Dietary Intake of Vitamins and Minerals in Adolescent Sprint Athletes: A Three Year Follow-up Study

Dirk Aerenhouts (Corresponding author)
Department of Human Biometry and Biomechanics
Vrije Universiteit Brussel, Pleinlaan 21050 Brussel, Belgium
Tel: 32-2629-2733E-mail: dirk.aerenhouts@vub.ac.be

Peter Deriemaeker
Department of Human BiometryandBiomechanics
Vrije Universiteit Brussel, Pleinlaan 21050 Brussel, Belgium
Tel: 32-2629-2731 E-mail: pderiema@vub.ac.be

Marcel Hebbelinck
Department of Human BiometryandBiomechanics
Vrije Universiteit Brussel, Pleinlaan 21050 Brussel, Belgium
Tel: 32-2629-2729 E-mail: mhebbel@vub.ac.be

Peter Clarys
Department of Human Biometry and Biomechanics
VrijeUniversiteitBrussel, Pleinlaan 21050 Brussel, Belgium
Tel: 32-2629-2739 E-mail: pclarys@vub.ac.be

Received: November 23, 2011 Accepted: December 6, 2011 Published: February 1, 2012
doi:10.5539/jfr.v1n1p277 URL: http://dx.doi.org/10.5539/jfr.v1n1p277

The research is financed by the Research Council of the VrijeUniversiteitBrussel

Abstract

This study aimed to assess micronutrient intake and supplement use in adolescent sprint athletes. Anthropometrics, micronutrient intake and supplement use of 60 adolescent sprint athletes were recorded every six months over a 3-year period. Age at start was 14.8 ± 1.6 years for the female and 14.7 ± 1.9 years for the male athletes. Over the 3 years, both girls and boys normally gained in body height and - weight. Consistent low intakes were observed for iron in girls, and for calcium, vitamin E and B2 in both sexes, whilst sodium intake exceeded the upper reference limit. Supplements were used without prescription and athletes with the better nutritional profile showed higher supplement use compared to those with poorer habits. General non-stringent advice for dietary improvement resulted in significantly favourable changes only for the consumption of wholegrain bread, vegetables, and soft drinks. Micronutrient intakes of adolescent sprint athletes are relatively stable and not always according the guidelines, regardless of supplement use. Repeated nutritional feedback induced only moderate improvements.

Keywords: Adolescents, Micronutrients, Supplements, Sprint athletes

1. Introduction

Pubertal growth and development increase the need for energy and nutrients. For adolescent athletes, extra care should be given to their diet, since the needs of their physical activities are added to their nutritional needs for

growth and development (Petrie, Stover, &Horswill, 2004).

Since literature on the nutritional profile in adolescent sprint athletes is scarce, there is a need for more research on the nutritional requirements of young athletes in specific disciplines (Meyer, O'Connor, & Shirrefs, 2007; Tipton, Jeukendrup, & Hespel, 2007). Dietary guidelines for athletes focus primarily on energy, macronutrient and fluid intake. Less attention goes to adequate intakes of micronutrients. Nonetheless, minerals, trace elements and vitamins facilitate the use of macronutrients for physiologic processes and they are involved in homeostasis, nerve conduction, muscle contraction, and some have antioxidant capacities (Lukaski, 2004; Kreider et al., 2010).

As is the case for energy and macronutrients, adolescent sprint athletes probably have additional needs for micronutrients as compared to their non-athletic peers. In adolescents involved in different sports, inadequate intakes for fluid, fibre, iron, calcium, potassium, magnesium, folate, vitamin A, D and E have been reported (Ziegler et al., 1998; Garrido, Webster, & Chamorro, 2007; Aerenhouts, Hebbelinck, Poortmans, & Clarys, 2008; de Sousa, Da Costa, Nogueira, & Vivaldi, 2008; Juzwiak, Amancio, Vitalle, Pinheiro, & Szejnfeld, 2008; Kabasakalis et al., 2009).

Supplementation of vitamins and minerals is very common amongst athletes in an attempt to maintain health, to optimize performance and recovery and to compensate for an imbalanced diet (Dorsch & Bell, 2005; Maughan, Depiesse, & Geyer, 2007). Athletic trainers appear to have the greatest influence on nutritional and supplementation practices of athletes (Burns, Schiller, Merrick, & Wolf, 2004; Nieper, 2005). However, improper dietary habits and supplement use is often observed in combination. In most of the research on dietary habits of athletes it is concluded that proper monitoring of the diet is highly recommended and that the individual athlete should receive adequate nutritional information. Consumption of micronutrient-rich foods such as wholegrain foods, fruit and vegetables is very important (Lukaski, 2004). In general, for maintaining and optimizing health and performance, adolescent athletes should be advised to consume a well-balanced diet containing a variety of foods in sufficient amounts to meet energy demands (Meyer et al., 2007; Kreider et al., 2010). Dietary supplements should only be advised when a food-based solution is not available (Maughan et al., 2007; Kreider et al., 2010).

