Comparison of Calcium Absorption In Healthy Human Adults: From Various Calcium-Containing Products A Bioavailability Study

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Abstract

The present study was undertaken to compare the bioavailability of calcium after supplementation with four preparations - Calcium AA Chelate (18%; A), Dicalcium malate (B), Calcium AA Chelate (26%; C) and Calcium carbonate (D). After ingestion of a single dose containing 900 mg of elemental calcium, no significant differences were observed in AUC suggesting that bioavailability of all four Supplements is similar. However, there were significant differences between the groups in the maximum concentration (Cmax), time to reach maximum concentration (Tmax) and half-life of elimination. Supplement A showed the maximum increase in serum calcium concentration compared to baseline followed by Supplements B, C and D. Time required to reach the maximum serum concentration was shortest for Supplement D followed by Supplements C, A and B. This suggests that absorption of Supplement D is better compared to the other Supplements. However, the half-life of Supplement D in serum was shortest suggesting that it is cleared from the blood faster than the other Supplements. Supplement B had the longest half-life and seems to be most bioavailable followed by supplement A, C and D. This work was sponsored by Albion Advanced Nutrition.

Introduction

According to the Osteoporosis Society of Canada, approximately 1.4 million Canadians suffer from osteoporosis (www.osteoporosis.ca). Although more prevalent in older women, older men and younger individuals also get the disease. The cost of treating osteoporosis and the fractures it causes is estimated to be $1.3 billion each year in Canada. Given the increasing proportion of older people in the population over the next few years, these costs, as well as the number of individuals with osteoporosis, will likely rise.

Adequate calcium intake is necessary for bone remodeling to take place in healthy individuals. In older adults adequate calcium intake can slow bone loss and lower the risk of fracture (Lin and Lane, 2004). Furthermore, calcium supplementation is an important part of the medical management of osteoporosis in combination with various prescription medications.

Calcium bioavailability is important when calcium intakes are low, or when an individual is growing or losing bone (Fairweather-Tait and Teucher, 2002). Calcium absorption is dependent on many dietary and environmental factors, including the level of protein, sodium, caffeine, vitamin D, fructose and phosphorous in the body. Furthermore, one's genetic makeup, including the vitamin D receptor genotype, may also play a role in calcium absorption (Dawson-Hughes et al., 1995).

Supplementation with various calcium preparations is now the most common approach to increase calcium intake in individuals concerned with osteoporosis. However, it has been shown that the bioavailabilities of many commercial calcium preparations are different (Fairweather-Tait and Teucher, 2002). The most common calcium supplement, calcium carbonate, is known to be generally well absorbed but other calcium forms, such as citrate, malate and amino acid chelate, have shown superior efficacy in some studies (Sakhaee et al., 1999, Heaney et al., 1990).

Objective

The objective of this study was to compare in healthy individuals the bioavailability of calcium from four separate calcium-containing products. This information will increase the overall knowledge of these compounds.

Methods

The calcium treatments are identified in the following table:

Table 1.

Treatment Groups	Supplements	No. of Subjects
Calcium amino acid chelate (18%)	A	15
Dicalcium malate	B	15
Calcium amino acid chelate (26%)	C	15
Calcium carbonate	D	15

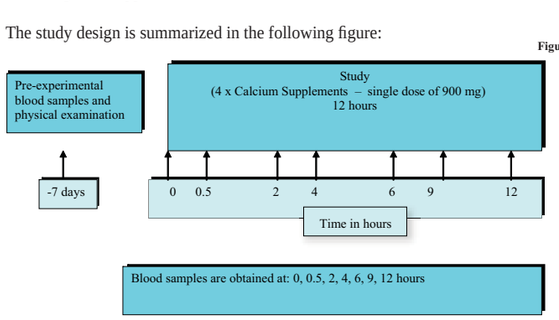
Study Outline

Individuals were studied for a total of approximately 5 weeks. All subjects were studied as outpatients. The screening process consisted of CBC count, platelets, electrolytes, glucose, BUN, creatinine, liver function tests, total protein, albumin, calcium, phosphorous, PT/PTT, and urinalysis. Women of childbearing age also had a urine pregnancy test. Subjects were asked questions to determine present health and past medical history and underwent a brief physical exam. Those deemed eligible after the screening process were asked to return for the four supplementation days. On the first supplementation day, subjects were randomized for receiving the four supplements in a random order. Blood was taken immediately before supplement administration and 0.5, 2, 4, 6, 9 and 12 hours after the dose. Standard low calcium meals, breakfast, lunch and dinner, were provided immediately after the dose, following the 4-h blood sample and following the 9-h blood sample, respectively. Each individual was given 6 capsules containing a total of 900 mg of elemental calcium. This dose of elemental calcium is within the RDI recommended by the United States National Institutes of Health (United States National Institutes of Health 1994. Optimal calcium intake. NIH Consensus Statement, Vol. 12, No. 4. 31 pp.) Each subject returned three more times for supplementation with the identical level of elemental calcium in an alternative form. Each visit was separated by a minimum of 1 week. The identical food was supplied to the subjects on each supplementation day. Blood levels of calcium were determined at each time point.

Blood: Peripheral blood was taken by venipuncture prior to baseline to determine overall health. Blood was subsequently taken at 0, 0.5, 2, 4, 6, 9 and 12 hours following each supplementation for measurement of calcium in the blood serum.

