Open access • Journal Article • DOI:10.1123/IJSNEM.2014-0155

Nutritional Supplement Habits of Athletes With an Impairment and Their Sources of Information — Source link

Terri Susan Graham-Paulson, Claudio Perret, Brett Smith, Jeanette Crosland ...+1 more authors

Institutions: Loughborough University

Published on: 01 Aug 2015 - International Journal of Sport Nutrition and Exercise Metabolism (Human Kinetics)

Topics: Athletes and Population

Nutritional supplement habits of athletes with an impairment and their sources of information.

Graham-Paulson Terri Susan[1], Perret Claudio[2], Smith Brett[1], Crosland Jeanette[3], and Goosey-Tolfrey Victoria Louise[1].

[1]The Peter Harrison Centre for Disability Sport

National Centre for Sport and Exercise Medicine, Loughborough University, Epinal Way

Loughborough, LE11 3TU, United Kingdom

[2]Swiss Paraplegic Centre

Institute of Sports Medicine, CH-6207 Nottwil, Switzerland

[3]Freelance dietitian and sports nutritionist

Lancashire, United Kingdom

Corresponding author: Prof. Victoria Louise Goosey-Tolfrey

The Peter Harrison Centre for Disability Sport

Loughborough University

Epinal Way

Loughborough

LE11 3TU

United Kingdom

Phone Number: +44 (0) 1509 226 386

Fax Number: +44 (0)1509 226301

Email: V.L.Tolfrey@lboro.ac.uk

Abstract

The consumption of nutritional supplements (NS) is common among able-bodied (AB) athletes yet little is known about NS use by athletes with an impairment. This study examined the: (i) prevalence of NS use by athletes with an impairment; (ii) reasons for use/ non-use; (iii) sources of information regarding NS; and (iv) whether age, gender, impairment, performance level and sport category influence NS use. The questionnaire was completed by 399 elite (n=255) and non-elite (n=144) athletes (296 M, 103 F) online or at a sporting event/training camp. Data were evaluated using chi-square analyses. Fifty-eight percent (n=232) of athletes used NS in the previous 6-month period and 41% (n=102) of these followed the instructions on the label to determine dose. Adherence to these AB recommendations may partly explain why 9% (n=37) experienced negative effects from NS use. As expected, the most popular NS were: protein, sports drinks, multivitamins and carbohydrate supplements, which were obtained from health food/sport shops, internet and supermarkets (top 3) where evidence-based, impairment-specific advice is limited. The nutritionist/dietitian was the most used and trusted source of information, which is a promising finding. The most prevalent reasons for use were to support exercise recovery, support the immune system and provide energy. Elite athletes were more likely to use NS, which may reflect greater training hours and/or access to nutritionists. Fifty-two percent of athletes (n=209) requested more information/ education regarding NS. NS use is prevalent in this population. Education on dosage and appropriate sources of information is required.

Keywords: disability, sports nutrition, education, Paralympic

Introduction

It is widely accepted that nutrition can influence exercise performance (Rodriguez et al., 2009) and that it should be integrated into an athlete's programme to fully capitalize on their athletic potential (Broad, 2014). Likewise, the use of some nutritional supplements (NS), which are defined by the Dietary Supplement Health and Education Act of 1994 as 'any product intended to supplement the diet', may have the ability to improve sporting performance (Maughan et al., 2004). It is therefore unsurprising that the consumption of NS is common among able-bodied (AB) athletes (Braun et al., 2009; Erdman et al., 2006; Sundgot-Borgen et al., 2003). With the increased popularity of disability and Paralympic sport in recent years there is a need to also understand the nutritional practices of athletes with an impairment. That said few studies have focused on the nutritional requirements and behaviours of athletes with a physical impairment (Bertoli et al., 2006; Goosey-Tolfrey & Crosland, 2010; Krempien & Barr, 2012; Rastmanesh et al., 2007). The only study to investigate the NS habits of Paralympic athletes (Athens 2004 Paralympic Games), revealed that vitamins (43.5%), minerals/electrolytes (16.1%) and proteins/amino acids (10.5%) were most commonly consumed (Tsitsimpikou et al., 2009). This study however failed to report the athletes' reasons for NS use or the sources of information they consulted.

