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**Brief communication (Original)**

# Development and validation of a scale for "attitudes towards calcium consumption"

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***Background:*** Attitude is recognized as a key determinant of health-related behaviors, including calcium intake for prevention of osteoporosis. Most existing instruments that measure attitudes towards calcium consumption are not appropriate for use in the Thai population because they focus on attitudes towards the consumption of dairy products, which are not a common source of calcium for Thais.
***Objectives:*** To develop and validate an instrument for measuring attitudes towards calcium consumption among Thai adults.
***Methods:*** An initial attitudinal scale (25 items) was developed and administered to 250 Thais (age ≥20 years) living in Khon Kaen, the largest province in the northeast Thailand, to assess its dimensions using exploratory factor analysis. Three factors were identified. The scale was reduced to 15 items and administered to 733 subjects to validate the identified factor structure and optimize the length of the scale.
***Results:*** A three-factor model (10 items) was validated and interpreted as (1) a negative effect of calcium consumption on the body (4 items, reliability = 0.90), (2) the health benefits of calcium consumption for the body (3 items, reliability = 0.78), and (3) the need to take calcium on a regular basis (3 items, reliability = 0.86). The model fitted the data well (relative $\chi^2$ = 1.43, adjusted goodness-of-fit index = 0.98, confirmatory fit index = 0.997, root mean square error of approximation = 0.024).
***Conclusion:*** The developed scale is a reliable and useful instrument for measuring attitudes towards calcium consumption. Further research is needed to validate the scale in different populations.

***Keywords:*** Attitudes towards calcium, attitudinal scale, calcium, factor analysis, validation of an instrument

Calcium is an important nutrient for bone health. At an early age, the human body uses calcium together with vitamin D to build strong and dense bone [1]. Later in life, calcium is used to maintain bone health and prevent osteoporosis [2]. Inadequate calcium intake is a problem worldwide and is more serious in countries where the consumption of dairy products is low [3-5], such as Thailand [6-10]. Given the predicted increase in the proportion of the aging population (60 years old or more) in Thailand [11, 12] in the coming decades, inadequate intake of calcium will become a major health problem in this country.

To promote calcium consumption in a population, it is necessary to understand the attitude of the target population towards calcium consumption because attitudes, once formed, play powerful roles in determining an individual's tendency to a specific behavior [13, 14], such as consuming calcium-containing food.

A literature review found that some of the existing scales measure attitudes toward an object rather than an action with respect to the object. For example, Susiyanti and Chambers [15] measured attitudes towards calcium, Kim [16] measured attitudes towards milk and dairy products, and Cradler [17] measured attitudes towards food containing calcium. Although these scales are helpful for understanding how individuals perceive calcium or sources of calcium, attitudes towards an object do not correspond closely to actual behavior, by contrast with attitudes towards behavior with respect to an object [18, 19]. Although some existing scales measure attitudes towards consumption, these scales ask about the

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tendency to consume milk and dairy products, which are common sources of calcium in western countries [15]. These tools are not suitable for assessing the attitudes of Thai populations towards calcium consumption because most Thais stop drinking milk when they reach adulthood, and dairy products are not common ingredients in Thai cuisine. Therefore, it was necessary to develop a scale that can be used to determine the attitude of Thai adults towards calcium consumption.

Therefore, the current study aimed to develop and validate an instrument to measure the attitudes of Thai adults towards calcium consumption in the context of osteoporosis prevention.

## Methods

The study protocol was approved by the Ethics Committee for Human Research of Khon Kaen University. Each participant was advised about the rights of volunteers and signed an informed consent form.

### *Development of the attitudinal scale*

A procedure for scale development suggested by DeVellis [20] was adopted to guide the development of the attitudes towards calcium (ATC) scale.

**Step I**: Determining what should be measured. At this step, a literature review was conducted to gain an understanding of the current knowledge regarding attitudes towards calcium consumption. The literature review was undertaken using the electronic databases of the Thailand Library Integrated System (ThaiLIS), ScienceDirect, and Scopus. Following the literature review, in-depth, face-to-face interviews were conducted with 30 adults who resided in Khon Kaen province, the largest province in the northeast Thailand, using a semistructured interview protocol. The aim of these interviews was to elicit the three components of attitudes [21]: individuals' beliefs, feelings, and behavioral tendencies towards calcium consumption.

