

## The estimation of mineral contents in oriental supplements consumed by elite athletes

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### ABSTRACT

The purpose of this study is twofold: to examine macro (calcium, magnesium, and phosphorus) and trace mineral (iron) concentration in oriental supplements (OS), and to define OS prevalence in elite athletes. Participants of this study were 928 varsity athletes (male: 680, female: 248) with 23 sports types. Recent 3-month dietary supplements (DS) and OS practice was surveyed during training period, and mineral concentration in 72 randomly collected OS samples were analyzed. DS use was 41% and OS use was 20% in university elite athletes. Most common OS use informants were parents (74%). OS intake reason was for health maintenance (37%), energy supplement (25%), and recovery improvement (15%). Moreover, health maintenance was higher in females (47%) than males (32%) while energy supplement was higher in males (28%) than females (18%) ( $\chi^2(8) = 17.676, p = 0.024$ ). Beliefs in OS efficacy and importance were significantly higher in female athletes compared to male athletes ( $p < 0.05$ ). Macro mineral concentration in OS was calcium (7.54 ppm), magnesium (4.63 ppm), and phosphorus (205.34 ppb) and trace mineral concentration in OS was iron (8.10 ppb), which was a small amount. An association between OS intake reason and mineral concentration in calcium, phosphorus, and iron was found, but no association between OS intake and magnesium. In conclusion, an association between OS intake reason and mineral concentration differed by the ingredients. Minerals in OS were very small amount, which would be improved for mineral balance in elite athletes.

*Keywords:* dietary supplements, mineral balance, macro, trace, intake reason

### INTRODUCTION

Oriental supplements (OS) are defined as oriental medicine composed of extracted mixed animal and vegetable ingredient and as herbal medicine composed of extracted flower, stem, and seed ingredient from plants [1-3]. OS use has been from ancient China and pharmacologically utilized and OS has been widely used as a treatment of diseases as well as preventive medicine for general population. ("Pharmacologically utilized, OS has been used from ancient China to treat diseases and as a preventive medicine for the general population.")

Elite athletes reported the reasons for OS use as energy supplement, health maintenance, recovery improvement, and energy use enhancement; the OS use frequency of athletes was 26-58% during the training season and 18-21% right

before the competition season [1, 4-6]. In particular, OS practice by Korean elite athletes was higher in mixed oriental medicine than single herbal medicine (i.e. ginseng, red ginseng, deer antler) [4], a distinguishing feature from the Western athletes who consume garlic, soy, ginger, curcuma, and ginseng [7,8]. Past few international events showed positive doping test results in Chinese and North Korean athletes consuming herbal OS; however, a recent study [5] proved the OS safety through negative doping test results by analyzing 9 items with 210 ingredients. Athletes might expect to have ergogenic efficacy induced by OS use; otherwise, it might not be fully understood.

Elite athletes consumed OS to supplement insufficient minerals and to reduce the health risks arising from the insufficient minerals. Minerals contained in herbal medicine might have

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a positive interaction in each ingredient and a positive contribution to the minerals such as building, repairing, and maintaining lean body mass [4,9-11]. However, there has not been a biochemical analysis report for OS mineral contents including macro and trace minerals. Some previous studies insisted that the reason of taking OS in elite athletes was for enhancing ergogenic efficacy [1,4,5]. Nevertheless, the scientific evidence for the positive contribution of minerals in OS is still insufficient. Therefore, the purpose of this study is to examine the macro and the trace mineral concentration in OS and define OS prevalence in elite athletes to examine the ergogenic efficacy of OS in enhancing athletic performance capacity.