The nutritional requirements for AB athletes are almost certainly not directly transferable to athletes with a physical impairment (Broad, 2014). For example, athletes who use a wheelchair utilise a smaller working muscle mass during movement, which will lead to lower energy requirements than those of AB athletes (Glaser, 1985). Furthermore, within this category there are likely to be a wide range of requirements based on whether the individual has a spinal cord injury (SCI) and the level and completeness of the lesion, or whether the athlete uses a wheelchair because of a different impairment (Goosey-Tolfrey et al., 2014). In cases where a wheelchair is used for mobility, there may be considerable muscle atrophy in the lower limbs, leading to a lower resting metabolic rate, and in turn, a further reduction in daily energy expenditure (Goosey-Tolfrey & Sutton, 2012; Goosey-Tolfrey et al., 2014). To prevent unwanted weight gain, energy intake must be correspondingly reduced. This lower

total food intake could encourage a reliance on vitamin and mineral supplementation to meet micronutrient needs. In addition, there are practical issues to consider associated with food preparation. For example, individuals with an upper-limb amputation (or visual impairment (VI)) may have difficulties accessing, purchasing or preparing food (Meyer & Edwards, 2014), and some individuals with cerebral palsy (CP) may use NS to overcome feeding difficulties (Crosland & Boyd, 2014). Athletes' reasons for NS use may therefore reflect a nutritional requirement and hence NS may be viewed as 'essential' rather than 'optional' in some circumstances. For this reason, health-related and performance-enhancing NS can be categorized separately.

The number of NS available on the market continues to increase despite insufficient supporting scientific evidence (Abel et al., 2005; Jeukendrup & Randall, 2011) and many are ineffective despite their widespread use (Maughan et al., 2004). There is currently very little evidence regarding the effects of ergogenic aids (Flueck et al., 2014; Perret et al., 2006) and macronutrient-providing NS (Spendiff & Campbell, 2005) in athletes with a physical impairment. This raises concern given the potential for, or more acute sensitivity to, side-effects in some sportspeople with a physical impairment (Van de Vliet et al., 2011). The potential risks associated with NS use in AB athletes have been well-researched (Molinero & Márquez, 2009) and are acknowledged by the authors; however, this will not be the central theme of this study.

The use of NS is often a personal choice made by the athlete in conjunction with their dietitian/nutritionist, ideally following a full cost-benefit analysis. Previous AB research shows that athletes are often more likely to report the use of family members, self, coaches and fellow athletes than more informed sources such as registered dietitians/nutritionists (Dolan et al., 2011; Froiland et al., 2004; Krumbach et al., 1999). The sources of information used by athletes with an impairment are currently unknown despite the importance of impairment-specific advice. Therefore, the objectives of this study were to determine the: (i) prevalence of NS use by athletes with an impairment; (ii) reasons for use/ non-use; (iii) sources of

information regarding NS; and (iv) whether age, gender, impairment, performance level and sport category influence NS use.

Methods

Survey instrument and survey procedure

A self-designed questionnaire which was developed by six professionals (a dietitian, a qualitative scientist and sport nutritionists/ scientists) and tested for reliability using McNemar and Cronbach's Alpha tests in a representative sample (n=10; p(range)=0.582-1.000, with the exception of one question where p=0.125). It included; i) 12 closed and 9 open-ended; ii) 10 multiple-choice; iii) 7 Likert-type rating scale; and iv) 2 ranking questions. The questionnaire captured data pertaining to individual characteristics (e.g. age, gender, sport participation, impairment etc.), NS habits, reasons for NS use/ non-use and sources of information. The questionnaire took approximately 20 minutes to complete electronically or on paper. A copy of the questionnaire is posted on the following website: http://www.lboro.ac.uk/research/phc/resources/resources/ and was made available in English, French, German, Portuguese and Spanish. The study was approved by the University Research Ethics Committee and informed consent was provided prior to completion of the questionnaire.

Participants were recruited during the 2012-13 athletic season at training camps/competitions across a variety of sports (e.g. Wheelchair Rugby/Tennis/Basketball, Sitting Volleyball and Athletics) in Great Britain, Canada, America, Switzerland and Germany following event organisers' approval. Despite unsuccessful attempts to gather information from Powerlifting, Swimming and Boccia events, the investigators distributed links to the online questionnaire through their own network of sport coaches/ scientists and at the International Paralympic Congress to widen the participant pool.

Athletes with a VI were aided by one of the authors to complete the questionnaire where necessary. Since the questionnaire was developed without consideration of athletes with an intellectual impairment, only athletes with a physical or visual impairment, over 18 years of age, who regularly took part in disability or Paralympic sport were included. Sighted guides were excluded.

In order to maintain the accuracy of participant responses, a 6-month recall period was set. For the purpose of this questionnaire the term 'nutritional supplement' was defined as 'any product intended to supplement the diet, provide nutrients and/or improve performance.' Examples of health-related and performance-enhancing NS were provided, and reported NS were categorised prior to analysis (Table 1). Categories were based on the macro- and micro-nutrient components i.e., 'carbohydrate supplements' contained predominantly carbohydrate for the purpose of providing energy, 'protein' contained predominantly protein for the purpose of power, strength, muscle building etc.; whereas 'recovery' contained both carbohydrate and protein for the purpose of recovery.