**Step II**: Generating an item pool and determining the response format for measurement. Based on the results of the literature review and the interviews, a draft of the ATC scale was developed that comprised 35 opinion items. The response format was designed to be a rating scale. Based on the literature review, the optimal number of response categories remained unclear. Several studies, such as Alwin [22] and Dawes [23], supported the conclusion that scales with more response categories are more reliable and more valid. However, Hulbert's study suggested that ten categories may be the upper limit in terms of respondents' ability to differentiate between categories [24]. Therefore, at this stage, the response option was designed as an 11-point rating scale ranging from 0 ("totally disagree") to 10 ("totally agree").

**Step III**: Reviewing the scale for coverage, quality, and suitability. The scale was sent to five experts for content validity assessment using the index of item-objective congruence (IOC). Items for which the IOC values were <0.5 were not considered valid [25] and were removed. The scale was then modified and reduced to 27 items. The scale was then pretested using 50 adults residing in an urban and a rural community in *Nakhon Ratchasima*, a province neighboring Khon Kaen province, to assess the language clarity, flow of questions, appearance of the instrument, and appropriateness of adopting an 11-point rating scale. Based on feedback, modifications were made. Therefore, the initial version of the ATC scale contained 25 items. Of these, 21 were positive statements, and 4 were negative statements. The response format was a 7-point rating scale ranging from (1) strongly disagree to (7) strongly agree.

**Step IV**: Evaluation of the instrument. At this step, the initial version of the ATC scale (25 items) was administered. Exploratory factor analysis was used to identify the dimensionality and reliability of the ATC scale.

**Step V**: Optimizing the scale length and confirming the construct validity of the instrument. The result from step IV was used to guide the reduction of the scale length from 25 items to 15 items. No changes were made to the response format. Confirmatory factor analysis was employed.

### *Sample size and sample recruitment*

The number of study participants was dictated by the statistical analysis method used. For exploratory factor analysis in step IV (evaluation of the ATC scale), a sample size of 250 was determined based on the 10 participants to 1 variable ratio rule [26]. For confirmatory factor analysis in step V (confirming the construct of the ATC scale), the number of participants was estimated based on the 20 participants to 1 parameter to be estimated ratio rule [27]. For a three-factor model containing 15 items, there were 33 parameters to be estimated; hence, at least 660 participants were needed. Because of the sample recruitment protocol employed (**Figure 1**), the number of participants was increased to 733.

The participants were Thai adults at least 20 years old living in Khon Kaen province. The same protocol was used to determine the number of participants required for step IV (evaluation of the ATC scale) and step V (confirming the construct of the ATC scale). A multi-stage sampling technique was employed, taking into consideration the proportion of communities and the populations in the urban and rural areas. Potential participants who the researchers could not reach after five follow-ups were discarded. The details are shown in **Figure 1**.

### *Administration of the instrument (ATC scale)*

Before the interview, each study participant was advised about the rights of volunteers and signed an informed consent form. The same protocol was used for the administration of the initial version and the second version of the ATC scale. The scale was read to the participants either by the researchers or by research assistants who were trained to apply the protocol. This approach was used to ensure consistency in the data collection. The initial version of the scale was administered between September and October 2011. The second version was administered between November and December 2011.

## Statistical analyses

### *Exploratory factor analysis*

Before performing an analysis, the suitability of the data for factor analysis was assessed by inspecting the correlation matrix, the Kaiser–Meyer–Olkin (KMO) value, and the result of Bartlett's test of sphericity. To be considered suitable for factor analysis, the correlation matrix should show at least some correlations of $r \geq 0.3$, the KMO value should be $\geq 0.6$, and Bartlett's test of sphericity should be statistically significant at $P < 0.05$ [28].