It was the aim of the present study to estimate intakes of micronutrients and supplements in adolescent sprint athletes over a period of 3 years. In addition, the study protocol allows an evaluation of dietary habits between seasons and throughout a 3-year period during adolescence.

2. Methods

2.1 Participants

Based on the Flemish Athletics League rankings, 120 sprint athletes aged 12 to 18 years were selected and invited to participate in a 3-year follow-up study on sprint start performance, physical parameters and nutrition. Due to logistical limitations, only 60 of the 76 responders were retained (29 girls and 31 boys, age 14.8 ± 1.6 years and 14.7 ± 1.9 years respectively). Participating athletes and their parents were given detailed information about the study. They were asked to give their written informed consent, in accordance with requirements of the university's ethical committee.

2.2 Food intake

A 7-day food record was administered in both the spring and autumn of 2006, 2007 and 2008. The participants were clearly instructed to maintain their normal eating patterns and to report all foods as accurately as possible by time of the day, portion size, preparation and composition of foods. For portion sizes they were asked to weigh the items. When this was impossible, household measures were used to provide an estimate of the portion size (Health council, 2009). The participants were also asked to weigh themselves before breakfast of day 1 when they started recording as well as after day 7. Within 2 weeks of completion, the record was checked by the investigator in the presence of the athlete and at least one of his or her parents. At that moment, extra information was obtained where necessary. Analysis of the food records was done by the same investigator using the Becel nutrition software program BINS 3.0.1, based on the Belgian (NUBEL 2004) and Dutch (NEVO 2001) food composition databanks. Since the Recommended Dietary Intake (RDI) for micronutrients is gender and age specific, micronutrient intakes are represented as a percentage of this RDI ((intake/RDI) x 100). Due to incompleteness of the food data banks used, only a selection of micronutrients (sodium, potassium, calcium, phosphorus, iron, magnesium, retinol equivalents (RE), and vitamins E, B1, B2, B12 and C) are discussed in the present study. Vitamin A (retinol) and beta-carotene intakes were used in the calculation of retinol equivalents (RE (μg) = retinol (μg) + beta-carotene/12 (μg)). Dietary supplements were taken into account after dietary

analysis. Supplements were defined as products delivering extra micronutrients or amino acids, creatine or having an alkalizing effect. Sports drinks, energy bars and homeopathic products were not considered as a supplement. Results and non-stringent advice for improvement of the diet regarding fluid intake, wholegrain instead of refined foods, fruit and vegetable consumption were fed back to each individual by e-mail.

2.3 Anthropometry

During the same visit when handing over the food records, anthropometric data were collected. Standing height was measured to the nearest 0.1 cm using a wall-mounted stadiometer. Weight was measured with the TANITA-TBF 410 weighing scale to 100 g, and body composition was estimated by underwater weighing densitometry using the formula of Siri (1961). Basal energy expenditure (BEE) was calculated using the Institute of Medicine equation (2005). A ratio of 1.1 between total energy intake and BEE was used as a tool for detecting underreporting (Goldberg et al., 1991). Criteria for not including records for analysis were underreporting and reporting less than 7 days.

2.4 Statistical analysis

Statistical analysis was performed with SPSS 17.0. The Kolmogorov-Smirnov test was used to test for normal distribution of the data. A repeated-measures ANOVA followed by a paired t –test with Bonferroni correction were applied to compare nutrient and food intakes between occasions. In the case of non-parametric data, the Kruskal-Wallis test and Mann-Whitney U test were applied. Descriptive statistics on physical characteristics and number of participants using food supplements was done on all accepted data per occasion. Micronutrient intakes of girls and boys were compared to the recommendations of the Belgian Health Council (2009) with a Student's t-test. The significance level was set at $p < 0.05$.

3. Results

The total numbers of records and rejected records on each occasion, as well as age and anthropometric data have been published elsewhere (Aerenhouts, Deriemaeker, Hebbelinck, & Clarys, 2011). Self-measured body weight at start of the week of recording was not statistically different from on the day after, except in boys on occasion 5 (66.9 ± 8.1 kg vs. 66.6 ± 8.1 kg, $p = 0.024$).

Intakes of vitamins and minerals as a percentage of the RDI are presented in figures 1 and 2, respectively. Table 1 shows the percentage of athletes reaching the RDI, as well as the ratio: number of supplementing athletes / number of these athletes who already reached the RDI through their diet.