Statistical analysis

The Statistical Package for the Social Sciences version 20 software (SPSS Inc., Chicago, IL) was used to analyse the data. All descriptive data are presented as frequencies (%, n). Data were evaluated by age, gender, impairment, performance level and sport category (intermittent, speed and power, endurance, skill-based) (Table 2)) using chi-square (χ^2) analyses. Where appropriate, data were subsequently interpreted using odds ratios. Significance was determined at $p<0.05$.

Results

Participant characteristics

A total of 399 athletes (74% male, 26% female) across 5 impairment categories (42% SCI, 19% amputation, 18% Les Autres, 11% CP and 10% VI), 28 sports and 21 Nationalities (44% British, 17% American and Canadian, 13% Swiss, 11% other, 8% German, 6% Brazilian)

completed the questionnaire. Athletes were aged 18-24 (24%), 25-30 (24%), 31-35 (18%), 36-40 (12%), 41-45 (9%) and 46+ (13%) years and reported weekly average training hours of 0-5 (17%), 6-10 (30%), 11-15 (23%), 16-20 (20%) and 21+ (10%) h. Sixty four percent (n=255) and 36% (n=144) of athletes reported playing at an elite (represent their country Nationally or Internationally) and non-elite (train and compete for a club, regional or development team) performance level, respectively. Seventy-nine percent of athletes completed the questionnaire online (n=317) and the remainder completed a paper version (n=82).

Nutritional supplement habits

In total, 58% of athletes (n=232) used NS in the previous six months. The use of multiple NS was commonplace with 33%, 30%, 15%, 8%, 6% and 8% reporting the use of 1, 2, 3, 4, 5 or 6 different types of NS, respectively. Forty percent (n=259) of NS were used daily (at least 4-5 times per week), 36% (n=231) were used before/during/after training, 6% (n=38) were competition-specific, with only 2% (n=13) used rarely.

The most popular health-related NS were multivitamins, other health-related NS (e.g. aloe vera, coenzyme Q10, mushroom extract, evening primrose oil and chromium) and essential fatty acids; and the most popular performance-enhancing NS were protein, sports drinks and carbohydrate supplements (Figure 1). The three most common outlets where athletes obtained NS were the supermarket (23%, n=71), internet (22%, n=67) and health food/sports shop (21%, n=65); others included pharmacy, sports nutritionist/dietitian and team sponsor. The most prevalent reasons reported for use/ non-use of NS are reported in Table 3.

When NS users were asked ‘How do you decide how much of a supplement to take?’, 102 (41%) followed the (AB) recommendations on the label/manufacturers website, 60 (24%) were told by a sports nutritionist/dietitian, 35 (14%) calculated it based on their body weight, 22 (9%) were unsure and 32 (13%) indicated ‘other’ (e.g. ‘doctor’s advice’, ‘how I feel’, ‘a third of the recommended as I have roughly a third of body function’, ‘half the instructions,’ and ‘trial and error’). Nine percent of all athletes (n=37) reported having experienced a

negative effect from using NS such as gastrointestinal/digestive problems (protein, sports drinks/gels, creatine, cherry juice, beetroot juice), itchiness (beta-alanine) and palpitations (caffeine).

Comparisons by age, gender, impairment, performance level and sport category

Whether an athlete used NS did not differ by age (p>0.05). However, when the two oldest categories were combined, those over 41 y were most likely to use multivitamins compared to the younger age categories (p<0.05). Whether an athlete used NS or which type they used did not differ between gender (p=0.661) or impairment (p=0.489). Of note however, 9% of athletes (14 of 152) with a SCI reported using cranberry.

Elite athletes trained significantly more hours per week (p<0.05) and odds ratio analysis revealed they were 1.6 times more likely to use NS than non-elite athletes. Elite athletes were significantly more likely to use multivitamins, amino acids and sports drinks compared to non-elite (p<0.05). There was a significant association (p<0.05) between sport category and whether an athlete used NS. Individuals who took part in predominantly endurance sports were most likely to use sports drinks, carbohydrate supplements, protein, multivitamins and NS in general, compared to those in skill-based, intermittent or speed/power sports (p<0.05). Figure 2 indicates the use of NS within the sport categories.

Sources of information

Athletes ranked sports nutritionist/dietitian (18%, n=155), coach (14%, n=122) and training partner/athlete (13%, n=114) as their top three sources of information. When asked who provided the most trusted source (top 3), athletes chose the sports nutritionist/dietitian (24%, n=248), doctor/medical professional (21%, n=214) and coach (12%, n=128). Other sources included friends/family, physiotherapist, supplement/health food store, evidence-based/scientific journals and books/magazines. Elite athletes had greater access to nutritionists/dietitians (60%, n=153) compared to non-elite (22%, n=31). Fifty-two percent of

athletes (n=209) would like more information and education regarding NS. The type of information sought by athletes is shown in Figure 3.