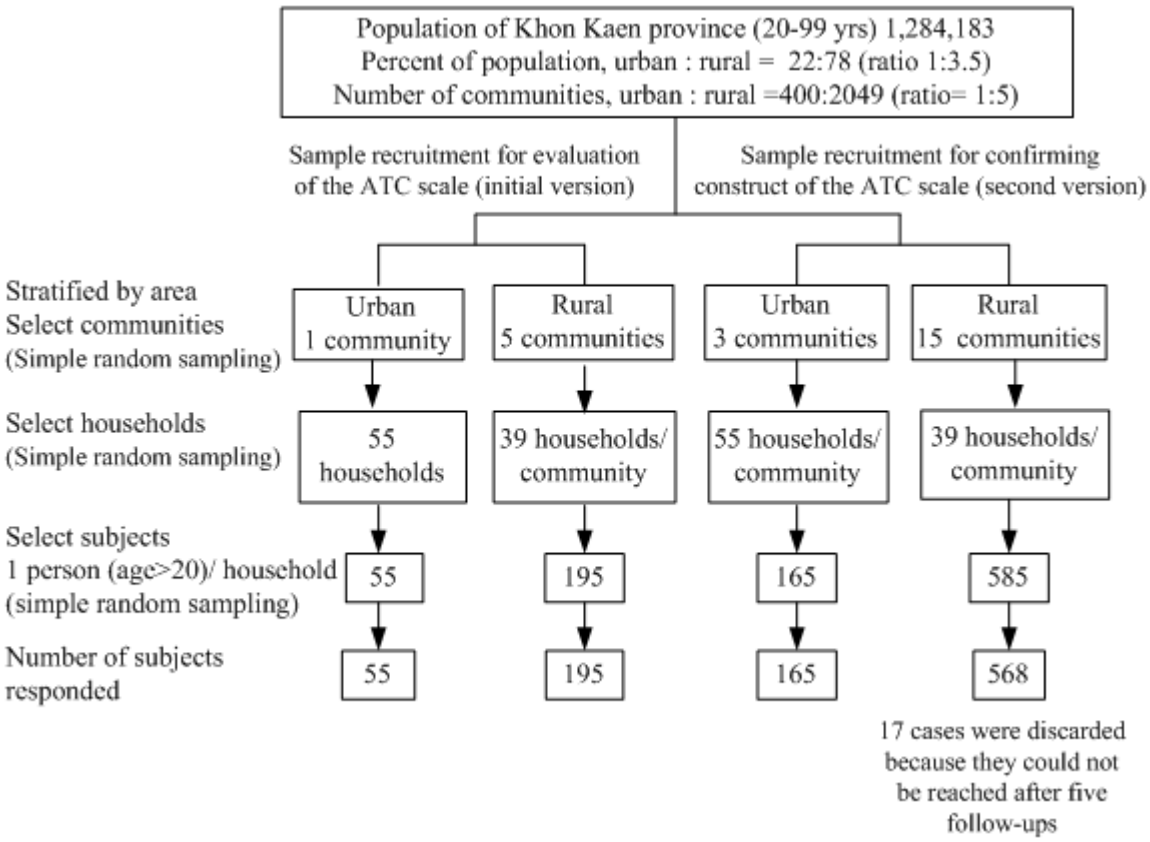


**Figure 1.** Participating subject recruitment process

Factor analysis with orthogonal rotation was used to identify the factor structure. Orthogonal rotation was chosen because it provided a clear and distinct meaning for each identified factor. The optimal numbers of factors (dimensions) were determined using four criteria: (1) a scree plot; (2) eigenvalues >1; (2) a percentage of variance explained ≥60; and (4) interpretability [29]. Factor loadings were used to interpret the factors. A factor loading value >0.5 was considered sufficient to assume a strong relationship between an opinion item and a factor [30].

The reliability (internal consistency) of each factor was evaluated using Cronbach's alpha coefficient. A Cronbach's alpha coefficient value >0.7 was considered to indicate that the factor was reliable [31].

### *Confirmatory factor analysis*

The process of modeling suggested by Holmes-Smith et al. [32] was employed. The three-factor model was tested and respecified until the most parsimonious model was achieved. Opinion items that had a standardized factor loading >0.7, a square multiple correlation >0.5, and a standardized residual $< \pm 2.5$ were retained in the final model as valid indicative variables for the ATC scales. The model was then assessed for its fit, reliability, and validity.

