Research Article

Nutrition Knowledge and Food Choice in Young Athletes

Authors:

Juliane Heydenreich[1,2]
e-mail: juliane.heydenreich@baspo.admin.ch

Anja Carlsohn[1,3]
e-mail: anja.carlsohn@ph-gmuend.de

Frank Mayer[1]
e-mail: fmayer@uni-potsdam.de

[1]University Outpatient Clinic Potsdam, Sports Medicine and Sports Orthopaedics, University of Potsdam, Germany

[2]Swiss Federal Insitute of Sport Magglingen SFISM, Magglingen, Switzerland

[3]Institute of Health Science, University of Education Schwäbisch Gmünd, Schwäbisch Gmünd, Germany

Received date: 30 July 2014; Accepted date: 30 October 2014

Academic Editor: Katharina Diehl

Contact Author:

Juliane Heydenreich
Swiss Federal Insitute of Sport Magglingen SFISM
Hauptstrasse 247
CH-2532 Magglingen
Switzerland
Phone: +41 58 467 61 37
e-mail: juliane.heydenreich@baspo.admin.ch

Abstract

For young athletes, an optimized diet is important for growth, health and athletic performance. Data about nutrition knowledge, nutrient intake and food choice in athletes are rare. Aim of the study was to analyze nutrition knowledge and food choice of young athletes.

559 young athletes (59% male; 11.7±0.8 years; 18.4±2.5 kg/m^2) were included in the study. Food choice was assessed by a standardized Food-Frequency-Questionnaire and Healthy-Eating-Index (maximum 50 points, HEI_{max}). Nutrition knowledge was checked using a nutrition knowledge questionnaire (NKQ; 12 items, maximum 24 points). For a better overview, total NKQ-score was divided into 6 categories according to the German school grading system. All results are presented as mean±standard deviation. Mann-Whitney U tests and Kruskal-Wallis one-way ANOVA by ranks were used, respectively, to check for differences between gender and sports discipline. Relationship between total NKQ- and HEI-score was assessed with Pearson´s correlation coefficient (α=0.05).

Young athletes reached 35±10 points (70±18% HEI_{max}) in food choice and 9±3 points (37±12% of the maximum score) in NKQ. There were no statistically significant gender differences in NKQ- (p=0.21) or HEI-score (p=0.48), respectively. NKQ-score showed that intake of vegetables and fruits was significantly affected by sports discipline ($p<0.05$). Intake of dairy product was higher in males than in females (p=0.02). No correlation between NKQ-score and HEI-score was observed (r_p=0.03, 95% CI [-0.17, 0.39], p=0.45).

In conclusion, both nutrition knowledge and food choice is insufficient in young athletes. Focus should be set on nutrition education programs to improve nutrition knowledge and food choice of athletes.

Key words: adolescent athletes, Healthy Eating Index, nutrient intake, nutrition questionnaire

Introduction

Adequate dietary intake is important for athletes to maintain health and athletic performance (Meyer, O'Connor, & Shirreffs, 2007; Heaney, O'Connor, Michael, Gifford, & Naughton, 2011). However, athletes` diets often fail to meet the current recommendations of sports nutrition and general population (Burke, Cox, Culmmings, & Desbrow, 2001). One reason for the inadequate dietary intake might be a poor nutrition knowledge (Torres-McGehee et al., 2012). However, it is not clear whether a relationship between nutrition knowledge and diet quality exists. Some authors reported a link between higher nutrition knowledge and better dietary intake in adult athletes (Harrison, Hopkins, MacFarlane, & Worsley, 1991; Hamilton, Thomson, & Hopkins, 1994; Wiita, Stombaugh, & Buch, 1995), whereas others did not (Chapman, Toma, Tuveson, & Jacob, 1997; Rash, Malinauskas, Duffrin, Barber-Heidal, & Overton, 2008). One reason for the lack of linkage might be the poor assessment methods of both nutrition knowledge and dietary intake (Parmenter & Wardle, 1999). There is a need to develop valid instruments to assess general and sport-specific nutrition knowledge and to compare nutrition knowledge to the athletes´ dietary intake (Heaney et al., 2011). Nutrition education programs for athletes might have the potential to close the gap between diet recommendations and individual food intake. Unfortunately, an evaluation of nutrition education programs is rarely reported for athletes (Abood, Black, & Birnbaum, 2004). One issue might be that the nutrition knowledge is affected by several factors, such as gender, educational level, and age. Female sex and a high educational level are positively influencing nutrition knowledge (Jessri, Jessri, Rashidkhani, & Zinn, 2010; Heaney et al., 2011). Additionally, the nutrition knowledge is increasing during maturation (Kersting et al., 2008). However, athletic status does not influence general nutrition knowledge, but slightly increases sport-specific nutrition knowledge (Heaney et al., 2011).