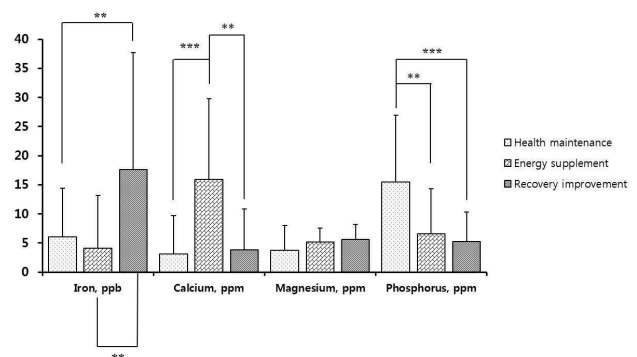
## METHODS

### Participants

Participants in this study were 928 varsity athletes from K University in Seoul and Y University in Yongin. Recent 3-month dietary supplements (DS) and OS practice was surveyed from September, 2011 to January, 2012. Male athletes from 23 sports types such as kendo (male: n = 39, female: n = 7), pentathlon (female: n = 11), basketball (female: n = 15), jumping (male: n = 11), sprint (male: n = 19), wrestling (male: n = 18, female: n = 38), boxing (male: n = 25, female: n = 25), bowling (female: n = 13), skating (female: n = 16), badminton (female: n = 18), shooting (male: n = 9, female: n = 20), swimming (male: n = 24), cycle (male: n = 8), ssireum (male: n = 19), archery (male: n = 14), weight lifting (male: n = 24), judo (male: n = 114, female: n = 33), long-distance running (male: n = 18), rowing (male: n = 16), soccer (male: n = 45), gymnastics (male: n = 23), canoe (male: n = 19), table tennis (female: n = 13), throwing (male: n = 17), taekwondo (male: n = 149, female: n = 38), tennis (male: n = 9), hockey (male: n = 34), handball (male: n = 27) participated in this study (see Fig. 1).

### Study Design

The study design was descriptive and cross-sectional as it investigated DS and OS practices of all participants. After investigating OS practice, 38 males (30%) and 34 females (60%) from OS consumers (125 males and 57 females) were randomly selected; then, the collected OS was analyzed for mineral contents. Minerals related to sports performance such as macro (calcium, magnesium, and phosphorus) and trace minerals (iron) were quantitatively analyzed.



**Fig. 1.** Macro minerals and trace mineral concentration difference based on oriental supplementation intake reason. Only top 3-ranked oriental supplementation intake was used (health maintenance, energy supplement, recovery improvement).

### Oriental and dietary supplementation questionnaires

Recent 3-month DS and OS status of all participants was surveyed through standardized questionnaires. Modified DS and OS questionnaires for Korean national team [4] were used. The face validity of the questionnaires was experience (yes or no); phi = 0.99 with 75 varsity athletes (Kuder-Richardson 20 = 0.99) [1]. All participants' beliefs in OS efficacy, OS importance level (100 mm visual analogue scale), and OS intake informants (open-ended responses) were examined to verify OS practice.

### Macro and trace mineral analysis of oriental supplements (OS)

ICP/MASS spectrometer (ELAN DRC-e, USA) was used to estimate ppm level of calcium and magnesium and ppb level of phosphorus and iron in the collected OS. The collected OS were turned into specimen powder for analysis, and 0.1-0.5g of specimen powder was put into the microwave sample preprocessing equipment container. Next, the macro and the trace mineral analysis of OS was conducted by ICP/MASS with RF power 1400W and cooling condition under assistant atomizing gas hydrometry with 15, 1.5, and 0.1 L/min speed each.

### Data analysis

Statistical Package for Social Science version 16.0 software (SPSS Inc., Chicago, IL, USA) was used to process this study data. Descriptive statistical baseline was age, height, and weight based on the sports type. Chi-square test ( $\chi^2$ ) was used to verify DS and OS prevalence, gender difference of top 3 ranked informants, and the intake reason. Independent t test