The fit of the data to the proposed factor model was assessed using four indices that were less dependent on sample size [33, 34]. The relative $\chi^2$ ($\chi^2$/df) was used to determine model parsimony. An adequate model fit is obtained when the relative is between 2.1 and 3.0, and a good fit is obtained when the relative $\chi^2$ is between 1.0 and 2.0. The adjusted goodness-of-fit index (AGFI) and the root mean-square error of approximation (RMSEA) were used to assess the absolute fit of the model. An adequate fit is obtained when the AGFI is >0.90 and the RMSEA is between 0.05 and 0.08. A good fit is obtained when the AGFI is >0.95 and the RMSEA is <0.05. The comparative fit index (CFI) was used to assess incremental fit. An adequate fit was obtained when the CFI is >0.09, and a good fit is obtained when the CFI is >0.95.

The validity of the construct of the proposed factor model was assessed using the model $\chi^2$. $P >$ 0.05 indicated that the validity of the construct had been achieved [31]. In addition, discriminant validity was assessed using the correlation between each factor. A correlation of 0.85 or larger indicated poor discriminant validity [35, 36].

The reliability of each factor was calculated based on parameters in the model using the formula suggested by Fornell and Larcker [37]. This formula is $\rho_c = (\Sigma\lambda_i)^2/[(\Sigma\lambda_i)^2 + \Sigma\varepsilon_i]$, where $\rho_c$ is the model-based reliability, $\lambda_i$ is the standardized loading for each observed variable (opinion item), and $\varepsilon_i$ is the standardized error variance associated with each observed variable. Reliability values >0.7 were considered to indicate good internal consistency [30].

In addition, structural invariance was considered to assess whether the models for the different sample groups were identical. The structure of the models for the different sample groups is not different when the $\chi^2$ difference test was not significant [32].

## Results

The characteristics of the study sample in both step IV (evaluation of the ATC scale) and step V (confirming the construct of the ATC scale) were similar to those of the Khon Kaen population (**Table 1**).

### *Evaluation of the ATC scale using exploratory factor analysis*

An inspection of the correlation matrix revealed that most of the coefficients were >0.3. The KMO value was 0.85, and Bartlett's test of sphericity reached statistical significance ($\chi^2_{105} = 2524.90$, $P < 0.001$), supporting the suitability of the data for factor analysis.

The scree plot revealed a clear break after the third component, suggesting a three-factor solution. Inspection of the eigenvalues also showed that three factors (dimensions) had eigenvalues > 1 (5.13, 3.87, and 1.4, respectively). The percentage of variance explained by these three factors was 69.55 (34.21, 25.78, and 9.57, respectively). The first dimension consisted of five items and was labeled "negative effect of calcium consumption on the body". The second dimension consisted of six items was labeled "health benefits of calcium consumption for the body". The third dimension, which consisted of four items, was labeled "necessity of taking calcium on a regular basis". The Cronbach's alpha coefficients for each of the three dimensions were >0.70. The factor loadings and Cronbach's alpha coefficients are presented in **Table 2**.

**Table 1.** Characteristics of studied sample and population of Khon Kaen province

| Characteristics | Sample for EFA (n = 250) | | Sample for CFA (n = 733) | | Khon Kaen population (n =1,284,183)[+] | |
|---|---|---|---|---|---|---|
| | Frequency | (%) | Frequency | (%) | Frequency | (%) |
| Gender | | | | | | |
| Female | 130 | (52.0) | 380 | (51.8) | 657,638 | (51.2)[+] |
| Male | 120 | (48.0) | 353 | (48.2) | 626,545 | (48.8) |
| Age (years) | | | | | | |
| 20–34 | 85 | (34.0) | 220 | (30.0) | 413,769 | (32.2)[+] |
| 35–49 | 98 | (39.2) | 272 | (37.1) | 449,719 | (35.0)[+] |
| ≥50 | 67 | (26.8) | 241 | (32.9) | 420,695 | (32.8) |
| Area of living | | | | | | |
| Rural | 195 | (78.0) | 568 | (77.5) | 1,002,821 | (78.1)[+] |
| Urban | 55 | (22.0) | 165 | (22.5) | 281,362 | (21.9)[+] |
| Education attainment | | | | | | |
| Primary school and lower | 105 | (42.0) | 260 | (35.5) | N/A | |
| Secondary and high school | 104 | (41.6) | 312 | (42.5) | N/A | |
| More than high school | 41 | (16.4) | 161 | (22.0) | N/A | |
| Income (baht per month)[π] | | | | | 6851[+] | |
| <7000 | 107 | (42.8) | 338 | (46.2) | N/A | |
| ≥7000 | 110 | (44.0) | 339 | (46.2) | N/A | |
| Not specified | 33 | (13.2) | 56 | (7.6) | N/A | |