On the first occasion, one male subject took an essential amino acid supplement and on the final occasion another one supplemented with creatine. On all other occasions only vitamin and mineral supplements, often in combination, were taken. The number of girls and boys taking supplements was comparable. For both sexes per occasion, 15%, 34%, 35%, 28%, 27% and 15% of the athletes supplemented one or more micronutrients. As shown in Table 1, athletes taking supplements had in many cases already sufficient intake through the diet alone (for example vitamin C and magnesium) whilst athletes with dietary shortages often did not take supplements (for example iron in girls and calcium). One girl supplemented micronutrients on prescription after being diagnosed with low iron blood concentration (occasions 2, 3, 4, 5).

(Figure 1)

(Figure 2)

(Table 1)

Consumption of bread, fruit and vegetables is illustrated in Aerenhouts et al. (2011). The quantity of white bread consumed by both girls and boys did not change over the 3 years, as did the quantity of wholegrain bread for boys only. Girls ate more wholegrain bread on occasions 4, 5, and 6 than on occasion 1 ($p = 0.001$, $p = 0.010$, and $p = 0.003$) and more on occasion 4 compared with occasions 2 and 3 ($p = 0.012$ and $p = 0.002$).

In both sexes, no significant change in fruit consumption was observed and there was no difference between girls and boys. The reference dietary intake for fruit of 250 g per day was achieved by 13%, 25%, 36%, 28%, 32%, and 28% of girls, and by 29%, 19%, 15%, 20%, 31%, and 27% of boys on occasions 1–6. Mean daily vegetable consumption was similar between girls and boys during the study, but vegetable intake significantly increased during the study period for boys only. In boys, more vegetables were consumed on occasions 3, 5, and 6 than on occasion 1 ($p = 0.004$, $p < 0.001$, and $p = .001$), as well as on occasion 5 compared with occasion 2 ($p = 0.003$). None of the girls reached the reference intake for vegetables of 300 g per day on occasion 1–4 and only one on occasions 5 and 6, while none of the boys reached the reference dietary intake on occasions 1 and 4, only one boy on occasions 3, 5, and 6, and two boys on occasion 2.

4. Discussion

This follow-up study provided a clear picture of adolescent's dietary habits with respect to micronutrient and supplement intake in combination with their physical development over a 3-year period. Since the first aim of this study was the estimation of dietary habits among these athletes we deliberately did not intervene directly in the diet, but we did provide limited and non-stringent nutritional feedback and information to the athletes and their parents.

Due to a lack of specific reference data, micronutrient intakes of the athletes in this study were compared to the age and gender dependent RDI for non-athletic adolescents (Health council, 2009). Although the self-measured body weights at start and at the end of the recording weeks were stable, observed shortages should be interpreted with caution since dietary underreporting is commonly observed, also in highly motivated athletes (Burke, 2001). True nutrient shortages can only be revealed by using biomarkers (Jenab, Slimani, Bictash, Ferrari, & Bingham, 2009), which were not used in this study.

High standard deviation scores of food and micronutrient intakes indicate a high variability in intake of certain micronutrient-rich foods among these athletes. However, mean intake values over the 3-year period show a stable dietary intake with only little improvement despite repeated, but non-stringent, dietary feedback. Girls had significant higher vitamin B1 intakes on occasion 4 and 5 as compared to the first occasion. This might be explained by the simultaneous change observed in wholegrain bread consumption since wholegrain foods are rich in vitamin B1. Sufficient intakes as compared to the RDI for Belgian adolescents were observed for RE, vitamins B1, B12 and C and for potassium, phosphorus, magnesium and in boys only, iron. Only a limited number of girls and boys reached the RDI values for vitamin B2, vitamin E, calcium, and in girls only, iron. Dietary shortages of these micronutrients can have consequences for both health and performance (Lukaski, 2004; Kreider et al., 2010). Severe vitamin E deficiency increases oxidative stress in the muscle, causing degradation and inflammatory processes leading to muscle dystrophy. Vitamin B2 is involved in glucose metabolism during exercise and a shortage can therefore have an immediate impact on the performance level of these athletes. Calcium is in first place necessary for bone acquisition and the needs for calcium reach maximal levels during puberty. Considering the physical activities characterized by high impacts these athletes are involved in, optimal bone density can be expected if combined with an adequate calcium intake (Vicente-Rodriguez et al., 2008). Low iron intakes in girls are a matter of concern, since low iron stores is one of the most prevalent nutrient deficiencies observed among female athletes. Iron deficiency can impair muscle function and limit work capacity.

High intakes of sodium were observed. However, these athletes may have elevated sodium needs because of elevated sweat losses.

Dietary shortages of vitamin B2, vitamin E, calcium and iron were earlier observed in other studies on children and adolescent athletes. On the other hand, most sprint athletes in this study had sufficient intakes for vitamin A, magnesium and potassium which is in contrast with other reports (Ziegler et al., 1998; Aerenhouts et al., 2007; Garrido et al., 2007; de Sousa et al., 2008; Juzwiak et al., 2008; Kabasakalis et al., 2009).