For young athletes dietary intake and nutrition knowledge is rarely reported. Furthermore, the impact of nutrition knowledge on food choice is still unknown (Worsley, 2002). There is a need to assess the food choice and the nutrition knowledge in young athletes, since they experience sports-related nutritional demands additionally to the growth-related requirements (Meyer et al., 2007).

Furthermore, it is well known that eating patterns are established during childhood and adolescence and are easily carried forward into adulthood (Kelder, Perry, Klepp, & Lytle, 1994; Krebs-Smith, Heimendinger, Patterson, Subar, & Kessler, 1995). Therefore, corrections of dietary intake should be performed at an early age (Mikkila, Rasanen, Raitakari, Pietinen, & Viikari, 2005). Many factors, like personal characteristics, socio-cultural and psychological determinants are influencing the establishment of eating patterns (Serra-Majem et al., 2007). Especially children and adolescents are easily persuaded to change their diet due to trends of the food industry (Meyer et al., 2007). Furthermore, adolescents are using their eating behavior to declare independence from home (McKinley et al., 2005). This results in food habits like snacking, fast food consumption, meal skipping or the intake of unorthodox meals.

For athletes it is important to achieve an adequate dietary intake from the beginning of their competitive career, since health and performance are influenced by optimum nutritional supply (Meyer et al, 2007; Heaney et al., 2011). Unfortunately, there is a lack of knowledge about the food choice and nutrition knowledge of young athletes. Therefore, the aim of the study is (1) to analyze food choice and nutrition knowledge of young athletes during preparticipation examination before entering a German Elite School of Sports, (2) to investigate the influence of gender and sport discipline on food choice and nutrition knowledge, and (3) to examine the relationship between nutrition knowledge and food choice in young athletes.

Methods

Subjects

A total of 559 young athletes (59% male) from 18 different sports disciplines with a mean training age of 3.9±2.6 years participated in this study. The anthropometrical data of the total sample size and differentiated by gender are shown in Table 1. Athletes were categorized into either technical sports (horse riding, shooting, modern pentathlon; N=50), endurance sports (swimming, cycling, triathlon, rowing, canoeing; N=179), weight-dependent sports (wrestling, weight-lifting, judo, boxing; N=90), ball games (soccer, handball, volleyball, tennis; N=154), and power sports (gymnastics, track and field; N=86). Data were collected from January 2010 until March 2011 during preparticipation examination at the University Outpatient Clinic before athletes were sent to one of the Elite Schools of Sports in Germany. Both athletes and their parents gave written informed consent to participate in the study. Each athlete was interviewed face-to-face by an experienced examiner about their personal data (sports discipline, training load, training age, etc.), followed by questions about habitual food and supplement intake and finally, nutrition knowledge was assessed. The study was approved by the scientific board of the University Outpatient Clinic Potsdam, Germany.

Food choice

To evaluate food choice of young athletes, a modified version of the Healthy-Eating-Index (HEI) was used (Kennedy, Ohls, Carlson & Fleming, 1995; Von Rüsten, Illner, Boeing, & Flothkötter, 2009). On the basis of the Swiss Food Pyramid for athletes (Mettler, Mannhart, & Colombani, 2009), the frequency of intake of five different food groups (fruits, vegetables, grains, fish and meat, dairy products) was assessed. The 6-5-4-3-2-1- rule for food frequency of different food groups (Koelsch & Brüggemann, 2007) served as the base of HEI calculation. The authors recommended six portions of water, five portions of fruits and vegetables, four portions of bread and grain products, three portions of dairy products plus one portion of meat and sausages, two portions of oil and fat, and one portion of specialties (e.g. sweets) per day. For the present study recommended intake frequency of three portions vegetables, two portions fruits, four portions of grains, three portions of dairy products and one portion of fish and meat per day were applied. The higher the accordance of the individual food intake with the recommended food frequency, the higher the final HEI-score. For every food category a maximum of ten points was possible to achieve. Only for the categories fruit and vegetable intake it was possible to obtain bonus points (max. ten bonus points for each group), in the case that the individual food frequency surpassed the intake recommendations. For calculation of the HEI-score in the categories of fruits and vegetables, equation 1 was used (Von Rüsten et al., 2009). Due to the small caloric density of these products, exceeding intake can hardly influence a positive energy balance. Equation 1 was also used for the categories of grain products, dairy products, fish and meat if individual intake was less than recommended. If individual intake surpassed the recommendations, equation 2 was used for HEI-score calculation. Maximum HEI-score (HEI_{max}) was 50 points. When the young athletes surpassed the maximum score (due to bonus points obtained in the categories fruits and vegetables) the final HEI-score was set to 50 points. For a better interpretation of the results, the score was categorized into three groups. A total score of 80% of HEI_{max} was associated with a "good" food choice, a score between 50 and 80% of HEI_{max} was associated with an "improvable" and a score of less than 50% of HEI_{max} with a "poor" food choice.