The study design is summarized in the following figure:

Figure 1.



The participants, clinical assistants and those assessing the outcome were blinded to the group assignment.

Results

The data presented in the following table show the changes between the groups in serum calcium concentrations at all the time points after oral supplementation.

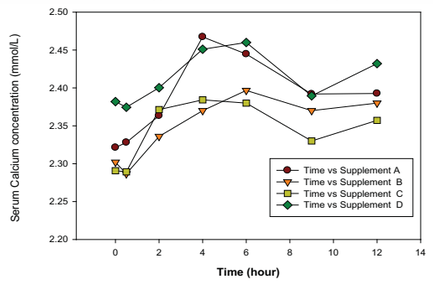
Table 2.

Treatments	Time Point 0		Time Point 0.5		Time Point 2		Time Point 4		Time Point 6		Time Point 9		Time Point 12	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Supplement A *	2.32 *	0.1	2.32 *	0.1	2.36 *	0.11	2.47 *#	0.13	2.44	0.09	2.39 *	0.09	2.39	0.09
Supplement B #	2.3 #	0.09	2.29 #	0.08	2.34 *	0.09	2.37 *+	0.1	2.4	0.08	2.37 #	0.09	2.38	0.12
Supplement C $	2.3 $	0.07	2.29 $	0.08	2.7	0.1	2.38 #$	0.11	2.38	0.1	2.33 * # $	0.08	2.36	0.09
Supplement D * # $	2.38 * # $	0.08	2.38 * # $	0.1	2.4 *	0.08	2.45 $+	0.1	2.45	0.1	2.4 $	0.06	2.43	0.09

Symbols (*, #, $ and +) represent corresponding groups with statistically significant differences ($p<0.05$).

It was observed that supplementation with A, B and C elevated the serum calcium levels from baseline. A significant difference from baseline within the Supplement A, B and C-treated groups was observed for all time points except for 0.5 hours. Also in the Supplement B-treated group at 2 hours there was no significant difference from baseline. No Significant difference was observed in the Supplement D-treated group.

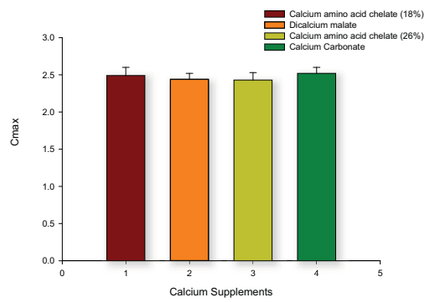
Figure 2: Serum Concentration of Calcium At Different Time Points After Supplementation with Different Preparations



The results of the pharmacokinetic analysis for serum calcium concentrations demonstrated that the AUC_0^{-12h} values were similar for all four Supplements and there was no significant difference.

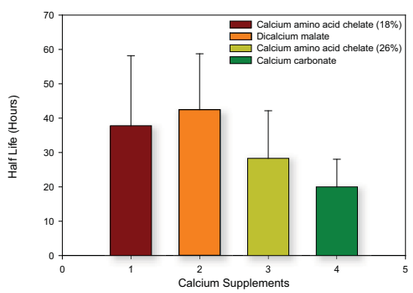
It was observed that supplementation with different calcium preparations led to different serum concentrations suggesting a difference in absorption. A significant difference in the maximum concentration of serum calcium (Cmax) was observed between Supplement D and Supplement B groups and also between Supplement D and Supplement C groups (Figure 2)

Figure 3: Maximum Concentration of Calcium in Serum After Oral Supplementation



It was observed that the half-life of elimination was similar for Supplement A and B, but substantially shorter for Supplement D.

Figure 4: Half Life of Different Calcium Preparations After Absorption



Discussion

In the present study, the pharmacokinetic characteristics and bioavailability of four calcium components were investigated. It was observed that all the supplements had a poor bioavailabiity as suggested by the low values for AUC. This could be due to the elimination of the majority of the supplement after the first pass through the liver.

The results demonstrated that an oral administration of Supplement B (900 mg dose) led to more bioavailable calcium compared to the other three supplements.

Remarkably little is known about the relative efficacy of amino acid chelates of calcium. In the only commonly cited trial, absorption was measured for an amino acid chelate called calcium bisglycinate and compared with absorption from citrate, carbonate, and MCHC (Heaney, et al., 1990). In that trial, the amino acid chelate showed the best absorption and MCHC the worst. Although CCM was studied in that trial, it was taken under different circumstances than the chelate (with meals), so drawing definitive conclusions is not possible. In this study, Dicalcium malate was found to be more bioavailable than the amino acid chelate form of calcium with almost similar absorption but with Dicalcium malate having a longer half-life.

Conclusion

The present study was undertaken to compare the bioavailability of calcium after supplementation with four preparations. It was observed that the calcium present in the four Supplements is absorbed and is bioavailable in humans and can be detected in serum after ingestion of a single dose containing 900 mg of elemental calcium.

All the Supplements had a poor bioavailabiity as suggested by the low values for AUC. This is likely due to substantial first-pass elimination. Based on the results of this study, Supplement B seems to be most bioavailable than other Supplements with a longer half-life followed by Supplement A, C and D.

References

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