Supplement use was observed in athletes regardless their dietary intake. Micronutrient intakes that where below the RDI as well as micronutrient intakes that reached the RDI were supplemented by a comparable number of athletes. Apparently, athletes with concern about sufficient micronutrient intakes who took dietary supplements met already the RDI through the diet alone. On the other hand, otherathletes with dietary shortages were not aware of this deficiency or its possible consequence since these were not taking any supplement. This can indicate for subgroups within this sample of athletes with higher and on the other hand lower concern for sufficient nutrient intakes. Higher supplement use in more health conscious people was earlier observed (Stang, Story, Harnack, & Neumark-Sztainer, 2000; Rock, 2007; Mullie et al., 2009). In the present study, supplements were taken without consulting a physician or dietician, with one exception. This is a matter of concern since overuse of micronutrients can be potentially harmful for health (Maughan et al., 2007; Rock, 2007; Kreider et al., 2010). A review by Bjelakovic, Nikolova, Gluud, Simonetti, & Gluud (2007) pointed out that overuse of beta-carotene and vitamin A and E, singly or combined, significantly increases mortality. Still, compared to other findings on supplement use by track and field athletes, relatively few (<40%) athletes in this study took supplements. Around 80% of the sprint athletes competing at international championships from 2005 to 2007 reported to use supplements (Maughan et al., 2007). The definition of supplements (including energy bars and sports drinks or not) as well as a different performance level and age could explain this difference.

The important role of athletic coaches, more than dieticians and physicians, in providing nutritional information has been shown (Burns et al., 2004, Nieper, 2004). Therefore, there is an urge for well-educated coaches in

collaboration with dieticians and doctors in order to provide an adequate nutritional support for athletes. The use of biomarkers should provide the decisive answer in whether advising supplements or not.

Shortages of micronutrients may be related to the low consumption of wholegrain foods and cereals, fruits and vegetables. These foods are highly necessary in an athlete's diet since they contain indispensAble fibre, micronutrients and antioxidants. This information was shared with the athletes. Although there was a trend towards a higher fruit intake, there were no significant changes throughout the study period. For vegetables, significant but insufficient improvements were observed since practically all participants remained far below the recommended 300g/day on all occasions. A higher consumption of fruit and vegetables will be crucial also after the athletics career to maintain health at older ages. Indeed, it has been suggested that these foods help prevent cancer, cardio-vascular and metabolic diseases (Craig & Mangels, 2009).

No seasonal influences on intakes of selected foods and micronutrients were observed. A positive but rather modest evolution over the 3 years was observed only for consumption of vegetables and wholegrain bread. Other studies on dietary habits of adolescents (Löwik et al., 1994; Alexy, Sichert-Hellert, & Kersting, 2002) show that dietary changes occur gradually. These changes are mainly influenced by commercial advertising, mass communication and the food industry itself (Nicklas, Webber, Srinivasan, & Berenson, 1993). Therefore, observed changes in the diet of these sprint athletes may also be attributed to other sources.

This study shows that the micronutrient intake of adolescent sprint athletes is relatively stable. A higher consumption of micronutrient-dense foods offers a dietary based solution to reach the RDI for nutrients with shortages. Dietary supplementation should be done with more care and only after acquiring qualified advice. It appears to be difficult to improve dietary habits solely based on providing nutritional information.

References

Aerenhouts, D., Deriemaeker, P., Hebbelinck, M., & Clarys, P. (2011). Energy and macronutrient intake in adolescent sprint athletes: A follow-up study. *Journal of Sports Sciences,* 29(1), 73-82. http://dx.doi.org/10.1080/02640414.2010.521946

Aerenhouts, D., Hebbelinck, M., Poortmans, J. R., & Clarys, P. (2008). Nutritional Habits of Flemish Adolescent Sprint Athletes. *International Journal of Sport Nutrition and Exercise Metabolism,* 18(5), 509-523.

Alexy, U., Sichert-Hellert, W., & Kersting, M. (2002). Fifteen-year time trends in energy and macronutrient intake in German children and adolescents: results of the DONALD study. *British Journal Nutrition, 87,* 595-604.http://dx.doi.org/10.1079/BJN/2002572

Bjelakovic, G., Nikolova, D., Gluud, L. L., Simonetti, R. G., & Gluud, C. (2007). Mortality in randomized trials of antioxidant supplements for primary and secondary prevention: systematic review and meta-analysis. *Journal of the American Medical Association*, 297(8), 842-857. http://dx.doi.org/10.1001/jama.297.8.842.