Discussion

Nutritional supplement habits

This study demonstrates that a wide-variety of NS are currently being used across a range of disability and Paralympic sports, and that 58% of athletes surveyed used NS in the previous six months. To our knowledge the only other study to investigate the use of NS by athletes with an impairment reported that 64% of athletes tested for doping control at the Athens 2004 Paralympic Games declared the use of medications and food supplements (58% and 42%, respectively) (Tsitsimpikou et al., 2009). Interpretation of these data would suggest that 27% of all athletes (n=1173) tested used at least one food supplement, which is less than half that reported in the current study. The higher reported NS use in the current study may reflect an increase in i) NS use over the previous decade, ii) the popularity and availability of NS, and/or iii) the training load/demand placed on the modern day athlete.

The prevalence of NS use in the current study was at the lower end of that reported by elite and collegiate AB athletes where 51-88% reported the use of NS (Dascombe et al., 2010; Erdman et al., 2006; Sundgot-Borgen et al., 2003). Thus, this supports the observations of Tsitsimpikou et al. (2009), who found Paralympians to use a more rational intake pattern compared to their Olympic counterparts. However, the lower reported use in the current study may also reflect a non-homogenous sample that included elite and non-elite athletes, which when separated suggests that more elite athletes used NS than non-elite. The lower reported use may also reflect a lack of knowledge regarding their effectiveness, side-effects and the dosage recommendations for this specific population given that 52% indicated they would like more information on these topics.

The most common NS were similar to those reported by the Athens 2004 Paralympic athletes (vitamins, minerals/electrolytes and proteins/amino acids) (Tsitsimpikou et al., 2009) but also included sports drinks. Previous research has shown that some athletes do not

consider calorie/fluid replacement products as NS (Froiland et al., 2004) and may therefore fail to report them as such. The addition of sports drinks in the current study may reflect its inclusion on the list of NS examples. The prevalence of some macro- and micronutrient-providing supplements such as sports drinks, protein and multivitamins appears to be lower in this population of athletes with an impairment compared to AB athletes; used by 20%, 26% and 14% in the current study. Kristiansen et al. (2005) reported the use of sports drinks, protein and vitamins/minerals by 87%, 51% and 52% of male varsity athletes. Froiland et al. (2004) reported the use of energy drinks, protein and multivitamins by 73%, 48% and 47% of varsity athletes. Potential reasons for these differences may include; i) some athletes with an impairment may be more aware of eating a well-balanced diet for health reasons and therefore may not deem multivitamins and protein supplements necessary, ii) some individuals may be aware of their lower daily energy expenditure and therefore avoid sports drinks and protein supplements which provide additional energy to help prevent weight gain, iii) athletes may lack an understanding of the role that sports foods can play in improving performance/ training capability, and iv) some athletes with an impairment may not understand their training needs and how NS may support their training goals compared to weight management goals which are common in a rehabilitation setting.

Athletes used various methods to calculate how much of a NS to use but 41% indicated that they follow the (AB) instructions on the label/manufacturers website. The NS dose for some individuals with a SCI, amputation or CP may need to be adjusted from the AB recommendations due to a reduced active muscle mass or the potential side-effects that may occur. The use of AB guidelines may therefore have been a contributing factor to the 9% that experienced side-effects having consumed a NS. It is encouraging that a number of athletes did however indicate that they use a proportion of the recommended dose, or adapt the dose based on personal experience. Given the nature of a questionnaire we cannot be sure whether these adaptations are the athlete's decision or those of a nutritionist/dietitian. Although there are no specific recommendations for NS dosage, some individuals may be aware of emerging evidence regarding the segmental body composition (obtained via DEXA)

of athletes with a SCI (Goosey-Tolfrey & Sutton, 2012) and also the energy requirements of some disability sports (Abel et al., 2008). This type of evidence provides some basic information on which to base NS dosage recommendations, however, further research is required.

It may be concerning that the internet (22%) was a popular place to obtain NS. Previous research suggests that there are issues with NS being improperly tested, containing substances not declared on the label and/or not containing significant amounts of the active ingredients listed on the label (Geyer et al., 2004; Maughan, 2005). A lack of regulatory controls on the internet may increase the likelihood of inadvertent doping when purchasing products in this manner. Unfortunately in some countries, these problems also occur with products bought over-the-counter or in stores. The nature of the questionnaire means we cannot be sure if athletes checked whether the products they purchased were regularly tested for prohibited substances (e.g. via Informed-Sport) but it does suggest that 'where to obtain NS' should be a topic of education for athletes.

Reasons for nutritional supplement habits

Athletes reported similar reasons for NS use (support recovery, support the immune system, to improve strength/power and to provide energy) and non-use (I don't know enough about them and I don't need them) to those of AB athletes (Froiland et al., 2004; Neiper et al., 2005). The most popular health-related answer in the current study was 'to support the immune system' (32%). This is understandable given the depressed immune function experienced by individuals with a SCI (Leicht et al., 2013), who formed a large proportion of the athletes (42%). The top reason for non-use was 'I don't know enough about them' (30%), which suggests that NS information may be either unavailable, inaccessible or the athletes are not interested. One athlete's reason for non-use was 'I take enough medication as it is'. The use of medication by Paralympic athletes', highlighted by Tsitsimpikou and colleagues (2009), may help to explain the lower reported use of NS by athletes with an impairment because they do not want to take anything beyond what they need to maintain health.