EFA = Exploratory factor analysis with orthogonal rotation, CFA = Confirmatory factor analysis, [π]Median 7000 (IQR 4000, 10000), 30 baht approximately equivalent to US$1, source: Khon Kaen Public Health Office (2010), [+]Per capita income of population in Khon Kaen province: 2010, source: Office of the National Economic and Social Development Board, Office of the Prime Minister (2010)

**Table 2.** Exploratory factor analysis and confirmatory factor analysis of a three-factor solution of attitudes towards calcium

| | EFA | | CFA | | |
|---|---|---|---|---|---|
| | Factor loading ($\lambda$) | Cronbach's $\alpha$ | Factor loading ($\lambda$) | $\theta$ | Model based reliability($\rho_c$) |
| **Negative effect of calcium consumption to the body** | | 0.95 | | | 0.90 |
| • Consuming calcium could make me feel sick and nauseous | 0.92 | | 0.87 | 0.24 | |
| • Consuming calcium daily causes me to suffer from flatulence | 0.89 | | 0.79 | 0.38 | |
| • Calcium may harm my internal organs | 0.92 | | 0.84 | 0.29 | |
| • Consuming calcium regularly will make stones form in my urinary tract | 0.86 | | 0.80 | 0.35 | |
| • Long term consumption of calcium may pose a danger to my body | 0.73 | | | | |
| **Health benefit of calcium consumption to the body** | | 0.78 | | | 0.78 |
| • Calcium prevents a stooped posture when I am old | 0.75 | | 0.79 | 0.50 | |
| • Calcium prevents osteoporosis | 0.71 | | 0.77 | 0.50 | |
| • Calcium prevents my bone being broken when I fall | 0.71 | | 0.75 | 0.54 | |
| • Calcium helps my teeth to work effectively | 0.65 | | | | |
| • Calcium promotes my body's growth and height | 0.65 | | | | |
| • Calcium helps strengthen my bone | 0.63 | | | | |
| **Necessity of taking calcium on a regular basis** | | 0.87 | | | 0.86 |
| • I need to consume calcium regularly otherwise my body will not obtain sufficient calcium | 0.86 | | 0.77 | 0.43 | |
| • Consuming calcium regularly is necessary for my body | 0.74 | | 0.89 | 0.25 | |
| • I must consume calcium every day because my body needs it every day | 0.73 | | 0.84 | 0.31 | |
| • Consuming calcium every day can replace my body's calcium which was excreted daily | 0.55 | | | | |

EFA = Exploratory factor analysis with oblique rotation, only loadings >0.5 have been reported, n = 250
CFA = Confirmatory factor analysis, all factor loadings were statistically significant ($P < 0.05$), all squared multiple correlations of each opinion statement ($\lambda^2$) > 0.05, n = 733
$\theta$ = Standardized error variance ($\theta_i = 1 - \lambda_i^2$)

***Validating the construction of the ATC scale using confirmatory factor analysis***

The three-factor model was validated, and the final model contained 10 opinion items. Five items were removed because their square multiple correlations were <0.5; thus, they were considered invalid indicative variables for ATC. The final model, which retained 10 items, fit the data well (model $\chi^2_{32} = 45.85$, n = 733, $P = 0.054$, relative $\chi^2 = 1.43$, AGFI = 0.98, CFI = 0.997, RMSEA = 0.024). The factor loading ($\lambda$), standardized error variance ($\theta$), and model-based reliability ($\rho_n$) are presented in **Table 2**. Intercorrelations are presented in **Table 3**.