Burke, L. M. (2001). Energy needs of athletes. *Canadian Journal of Applied Physiology,* 26, S202-219. http://dx.doi.org/10.1016/j.jada.2003.11.013

Burns, R. D., Schiller, M. R., Merrick, M. A., & Wolf, K. N. (2004). Intercollegiate student athlete use of nutritional supplements and the role of athletic trainers and dietitians in nutrition counselling. *Journal of the American Dietetic Association,* 104(2), 246-249.

Craig, W. J., & Mangels, A. R. (2009). Position of the American Dietetic Association: vegetarian diets. *Journal of the American Dietetic Association,* 109(7), 1266-1282. http://dx.doi.org/10.1016/j.jada.2009.05.027

de Sousa, E. F., Da Costa, T. H., Nogueira, J. A., & Vivaldi, L. J. (2008). Assessment of nutrient and water intake among adolescents from sports federations in the Federal District, Brazil. *British Journal of Nutrition,* 99(6), 1275-1283. http://dx.doi.org/10.1017/S0007114507864841

Dorsch, K. D., & Bell, A. (2005). Dietary supplement use in adolescents. *Current Opinion in Pediatrics,* 17(5), 653-657. http://dx.doi.org/10.1097/01.mop.0000172819.72013.5d

Garrido, G., Webster, A. L., & Chamorro, M. (2007). Nutritional adequacy of different menu settings in elite Spanish adolescent soccer players. *International Journal of Sport Nutrition and Exercise Metabolism,* 17(5), 421-432.

Goldberg, G. R., Black, A. E., Jebb, S. A., Cole, T. J., Murgatroyd, P. R., Coward, W. A. et al. (1991). Critical evaluation of energy intake data using fundamental principles of energy physiology:1. Derivation of cut-off limits to identify under-reporting. *European Journal of Clinical Nutrition,* 45, 569-581.

Health Council – Nutritional recommendations for Belgium - Review 2009HGR8309 (Hogegezondheidsraad – VoedingsaanbevelingenvoorBelgië- Herziening 2009 HGR8309) [Online]Available:http://www.health.belgium.be/eportal/Aboutus/relatedinstitutions/SuperiorHealthCouncil/publications/index.htm (December 2011)

Institute of Medicine. (2005). *Dietary reference intakes for energy, carbohydrate, fiber, fat, fatty acids, cholesterol, protein, and amino acids (macronutrients). Appendix I: Doubly labelled water data used to predict energy expenditure.* Washington, DC: National Academy Press.

Jenab, M., Slimani, N., Bictash, M., Ferrari, P., & Bingham, S. A. (2009). Biomarkers in nutritional epidemiology: applications, needs and new horizons. *Human Genetics*, 125(5-6), 507-525. http://dx.doi.org/10.1007/s00439-009-0662-5

Juzwiak, C. R., Amancio, O. M. S., Vitalle, M. S. S., Pinheiro, M. M., &Szejnfeld, V. L. (2008). Body composition and nutritional profile of male adolescent tennis players. *Journal of Sports Science,* 26(11), 1209-1217. http://dx.doi.org/10.1080/02640410801930192

Kabasakalis, A., Kalitsis, K., Nikolaidis, M. G., Tsalis, G., Kouretas, D., Loupos, D. et al. (2009). Redox, iron, and nutritional status of children during swimming training. *Journal of Science and Medicine in Sport*, 12(6), 691-696. http://dx.doi.org/10.1016/j.jsams.2008.05.005

Kreider, R. B., Wilborn, C. D., Taylor, L., Campbell, B., Almada, A. L., Collins, R. et al. (2010). ISSN exercise & sport nutrition review: research & recommendations. *Journal of the International Society of Sports Nutrition,* 7(7), 1-43.

Löwik, M. R. H., Brussard, J. H., Hulshof, K. F. A. M., Kistemaker, C., Schafsmaa, G., Ockhuizen, T. et al. (1994). Adequacy of the diet in the Netherlands in 1987-1988; Dutch nutrition surveillance system. *International Journal of Food Sciences and Nutrition*,45(suppl. 1), S56-S60.

Lukaski, H. C. (2004). Vitamin and Mineral Status: Effects on Physical Performance. *Nutrition*, 20, 632-644. http://dx.doi.org/10.1016/j.nut.2004.04.001

Maughan, R. J., Depiesse, F., & Geyer, H. (2007). The use of dietary supplements by athletes. *Journal of Sports Science*,25(suppl. 1), S103-S113. http://dx.doi.org/10.1080/02640410701607395

Meyer, F., O'Connor, H., &Shirrefs, S. M. (2007). Nutrition for the young athlete. *Journal of Sports Science*, 25, S73-S82. http://dx.doi.org/10.1080/02640410701607338

Mullie, P., Guelinckx, I., Clarys, P., Degrave, E., Hulens, M., & Vansant, G. (2009). Cultural, socioeconomic and nutritional determinants of functional food consumption-patterns. *European Journal of Clinical Nutrition*, 63(11), 1290-1296. http://dx.doi.org/10.1038/ejcn.2009.89

Nicklas, T. A., Webber, L. S., Srinivasan, S. R., & Berenson, G. S. (1993). Secular trends in dietary intakes and cardiovascular risk factors of 10-y-old children: The Bogalusa Heart Study (1973-1988). *American Journal of Clinical Nutrition*, 57, 930-937.