Comparisons by age, gender, impairment, performance level and sport category

There was no influence of age on NS use until the upper two age categories were combined. The increased use by older athletes (≥41 y) has not been seen in previous literature because it is rare to find a group of AB athletes in this age category. Older athletes may feel the need to consume multivitamins to maintain health and this may be heightened in athletes with an impairment if their diet is restricted in some way.

A number of AB studies show that female athletes tend to use more NS than males (Froiland et al., 2004; Krumbach et al., 1999; Neiper, 2005; Ziegler et al., 2003). This can partly be explained by the fact that females may be more aware of their nutritional needs and that their actual need may be heightened due to their gender (Neiper, 2005). In contrast there was no influence of gender on NS use in the current study (59% male; 56% female). Zeigler et al. (2003) reported that female AB elite figure skaters were more likely to use multivitamin-minerals than their male counterparts. In aesthetic sports such as figure skating low energy intakes are common, especially in females, and multivitamins may be used to help maintain the overall diet quality. This difference may not have been apparent in the current study because both male and female athletes may reduce their energy intake due to their impairment and therefore feel the need to consume a multivitamin to meet their micronutrient needs.

There was no significant influence of impairment on NS use however, 9% of athletes with a SCI reported the use of cranberry supplements which is likely due to the perceived prevention of urinary tract infections (UTIs) which are common in this population (Dermen et al., 2014). The limited evidence available, however, shows that cranberry supplements are ineffective at preventing and/or treating UTIs (Opperman, 2010).

It is well-documented that AB athletes report the use of more NS than the general population (Erdman et al., 2006, Sobal & Marquart, 1994). The current study supports ‘level of

299 performance' as a key indicator of NS use because elite athletes were 1.6 times more likely
300 to use them. The significant positive association between training hours and performance
301 level may help to explain the greater use by elite athletes. The energy requirements of
302 greater training hours may influence an athlete's (perceived) need for NS. Elite athletes also
303 had greater access to nutritionists/dietitians and may thus have more knowledge regarding
304 NS for performance or enhanced training capacity, and therefore the confidence to use them.
305 The energy requirements of an endurance athlete may also influence their use of NS.
306 Heikkinen et al. (2011) found that endurance and speed/power athletes reported the use of
307 NS significantly more often than team sport athletes. This partly agrees with the finding that
308 athletes who took part in endurance sports in the current study were most likely to use sports
309 drinks, carbohydrate supplements, protein, multivitamins and NS in general.
310
311 **Sources of information**
312 Knowledge of where athletes seek advice regarding NS is essential to devise and implement
313 educational strategies (Erdman et al., 2006). Athletes in the current study reported the use of
314 similar sources of information as AB athletes (Erdman et al., 2006; Froiland et al., 2004;
315 Krumbach et al., 1999) and the top three were sports nutritionist/dietitian, coach and training
316 partner/athlete. Registered nutritionists/dietitians should be knowledgeable and trustworthy
317 sources; however, athletes and even coaches may lack the desired level of NS knowledge.
318 The coach-athlete relationship however, puts the coach in a unique position to influence
319 his/her athlete's diet, which emphasises the need to educate coaches regarding issues
320 pertaining to the use of NS. It also highlights that there may be a need to educate athletes
321 themselves on who is a knowledgeable source. It is clear that impairment-specific
322 information and education regarding NS for this population is required, with 52% of all
323 athletes indicating they would like more.
324 When the question was rephrased to ask 'who the most trusted sources of information are'
325 the athletes' replaced training partner/athlete with doctor/medical professional (top 3). This
326 change may be due to regular consultations/visits regarding their impairment, medication or

secondary complications, and the on-going relationship that may develop as a result. Despite being trustworthy, doctors/medical professionals do not necessarily possess the area-specific expertise to advise athletes on their use of NS for sport and should therefore be educated on how to deal with these questions should they arise.

Direct athlete education should be provided through sources of information that they trust and already use e.g. sports nutritionist/dietitians and coaches. Education regarding impairment-specific advice should therefore be directed at these professions. Information on NS for athletes with an impairment should also be made available to a wider audience online through organisations such as the World Anti-Doping Agency, National governing bodies and sport science/nutrition/medicine providers.

