Exploring Dietary Supplementation Practices and Predictors of Dietary Supplement Use Among Varsity Athletes at the University of Guelph

by

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ABSTRACT

EXPLORING DIETARY SUPPLEMENTATION PRACTICES AND PREDICTORS OF DIETARY SUPPLEMENT USE AMONG VARSITY ATHLETES AT THE UNIVERSITY OF GUELPH

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The purpose of this project was to gain insight into patterns and predictors of dietary supplement use among varsity athletes. An online questionnaire was completed by 302 varsity athletes (30.5% male, 69.5% female; 20.5 ± 1.8 years old) competing in intermittent, power and endurance-based sports at the University of Guelph. Overall, 58.3% of athletes reported having used at least one type of dietary supplement in the past six months. Gender and age had significant associations with prevalence of supplement use, with male athletes and athletes over 20 years old more likely to be supplement users. Protein, vitamins and minerals and carbohydrate were the most commonly used dietary supplements. Individual types of dietary supplements consumed and frequency of supplementation were influenced by gender, age, weekly training hours and type of sport practiced. Reasons for consuming dietary supplements, sources of information as well as predictors of supplement use were also explored. Although most athletes were using reliable sources of information, with health care professionals being the most frequently reported source, 58.6% of athletes still mentioned wanting to become more knowledgeable about dietary supplements, highlighting the need for additional educational resources.

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ATP	Adenosine Triphosphate
CAS	Court of Arbitration for Sport
FFM	Fat Free Mass
FM	Fat Mass
GI	Gastrointestinal
GLUT4	Glucose Transporter Type 4
IOC	International Olympic Committee
MRF4	Myogenic Regulatory Factor 4
mRNA	Messenger Ribonucleic Acid
NCAA	National Collegiate Athletic Association
TPB	Theory of Planned Behaviour
URTI	Upper Respiratory Tract Infection
WADA	World Anti-Doping Agency
25(OH)D	25-hydroxyvitamin D

1 Introduction

Elite athletes are constantly looking for ways to improve their performance, which can occur through the optimisation of their dietary intakes. It is well documented that most athletes are turning towards dietary supplements in order to complement their diet as well as enhance their performance. While no legal definition exists as to what constitutes dietary supplements, they usually include “foods, food components, nutrients, or non-food compounds that are purposefully ingested in addition to the habitually-consumed diet with the aim of achieving a specific health and/or performance benefit” (Maughan et al., 2018, para. 3). In the United States, the Food and Drug Administration (FDA) (2018, para. 1) defines a dietary supplement as “ a product, other than tobacco, which is used in conjunction with a healthy diet and contains one or more of the following dietary ingredients: a vitamin, mineral, herb or other botanical, an amino acid, a dietary substance for use by man [sic] to supplement the diet by increasing total daily intake, or a concentrate, metabolite, constituent, extract, or combinations of the preceding substances”. In Canada, dietary supplements are referred to as natural health products and are defined as “naturally occurring substances that are used to restore or maintain good health and include: vitamins and minerals, herbal remedies, homeopathic medicines, traditional medicines like traditional Chinese and Ayurvedic medicines, probiotics and other products like amino acids and essential fatty acids” (Government of Canada, 2016, para. 3). Unlike the rigorous regulations to which food and drugs are subjected to under the Food and Drugs Act in Canada, the supplement industry is subject to almost no control by the government, hence leading to inaccurate labelling of ingredients and potential contamination with illegal substances (Temple, 2017).

Despite the risks associated with supplements' consumption, their use in the athletic population remains extremely high. Indeed, Lun et al. (2012) explored dietary supplement use by high-performance Canadian athletes and reported that 87% of the 440 athletes included in the study had consumed at least three different types of supplements within the last 6 months. Similarly, Erdman et al. (2007) studied supplementation practices of 582 Canadian elite athletes from different age groups and reported that 88% of the participants had used at least one dietary supplement in the previous 6 months. Although very limited studies have focused exclusively on varsity athletes, supplement use appears to reach an even higher prevalence in this population, as it has been suggested by Kristiansen et al. (2005) who reported that 98.6% of varsity athletes at the University of British Columbia were consuming dietary supplements. Notwithstanding the risks associated with dietary supplement use, it is also important to recognize the high nutritional needs of athletes, which can be hard to meet through the diet alone. Therefore, in many situations, dietary supplements can be beneficial for this population and even necessary in some circumstances. However, the lack of regulations and the lack of knowledge related to dietary supplements are problematic and illustrate the importance of understanding supplementation practices of varsity athletes in order to offer safe recommendations that are adapted to their specific needs.

In Canada, a few studies have been conducted regarding dietary supplementation practices of athletes. However, almost none of those studies focused exclusively on varsity athletes, which are a sub-population of athletes with unique requirements, such as balancing university studies with high-performance sports. Hopefully, findings from this research on varsity athletes at the University of Guelph will contribute to better understanding the supplement use behaviors and their determinants in this specific population. Results from this research will be useful in informing the University's policies and guidelines about the supplementation practices among its varsity teams and in identifying any deficiencies in their knowledge about risks and benefits of dietary supplements that need to be addressed; perhaps by creating education programs or ensuring access of varsity athletes to professionals regarding their supplement choices. Furthermore, there is a lack of data available on dietary supplement usage in Ontario, since most studies exploring supplementation practices of athletes were conducted in Western Canada (Erdman et al., 2007; Kristiansen et al., 2005; Wiens et al., 2014). Thus, it is unknown whether the use of dietary supplements by athletes differs in Eastern Canada due to possible differences in the supplement market or in the cultural context. Therefore, the overall purpose of this research was to explore dietary supplementation practices of varsity athletes attending the University of Guelph, including the proportion of varsity athletes using dietary supplements, the types of supplements consumed, the frequency of supplementation, the reasons for which varsity athletes are using dietary supplements, the sources of information used by athletes regarding dietary supplements as well as the potential predictors of dietary supplements use.

2 Literature Review

2.1 Evidence of Efficacy of Dietary Supplements in Athletes

Despite the widespread use of dietary supplements by athletes, only a small proportion of those supplements are supported by strong evidence regarding their efficacy and safety. However, given the lack of governmental control over the dietary supplement industry, almost all products are using health claims as part of their marketing strategies (Temple, 2013). Unfortunately, many of those claims are based on weak scientific evidence and can be misleading to anyone without strong knowledge in this field. In 1999, in an attempt to address this issue and improve regulations of dietary supplements, the Natural Health Products Directorate, which was recently renamed the Natural and Non-prescription Health Products Directorate, was established by Health Canada. This organization has been given the responsibility to ensure that health claims made by supplement companies were supported by appropriate scientific evidence and that information on labels were truthful (Temple, 2017). While those regulations seemed promising, multiple studies have revealed that almost two decades later, no significant changes were observed within the industry and that dishonest claims and deceitful health benefits associated with supplements consumption remain problematic (Temple, 2017). Nonetheless, when consumed appropriately, there is moderate to strong evidence supporting the efficacy of some dietary supplements in assisting athletes enhance their performance and recovery, improve their immune function and optimize their body composition. It should however be noted that the order of magnitude of the advantages resulting from supplements' consumption is very small but can nevertheless be highly meaningful for elite athletes.

Dietary supplements presented in the subsequent section have moderate to strong evidence of efficacy as classified by Maughan et al. (2018), Peeling and Bennie (2018) as well as Burke (2017). In order for dietary supplements to be considered effective, consistent conclusions across numerous controlled trials, meta-analyses and systematic-reviews are required. Cohort studies, case control studies as well as cross-sectional studies also contribute to generate scientific evidence related to the efficacy of dietary supplements (Maughan et al., 2018).

2.1.1 Ergogenic Supplements with Moderate to Strong Evidence of Efficacy

Over the past decades, sport scientists have been able to generate robust evidence on the performance-enhancing properties of caffeine, creatine, sodium bicarbonate, beta-alanine and nitrate (Burke, 2017; Maughan et al., 2018). However, to exert their ergogenic effects, those supplements must be consumed following detailed protocols of use, including dosage and timing of consumption. Thus, athletes need to be knowledgeable of those protocols and be aware of possible interactions with other supplements they are consuming, which can be challenging and complex without professional advice.

Caffeine is a well-established ergogenic supplement used by athletes across a wide variety of sports, including both endurance and sprints events (Maughan et al., 2018). Its effects on increasing the mobilization of intracellular calcium, increasing free fatty acid oxidation and serving as an adenosine receptor antagonist in the central nervous system are the proposed mechanisms behind caffeine's ability to improve both physical and mental capacities of athletes (Ganio et al., 2009). Ganio et al. (2009) reviewed 21 studies, looking at the effects of caffeine ingestion on time trial endurance performance and reported that on average, when compared with placebo, caffeine ingestion improved performance by 3.2 ± 4.3%. Similarly, Burke et al. (2008) summarized studies exploring the effects of caffeine on athletic performance and concluded that evidence also exists for performance-enhancing capacities of caffeine in high-intensity events, which were defined as lasting between 1 and 20 minutes. While different dosage and timing of consumption have been found to positively impact performance, 3-6 mg of anhydrous caffeine per kilogram of body weight 60 minutes before exercise is considered the standard protocol of use (Maughan et al., 2018).

Creatine is a metabolite naturally synthesized in the body, primarily by the liver, from a reaction between three amino acids; arginine, glycine and methionine (Cooper et al., 2012). Pre-formed creatine is also found in the diet, with the main sources being meat and fish (Maughan et al., 2007). Creatine is stored within muscles in its phosphorylated form and serves as a readily available source of adenosine triphosphate (ATP) in skeletal muscles. Creatine supplementation is therefore of particular interest for athletes performing high-intensity exercises of short duration, which are known to rely heavily on the ATP-phosphorylated creatine energy system (Terjung et al., 2000). By increasing creatine store, ATP resynthesis rate is accelerated and can improve athletes' ability to sustain high-intensity efforts (Burford et al., 2007). A meta-analysis by Branch et al. (2003) reported that creatine supplementation had an overall effect size of 0.24 ± 0.02 on performance of activities lasting 30 seconds or less, with the greatest effect found on the ability to perform more repetitions of a given exercise (0.64 ± 0.18). In fact, the International Society of Sports Nutrition declared creatine monohydrate to be the most effective ergogenic dietary supplement in terms of increasing the ability of athletes to perform high-intensity exercises (Buford et al., 2007). Although some studies have demonstrated the potential of creatine supplementation in increasing endurance performance by modifying substrate utilization during aerobic activity, there is still considerable controversy in results across studies (Branch et al., 2003; Cooper et al., 2012). More research is therefore needed to establish evidence regarding the efficacy of creatine supplementation to enhance endurance performance. The recommended protocol of use generally includes a loading phase of 4 to 6 days during which athletes consume approximately 20g per day, followed by a maintenance phase during which 3-5g per day are consumed for the duration of the supplementation period (Maughan et al., 2007). However, once muscle creatine content is elevated, consuming 2 grams per day has been proven to be sufficient to maintain muscle creatine delivery slightly above the rate of muscle creatine degradation to creatinine, ensuring constantly elevated creatine stores (Terjung et al., 2000).

Sodium bicarbonate is considered the most effective buffering agent for enhancing performance (Siegler et al., 2016). Under normal conditions, blood bicarbonate concentration ranges between 23 and 27mmol/L and plays a critical role in maintaining extracellular and intracellular pH (Herbert et al., 2015). As described above, creatine phosphate supplies energy to muscles at very high rate during high-intensity exercise; however, its contribution is limited to approximately 30 seconds, time after which anaerobic glycolysis takes over (Maughan et al., 2007). Within this energy system, the conversion of muscle glycogen to lactate allows for high rate of ATP synthesis to ensure adequate energy supply. However, this rise in lactate leads to a decrease in pH, which is associated with numerous effects within muscle, such as reduced rate of glycolysis, disrupted contractile process and stimulated nerve endings causing discomfort and negatively impacting performance (Maughan et al., 2007). Good evidence exists supporting the ability of sodium bicarbonate supplementation to increase extracellular buffering capacity, which enhances the rate at which accumulating H+ are removed from muscles and therefore contributing to improve intramuscular pH maintenance (Herbert et al., 2015). Thus, athletes consuming sodium bicarbonate supplements can expect a delay in the onset of muscle fatigue when performing high-intensity efforts. Bicarbonate supplementation has been found to be the most effective in enhancing performance lasting between 1 and 10 minutes, for which 2-3% improvement was reported (Siegler et al., 2016). Although supplementation protocol should be individually tailored due to inter-individual variability in the time-to-peak buffering response after sodium bicarbonate ingestion as well as gastrointestinal (GI) tolerance, a single dose of 0.2-0.4g/kg of body mass consumed 60-150 minutes prior to exercise is the typical recommended protocol of use (Maughan et al., 2018; Siegler et al., 2016).

Beta-alanine is a non-essential amino acid endogenously produced in the liver, and it is the precursor to carnosine, which is an important physiological buffer within skeletal muscles (Herbert et al., 2015). The ability of beta-alanine supplementation to increase muscle carnosine concentration has been well documented and was associated with improved performance in exercises that induce high level of muscle acidosis (Bellinger et al., 2014). Therefore, similarly to sodium bicarbonate, beta-alanine supplementation is most interesting to athletes engaging in high-intensity exercises of short duration, since those types of efforts rely on the anaerobic glycolysis energy system, which is accompanied with muscular acidosis. A meta-analysis by Hobson et al. (2012) aiming at exploring the effects of beta-alanine supplementation on exercise performance concluded that beta-alanine supplementation improved performance by 2.85%, on average, across the 15 studies included in their review. Various protocols of supplementation have been tested, however the strongest evidence exists for daily consumption of approximately

65mg/kg of body mass, ingested as doses of 0.8-1.6g every 3 to 4 hours throughout the day, for a period of 10-12 weeks (Maughan et al., 2018).

Nitrate supplementation keeps growing in popularity, especially among endurance athletes, due to its ability to reduce the oxygen cost of submaximal exercise by improving muscle oxygenation as well as muscle metabolic efficiency (Jones, 2014; Thompson et al., 2016). Once ingested, nitrate is reduced to nitrite, which can then be converted to nitric oxide in conditions of low oxygen availability (Jones, 2014). Enhanced nitric oxide bioavailability has the potential of improving performance through various mechanisms such as increased efficiency of mitochondrial respiration, reduced ATP demands for muscle contraction and increased blood flow to muscles (Peeling et al., 2018). High nitrate-containing foods include beetroots and green leafy vegetables, with beetroot juice being the most commonly used source of nitrate in exercise interventions (McMahon et al., 2016). Recently, Thompson et al. (2016) also demonstrated the potential of dietary nitrate to improve sprint and high-intensity intermittent running performance. While a single intake of 5-9mmol of nitrate 2-3 hours prior an exercise session has been linked to acute performance benefits, prolonged period of supplementation is often recommended for highly trained athletes, since the ergogenic effects associated with nitrate supplementation appear harder to obtain within that population (Maughan et al., 2018).

2.1.2 Supplements for Recovery, Muscle Soreness and Injury Management with Moderate Evidence of Efficacy

With demanding training schedule and high training load, elite athletes are putting their bodies under significant stress, making muscle soreness and injuries inevitable. The ability to recover properly between training sessions and after competitions is critical since it allows athletes to sustain their training regimen and deliver performance while staying healthy. Although many dietary supplements claim to assist athletes in their recovery, only creatine and vitamin D have moderate evidence supporting their efficacy in helping athletes minimize their risks of injuries as well as enhance their recovery.

In addition to its ergogenic properties, creatine supplementation has been shown to be effective at improving recovery from injury, muscle damage and oxidative stress induced by exercise (Cooper et al., 2012). Injuries requiring immobilization are particularly problematic for athletes since on top of impacting their ability to train, they are also accompanied with a decrease in muscle mass and function which can lead to longer rehabilitation periods (Rawson et al., 2018). Several studies looking into the effects of creatine supplementation during immobilization demonstrated that creatine had the ability to improve maintenance of muscle mass and strength and endurance, maintain or increase muscle creatine and glucose transporter type 4 (GLUT4) as well as increase growth factor (MRF4) expression and glycogen content, which are all indicators of enhanced recovery processes (Rawson et al., 2018). Creatine supplementation also appears to improve regenerative responses post-exercise, leading to attenuated muscle damage and oxidative stress (Cooper et al., 2012). Indeed, Bassit et al. (2010) and Cooke et al. (2009) both demonstrated that creatine ingestion prior to an intense exercise session was associated with a decrease in markers of muscle damage, such as creatine kinase and lactate dehydrogenase, post-exercise. Proposed mechanisms behind the reduction in muscle damage and the antioxidants' effects of creatine include creatine's ability to enhance calcium buffering capacity of muscles, reduce calcium-activated proteases and remove superoxide anion and peroxinitrite radicals (Cooper et al., 2012).

Vitamin D is well known for its essential role in bone health; however, emerging research strongly suggests important physiological roles of vitamin D in muscle growth and muscle repair, therefore contributing to enhanced recovery (Maughan et al., 2018). Stress fractures, which are caused by repetitive mechanical loading, are the most common overuse injuries in athletes (Duckham et al., 2012). While stress fractures are problematic in both male and female athletes across many sport disciplines, the highest rates have been reported in female endurance athletes (Duckham et al., 2012). Indeed, in their research regarding bone stress injuries in collegiate track and field athletes, Nattiv et al. (2013) reported that 65% of athletes diagnosed with bone stress injuries were female and 59% were distance runners, which is consistent with findings from previous studies (Arendt & Griffiths, 1997; Brunet et al., 1990; Johnson et al., 1994; Zernicke et al., 1994). As suggested by Ruohola et al. (2006), low vitamin D status appears to be associated with higher risks of stress fracture; in this study, a 3.6-time higher risk of stress fractures was shown in military recruits with inadequate vitamin D levels. A randomized control trial conducted by Lappe et al. (2008) demonstrated that vitamin D and calcium supplementation significantly lowered the incidence of stress fracture by 20% in the intervention group compared to the placebo group. Although more research is needed, current data suggest an association between vitamin D status and stress fractures as well as the potential of supplementation to reduce the risk of bone stress injuries. Furthermore, enhanced adaptive response to exercise related to improved skeletal muscle regeneration was reported with vitamin D supplementation. With their randomized placebo-controlled trial, Owens et al. (2015)

demonstrated that 4000IU of supplemental vitamin D per day improved recovery of peak torque at 48 hours and 7 days post eccentric exercise bout. Detrimental effects on muscle functions have been observed with vitamin D serum level below 30nmol/L, illustrating the importance for athletes to achieve optimal vitamin D status, which often require supplementation (Close et al., 2013).

2.1.3 Supplements for Immune Health with Moderate Evidence of Efficacy

Illness in athletes can negatively impact their ability to perform. It is well known that high training load with limited recovery can suppress immune functions, putting athletes at a higher risk of contracting illnesses (Smith, 2003). Hence, a wide variety of dietary supplements are used by athletes aiming at enhancing their immune health and reducing their risks of developing illnesses. However, only vitamin D, probiotics and vitamin C have moderate evidence supporting their efficacy in enhancing athletes' immune system.

Vitamin D has recently been recognized as playing critical roles in both innate immunity, by up-regulating gene expression of a broad spectrum of anti-microbial peptides, and acquired immunity, by exerting immunomodulatory effect on T and B lymphocytes (Bermon et al., 2017). Numerous studies have reported negative associations between vitamin D status and incidence of upper respiratory tract infections (URTI) in athletes, reinforcing the fact that vitamin D serum concentration has the potential to influence immune responses (Bermon et al., 2017). Indeed, Halliday et al. (2011) reported that college athletes with lower 25(OH)D during the spring had significantly higher frequency of illness. Similarly, He et al. (2013) found that, in a cohort of 260 endurance athletes in winter training period, 38% had inadequate vitamin D status (25(OH)D 30-

50nmol/L) and 55% were vitamin D deficient (25(OH)D <30nmol/L). A significantly higher proportion of those athletes reported symptoms of URTI compared with athletes in the optimal vitamin D status group (25(OH)D >120nmol/L). The enhanced resistance to illness associated with adequate vitamin D serum concentrations has been suggested to be mediated by the up-regulating effects of vitamin D on secretory immunoglobulin A and cathelicidin, which are antimicrobial peptides acting against a broad spectrum of bacteria, viruses and fungi (He et al., 2016).

Moderate evidence also exists in the literature regarding the efficacy of probiotic supplementation in enhancing immune health in athletes. In addition to being an important line of defense against infections, the gut plays critical roles in regulating mucosal homeostasis of both the respiratory and GI tracts (Pyne et al., 2015). Probiotics are non-pathogenic bacteria located in the digestive tract, which by their growth and metabolism have the ability to inhibit the proliferation of pathogenic bacteria, thus decreasing risks of respiratory and GI illness symptoms (Bermon et al., 2017). Interactions between probiotics and immune cells in the gut also allow beneficial immunomodulation of local immunity and systemic immunity (Bermon et al., 2017). A Cochrane review published in 2015 reported that across 12 randomized controlled trials, probiotics supplementation in the general population decreased the incidence of URTI by almost 50% and reduced the duration of a given URTI episode by approximately 2 days on average (Hao et al., 2015). Similarly, Pyne et al. (2015) reviewed studies examining probiotic supplementation specifically in athletes and concluded that taken together those studies provide modest evidence that probiotic supplementation could indeed be beneficial in enhancing health and reducing risk of respiratory illnesses in athletes, especially during stressful periods of training and competition. Vigorous exercise is known to put significant stress on the GI tract causing GI issues in many athletes, especially those involved in prolonged sports events. Ischemia in the gut caused by splanchnic hypoperfusion has been identified as the main cause of GI problems in athletes, and it was proposed that probiotics could potentially improve mucosal and epithelial barriers preventing some GI issues associated with ischemia (Rawson et al., 2018). However, despite promising data published recently regarding small to moderate decrease in severity and/or duration of GI issues in athletes randomized to probiotics supplements' intervention groups, more evidence is still needed to determine the effectiveness of probiotics supplementation in reducing GI distress (Rawson et al., 2018).

Finally, although it has been clearly established that vitamin C offers no benefit in treating URTI, moderate support exists regarding its efficacy in preventing URTI (Bermon et al., 2017; Maughan et al., 2018). A Cochrane review published in 2013 reported that highly trained individuals consuming 0.25-1.0 gram of vitamin C per day had a reduction of approximately 50% in URTI compared with placebo groups (Hemila & Chalker, 2013). Decreasing incidence of illness can offer significant advantages to athletes by allowing them to train consistently without disruption in their training programs, which over the long term can indirectly enhance their performance.

2.1.4 Supplements Assisting Changes in Body Composition with Moderate Evidence of Efficacy

Optimising body composition, either by increasing lean body mass, decreasing fat mass (FM) and losing or gaining weight, can indirectly improve performance. Increasing muscle mass may help athletes generate more power, and there is evidence that both protein supplements as well as creatine supplementation can assist athletes in gaining fat free mass (FFM) (Maughan et al., 2018). Protein supplementation has also been shown to be effective in supporting athletes losing FM, which can offer significant advantages especially for athletes competing in endurance sports, by improving their power to weight ratio, as well as in aesthetic sports, given the appearance-oriented nature of those disciplines (Maughan et al., 2018).

Protein supplements are usually composed of isolated proteins from various sources, with whey and soy being the most commonly used (Maughan et al., 2018). Data from 22 randomized controlled trials, assessing the effects of protein supplementation on the adaptive response of skeletal muscles to prolonged resistance-type exercise, were reviewed in a meta-analysis published in 2012 by Cermak et al. Overall, adults aged between 18 and 49 years consuming an additional 50 grams of protein per day on top of their usual protein intake, gained on average 1kg of FFM more than participants in placebo groups after 12 ± 1 weeks of resistance-type exercise training. Interestingly, usual protein intakes of participants before any interventions were deemed optimal, with an average consumption of 1.2g/kg/day. Therefore, it appears that when combined with resistance training, supplementing diets already adequate in their protein content with additional dietary protein can offer advantages to athletes aiming to increase their muscle mass. On the other hand, protein supplementation has also been shown to be beneficial in enhancing weight loss and decreasing FM (Maughan et al., 2018). Indeed, in their meta-analysis published in 2012, Wycherley et al. established that across the 24 randomized controlled trials comparing energy-restricted diets with various protein to fat ratios, high protein diets resulted in modest but significant benefits compared to standard protein diets in reducing body weight and FM.

Additionally, higher protein diets were shown to promote lean mass retention and to mitigate the loss of FFM occurring during diet-induced weight loss, which typically represent almost 20% of total weight loss (Wycherley et al., 2012).

Moderate evidence also supports the ability of creatine supplementation to increase lean body mass (Maughan et al., 2018). Upon reviewing 96 published research regarding the effects of creatine on body composition, Branch et al. (2003) concluded that participants in creatine supplementation groups had increased FFM by an average of 2.2 ± 0.7% from baseline. It has been proposed that the significant increase in collagen mRNA, GLUT4 and myosin heavy chain IIA associated with creatine supplementation may induce an anabolic environment conductive to muscle mass development (Deldicque et al., 2007).

2.2 Risks Associated with Dietary Supplementation

As presented above, when used appropriately, dietary supplements can help athletes enhance their training and performance. However, risks associated with dietary supplementation need to be taken into consideration, and athletes have the responsibility of carefully assessing the risks and benefits of any supplement they are using or planning to use. Major risks described in the following section include anti-doping rule violations associated with the use of dietary supplements, as well as adverse health effects resulting from inadequate supplementation practices or from undesirable interactions between various dietary supplements.

2.2.1 Anti-Doping Rule Violations Associated with Dietary Supplementation

Perhaps the biggest concern for athletes consuming dietary supplements are anti-doping infringements related to supplement use. An analysis of available empirical data from the World Anti-Doping Agency (WADA), the International Court of Arbitration for Sport (CAS) and National Anti-Doping organizations from Australia, the United Kingdom and the United States revealed an alarming estimation of 10-15% of dietary supplements possibly containing prohibited substances (Outram & Steward, 2015). Cross-contamination resulting from inadequate manufacturing practices, deliberate adulteration of supplements and inaccurate labelling of ingredients are highly problematic within this industry and require high vigilance from consumers (Maughan et al., 2005).

From 2006 to 2013, 7.7% of anti-doping rule violations in the United States, 8.8% in United Kingdom and 6.4% in Australia have been associated with supplement use (Outram & Stewart, 2015). Those statistics are extremely high considering that they only include cases that were proven to be related to supplement use, which is a complex procedure requiring strong evidence. It has been demonstrated that even a few micrograms of a prohibited substance in a dietary supplement were enough to lead to adverse analytical findings. Indeed, Van Der Merwe and Grobbelaar (2005) showed that the consumption of only one capsule of a supplement containing between 8.4 and 31.8 micrograms of 19-nor-4-androstenedione, an anabolic androgenic steroid, was enough to increase the urinary concentrations of 19-nor-4-androstenedione above the WADA-defined threshold 2 hours post administration in all participants and was still detected up to 36 hours post ingestion in some participants. Those results are even more alarming, considering that the recommendation of the manufacturer for this specific supplement was to consume 4 capsules three times per day, which would obviously lead to significantly higher levels of 19-nor-4-androstenedione in the urine.