Equation 1: Formula for the calculation of the Healthy-Eating-Index-score for the categories fruits and vegetables and for categories grain products, dairy products and fish and meat, if the actual food frequency was below the recommended food frequency (Von Rüsten et al., 2009)

$$score\ for\ category = \frac{actual\ food\ frequency}{recommended\ food\ frequency} \times 10$$

Equation 2: Formula for the calculation of the Healthy-Eating-Index-score for the categories grain products, dairy products and fish and meat, if the actual food frequency was above the recommended food frequency (Von Rüsten et al., 2009)

$$score\ for\ category = \frac{recommended\ food\ frequency}{actual\ food\ frequency} \times 10$$

Nutrition knowledge

The nutrition knowledge of the young athletes was examined using a modified, shortened version of the Nutrition Knowledge Questionnaire originally developed for adults by Parmenter & Wardle (1999). All subjects had to answer twelve questions about macro- and micronutrient content of different food items and their recommended daily intake. The questionnaire was structured into one open question, six closed questions with two response options, and five closed questions with four response options (at least one response option was correct). If the answer was completely correct, subjects received a maximum of two points. Subjects obtained one point if the answer was partially correct. A maximum score of 24 points could be achieved when each item was answered completely correct. For better interpretation, the total score was classified into six categories using the German school grading system (1 =”very good”, 6 =”insufficient” nutrition knowledge).

Statistical analysis

For the statistical analysis the software SPSS 19.0 for Windows (IBM Corp., Armonk, NY, USA) was used. All data are presented as mean ± standard deviation (M ± SD), median (*Mdn*), and 95% Confidence Intervals (CI) where appropriate. Data were tested for normal distribution with the Shapiro-Wilk test and were not normally distributed for all outcomes except for the height. Mann-Whitney U tests were performed to test for gender differences in intake of different food groups, HEI-score, and nutrition knowledge score. To detect sports-specific differences in the same parameters Kruskal-Wallis one-way ANOVA by ranks was applied. For the post-hoc tests pairwise comparisons (Mann-Whitney U tests) with adjusted p-values were applied. The relationship between food choice (HEI-score) and total nutrition knowledge score was analyzed with the Pearson´s correlation coefficient (r_p). To test for differences in food choice of the categories of the nutrition knowledge score, a Kruskal-Wallis one-way ANOVA by ranks was applied. Effect sizes (r) are reported for all hypothesis-testing analyses. For the α-error $p<0.05$ was considered significant.

Results

Food choice

Complete datasets of food frequency were available for 542 (97.0%) subjects. Mean intake of all food categories is shown in Table 2. The mean intake of vegetables was 2.0 ± 1.6 servings per day and not significant different between gender ($p=0.45$, $r=0.03$). Daily intake of vegetables was significantly affected by sports discipline, $H(4)=10.10$, $p=0.04$. However, pairwise comparisons with adjusted p-values showed that there were no significant differences in vegetable intake between sports disciplines ($p>0.05$). Recommended intake of three servings of vegetables per day was reached or surpassed by 23.6% of the young athletes (Table 3). More than two third (71.4%) of the young athletes had a daily intake of at least two servings of fruits. The mean intake was 2.4 ± 1.4 servings of fruits per day and was not significant between gender ($p=0.98$, $r=0.00$). Daily intake of fruit was significantly affected by sports discipline, $H(4)=10.73$, $p=0.03$. Endurance athletes ($Mdn=2.00$) had significant higher daily fruit intake than ball sport athletes ($Mdn=2.00$; $p=0.02$, $r=0.17$), whereas between all other sport disciplines no significant differences were detected ($p>0.05$). With an average of 2.4 ± 1.5 servings of grain products per day, 93.1% of the young athletes did not reach the recommended amount of four servings grain products per day. There were no statistically significant differences in intake of grain products between gender ($p=0.08$, $r=-0.08$) or sports discipline, $H(4)=0.17$, $p=1.00$. The mean daily intake of dairy products was 2.6 ± 1.7 servings. The males ($Mdn=2.00$) had a higher intake of dairy products than the female athletes ($Mdn=2.00$, $p=0.02$, $r=-0.10$). Only 16.9% (N=94) of the young athletes met the recommendations of three servings per day. There was no significant difference in dairy intake between categories of sports discipline, $H(4)=4.35$, $p=0.36$. With a mean daily intake of meat and fish of 0.7 ± 0.3 servings, only 6.6% of the young athletes met the recommended intake of one serving per day. There were no statistically significant differences for meat and fish intake between gender ($p=0.68$, $r=-0.02$) and sports discipline, $H(4)=3.18$, $p=0.53$.