**Table 1.** Summary of participant characteristics

Sports type	Gender	Frequency	Percent	Age	Weight	Height
Kendo	Male	39	5.7	19.54 ± 1.12	75.01 ± 8.38	175.44 ± 6.24
	Female	7	2.8	19.29 ± 0.95	68.69 ± 7.89	166.43 ± 4.65
Pentathlon	Male	-	-	-	-	-
	Female	11	4.4	20.10 ± 1.16	65.45 ± 5.87	175.73 ± 6.21
Basketball	Male	-	-	-	-	-
	Female	15	6.0	21.00 ± 2.83	68.42 ± 7.29	170.93 ± 7.33
Jumping	Male	11	1.6	19.69 ± 1.14	60.73 ± 5.85	174.64 ± 5.50
	Female	-	-	-	-	-
Sprint	Male	19	2.8	19.56 ± 1.04	66.00 ± 7.93	177.63 ± 6.08
	Female	-	-	-	-	-
Wrestling	Male	18	2.6	19.78 ± 1.26	84.67 ± 13.84	174.35 ± 5.29
	Female	38	15.3	19.41 ± 2.15	74.42 ± 8.17	168.32 ± 3.83
Boxing	Male	25	3.7	20.18 ± 1.47	69.05 ± 8.83	174.38 ± 4.76
	Female	25	10.1	20.47 ± 0.85	68.26 ± 14.68	173.88 ± 7.62
Bowling	Male	-	-	-	-	-
	Female	13	5.2	22.07 ± 3.39	73.31 ± 10.99	173.10 ± 7.88
Skating	Male	-	-	-	-	-
	Female	16	6.5	19.61 ± 1.18	67.44 ± 10.99	171.00 ± 8.83
Badminton	Male	-	-	-	-	-
	Female	18	7.3	19.77 ± 1.49	66.50 ± 9.40	174.14 ± 8.75
Shooting	Male	9	1.3	20.33 ± 1.51	86.67 ± 21.42	177.78 ± 6.06
	Female	20	8.1	19.95 ± 1.47	67.05 ± 16.76	170.54 ± 7.56
Swimming	Male	24	3.5	19.83 ± 1.18	74.88 ± 7.53	180.08 ± 5.23
	Female	-	-	-	-	-
Cycle	Male	8	1.2	19.29 ± 1.10	71.38 ± 11.95	173.88 ± 7.24
	Female	-	-	-	-	-
Ssireum	Male	19	3.0	20.02 ± 1.15	99.10 ± 22.56	178.50 ± 4.48
	Female	-	-	-	-	-
Archery	Male	14	2.1	19.54 ± 1.12	65.14 ± 8.84	167.92 ± 7.57
	Female	-	-	-	-	-
Weight lifting	Male	24	3.5	21.12 ± 1.85	86.88 ± 22.13	170.71 ± 8.37
	Female	-	-	-	-	-
Judo	Male	114	16.8	20.41 ± 1.42	79.86 ± 15.54	174.04 ± 7.63
	Female	33	13.3	19.95 ± 1.47	70.09 ± 14.76	163.97 ± 5.35
Long-distance running	Male	18	2.6	19.47 ± 1.58	65.89 ± 5.80	177.89 ± 3.94
	Female	-	-	-	-	-
Rowing	Male	16	2.4	19.15 ± 2.12	74.69 ± 9.32	180.13 ± 4.82
	Female	-	-	-	-	-
Soccer	Male	45	6.6	19.43 ± 1.28	70.96 ± 6.61	177.14 ± 5.95
	Female	-	-	-	-	-
Gymnastics	Male	23	3.4	20.15 ± 1.09	55.78 ± 7.01	163.78 ± 7.31
	Female	-	-	-	-	-
Canoe	Male	19	2.8	20.05 ± 1.68	69.55 ± 9.51	172.97 ± 7.28
	Female	-	-	-	-	-
Table tennis	Male	-	-	-	-	-
	Female	13	5.2	19.46 ± 1.88	57.78 ± 5.50	162.08 ± 5.09
Throwing	Male	17	2.5	19.52 ± 2.01	90.59 ± 14.32	178.24 ± 6.54
	Female	-	-	-	-	-
Taekwondo	Male	149	21.9	20.54 ± 2.12	70.86 ± 9.33	177.10 ± 6.56
	Female	38	15.3	20.67 ± 2.01	59.86 ± 5.94	166.00 ± 5.61
Tennis	Male	9	1.3	19.42 ± 1.88	70.22 ± 10.45	175.89 ± 10.23
	Female	-	-	-	-	-
Hockey	Male	34	5.0	20.15 ± 2.45	67.21 ± 7.89	169.47 ± 7.93
	Female	-	-	-	-	-
Handball	Male	27	4.0	19.45 ± 2.67	72.70 ± 11.65	176.78 ± 8.52
	Female	-	-	-	-	-
Total	Male	680	100.0	19.86 ± 1.31	73.98 ± 14.30	175.11 ± 7.52
	Female	248	100.0	19.97 ± 1.89	67.63 ± 12.19	169.56 ± 7.79

**Table 2.** Dietary supplementation and oriental supplementation practice according to gender differences

	All	Males (n = 680)	Females (n = 248)
Prevalence (%)			
Dietary supplements $\int$	381 (41)	343 (50)	38 (15)
Oriental supplements	182 (20)	125 (18)	57 (23)
Top 3 Informants (%)			
parents	134(74)	86(69)	48(84)
coaches	29(16)	21(17)	8(14)
self	13(7)	12(10)	1(2)
Top 3 intake reason (%) $\int$			
health maintenance	67(37)	40(32)	27(47)
energy supplement	45(25)	35(28)	10(18)
recovery improvement	27(15)	19(15)	8(14)
Beliefs in oriental supplements efficacy (mean $\pm$ SD) $\int$	63.86 $\pm$ 18.45	44.46 $\pm$ 6.09	72.70 $\pm$ 15.10
Oriental supplements importance (mean $\pm$ SD) $\int$	62.41 $\pm$ 19.89	46.26 $\pm$ 8.74	69.77 $\pm$ 19.20

