows (SPSS 14.0, Chicago, Ill, 2006). Two-tailed p-values were calculated throughout the study, and a p < 0.05 was considered significant.

Table 1. Mean, number, and standard deviations of descriptive characteristics of study population.

Characteristic	Number of Mean ± SD
Gender	16 male, 31 female
Athlete vs. Non-athlete	33 athletes, 14 non-athletes
Supplement Use	23 supplement users, 24 non-supplement users
Age (years)	20.3 ± 1.1
Physical activity (MET-hrs/week)	113.8 ± 58.4
Daily kcals from 3DR	2342 ± 764
BMI (kg·m ⁻²)	22.8 ± 2.9

MET-hrs/week: Metabolic Equivalent hours per week

3DR: Three-day Diet Record

BMI: Body Mass Index

Results

Table 1 displays descriptive data of the study population. Participants were considered athletes if they were a member of a varsity team at LMU. The athletic population included: 13 cross-country runners, 13 rowers, 3 swimmers, 1 soccer player, 2 water polo players, and 1 softball player. The population identified their ethnicities as Caucasians (n = 28), Latinos (n = 5), other (n = 5), Asian/Caucasian (n = 3), Latino/Caucasian (n = 3), African Americans (n = 2), and Asian (n = 1). Mean calcium intakes did not differ by sex nor athletic status, therefore data analysis was completed on the group as a whole.

Supplements were defined as protein bars, energy bars, smoothies, meal replacement shakes, protein shakes,

multi-vitamins, individual mineral supplements, and fortified juice. Table 2 displays the number of participants who consumed dietary supplements according to data collected from the LMU RAM. None of the control subjects reported consuming supplements, while 23 out of the 33 athletes consumed supplements, contributing approximately 350 mg of calcium to their average daily intake.

Table 2. Number of participants who did or did not consume dietary supplements.

	Did Not Consume Supplements	Consumed Supplements	Gender Total
Normally Active Men	9	0	9
Athletic Men	3	4	7
Normally Active Women	5	0	5
Athletic Women	7	19	26
Supplement use total	24	23	47

LMU RAM = Loyola Marymount University Rapid Assessment Method questionnaire.

The mean calcium intake calculated via the LMU RAM for all participants was 935 mg \pm 420 mg, while the mean calcium intake quantified via the 3DR was 1085 mg \pm 573 mg, which did not differ significantly between methods. This was above the national average intake of 863 mg for men and women of all ages (Wright et al., 2003). In addition, the 3DRs demonstrate our population was consuming more than the adequate intake (AI) set by the IOM for adults, of 1,000 mg per day for calcium (Institute of Medicine, 1997). There were 8 of the 16 men and 13 of the 31 women who consumed less than 100% of the calcium AI for their age. When calculating calcium intake via the LMU RAM without considering supplement use, calcium intake decreased to 763 \pm 290 mg per day.

The validity of the LMU RAM was assessed by comparing calcium intake values from the LMU RAM and the 3DR (Table 3). A Pearson correlation coefficient was calculated to evaluate the relationship between calcium quantified via the LMU RAM and the calcium derived from the 3DR. A strong positive correlation was found between calcium intake measured with the LMU RAM and 3DRs ($r(45) = 0.83$, $p < 0.01$), indicating a significant linear relationship between the two variables. Agreement between the two instruments was good (ICC = 0.76, $df = 45$, $p < 0.01$). The Pearson correlation for the

RAM when excluding dietary supplements was moderate ($r(45) = 0.56$, $df = 45$, $p < 0.001$). Also, agreement between the instruments was fair (ICC = 0.30, $df = 45$, $p < 0.05$) when dietary supplement sources of calcium were not considered.

When athletes and non-athletes were examined separately, calcium intake remained strongly correlated between the 3DR and LMU RAM ($r(31) = 0.84$, $p < 0.01$ for athletes and $r(12) = 0.69$, $p < 0.01$ for non-athletes). Agreement between the two instruments also remained good (ICC = 0.84, $df = 31$, $p < 0.01$ for athletes and ICC = 0.69, $df = 12$, $p < 0.01$ for non-athletes). In athletes, the correlation values calculated between the 3DR and the LMU RAM without inclusion of supplements decreased ($r(31) = 0.59$, $p < 0.01$) and the ICC value became non-significant (ICC = 0.25, $df = 31$, $p > 0.05$).