The mean HEI-score was 35.3 ± 9.8 points, which corresponds to 70 ± 18% of HEI_{max}. There was no difference for HEI-score between gender ($p=0.52$, $r=-0.03$) or sports discipline, $H(4)=5.51$, $p=0.24$. Most points were reached in the category of fruits (11.2 ± 5.2 points), whereas in the category of grain products the fewest points were reached (5.2 ± 2.2 points). Only 30% (N=164) of all young athletes attained more than 80% of HEI_{max}, which corresponds to a “good“ food choice. Most of the athletes (N=307; 57%) reached a score between 50 and 80% of HEI_{max}, which is interpreted as a food choice that should be improved. The percentage of athletes, who reached less than 50% of HEI_{max} and therefore were categorized as having a “poor“ diet, was 13% (N=71).

Nutrition knowledge

Data of nutrition knowledge was available for 559 (100%) athletes. The mean nutrition knowledge score of all athletes was 8.9 ± 3.0 points, which was 36.9 ± 12.3% of the maximum score that could have been achieved. There was no gender difference neither in total score nor in percentage of maximum score ($p=0.13$, $r=-0.06$). The nutrition knowledge score was significantly affected by sports discipline, $H(4)=10.85$, $p=0.03$. Pairwise comparisons with adjusted p-values showed that there were no significant differences in nutrition knowledge score of power sport athletes compared to athletes performing either technical sports ($p=1.00$, $r=-0.02$), ball games ($p=1.00$, $r=0.03$), endurance sports ($p=0.58$, $r=0.12$), or weight-dependent sports ($p=0.07$, $r=0.20$). There were also no significant differences in nutrition knowledge score between athletes performing technical sports and ball sport athletes ($p=1.00$, $r=0.01$), endurance athletes ($p=1.00$, $r=0.08$), or weight-dependent athletes ($p=0.43$, $r=0.17$). Furthermore, nutrition knowledge score did not differ between ball sport athletes and athletes of technical sports ($p=1.00$, $r=0.09$) or weight-dependent athletes ($p=0.11$, $r=-0.16$). Finally, there was no significant difference between endurance athletes and athletes performing weigh-dependent sports ($p=1.00$, $r=-0.07$). The highest individual score was 16 of total 24 points, reached by three male young athletes. Two female young athletes reached zero points. The classification into the German grading system showed that no athlete received a grade of “very good” or “good” in nutrition knowledge. The majority (59%) of the young athletes received a "deficient" and 22% an "insufficient" grading (Figure 1).

Relationship between food choice and nutrition knowledge

For the total sample size (N=542) no correlation between nutrition knowledge score and food choice (HEI-score) was observed (r_p=0.03, 95% CI [-0.17, 0.39], p=0.45). In addition, no differences in food choice among different categories of the nutrition knowledge score were detected $H(3)$=2.24, p=0.52. Neither in male (N=319, r_p=0.05, 95% CI [-0.22, 0.54], p=0.41) nor in female athletes (N=223, r_p=0.01, 95% CI [-0.39, 0.45], p=0.89) was a significant correlation between nutrition knowledge and HEI-score found. No correlation between nutrition knowledge score and HEI-score was observed among the different categories of sports discipline (p>0.05). Furthermore, for the total study population no relationship between nutrition knowledge and fruit or vegetable intake was found (data not shown).