Nieper, A. (2005). Nutritional supplement practices in UK junior national track and field athletes. *British Journal of Sports Medicine*, 39, 645-649. http://dx.doi.org/10.1136/bjsm.2004.015842

Petrie, H. J., Stover, E. A., & Horswill, C. A. (2004). Nutritional concerns for the child and adolescent competitor. *Nutrition*, 20, 620-631. http://dx.doi.org/10.1016/j.nut.2004.04.002

Rock, C. L. (2007). Multivitamin-multimineral supplements: who uses them? *American Journal of Clinical Nutrition,* 85, S277-S279.

Siri, W. E. (1961). *Techniques for measuring body composition*. Washington, DC: National Academy Press.

Stang, J., Story, M. T., Harnack, L., & Neumark-Sztainer, D. (2000). Relationships between vitamin and mineral supplement use, dietary intake, and dietary adequacy among adolescents. *Journal of the American Dietetic Association*, 100, 905-910. http://dx.doi.org/10.1016/S0002-8223(00)00262-5

Tipton, K. D., Jeukendrup, A. E., & Hespel, P. (2007). Nutrition for the sprinter. *Journal of Sports Science,* 25, S5-S15. http://dx.doi.org/10.1080/02640410701607205

Vicente-Rodriguez, G., Ezquerra, J., Mesana, M. I., Fernández-Alvira, J. M., Rey-López, J. P., Casajus, J. A. et al. (2008). Independent and combined effect of nutrition and exercise on bone mass development. *Journal of Bone and Mineral Metabolism*, 26, 416-424.http://dx.doi.org/10.1007/s00774-007-0846-9

Ziegler, P. J., San Khoo, C., Kris-Etherton, P. M., Jonnalagadda, S. S., Sherr, B., & Nelson, J. A. (1998).

Nutritional status of nationally ranked junior US figure skaters. *Journal of the American Dietetic Association*, 98(7), 809-811. http://dx.doi.org/10.1016/S0002-8223(98)00181-3

Table 1. Percentage of girls and boys reaching the RDI for micronutrients, followed by the ratio:number of participants supplementing/ number of participants supplementing with dietary shortage

	Spring '06	Autumn '06	Spring '07	Autumn '07	Spring '08	Autumn '08
RE (µg) ♀	67%, 1/1	79%, 2/0	72%, 1/0	84%, 3/0	64%, 1/0	72%, 2/0
♂	62%, 3/1	88%, 4/0	65%, 8/1	72%, 5/1	73%, 3/0	95%, 2/0
vit E (mg) ♀	37%, 2/2	21%, 3/3	12%, 1/1	24%, 4/1	45%, 3/2	50%, 2/0
♂	42%, 3/2	50%, 5/4	46%, 8/5	48%, 5/3	58%, 3/2	36%, 2/2
vit B1 (mg) ♀	96%, 1/0	96%, 3/0	92%, 1/0	92%, 4/0	91%, 4/1	94%, 1/0
♂	83%, 3/1	87%, 5/1	88%, 8/1	92%, 5/0	88%, 3/0	91%, 2/0
vit B2 (mg)♀	71%, 1/0	62%, 3/1	72%, 1/0	76%, 4/1	77%, 4/2	72%, 1/0
♂	54%, 3/1	46%, 5/3	61%, 8/2	60%, 5/2	50%, 3/3	59%, 2/1
vit B12 (µg) ♀	100%, 2/0	96%, 4/0	88%, 2/1	92%, 3/0	95%, 4/0	94%, 1/0
♂	100%, 3/0	100%, 4/0	100%, 8/0	96%, 5/0	96%, 3/0	100%, 2/0
vit C (mg) ♀	83%, 2/0	83%, 6/0	80%, 4/1	80%, 4/0	86%, 3/1	83%, 2/2
♂	79%, 3/0	81%, 6/2	92%, 9/0	72%, 8/2	88%, 4/0	91%, 2/2
Na (mg) ♀	0%, 0/0	0%, 0/0	0%, 0/0	0%, 0/0	0%, 0/0	0%, 0/0
♂	0%, 0/0	0%, 0/0	0%, 0/0	0%, 0/0	0%, 0/0	0%, 0/0
K (mg) ♀	96%, 0/0	100%, 0/0	100%, 0/0	100%, 0/0	91%, 1/1	94%, 0/0
♂	100%, 0/0	96%, 1/1	100%, 3/0	100%, 0/0	100%, 0/0	100%, 1/0
Ca (mg) ♀	12%, 1/1	17%, 1/0	12%, 0/0	8%, 1/1	14%, 1/1	11%, 1/1
♂	12%, 0/0	23%, 3/3	35%, 6/4	24%, 2/2	27%, 2/2	9%, 2/2
P (mg) ♀	100%, 1/0	75%, 1/0	96%, 0/0	96%, 1/0	95%, 0/0	89%, 1/0
♂	100%, 0/0	77%, 1/1	100%, 1/0	96%, 2/0	100%, 2/0	100%, 1/0
Fe (mg) ♀	0%, 2/2	4%, 3/3	4%, 4/4	4%, 5/4	0%, 5/5	0%, 2/2
♂	67%, 1/0	77%, 4/1	81%, 6/1	72%, 5/2	77%, 3/1	82%, 2/0
Mg (mg)♀	79%, 1/0	75%, 3/0	72%, 2/0	84%, 4/0	86%, 3/0	78%, 1/0
♂	92%, 2/1	92%, 5/0	92%, 8/0	72%, 4/1	92%, 4/0	77%, 2/0