Muscle-building and weight loss supplements are of particular concern and have been found to pose greater threat of contamination. Anabolic androgenic steroids in muscle-building supplements and stimulants (ephedrine and amphetamine analogues) as well as anorectic agents (sibutramine and fenfluramine) in weight loss supplements are extremely common cases of contamination (Maughan, Shirreffs & Vernec, 2018). Those types of supplements often make unrealistic claims regarding their effects, which can only potentially be achieved with prohibited substances and pharmaceutical agents. This trend is reflected when analyzing the FDA Tainted Supplement List, on which 39% of listed dietary supplements are weight loss supplements and 12% are muscle building supplements (Mathews, 2018). While this list only applies to dietary supplements sold in the United-States, it has been well demonstrated that dietary supplement contamination is problematic on a worldwide scale. Indeed, upon analyzing 634 samples of non-hormonal dietary supplements that were purchased from 215 companies across 13 countries, Geyer et al. (2004) demonstrated that 94 samples contained anabolic androgenic steroids, including prohormones of nandrolone and testosterone.

Although anti-doping rule violations are very serious and can significantly impact an athletic career, only 63% of elite Canadian athletes reported having access to anti-doping information (Erdman et al., 2007). This illustrates the lack of educational programs available to athletes in Canada and highlights the serious responsibilities of sports authorities to provide guidance and ensure access of athletes to the necessary nutritional and dietary supplement education. However, athletes also have their share of responsibilities in preventing anti-doping infractions related to dietary supplement use. Given that strict liability is the principle outlined in the WADA Code, athletes are responsible for what they are ingesting and are penalized for adverse analytical findings whether they intentionally consumed prohibited substances or not (Maughan et al., 2005). Therefore, it is expected that elite athletes are aware of and knowledgeable about the List of Prohibited Substances and Methods by WADA. Unfortunately, this does not seem to be the case in high-performance Canadian athletes, with only 59% reporting being aware of current WADA List of Prohibited Substances and Methods (Lun et al., 2012). Consequently, the prevention of anti-doping rule violations associated with supplement use needs to be tackled from different angles, including the implementation of appropriate regulations at the governmental level, the development of educational programs by sports authorities, as well as increased awareness about the benefits and risks of dietary supplements among athletes.

2.2.2 Health Risks Associated with Dietary Supplements

It is well documented in the literature that athletes using dietary supplements tend to report the concurrent use of multiple different products (Burke et al., 2017). Given that interactions between various supplements have not been well studied yet, the possible adverse effects of polypharmacy are mostly unknown. Preliminary studies have suggested that those effects can be problematic both from performance and health perspectives. For example, as described above, good evidence exists supporting the ability of nitrate supplementation to enhance sustained high-intensity exercises. However, the simultaneous consumption of bicarbonate has been shown to blunt the ergogenic effect of nitrate (Burke et al., 2017). From a health standpoint, bicarbonate supplementation is frequently associated with GI issues, which can be further exacerbated by the co-ingestion of caffeine (Burke et al., 2017; Maughan et al., 2018).

Furthermore, inadequate supplementation practices, such as excessive intakes above physiological needs, are also putting athletes at risks. For instance, excessive iron supplementation can cause vomiting, diarrhea as well as abdominal pain, and if not addressed can eventually lead to haemochromatosis and liver failure (Mettler & Zimmermann, 2010). Similarly, excessive caffeine intake may result in nausea, anxiety, accelerated heart rate as well as insomnia (Maughan et al., 2018). Those adverse health effects can undoubtedly impair performance and illustrate the importance of professional supervision of athletes using dietary supplements.

Recently, exposure to heavy metals related to protein supplement consumption has also been reported. In a review published in 2010 by ConsumerLab, an independent American laboratory specialized in testing health and nutritional products, two out of the twenty-four commercially-available protein supplements analyzed were contaminated with lead and delivering daily doses ranging from 6 to 18 micrograms, which in cases of chronic use can potentially be harmful. Similarly, in another report published in 2012, levels of heavy metals including arsenic, cadmium, lead and mercury above safe levels were found in various protein powders and drinks (ConsumerLab, 2012).

Finally, despite multiple case reports published in the past few years, it is challenging to associate adverse health outcomes to specific supplements and a significant number of events have to occur before a product is removed from the market (Maughan, 2018). While no definitive conclusions have been drawn, there appear to be an agreement regarding the associations between cardiovascular and central nervous system events and the use of supplements containing ephedra alkaloids (Haller & Benowitz, 2000). Ephedra alkaloids is often found in weight loss supplements and has been associated with hypertension, palpitations, tachycardia, stroke and seizure. With the growing number of cases of adverse health effects related to ephedra alkaloids, which some resulted in permanent injuries and death, the FDA requested an independent review of cases that took place between June 1997 and March 1999. Although the conclusions of this report were alarming with 31% of cases considered definitely or probably related to the consumption of ephedra alkaloids and another 31% of cases deemed possibly related, no significant measures were taken to remedy the situation (Haller & Benowitz, 2000). Various other adverse health outcomes have also been linked to dietary supplement use, such as liver damage and pancreatitis associated with hydroxycitric acid as well as acute liver failure related to weight loss and fat burners supplements (Food and Drug Administration, 2009; Grigos et al., 2016; Krishnan et al., 2011; Melendex-Rosado et al., 2015). Therefore, caution should be exerted by athletes using dietary supplement in general, but more specifically towards weight loss supplements since they have been associated with numerous adverse health effects.

2.3 The Nutritional Needs of Athletes

Notwithstanding risks associated with the consumption of dietary supplements, it is also important to recognize the high nutritional needs of athletes, which are substantially higher than those of the general population. Given the significant increase in energy expenditure associated with training and exercise, athletes are expected to increase their macronutrients' intake in order to remain in caloric balance and provide adequate nutrients to their bodies. Furthermore, the high prevalence of nutritional deficiencies in the athletic population indicates that intense training regimen also increases their micronutrients' needs. The energy and macronutrients' needs as well as the common nutritional deficiencies reported in the athletic population will be described in the following section.

2.3.1 Energy and Macronutrients' Needs

While all athletes have increased energy needs, some sport disciplines are known for their extremely high metabolic demands. For example, using the doubly-labeled water technique, Trappe et al. (1997) measured the energy expenditure of elite female swimmers, members of the United States National Team, and reported mean energy expenditure of 5593 kcals per day during high volume training. Similarly, Hulton et al. (2010) and Rehrer et al. (2010) measured daily mean energy expenditure of 4918 kcals and 6544 kcals respectively in elite cyclists. Furthermore, protein needs can reach 2.0g/kg/day during periods of intense training, which is significantly above the recommended dietary allowance established by Health Canada of 0.8g/kg/day for adults (Government of Canada, 2006; Stuart, 2011). Although protein needs can be met through a well-planned diet, many athletes rely on different types of protein supplements, which are easy to prepare, portable and practical for busy training and competition schedules. Finally, athletes also face the challenge of consuming the needed amount of energy while exercising. It is now well understood that carbohydrates are an important fuel for exercise, and recommendations regarding carbohydrate intake during exercise are often more easily consumed from carbohydrates-rich supplements rather than food. This is especially true for athletes involved in prolonged events, given that it is recommended to consumed 60g of carbohydrate per hour during exercise lasting between 2-3 hours and up to 90g of carbohydrate per hour for efforts lasting over 2.5 hours (Jeukendrup, 2014). From a practical perspective, sport drinks, gels or confectioneries are interesting alternatives for athletes to meet those requirements since they can be easily consumed while training and competing and are generally well tolerated by the GI system. Therefore, in many situations, dietary supplements can be beneficial and even necessary for athletes. This again highlights the importance of understanding the supplementation practices of athletes in order to offer safe recommendations that are adapted to their specific needs.

2.3.2 Nutritional Deficiencies in Athletes

Some nutrient deficiencies are recognized to be common in athletes and frequently require supplementation. In the American College of Sport Medicine Joint Position Statement regarding nutrition and athletic performance, it is agreed that iron, calcium and vitamin D are micronutrients of concerns in athletes, for which supplements are often necessary (Thomas et al., 2016). However, the Joint Position Statement also emphasized the risks of excessive intake associated with unnecessary micronutrients supplementation, which seems to be a common practice in the athletic population (Thomas et al., 2016). Indeed, Lun et al. (2012) reported that multivitamin and mineral were the second most frequently used supplements by high-performance Canadian athletes, with 16% of the participants consuming them on a daily basis. Athletes should therefore be well-educated about the lack of scientific evidence on the benefits of micronutrient supplementation in the absence of deficiencies, to be able to take informed decisions.

Iron serves as a critical factor in hemoglobin formation, which is the protein in red blood cells responsible for carrying oxygen (Rowland et al., 2012). Suboptimal iron status can therefore decrease work capacity and impair muscle function, resulting in decreased performance. Iron deficiency is characterized by serum ferritin concentration below 12 to

20ng/mL and can lead to anemia, which is defined as hemoglobin concentration below 12g/dL for females and 13g/dL for males. However, this is not always the case and nonanemic iron deficiency, a condition in which hemoglobin concentration is adequate despite serum ferritin concentration being below 12 to 20ng/mL, is highly prevalent in athletes, especially in female athletes (Rowland et al., 2012). Indeed, frequencies of nonanemic iron deficiency between 40% and 47% was reported in groups of female runners and swimmers, and it was estimated that iron requirements for female athletes may be increased by up to 70% of the estimated average requirement (Brown et al., 1985; Nickerson et al., 1985; Rowland et al., 1987; Thomas et al., 2016). Numerous factors are known to lead to suboptimal iron status in athletes, including inadequate iron intake from heme food sources, inadequate energy intake, periods of rapid growth, high-altitude training, menstrual blood loss, foot-strike hemolysis, injuries, as well as increased iron losses in sweat, urine and feces during periods of intense training (Thomas et al., 2016). For those reasons, athletes at risk of iron deficiency, which include female athletes, distance runners as well as vegetarian athletes, should typically aim for iron intakes above the recommended dietary allowance of 18mg per day for women and 8mg per day for men, and oral iron supplementation might be necessary for athletes presenting with a deficiency (Thomas et al., 2016). However, Coates et al. (2017) demonstrated that despite adequate medical monitoring and appropriate iron supplementation treatments, iron deficiency and iron deficiency anemia remain highly prevalent in elite runners and triathletes.

As described above, vitamin D is involved in various physiological processes including bone health, immunity and muscle functions. Due to dietary sources of vitamin D being very limited, and the endogenous synthesis resulting from sun exposure often being insufficient, vitamin D deficiency is highly prevalent worldwide (Larson-Meyer & Willis, 2010). Therefore, supplementation ranging between 800IU to 2000 IU per day is typically recommended for the general population (Maughan et al., 2018). While specific guidelines for athletes have not been established yet, the prevalence of vitamin D insufficiency reaching 73% in some groups of athletes, indicates the common need for supplementation (Constantini et al., 2010). Doses as high as 10 000IU per day have been shown to be beneficial in restoring vitamin D status of deficient athletes; however, high-dose supplementation protocols should not be undertaken without professional advice and supervision, in order to avoid possible toxicity that can lead to hypercalcemia, renal stones as well as renal calcification (Heaney, 2008; Maughan et al., 2018)

Finally, calcium is another micronutrient frequently requiring supplementation in athletes. Although there is no direct indicator of calcium status, measuring bone mineral density can be indicative of chronic calcium intake (Maughan et al., 2018). Disordered eating patterns, restricted energy intake and menstrual dysfunction are highly prevalent in athletes and lead to decreased bone density and increased risk of stress fractures (Thomas et al., 2016). In addition, disordered eating patterns and restricted energy intake are also major determinants of inadequate calcium intake, which can further negatively impact bone density (Thomas et al., 2016). Therefore, in order to optimize bone heath, it is recommended that athletes with low energy availability and/or menstrual dysfunctions aim for at least 1500mg of calcium per day, which might require supplementation (Maughan et al., 2018).

2.4 Dietary Supplement Use Among Athletes

Although limited data are available regarding dietary supplementation practices of varsity athletes in Ontario specifically, similar research on the use of dietary supplements by elite athletes in general has been conducted in Canada and around the world. Some information on patterns of prevalence of dietary supplement use, types of dietary supplement consumed, frequency of supplementation, sources of information used regarding dietary supplements as well as reasons for using dietary supplements have emerge from those studies and will be reviewed in the subsequent sections.

2.4.1 Prevalence of Dietary Supplement Use

Extremely high prevalence rates of dietary supplementation in the athletic population have been consistently reported in the literature, across all sports disciplines. Indeed, various studies conducted worldwide have reported prevalence of supplement use in elite athletes ranging between 62% and 99% (Baylis et al., 2001; Braun et al., 2009; Dascombe et al., 2010; Erdman et al., 2006). In Canada specifically, research conducted by Wiens et al. (2014) revealed that 98.1% of Canadian athletes aged between 11 and 25 years had consumed, on average, seven different types of supplements over the past 3 months, while Lun et al. (2012) reported that 87% of high-performance Canadian athletes had been using on average three different types of supplements in the past 6 months. Similarly, in another sample of 582 elite Canadian athletes, 88.4% reported using on average 3 dietary supplements (Erdman et al., 2007). Although limited data are available regarding prevalence of supplementation in varsity athletes, rate as high as 91% and 98.6% have been reported (Erdman et al., 2007; Kristiansen et al., 2005).

The International Olympic Committee (IOC) consensus statement recognizes that comparison across various studies to define factors influencing the rates of dietary supplementation is challenging, given the wide variety of questionnaires used (Maughan et al., 2018). However, despite limitations such as the variation in the definition of what constitutes a dietary supplement, which supplements are included in the questionnaires and the use of non-validated and non-standardized questionnaires, some patterns of supplementation emerged from the literature (Maughan et al., 2018). In general, research has shown that supplement use is higher in men than in women, increases with age and with level of training and performance, and varies across different sports discipline (Maughan et al., 2018).

Although the IOC agrees that gender has a significant influence on the patterns of dietary supplementation, studies conducted on Canadian athletes did not reveal higher rate of supplement use in male athletes. Indeed, Wiens et al. (2014) did not find any significant difference in prevalence of use based on gender, with 97.8% of male and 98.2% of female athletes consuming supplements, nor did Erdman et al. (2007) who reported rate of supplementation of 89.5% and 87.6% for female and male athletes respectively. However, in a group of American student-athletes, the prevalence of supplement use was found to be significantly higher in male (71.4%) than female (42.9%) athletes, which is consistent with findings from a study including almost 3000 Greek athletes revealing a significantly greater prevalence of supplement intake in male compared to female athletes (Giannopoulou et al., 2010; Valentine et al., 2017).

For high-performance athletes under the age of 20 years old, a prevalence of dietary supplement use ranging from 62-80% was reported across the literature (Braun et al., 2009;

Crowley & Wall, 2004; Erdman et al., 2007; Lun et al., 2012; Nieper, 2005). While it is well established that a high proportion of young athletes are consuming dietary supplements, limited studies have been conducted comparing supplementation practices of elite athletes based on their age. However, in the IOC consensus statement regarding dietary supplements and high-performance athletes, it has been concluded that generally the prevalence increases with age. This trend was indeed observed in the study conducted by Erdman et al. (2007), in which older Canadian athletes were significantly more likely to report dietary supplement use. On the other hand, Wiens et al. (2014) failed to observe any significant difference in prevalence of supplement use in another sample of Canadian athletes based on their age.

While contradictions exist regarding the influence of gender and age on supplementation, the impact of the level of training and performance on the use of dietary supplements is consistent across the literature. It has been observed that a significantly greater proportion of athletes undergoing high training loads are consuming dietary supplements compared with athletes reporting low or moderate training levels (Giannopoulou et al., 2010). This association was also reported in Canadian elite athletes, with rate of supplementation as low as 66.6% in athletes training 5 hours or less per week and up to 95.1% in athletes training over 25 hours weekly (Lun et al., 2012). Performance level has a similar effect on dietary supplement usage, as illustrated by Erdman et al. (2006) who reported that athletes competing at the provincial level had a significantly lower rate of supplementation (76.5%) than varsity (90.8%), national (83.0%), continental (95.0%) and international or professional athletes (93.3%).

Finally, differences in rates of supplementation have been observed based on the type of sports practiced. Lun et al. (2012) reported that athletes involved in endurance and power sports were the most likely to declare supplement use, with respective prevalence rates of 90.9% and 90.5%, while athletes competing in intermittent events, which include sports such as volleyball and basketball, were the least likely to use dietary supplements, with a prevalence of 78.9%. From a more general perspective, it was also shown that the proportion of individual-sports athletes consuming supplements is significantly higher than team-sports athletes; however, this association has only been observed in athletes undergoing high training load (Giannopoulou et al., 2010).

2.4.2 Types of Dietary Supplements Consumed and Frequency of Supplementation

Determining which types of supplements are most frequently consumed by athletes is challenging due to the variations in the questionnaires used to assess supplementation practices. However, Erdman et al. (2007) and Lun et al. (2012) both reported similar findings regarding the five dietary supplements most frequently consumed by Canadian athletes. In the Erdman et al. (2007) study, the five most prevalent supplements were sport drinks (22.4%), sport bars (14.0%), multivitamins and mineral (13.5%), protein supplements (9.0%) and vitamin C (6.4%); in the study by Lun et al. (2012), the five most prevalent supplements were sport drinks (24.1%), multivitamins and mineral (16.1%), carbohydrate sport bars (11%), protein powders (9.8%) and meal-replacement products (4.9%). Therefore, these findings suggest that sport drinks, multivitamin and minerals as well as protein supplements are widely used in the Canadian athletic population. Additionally, in both studies, over 50% of athletes classified as dietary supplement users reported consuming supplements on a daily basis, independently of gender and age.

In varsity athletes specifically, sport drinks, caffeine and carbohydrate bars have been reported as the three types of supplements most commonly used (Kristiansen et al., 2005). In this group of varsity athletes from the University of British Columbia, gender did not have a significant impact on the type of supplements chosen, except for creatine and iron supplements which were reported to be used by a higher proportion of men and women respectively. Regarding the frequency of supplementation, Kristiansen et al. (2005) revealed that varsity male athletes consumed creatine, carbohydrate gels, sport drinks and protein powder significantly more frequently than varsity female athletes, while female athletes used iron supplements significantly more frequently than men. No differences were recorded for the consumption of energy bars, caffeine and vitamins/minerals supplements by gender.

The influence of performance levels, weekly training hours and sport discipline on the types of supplements consumed and the frequency of supplementation remains unclear. Wiens et al. (2014) reported that approximately 40% of endurance as well as strength and power athletes used recovery drinks, which is almost twice as high as the prevalence reported in aesthetic and intermittent athletes. Furthermore, strength and power Canadian athletes were found to have a significantly higher usage of B vitamin preparations, vitamin E, creatine, glutamine and protein powder, while aesthetic athletes were significantly less likely to consume sport or electrolyte beverages (Wiens et al., 2014). However, Giannopoulou et al (2010) did not report any significant difference in the types of supplements consumed by athletes of individual sports vs. team sports, nor did they find any influence of different performance levels on supplementation practices. Those results partly contradict Erdman et al. (2006) findings, in which multivitamin and minerals were found to be the most frequently consumed supplements by athletes competing at the international level, while all other performance levels reported sport drinks as their most frequently used supplement. Finally, independently of weekly training hours, elite Canadian athletes reported the use of the same types of supplements (Lun et al., 2012).

2.4.3 Reasons for Using Dietary Supplements

As it is the case within the general population, one of the main reason athletes are using dietary supplements is to prevent or correct nutrient deficiencies that may impair health or performance (Erdman et al., 2007). However, elite athletes are also turning towards supplements for a variety of additional reasons, including the provision of a convenient form of energy and nutrients around exercise sessions (Maughan et al., 2018). From a practical standpoint, many athletes prefer consuming sports foods, such as sport drinks and gels, rather than normal foods during training periods, because they are readily available, easy to consume and normally well tolerated by the digestive system. Moreover, another major motive for athletes using dietary supplements is to enhance performance, either directly or indirectly. As mentioned previously, some supplements have been shown to improve performance indirectly by allowing athletes to train harder and more consistently, which over the long term might be translated to increased performance. For instance, those supplements aim at improving recovery, optimising body composition or reducing risks of illness or injury (Maughan et al., 2018). Financial gain associated with sponsorships is another major reason for athletes to use certain types of supplements, when products are provided free of charge or when companies offer financial incentives for athletes to use their supplements (Maughan et al., 2018). Finally, knowing or believing that other athletes and competitors are using specific types of supplement has also been shown to significantly influence athletes' decision to use these supplements (Maughan et al., 2018).

The rationale for supplementation appears to vary based on gender and age. Common reasons given by female athletes for using supplements include health maintenance, prevention or correction of nutrient deficiencies and compensation for an inadequate diet, while male athletes tend to use supplements to increase or maintain muscle mass, strength and power (Erdman et al., 2007; Froiland et al., 2004; Lun et al., 2012). Among Canadian athletes specifically, men were found to be significantly more likely than women to use supplements to increase or maintain muscle mass, strength and power as well as to increase endurance, while female athletes were reported to consume dietary supplements mainly for medical reasons (Wiens et al., 2014). In the same study, older athletes were found to be significantly more likely to use dietary supplements to increase or maintain muscle mass, strength and power as well as to improve diet, whereas younger athletes were more likely to use supplements because their friends/teammates were using them.

Finally, unlike the significant influence weekly training hours have on prevalence of supplementation, training level does not seem to affect the reasons for using supplements. Indeed, regardless of training hours, Lun et al. (2012) reported that health maintenance, increased energy and support of exercise recovery were the most frequent justifications given by athletes. However, variations in the reasons for using dietary supplements based on the type of sports practiced have been observed in Canadian high-performance athletes. While power, judged and endurance athletes have ranked "health maintenance/prevent nutritional deficiency" as their primary reason for supplementation, intermittent athletes consumed supplements primarily to increase energy (Lun et al., 2012). Furthermore, power (16%) and intermittent (18.1%) athletes were significantly more likely to consume supplements to increase lean body mass and strength compared to judged (5.6%) and endurance (0%) athletes, whereas athletes involved in endurance sports used supplements to enhance recovery and for medical indications significantly more than athletes competing in any other types of sports. While Wiens et al. (2014) did not observe any significant effect of the level of competition on the rationale for using dietary supplements, Erdman et al. (2006) reported that international/professional level athletes were significantly more likely to use supplements to facilitate exercise recovery, while international/professional as well as national athletes were both significantly more likely to select "enhance immunity" to justify their supplementation practices. Those patterns indicate that athletes competing at higher levels place more emphasis on indirect improvements to performance, by aiming at optimising their recovery and reducing their risks of illness, which is expected from high-performance athletes.

2.4.4 Sources of Information Regarding Dietary Supplements

Regardless of the gravity of the consequences associated with anti-doping infractions and the potential health risks associated with supplement use, most athletes are unfortunately using non-reliable sources of information regarding their supplement choices. This problem has been identified repeatedly in various athletic populations, including Canadian athletes. Indeed, Erdman et al. (2006) reported that the top three sources of information on supplements among high-performance Canadian athletes were family and/or friends, followed by coaches and then teammates. Overall, in this study, 52.7% of athletes revealed referring to their family and friends regarding their supplement choices. Similarly, in their subgroup of Canadian varsity athletes, Erdman et al. (2007) reported that 56% used their family and friends as advisors on their dietary supplement choices, while 57% referred to their teammates. Furthermore, when compared with athletes of different levels, varsity athletes were found to refer significantly more to magazines as a source of information (Erdman et al., 2007). Interestingly, varsity athletes attending the University of British Columbia ranked health professionals as their primary source of information when starting a new supplement, which is the only study conducted in Canada reporting such findings and reflects perhaps well-planned educational programs and/or convenient access to health professionals for varsity athletes attending this university (Kristiansen et al., 2005). Unfortunately, other studies have reported very low prevalence of athletes referring to health professionals regarding their supplementation practices. Indeed, when asked about their most used sources of information, elite Canadian athletes ranked physicians as their eighth choice while dietitians were ranked sixteenth (Lun et al., 2012). It is therefore not surprising that the Canadian Center for Ethics in Sports (n.d.) estimated that only 4% of athletes are referring to sport physicians and not even 1% to sport dietitians when starting to use dietary supplements, clearly reflecting the need for better professional guidance.

Gender has been shown to significantly influence athletes' sources of information on dietary supplements; however, results vary across studies and no consensus exists regarding which sources are used the most by each gender. Erdman et al. (2007) reported that males were significantly more likely than females to acquire supplement information from the internet (22% vs. 13%), while females were significantly more likely than males to be influenced by dietitians regarding their supplementation practices (23% vs. 19%). However, in another sample of Canadian athletes, Wiens et al. (2014) found that males were significantly more likely than females to refer to teammates (36% vs 25%) and health food stores (27% vs 19%), while females were more likely to attend workshops or seminars regarding nutrition and dietary supplements (8% vs 2%). Thus, the current literature does not reveal specific patterns and more research is needed to determine the influence of gender on sources of information used by athletes regarding dietary supplement choices.

The influence of age on sources of information has barely been explored in previous studies. Wiens et al. (2014) reported that a significantly lower proportion of athletes aged 19-25 years old were referring to their family and friends for information on supplements compared to athletes aged 19 years old or less. From this study, it seems that as athletes are getting older, they tend to turn towards more reliable sources of information regarding their supplementation practices, although more data are needed for more definitive conclusions to be drawn.

Finally, some researchers have examined associations between performance level, training volume or types of sports practiced and sources of information on dietary supplements. Erdman et al. (2006) found that international or professional athletes were significantly more likely than provincial, national and continental athletes to identify their strength trainers as their primary choice for obtaining information on dietary supplements. Furthermore, athletes involved in endurance or intermittent sports (i.e., soccer, volleyball, etc.) were also found to be significantly more likely to refer to coaches and doctors, while strength athletes were more likely to use athletic or strength trainers as sources of information (Wiens et al., 2014). As it is the case with gender, more research is needed to better establish the influence of performance levels and sports disciplines on athletes' sources of information regarding dietary supplement choices.

Understanding where athletes are seeking their information is critical for developing appropriate and relevant education programs at different levels of these sources of information. For instance, if coaches and strength trainers are often solicited for information on dietary supplements, offering educational workshops on the benefits and risks of dietary supplements to coaches and strength trainers may ensure that the appropriate information is transmitted to athletes.