Discussion

Food choice

Two third of the young athletes of the present study did not reach the recommended five portions of fruits and vegetables per day. Similar results were obtained in the Dortmund Nutritional and Anthropometric Longitudinally Designed (DONALD)-study, where diet quality and nutrient intake of 500 German children aged 4-18 years was examined. The intake of fruits and vegetables was 50% below the recommendation (Kersting, Alexy, Kroke, & Lentze, 2004). Additionally, for 1,138 elite adolescent German athletes (Diehl et al., 2013) similar results were found. Only 62% of the athletes reported to eat fresh fruits at least once a day. The authors further reported that daily consumption of products rich in vitamin and fiber was higher in female than in male athletes, and in endurance than weight-dependent athletes, respectively. In the present study fruit and vegetable intake did not differ between male and female athletes. However, fruit and vegetable intake was significantly affected by sports discipline. After the application of pairwise comparisons with adjusted p-values, no significant differences for vegetable intake among sports disciplines were observed anymore. Hence, differences in fruit intake between endurance and ball sport athletes were detected, with the intake being significantly higher in the endurance group. However, it remains purely speculative why intake of fruits was higher in endurance athletes.

The intake of grain products was insufficient in young athletes of the present study. Only six percent of the athletes reached the recommendations of four grain products per day. The DONALD-study revealed similar results. The mean intake of grain products was considerably below the recommendations of the concept of an optimized mixed diet (Kersting et al., 2004). However, the low intake of grain products in young athletes must be seen critical, since grain products are nutritious sources of carbohydrate and other key nutrients, which are important fuels to optimize athletic performance and recovery (Meyer et al., 2007). Another relevant outcome of the present study was the low intake of dairy products. Only 17% of the young athletes reached the recommendation of three servings of dairy products per day. The intake was significantly higher in male compared to female athletes, but still insufficient when compared to the recommendations. These findings support the results of the DONALD-study, where only males reached the intake recommendations for dairy products (Kersting et al., 2004). However, dairy products contain high amounts of vital nutrients, like essential amino acids or calcium, which are important for young athletes to achieve optimum growth and bone accretion (Meyer et al. 2007). Therefore, it is important to ensure an adequate intake of protein and calcium in young athletes. Another crucial food group for young athlete's diet are fish and meat, since they contain huge amounts of essential fat, protein, iron, zinc, and calcium (Petrie, Stover, & Horswill, 2004). Though, the intake of fish and meat products was poor in young athletes. Only 7% of the young athletes met the recommendations of one serving fish and meat per day.

Many of the young athletes had low HEI-score, which represents a "poor" or "improvable" food choice. The diets of only one third of athletes were characterized as "good". Gender differences or differences between sports disciplines did not occur. The main insufficiency detected in young athletes` diets was the low intake of grain and dairy products. In summary, the results of food choice of the present study resemble the results that were obtained in non-active (Kersting et al., 2004) and active (Diehl et al., 2013) children and adolescents in Germany. However, gender-specific differences in food choice as reported for non-active adolescents (Downs, Dinallo, Savage, & Davison, 2007; Kersting et al., 2004) were not observed in young athletes of the present study.

Nutrition knowledge

The nutrition knowledge of the young athletes was categorized as “deficient” or even “insufficient”. None of the athletes reached a “very good” or “good” grading in the nutrition knowledge questionnaire. Several studies reported better nutrition knowledge in females than in males (Kersting et al., 2008; Jessri et al., 2010). However, the present study does not confirm these findings in young athletes. Furthermore, sport-specific differences in nutrition knowledge were not detected. In a systematic review conducted by Heaney et al. (2011) nutrition knowledge in adolescent and adult athletes was assessed. Most of the studies reported mean nutrition knowledge scores of 50-70%. In the present study the mean nutrition knowledge score was lower (~37%). One explanation might be the fact that the used Nutrition Knowledge Questionnaire was originally developed for adults (Parmenter & Wardle, 1999). Although, for the present study a modified, shortened version was used, the questions might have been too difficult for the young athletes to be answered correctly .

Relationship between food choice and nutrition knowledge

While some authors reported a close relationship between higher nutrition knowledge and better diet qualities in athletes (Harrison et al., 1991; Hamilton et al., 1994; Wiita et al., 1995), other studies showed no or only a weak relationship (Chapman et al., 1997; Rash et al., 2008). Sole the fact that there is a relationship between higher nutrition knowledge and higher intake in fruits and vegetables seems to be evident (De, Matthys, Verbeke, Pynaert, & De, 2009). In the present study no relationship between nutrition knowledge and food choice was observed neither for the total study population, nor for gender- or sports-specific subgroups. Furthermore, there was no association between nutrition knowledge and fruit or vegetable intake detected for the total study population. There might be several reasons for a lack of correlation. In the literature cultural, religious, and family beliefs are discussed to have a greater impact on food intake than nutrition knowledge (Worsley, 2002; Heaney et al., 2011). Although the relationship between nutrition knowledge and food choice in the youth is not clear, nutrition education programs supposedly improve the food intake of children and adolescents (Sichert-Hellert, Kersting, & Manz, 2001, Diehl et al., 2013).