Limitations

As with all questionnaire-based data, the results of the current study rely on the honesty, recall, and self-report accuracies of athletes. An alternative to using an open-ended approach would be to prompt subjects with a list of common NS to choose from (Erdman et al., 2006), which may help reduce recall error. We appreciate the limitations of a 6-month recall period and that a longer survey period (i.e. 12 months) or biannual reporting may provide a more accurate representation of seasonal NS usage. However, the accuracy of recall and/or participant adherence may be reduced.

Conclusions

This study provides previously unknown information regarding NS habits and sources of information used by athletes with an impairment. Fifty-eight percent of those surveyed used NS. Athletes with an impairment appear to require and more importantly want more information and advice regarding NS. Education should be delivered to practitioners in order to access the athletes themselves, and this should include impairment-specific information (where available) regarding effective and safe NS and doses. Ultimately, further impairment-specific NS investigations are required in order to provide evidence-based recommendations.

Acknowledgments

The study was designed by TSG, VLG, JC, CP, and BS; data were collected by TSG, JC, and CP, and analysed by TSG, and VLG; data interpretation and manuscript preparation were undertaken by TSG, VLG, and CP. All authors approved the final version of the paper.

The authors would like to acknowledge Dr Susan Shirreffs and Prof Ron Maughan for their help and advice during the questionnaire design phase. We would also like to thank all of the athletes for taking their time to complete the questionnaire.

The authors would also like to thank the International Paralympic Committee for promoting the questionnaire on their website.

Declaration of funding sources and conflicts of interest

This study was supported by a grant from the World Anti-Doping Agency (WADA). No other sources of funding were used to assist in the preparation of this review, and the authors declare no conflict of interest.

References

Abel, T., Knechtle, B., Perret, C., Eser, P., von Arx, P., & Knecht, H. (2005). Influence of chronic supplementation of arginine aspartate in endurance athletes on performance and substrate metabolism: A randomized, double-blind, placebo-controlled study. *International Journal of Sports Medicine, 26*, 344-349.

Abel, T., Platen, P., Rojas Vega, S., Schneider, S., & Stüder, H.K. (2008). Energy expenditure in ball games for wheelchair users. *Spinal Cord*, *46*, 785-790.

Bertoli, S., Battezzati, A., Merati, G., Margonato, V., Maggioni, M., Testolin, G., & Veicsteinas, A. (2006). Nutritional status and dietary patterns in disabled people. *Nutrition, Metabolism and Cardiovascular Diseases, 16*, 100-112.

Bond-Brill, J.B., & Keane, M.W. (1994) Supplementation patterns of competitive male and female bodybuilders. *International Journal of Sport Nutrition, 4***,** 398-412.

Braun, H., Koehler, K., Geyer, H., Kleinert, J., Mester, J., & Schänzer, W. (2009). Dietary supplement use among elite young German athletes. *International Journal of Sport Nutrition and Exercise Metabolism, 19*, 97-109.

Broad, E. (2014). Introduction. In E. Broad (Ed.), *Sports Nutrition for Paralympic Athletes* (pp. 1-5). Boca Raton FL: CRC Press.

Crosland, J., & Boyd, C. (2014). Cerebral palsy and acquired brain injuries. In E. Broad (Ed.), *Sports Nutrition for Paralympic Athletes* (pp. 91-105). Boca Raton FL: CRC Press.

Dascombe, B.J., Karanaratna, M., Cartoon, J., Fergie, B., & Goodman, C. (2010). Nutritional supplementation habits and perceptions of elite athletes within a state-based sporting institute. *Journal of Science and Medicine in Sport, 13*, 274–280.

Dermen, W., Shwellness, M., & Jordaan, E. (2014). Clinical characteristics of 385 illnesses of athletes with impairment reported on the WEB-IISS system during the London 2012 Paralympic Games. *American Academy of Physical Medicine and Rehabilitation, 6*, 23-30.

392 Dietary Supplement Health and Education Act of 1994. Public Law 103-417, 1994.

393 Dolan, S.H., Houston, M., & Martin, S.B. (2011). Survey results of the training, nutrition, and
394 mental preparation of triathletes: Practical implications of findings. *Journal of Sports*
395 *Sciences*, *29*, 1019-1028.

396 Erdman, K.A., Fung, T.S., & Reimer, R.A. (2006). Influence of performance level on dietary
397 supplementation in elite Canadian athletes. *Medicine and Science in Sports and Exercise,*
398 *38*, 349-356.

399 Flueck, J.L., Mettler, S., & Perret, C. (2014). Influence of caffeine and sodium citrate
400 ingestion on 1500 m exercise performance in elite wheelchair athlete: A pilot study.
401 *International Journal of Sport Nutrition and Exercise Metabolism*. Advanced online
402 publication.

403 Froiland, K., Koszewski, W., Hingst, J., & Kopecky, L. (2004). Nutritional supplement use
404 among college athletes and their sources of information. *International Journal of Sport*
405 *Nutrition and Exercise Metabolism*, *14*, 104-120.