RE: Retinol Equivalent.

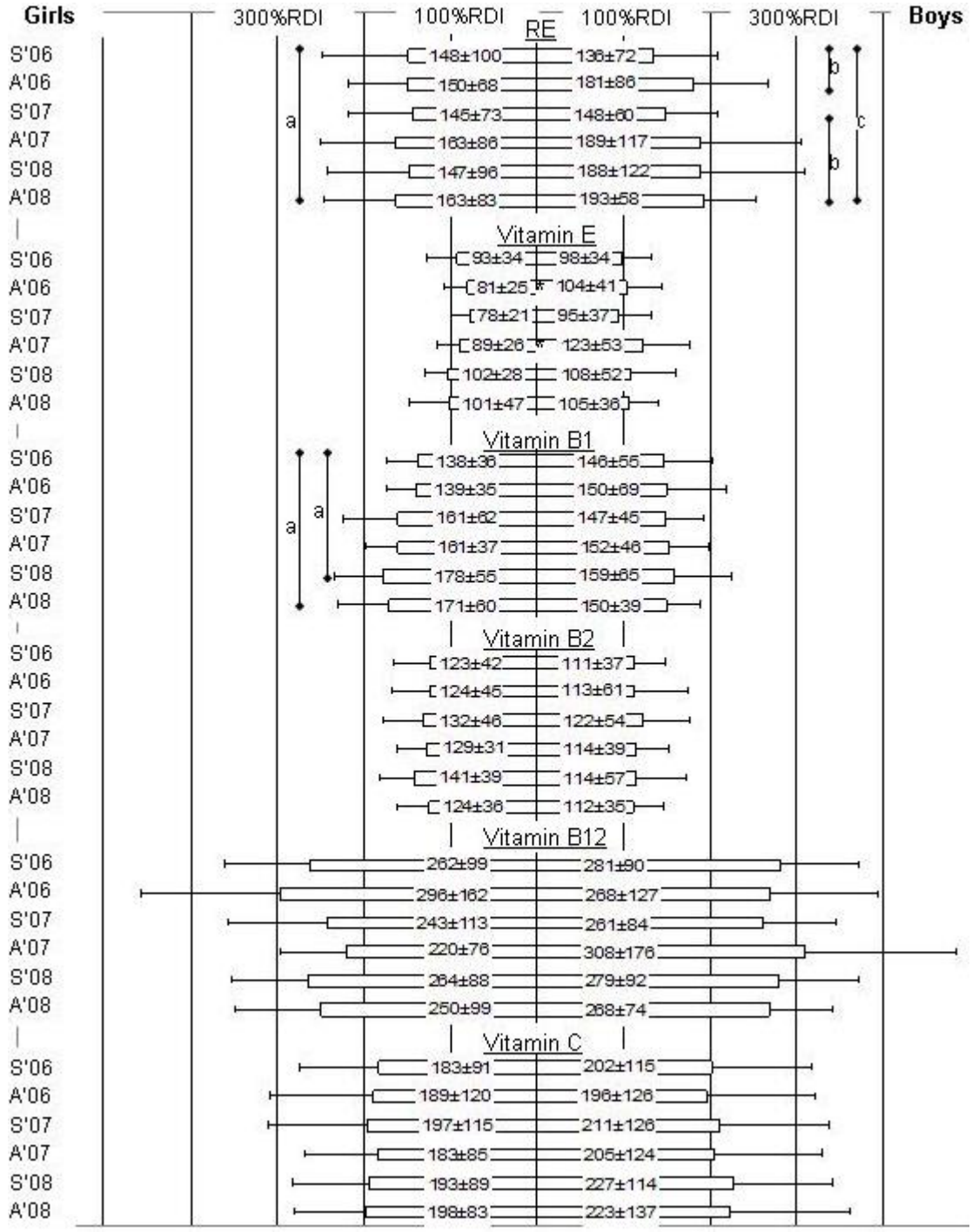

Figure1. Mean dietary vitamin intake as a percentage of the RDI (Health Council, 2009)

S: Spring period, A: Autumn period. RE: Retinol Equivalent. a, b, c: difference between occasions at $p < .05, .01, .001$, respectively. *: difference between girls and boys at $p < .05$.