Strength and limitations of the study

The strengths of the study are that nutrition knowledge and food choice were assessed in parallel in young athletes. So far there are only studies available which assessed either nutrition knowledge or dietary intake alone in young athletes or were conducted with adult athletes. Furthermore, sample size of the present study was high and therefore, it was possible to distinguish between gender and sports disciplines. Due to the high number of subjects the outcomes might reflect the actual situation of young German athletes before entering an Elite School of Sports in Germany accurately.

The present study has several limitations. First, the use of a shortened and modified version of the Nutritional Knowledge Questionnaire of Parmenter & Wardle (1999) in the present study population is questionable. The questionnaire was originally developed for non-athletic adults. Questions might have been too difficult for the young athletes to answer correctly. Furthermore, food choice was self-reported by the young athletes. Therefore, a social desirability bias might have occurred. In addition, the socio-economic background of the young athletes was not assessed.

Conclusion

In the present study, young athletes displayed improvable food choice and poor nutrition knowledge. No linkage between food choice and nutrition knowledge was obtained. In young athletes, the intake of grain products, vegetables and dairy products should be increased to meet carbohydrate and micronutrient requirements and to ensure optimum growth and performance. Future research is needed to study the effect of the nutrition education programs on nutrition knowledge in young athletes, and to assess the linkage between food choice and nutrition knowledge. In addition, the intra-subject development of food choice and nutrition knowledge in young athletes during aging should be investigated.

Conflict of interests

None of the authors have any conflict of interest in the present study.

References

Abood, D. A., Black, D. R. and Birnbaum, R. D. (2004) “Nutrition education intervention for college female athletes,” *Journal of Nutrition Education and Behavior,* 36 (3) 135-137.

Burke, L. M., Cox, G. R., Culmmings, N. K. and Desbrow, B. (2001) “Guidelines for daily carbohydrate intake: do athletes achieve them?,” *Sports Medicine*, 31 (4) 267-299.

Chapman, P., Toma, R.B., Tuveson, R.V. and Jacob, M. (1997) “Nutrition knowledge among adolescent high school female athletes,” *Adolescence,* 32 (126) 437–446.

De, V. T., Matthys, C., Verbeke, W., Pynaert, I. and De, H. S. (2009) “Determinants of nutrition knowledge in young and middle-aged Belgian women and the association with their dietary behaviour,” *Appetite,* 52(3) 788-792.

Diehl, K., Yarmoliuk, T., Mayer, J., Zipfel, S., Schnell, A., Thiel, A. and Schneider, S. (2013) “Eating patterns of elite adolescent athletes: Results of a cross-sectional study on 51 Olympic sports,” *Deutsche Zeitschrift für Sportmedizin,* 64 (5) 126-131.

Downs, D. S., Dinallo, J. M., Savage, J. S. and Davison, K. K. (2007) “Determinants of eating attitudes among overweight and non-overweight adolescents,” *Journal of Adolescent Health,* 41(2) 138-145.

Hamilton, G.J., Thomson, C.D. and Hopkins, W.G. (1994) “Nutrition knowledge of elite distance runners,” *New Zealand Journal of Sports Medicine,* 22 (2) 26–29.

Harrison, J., Hopkins, W.G., MacFarlane, D.J. and Worsley, A. (1991) “Nutrition knowledge and dietary habits of elite and non-elite athletes,” *Australian Journal of Nutrition and Dietetics,* 48, 124–127.

Heaney, S., O'Connor, H., Michael, S., Gifford, J. and Naughton, G. (2011) “Nutrition knowledge in athletes: a systematic review,” *International Journal of Sport Nutrition and Exercise Metabolism,* 21 (3) 248-261.

Jessri, M., Jessri, M., Rashidkhani, B. and Zinn, C. (2010) “Evaluation of Iranian college athletes' sport nutrition knowledge,” *International Journal of Sport Nutrition and Exercise Metabolism*, 20 (3) 257-263.

Kelder, S. H., Perry, C. L., Klepp, K. I. and Lytle, L. L. (1994). "Longitudinal tracking of adolescent smoking, physical activity, and food choice behaviors," *American Journal of Public Health,* 84 (7) 1121-1126.