406 Geyer, H., Parr, M.K., Mareck, U., Reinhart, U., Schrader, Y., & Schänzer, W. (2004).
407 Analysis of non-hormonal nutritional supplements for anabolic-androgenic steroids - Results
408 of an international study. *International Journal of Sports Medicine, 25*, 124-129.
409 Glaser, R.M. Exercise and locomotion for the spinal cord injured. *Exercise and sport*
410 *sciences reviews, 13*, 263-304.

411 Goosey-Tolfrey, V.L., & Crosland, J. (2010). Nutritional Practices of Competitive British
412 Wheelchair Games Players. *Adapted Physical Activity Quarterly, 27*, 47-59.

413 Goosey-Tolfrey, V., Krempien, J., & Price, M. (2014). Spinal Cord Injuries. In E. Broad (Ed.),
414 *Sports Nutrition for Paralympic Athletes* (pp. 67-90). Boca Raton FL: CRC Press.

415 Goosey-Tolfrey, VL., & Sutton, L (2012) Body Composition in Sport, Exercise and Health. In
416 A. Stewart, A and L. Sutton (Eds.) *Disability, chronic disease and body composition*,
417 (pp.166-186). London and New York: Routledge.

418 Heikkinen, A., Alaranta, A., Helenius, I., & Vasankari, T. (2011) Use of dietary supplements
419 in Olympic athletes is decreasing: a follow up study between 2002 and 2009. *Journal of the*
420 *International Society of Sports Nutrition*, *8*, 1.

421 Jeukendrup, A.E., & Randell, R. (2011). Fat burners: nutrition supplements that increase fat
422 metabolism. *Obesity, 12*, 841-851.

423 Krempien, J.L., & Barr, S.I. (2012). Eating attitudes and behaviors in elite Canadian athletes
424 with spinal cord injury. *Eating Behaviors*, *13*, 36-41.

425 Kristiansen, M., Levy-Milne, R., Barr, S., & Flint, A. (2005). Dietary supplement use by
426 varsity athletes at a Canadian university. *International Journal of Sport Nutrition and*
427 *Exercise Metabolism, 15*, 195-210.

428 Krumbach, C.J., Ellis, D.R., & Driskell, J.A. (1999). A report of vitamin and mineral
429 supplement use among university athletes in a division 1 institution. *International Journal of*
430 *Sport Nutrition, 9*, 416-425.

431 Leicht, C.L., Goosey-Tolfrey, V.L., & Bishop, N.C. (2013). Spinal cord injury: Known and
432 possible influences on the immune response to exercise. *Spinal Cord Injury and Exercise*
433 *Immunology*, *19*, 144-163.

434 Maughan, R.J. (2005). Contamination of dietary supplements and positive drug tests in sport.
435 *Journal of Sport Sciences, 23*, 883-889.

436 Maughan, R.J., King, D.S., & Lea, T. (2004). Dietary supplements. *Journal of Sports*
437 *Sciences*, *22*, 95-113.

438 Meyer, N.L., & Edwards, S. (2014). Amputees. In E. Broad (Ed.), *Sports Nutrition for*
439 *Paralympic Athletes (pp. 107-126)*. Boca Raton FL: CRC Press.

440 Molinero, O., & Márquez, S, (2009). Use of nutritional supplements in sports: risks,
441 knowledge, and behavioural-related factors. *Nutrición Hospitalaria, 24*, 128-134.

442 Neiper, A. (2005). Nutritional supplement practices in UK junior national track and field
443 athletes. *British Journal of Sports Medicine*, *39*, 645-649.

444 Opperman, E.A. (2010). Cranberry is not effective for the prevention or treatment of urinary
445 tract infections in individuals with spinal cord injury. *Spinal Cord*, 48, 451-456.
446 Perret, C., Mueller, G., & Knecht, H. (2006). Influence of creatine supplementation on 800m
447 wheelchair performance. *Spinal Cord, 44*, 275-279.
448 Rastmanesh, R., Taleban, F., Kimiagar, M., Mehrabi, Y., & Salehi, M. (2007). Nutritional
449 knowledge and attitudes in athletes with physical disabilities. *Journal of Athletic Training, 42*,
450 99–105.

451 Rodriguez, N.R., DiMarco, N.M., & Langley, S. (2009). Nutrition and athletic performance.
452 *Medicine and Science in Sports and Exercise*, *41*, 709-731.

453 Sobal, J., & Marquart, L. (1994). Vitamin/mineral supplement use among athletes: A review
454 of the literature. *International Journal of Sport Nutrition*, *4*, 320-334.

455 Sundgot-Burgen, J., Berglund, B., & Torstveit, M.K. (2003). Nutritional supplements in
456 Norwegian elite athletes – Impact of International ranking and advisors. *Scandinavian*
457 *Journal of Medicine and Science in Sports, 13*, 138-144.