2.5 Predictors of Dietary Supplement Use Among Athletes

In order to identify athletes who are most likely to use dietary supplements, researchers have been trying to identify the predictors of supplement use and establish predictive profiles. In a cohort of young German elite athletes, being over 16 years old, having a high desire to enhance performance and being educated about dietary supplements were found to be positively correlated with supplement use, while high training frequency and the use of nicotine were found to be negatively correlated with supplement use (Dietz et al., 2014). A logistic regression with these five predictors allowed Dietz et al. (2014) to create a statistically significant model able to distinguish between supplement users and non-users. Similarly, Bartee et al. (2004) worked on identifying predictors of supplement among adolescent athletes with various logistic regression models. Demographic variables and scales for attitude, subjective norms and intention were included in different regression analyses, and overall grade level, participation in multiple sports, as well as scales for attitudes, subjective norms and intention were all found to be significant predictors of supplement use. More recently, Sassone, Muster, and Barrack (2018) studied the prevalence and predictors of higher-risk dietary supplement use, which included herbal supplements, caffeine, weight loss and muscle-building supplements as well as pre-workout supplements, in National Collegiate Athletic Association (NCAA) division 1 athletes. Significant predictors revealed by their multiple regression analysis included the number of supplements used in the past year, the motivation of taking supplements to gain muscle and lose body fat and finally the motivation to increase athletic endurance.

Identifying predictors of supplement use is of great importance in order to facilitate screening of athletes with greater intention to use dietary supplements and their referral to professionals when needed. Having access to professional guidance regarding their dietary supplements' choices could ensure safe and effective supplementation practices by athletes. However, the amount of research related to predictors of supplement use specifically in the athletic population is very limited and most studies have been looking at different predictors, making comparisons challenging. Therefore, the current literature does not allow to establish the most important predictors of supplement use in athletes, and further research in this area is warranted.

3 Research Purpose, Objectives and Hypotheses

3.1 Research Purpose

The overall purpose of this project was to explore dietary supplementation practices and predictors of dietary supplement use among varsity athletes attending the University of Guelph in Ontario. Types of dietary supplements consumed, frequency of supplement intake, sources of information regarding dietary supplements, reasons for consuming supplements as well as predictors of supplement use were investigated in order to gain insight into supplementation practices of varsity athletes in this specific university setting.

3.2 Research Objectives

Specifically, this research aimed to determine 1) the percentage of varsity athletes using dietary supplements, 2) the types of supplements consumed, 3) the frequency of supplementation, 4) the sources of information used by varsity athletes regarding their supplementation practices, 5) the reasons for which varsity athletes use dietary supplements and 6) predictors of supplement use in varsity athletes.

3.3 Research Hypotheses

Research hypothesis for each objective, accompanied by its rationale, will be presented in the following section.

Hypothesis 1:

The prevalence of supplement use will vary based on gender, age, weekly training hours and types of sport practiced. Specifically, prevalence of supplement use will be higher in male athletes than female athletes, higher in older athletes compared to younger athletes, and higher in athletes with high weekly training hours compared to athletes with low to moderate weekly training hours.

Based on a report by the IOC, research has shown that supplement use is higher in men than in women, increases with age and with level of training and performance, and varies across different sports discipline (Maughan et al., 2018). However, studies conducted on Canadian athletes did not reveal higher rates of supplement use in male athletes compared to female athletes and revealed conflicting prevalences based on age (Erdman et al., 2007; Wiens et al., 2014). Similarly, differences in rates of supplementation have been observed based on the type of sports practiced, although no definite pattern emerges from the literature regarding the influence of sports discipline on the prevalence of dietary supplement use (Lun et al., 2012). Finally, the impact of weekly training hours on the use of dietary supplements is fairly consistent across the literature. It has been reported that a significantly greater proportion of athletes undergoing high training loads consumes dietary supplements compared with athletes reporting low or moderate training levels (Giannopoulou et al, 2010; Lun et al., 2012).

Hypothesis 2:

Types of supplements consumed will vary based on gender, age, weekly training hours and type of sports practiced. Carbohydrates, vitamins and minerals and protein supplements will be the most used dietary supplements across the various groups.

The influence of gender, age, weekly training hours and sport discipline on the types of supplements consumed remain unclear in the literature. However, Erdman et al. (2007) and Lun et al. (2012) reported similar findings regarding the five dietary supplements most frequently consumed by Canadian athletes, suggesting that sport drinks, multivitamin and minerals as well as protein supplements are widely used in the Canadian athletic population.

Hypothesis 3:

Frequency of dietary supplement use will vary based on gender, age, weekly training hours and type of sports practiced. Daily consumption of dietary supplements will be the most commonly reported frequency of supplementation across the various groups.

While some differences regarding frequency of supplementation based on gender, age, weekly training hours and type of sports practiced have been observed, no definite pattern emerges from the literature. However, both Wiens et al. (2014) and Lun et al. (2012) reported that over 50% of Canadian athletes, classified as dietary supplement users, reported consuming supplements on a daily basis.

Hypothesis 4:

Sources of information used by athletes regarding dietary supplements will vary based on gender, age, weekly training hours and type of sports practiced. Overall, coaches, friends/teammates, and family will be the most common sources of information used by athletes on dietary supplements.

Gender has been shown to significantly influence athletes' sources of information on dietary supplements; however, results vary across studies and no consensus exists regarding which sources are used the most by each gender (Erdman et al., 2007; Wiens et al., 2014). Similarly, the associations between age, weekly training hours and sports discipline on sources of information used by athletes remain unclear (Wiens et al., 2014). In two studies conducted on Canadian athletes, the top three sources of information on supplements were family and/or friends, followed by coaches and then teammates (Erdman et al., 2006; Erdman et al., 2007).

Hypothesis 5:

Rationale for using supplements will vary based on gender, age and type of sports practiced, but not based on weekly training hours. It is expected that the prevention and/or correction of nutrient deficiencies that may impair health or performance will be the most frequently reported reason for consuming dietary supplements.

The rationale for supplementation has been shown to vary based on gender. Indeed, common reasons given by female athletes for using supplements include health maintenance, prevention or correction of nutrient deficiencies, and compensation for an inadequate diet, while male athletes tend to use supplements to increase or maintain muscle mass, strength, and power (Erdman et al., 2007; Froiland et al., 2004; Lun et al., 2012). Older athletes have been using supplements to increase or maintain muscle mass, strength and power as well as to improve diet, whereas a common reason for using dietary supplements given by younger athletes is because their friends/teammates were using them (Erdman et al., 2007). Variations in the reasons for using dietary supplements based on the type of sports practiced have also been observed in Canadian high-performance athletes (Lun et al., 2012). On the other hand, training level does not seem to affect the reasons for using dietary supplements. Indeed, regardless of training hours, Lun et al. (2012) reported that health maintenance, increased energy, and support of exercise recovery were the most frequent justifications given by athletes. Overall, across various studies, one of the main reasons for which athletes are using dietary supplements is to prevent or correct nutrient deficiencies that may impair health or performance (Erdman et al., 2007; Lun et al., 2012; Wiens et al., 2014).

Hypothesis 6:

Predictors of dietary supplements use will include age and possibly gender, training hours, type of sport practiced and other demographic attributes.

Very limited research aiming at identifying predictors of supplement use in athletes has been conducted. Both Dietz et al. (2014) and Bartee et al. (2004) reported that age was a significant predictor of supplement use. Indeed, in both studies, older athletes were significantly more likely than younger athletes to be consuming supplements. However, no consensus has been reached regarding gender, training hours, type of sport practiced and demographic characteristics; it is therefore unknown whether those variables will be significant predictors of supplements use.

4 Methodology

4.1 Study Design

Types of dietary supplements consumed, frequency of supplement intake, sources of information on dietary supplements, reasons for consuming supplements, as well as predictors of supplement use, were explored through an online questionnaire, using a cross-sectional research design.

4.1.1 Participants' Recruitment and Eligibility

Varsity athletes from the University of Guelph were recruited for this study. Inclusion criteria were therefore requiring participants to be a member of any varsity team, including (a) baseball, basketball, cross-country, football, golf, hockey, lacrosse, nordic skiing, rowing, rugby, soccer, swimming, volleyball, track and field and wrestling for men and (b) basketball, cross-country, field hockey, figure skating, golf, hockey, lacrosse, nordic skiing, rowing, rugby, soccer, swimming, volleyball, track and field and wrestling for women. No age restriction was imposed since the purpose of the study was to explore supplementation practices of all varsity athletes enrolled as part-time or full-time students at the University of Guelph.

Participants for this study were recruited through posters and emails. Recruitment posters were brought to various classes for announcements and were shared on CourseLink pages of various courses as well as on the Student-Athletes Mentor page. In total, two in-class announcements were made, seven professors posted our recruitment poster on the CourseLink pages of eight different classes and one professor did a verbal announcement in class. Furthermore, emails were sent to team captains and student-athlete mentors of the 22 varsity teams asking them to share our recruitment poster with their teams to invite all athletes to participate in this research project (Appendix A). A follow-up email to coaches of teams for which less than a third of the athletes completed our online questionnaire was sent a few weeks later. Finally, approximately two weeks before the Qualtrics online questionnaire closed, strength and conditioning staff were contacted to circulate a final reminder to all varsity teams.

Out of a total number of approximately 730 varsity athletes registered at the University of Guelph during the Fall 2018 semester, 306 completed the online questionnaire; however, 4 questionnaires were excluded, so 302 questionnaires were used for analysis. The excluded questionnaires did not include any information except which varsity team the athletes were affiliated with; no other questions were answered.

The supplement use questionnaire was only available in English; thus, all participants were required to be fluent in English. However, as expected, we did not exclude any participant based on this criterion since all participants were students from the University of Guelph, and to be accepted at the University of Guelph students must demonstrate adequate understanding of English. Finally, given that participants in this study were students from the University of Guelph, no issues with literacy were encountered.

4.1.2 Procedures

Participants agreeing with the consent form were directed to the online anonymized questionnaire, which was available through Qualtrics. Fifteen to twenty minutes was the expected duration for participants to complete the questionnaire.

Every participant received a $5 Starbucks online gift as a token of appreciation. Once their questionnaire was submitted, participants were re-directed to a new survey, which was not linked to their questionnaire's responses. They had the option to provide their email addresses if they wished to receive a Starbucks online gift card, even if they had submitted a questionnaire that was not entirely complete.

4.1.3 Ethical Considerations

This research project was reviewed and approved by the Research Ethics Board of the University of Guelph for compliance with federal guidelines for research involving human participants (REB#18-08-007).

The consent document appeared before the online questionnaire, explaining study details and the process of informed consent (See Appendix C). Clicking the "submit" button at the end of the survey represented voluntary consent. Participants were encouraged to print the consent information provided online before they started filling in the questionnaire; this consent form provided them the contact information of the ethics committee as well as the principal investigator in case they had any questions about the project. No researchers directly interacted with participants during the consent process since the consent document was delivered electronically.

Participants were informed in the consent form of their right to withdraw from the study without any consequences and that they did not have to answer questions they did not want to answer. Participants could withdraw at any time before submission of the questionnaire;

however, given that data collected were anonymized, participants were not able to withdraw from the study once they had submitted their questionnaire.

4.2 Measures

Data collection occurred through a Qualtrics-based questionnaire developed by Dr. El Khoury (See Appendix B). One undergraduate thesis student, one undergraduate research intern student, one undergraduate research assistant and two graduate students were also involved in the development process of the questionnaire. The format of the questionnaire included multiple responses options, Likert scale-based responses, and open-ended responses, addressing dietary supplement usage patterns, timing of use, length of dietary supplement use, motivational factors (intention, attitude, subjective norm, and perceived behavioural control), reasons for choosing dietary supplements, sources of information, and level of knowledge on dietary supplements. The list of supplements chosen for investigation was based on an in-depth scan of the supplement market in Ontario as well as on the current literature, and the list excluded prohibited substances by WADA such as anabolic steroids or other illegal hormones and drugs.

Three steps were followed for the development of the questionnaire, including an elicitation study as well as content validity and reliability testing. In the elicitation study, 15 students from the University of Guelph (5 varsity athletes, 5 active university students and 5 non-active university students) were interviewed regarding their intentions, attitudes, subjective norms and perceived behavioral control with respect to dietary supplements. Subsequently, the content of the questionnaire was evaluated by various experts in the field of sports nutrition, including academic researchers, a sport doctor, an exercise physiologist and registered dietitians, for content validation. As a final step, the questionnaire has undergone internal-consistency reliability testing using a sample of 84 undergraduate students in the Applied Human Nutrition program.

The questionnaire was composed of four sections: physical activity patterns, dietary supplements, cognitive constructs, and demographics (See Appendix A).

4.2.1 Physical Activity Patterns

The data collected in the physical activity patterns section allowed to group athletes based on the types of sports practiced as well as weekly training hours.

Participants were asked to select which varsity team they are on. Given the wide variety of varsity sports at the University of Guelph, sports were categorized into 3 categories based on their physiological demands: power, intermittent and endurance. Similar sport classifications have been used by Lun et al. (2009, 2012) and Wiens et al. (2014) when looking at dietary supplementation practices of Canadian athletes (See Table 1). Power sports were defined by short efforts of less than 3 minutes with substantial rest between intervals, and therefore included: rugby, football, and wrestling as well as some track and field events. Intermittent sports were defined by their stop-start nature, and included basketball, field hockey, lacrosse, volleyball, soccer and golf. Endurance sports were continuous events lasting at least 3 minutes, and included cross-country, swimming, nordic skiing, and rowing as well as some track and field events. Finally, despite the fact that figure skating was considered a judged/aesthetic sport in most studies due to its appearance-oriented nature and because performances are judged by a panel, it has been classified as an intermittent sport in this study. Given that figure skating was the only varsity team from the University of Guelph considered as a judged/aesthetic sport, the sample size would not have been sufficient to represent the dietary supplementation practices of athletes from all judges/aesthetic sports.

Table 1: Sports Classification in Studies

Sport category	**Lun et al. (2009)**	**Wiens et al. (2014)**	**Classification for this study**
Power/Strength	Soccer, hockey, long-track speed skating, alpine ski, some athletics, short-track speed skating, swimming, luge, skeleton, wrestling, bobsleigh, rugby, sprint cycling, weightlifting	Rugby, football, hockey	Rugby, football, wrestling, hockey, track and field - sprints, throws & jumps
Intermittent	Volleyball, basketball, beach volleyball, squash, racquetball, softball, rugby	Soccer, volleyball, basketball	Basketball, field hockey, lacrosse, volleyball, soccer, golf, baseball, figure skating
Endurance	Rowing, kayak, some athletics, biathlon, sailing, triathlon, mountain bike, cross-country ski, pentathlon	Cross-country skiing, swimming, track	Cross-country, swimming, nordic skiing, rowing, track and field – middle distance and distance
Judged/Aesthetic	Figure skating, snowboard, gymnastics and trampoline, freestyle ski-aerials, curling, taekwondo, ski jumping, archery	Cheerleading, dance, synchronized swimming	N/A

Athletes were also asked how many hours they are training per week. They had the option to select between 6 categories of weekly training hours: 0-5h, 6-10h, 11-15h, 16-20h, 21-25h, >25h. Those categories are based on the Lun et al. (2012)'s study, in which they used the same ranges to explore dietary supplementation practices among Canadian high-performance athletes. However, in our analyses, 0-5h and 6-10h as well as 21-25h and >25h were combined generating the following 4 categories: ≤10h, 11-15h, 16-20h, >20h.

4.2.2 Dietary Supplements

The dietary supplements section provided information on the prevalence of dietary supplement use, the types of supplements used, the frequency of supplementation, the sources of information on dietary supplements, and the reasons for using dietary supplements.

First of all, participants were asked to select whether or not they had consumed a dietary supplement in the past 6 months. Participants who did not use any dietary supplements were automatically directed to the next section “Cognitive Constructs”, while participants who did use dietary supplements were further inquired on their supplementation practices. The first step consisted of selecting category(ies) of dietary supplements they have been using in the past 6 months: vitamins/minerals, protein, amino acids, carbohydrate, stimulants/energy boosters, non-vitamin/mineral antioxidants, fatty acids, herbs and botanicals, fat burners/weight loss, meal replacements/weight gainers, nitrates/nitric oxide/ “pump” and vasodilators, prebiotics/probiotics, and digestive enzymes. Participants also had the opportunity to specify any other unlisted category(ies) of supplements they were using. For each category selected, participants were then asked which dietary supplements they are specifically using. Common supplements within each category were listed, with the option of adding any unlisted supplements. For instance, in the vitamins/minerals supplements category, athletes were able to select vitamin C, vitamin D, vitamin B12, iron, calcium, multi-vitamin and mineral supplements, and/or other(s). Thereafter, for each category selected, athletes were given ranges regarding weekly frequency of supplementation (≤ 1 time per week, 2-3 times per week, 4-5 times per week, 6-7 times per week). For each category, participants were also asked to select reason(s) for using this type of dietary supplements. Once again, they had the opportunity to select the "other(s)" option and to specify any additional reason not listed in the questionnaire.

Finally, multiple choices responses and yes/no questions regarding sources of information used for dietary supplement information, whether they read labels on dietary supplements, and whether they have ever used anabolic steroids, injectable peptides, amphetamines, pro-hormones or ephedrine in an exercising context completed this section of the questionnaire.

4.2.3 Cognitive Constructs

The cognitive constructs section, which is based on the Theory of Planned Behaviour (TPB), aimed at defining the cognitive determinants of dietary supplement use among athletes; however, data collected in this section were not analyzed as the cognitive constructs section was outside the scope of the present thesis. The main purpose of the TPB model is to predict and explain human behavior in specific contexts. The intention of performing a behavior is at the core of this theory and is believed to be the most important predictor of behavior (Ajzen, 1991). Indeed, according to the TPB model, the stronger is ones' intention to perform a behavior, the greater the chances they will perform the behavior under volitional control. Originally, the Theory of Reasoned Action stated that behavioral intention was determined by attitude as well as subjective norms; however, the TPB model now recognizes that perceived behavioral control also influences intention (Ajzen, 1991). Attitude is defined as an individual's feeling towards the behaviour and is influenced by behavioural beliefs, which represent a person's perceived outcome of engaging in a given behaviour (Pawlak, Malinauskas & Rivera, 2009). Subjective norms represent societal pressure to engage or not to engage in a behaviour and are influenced by normative beliefs which are a person's perception of those social pressure and the motivation and desire to comply with them (Pawlak et al., 2009). Normative beliefs can be further differentiated into injunctive and descriptive normative beliefs. Injunctive normative beliefs represent an individual's perception of what their significant others would think of them engaging or not engaging in the behaviour, while descriptive normative beliefs are perception of whether or not their significant others are engaging in the behaviour (Ajzen, 2006). Perceived behavioral control is defined as an individual's evaluation of their own ability to perform a behavior, and it has been shown that self-confidence in aptitudes and skills significantly influences the likelihood of engaging in a specific behavior (Ajzen, 1991). Perceived presence of resources and/or absence of impediments also contribute to an individual's perceived behavioral control (Pawlak et al., 2009). Intention of using dietary supplements (3 items), attitudes towards supplementation (4 items), injunctive subjective norm regarding supplement use (5 items), descriptive subjective norm regarding supplement use (4 items), and perceived behavioural control over supplementation practices (4 items) were assessed in this section. Each item was scaled 1 (strongly disagree) to 5 (strongly agree) in a Likert-scale format with an additional "not applicable" option.

Intention to consume dietary supplement was measured in questions 1 to 3 with statements such as: "In the next 6 months, I intend to take or keep taking a dietary supplement to improve my performance and/or general health" and "In the next 6 months, I plan to take or keep taking a dietary supplement to improve my performance and/or general health". Pilot testing yielded a reliability Cronbach alpha of 0.96 for this measure.

Attitude towards supplementation was measured in questions 4 to 7 with statements such as: "I believe that using dietary supplements will improve my performance" and "I believe that using dietary supplements will improve my physical appearance". Pilot testing yielded a reliability Cronbach alpha of 0.54 for this measure.

Injunctive subjective norm regarding dietary supplements was measured in questions 8-12 with statements such as: "My immediate family (parents, brothers, sisters, grandparents, or significant others) thinks I should use dietary supplements to improve my performance, physical health or general health" and "My peers/friends think I should use dietary supplements to improve my performance, physical health or general health". Pilot testing yielded a reliability Cronbach alpha of 0.83 for this measure.

Descriptive subjective norm regarding dietary supplements was measured in questions 17-20 with statements such as: "My immediate family (parents, brothers, sisters, grandparents, or significant others) regularly uses dietary supplements to improve performance, physical appearance or general health" and "My peers/friends regularly uses dietary supplements to improve performance, physical appearance or general health". Pilot testing yielded a reliability Cronbach alpha of 0.82 for this measure.

Perceived behavioural control over supplementation practices was measured in questions 13 to 16 with statements such as: "Whether I take or do not take dietary supplements from now on is entirely up to me" and "It is easy for me to take dietary supplements from now on". Pilot testing yielded a reliability Cronbach alpha of 0.74 for this measure.

Finally, three open-ended questions concluded the cognitive constructs section. Participants were asked about any negative effects they might have ever experienced with dietary supplements, which dietary supplements they would be interested to learn more about, and information they would like to learn related to those supplements as well as the format in which they would prefer this information to be delivered.

4.2.4 Demographics

In the demographics section, through multiple responses options and open-ended questions, information on gender, age, ethnic background, program major, parents' or guardians' education, smoking status, alcohol consumption, medical conditions, weight, and height were collected. Given that those questions might have been sensitive for some participants, the option "prefer not to disclose" was included for all questions in the demographics section.

4.3 Statistical Analyses

Statistical analyses were performed with the Statistical Package for the Social Sciences (SPSS), version 25.0, and a P value of <0.05 was considered statistically significant for all analyses. Descriptive and frequency statistics were used to characterize the sample of varsity athletes based on gender, age, types of sports practiced, weekly training hours as well as other demographic attributes.

There were approximately 730 varsity athletes at the University of Guelph during the fall 2018 semester. Post-hoc G-POWER analysis were conducted to determine the needed sample size to reach statistical significance. The first analysis was performed with 5 predictors (gender, age, weekly training hours, type of sport practiced, parent's/guardian's education and BMI) and a total sample size of 296 athletes was calculated to be needed using a two-tailed logistic regression with an alpha of 0.05 and a power of 0.8. In order to achieve a power of 0.95, a sample size of 487 athletes would have been needed. A second analysis was conducted with age only, since it was found to be the only significant predictor of supplement use. A sample size of 264 athletes was calculated to be needed with an alpha of 0.05 and a power of 0.8. Again, in order to obtain a power of 0.95, 435 athletes would have been needed.

Hypotheses 1 to 5 were tested with Pearson's chi-square tests and Fisher exact tests, to determine whether relationships existed between categorical variables. This statistical analysis allowed us to determine if there was a significant difference in the prevalence of supplement use, types of supplement consumed, frequency of supplementation, sources of information regarding dietary supplements, and rationale for using supplements across various categorical variables; gender, age, type of sport practiced, and weekly training hours. Before running the analysis, contingency tables were observed to verify that the assumption regarding expected frequencies was respected. With 2 x 2 contingency tables, no expected values should be below 5, while larger tables should expect counts greater than 1 and no more than 20% of expected counts should be less than 5 (Field, 2013).

Hypothesis 1:

Hypothesis 1 was that the prevalence of supplement use would vary based on gender, age, weekly training hours and type of sport practiced. Prevalence was expected to be higher in male athletes than female athletes, higher in older athletes compared to younger athletes and higher in athletes with high weekly training hours compared to athletes with low to moderate weekly training hours. Therefore, dietary supplement use (yes or no) was tested against gender (men or women), age (≤20 years old, >20 years old), type of sport practiced (power/strength, intermittent, endurance) and weekly training hours (0-10h, 11-15h, 16-20h, ≥21h).

Hypothesis 2:

Hypothesis 2 was that the types of dietary supplements consumed would vary based on gender, age, weekly training hours, and type of sport practiced, and that carbohydrates, vitamins and minerals and protein supplements would be the most used dietary supplements across the various groups. In this analysis, types of supplements (vitamins/minerals, protein amino acids, carbohydrate, stimulants/energy boosters, non-vitamin/mineral antioxidants, fatty acids, herbs and botanicals, fat burners/weight loss, meal replacements/weight gainers, nitrates/nitric oxide/ 'pump'/vasodilators (e.g., beetroot juice or powder, l-arginine, and citrulline malate), prebiotics/probiotics, and digestive enzymes) were tested against gender (men or women), age (≤20 years old, >20 years old), type of sport practiced (power/strength, intermittent, endurance) and weekly training hours (0-10h, 11-15h, 16-20h, ≥21h).

Hypothesis 3:

Hypothesis 3 was that the frequency of dietary supplement use would vary based on gender, age, weekly training hours, and type of sport practiced, and that daily consumption of dietary supplements would be the most commonly reported frequency of supplementation across the various groups. For every type of dietary supplements used, participants were asked to report the frequency of consumption; the average frequency was used for the statistical analysis. The highest frequency of dietary supplement use (≤ 1 time/week, 2-3 times/week, 4-5 times/week, 4-5 times/week, 6-7 times/week) was tested against gender (men or women), age (≤20 years old, >20 years old), type of sport practiced (power/strength, intermittent, endurance) and weekly training hours (0-10h, 11-15h, 16-20h, ≥21h).

Hypothesis 4:

Hypothesis 4 was that sources of information used by athletes regarding dietary supplements would vary based on gender, age, weekly training hours, and type of sport practiced, and that coaches, friends/teammates, and family would be the most common sources of information. In this analysis, sources of information (health care professionals [e.g., physicians, team physicians, specialists, dietitians, sports nutritionists], coaches, trainers, teammates/training partners, friends/family, print (e.g. magazines, books), internet, television, national governing body, supplement companies, pharmacies, health food/grocery stores, and my own judgment) were tested against gender (men or women), age (≤20 years old, >20 years old), type of sport practiced (power/strength, intermittent, endurance) and weekly training hours (0-10h, 11-15h, 16-20h, ≥21h).

Hypothesis 5:

Hypothesis 5 was that the rationale for using supplements would vary based on gender, age and type of sport practiced, but not based on weekly training hours, and that the prevention and/or correction of nutrient deficiencies that may impair health or performance would be the most frequently reported reason for consuming dietary supplements. Reasons for using dietary supplements were regrouped in the following categories: General health (correct or prevent micronutrients deficiencies, maintain good health, improve immunity, improve mood and/or decrease stress, and correct or prevent disease), convenience (supply convenient forms of energy and/or macronutrients, serve as meal replacement), provision of direct benefits to performance (enhance competitive performances, increase energy, and increase alertness and mental activity), provision of indirect benefits to performance (support intense training regimens, promote recovery, alleviation of musculoskeletal pain, lose weight/decrease fat mass, gain weight, and increase or maintain muscle mass), and financial gain and knowing or believing that others (e.g., friends, athletes, and competitors) use this supplement. Reasons for using dietary supplements were tested against gender (men or women), age (≤20 years old, >20 years old), type of sport practiced (power/strength, intermittent, endurance) and weekly training hours (0-10h, 11-15h, 16-20h, ≥21h).