Kennedy, E.T., Ohls, J., Carlson, S. and Fleming, K. (1995) "The Healthy Eating Index: design and applications," *Journal of the American Diet Association,* 95 (10) 1103-8.

Kersting, M., Alexy, U., Kroke, A. and Lentze, M. J. (2004) "Nutrition of children and adolescents. Results of the DONALD Study," *Bundesgesundheitsblatt Gesundheitsforschung Gesundheitsschutz,* 47 (3) 213-218.

Kersting, M., Sichert-Hellert, W., Vereecken, C. A., Diehl, J., Beghin, L., De, H. S. et al. (2008) "Food and nutrient intake, nutritional knowledge and diet-related attitudes in European adolescents," *International Journal of Obesity (London),* 32 (Suppl 5) S35-S41.

Koelsch, C. and Brüggemann, I. (2007) "Die aid-Ernährungspyramide – richtig essen lehren und lernen," aid-Heft, Bestell-Nr.3899, 18-19.

Krebs-Smith, S.M., Heimendinger, J., Patterson, B.H., Subar, A.F., Kessler, R. and Pivonka, E. (1995) "Psychosocial factors associated with fruit and vegetable consumption," *American Journal of Health Promotion,* 10 (2) 98-104.

McKinley, M. C., Lowis, C., Robson, P. J., Wallace, J. M., Morrissey, M., Moran, A. et al. (2005) "It's good to talk: children's views on food and nutrition," *European Journal of Clinical Nutrition,* 59 (4) 542-551.

Mettler, S., Mannhart, C. and Colombani, P. C. (2009) "Development and validation of a food pyramid for Swiss athletes," *International Journal of Sport Nutrition and Exercise Metabolism, 19 (5)* 504-518.

Meyer, F., O'Connor, H. and Shirreffs, S. M. (2007) "Nutrition for the young athlete," *Journal of Sports Sciences,* 25 (Suppl 1) S73-S82.

Mikkila, V., Rasanen, L., Raitakari, O. T., Pietinen, P. and Viikari, J. (2005) "Consistent dietary patterns identified from childhood to adulthood: the cardiovascular risk in Young Finns Study," *British Journal of Nutrition,* 93 (6) 923-931.

Parmenter, K. & Wardle, J. (1999) "Development of a general nutrition knowledge questionnaire for adults," *European Journal of Clinical Nutrition*, 53 (4) 298-308.

Petrie, H. J., Stover, E. A., and Horswill, C. A. (2004) "Nutritional concerns for the child and adolescent competitor," *Nutrition*, 20 (7-8) 620 – 631.

Rash, C.L., Malinauskas, B.M., Duffrin, M.W., Barber-Heidal, K. and Overton, R.F. (2008) "Nutrition-related knowledge, attitude, and dietary intake of college track athletes," *The Sport Journal*, 11(1) 48-54.

Serra-Majem, L., Roman-Vinas, B., Salvador, G., Ribas-Barba, L., Ngo, J., Castell, C. et al. (2007) "Knowledge, opinions and behaviours related to food and nutrition in Catalonia, Spain (1992-2003)," *Public Health Nutrition,* 10 (11A) 1396-1405.

Sichert-Hellert, W., Kersting, M. and Manz, F. (2001) "Changes in time-trends of nutrient intake from fortified and non-fortified food in German children and adolescents--15 year results of the DONALD study. Dortmund Nutritional and Anthropometric Longitudinally Designed Study," *European Journal of Nutrition*, 40 (2) 49-55.

Torres-McGehee, T.M., Pritchett, K.L., Zippel, D., Minton, D.M., Cellamare, A. and Sibilia, M. (2012) “Sports nutrition knowledge among collegiate athletes, coaches, athletic trainers, and strength and conditioning specialists,” *Journal of Athletic Training,* 47(2) 205-11.

Von Rüsten, A., Illner, A., Boeing, H. and Flothkötter, M. (2009) “Die Bewertung der Lebensmittelaufnahme mittels eines „Healthy Eating Index“, *Ernährungs Umschau*, 56 (8) 450-456.

Wiita, B., Stombaugh, I. and Buch, J. (1995) “Nutrition knowledge and eating practices of young female athletes,” *Journal of Physical Education, Recreation & Dance,* 66 (3) 36–41.

Worsley, A. (2002) “Nutrition knowledge and food consumption: can nutrition knowledge change food behaviour?,” *Asia Pacific Journal of Clinical Nutrition,* 11 (Suppl 3) S579-S585.