Table 4 reports mean calcium intakes, Pearson correlations, and ICC values for participants when separated according to supplement use. A strong positive correlation was found between calcium intake measured with the LMU RAM and 3DRs ($r(21) = .82$, $p < 0.01$ for supplement users, and $r(22) = 0.78$, $p < 0.01$ for non-supplement users), indicating significant linear relationships between the two variables. Agreement between the two instruments was also good for supplement and non-supplements users. The Pearson correlation for the RAM when excluding dietary supplements was moderate ($r(21) = 0.53$, $df = 45$, $p < 0.01$) while the ICC value became nonsignificant (ICC = 0.05, $df = 21$, $p > 0.05$).

Discussion

We report that estimated calcium intake from the LMU RAM has good agreement with 3DRs. The two methods are also strongly correlated with about 69% ($r = 0.83$, $r^2 = 0.69$) of the variability in calcium intake quantified via the LMU RAM being accounted for by variability of calcium intake quantified by the 3DR. The questionnaire appears to be a valid tool for use in both athletes and non-athletes as demonstrated by the strong correlation and good agreement values reported in Table 3. The LMU RAM is shown to be a valid tool, even when assessing calcium intake in non-supplement users as 61% ($r = 0.78$, $r^2 = 0.61$) of the variability in calcium intake of non-supplement users is accounted for by the LMU RAM, while the interchangeability of the 3DR and LMU RAM

Table 3. Means (\pm standard deviations) of estimated daily calcium intake in all participants, athletes, and controls, measured via the LMU RAM and the 3DR are reported. The agreements between the data derived from the 3DR and LMU RAM, or LMU RAM with out supplements, are evaluated using the Pearson correlation coefficients (r) and Intraclass Correlation Coefficients (ICC).

	All Participants (n = 47)	Athletes (n = 33)	Non-athletes (n = 14)
Calcium Intake Measured by 3DR (mg/d)	1085 (573)	1142 (641)	951 (353)
Calcium Intake Measured by LMU RAM (mg/d)	935 (420)	983 (463)	824 (278)
Pearson (r)	.83 *	.84 *	.69 *
ICC	.76 †	.77 †	.63 †
Calcium Intake Measured by LMU RAM (mg/d) w/o Supplements	763 (290)	737 (296)	824 (278)
Pearson (r)	.56 *	.59 *	.69 *
ICC	.30 †	.25	.63 †

* Pearson correlation coefficient (r), $p < 0.01$, † Intraclass correlation coefficient (ICC), $p < 0.001$. LMU RAM = Loyola Marymount University Rapid Assessment Method questionnaire, 3DR = three-day diet record, mg/d = milligrams per day.

Table 4. Means (\pm standard deviations) of estimated daily calcium intake in supplement users and nonusers, measured via the LMU RAM and the 3DR are reported. The agreements between the data derived from the 3DR and LMU RAM, or LMU RAM with out supplements, are evaluated using the Pearson correlation coefficients (r) and Intraclass Correlation Coefficients (ICC).

	Supplement User (n=23)	Non-supplement User (n=24)
Calcium Intake Measured by 3DR (mg/d)	1303 (656)	877 (393)
Calcium Intake Measured by LMU RAM (mg/d)	1125 (420)	754 (338)
Pearson (r)	.82 *	.78 *
ICC	.71 †	.74 †
Calcium Intake Measured by LMU RAM (mg/d) w/o Supplements	773 (238)	754 (338)
Pearson (r)	.53 *	.78 *
ICC	.05	.74 †

* Pearson correlation coefficient (r), $p < 0.01$, † Intraclass correlation coefficient (ICC), $p < 0.001$. LMU RAM = Loyola Marymount University Rapid Assessment Method questionnaire, 3DR = three-day diet record, mg/d = milligrams per day.

is strong at 0.74 ($p < 0.001$). When evaluating calcium intake among supplement users without questionnaire modifications, agreement (ICC) and correlation (r) values decreased considerably. In this case, only 28% ($r = 0.53$, $r^2 = 0.28$) of the variability in calcium intake from the LMU RAM without including supplements can be explained by the 3DR. Moreover, according to the ICC value of 0.05 ($p > 0.05$) the RAM questionnaire without inclusion of supplement use is not a suitable measure of calcium intake as compared with 3DRs.