ISSN 1927-0887 E-ISSN 1927-0895

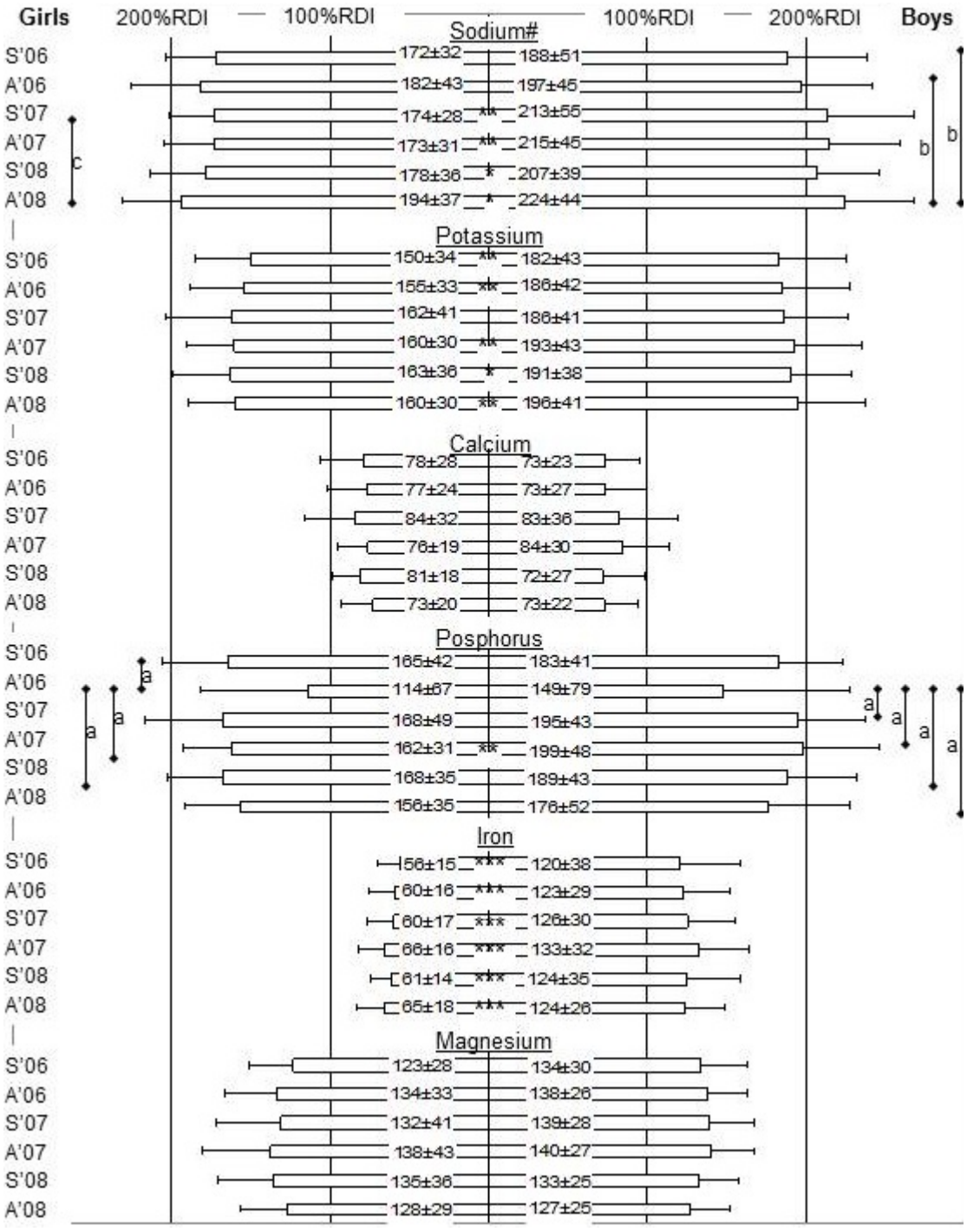

Figure 2. Mean dietary mineral intake as a percentage of the RDI (Health Council, 2009)

S: Spring period, A: Autumn period. #: 100% = upper RDI limit. a, b, c: difference between occasions at $p < .05, .01, .001$, respectively. *, **, ***: difference between girls and boys at $p < .05, .01, .001$, respectively.