$\int$ ;  $p < 0.05$ , gender differences

**Table 3.** Macro minerals and trace mineral concentration in oriental supplements

Factors	Gender (n = 72)	Mean $\pm$ SD.	Mean $\pm$ SD.
Iron, ppb	Male (n = 38)	8.31 $\pm$ 11.77	8.10 $\pm$ 13.27
	Female (n = 34)	7.89 $\pm$ 14.94	
Calcium, ppm	Male (n = 38)	6.30 $\pm$ 9.65	7.54 $\pm$ 11.30
	Female (n = 34)	8.92 $\pm$ 12.89	
Magnesium, ppm	Male (n = 38)	3.98 $\pm$ 3.46	4.63 $\pm$ 3.45
	Female (n = 34)	5.34 $\pm$ 3.35	
Phosphorus, ppb	Male (n = 38)	118.54 $\pm$ 113.86	205.34 $\pm$ 103.99
	Female (n = 34)	90.59 $\pm$ 91.15	

was used to verify the gender difference of beliefs in OS efficacy, OS importance, and macro and trace mineral concentration. One-way ANOVA was used to verify macro and trace mineral concentration difference according to top 3-ranked intake reasons.  $P$  value of all tests was set at  $p < 0.05$ .

## RESULTS

DS use was 41% and OS use was 20% in university elite athletes. DS prevalence was higher in male athletes than in female athletes ( $\chi^2(1) = 92.613$ ,  $p < 0.0001$ ). OS prevalence was higher in female athletes than in male athletes; however, there was no significant difference ( $\chi^2(1) = 2.441$ ,  $p = 0.07$ ). The top 3-ranked informants of OS use was parents (74%), coach (16%), and self (7%), and there was no significant gender difference ( $\chi^2(1) = 7.971$ ,  $p = 0.24$ ). OS intake reason included health maintenance (37%), energy supplement (25%), and recovery improvement (15%), and there was significant gender difference ( $\chi^2(8) = 17.676$ ,  $p = 0.024$ ). Beliefs in OS

efficacy was 63.86  $\pm$  18.45 (scaled from 0 to 100; from very poorly believed to very much believed), and it was higher in female athletes compared to male athletes ( $t = -13.606$ ,  $p < 0.0001$ ). OS importance was 62.41  $\pm$  19.89 (scaled from 0 to 100; from very poorly believed to very much believed), and it was also higher in female athletes than in male athletes ( $t = -8.831$ ,  $p < 0.0001$ ).

Macro mineral concentration in OS was calcium (7.54  $\pm$  11.30 ppm), magnesium (4.63  $\pm$  3.45 ppm), and phosphorus (205.34  $\pm$  103.99 ppb), while trace mineral concentration in OS was iron (8.10  $\pm$  13.27 ppb), with no significant gender difference.

An association between top 3-ranked OS use reason and macro and trace mineral concentration showed a significantly higher concentration in iron related to recovery improvement compared to health maintenance ( $p = 0.001$ ) and energy supplement ( $p = 0.001$ ). There was a significantly higher association between Calcium concentration and energy supplement compared to health maintenance ( $p < 0.0001$ ) and recovery improvement ( $p = 0.001$ ); however, no significant association between Magnesium concentration and OS use reason was found. A significantly higher association between Phosphorus concentration and health maintenance compared to energy supplement ( $p = 0.001$ ) and recovery improvement ( $p < 0.0001$ ) was also found.

## DISCUSSION

It has been reported that DS use in Korean elite athletes was 46% with a higher rate for male athletes compared to female athletes. On the other hand, OS use was 28% with

a higher rate for female athletes than male athletes [1]. The current study results showed the same DS and OS prevalence in athletes. DS use in Korea National Team was 80%, higher than OS use (58%) [4]; for both DS and OS use, female athletes showed a higher rate than male athletes.

Characteristics of DS and OS use in Korea National Team showed a greater tendency for increasing DS and OS use among female athletes as they age, compared to male athletes. The assumption that enhanced athletic performance capacity might come from DS and OS use in athletes [12], has not been strengthened by other studies [13,14]. This study found that OS importance was higher in female athletes as they have a higher OS intake; this might be the main reason for the gender difference in OS use.