Hypothesis 6:

Finally, for hypothesis 6, logistic regressions were used to test whether gender, age, weekly training hours, type of sport practiced, and demographic attributes would predict supplement use in varsity athletes.

Prior to performing regression analysis, data were screened to assess if regression assumptions were respected. First of all, scatterplots were examined to identify outliers and ensure linear relationships between independent and dependent variables. Multivariate normality was tested with histograms and Q-Q-Plots, and tolerance statistics were analyzed to verify whether collinearity existed between predictors. The assumption regarding the absence of autocorrelation was tested with the Durbin-Watson test statistics. Finally, standardized residuals were plotted against standardized predicted values to test the homoscedasticity assumption (Field, 2013).

All variables met the assumptions for logistic regression, except body mass index (BMI) which is weight (kg)/height^2 (m). Indeed, BMI violated the assumption of linearity of the logit with a significant interaction term. The variable was therefore further investigated, and 6 outliers were found. Even after removing the outliers, the linearity assumption was still not respected. Caution in the interpretation of this variable would have been warranted, however BMI was not found to be a significant predictor of supplement use.

Three different logistic regressions were conducted; individual logistic regressions for all predictors, a multiple logistic regression with the significant individual predictors and a multiple logistic regression with all predictors. For each logistic regression, the outcome was the categorical binary variable supplement use (Yes or No). For multiple logistic regressions, different methods of data entry were performed; forced entry and stepwise (forward and backward), but results obtained were the same with all methods of data entry. Forced entry was therefore selected since stepwise methods are generally not recommended by statisticians given that they solely rely on mathematical criteria to decide in which order the predictors are entered in the model (Field, 2013). Furthermore, forced entry, a method forcing all the predictors into the model simultaneously, was selected over hierarchical entry since the literature did not reveal any definite predictors of supplement use that should have been entered first into the model.

5 Manuscript to Submit for Publication

Manuscript was prepared in the format of the International Journal of Sport Nutrition and Exercise Metabolism. Please note that the Results and Discussion sections of the manuscript are the Results and Discussion sections of the thesis. The necessary edits per journal's instructions for authors will be introduced to the manuscript at the time of submission to the target journal.

Results not included in the manuscript as well as additional tables and figures are included in appendices D-O.

Dietary Supplementation Practices and Predictors of Dietary Supplement Use Among Varsity Athletes at a Canadian University

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5.1 Abstract

The purpose of this study was to gain insight into dietary supplementation practices and predictors of dietary supplement (DS) use among varsity athletes in a university setting in Ontario, Canada. An online supplement use questionnaire was completed by 302 varsity athlete students (30.5% male, 69.5% female; 20.5 ± 1.8 years old) who were competing in a variety of intermittent, power and endurance-based sports at the university. Overall, 58.3% of athletes reported having used at least one type of DS in the past six months. Both gender and age had significant associations with prevalence of DS use, with male athletes and athletes over 20 years old being significantly more likely to be DS users. Protein supplements, vitamins and minerals supplements and carbohydrate supplements were the most commonly used DS by varsity athletes. Patterns of use, including specific types of DS consumed and frequency of supplementation, were influenced by athletes' gender, age, weekly training hours and type of sport practiced. The most frequently reported reasons for consuming DS by athletes were to maintain good health, increase energy, promote recovery, correct or prevent micronutrient deficiencies and supply convenient forms of energy and/or macronutrients. Although most athletes were using reliable sources of information, with health care professionals being the most frequently reported sources, 58.6% of athletes still mentioned wanting to become more knowledgeable about DS, highlighting the need for additional educational resources. Findings from this study may guide the development of educational materials needed to address the knowledge gaps on DS among varsity athletes.

Keywords: Nutritional supplements; sport nutrition; prevalence

5.2 Introduction

Elite athletes are constantly looking for ways to improve their performance, which can occur through the optimisation of their dietary intakes. It is well documented that most athletes are turning towards dietary supplements (DS) in order to improve the nutritional value of their diet as well as enhance their performance. The International Olympic Committee (IOC) defines dietary supplement as “a food, food component, nutrient, or non-food compound that is purposefully ingested in addition to the habitually consumed diet with the aim of achieving a specific health and/or performance benefit” (Maughan et al., 2018, p.1). Unlike the rigorous regulations to which food and drugs are subjected under the Food and Drugs Act in Canada, the DS industry is subject to almost no control by the government, leading to increased reported cases of inaccurate labelling of ingredients and/or contamination with illegal substances (Temple, 2017).

Extremely high prevalence of dietary supplementation in the athletic population has been consistently reported in the literature, across all sports disciplines. In Canada specifically, research conducted by Wiens et al. (2014) revealed that 98.1% of Canadian athletes aged between 11 and 25 years were consuming, on average, seven different types of DS, while Lun et al. (2012) reported that 87% of high-performance Canadian athletes had been using DS in the past 6 months. Similarly, in another sample of elite Canadian athletes, 88.4% reported using on average 3 DS in the past 6 months (Erdman et al., 2007). Although limited data are available regarding prevalence of DS use among varsity athletes, rates as high as 91% and 98.6% were reported (Erdman et al., 2007; Kristiansen et al., 2005). Comparison across various studies to define the factors influencing the prevalence of dietary supplementation is challenging, given the wide variety of questionnaires used, variation in the definition of what constitutes a DS and which DS are included in the questionnaires; however, some patterns of supplementation emerged from the literature. In general, research has shown that DS use tends to be higher in men, increases with age and with level of training and performance, and varies across different sport disciplines (Maughan et al., 2018).

Despite the widespread use of DS by athletes, only a small proportion of those DS are supported by strong evidence regarding their efficacy and safety. However, given the lack of governmental control over the DS industry, almost all products are using weakly-supported health claims as part of their marketing strategies. In addition, regardless of the potential health risks associated with DS use, most athletes are relying on non-reliable sources of information regarding their DS choices. This problem has been identified repeatedly in various athletic populations, including Canadian athletes. Indeed, Erdman et al. (2006) reported that the top three sources of information among high-performance Canadian athletes were family and friends, followed by coaches and then teammates. Furthermore, when asked about their most used sources of information, elite Canadian athletes ranked physicians as their eighth choice while dietitians were ranked sixteenth (Lun et al., 2012). It is therefore not surprising that the Canadian Center for Ethics in Sports (n.d.) estimated that only 4% of athletes are referring to sport physicians and not even 1% to sport dietitians when starting to use DS, clearly reflecting the need for better professional guidance.

In Canada, very few studies exploring dietary supplementation practices have focused exclusively on varsity athletes, which are a sub-population of athletes with unique requirements, such as balancing university studies with high-performance sports. Furthermore, given the risks of inadvertent doping associated with DS use, it is critical to gain insight into dietary supplementation practices of varsity athletes. An analysis of available empirical data from the World Anti-Doping Agency (WADA), the International Court of Arbitration for Sport (CAS) and National Anti-Doping organizations from Australia, the United Kingdom and the United States revealed an alarming estimation of 10-15% of DS possibly containing prohibited substances (Outram & Steward, 2015). In addition to risks of inadvertent doping, studies have also reported strong associations between DS use and intentional doping (Mathews, 2018). Indeed, in a cohort of competitive athletes, composed of 34% of varsity athletes, Blackhouse, Whitaken, and Petroczi (2013) found that doping was 3.5 times more prevalent in supplement users and therefore concluded that DS were a possible gateway to doping.

The objective of the current study was to explore dietary supplementation practices and predictors of DS use among varsity athletes in a specific university setting in Ontario, Canada. Findings from this study may contribute to a better understanding of the DS use behaviors and their determinants in this specific population and may inform universities' policies for a more effective and individualized guidance of the supplementation practices of their varsity teams.

5.3 Methods

5.3.1 Participants

This research project received clearance from the Research Ethics Board of the university for compliance with federal guidelines for research involving human participants.

Varsity athletes from the university were recruited for this study, based on convenience, through posters and emails. Recruitment posters were brought to various classes for announcements and were shared on online pages of different courses as well as on the Student-Athletes Mentor page. Furthermore, emails were sent to team captains, team coaches and strength and conditioning staff inviting athletes to participate in this research project. A total of 306 varsity athletes registered as part-time or full-time students at the university completed the supplement use questionnaire. Four incomplete questionnaires were excluded, so data from 302 questionnaires were analyzed. No age restriction was imposed since the purpose of the study was to explore supplementation practices of all varsity athlete students irrespective of their age. On the other hand, participants were required to have an adequate literacy of English in order to complete the questionnaire.

Participants agreeing with the consent form were directed to the online anonymized questionnaire, which was available through Qualtrics. Every participant received a $5 Starbucks online gift as a token of appreciation.

5.3.2 Questionnaire Development and Design

The supplement use questionnaire was tested for content validity and reliability on the target population and included multiple responses options, Likert scale-based responses, and open-ended responses. The list of DS chosen for investigation was based on an in-depth scan of the supplement market in Ontario as well as on the current literature and excluded prohibited substances by the World Anti-Doping Agency (WADA) such as anabolic steroids or other illegal hormones and drugs.

The questionnaire consisted of three sections: 1) physical activity patterns, 2) dietary supplements and 3) demographics. In the physical activity patterns section, participants were asked to select which varsity team they were on and how many hours they are training per week. Given the wide variety of varsity sports at the university, sports were categorized into 3 categories based on their physiological demands: power, intermittent and endurance. Similar sports classification, in which intermittent sports are defined by their stop-start nature, power sports by short efforts of less than three minutes with substantial rest between intervals and endurance sports as continuous events lasting at least three minutes, have been used by Lun et al. (2009, 2012) and Wiens et al. (2014) when looking at dietary supplementation practices of Canadian athletes. In the DS section, participants were asked to select whether or not they had consumed any DS in the past 6 months. Participants who responded no to this question were automatically directed to the next section, while participants who answered yes were further inquired on their supplementation practices including selecting category(ies) and the corresponding specific types of DS they have been using, as well as the frequency of use and the reasons for use for each chosen DS. In addition, multiple choices and open-ended questions regarding DS-related sources of information, whether they read nutritional labels on DS, whether they have ever experienced negative side effects from supplementation as well as their learning interest regarding DS completed this section of the questionnaire.

5.3.3 Statistical Analysis

Statistical analyses were performed with the Statistical Package for the Social Sciences (SPSS), version 25.0, and a P value of <0.05 was considered statistically significant. Descriptive and frequency statistics were used to characterize the sample of athletes based on gender, age, type of sport practiced, weekly training hours as well as other demographic attributes. Chi-square tests and Fisher Exact tests were used to explore associations between gender, age, type of sport practiced, weekly training hours and supplementation practices. Logistic regression was used to investigate possible predictors of DS use in varsity athletes. For multiple logistic regressions, different methods of data entry were performed; forced entry and stepwise (forward and backward), but results obtained were the same with all methods of data entry. Forced entry was selected since the literature did not reveal any definite predictors of supplement use that should have been entered first into the model.

5.4 Results

5.4.1 Participants Characteristics

In total, 302 varsity athletes, mean age 20.5 ± 1.8 years old, completed the online questionnaire. The majority of the participants were females (69.5%) and undergraduate students (87.3%). Weekly training hours varied from less than 10 hours per week to above 21 hours weekly; 16.2% of athletes were training 10 hours or less weekly, 47.4% between 11 and 15 hours weekly, 25.5% between 16 and 20 hours weekly and 9.9% 21 hours or more weekly. All varsity teams were represented in the sample; 125 athletes were involved in intermittent sports, 79 in endurance sports and 96 in power sports.

5.4.2 Prevalence of Dietary Supplement Use

Overall, 58.3% of varsity athletes reported having consumed at least one type of DS in the past 6 months. Gender was significantly related to prevalence of supplement use, with a significantly higher percentage of male athletes using DS (66.3%) compared to female athletes (53.1%) (χ^2 (1) = 4.26, p = 0.04). Age was also found to be associated with prevalence of DS use, with a significantly higher percentage of athletes over 20 years old using DS (65.9%) compared to athletes aged ≤ 20 (48.6%), (χ^2 (1) = 8.40, p = 0.004) (Table 2). No significant differences in prevalence of supplementation were observed based on weekly training hours and type of sport practiced.

[Table 2 to be inserted here]

5.4.3 Types of Dietary Supplements

The types of DS most commonly consumed by varsity athletes were protein supplements, vitamins and minerals supplements and carbohydrate supplements. Overall, 48.7% of varsity athletes were using protein supplements, followed by 48.0% using vitamins and minerals supplements and 36.1% using carbohydrate supplements (Figure 1). Gender, age and type of sport practiced all had significant associations with types of supplements varsity athletes were using. Female athletes were significantly more likely to consume prebiotics and probiotics supplements (11.7% vs. 3.5%) ($\chi^2(1) = 4.89$, $p = 0.03$), while male athletes were more likely to consume amino acids supplements (22.1% vs. 11.7%) ($\chi^2(1) = 5.06$, $p = 0.03$) and stimulants (31.4% vs. 12.8%) ($\chi^2(1) = 13.81$, $p \leq 0.001$) (Figure 2). Athletes over 20 years old were significantly more likely to use protein (58.3% vs. 41.0%) ($\chi^2(1) = 8.31$, $p = 0.04$), carbohydrates (45.5% vs. 26.4%) ($\chi^2(1) = 10.93$, $p = 0.001$) and stimulants (25.8% vs. 11.8%) ($\chi^2(1) = 8.90$, $p = 0.003$) supplements compared to younger athletes (Figure 3). Finally, a significantly higher percentage of athletes from power sports were using stimulants (27.1% vs. 20.3% vs. 12.0%) ($\chi^2(2) = 8.14$, $p = 0.02$) and fatty acids supplements (16.7% vs. 8.9% vs. 6.4%) ($\chi^2(2) = 6.43$, $p = 0.04$) compared to athletes from endurance and intermittent sports (Figure 4). Weekly training hours did not have any significant relationships with types of DS consumed by varsity athletes (Figure 5).

[Figures 1-5 to be inserted here]

Considering that protein, vitamins and minerals and carbohydrate supplements were the types of DS most commonly used by athletes, further analysis of specific supplements within those categories was performed. A significantly higher percentage of female athletes were using iron supplements (23.5% vs. 12.8%) (χ^2 (1) = 4.23, p = 0.04), whereas a higher percentage of male athletes reported consuming whey (45.3% vs. 29.1%) (χ^2 (1) = 7.04, p = 0.008), casein (4.7% vs. 0.5%) (Fisher's Exact Test, p =0.03) and creatine (19.8% vs. 2.0%) (χ^2 (1) = 27.25, $p \leq$ 0.001). Varsity athletes over 20 years old were significantly more likely to declare the use of whey (44.7% vs. 25.0%) (χ^2 (1) = 11.84, p = 0.001), protein bars/powder/shake (47.7% vs. 31.9%) (χ^2 (1) = 7.18, p = 0.007) as well as sport drinks (41.7% vs. 22.9%) (χ^2 (1) = 11.15, p = 0.001) compared to younger athletes. Weekly training hours also had a significant association with the types of protein selected by participants, with a higher percentage of athletes training ≥ 21 hours per week consuming casein (10.0%) (χ^2 (3) = 15.19, p = 0.002) compared to athletes training ≤10h (2.0%), 11-15h (0.0%) and ≥21h (1.3%) weekly. Athletes training ≥ 21 hours (20.0%) per week were also significantly more likely to be using vitamin B12 supplements, as were athletes training ≤ 10h per week (20.4%), compared to participants with weekly training hours of 11-15h (7.0%) and 16-20h (11.7%) (χ^2 (3) = 8.66, p = 0.03). Lastly, vitamin C (30.2% vs. 12.7% vs. 22.4%) (χ^2 (2) = 7.70, p = 0.02), whey (49.0% vs. 25.3% vs. 29.6%) (χ^2 (2) = 13.12, p = 0.001) and creatine (14.6% vs. 3.8% vs. 4.8%) (χ^2 (2) = 9.61, p = 0.008) supplements were all used significantly more by power sports athletes than athletes from endurance or intermittent sport disciplines.

5.4.4 Frequency of Supplementation

In supplement users, 44.9% were consuming at least one type of DS ≥ 6 times per week, 26.1% 4-5 times per week, 25.0% 2-3 times per week and only 4.0% ≤ 1 time per week. Training hours as well as type of sport practiced both were significantly related to the overall frequency of supplement use. As weekly training hours increased, a significantly higher percentage of athletes were using at least one type of DS ≥ 6 times weekly; 35.7% of athletes training ≤ 10 hour per week, 40.5% of athletes training 11-15 hours per week, 52.1% of athletes training 16-20 hours per week and 60.0% of athletes training ≥21 hours per week (χ^2 (9) = 25.45, p = 0.003). Similarly, endurance athletes using DS were also found to be significantly more likely to report a frequency of use ≥ 6 times weekly (60.4%) compared to athletes from intermittent (41.5%) and power sports (37.1%) (χ^2 (6) = 13.47, p = 0.04).

Also, gender, age, training hours as well as type of sport practiced were significantly associated with the frequency of use of various types of supplements. Male athletes reported consuming amino acids and creatine supplements significantly more frequently than female athletes. In varsity athletes using amino acids supplements, 52.6% of males were using them 4-5 times weekly while only 13.0% of females were consuming them at the same frequency (χ^2 (3) = 11.10, p = 0.01). Similarly, in athletes using creatine supplements, 16.7% of males were using them ≥ 6 times per week, whereas none of the female athletes reported this frequency of use for creatine (χ^2 (4) = 29.06, p < 0.001). In participants using stimulants, younger athletes were consuming them at a significantly higher frequency, with 17.6% of athletes ≤ 20 years old using them 4-5 times weekly while no athletes above 20 years old were using them at this frequency (χ^2 (3) = 8.38, p = 0.04). Furthermore, higher training hours (≥21 hours weekly) were associated with higher frequencies of use of amino acids (χ^2 (9) = 23.79, p = 0.005), stimulants (χ^2 (9) = 21.85, p = 0.01), vitamin C (χ^2 (12) = 21.64, p = 0.04) and casein supplements (χ^2 (9) = 19.11, p = 0.02). In participants using amino acids, 71.4% of athletes training ≥21 hours weekly were using at least one type of amino acids supplement ≥6 times a week, compared to 14.3%, 4.3% and 0.0% in athletes training respectively ≤10 hours, 11-15hours and 16-20 hours weekly. In athletes using stimulants, 75.0% of participants training ≥21 hours weekly were using at least one type of stimulant ≥ 6 times per week, compared to athletes training ≤10 hours (20.0%), 11-15 hours (6.5%) and 16-20 hours (0.0%). Moreover, a significantly higher percentage of athletes training ≥21 hours weekly were consuming vitamin C ≥ 6 times per week (38.5%) in comparison to athletes with lower training hours (16.7%, 9.1%, 0.0%) as well as casein supplements 4-5 times per week (6.3%) compared to athletes with lower training hours (4.8%, 0.0%, 0.0%). Finally, power sports athletes reported higher frequency of use of whey (χ^2 (8) = 18.58, p = 0.02), with a significantly lower percentage of power sports athletes using whey ≤1 time per week (13.0%) compared to intermittent (36.2%) and endurance (45.7%) athletes, while endurance athletes were consuming protein bars/powders/shakes significantly more frequently than athletes from other types of sports (χ^2 (8) = 17.12, p = 0.03), with a significantly higher percentage using them ≥6 times per week (34.3%) compared to athletes from intermittent (12.1%) and power (7.4%) sports.

5.4.5 Reasons for using Dietary Supplements

The most frequently reported reasons for consuming DS by supplement users were: maintaining good health (83.3%), increasing energy (71.3%), promoting recovery (69.0%), correcting or preventing micronutrient deficiencies (60.3%) and supplying convenient forms of energy and/or macronutrients (58.0%).

To examine associations between gender, age, training hours and types of sport, reasons for using DS listed in the questionnaire were grouped into the following categories (Maughan et al., 2018):

1) General Health: Correct or prevent micronutrients deficiencies, maintain good health, improve immunity, improve mood and/or decrease stress, correct or prevent disease.
2) Convenience: Supply convenient forms or energy and/or macronutrients, serve as meal replacement.
3) Direct Benefits to Performance: Enhance competitive performances, increase energy, increase alertness and mental activity
4) Indirect Benefits to Performance: Support intense training regimens, promote recovery, alleviation of musculoskeletal pain, lose weight/decrease fat mass, gain weight/increase or maintain muscle mass.
5) Influence: Knowing or believing other athletes/teammates/competitors use DS.
6) Just in Case

Varsity athletes over 20 years old were significantly more likely to be using DS for convenience purposes compared to athletes ≤ 20 years old (χ^2 (1) = 4.55, p = 0.03). Indeed, in supplement users, 75.9% of participants above 20 years old were consuming at least one type of DS for its convenience, against 60.0% of participants ≤ 20 years old (Table 3). For the remaining reasons, no significant associations were found, indicating that independently of their gender, age, training hours and type of sport, varsity athletes tend to be consuming DS for similar reasons (Table 3).

[Table 3 to be inserted here]

However, rationale for using specific types of DS did vary based on those variables. A significantly higher percentage of female athletes using vitamins and minerals supplements consumed them for direct benefits to performances (48.9% vs. 25.6%) (χ^2 (1) = 6.09, p = 0.01), and a higher percentage of male athletes were using protein supplements for health reasons (56.3% vs. 37.8%) (χ^2 (1) = 4.33, p = 0.04). The percentage of participants over 20 years old using protein supplements for convenience purpose was significantly higher than in younger athletes (72.7% vs. 54.2%) (χ^2 (1) = 5.00, p = 0.03); however, athletes ≤ 20 years old were more likely to use carbohydrate supplements because they knew or believed other athletes were using them (13.2% vs. 1.7%) (Fisher's Exact Test p = 0.03). Furthermore, a significantly higher percentage of athletes training ≥ 21 hours weekly using stimulants reported using them for indirect benefits to performance compared to stimulants users with lower training hours (100.0% vs. 45.5% vs. 29.0% vs. 20.0%) (χ^2 (3) = 9.33, p = 0.03). Athletes from intermittent sports using stimulants were significantly less likely than power and endurance athletes to use these supplements for direct benefits to performance (73.7% vs. 96.2% vs. 100.0%) (χ^2 (2) = 8.10, p = 0.02), but more likely to be using carbohydrate supplement because they knew or believed other athletes were using them (15.0% vs. 2.6% vs. 0.0%) (χ^2 (2) = 7.80, p = 0.02). Finally, endurance athletes were significantly more likely (45.0%), while athletes from intermittent sports were significantly less likely (20.8%) to use vitamin and mineral supplement for the provision of indirect benefits to performances compared to athletes from power sports (36.7%) (χ^2 (2) = 6.50, p = 0.04).

5.4.6 Sources of Information

The most common sources of information regarding DS-related information used by supplement users were health care professionals (59.2%), friends/family (53.4%), internet (48.3%), their own judgement (48.3%), teammates/training partners (44.8%) and coaches (39.1%). Age and types of sport both had significant associations with sources of information, whereas gender and training hours did not have any influence. A significantly higher percentage of supplement users ≤ 20 years old referred to their trainers (48.6%) (χ^2 (1) = 7.33, p = 0.007) for information on DS compared to older athletes (27.6%). Endurance athletes using DS were found to be significantly more likely to ask health care professionals (75.0% vs. 46.8% vs. 60.3%) (χ^2 (2) = 8.97, p = 0.01) and coaches (56.3% vs. 38.7% vs. 27.0%) (χ^2 (2) = 9.80, p = 0.007) for information on DS compared to supplement users involved in power and intermittent sports while athletes from intermittent sports were more likely to ask friends and family (66.7% vs. 43.8% vs. 46.8%) (χ^2 (2) = 7.34, p = 0.03) as well as refer to information available in health food and grocery stores (23.8% vs. 12.5% vs. 8.1%) (χ^2 (2) = 6.40, p = 0.04) than varsity athletes from endurance and power sports. When asked to rank their sources of information, 35.3% of varsity athletes ranked health care professionals as their number one source of information, followed by 14.1% who ranked internet and 12.8% who selected friends/family as their primary source of information regarding their DS choices and usage.

5.4.7 Predictors of Dietary Supplement Use

In order to identify factors that may impact or predict DS use among varsity athletes, univariate logistic regressions were performed for each of the following variables: gender, age, weekly training hours, type of sport practiced, parent's/guardian's education, weight, height and BMI. The models for gender (OR: 0.58, 95% CI: 0.34-0.98, p = 0.04) and age (OR: 2.04, 95% CI: 1.26-3.32, p = 0.004) were significant, while all other individual variables did not significantly predict DS use in athletes. Age was tested as a continuous and a categorical variable ($\leq$ 20 years old and >20 years old); while both models were significant, the model with age as a categorical variable had a higher accuracy in predicting DS use and thus was the one reported. Other demographic attributes collected in the questionnaire, including ethnicity, program of study, medical conditions, smoking habits and alcohol intake had very unequal distributions of participants across categories. Multi-way cross tabulations analysis of those variables revealed expected frequencies of less than 1, which led those factors to be excluded from logistic regression analysis.

A multivariate logistic regression including both gender and age, being the only significant predictors individually, was then conducted and yielded a significant chi-square test for the model (χ^2 (2) = 11.94, p = 0.003). The accuracy of the model in predicting supplement use was 61.2%, and it can be estimated that between 42% and 57% of variance in supplement use by varsity athletes can be explained by their gender and age (Cox and Shell R^2: 0.042, Nagelkerke R^2: 0.057). In the final model, gender was not found to be a significant predictor (b = -0.51, *Wald* (1) = 3.41, p =0.07), indicating that the higher prevalence of supplementation in male athletes was mostly attributable to their older age. Age, on the other hand, had a significant regression coefficient (b = 0.71, *Wald* (1) = 8.11, p =0.004), and athletes over 20 years old were found to have 2.04 times higher odds to be consuming DS than those 20 years old or younger (OR = 2.04, 95% CI: 1.25, 3.32).

5.4.8 Nutritional Labels and Negative Side Effects

Most athletes using DS declared reading nutritional labels on all their supplements. Indeed, 76.5% of supplement users reported always reading labels on their supplements, whereas 18.7% stated sometimes and 4.8% declared never reading them. The most common reasons given by athletes who were not reading nutritional labels were because they trusted their sources of information, knew enough about their DS and/or lacked knowledge on how to read food labels.

Although the majority of varsity athletes using DS reported having never experienced negative side effects related to supplement consumption, 8.3% of supplement users declared having experienced gastrointestinal issues as a result of supplementation.