Construct invariance tests showed that there was no difference in the construct of the ATC scale between men and women ($\chi^2_7 = 12.70$, $P = 0.080$), between the three age groups (20–34, 35–49, and ≥50) ($\chi^2_{14} = 10.89$, $P = 0.695$), between individuals living in urban and rural areas ($\chi^2_7 = 9.20$, $P = 0.238$), or between the different levels of education attained (primary, secondary, and university graduate) ($\chi^2_{14} = 6.45$, $P = 0.954$). There was also no difference in the construct of the model between individuals with an income <7000 baht and individuals who had an income ≥7,000 baht ($\chi^2_7 = 13.17$, $P = 0.068$).

The mean attitudinal score of this sample group (n = 733) was 5.32 (SD: 0.91). When assessing attitude towards calcium consumption by sociodemographic characteristics, it was found that the average attitudinal score of those living in a rural area (mean: 5.38; SD: 0.89) was higher than that of those living in an urban area (mean: 5.12, SD: 0.94). This difference was statistically significant (mean difference: 0.26; 95%CI 0.103, 0.417; $P = 0.001$). There was no difference in the attitudinal score between male and female, between different age groups, between different levels of educational attained, or between different levels of income.

**Discussion and conclusion**

This study developed a scale for "attitudes towards calcium consumption" (ATC) in the context of osteoporosis prevention. This is the first instrument to focus directly on the consumption of calcium rather than milk and dairy products. This ATC scale is useful for the assessments of attitudes of individuals towards calcium consumption, particularly in communities where calcium is obtained from various sources.

An exploratory factor analysis in the early stages of this study was used to identify three dimensions of attitudes towards calcium. Two of these dimensions reflected individuals' beliefs about the outcome of the behavior, such as a "negative effect of calcium consumption on the body" and a "health benefit of calcium consumption for the body". The other dimension reflected individuals' belief about the behavior, such as the "necessity of taking calcium on a regular basis". The three dimensions of the ATC were validated by confirmatory factor analysis.

It is important to note that the initial version of the ATC scale included both positive and negative statements to avoid agreement bias. However, the factor analysis suggested that the negative statements were not valid indicative variables for ATC. As a result, all 10 statements retained in the final version were positive.

The results of the confirmatory factor analysis supported the validity and reliability of the scale. A $P$ value of the model $\chi^2 > 0.05$ indicated that construct validity was achieved. An examination of intercorrelations showed that none of the correlations between the three dimensions was >0.85, suggesting that the ATC scale achieved discriminant validity (i.e., each dimension independently measured each element of attitudes towards calcium consumption). The strongest correlation was found between the health benefits of calcium consumption and

**Table 3.** Intercorrelations of the three dimensions of attitudes towards calcium consumption

| | Negative effect of calcium consumption | Health benefit of calcium consumption | Necessity of taking calcium on regular basis |
|---|---|---|---|
| • Negative effect of calcium consumption | 1 | | |
| • Health benefit of calcium consumption | –0.07 | 1 | |
| • Necessity of taking calcium on regular basis | –0.06 | 0.84 | 1 |

the need to take calcium on a regular basis. This finding indicated that individuals who recognized the health benefits of calcium tended to consume it regularly. The model-based reliabilities of all three dimensions were >0.70, which signified that the items that constituted each dimension shared a large percentage of the variances and that each dimension was reliable. In addition, the results from the construct invariance tests suggested that the developed ATC scale could be administered to adults who were 20 years of age or older regardless of differences in gender, urban/rural living, education status, or income.

As attitudes influenced tendency to behavior, prevention of osteoporosis by modifying calcium consumption should also be conducted by promoting positive attitudes towards calcium consumption. The findings of this study showed that the attitudes of the sample Thai adults were relatively, but not yet highly, positive. This suggested that an intervention to promote and maintain positive attitudes towards calcium consumption, particularly among urban adults, is needed. Because people in most urban areas, including Khon Kaen province, lack a sense of community, a traditional group intervention is unlikely to be effective. A suitable program to promote positive attitudes among urban adults should be further explored.

Although we have demonstrated that the characteristics of the sample in both steps (for EFA and for CFA) were comparable to those of the adult population of Khon Kaen, given that these sample groups were from one province, the results of the study may not necessarily be generalizable to Thai adults nationally. Further research is needed to test and validate the developed ATC scale with a more representative sample of the Thai adult population.

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