Table 1 – Anthropometric data of the young athletes. Mean ± standard deviation; BMI=body mass index.

Sample (N)	Age [y]	Height [cm]	Body Mass [kg]	BMI [kg/m^2]	Body Fat [%]
Males (330)	11.8 ± 0.9	157 ± 10	45.5 ± 10.7	18.3 ± 2.6	18.2 ± 4.5
Females (229)	11.6 ± 0.7	160 ± 8	47.7 ± 9.2	18.6 ± 2.4	22.1 ± 3.7
Total (559)	11.7 ± 0.8	158 ± 10	46.4 ± 10.2	18.4 ± 2.5	19.8 ± 4.6

Table 2 – Recommended intake and habitual intake of different food groups. Mean ± standard deviation; p-values describe the significance of the statistical difference between male and female young athletes; * signifies a significant difference between male and female athletes ($p<0.05$).

Sample (N)	Vegetables [Servings/d]	Fruits [Servings/d]	Grain Products [Servings/d]	Dairy Products [Servings/d]	Meat and Fish [Servings/d]
Males (319)	2.0 ± 1.8	2.4 ± 1.5	2.5 ± 1.6	2.8 ± 1.7	0.7 ± 0.3
Females (223)	2.0 ± 1.3	2.4 ± 1.3	2.3 ± 1.4	2.4 ± 1.6*	0.7 ± 0.3
Total (542)	2.0 ± 1.6	2.4 ± 1.4	2.4 ± 1.5	2.6 ± 1.7	0.7 ± 0.3
Recommendations [Servings/d]	3	2	4	3	1
p-values	0.45	0.98	0.08	0.02	0.68

Table 3 – Percentage of young athletes who met or surpassed the recommended intake of the different food categories

Sample (N)	Vegetables [%]	Fruits [%]	Grain Products [%]	Dairy Products [%]	Meat and Fish [%]
Males (319)	23.5	70.8	6.9	16.9	6.6
Females (223)	23.8	72.2	4.5	17.9	4.9
Total (542)	23.6	71.4	5.9	17.3	5.9

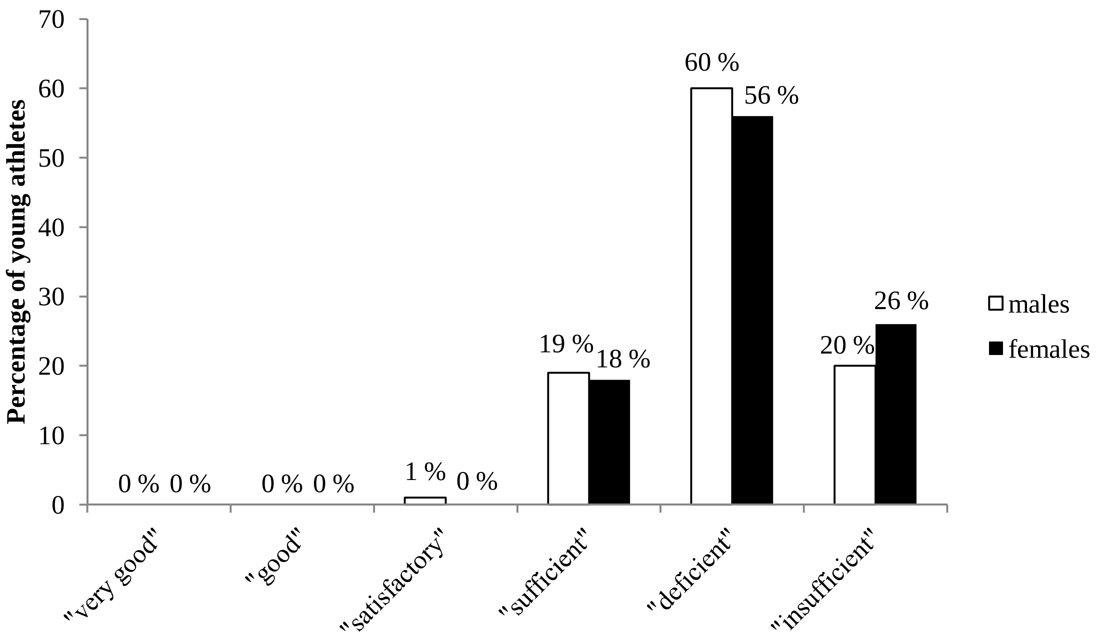

Figure 1 – Classification of the nutrition knowledge score of male (N=330) and female (N=329) young athletes according to the German school grading system.