5.4.9 Athletes' Learning Interests

Overall, 58.6% of varsity athletes were interested in learning more about at least one type of DS, with the most frequently reported types of supplement being protein supplements (19.5%), vitamin and mineral supplements (17.2%) and amino acids supplements (11.9%).

Additionally, 14.6% of varsity athletes mentioned being interested in learning more about the pros and cons of consuming DS, 10.6% were interested in having more information regarding the effectiveness of various supplements and 7.9% wanted to learn more about best practices, such as how much they should consume as well as frequency and timing of use. Another 7.0% of varsity athletes were interested in gaining more knowledge about the mechanisms of actions of different DS. Finally, 4.3% of participants wanted more information regarding DS contamination, prohibited substances possibly found in DS and whether different types of DS are safe to consume in competition and comply with anti-doping rules.

The preferred means selected by athletes for receiving DS information were internet (34.4%), group presentations (18.2%), individual consultations with health professionals (10.3%) and prints (2.6%).

5.5 Discussion

The prevalence of DS use in our sample was considerably lower than those reported in previous studies. Only 58.3% of athletes declared having used at least one type of DS in the past 6 months, which is well below rates of supplementation ranging between 87% and 99% reported in previous studies on Canadian athletes (Erdman et al., 2007; Lun et al., 2012; Wiens et al., 2014). In a similar study to ours, conducted on varsity athletes from British-Columbia, Kristiansen et al. (2005) found that 99% of athletes were using DS, which is consistent with the prevalence of supplementation of 91% reported by Erdman et al. (2007) for their sub-sample of varsity athletes. The lower prevalence rates of DS use reported among athletes attending the university may be due to the well-developed educational programs on DS tailored for varsity athletes as well as the close monitoring and guidance of athletes by qualified health professionals; however, these reasons should be further explored in future research. Moreover, some athletes might not have read carefully or completely understood the definition of DS provided in the questionnaire and might not have considered some of the products they were using as DS.

In this study, both gender and age had significant associations with prevalence of DS use, with a significantly higher percentage of male athletes and athletes over 20 years old using DS. Although the IOC agrees that DS use tends to be higher in male athletes, studies conducted on Canadian athletes did not reveal any significant relationships between gender and rates of supplementation (Erdman et al., 2007; Maughan et al., 2018; Wiens et al., 2014). This is, therefore, the first study conducted on a Canadian varsity athlete sample reporting a significantly higher percentage of supplement users in male athletes, which is consistent with findings from studies conducted internationally (Giannopoulou et al., 2013; Valentine et al., 2017). Limited studies have compared supplementation practices of elite athletes based on their age. In our sample, varsity athletes over 20 years old were significantly more likely to report the use of DS, which is in accordance with the IOC's conclusion that prevalence of DS use tends to increase with age (Maughan et al., 2018). This aligns with the general trend of increased health awareness with aging, and may in particular reflect an increased interest among older athletes in exploring nutritional strategies aiming at optimizing their performance and improving recovery. This trend was also observed in the study conducted by Erdman et al. (2007), in which older Canadian athletes were significantly more likely to report DS use. On the other hand, Wiens et al. (2014) failed to observe any significant association between age and DS use in another sample of Canadian athletes. Although the significant association between weekly training hours and rates of supplementation seems well established in the literature, this relationship was not observed in our sample. Contrary to studies that have reported significantly greater proportions of athletes with high weekly training hours consuming DS (Giannopoulou et al., 2013; Lun et al., 2012), the proportion of varsity athletes using DS was similar across the different categories of training hours in the present study. Although the prevalence of DS use increased from 57.1% in athletes training 10 hours or less per week up to 66.7% in those training more than 10 hours per week, this association did not reach statistical significance, which may be due to an insufficient sample size. Finally, unlike findings from Lun et al. (2012) reporting that athletes involved in endurance and power sports were more likely to declare DS use than athletes from intermittent sports, the types of sport practiced did not impact prevalence of DS use in the present study.

The most commonly used types of DS in the current study were protein, vitamins and minerals and carbohydrate supplements, a finding in accordance with the most frequently reported reasons for consuming DS. Indeed, varsity athletes declared using DS for maintaining good health as well as correcting and preventing micronutrient deficiencies which can explain the use of vitamin and mineral supplements, for increasing energy, which can be associated with the use of carbohydrate supplements, and finally for promoting recovery which can be linked to the use of protein supplements. This finding is also similar to results from studies conducted on Canadian athletes in which sport drinks, multivitamin and minerals as well as protein supplements were found to be widely used (Erdman et al., 2007; Lun et al., 2012). As it had been observed by Kristiansen et al. (2005) and Dascombe et al. (2010), female athletes were significantly more likely than males to use iron supplements in the current study; a supplementation trend in alignment with the high prevalence of iron deficiency reported among female athletes (Rowland et al., 2012). Males, on the other hand, were significantly more likely to be using amino acids supplements, whey and casein, which is also in agreement with previously published results indicating that males are more likely to be using muscle-building and/or muscle-maintenance DS such as protein and amino acids supplements (Dascombe et al., 2010; Diehl et al., 2012; Froiland et al., 2004; Wiens et al., 2014). Furthermore, a significantly higher percentage of varsity athletes over 20 years old reported using protein, carbohydrate and stimulants supplements, which aligns with the age-related trends in DS use reported by Wiens et al. (2014). Indeed, DS aiming at building muscles and increasing energy tend to be consumed increasingly more as athletes age, a tendency likely linked to an increased emphasis on improving health and enhancing performance in older athletes (Wiens et al., 2014). In the literature, weekly training hours were not linked to patterns of specific types of DS use, and elite Canadian athletes have reported the use of the same types of DS independently of weekly training hours (Lun et al., 2012). However, in the current study, athletes training 21 hours or more per week were significantly more likely to be consuming casein and vitamin B12 supplements. Associations between training hours and specific types of DS remain unclear and reasons underlying the higher use of casein and vitamin B12 supplement in the present study need to be explored further. As expected, a significantly greater percentage of athletes from power sports were using whey and creatine supplements in the present study, a commonly seen sport-type pattern of DS use across the literature (Erdman et al., 2007; Diehl et al., 2012; Lun et al., 2012; Wiens et al., 2014).

The frequency of supplementation was generally very high, with 45% of supplement users consuming at least one type of DS $\geq$ 6 times per week; it was nonetheless lower than the one reported in Canadian high-performance athletes, with 58% declaring daily use of DS (Lun et al., 2012). Although training hours did not have any associations with prevalence of DS use, supplement users with high training hours were using DS significantly more frequently than athletes with lower training hours. In terms of type of sport practiced, endurance athletes were significantly more likely to use DS ≥ 6 times per week compared to athletes involved in power and intermittent sports, a finding that partly contradicts Diehl et al. (2012)'s results in which athletes from endurance and power sports were equally more likely than athletes from technical sports to report daily DS use.

The most common reasons reported by varsity athletes for using DS, which included maintain good health, increasing energy, promoting recovery and correcting or preventing micronutrient deficiencies, are in accordance with findings from previous studies (Erdman et al., 2006; Erdman et al., 2007; Kristiansen et al., 2005; Lun et al., 2012; Wiens et al., 2014). Another frequently declared reason for consuming DS in the current study was for supplying convenient forms of energy and/or macronutrients, a motive which has not been investigated in previous research. Given the busy schedules of varsity athletes, it is not surprising that 58% of supplement users were using DS for the provision of convenient form of energy and nutrients around exercise sessions. From a practical standpoint, many athletes might prefer consuming supplements such as sport drinks and gels during training periods rather than consuming food, since they are readily available, easy to consume and usually well tolerated by the digestive system. In the literature, rationale for supplementation was found to vary based on gender, with female athletes being more likely to use DS for health maintenance, prevention or correction of nutritional deficiencies and compensation for an inadequate diet, while male athletes being more likely to use DS to increase muscle mass, strength and power (Erdman et al., 2007; Froiland et al., 2004; Lun et al.,2012). However, in the present study, no significant differences in rationale for supplementation were observed based on gender. Reasons for using each specific type of supplements were also explored, and similarly to findings reported by Wiens et al. (2014), athletes from power and endurance sports were more likely to be consuming stimulants for direct benefits to performance and endurance athletes were using vitamins and mineral supplements for indirect benefits to performances such as improved recovery.

Numerous studies have reported that the most common sources of information selected by athletes were family and friends (Erdman et al., 2006; Erdman et al. 2007; Lun et al., 2012; Wiens et al., 2014). The use of non-reliable sources of information regarding DS choices is of great concern given the alarmingly high occurrence of DS contamination and the gravity of the consequences associated with anti-doping infractions as well as the potential health risks associated with inadequate DS use. Interestingly, in the current study, the most frequently reported source of information on DS were health professionals, which might in part explain the lower than expected prevalence of use of DS in this population. With the exception of varsity athletes from the University of British Columbia who also ranked health professionals as their primary source of information, other studies have reported very low rates of athletes referring to health professionals regarding their supplementation practices (Kristiansen et al., 2005).

Identifying predictors of DS use is of great importance in order to facilitate screening for athletes more prone to use DS and their referral to professionals when needed. Having access to professional guidance regarding DS choices could ensure safe and effective supplementation practices by athletes. However, the amount of research related to predictors of DS use specifically in the athletic population is very limited and most studies have been looking at different predictors, making comparisons challenging. In the present research, being over 20 years old was found to significantly predict DS use; yet other studies have reported different significant predictors including high desire to enhance performance, higher DS-related knowledge, low training frequency and a high number of DS consumed (Bartee et al., 2004; Dietz et al., 2014; Sassone et al., 2018). Further research in this area is warranted to establish the most important predictors of DS use among athletes.

To our knowledge, this is the first study exploring dietary supplementation practices specifically in varsity athletes in Eastern Canada. Strengths of this study include the extensive information collected with respect to DS use, the use of a questionnaire validated and tested for reliability on the target population of varsity athletes as well as the balanced representation of varsity athletes from a variety of sport disciplines. Limitations inherent to this study include the self-reported nature of collected data and therefore the inability to ensure accuracy and honesty from participants. In order to minimize this effect, anonymity of the athletes' answers was emphasized in recruitment materials and consent form. Moreover, the online questionnaire was designed so that it could be completed only once on any given electronic device; however, it is possible that some athletes completed the questionnaire more than once on different devices, which we could not track given the anonymized nature of the questionnaire. Finally, data were collected in one specific Canadian university setting in Ontario, thus findings may not be generalized to the entire population of varsity Canadian athletes.

5.6 Conclusion

This study gives insight into the dietary supplementation practices of Canadian varsity athletes in a specific university setting. Despite a lower than expected prevalence of DS use, it confirms the widespread consumption of DS in this population. A novel finding from the present study is the high percentage of athletes consuming DS for convenience purposes, especially in athletes over 20 years old. Another interesting finding, rarely reported in the literature, was that the most frequently reported source of DS-related information used by varsity athletes were health care professionals. However, despite their referral to reliable sources of information, a high proportion of athletes are still interested in becoming more knowledgeable about DS, particularly DS effectiveness, risks and benefits, optimal dietary supplementation practices as well as contamination risks and anti-doping violations possibly associated with DS use. Health care professionals working with varsity athletes should therefore consider developing programs addressing these subjects in order to better guide athletes and inform their decisions regarding dietary supplementation practices.

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5.8 References

Backhouse, S.H., Whitaker, L., Petroczi, A. (2013). Gateway to doping? Supplement use in the context of preferred competitive situations, doping attitude, beliefs, and norms. *Scandinavian Journal of Medicine & Science in Sports,* 23, 244-252. doi: 10.1111/j.1600-0838.2011.01374.x

Bartee, R.T., Grandjean, B., Dunn, M.S., Perko, M.A., Eddy, J.M., & Wang, M.Q. (2004). Predictors of dietary supplement use among adolescent athletes. *Pediatric Exercise Science, 1*6(3), 250-264. doi: http://dx.doi.org/10.1123/pes.16.3.250

Burke, L.M. (2017). Practical issues in evidence-based use of performance supplements: Supplement interactions, repeated use and individual response. *Sports Medicine,* 47(1), 79-100. doi:10.1007/s40279-017-0687-1

Canadian Center for Ethics in Sports. (n.d.). *Supplements.* Retrieved from https://cces.ca/supplements

Dascombe, B.J., Karunaratna, 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(2), 274-280. doi: 10.1016/j.jsams.2009.03.005

Diehl, K., Thiel, A., Zipfel, S., Mayer, J., Schnell, A., & Schneider, S. (2012). Elite Adolescent Athletes' Use of Dietary Supplements: Characteristics, Opinions, and Sources of Supply and Information. *International Journal of Sport Nutrition and Exercise Metabolism,* 22(3), 165-174. doi: 1543-2742

Dietz, P., Ulrich, R., Niess, A., Best, R., Simon, P., & Striegel, H. (2014). Prediction profiles for nutritional supplement use among young German elite athletes. *International Journal of Sport Nutrition and Exercise Metabolism.* 24(6), 623-631. doi: 10.1123/ijsnem.2014-0009

Erdman, K.A., Fung, T.K., Raylene, A.R. (2006). Influence of performance level on dietary supplementation in elite Canadian athletes. *Medicine and Science in Sports and Exercise,* 38(2), 349-356. doi: 10.1249/01.mss.0000187332.92169.e0

Erdman, K.A., Fung, T.S., Doyle-Baker, P.K., Verhoef, M.J., & Reimer, R.A. (2007). Dietary supplementation of high-performance Canadian athletes by age and gender. *Clinical Journal of Sport Medicine,* 17(6), 458-464. Retrieved from http://ovidsp.tx.ovid.com.subzero.lib.uoguelph.ca

Froiland, K., Koszewski, W., Hingst, J., & Kopecky, L. (2004). Nutritional supplement use among college athletes and their sources of information. *International Journal of Sport Nutrition and Exercise Metabolism,* 14(1), 104-120. Retrieved from https://journals-humankinetics-com.subzero.lib.uoguelph.ca/doi/abs/10.1123/ijsnem.14.1.104

Giannopoulou, I., Noustos, K., Apostolidis, N., Bayios, I., & Nassis, G.P. (2013). Performance level affects the dietary supplement intake of both individual and team sports athletes. *Journal of Sports Science and Medicine,* 12(1), 190-196. Retrieved from http://go.galegroup.com.subzero.lib.uoguelph.ca/ps/i.do?&id=GALE|A322330411&v=2.1&u=guel77241&it=r&p=AONE&sw=w&authCount=1

Government of Canada. (2016, March 14). *About Natural Health Products.* Retrieved from https://www.canada.ca/en/health-canada/services/drugs-health-products/natural-non-prescription/regulation/about-products.html

Knapik, J.J., Steelman, R.A., Hoedebecke, S.S., Austin, K.G., Farina, E.K., & Lieberman, H.R. (2016). Prevalence of dietary supplement use by athletes: Systematic review and meta-analysis. *Sports Medicine,* 46(1), 103-123. doi: 10.1007/s40279-015-0387-7

Kristiansen, M., Levy-Milne, R., Barr, S., & Flint, A. (2005). Dietary supplement use by varsity athletes at a Canadian university. *International Journal of Sport Nutrition and Exercise Metabolism,* 14, 217-232. Retrieved from https://journals-humankinetics-com.subzero.lib.uoguelph.ca

Lun, V., Erdman, K.A., Fung, T.S., & Reimer, R.A. (2012). Dietary supplementation practices in high-performance athletes. *International Journal of Sport Nutrition and Exercise Metabolism*, 22(1), 31-37. doi: 1543-2742

Maughan, R.J., Shirreffs, S.M., & Vernec, A. (2018). Making decisions about supplement use. *International Journal of Sport Nutrition and Exercise Metabolism*, 28(2), 212-219. doi: https://doi .org/10.1123/ ijsnem.2018 -0009

Mathews, N.M. (2018). Prohibited contaminants in dietary supplements. *Sports Health: A multidisciplinary Approach,* 10(1), 19-30. doi: 10.1177/1941738117727736

Outram, S., & Stewart, B. (2015). Doping through supplement use: A review of the empirical data. *International Journal of Sport Nutrition and Exercise Metabolism,* 25(1), 54-59. doi: 10.1123/ijsnem.2013-0174

Peeling, P., Binnie, M.J., Goods, P.S.R., Sim, M., & Burke, L.M. (2018). Evidence-based supplements for the enhancement of athletic performance. *International Journal of Sport Nutrition and Exercise Metabolism,* 28, 178-187. doi: 10.1123/ijsnem.2017-0343

Rowland, T. (2012) Iron deficiency in athletes. A*merican Journal of Sport Medicine,* 6(4). doi: 10.1177/1559827611431541

Sassone, J., Muster, M., & Barrack. M.T. (2018). Prevalence and predictors of higher-risk supplement use among collegiate athletes. *Journal of Strength and Conditioning Research,* 0(0), 1-8. doi: 10.1519/JSC.0000000000002979

Temple, N.J. (2017). The regulation of dietary supplements in Canada: Many promises but little progress. *Journal of Dietary Supplements,* 14(1), 117-120. doi: 10.1080/19390211.2016.1201719

Valentine, A.A., Schumacher, J.R., Murphy, J., & Jin Ma, Yoon. (2017). Dietary supplement use, perceptions, and associated lifestyle behaviors in undergraduate college students, student-athletes, and ROTC cadets. *Journal of American College Health,* 0(0), 1011. doi: https://doi.org/10.1080/07448481.2017.1377205

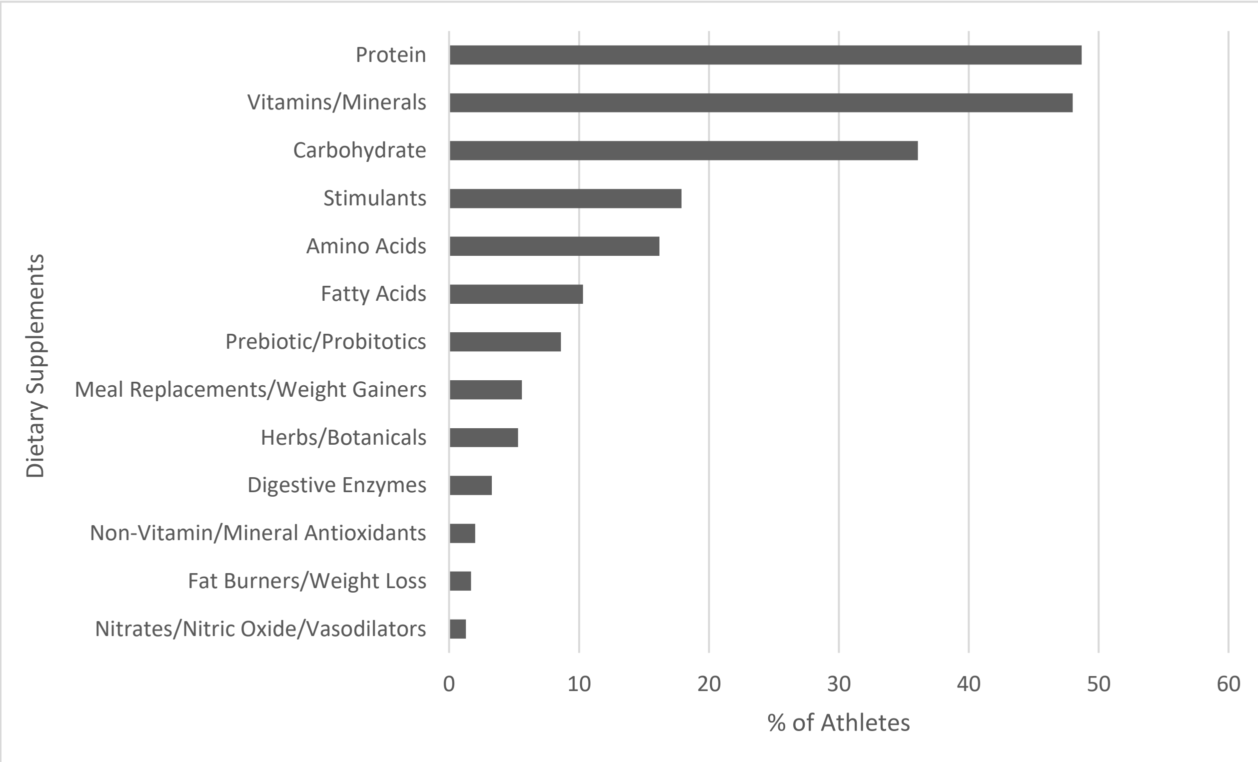
Wiens, K., Erdman, K.A., Stadnyk, M., & Parnell, J.A. (2014). Dietary supplement usage, motivation, and education in young Canadian athletes. *International Journal of Sport Nutrition and Exercise Metabolism,* 24(6), 613-622. doi: 10.1123/ijsnem.2013-0087

Table 2: Prevalence (%) of Dietary Supplement Use by Gender, Age, Training Hours and Type of Sport (n= 306)

Characteristic	Prevalence of use	χ^2 p-value
Overall	58.3%	NA
Gender		
Female	53.1%	0.04
Male	66.3%	
Age		
≤20	48.6%	0.004
>20	65.9%	
Training Hours		
≤10h	57.1%	
11-15h	55.2%	0.58
16-20h	62.3%	
≥21h	66.7%	
Type of Sport		
Intermittent	52.0%	0.15
Endurance	60.8%	
Power	64.6%	

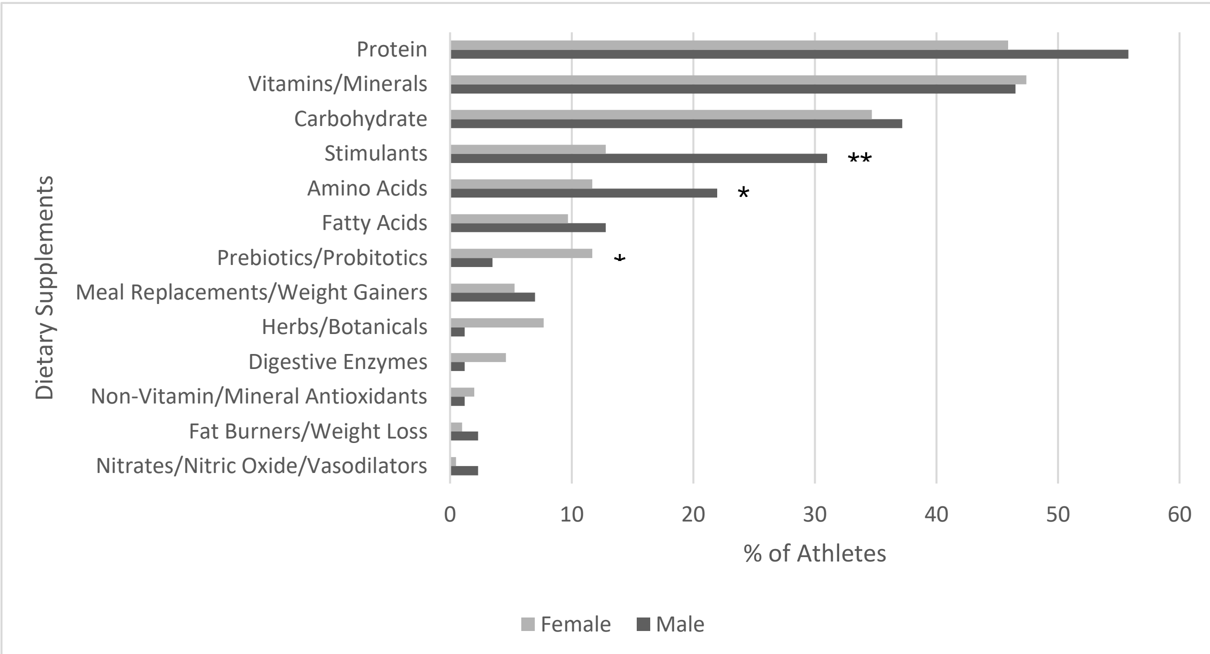
n: total number of athletes; χ2: chi-square test; NA: Non-Applicable; p-values < 0.05 represent significant differences between categories of a variable (gender, age, training hours and type of sport)

Figure 1: Percentage (%) of Athletes (n = 302) Using Each Type of Dietary Supplements



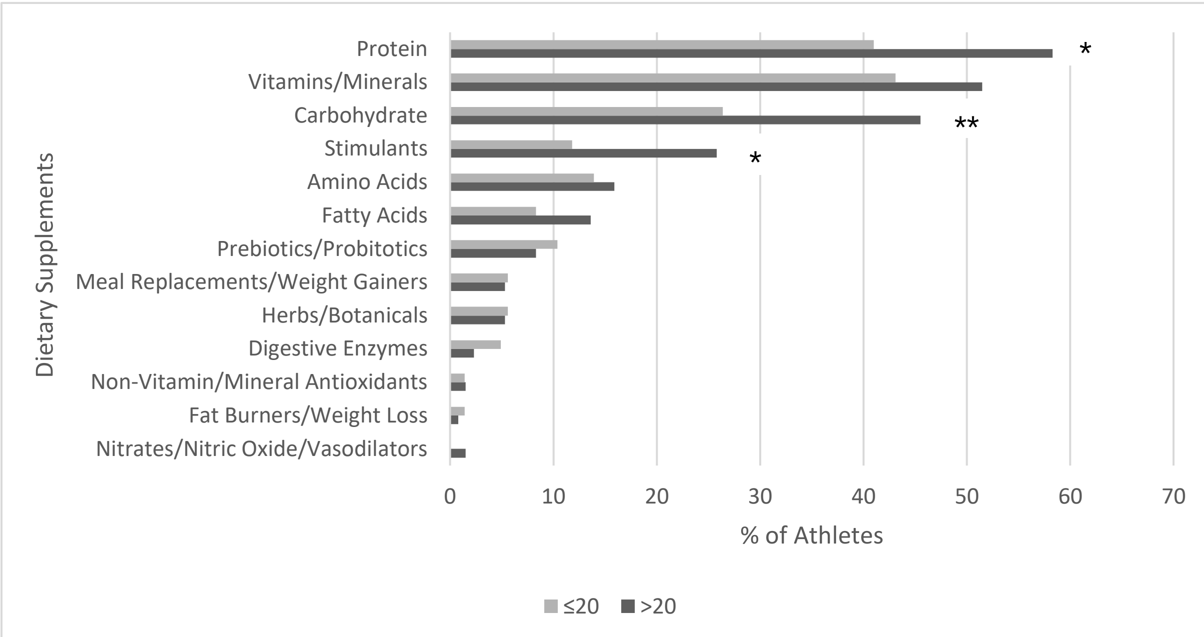
n: total number of athletes

Figure 2: Percentage (%) of Athletes Using Each Type of Dietary Supplements Based on Gender (n = 196 for females; and n = 86 for males)