458 Tsitsimpikou, C., Jamurtas, A., Fitch, K., Papalexis, P., & Tsarouhas, K. (2009). Medication
459 use by athletes during the Athens 2004 Paralympic games. *British Journal of Sports*
460 *Medicine, 43*, 1062-1066.

461 Van de Vliet, P., Broad, E., & Strupler, M. (2011). Nutrition, body composition and
462 pharmacology. In Y.C. Vanlandewijck & W.R. Thompson (Eds.) *The Paralympic Athlete* (pp.
463 172-197). West Sussex: Wiley-Blackwell.

464 Ziegler, P.J., Nelson, J.A., & Jonnalagadda, S.S. (2003). Use of dietary supplements by elite
465 figure skaters. *International Journal of Sport Nutrition and Exercise Metabolism, 13, 266-276.*

Tables

Table 1 Nutritional supplement categories and frequency of use.

Category	Types of nutritional supplement included	Frequency ((%) (n))
Sports drinks	Isotonic and hypotonic drinks/powders	20% (81)
Carbohydrate	Energy drinks (>10% carbohydrate), carbohydrate gels and energy bars	13% (53)
Protein	Protein bars, powders and ready-to-drink shakes (<20 g carbohydrate per serve)	26% (102)
Recovery	Products containing carbohydrate (>20 g carbohydrate per serve) and protein to aid recovery	6% (25)
Caffeine	Any product containing caffeine/guarana as an active ingredient	5% (20)
Buffering agents	Beta-alanine, sodium bicarbonate, sodium citrate	2% (7)
Amino acids	Any amino acids/BCAAs e.g. leucine, glutamine, l-carnitine	8% (31)
Creatine	Any pure creatine products	4% (16)
Combination	Products containing carbohydrate and/or protein, and other ingredients e.g. vitamins	3% (13)
Essential fatty acids	Omega 3 and 6 fish oils/cod liver oil	8% (30)
Joint care	Glucosamine and chondroitin	4% (14)
Multivitamin	Multivitamins	14%(55)
Probiotics	Probiotics	2% (9)
Vitamin C	Vitamin C only	4% (17)
Vitamin D/calcium	Vitamin D and/or calcium only	5% (20)

Iron	Iron	2% (7)
Cranberry	Cranberry tablets/extract/capsules	4% (15)
Herbal	Any product containing herbal ingredients e.g. Echinacea, turmeric, arnica	3% (18)
Unknown (health or performance)	If a product's content could not be identified it was recorded as unknown	1% (2) health 3% (10) performance
Other (health or performance)	Products which do not fit into the other categories were recorded as other	10% (38) health 3% (11) performance

468 Note: Total number of supplements reported = 594.

469 **Table 2** Sport grouping according to the nature of the sport (n=399).

Group	Sports
Intermittent	Badminton (3), Football (16), Sitting Volleyball (26), Sledge Hockey (15), Wheelchair Basketball (48), Wheelchair Tennis (39), Wheelchair Rugby (80), Wheelchair Flag Football (1)
Speed/power	Athletics (Field/Sprint) (6), Goalball (20), Kickboxing (1), Paracanoeing (2), Paraclimbing (1), Rowing (4), Swimming (17), Powerlifting (2), Apline Skiing (8)
Endurance	Biathlon (1), Cycling (24), Paratriathlon (23), Athletics (mid-long-distance running) (26)
Skill-based	Archery (1), Boccia (4), Equestrian (3), Shooting (6), Table Tennis (7), Wheelchair Curling (7), Wheelchair Dance (1), Wheelchair Fencing (7)

470 Values reported as frequency (n).

471

472

473 **Table 3** Reasons for use and non-use of nutritional supplements.

Reasons for use of performance-enhancing NS (%, n))	Reasons for use of health-related NS (%, n))	Reasons for non-use of NS (%, n))
Support exercise recovery (32%, 224)	Support immune system (32%, 114)	I don't know enough about them (30%, 77)
Provide energy (28%, 200)	Medical need/deficiency (22%, 80)	I don't need them (25%, 65)
Increase strength/power (20%, 142)	Inadequate diet (11%, 40)	I am concerned about a positive drugs test (18%, 47)

474 *Note: Athletes could select as many responses as were applicable. Reasons in the health-*
475 *related 'other' category included anti-inflammatory, joint care, I thought I'd give it a go, heart*
476 *health, to help promote lean body mass, and to support female reproduction.* Total number
477 of supplements reported = 594.

478 **Figure legends**

479

480 **Figure 1.** Frequency distribution for the type of nutritional supplements used.

481

482 **Figure 2.** Frequency distribution of nutritional supplement use within sport categories.

483

484 **Figure 3.** Frequency distribution for the type of information sought by athletes who indicated
485 they would like more information/education regarding nutritional supplements and anti-
486 doping. *Note: Athletes were able to select multiple responses where applicable.*