This study has several strengths. To our knowledge, this is the first abbreviated food frequency questionnaire developed to evaluate calcium intake which includes a section on dietary supplements. Second, we believe the newly modified LMU RAM to be a more valid tool for assessing calcium intake in college-age individuals, including athletic and non-athletic populations. This user-friendly, self-administered, and time efficient questionnaire provides improved opportunities to evaluate the relationship between diet and disease, particularly osteoporosis, bone injuries, and the female athlete triad. Third, the use of Intraclass Correlation Coefficients, which is recommended by others (Eck et al., 1996; Ward et al., 2004), allows for the evaluation of agreement and interchangeability between methods, rather than simply evaluating proportionality, as with Pearson correlations alone. Lastly, our subject pool is fairly diversified, including many ethnicities, athletes of various sports, and a wide range of calcium intakes.

In noting this study's weaknesses, it is important to observe the small sample size ($n = 47$). Although participants were asked to record their diet on typical days, one of the faults of a 3DR is the possibility that 1 of the 3 days was atypical. This problem is intensified when the sample size is not large. Additionally, the LMU RAM could be improved if additional categories were included for campus specific foods and geographically appropriate choices (like sushi). For example, we included frequently consumed smoothies from a juice store on campus in the dietary supplement section because they may be a considerable source of calcium. Lastly, others (Leachman Slawson et al., 2001) have placed food models in front of the participants as they completed the RAM questionnaires in order to demonstrate serving sizes. We hypothesize that more accurate results would occur if some of the error associated with estimating portion sizes was removed.

Hertzler and Frary (1994) reported a correlation of

0.28 ($p < 0.001$) between calcium intake measured via a RAM and 3DRs. This correlation was improved to 0.68 when removing outliers (Hertzler and Frary, 1994). Ward et al. (2004) reported an r -value of 0.42 ($p < 0.05$) and an ICC of 0.41 ($p = 0.01$) when comparing six-day diet records with a RAM questionnaire. Our results indicate a stronger relationship ($r = 0.83$, $p < 0.01$) and greater equivalency (ICC = 0.76, $p < 0.01$) between 3DRs and the LMU RAM. We believe the stronger correlation and improved equivalency to be a result of including specific inquiry of dietary supplement intake which was not present in previous research. We found that 49% of our total population was consuming supplements. However, of the athletic population, 70% reported supplement use. This complements data reported by Roetert (2006) and demonstrates a need for supplement evaluation when estimating daily calcium intake by food frequency questionnaires. The most commonly consumed dietary supplements were energy bars followed by meal replacement shakes. Multivitamins, individual mineral supplements, smoothies, and protein bars were also consumed frequently. Rationale as to why dietary supplements were being consumed was not evaluated.

Conclusion

We have found the LMU RAM is a valid tool which can be used to measure calcium intake in college-age athletes and non-athletes. The accuracy of this instrument improved by including assessment of dietary supplement sources of calcium. Further analysis revealed that the LMU RAM appears to be a valid tool for assessing calcium intake in those who do and do not use supplements. The modified questionnaire developed here was designed for young individuals residing in the Western United States. However, because the modifications we have made meet the needs that are prevalent throughout many populations, the LMU RAM contains generalizability beyond the sample represented in this investigation.

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Key points

- When conducting research on bone health, accurate measurement of calcium intake is crucial. The rapid assessment method (RAM) is one technique that has frequently been used for its measurement; however, currently established questionnaires lack assessment of dietary supplement use, which is common for athletes.
- We report that estimated calcium intake from the LMU RAM modified to evaluate supplement use has good agreement with three-day diet records (3DRs). There was a strong correlation between the two methods with about 69% ($r = 0.83$, $r^2 = 0.69$) of the variability in calcium intake quantified via the LMU RAM being accounted for by the 3DR.
- Calculated intraclass correlation coefficients between 0.63 and 0.77 reveal that the LMU RAM appears to be a valid tool of measuring daily calcium intake in athletes and non-athletes and among those who do and do not use supplements.
- When evaluating calcium intake without considering supplements, agreement (ICC) and correlation (r) values decreased considerably.
- We found the LMU RAM to be a valid measurement of calcium intake in athletes and controls. Without the addition of a section on supplement use, estimated calcium intake would have decreased an average of 32%.

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