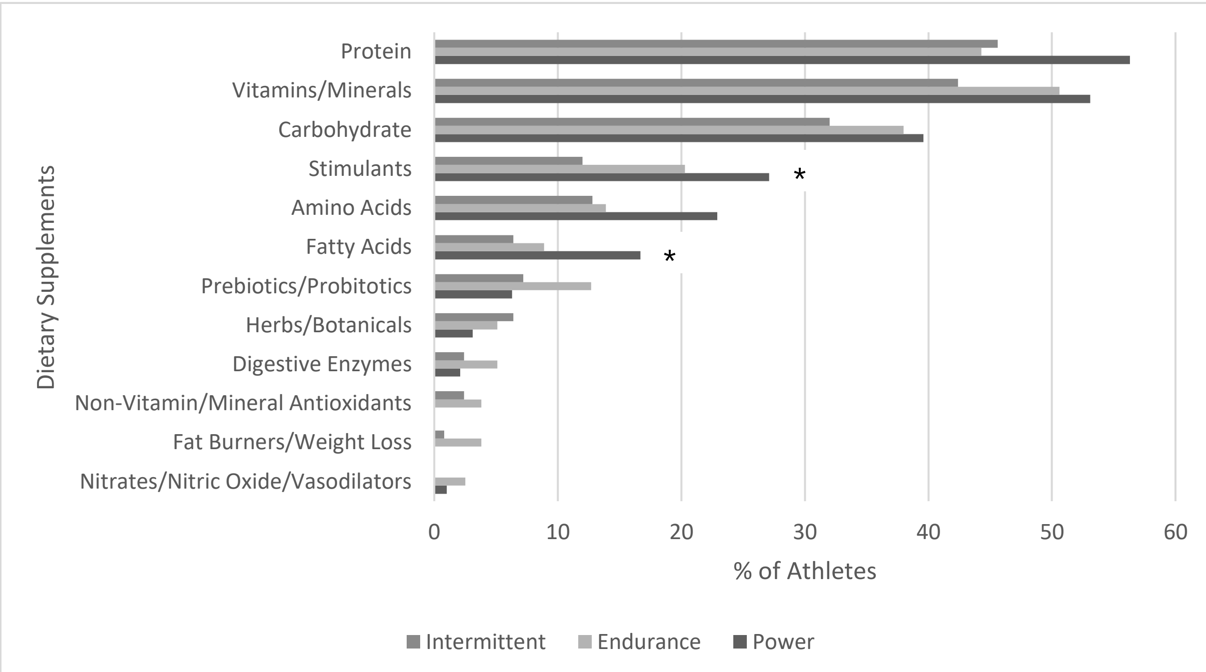
* p-values < 0.05: Significant differences in prevalence of use of amino acids (χ^2 (1) = 5.06, p = 0.03) and prebiotics/probiotics (χ^2 (1) = 4.89, p = 0.03) between female and male athletes; ** p-value ≤ 0.001: Significant difference in prevalence of use of stimulant (χ^2 (1) = 13.81, p ≤ 0.001) between female and male athletes; n: total number of female and male athletes

Figure 3: Percentage (%) of Athletes Using Each Types of Dietary Supplements Based on Age (n = 144 for ≤ 20 years old; and n = 132 for > 20 years old)



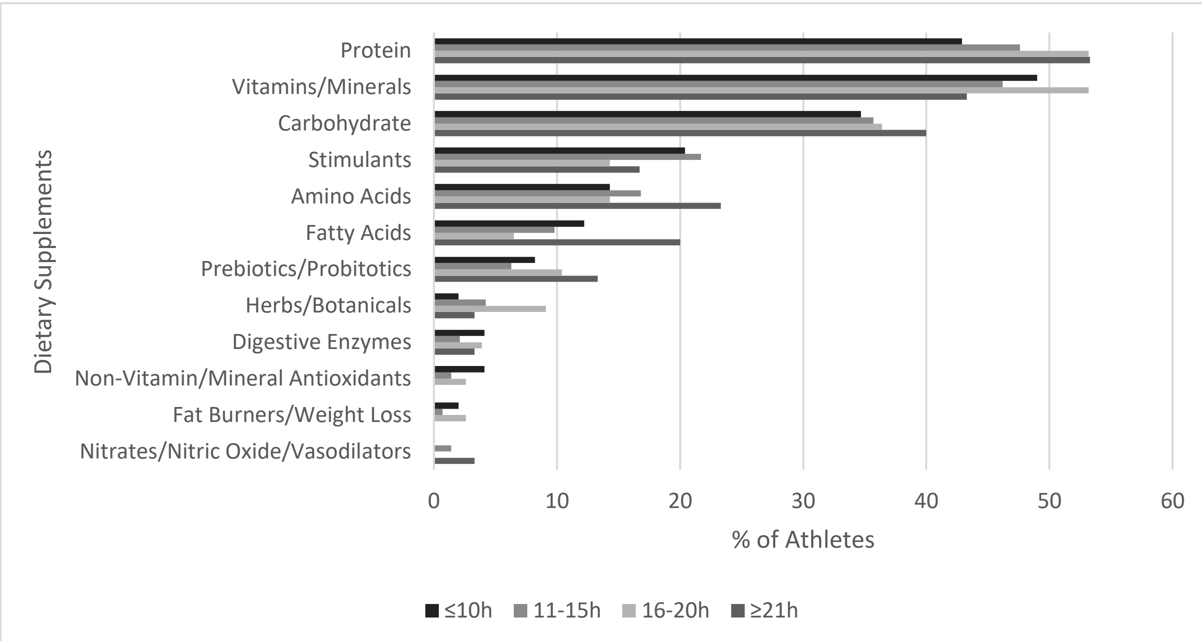
* p-values < 0.05: Significant differences in prevalence of use of protein (χ^2 (1) = 8.31, p = 0.04) and stimulant (χ^2 (1) = 8.90, p = 0.003) between athletes ≤ 20 years old and athletes > 20 years old; ** p-value ≤ 0.001: Significant difference in prevalence of use of carbohydrate (χ^2 (1) = 10.93, p = 0.001) between athletes ≤ 20 years old and athletes > 20 years old; n: total number of athletes ≤ 20 years old and athletes > 20 years old

Figure 4: Percentage (%) of Athletes Using Each Types of Dietary Supplements Based on Type of Sport (n = 125 for intermittent; n = 79 for endurance; and n = 96 for power)



* p-value < 0.05: Significant difference in prevalence of use of stimulant ($\chi^2(2) = 8.14$, $p = 0.02$) and fatty acids ($\chi^2(2) = 6.43$, $p = 0.04$) between athletes from intermittent, endurance and power sports; n: total number of athletes from intermittent, endurance and power sports

Figure 5: Percentage (%) of Athlete Using Each Types of Dietary Supplements Based on Weekly Training Hours (n = 96 for ≤ 10 hours; n = 143 for 11-15 hours, n = 77 for 16-20 hours; and n = 30 for ≥ 21 hours)



n: total number of athletes training ≤ 10 hours weekly, 11-15 hours weekly, 16-20 hours weekly and ≥ 21 hours weekly

Table 3: Percentage (%) of Supplement Users (n=174) Selecting Each Reason for Using Dietary Supplements Based on Gender, Age, Training Hours and Type of Sport

	Gender			Age			Training Hours					Type of Sport			
	Male (n=57)	Female (n=104)	χ^2 p value	≤20 (n=62)	>20 (n=66)	χ^2 p value	≤10 (n=27)	11-15 (n=78)	16-20 (n=48)	≥21 (n=20)	χ^2 p value	Intermittent (n=63)	Endurance (n=48)	Power (n=62)	χ^2 p value
General Health	89.5%	92.3%	0.57	95.7%	89.7%	0.16	88.9%	93.6%	91.7%	85.0%	0.63	93.7%	89.6%	90.3%	0.71
Convenience	61.4%	71.2%	0.21	60.0%	75.9%	0.03	66.7%	67.9%	72.9%	55.0%	0.56	76.2%	60.4%	64.5%	0.17
Direct Benefits to Performance	78.9%	81.7%	0.67	84.3%	80.5%	0.53	85.2%	84.6%	75.0%	60.0%	0.07	71.4%	85.4%	82.3%	0.15
Indirect Benefits to Performance	80.7%	88.5%	0.18	87.1%	87.4%	0.97	85.2%	88.5%	77.1%	90.0%	0.32	84.1%	83.3%	87.1%	0.84
Influence	14.0%	12.5%	0.78	15.7%	11.5%	0.44	3.7%	14.1%	18.8%	10.0%	0.31	20.6%	12.5%	6.5%	0.06
Just in Case	21.2%	21.2%	0.99	22.9%	19.5%	0.61	25.9%	16.7%	22.9%	15.0%	0.63	22.5%	16.7%	19.4%	0.76

n: number of supplement users in each category; p-values < 0.05 represent significant differences between categories of a variable (gender, age, training hours and type of sport); χ^2: chi-square test

6 Summary

This project gives insight into the dietary supplementation practices of Canadian varsity athletes. Despite a lower than expected prevalence of dietary supplement use, it confirms the widespread consumption of supplements in this population. Indeed, 58% of varsity athletes declared having use at least one type of dietary supplement in the past 6 months, with male athletes and athletes over 20 years old being significantly more likely to be supplement users. Individual types of dietary supplements consumed by athletes were influenced by their gender, age, weekly training hours and type of sport practiced. Overall protein, vitamins and minerals as well as carbohydrates supplements were the most frequently reported types of dietary supplements used by varsity athletes. Although high weekly training hours were not associated with a higher prevalence of supplement use, high training load was significantly related to the frequency of supplementation, with athletes training ≥21 hours per week being significantly more likely to report using dietary supplements ≥ 6 times per week. Similarly, endurance athletes reported a significantly higher frequency of dietary supplement use compared to athletes involved in power and intermittent sport disciplines. Common reasons cited by athletes for using supplements were similar to what has been reported in previous studies, including maintaining good health, increasing energy, promoting recovery and correcting or preventing micronutrients deficiencies. A novel finding from the present study, is the high percentage of athletes consuming dietary supplements for convenience purposes, especially in athletes over 20 years old. Finally, it is interesting that the most frequently reported source of dietary supplements-related information used by varsity athletes were health care professionals, a finding which has been rarely reported in the literature. However, despite the use of reliable sources of information, it appears that a high proportion of athletes are still interested in becoming more knowledgeable about dietary supplements, particularly in relation to dietary supplements' effectiveness and risks and benefits, optimal dietary supplementation practices as well as contamination risks and anti-doping violations possibly associated with supplement use.

From a practical point of view, findings from this study may guide the development of educational materials needed to address any knowledge gaps on dietary supplements among varsity athletes. Since athletes reported relying on health care professionals as their main sources of information related to their supplementation practices, sport doctors and dietitians working in university settings should consider developing programs addressing athletes' learning interests. Providing guidance and accurate information is critical to ensure athletes are making informed decisions regarding their supplementation choices. Being knowledgeable about dietary supplements is crucial for athletes not only to minimize any risks possibly associated with supplement use but also to ensure the application of optimal supplementation protocol allowing them to reap the possible benefits associated with dietary supplements' consumption.

The differences in methodologies across studies exploring dietary supplement usage in athletes are major limitations of this field of research. The use of various data collection methods, the variation in the definition of dietary supplement, the differences in types of supplements explored in each study as well as variations in time frames investigated are only a few of the methodological differences making comparisons between studies challenging (Knapik et al., 2016). Therefore, future research should focus on the development of a standardized questionnaire related to dietary supplement use in athletic populations. Furthermore, based on findings from this study, research exploring in depth the knowledge of athletes on dietary supplements as well as intervention studies assessing the effectiveness of a variety of educational programs are warranted.

7 References

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes,* 50(2), 179-211. doi: 10.1016/0749-5978(91)90020-T

Ajzen, I. (2006). Constructing a theory of planned behavior questionnaire. Retrieved from http://people.umass.edu/aizen/pdf/tpb.measurement.pdf

Arendt, E.A., & Griffiths, H.J. (1997). The use of MR imaging in the assessment and clinical management of stress reactions of bone in high-performance athletes. *Clinics in Sports Medicine,* 16(2), 291-306. doi: 10.1016/S0278-5919(05)70023-5

Backhouse, S.H., Whitaker, L., Petroczi, A. (2013). Gateway to doping? Supplement use in the context of preferred competitive situations, doping attitude, beliefs, and norms. *Scandinavian Journal of Medicine & Science in Sports,* 23, 244-252. doi: 10.1111/j.1600-0838.2011.01374.x

Bassit, R.A., Pinheiro, C.H., Vitzel, K.F., Sproesser, A.J., Silveira, L.R., & Curi, R. (2009). Effect of short-term creatine supplementation on markers of skeletal muscle damage after strenuous contractile activity. *European Journal of Applied Physiology,* 108, 945-955. doi: 10.1007/s00421-009-1305-1

Bartee, R.T., Grandjean, B., Dunn, M.S., Perko, M.A., Eddy, J.M., & Wang, M.Q. (2004). Predictors of dietary supplement use among adolescent athletes. *Pediatric Exercise Science, 1*6(3), 250-264. doi: http://dx.doi.org/10.1123/pes.16.3.250

Bellinger, P.M. (2014), B-alanine supplementation for athletic performance: An update. *Journal of Strength and Conditioning Research,* 28(6), 1751-1770. Retrieved from http://ovidsp.tx.ovid.com/sp-3.28.0a/ovidweb.cgi

Bermon, S., Castell, L.M., Calder, P.C., Bishop, N.C., Blomstrand, E., … Nagatomi, R. (2017). Consensus statement immunonutrition and exercise. *Exercise Immunology Review,* 23, 8-50. Retrieved from htttp://web.b.ebscohost.com.subzero.lib.uoguelph.ca/ehost/pdfviewer/pdfviewer

Branch, J.D. (2003). Effect of creatine supplementation on body composition and performance: A meta-analysis. *International Journal of Sport Nutrition and Exercise Metabolism,* 13, 198-226. Retrieved from https://journals.humankinetics.com/doi/abs/10.1123/ijsnem.13.2.198

Braun et al. (2009). Dietary supplement use among elite young German athletes. *International Journal of Sport Nutrition and Exercise Metabolism,* 19, 97-109. Retrieved from: https://journals-humankinetics-com.subzero.lib.uoguelph.ca/doi/abs/10.1123/ijsnem.19.1.97

Brown, R.T., McIntosh, S.M., Seabolt, V.R. & Daniel, W.A. (1985). Iron status of adolescent female athletes. *Journal of Adolescent Health Care,* 6(5), 349-351. doi: 10.1016/S0197-0070(85)80001-2

Brunet, M.E., Cook, S.D., Brinker, M.R., & Dickinson, J.A. (1990). A survey of running injuries in 1505 competitive and recreational runners. *The Journal of Sports Medicine and Physical Fitness,* 30(3), 307-315.

Buford, T.W., Kreider, R.B., Stout, J.R., Greenwood, M., Campbell, B., … Antonio, J. (2007). International society of sports nutrition position stand: Creatine supplementation and exercise. *Journal of the International Society of Sports Nutrition,* 4(6). doi: 10.1186/1550-2783-5-6

Burke, L.M. (2008). Caffeine and sports performance. *Applied Physiology, Nutrition, and Metabolism,* 33, 1219-1334. doi: 10.1139/H08-130

Burke, L.M. (2017). Practical issues in evidence-based use of performance supplements: Supplement interactions, repeated use and individual response. *Sports Medicine,* 47(1), 79-100. doi:10.1007/s40279-017-0687-1

Cermak, N.M., Res, P.T., Groot, L., Saris, W., & Van Loon, L. (2012). Protein supplementation augments the adaptive response of skeletal muscle to resistance-type exercise training: A meta-analysis. *American Journal of Clinical Nutrition,* 96(6), 1454-1464. Retrieved from https://doi-org.subzero.lib.uoguelph.ca/10.3945/ajcn.112.037556

Canadian Center for Ethics in Sports. (n.d.). *Supplements.* Retrieved from https://cces.ca/supplements

Close, G.L., Russell, J., Cobley, J.N., Owens, D.J., Wilson, G., … Morton, J.P. (2013). Assessment of vitamin D concentration in non-supplemented professional athletes and healthy adults during the winter months in the UK: Implications for skeletal muscle function. *Journal of Sports Sciences,* 31(4), 344-353. doi: 10.1080/02640414.2012.733822

Coates, A., Mountjoy, M., & Burr, J. (2017). Incidence of iron deficiency and iron deficient anemia in elite runners and triathletes. *Clinical Journal of Sport Medicine,* 27(5), 493-498. doi: 10.1097/JSM.0000000000000390

Constantini, N., Arieli, R., Chodick, G., & Dubnov-Raz, G. (2010). High prevalence of vitamin d insufficiency in athletes and dancers. *Clinical Journal of Sport Medicine,* 20(5), 368-371. doi: 10.1097/JSM.0b013e3181f207f2

ConsumerLab.com ®. (2010). Product review: Protein powders & drinks (including sports, nutrition and diet products). Retrieved from https://www.consumerlab.com/reviews/Nutrition_Powders_Shakes_and_Drinks_Including_Protein_Diet_MealReplacement_and_Sports_Endurance_Recovery_Products/NutritionDrinks/

ConsumerLab.com ®. (2012). Protein drinks. Retrieved from http://www. consumerreports.org/cro/2012/04/protein-drinks/index.htm

Cooke, N.B., Rybalka, E., Williams, A.D., Cribb, P.L., & Hayes, A. (2009). Creatine supplementation enhance muscle force recovery after eccentrically-induced muscle damage in healthy individuals. *Journal of the International Society of Sports Nutrition,* 6(13). doi: 10.1186/1550-2783-6-13

Cooper, R., Naclerio, F., Allgrove, J., & Jimenez, A. (2012). Creatine supplementation with specific view to exercise/sports performance: an update. *Journal of the International Society of Sports Nutrition,* 9(33). doi:10.1186/1550-2783-9-33

Crowley, J.J, & Wall, C. (2004). The use of dietary supplements in a group of potentially elite secondary school athletes. A*sian Pacific Journal of Clinical Nutrition,* 13(Suppl.), S39.

Dascombe, B.J., Karunaratna, 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(2), 274-280. doi: 10.1016/j.jsams.2009.03.005

Deldicque, L., Atherton, P., Patel, R., Theisen, D., Nielsens, H., Rennie, M.J., & Francaux, M. (2007). Effects of resistance exercise with and without creatine supplementation on gene expression and cell signaling in human skeletal muscle. *Journal of Applied Physiology*, 104, 371-378. doi: 10.11521japplphysiol.00873.2007

Diehl, K., Thiel, A., Zipfel, S., Mayer, J., Schnell, A., & Schneider, S. (2012). Elite Adolescent Athletes' Use of Dietary Supplements: Characteristics, Opinions, and Sources of Supply and Information. *International Journal of Sport Nutrition and Exercise Metabolism,* 22(3), 165-174. doi: 1543-2742

Dietz, P., Ulrich, R., Niess, A., Best, R., Simon, P., & Striegel, H. (2014). Prediction profiles for nutritional supplement use among young German elite athletes. *International Journal of Sport Nutrition and Exercise Metabolism.* 24(6), 623-631. doi: 10.1123/ijsnem.2014-0009

Duckham, R.L., Peirce, N., Meyer, C., Summers, G.D., Cameron, N., & Brooke-Wavell, K. (2012). Risk factors for stress fracture in female endurance athletes: A cross-sectional study. *British Medical Journal*, 2. doi: 10.1136/bmjopen-2012-001920

Erdman, K.A., Fung, T.K., Raylene, A.R. (2006). Influence of performance level on dietary supplementation in elite Canadian athletes. *Medicine and Science in Sports and Exercise*, 38(2), 349-356. doi: 10.1249/01.mss.0000187332.92169.e0

Erdman, K.A., Fung, T.S., Doyle-Baker, P.K., Verhoef, M.J., & Reimer, R.A. (2007). Dietary supplementation of high-performance Canadian athletes by age and gender. *Clinical Journal of Sport Medicine,* 17(6), 458-464. Retrieved from http://ovidsp.tx.ovid.com.subzero.lib.uoguelph.ca

Field, A. (2013). *Discovering Statistics Using IBM SPSS Statistics.* London: Sage Publications

Food and Drugs Administration. (2009). Warning on hydroxycut products. Retrieved from https://www.fda.gov/ForConsumers/Consumer Updates/ucm152152.htm

Food and Drugs Administration. (2018). Dietary Supplement Labelling Guide: Chapter 1. General Dietary Supplement Labelling. Retrieved from https://www.fda.gov/Food/GuidanceRegulation/GuidanceDocumentsRegulatoryInformation/DietarySupplements/ucm070519.htm

Froiland, K., Koszewski, W., Hingst, J., & Kopecky, L. (2004). Nutritional supplement use among college athletes and their sources of information. *International Journal of Sport Nutrition and Exercise Metabolism*, 14(1), 104-120. Retrieved from https://journals-humankinetics-com.subzero.lib.uoguelph.ca/doi/abs/10.1123/ijsnem.14.1.104

Ganio, M.S., Klau, J.F., Casa, D.J., Armstrong, L.E., & Maresh, C.M. (2009). Effect of caffeine on sport-specific endurance performance: A systematic review. *The Journal of Strength and Conditioning Research,* 23(1), 315-324. doi: 10.1519/JSC.0b013e31818b979a

Geyer, H., Parr, M.K., Mareck, U., Reinhart, U., Schrader, Y., & Schanzer, W. (2004). Analysis of non-hormonal nutritional supplements for anabolic-androgenic steroids – Results of an international study. *International Journal of Sports Medicine*, 25(2), 124-129. doi: 10.1055/s-2004-819955

Giannopoulou, I., Noustos, K., Apostolidis, N., Bayios, I., & Nassis, G.P. (2013). Performance level affects the dietary supplement intake of both individual and team sports athletes. *Journal of Sports Science and Medicine*, 12(1), 190-196. Retrieved from http://go.galegroup.com.subzero.lib.uoguelph.ca/ps/i.do?&id=GALE|A322330411&v=2.1&u=guel77241&it=r&p=AONE&sw=w&authCount=1

Government of Canada. (2006, June 29). *Dietary Reference Intake*. Retrieved from https://www.canada.ca/en/health-canada/services/food-nutrition/healthy-eating/dietary-reference-intakes/tables/reference-values-macronutrients-dietary-reference-intakes-tables-2005.html

Government of Canada. (2016, March 14). *About Natural Health Products.* Retrieved from https://www.canada.ca/en/health-canada/services/drugs-health-products/natural-non-prescription/regulation/about-products.html

Grigos, A., Benmoussa, J., Sandhy, J., Chaucer, B., Clarke, M., & Patel, S.H. (2016). Acute pancreatitis secondary to garcinia Cambogia; The unknown cost of herbal supplements. *Journal of the Pancreas,* 17(3), 316-317.

Haller, C.A., & Benowitz, N.L. (2000). Adverse cardiovascular and central nervous system events associated with dietary supplements containing ephedra alkaloids. *The New England Journal of Medicine,* 343(25), 1833-1838. doi: 10.1056/NEJM200012213432502

Halliday, T.M., Peterson, N.J., Thomas, J.J., Kleppinger, K., Hollis, B.W., & Larson-Meyer, D.E. (2011). Vitamin D status relative to diet, lifestyle, injury and illness in collegiate athletes. *Medicine and Science in Sports & Exercise*, 43(2), 335-343. doi: 10.1249/MSS.0b013e3181eb9d4d

Hulton, A.T., Lahart, I., Williams, K.L., Godfrey, R., Charlesworth, S., Wilson, M., Pedlar, C., & Whyte, G. (2010). Energy expenditure in the Race Across America (RAAM). *International Journal of Sports Medicine*, 31(7), 463-467. doi: 10.1055/s-0030-1251992

Hao, W., Dong, B.R., & Wu, T. (2015). Probiotics for preventing acute upper respiratory tract infections (Review). *Cochrane Database of Systematic Reviews*, 2. doi: 10.1002/14651858.CD006895.pub3

He, C.S., Handzlik, M., Fraser, W.D., Muhamad, A., Preston, H., Richardson, A., & Gleeson, M. (2013). Influence of vitamin D status on respiratory infection incidence and immune function during 4 months of winter training in endurance sport athletes. *Exercise Immunology Review*, 19, 86-101. Retrieved from http://web.b.ebscohost.com.subzero.lib.uoguelph.ca/ehost/pdfviewer/pdfviewer

He, C.S., Aw Yong, X.H., Walsh, N.P., & Gleeson, M. (2016). Is there an optimal vitamin D status for immunity in athletes and military personnel? *Exercise Immunology Review,* 22, 42-64.