In this study, top-ranked OS informants was parents, similar to the previous study of Kim *et al.* [5]. Drawing from this, we can assert that OS purchase might have placed too much burden on athletes due to its higher price than DS [5,15]. OS use of athletes in Asian countries such as Korea, Japan [12,16], and Singapore [17] differed from DS use of athletes in Canada [14], Norway [13], and England [18,19]. The intake reason of OS in Asian athletes was for health maintenance, energy supplement, and recovery improvement. OS has been widely used in Asian athletes, and OS such as herbal medicinal mixture has been reported to be effective for metabolic enzyme activation [20]; however, mineral concentration in OS has not been fully discovered.

This study showed that mineral concentration of OS consumed by university elite athletes was not differed based on gender but had an individual variation, which could be explained by the different OS intake reason in athletes; however, this difference was not fully identified. Macro and trace mineral examined in this study has been reported to conduct a physiological function related to various enzyme activations and to exist in the body in a very small quantity [21]. Macro minerals are recommend to be taken over 100mg per day by RDA (Recommended Dietary Allowances); this amount contributes to the building, repairing, and maintaining lean body mass in athletes [9]. This study qualified calcium, magnesium, and phosphorus concentration in OS and each mean was 7.54 ppm, 4.63 ppm, and 205.34 ppb. Taking into account OS dose as 70 ml, calcium, magnesium, and phosphorus concentration in OS can be calculated as  $0.57E7$  mg (E means below decimal point;  $0.57E7 = 0.000000056$ ),  $0.32E7$  mg, and  $0.0035$ mg. We confirmed that this is a small dose of macro minerals in OS according to the RDA level even though athletes consume OS 3-5 times per day.

Moreover, calcium function in the body has been known to interact with iron, manganese, zinc, and phosphorus for

mineral balance, and calcium effects growth, maintenance, and repair of the bone tissue, maintenance of the blood calcium level, regulation of the muscle contraction, nerve conduction, and normal blood clotting [21]. In particular, calcium highly contributes to glycogen metabolism by activating phosphorylase kinase during glycolysis with high intensity exercise; calcium has been highly recommended for intake in order to improve performance in training and competition. This study found that calcium concentration had a highly significant association between OS intake reason and energy supplement. Additionally, calcium is recommend to maintain RDA because low calcium intake in female athletes might pose a risk of low bone mineral density [22], and this study found that calcium concentration in OS consumed by female athletes was higher compared to calcium concentration in OS consumed by male athletes.

Magnesium has been known to act on glycolysis, fat, and protein metabolism in cellular metabolism and it contributes greatly to hormonal functions and membrane stability regulation in immune, neuromuscular, and cardiovascular system [10]. In particular, magnesium is associated with endurance capacity in athletes and interacts with phosphorus and calcium [21]. This study showed that magnesium concentration was small and female athletes consumed more than male athletes; therefore, additional magnesium intake through foods needs to be recommended for athletes. However, there was no association between OS intake reason and magnesium concentration, which might be explained by the lack of understanding magnesium function.

Phosphorus is combined with organic matter and transformed as phosphoric acid ( $H_3PO_4$ ), which is involved in metabolic process. It has been known to interact with zinc, molybdenum, magnesium, manganese, iron, and calcium [23]. This study found that phosphorus concentration had an association with health maintenance, but not with energy supplement and recovery improvement; this matter should be corrected by optimal intake recommendation for athletes.

Iron as a trace mineral has been known to increase aerobic ATP [21]. This study found that iron concentration had an association with recovery improvement; this finding proved proper iron intake based on theoretical basis. Iron RDA is under 1 mg per day and mean iron concentration in OS was 0.56 ug. This study confirmed that optimal iron intake in athletes was done by consuming OS because they consumed OS 3-5 time per day.

Mineral concentration in OS consumed by athletes had an association between OS intake reason and calcium, phosphorus, and iron except magnesium; however, optimal amount of minerals according to RDA needs to be consumed for mineral

balance in athletes.

## CONCLUSION

We examined OS consumed by university elite athletes and analyzed essential mineral concentration for athletes. We found that iron, calcium, and phosphorus, except magnesium, were optimally consumed by athletes according to their preference and scientific basis. Although the purpose of OS intake was for activating enzymes in the body, each role of minerals in OS should not be ignored because OS is usually used by mixed herb medicine ingredients. Further studies on mineral enriched food for athletes are needed to suggest recommended minerals for balancing mineral level in the body. In addition, minerals are expected to interact with various minerals than to act alone; therefore, mineral interaction study related to athletic performance capacity are needed.

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