Hemila, H., & Chalker, E. (2013). Vitamin C for preventing and treating the common cold (Review). *Cochrane Database of Systematic Reviews,* 1. doi: 10.1002/14651858.CD00980.pub4

Herbert, A.L.J., Painelli, V.S., Saunders, B., & Artiolo, G.G. (2015). Nutritional strategies to modulate intracellular and extracellular buffering capacity during high-intensity exercise. *Sports Medicine*, 45(S1), 71-81. doi: 10.1007/s40279-015-0397-5

Hobson, R.M., Saunders, B., Ball, G., Harris, R.C., & Sale, C. (2012). Effects of B-alanine supplementation on exercise performance: A meta-analysis. A*mino Acids,* 43, 25-37. doi: 10.1007/s00726-011-1200-z

Housman, J., Dorman, S., Pruitt, B., Ranjita, M., & Perko, M. (2011). Consumption of sport-related dietary supplements among NCAA division 1 female student athletes. *American Journal od Health Behavior*, 35(4), 438-446. doi: 10.5993/AJHB.35.4.6

Jeukendrup, A. (2014). A step towards personalized sports nutrition: Carbohydrate intake during exercise. *Sports Medicine*, 44(1), 25-33. doi: 10.1007/s40279-014-0148-z

Johnson, A.W., Weiss, C.B., &Wheeler, D.L. (1994). Stress fractures of the femoral shaft in athletes: more common than expected. A new clinical test. *American Journal of Sports Medicine,* 22(2), 248-256. Retrieved from https://journals-scholarsportal-info.subzero.lib.uoguelph.ca/details/03635465/v22i0002/248_sfotfsiacte.xml

Jones, A.M. (2014). Dietary nitrate supplementation and exercise performance. *Sports Medicine,* 44(S1), 35-45. doi: 10.1007/s40279-014-0149-y

Knapik, J.J., Steelman, R.A., Hoedebecke, S.S., Austin, K.G., Farina, E.K., & Lieberman, H.R. (2016). Prevalence of dietary supplement use by athletes: Systematic review and meta-analysis. *Sports Medicine,* 46(1), 103-123. doi: 10.1007/s40279-015-0387-7

Krishnan, Y.R. Mittal, V., Grewal, P., Fiel, M.I., & Schiano, T. (2011). Acute liver failure caused by "fat burners' and dietary supplements: A case report and literature review. *Canadian Journal of Gastroenterology & Hepatology,* 25(3), 157-160. doi: http://dx.doi.org/10.1155/2011/174978

Kristiansen, M., Levy-Milne, R., Barr, S., & Flint, A. (2005). Dietary supplement use by varsity athletes at a Canadian university. *International Journal of Sport Nutrition and Exercise Metabolism,* 14, 217-232. Retrieved from https://journals-humankinetics-com.subzero.lib.uoguelph.ca

Lappe, J., Cullen, D., Haynatzki, G., Recker, R., Ahlf, E., & Thompson, K. (2008). Calcium and vitamin D supplementation decreases incidence of stress fractures in female navy recruits. *Journal of Bone and Mineral Research,* 23(5), 741- 749, doi: 10.1359/JBMR.080102

Larson-Meyer, D.E., & Willis, K.S. (2010). Vitamin D and athletes. *Current Sports Medicine Reports,* 9(4), 220-226. doi: 10.1249/JSR.0b013e3181e7dd45

Lun, V., Erdman, K.A., Fung, T.S., & Reimer, R.A. (2012). Dietary supplementation practices in high-performance athletes. *International Journal of Sport Nutrition and Exercise Metabolism,* 22(1), 31-37. doi: 1543-2742

Maughan, R.J. (2005). Contamination of dietary supplements and positive drug tests in sport. *Journal of Sports Sciences,* 23(9), 883-889. doi: 10.1080/02640410400023258

Maughan, R.J., Burke, L.M., Dvorak, J., Larson-Meyer, D.E., Peeling, P., … Engebretsen, L. (2018). IOC consensus statement: dietary supplements and the high-performance athletes. *British Journal of Sports Medicine,* 52(7), 439-455. doi: 10.1136/bjsports-2018-099027

Maughan, R.J., Depiesse, F., & Geyer, H. (2007). The use of dietary supplements by athletes. *Journal of Sports Sciences,* 25(S1), S110-S113. doi: 10.1080/02640410701607395

Maughan, R.J., Shirreffs, S.M., & Vernec, A. (2018). Making decisions about supplement use. *International Journal of Sport Nutrition and Exercise Metabolism,* 28(2), 212-219. doi: https://doi .org/10.1123/ ijsnem.2018 -0009

Mathews, N.M. (2018). Prohibited contaminants in dietary supplements. *Sports Health: A multidisciplinary Approach,* 10(1), 19-30. doi: 10.1177/1941738117727736

Melendez-Rosado, J. Snipelisky, D., Matcha, G., & Stancampiano, F. (2015). Acute hepatitis induced by pure gaciniacambogia. *Journal of Clinical Gastroenterology,* 49, 449-450. doi: 10.1097/MCG.0000000000000303

Mettler, S., & Zimmermann, M.B. (2010). Iron excess in recreation marathon runners. *European Journal of Clinical Nutrition,* 64, 490-494. doi: 10.1038/ejcn.2010.16

McDermott, M.S., Oliver, M., Simnadis, T., Beck, E.J., Iverson, D., Caputi, P., & Sharma, R. (2015). The theory of planned behaviour and dietary patterns: A systematic review and meta-analysis. *Preventive Medicine,* 81, 150-156. doi: http://dx.doi.org/10.1016/j.ypmed.2015.08.020

Mcmahon, N.F., Michael, L., D., & Pavey, T.G. (2016). The effect of dietary nitrate supplementation on endurance exercise performance in healthy adults: A systematic review and meta-analysis. *Sports Medicine,* 47(4), 735-756. doi: http: //dx.doi.org/10.1007/s40279-016-0617-7

Nattiv, A., Kennedy, G., Barrack, M.T., Abdelkerim, A., Goolsby, M.A., … Seeger, L.L. (2013). A 5-year prospective study in collegiate track and field athletes. *The American Journal of Sports Medicine,* 41(8), 1930-1941. doi: 10.1177/0363546513490645

Nickerson, H.J., Holubets, M., Tripp, A.D., & Pierce, W.G. (1985). Decreased iron stores in high school runners. *American Journal of Disease of Children,* 139, 1115-1119.

Nieper, A. (2005). Nutritional supplement practices in UK junior national track and field athletes. *British Journal of Sports Medicine,* 39(9), 645-649. doi: 10.1136/bjsm.2004.015842

Outram, S., & Stewart, B. (2015). Doping through supplement use: A review of the empirical data. *International Journal of Sport Nutrition and Exercise Metabolism,* 25(1), 54-59. doi: 10.1123/ijsnem.2013-0174

Owens, D., Sharples, A.P., Polydorou, I., Alwan, N., Donovan, T., … Close, G.L. (2015). A systems-based investigation into vitamin D and skeletal muscle repair, regeneration, and hypertrophy. A*merican Journal of Physiology-Endocrinology and Metabolism,* 309, E1019-E1031. doi: 10.1152/ajpendo.00375.2015

Pawlak, R., Malinauskas, B., & Rivera, D. (2009). Predicting intentions to eat a healthful diet by college baseball players: Applying the Theory of Planned Behavior. J*ournal of Nutrition Education and Behavior,* 41(5), 334-339. doi: 10.1016/j.jneb.2008.09.008

Peeling, P., Binnie, M.J., Goods, P.S.R., Sim, M., & Burke, L.M. (2018). Evidence-based supplements for the enhancement of athletic performance. *International Journal of Sport Nutrition and Exercise Metabolism,* 28, 178-187. doi: 10.1123/ijsnem.2017-0343

Pyne, D.B., West, N.P., Cox, A.J., & Cripps, W. (2015). Probiotics supplementation for athletes – Clinical and physiological effects. *European Journal of Sport Science,* 15(1), 63-72. http://dx.doi.org/10.1080/17461391.2014.971879

Rawson, E.S., Miles, M.P., & Larson-Meyer, D.E. (2018). Dietary supplements for health, adaptation and recovery in athletes. *International Journal of Sport Nutrition and Exercise Metabolism,* 1-12. doi: 10.1123/ijsnem.2017-0349

Rehrer, N.J., Hellemans, I.J., Rolleston, A.K., Rush, E., & Miller, B.F. (2010). Energy intake and expenditure during a 6-day cycling stage race. *Scandinavian Journal of Medicine & Science in Sports,* 20(4). doi: 10.1111/j.1600-0838.2009.00974.x

Rowland, T. (2012) Iron deficiency in athletes. A*merican Journal of Sport Medicine,* 6(4). doi: 10.1177/1559827611431541

Rowland, T.W., Black, S.A., & Kelleher, J.F. (1987). Iron deficiency in adolescent endurance athletes. *Journal of Adolescent Health Care,* 8(4), 322-326. doi: 10.1016/0197-0070(87)90002-7

Ruohola, J.P., Laaksi, I., Ylikomi, T., Haataka, R., Mattila, V.M., … Pihlajamaki, H. (2006). Association between serum 25(OH)D concentrations and bone stress fractures in Finnish young men. *Journal of Bone and Mineral Research,* 21(9), 1483-1488. doi: 10.1359/jbmr.060607

Sassone, J., Muster, M., & Barrack. M.T. (2018). Prevalence and predictors of higher-risk supplement use among collegiate athletes. *Journal of Strength and Conditioning Research,* 0(0), 1-8. doi: 10.1519/JSC.0000000000002979

Siegler, J.C., Marshall, P.W.M., Bishop, D., Shaw, G., & Green, S. (2016). Mechanistic insights into the efficacy of sodium bicarbonate supplementation to improve athletic performance. S*ports Medicine,* 2(41). doi: 10.1186/s40798-016-0065-9

Smith, L.L. (2003). Overtraining, excessive exercise, and altered immunity. *Sport Medicine, 2*2(5), 347-364. doi: 10.2165/00007256-200333050-00002

Stuart, M.P., & Van Loon, L.J.C. (2011). Dietary protein for athletes: From requirements to optimum adaptation. *Journal of Sports Sciences,* 29(1). doi: 10.1080/02640414.2011.619204

Terjung, R.I., Clarkson, P., Eichner, E., Greenhaff, P.I., Hespel, P.J., … Williams, M.H. (2000). The physiological and health effects of oral creatine supplementation. *Medicine and Science in Sports and Exercise,* 32(3), 706-717.

Temple, N.J. (2013). The marketing of dietary supplements: A Canadian perspective, *Current Nutrition Reports,* 2, 167-173. doi: 10.1007/s13668-013-0057-z

Temple, N.J. (2017). The regulation of dietary supplements in Canada: Many promises but little progress. *Journal of Dietary Supplements,* 14(1), 117-120. doi: 10.1080/19390211.2016.1201719

Thomas, D.T., Erdman, K.A., & Burke, L.M. (2016). American college of sports medicine joint position statement. Nutrition and athletic performance. *Medicine and Science in Sports Exercise,* 32(12), 2130-2146. doi: 10.1249/MSS.0000000000000852

Thompson, C., Vanhatalo, A., Jell, H., Fulford, J., Carter, J., … Jones, A.M. (2016). Dietary nitrate supplementation improves sprint and high-intensity intermittent running performance. *Nitric Oxide,* 61, 55-61. doi: 10.1016/j.niox.2016.10.006

Trappe, T.A., Gastaldelli, A., Jozsi, A.C., Troup, J.P., & Wolfe, R.R. (1997). Energy expenditure of swimmers during high volume training. *Medicine & Science in Sports & Exercise*, 29(7), 950-954.

U.S. Food and Drug Administration. (2017, November 29). *Dietary Supplement Products & Ingredients* Retrieved from https://www.fda.gov/Food/DietarySupplements/ProductsIngredients/default.htm

Valentine, A.A., Schumacher, J.R., Murphy, J., & Jin Ma, Yoon. (2017). Dietary supplement use, perceptions, and associated lifestyle behaviors in undergraduate college students, student-athletes, and ROTC cadets. *Journal of American College Health,* 0(0), 1011. doi: https://doi.org/10.1080/07448481.2017.1377205

Van der Merwe, P.J., & Grobbelaar, E. (2005). Unintentional doping through the use of contaminated nutritional supplements. *South African Medical Journal*, 95(7), 510-511.

Wiens, K., Erdman, K.A., Stadnyk, M., & Parnell, J.A. (2014). Dietary supplement usage, motivation, and education in young Canadian athletes. *International Journal of Sport Nutrition and Exercise Metabolism,* 24(6), 613-622. doi: 10.1123/ijsnem.2013-0087

Wycherley, T.P., Moran, L.J., Clifton, P.M., Noakes, M., & Brinkworth, G.D. (2012). Effects or energy-restricted high-protein, low-fat compared with standard-protein, low-fat diets: A meta-analysis of randomized controlled trials. A*merican Journal of Clinical Nutrition*, 96, 1281-1298. doi: 10.3945/ajcn.112.044321

Zernicke, R., McNitt-Gray, J., Otis, C., Loitz, B., Salem, G., & Finerman, G. (1994). Stress fracture risk assessment among elite collegiate women runners. *Journal of Biomechanics,* 27(6), 854. doi: 10.1016/0021-9290(94)91484-2

8 Appendices

Appendix A: Recruitment Poster

UNIVERSITY of GUELPH

Department of Family Relations and Applied Nutrition

College of Social and Applied Human Sciences

VARSITY ATHLETES NEEDED FOR SUPPLEMENT USE RESEARCH

WHY? Explore dietary supplement use and beliefs among varsity athletes at the University of Guelph

WHO? Varsity athletes, who are enrolled as students at the University of Guelph and fluent in English

WHAT? As a participant in this study, you would be asked to complete, anonymously, an online survey, addressing your use of dietary supplements and factors contributing to their use. Your participation would involve 1 online session of approximately 20 minutes. Please note that once your answers are submitted, you cannot withdraw from the study because of its anonymized nature. In recognition of your time, you will receive a $5 online Starbucks gift card.

INTERESTED TO PARTICIPATE?

Go to the following link:

https://tinyurl.com/guelphsup

Or contact us at: guelphsupplements@gmail.com

This project has been reviewed by the Research Ethics Board for compliance with federal guidelines for research involving human participants (REB#18-08-007). If you have any questions about this study, or to volunteer for this study, please contact us at: Email: guelphsupplements@gmail.com. You do not waive any legal rights by agreeing to take part in this study. If you have questions regarding your rights and welfare as a research participant in this study (REB#18-08-007), please contact: Director, Research Ethics; University of Guelph; reb@uoguelph.ca; (519) 824-4120 (ext. 56606).

Dalia El Khoury, PhD (Principal Investigator); Assistant Professor, Family Relations and Applied Nutrition, University of Guelph; Email: delkhour@uoguelph.ca; Phone: 519-824-4120; extension: 56326

Appendix B: Qualtrics Questionnaire

UNIVERSITY of GUELPH

Department of Family Relations and Applied Nutrition

College of Social and Applied Human Sciences

Questionnaire

This survey aims to determine the prevalence and potential determinants of dietary supplement use among university students with different exercising habits. **This survey is anonymized** and will not be linked to your name or other unique identifiers. **The data that are collected through this questionnaire will be kept confidential**. Participation in completing this questionnaire is voluntary. You are free to decline to answer any questions you do not wish to answer, or stop participating at any time. It should take you approximately 15 minutes to complete this survey.

Section 1: Physical Activity Patterns

1. Are you a varsity athlete?

- ☐ No **(If no, please proceed to IPAQ (questions 1-8 in the questionnaire))**
- ☐ Yes **(If yes, please answer questions 2 and 3, then proceed to question 1 of section 2)**

2. If yes, which varsity team(s) are you on?

- ☐ Baseball
- ☐ Basketball
- ☐ Cross Country
- ☐ Field Hockey
- ☐ Figure Skating
- ☐ Football
- ☐ Golf
- ☐ Hockey
- ☐ Lacrosse
- ☐ Nordic Skiing
- ☐ Rowing
- ☐ Rugby
- ☐ Soccer
- ☐ Swimming
- ☐ Track & Field; please specify___________
- ☐ Volleyball
- ☐ Wrestling

3. If yes, how many hours are you training per week in total?

- ☐ 0-5 h
- ☐ 6-10 h
- ☐ 11-15 h
- ☐ 16-20 h
- ☐ 21-25 h
- ☐ > 25 h

Please answer the following questions 1-6 from the International Physical Activity Questionnaire (IPAQ).

Think about all the **vigorous** activities that you did in the **last 7 days**. **Vigorous** physical activities refer to activities that take hard physical effort and make you breathe much harder than normal. Think *only* about those physical activities that you did for at least 10 minutes at a time.

1. During the last 7 days, on how many days did you do vigorous physical activities like heavy lifting, digging, aerobics, or fast bicycling?

_____ days per week

- ☐ No vigorous physical activities **(Skip to question 3)**

2. How much time did you usually spend doing vigorous physical activities on one of those days?

_____ hours per day

OR

_____ minutes per day

☐ Don't know/Not sure

Think about all the **moderate** activities that you did in the **last 7 days**. **Moderate** activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal. Think only about those physical activities that you did for at least 10 minutes at a time.

3. During the last 7 days, on how many days did you do moderate physical activities like carrying light loads, bicycling at a regular pace, or doubles tennis? Do not include walking.

_____ days per week

☐ No moderate physical activities **(Skip to question 5)**

4. How much time did you usually spend doing moderate physical activities on one of those days?

_____ hours per day

OR

_____ minutes per day

☐ Don't know/Not sure

Think about the time you spent **walking** in the **last 7 days**. This includes at work and at home, walking to travel from place to place, and any other walking that you have done solely for recreation, sport, exercise, or leisure.

5. During the last 7 days, on how many days did you walk for at least 10 minutes at a time?

_____ days per week

☐ No walking **(Skip to question 7)**

6. How much time did you usually spend walking on one of those days?

_____ hours per day

OR

_____ minutes per day

☐ Don't know/Not sure

7. Please specify the type(s) of physical activity/sports that you engage in regularly (check all that apply).

☐ Baseball
☐ Basketball
☐ Cross-country
☐ Football
☐ Golf
☐ Hockey
☐ Lacrosse
☐ Nordic skiing
☐ Rowing
☐ Rugby

- ☐ Soccer
- ☐ Swimming
- ☐ Volleyball
- ☐ Track and field
- ☐ Wrestling
- ☐ Fitness Classes (e.g., dance, aquafit, boot camp, cycling, pilates, yoga, TRX)
- ☐ Strength training
- ☐ Biking
- ☐ Walking/jogging
- ☐ Other(s). Please specify ________________
- ☐ None

8. What are your main reasons for engaging in the selected physical activity choice(s) (check all that apply)?

- ☐ Competition
- ☐ Fitness
- ☐ General Health
- ☐ Leisure
- ☐ Occupation
- ☐ Commuting
- ☐ Other(s). Please specify ______________
- ☐ No specific reason

<u>Section 2: Dietary Supplements</u>

Dietary supplements are defined as "an orally consumed product intended to supplement one's diet".

1. Have you consumed a dietary supplement in the past 6 months?

- ☐ Yes **(If yes, please proceed to questions 2 to 7)**
- ☐ No **(If no, please proceed to question 8)**

For each of the categories of dietary supplements listed below (a-n), the following questions will be asked individually for each category:

a. **Vitamins/Minerals**
   - Vitamin D
   - Vitamin C
   - Vitamin B12
   - Iron
   - Calcium
   - Multi-vitamin/multi-mineral supplements
   - Other(s). Please specify _________

b. **Protein**
   - Whey protein
   - Casein protein
   - Soy protein
   - Creatine
   - Protein bars/powder/shakes
   - Other(s). Please specify_______

c. **Amino Acids**
   - Glutamine
   - Amino acids blend
   - BCAA (branched chain amino acids)
   - L-leucine
   - Other(s). Please specify_______

d. **Carbohydrate**
   - Sports drinks
   - Gels
   - Powders
   - Other(s). Please specify ___________

e. **Stimulants/Energy Boosters**
   - Energy drinks
   - Pre-workout supplements
   - Caffeine pills
   - Others(s). Please specify___________

f. **Non-Vitamin/Mineral Antioxidants**
   - Food polyphenols (e.g., quercetin, açaí)

- CoQ10
- Glutathione
- Other(s). Please specify_______

g. Fatty Acids
- Omega-3
- CLA (conjugated linoleic acid)
- Fish oil
- Other(s). Please specify ______

h. Herbs and Botanicals
- Gingko biloba
- Ginseng
- Echinacea
- Natural testosterone boosters
- Other(s). Please specify __________

i. Fat Burners/Weight Loss
- Diuretics
- Garcinia cambogia
- Green coffee bean extract
- Green tea extract
- L-carnitine
- MCT oil/powder
- Other(s). Please specify __________

j. Meal Replacements/Weight Gainers

k. Nitrates, Nitric Oxide, 'Pump', and Vasodilators (e.g., beetroot juice or powder, l-arginine, and citrulline malate)

l. Prebiotics and Probiotics

m. Digestive enzymes

n. Other unlisted supplement(s) Please specify_____________________

2. Have you consumed (insert category of dietary supplement (a-n)) supplements (insert examples within category) at any time in the past 6 months?

- ☐ Yes **(If yes, please proceed to questions 3 to 5 of that category)**
- ☐ No **(If no, please proceed to the next category)**

3. On average, how many times in a typical week do you consume (insert category of dietary supplement (a-n)) supplements?

- ☐ **Insert example(s) within category of dietary supplement and repeat for each example individually**
  - Don't use
  - ≤ 1 time per week
  - 2-3 times per week
  - 4-5 times per week
  - ≥ 6 times per week

4. For how long have you been using (insert category of dietary supplement (a-n)) supplements?

- ☐ **Insert example(s) within category of dietary supplement and repeat for each example individually**
  - < 1 month
  - 1-2 months
  - 3-5 months
  - ≥6 months

5. Please specify your reason(s) for using (insert category of dietary supplement (a-n) supplements:

- ☐ **Insert example(s) within category of dietary supplement and repeat for each example individually**
  - Correct or prevent micronutrients deficiencies
  - Maintain good health
  - Improve immunity
  - Improve mood and/or decrease stress

- Correct or prevent diseases
- Supply convenient forms of energy and/or macronutrients
- Serve as meal replacement
- Enhance competitive performances
- Increase energy
- Increase alertness and mental activity
- Support intense training regimens
- Promote recovery
- Alleviation of musculoskeletal pain
- Lose weight/decrease fat mass
- Gain weight
- Increase or maintain muscle mass
- Financial gain (sponsorship)
- "Just in case" insurance policy
- Know or believe that others (e.g., friends, athletes, competitors) use this supplement
- Other(s). **(If checked off for any example, the question below will be asked)**

Please specify your other reason(s) for using (insert category of dietary supplement (a-n):

____

6. What is/are your source(s) of your information regarding dietary supplements in general (check all that apply)?

- ☐ Health care professionals (e.g., physicians, team physicians, specialists, dietitians, sports nutritionists)
- ☐ Coaches
- ☐ Trainers
- ☐ Teammates or training partners
- ☐ Friends/Family
- ☐ Print (e.g., magazines, books)
- ☐ Internet
- ☐ Television
- ☐ National governing body
- ☐ Supplement companies
- ☐ Pharmacies
- ☐ Health food/Grocery stores
- ☐ My own judgment
- ☐ Other(s). Please specify __________________

Rank your sources of information regarding dietary supplements from the most used to the least used ones.

____

7. Do you tend to read the labels (nutrition facts, ingredients, etc.) on your dietary supplements?

- ☐ Yes **(If yes, please proceed to question 8)**
- ☐ No **(If no, please proceed to If "No" or "Sometimes", why?)**
- ☐ Sometimes **(If sometimes, please proceed to If "No" or "Sometimes", why?)**

If "No" or "Sometimes", why?

- ☐ I trust my source of information/I already know enough about my supplements
- ☐ I do not know how to read food labels
- ☐ I do not care about reading food labels
- ☐ No specific reason

8. To your knowledge, have you ever used any of these non-dietary supplements, anabolic steroids, injectable peptides, amphetamines, pro-hormones (steroid analogues) or ephedrine, in an exercising context?

- ☐ Yes. Please specify ____
- ☐ Not to my knowledge
- ☐ Prefer not to disclose

<u>Section 3: Cognitive constructs</u>

1. Please rate each of the following questions/ statements by choosing a value from the corresponding scale that best represents your position.

		Strongly Disagree	Disagree	Neither Disagree Nor Agree	Agree	Strongly Agree	Not Applicable
	Question	1	2	3	4	5	6
1	In the next 6 months, **I intend to** take or keep taking a dietary supplement to improve my performance and/or general health.						
2	In the next 6 months, **I plan to** take or keep taking a dietary supplement to improve my performance and/or general health.						
3	In the next 6 months**, it is very likely that I** will take or keep taking a dietary supplement to improve my performance and/or general health.						
4	I believe that using dietary supplements will improve my **performance.**						
5	I believe that using dietary supplements will improve my **physical appearance.**						

6	I believe that using dietary supplements will help me **maintain/achieve a balanced diet** for a **better general health.**						
7	I believe that dietary supplements are **safe.**						
8	My **immediate family (parents, brothers, sisters, grandparents, or significant others)** think I should use dietary supplements to improve my **performance, physical appearance or general health.**						
9	My **peers/friends** think I should use dietary supplements to improve my **performance, physical appearance or general health.**						
10	My **health care professional (e.g., physician or dietitian)** think I should use dietary supplements to improve my **performance, physical appearance or general health.**						
11	My **teammates or training partners** think I should use						

	dietary supplements to improve my **performance, physical appearance or general health.**						
12	My **coach or trainer** think I should use dietary supplements to improve my **performance, physical appearance or general health.**						
13	Whether I take or do not take dietary supplements from now on is **entirely up to me.**						
14	It is **easy** for me to take dietary supplements from now on.						
15	I have **complete control** over whether to take or not to take dietary supplements from now on.						
16	Whether I take or do not take dietary supplements from now on is **beyond my control.**						
17	My **immediate family (parents, brothers, sisters, grandparents, significant others)** regularly uses dietary supplements to improve performance, physical appearance or general health.						

18	My **peers/friends** regularly use dietary supplements to improve performance, physical appearance or general health.						
19	My **teammates or training partners** regularly use dietary supplements to improve performance, physical appearance or general health.						
20	My **coaches or trainers** regularly use dietary supplements to improve performance, physical appearance or general health.						

2. Have you ever experienced negative effects with dietary supplements? Please explain.

____
____
____

3. Which dietary supplements would you like to learn more about?

____
____
____

4. What would you like to learn related to these dietary supplements and in which format would you like this information to be delivered (e.g., consultations, presentations or the Internet)?

____
____
____

Section 4: Demographics

Your answer to questions in this section will help us interpret the survey results.

1. Gender

- ☐ Female
- ☐ Male
- ☐ Non-binary/third gender
- ☐ Prefer to self-describe ________________
- ☐ Prefer not to disclose

2. Date of birth (DD/MM/YYYY)

____

3. Which of the following BEST describes your ethnic background? Please TICK ALL THAT APPLY.

- ☐ Indigenous (Aboriginal/First Nations/Métis)
- ☐ White/European
- ☐ Black/Africa/Caribbean
- ☐ Southeast Asian (e.g., Chinese, Japanese, Korean, Vietnamese, Cambodian, Filipino, etc.)
- ☐ Arab (Saudi Arabian, Palestinian, Iraqi, etc.)
- ☐ South Asian (East Indian, Sri Lankan, etc.)
- ☐ Latin American (Costa Rican, Guatemalan, Brazilian, Columbian, etc.)
- ☐ West Asian (Iranian, Afghani, etc.)
- ☐ Other (please specify)
- ☐ Prefer not to disclose

4. Program Major

- ☐ Bachelor of Applied Science (B.A.Sc.)
- ☐ Bachelor of Arts (B.A.)
- ☐ Bachelor of Arts & Sciences (B.A.S)
- ☐ Bachelor of Bio-Resource Management (B.B.R.M.)
- ☐ Bachelor of Commerce (B.Comm.)
- ☐ Bachelor of Computing (B.Comp.)
- ☐ Bachelor of Engineering (B.Eng.)
- ☐ Bachelor of Landscape Architecture (B.L.A)
- ☐ Bachelor of Science (B.Sc.)
- ☐ Bachelor of Science in Agriculture [B.Sc.(Agr.)]
- ☐ Bachelor of Science in Environmental Sciences [B.Sc.(Env.)]
- ☐ Doctor of Veterinary Medicine (D.V.M.)
- ☐ Master's Program. Please specify _______
- ☐ Doctoral/Postdoctoral Program. Please specify _______
- ☐ Other(s). Please specify ________________

5. Parent(s) or guardian(s) highest level of completed education

- ☐ No diploma
- ☐ Secondary (high school) diploma or equivalent
- ☐ College certificate or diploma
- ☐ Bachelor's degree
- ☐ University diploma above bachelor's degree
- ☐ Other(s). Please specify ________________

6. Do you currently smoke cigarettes?

- ☐ No
- ☐ Previously, but I have stopped
- ☐ Yes
- ☐ Prefer not to disclose

7. Do you currently consume alcohol?

- ☐ No
- ☐ Previously, but I have stopped
- ☐ Yes. Please specify number of drinks per week __________.
- ☐ Prefer not to disclose ___________

Note: One drink equals: (12 oz.) bottle of 5% beer, cider, or cooler; 142 ml (5 oz.) glass of 12% wine; 43 ml (1.5 oz.) serving of 40% distilled alcohol (e.g., rye, gin, rum)

8. Do you have any physician-diagnosed medical conditions that you are currently managing? (e.g., high blood pressure, diabetes, depression)

- ☐ Yes

Please state the condition(s) _____________________

____

- ☐ No
- ☐ Prefer not to disclose

9. Self-reported weight

☐ __________ lbs

OR

☐ ___________ kg

☐ Prefer not to disclose

☐

10. Self-reported height

☐ __________ ft. __________ in.

OR

☐ ___________________ cm

☐ Prefer not to disclose

Thank you for your valuable information.

If you have any questions on this questionnaire, feel free to contact:

Dalia El Khoury, PhD (Principal Investigator)

Email: delkhour@uoguelph.ca

Phone: 519-824-4120; extension: 56326

Once you click on the "submit" button, you will be redirected to the gift card website in order to provide your email address if you wish to receive the gift card. The gift card website will not be linked to the data collected through the survey, and the research team will not have access to your email address. Your responses to the questionnaire will be anonymized; the research team will make no attempt to link the data collected to your identity.

https://uoguelph.eu.qualtrics.com/jfe/form/SV_3pFZdKWDABginFb

Appendix C: Consent Document

Department of Family Relations and Applied Nutrition

College of Social and Applied Human Sciences

Consent to Participate in Research

Prevalence and determinants of dietary supplement use among varsity athletes and non-athlete students at the University of Guelph

INTRODUCTION AND PURPOSE

The purpose of the study is to explore dietary supplement use and beliefs among varsity athletes and non-athlete students at the University of Guelph. This project is funded by the General Purpose Research Account (Start-up Fund) as well as by Seed Funding of the Principal Investigator, Dr. El Khoury, provided by the College of Social and Applied Human Sciences (CSAHS).

This study is conducted by Dr. Dalia El Khoury (Principal Investigator), Dr. Paula Brauer (Co-Investigator) and Dr. John Dwyer (Co-Investigator) from the Department of Family Relations and Applied Nutrition (FRAN), Dr. Margo Mountjoy (Co-Investigator) from the Health and Performance Center, Dr. Lawrence Spriet (Co-Investigator) from Human Health and Nutritional Sciences, and Karol-Ann Roy and Joel Hansen (Master's Students) from FRAN at the University of Guelph.

INCLUSION CRITERIA

You are eligible to participate in this research project if you are enrolled as a student at the University of Guelph, and fluent in English.

PROCEDURE

You are being asked to voluntarily complete this online survey, which should take about 20 minutes to complete. It involves questions about your physical activity patterns, your demographic and health characteristics, and your use, experience and perceptions of dietary supplements. In order for all your answers to be collected, you must go to the end of the survey and click 'submit survey'. This will demonstrate your full consent to participation. Data collected from this survey will later be analyzed by the two graduate students, Karol-Ann Roy and Joel Hansen, under the supervision of Dr. El Khoury.

POTENTIAL BENEFITS AND RISKS

While there are no direct benefits to you, there are important implications of this type of research. This study addresses the gap in the research regarding the use of dietary supplements by university students in Ontario, including varsity athletes as well as physically active and inactive students. Findings from this research will contribute to better understanding the supplement use behaviors and their determinants in these specific populations. Results from this project may be used to inform the university' policies about the supplementation practices among its students and help identifying any deficiencies in their knowledge about the risks and benefits of dietary supplements that need to be addressed. Findings from this study may be used to improve the counselling process in this field, and design more individualized health education messages around this topic.

There are minimal risks to your participation in this study. You may feel uncomfortable answering some questions. However, you do not have to answer questions you do not wish to answer, and you can stop participating at any time by closing your browser. Also, please rest assured that data collected in this study are low risk in nature because they are anonymized.

TOKEN OF APPRECIATION FOR PARTICIPATION

For your participation in the survey, you will receive a $5 online Starbucks gift card. You will be asked to click through to a new website in order to provide your email address, if you wish to receive the gift card. The gift card website will not be linked to the questionnaire's responses and the research team will not have access to your email address. Your responses to the questionnaire will be anonymized; the research team will make no attempt to link the data collected to your identity.

CONFIDENTIALITY

Data generated during this study will not be linked to personal identifiers. This survey is anonymized. We will not be linking information that will easily identify you, like your name or other unique identifiers, to the data. Please note that confidentiality cannot be guaranteed while data are in transit over the internet.

All data generated during this study will remain confidential. This survey is anonymized and as such will not be linking information that will easily identify you, like your name or other unique identifiers, to the data. The principal investigator and the graduate students will have their laptops password protected and/or encrypted for the study. The list of identifiers for the provision of the incentive will be stored on their encrypted laptops; faculty coinvestigators will not have access to the list of participants who received the incentive. The list of identifiers will be permanently deleted once all gift cards are distributed. De- identified data will be kept under lock and key at the University of Guelph campus for 5 years after the results of the study are published. After this 5-year period, the electronic data from this survey will be permanently deleted.

DISSEMINATION

The results of this study will be included in the thesis reports of the two M.Sc. Students Karol-Ann Roy and Joel Hansen and the undergraduate student Melanie Beck, will be presented at conferences and will be submitted for publication in scientific journals. A summary of the results from this study will also be published, for your reference, on the principal investigator's public profile on the University of Guelph webpage: https://www.uoguelph.ca/family/faculty/el-khoury-dalia by Summer 2019.

PARTICIPATION AND WITHDRAWAL

Your participation in this study is completely voluntary. You are free to decline to answer any questions you do not wish to answer or stop participating at any time by closing your browser. If you close your browser before getting to the end of the survey, and do not click the 'submit' button at the end of the survey to confirm your consent to participate, your information collected up to that point will not be used. Once the survey answers are submitted, you cannot withdraw from the study because the survey is anonymized; the researchers will not be able to determine which survey answers belong to you so your information cannot be withdrawn after the submission point.

YOUR RIGHTS AS A RESEARCH PARTICIPANT

Please remember that your participation in this study is completely voluntary and will not impact or have any consequences on your status at the University of Guelph. You can withdraw your consent at any point *up to* clicking the submit button at the end of the survey. If you have any questions about this study, feel free to contact us at guelphsupplements@gmail.com. Also, feel free to contact the principal investigator, Dr. Dalia El Khoury, at email: delkhour@uoguelph.ca and/or phone: 519-824-4120; extension: 56326.

This project has been reviewed by the Research Ethics Board for compliance with federal guidelines for research involving human participants.

If you have questions regarding your rights and welfare as a research participant in this study (REB#18-08-007), please contact: Sandra Auld, Director, Research Ethics; University of Guelph; reb@uoguelph.ca; (519) 824-4120 (ext. 56606)

SIGNATURE OF RESEARCH PARTICIPANT

I have read the information provided for the study "Prevalence and determinants of dietary supplement use among varsity athletes and non-athlete students at the University of Guelph" **as described herein.**

Please note, that by clicking submit at the end of the study you are providing your consent for participation. You are encouraged to print this consent document for your reference.

Appendix D: Additional Demographic Characteristics

Variables	N (%)
Ethnicity	
Indigenous	4 (1.3%)
White/European	245 (81.1%)
Black/Africa/Caribbean	11 (3.6%)
Southeast Asian	7 (2.3%)
Arab	3 (1.0%)
South Asian	4 (1.3%)
Latin American	3 (1.0%)
West Indian	2 (0.7%)
Other(s)	1 (0.3%)
Program of Study	
Bachelor of Applied Science	22 (7.3%)
Bachelor of Arts	55 (18.2%)
Bachelor of Arts & Sciences	7 (2.3%)
Bachelor of Bio-Resource Management	1 (0.3%)
Bachelor of Commerce	34 (11.3%)
Bachelor of Computing	3 (1.0%)
Bachelor of Engineering	21 (7.0%)
Bachelor of Landscape	3 (1.0%)
Bachelor of Science	109 (36.1%)
Bachelor of Science in Agriculture	4 (1.3%)
Bachelor of Science in Environmental Sciences	5 (1.7%)
Master's Program	12 (4.0%)
Doctoral/Postdoctoral Program	2 (0.7%)
Other(s)	2 (0.7%)
Parents/Guardians Education	
Secondary or below	28 (9.3%)
College	54 (17.9%)
Bachelor	110 (36.4%)
Above Bachelor	83 (27.5%)

Height, Weight & BMI	
Height	1.73 ± 0.10 m
Weight	69.74 ± 12.87 kg
BMI	23.14 ± 2.97 kg/m^2
Smoking Habits	
Yes	2 (0.7%)
Previously, but I have stopped	3 (1.0%)
No	273 (90.4%)
Prefer not to disclose	2 (0.7%)
Alcohol Intake	
Yes	181 (59.9%)
Previously, but I have stopped	25 (8.3%)
No	52 (17.2%)
Prefer not to disclose	21 (7.0%)
Medical Conditions	
Yes	41 (13.6%)
No	233 (77.2%)
Prefer not to disclose	4 (1.3%)

Note: Percentages may not add up to 100%, since some participants did not specify some demographic characteristics; Values are presented as (N (%)) where N is the number of athletes presenting with the characteristic and % is the percentage of athletes in the sample presenting with the characteristic.

Appendix E: Categorization of Varsity Teams at the University of Guelph into Sport Type

Sport Type	Varsity Teams (n)	Total # of Athletes (N)
Intermittent Sports	Basketball (11), Field Hockey (12), Lacrosse (19), Volleyball (26), Soccer (29), Golf (4), Baseball (5), Figure Skating (19)	125
Endurance Sports	Cross-Country (23), Swimming (23), Nordic Skiing (8), Rowing (22), Track and Field – Middle Distance & Distance (27)	79
Power Sports	Rugby (39), Football (4), Wrestling (14), Hockey (24), Track and Field - Sprints, Throws & Jumps (20)	96

n: number of athletes from each team; N: total number of athletes in each sport type

Appendix F: Prevalence of Use of Specific Types of Protein Supplements Based on Gender, Age, Training Hours and Types of Sport

	Gender			**Age**			**Training Hours**					**Type of Sport**			
	Male (N=86)	Female (N=196)	χ^2 p value	≤20 (N=144)	>20 (N=132)	χ^2 p value	≤10 (N=96)	11-15 (N=143)	16-20 (N=77)	≥21 (N=30)	χ^2 p value	Interm ittent (N=125)	Endur ance (N=79)	Power (N=96)	χ^2 p value
Protein:															
Whey	45.3%	29.1%	0.008	25.0%	44.7%	0.001	28.6%	34.3%	39.0%	36.7%	0.69	29.6%	25.3%	49.0%	0.001
Casein	4.7%	0.5%	0.03*	0.7%	3.0%	0.15	2.0%	0.0%	1.3%	10.0%	0.002	0.8%	2.5%	2.1%	0.60
Soy	3.5%	7.1%	0.24	7.6%	4.5%	0.29	8.2%	4.9%	7.8%	3.3%	0.68	8.0%	6.3%	3.1%	0.32
Creatine	19.8%	2.0%	<0.001	5.6%	9.1%	0.26	6.1%	9.8%	2.6%	13.3%	0.16	4.8%	3.8%	14.6%	0.008
Bars/ Powder/ Shake	40.7%	38.3%	0.70	31.9%	47.7%	0.007	36.7%	38.5%	39.0%	43.3%	0.95	36.8%	34.2%	44.8%	0.31

p-values < 0.05 represent significant differences between categories of a variable (gender, age, training hours and type of sport); N represents the number of athletes using protein supplements in categories of each variable; χ^2: chi-square test; *Fisher Exact Test

Appendix G: Prevalence of Use of Specific Types of Vitamins and Minerals Based on Gender, Age, Training Hours and Types of Sport

	Gender			**Age**			**Training Hours**					**Type of Sport**			
	Male (N=86)	Female (N=196)	χ^2 p value	≤20 (N=144)	>20 (N=132)	χ^2 p value	≤10 (N=96)	11-15 (N=143)	16-20 (N=77)	≥21 (N=30)	χ^2 p value	Intermittent (N=125)	Endurance (N=79)	Power (N=96)	χ^2 p value
Vitamins and Minerals:															
Vitamin D	16.3%	24.0%	0.15	20.1%	23.5%	0.50	24.5%	19.6%	23.4%	36.7%	0.24	18.4%	29.1%	24.0%	0.20
Vitamin C	19.8%	21.4%	0.76	20.1%	22.0%	0.71	22.4%	21.7%	22.1%	26.7%	0.95	22.4%	12.7%	30.2%	0.02
Vitamin B12	5.8%	12.2%	0.10	9.7%	10.6%	0.81	20.4%	7.0%	11.7%	20.0%	0.03	12.0%	11.4%	11.5%	0.99
Iron	12.8%	23.5%	0.04	17.4%	23.5%	0.21	22.4%	16.1%	23.4%	30.0%	0.27	16.8%	27.8%	18.8%	0.15
Calcium	5.8%	8.2%	0.49	5.6%	9.1%	0.26	8.2%	7.0%	7.8%	13.3%	0.72	8.8%	5.1%	9.4%	0.53
Multivitamin /Mineral	27.9%	24.5%	0.55	22.9%	27.3%	0.41	32.7%	23.1%	28.6%	26.7%	0.58	24.8%	22.8%	31.3%	0.39

p-values < 0.05 represent significant differences between categories of a variable (gender, age, training hours and type of sport); N represents the number of athletes using vitamins and minerals supplements in categories of each variable; χ^2: chi-square test

Appendix H: Prevalence of Use of Specific Types of Carbohydrates Supplements Based on Gender, Age, Training Hours and Types of Sport

	Gender			Age			Training Hours					Type of Sport			
	Male (N=86)	Female (N=196)	χ^2 p value	≤20 (N=144)	>20 (N=132)	χ^2 p value	≤10 (N=96)	11-15 (N=143)	16-20 (N=77)	≥21 (N=30)	χ^2 p value	Interm ittent (N=125)	Endur ance (N=79)	Power (N=96)	χ^2 p value
Carbohydrate:															
Sport Drinks	33.7%	31.1%	0.67	22.9%	41.7%	0.001	30.6%	30.8%	35.1%	36.7%	0.86	30.4%	31.6%	35.4%	0.72
Gels	1.2%	2.6%	0.67	2.1%	2.3%	0.91	2.0%	3.5%	0.0%	0.0%	0.28	2.4%	2.5%	1.0%	0.72
Powders	3.5%	9.2%	0.09	6.3%	9.1%	0.37	4.1%	9.1%	6.5%	10.0%	0.64	5.6%	11.4%	7.3%	0.31

p-values < 0.05 represent significant differences between categories of a variable (gender, age, training hours and type of sport); N represents the number of athletes using carbohydrate supplements in categories of each variable; χ^2: chi-square test

Appendix I: Frequencies (%) of Supplementation in Athletes Using Each Type of Dietary Supplements

	≤1 time/week	2-3 times/week	4-5 times/week	≥ 6 times/week
Dietary Supplements (N=176)	4.0%	25.0%	26.1%	44.9%
Protein (N=145)	18.6%	33.8%	24.1%	23.4%
Vitamins/Minerals (N=142)	12.7%	24.6%	22.5%	40.1%
Carbohydrate (N=109)	47.7%	45.9%	4.6%	1.8%
Stimulants (N=56)	46.4%	35.7%	5.4%	12.5%
Amino Acids (N=48)	22.9%	35.4%	27.1%	14.6%
Fatty Acids (N=31)	25.8%	29.0%	19.4%	25.8%
Prebiotics/Probiotics (N=26)	26.9%	34.6%	26.9%	11.5%
Meal Replacements/Weight Gainers (N=16)	50.0%	25.0%	6.3%	18.8%
Herbs/Botanicals (N=16)	56.3%	31.3%	0.0%	12.5%
Digestive Enzymes (N=10)	50.0%	30.0%	20.0%	0.0%
Non-Vitamin/Mineral Antioxidants (N=6)	33.3%	66.7%	0.0%	0.0%
Fat Burners/Weight Loss (N=4)	0.0%	25.0%	0.0%	75.0%
Nitrates, Nitric Oxide, “Pump”, and Vasodilators (N=3)	0.0%	66.7%	33.3%	0.0%

N refers to the number of athletes using each type of dietary supplement

Appendix J: Percentages of Athletes Using Vitamins and Minerals Supplements Selecting Each Reason Based on Gender, Age, Training Hours and Type of Sport

	Gender			Age			Training Hours					Type of Sport			
	Male (N=40)	Female (N=92)	χ^2 p value	≤20 (N=62)	>20 (N=68)	χ^2 p value	≤10 (N=24)	11-15 (N=66)	16-20 (N=41)	≥21 (N=13)	χ^2 p value	Intermittent (N=53)	Endurance (N=40)	Power (N=49)	χ^2 p value
General Health	92.3%	96.8%	0.36	93.5%	98.5%	0.15	87.5%	93.8%	95.1%	92.3%	0.69	90.6%	95.0%	94.0%	0.67
Convenience	10.3%	16.3%	0.37	16.1%	12.1%	0.51	16.7%	14.1%	9.8%	15.4%	0.86	13.2%	15.0%	12.2%	0.93
Direct Benefits to Performance	25.6%	48.9%	0.01	37.1%	47.0%	0.26	45.8%	37.5%	36.6%	61.5%	0.37	32.1%	52.5%	40.8%	0.14
Indirect Benefits to Performance	25.6%	37.0%	0.21	30.6%	36.4%	0.49	33.3%	32.8%	29.3%	46.2%	0.74	20.8%	45.0%	36.7%	0.04
Influence	5.0%	8.6%	0.72	8.1%	7.4%	1.0	4.2%	6.1%	9.8%	7.7%	0.83	9.4%	7.5%	3.9%	0.54
Just in Case	22.5%	18.3%	0.57	14.5%	23.5%	0.19	29.2%	26.7%	14.6%	15.4%	0.48	20.8%	10.0%	21.6%	0.30

Note: # of participants are not equal in all categories, since some participants did not specify some demographic characteristics; p-values < 0.05 represent significant differences between categories of a variable (gender, age, training hours and type of sport); N represents the number of athletes using vitamins and minerals supplements in categories of each variable; χ^2: chi-square test

Appendix K: Percentages of Athletes Using Protein Supplements Selecting Each Reason Based on Gender, Age, Training Hours and Type of Sport

	Gender			Age			Training Hours					Type of Sport			
	Male (N=48)	Female (N=90)	χ^2 p value	≤20 (N=59)	>20 (N=77)	χ^2 p value	≤10 (N=21)	11-15 (N=68)	16-20 (N=41)	≥21 (N=16)	χ^2 p value	Intermittent (N=57)	Endurance (N=35)	Power (N=54)	χ^2 p value
General Health	56.3%	37.8%	0.04	40.7%	46.8%	0.48	38.1%	42.6%	53.7%	37.5%	0.54	45.6%	34.3%	50.0%	0.34
Convenience	54.2%	70.0%	0.06	54.2%	72.7%	0.03	71.4%	61.8%	73.2%	56.3%	0.49	77.2%	62.9%	55.6%	0.05
Direct Benefits to Performance	54.2%	53.3%	0.93	54.2%	53.2%	0.91	71.4%	54.4%	48.8%	50.0%	0.38	49.1%	54.3%	61.1%	0.45
Indirect Benefits to Performance	83.3%	82.2%	0.87	83.1%	83.1%	0.99	81.0%	85.3%	78.0%	93.8%	0.50	77.2%	88.6%	87.0%	0.25
Influence	8.3%	7.8%	1.0	10.2%	6.5%	0.53	0.0%	8.8%	14.6%	0.0%	0.13	12.3%	11.4%	1.9%	0.10
Just in Case	8.3%	2.2%	0.18	5.1%	3.9%	1.0	4.8%	5.9%	0.0%	6.3%	0.47	3.5%	5.7%	3.7%	0.86

Note: # of participants are not equal in all categories, since some participants did not specify some demographic characteristics; p-values < 0.05 represent significant differences between categories of a variable (gender, age, training hours and type of sport); N represents the number of athletes using protein supplements in categories of each variable; χ^2: chi-square test

Appendix L: Percentages of Athletes Using Amino Acid Supplements Selecting Each Reason Based on Gender, Age, Training Hours and Type of Sport

	Gender			Age			Training Hours					Type of Sport			
	Male (N=19)	Female (N=23)	χ^2 p value	≤20 (N=20)	>20 (N=21)	χ^2 p value	≤10 (N=7)	11-15 (N=24)	16-20 (N=11)	≥21 (N=7)	χ^2 p value	Intermittent (N=16)	Endurance (N=11)	Power (N=22)	χ^2 p value
General Health	5.3%	17.4%	0.36	15.0%	9.5%	0.66	14.3%	12.5%	0.0%	14.3%	0.65	18.8%	9.1%	4.5%	0.36
Convenience	10.5%	17.4%	0.67	10.0%	19.0%	0.66	0.0%	20.8%	18.2%	14.3%	0.62	12.5%	18.2%	18.2%	0.88
Direct Benefits to Performance	73.7%	65.2%	0.56	75.0%	61.9%	0.37	42.9%	66.7%	81.8%	57.1%	0.38	50.0%	72.7%	72.7%	0.29
Indirect Benefits to Performance	78.9%	87.0%	0.49	85.0%	81.0%	1.0	71.4%	91.7%	72.7%	85.7%	0.41	75.0%	90.9%	86.4%	0.49
Influence	10.5%	4.3%	0.58	10.0%	4.8%	0.61	0.0%	4.2%	18.2%	0.0%	0.28	2.5%	9.1%	0.0%	0.26
Just in Case	5.3%	4.3%	1.0	10.0%	0.0%	0.23	0.0%	4.2%	0.0%	14.3%	0.45	0.0%	9.1%	4.5%	0.50

Note: # of participants are not equal in all categories, since some participants did not specify some demographic characteristics; N represents the number of athletes using amino acids supplements in categories of each variable; χ^2: chi-square test

Appendix M: Percentages of Athletes Using Carbohydrate Supplements Selecting Each Reason Based on Gender, Age, Training Hours and Type of Sport

	Gender			Age			Training Hours					Type of Sport			
	Male (N=32)	Female (N=68)	χ^2 p value	≤20 (N=38)	>20 (N=60)	χ^2 p value	≤10 (N=17)	11-15 (N=51)	16-20 (N=28)	≥21 (N=12)	χ^2 p value	Intermittent (N=40)	Endurance (N=30)	Power (N=38)	χ^2 p value
General Health	28.1%	17.6%	0.23	18.4%	21.7%	0.70	23.5%	17.6%	5.4%	2.3%	0.62	22.5%	16.7%	18.4%	0.81
Convenience	37.5%	48.5%	0.30	52.6%	41.7%	0.29	35.3%	39.2%	50.0%	58.3%	0.49	47.5%	56.7%	28.9%	0.06
Direct Benefits to Performance	59.4%	69.1%	0.34	71.1%	63.3%	0.43	64.7%	66.7%	67.9%	41.7%	0.40	70.0%	56.7%	63.2%	0.51
Indirect Benefits to Performance	65.6%	76.1%	0.27	65.8%	78.0%	0.19	52.9%	76.0%	71.4%	91.7%	0.12	80.0%	73.3%	64.9%	0.33
Influence	6.3%	5.9%	1.0	13.2%	1.7%	0.03	5.9%	9.8%	3.6%	0.0%	0.54	15.0%	0.0%	2.6%	0.02
Just in Case	0.0%	2.9%	1.0	2.6%	1.7%	1.0	0.0%	3.9%	0.0%	0.0%	0.52	5.0%	0.0%	0.0%	0.18

Note: # of participants are not equal in all categories, since some participants did not specify some demographic characteristics; p-values < 0.05 represent significant differences between categories of a variable (gender, age, training hours and type of sport); N represents the number of athletes using carbohydrate supplements in categories of each variable; χ^2: chi-square test

Appendix N: Percentages of Athletes Using Stimulant Supplements Selecting Each Reason Based on Gender, Age, Training Hours and Type of Sport

	Gender			**Age**			**Training Hours**					**Type of Sport**			
	Male (N=27)	Female (N=24)	χ^2 p value	≤20 (N=17)	>20 (N=33)	χ^2 p value	≤10 (N=10)	11-15 (N=31)	16-20 (N=11)	≥21 (N=4)	χ^2 p value	Intermittent (N=15)	Endurance (N=15)	Power (N=26)	χ^2 p value
General Health	14.8%	4.2%	0.35	17.6%	6.1%	0.32	0.0%	16.1%	9.1%	0.0%	0.45	13.3%	6.7%	11.5%	0.83
Convenience	18.5%	16.7%	1.0	11.8%	21.2%	0.70	0.0%	29.0%	18.2%	25.0%	0.27	33.3%	6.7%	23.1%	0.20
Direct Benefits to Performance	88.9%	95.8%	0.61	94.1%	90.9%	1.0	100.0%	90.3%	90.9%	75.0%	0.52	73.3%	100.0%	96.2%	0.02
Indirect Benefits to Performance	33.3%	33.3%	1.0	35.3%	33.3%	0.89	20.0%	29.0%	45.5%	100.0%	0.03	33.3%	26.7%	42.3%	0.59
Influence	0.0%	8.3%	0.22	5.9%	3.0%	1.0	10.0%	0.0%	9.1%	0.0%	0.33	6.7%	6.7%	0.0%	0.41
Just in Case	3.7%	4.2%	1.0	5.9%	3.0%	0.07	0.0%	3.2%	9.1%	0.0%	0.68	13.3%	0.0%	0.0%	0.06

Note: # of participants are not equal in all categories, since some participants did not specify some demographic characteristics; p-values < 0.05 represent significant differences between categories of a variable (gender, age, training hours and type of sport); N represents the number of athletes using stimulant supplements in categories of each variable; χ^2: chi-square test

Appendix O: Percentage (%) of Supplement Users (n=174) Selecting Each Source of Information Regarding Dietary Supplements

Sources of Information	% of Supplement Users
Health Care Professionals	59.2%
Friends/Family	53.4%
Internet	48.3%
My own Judgement	48.3%
Teammates/Training Partners	44.8%
Coaches	39.1%
Trainers	36.2%
Health Food/Grocery Stores	14.9%
Prints	10.3%
Supplements Companies	8.6%
Pharmacies	7.5%
National Governing Bodies	2.9%
Television	1.7%