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Factors influencing dietary supplements use help identifying athletes with risky behaviors

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Résumé

La consommation de suppléments alimentaires (DS) est répandue chez les athlètes et peut entrainer des conséquences telles que de faciliter la transition vers la consommation de substances prohibées ou échouer un contrôle anti-dopage causé par la consommation de DS contaminés. Une recherche utilisant des méthodes mixtes a été mené pour étudier le processus décisionnel sous-tendant la consommation de DS chez les athlètes. Dans la partie qualitative de l'étude, des athlètes universitaires (n=10) ont participé à des entrevues semi-structurées. L'analyse thématique des entrevues indique que les athlètes consommant des DS pour augmenter leurs performances sans obtenir les bénéfices escomptés seraient plus à risque de consommer des substances prohibées. Selon les données quantitatives (n=162), la prévalence de consommation des DS est élevée chez les athlètes et les hommes consommeraient plus de DS différents. La majorité des participants considéraient les nutritionnistes comme la source d'information la plus importante, mais peu d'entre eux (4%) ont utilisé leurs services. La participation d'athlètes élites à des entrevues semi-structurées (n=7) et à un questionnaire (n=36) dans le cadre d'une recherche préliminaire a permis une comparaison entre ces deux populations. Minimiser les risques susmentionnés pourrait être fait en ciblant les athlètes les plus vulnérables selon les critères suivants : 1) être un homme; 2) ne pas être inscrit dans un programme académique dans le domaine de la santé; 3) n'avoir jamais suivi de formation sur les DS; 4) consommer des DS pour améliorer ses performances sans obtenir les bénéfices escomptés ou 5) consommer plus de 3 DS différents.

Mots-clés : Méthodes mixtes, Dopage, Théorie du comportement planifié, Gateway Theory

Abstract

Dietary supplements (DS) consumption is widespread among athletes. Despite evidence-based benefits, DS have proven to represent a risk for transitioning toward prohibited substances and even failing an anti-doping test due to contamination. A sequential mixed-method research design was used to explore the factors affecting athletes' decision-making process underlying DS use. Varsity athletes (n=10) participated in semi-structured interviews that were thematically analyzed. In addition, a survey was conducted (n=162). Results indicated that athletes who consume DS to improve performance and experiencing little to no benefits could be more prone to transition toward prohibited substances. A high prevalence of DS use in varsity athletes was also observed (>90%), with males consuming more DS products. Nutritionists were ranked as the most importance source of information regarding DS; however, only 4% of athletes consulted one. A follow-up preliminary study conducted on elite athletes (semi-structured interviews: n=7; questionnaire: n=36) was also performed to compare those athlete populations. Minimizing DS consumption risks could be achieved by targeting the most vulnerable segment of the athletics population based on the following criteria: 1) being a male; 2) not being enrolled in a health program; 3) not having followed a DS workshop; 4) consuming DS to improve performance without experiencing significant improvements; or 5) consuming more than three different DS.

Keywords : Mixed-method, Theory of Planned Behavior, Gateway Theory, Doping

Table of contents

Résumé 5

Abstract 7

Table of contents 9

List of tables 11

List of abbreviations 13

Acknowledgment 15

Chapter 1 – Introduction 17

- Prevalence 19
- Benefits associated with dietary supplements consumption 20
- Risks associated with dietary supplements consumption 22
  - Physical adverse effects 22
  - Contaminated dietary supplements 23
  - Transition from dietary supplements to prohibited substances 24
- Reasons for using dietary supplements 24
- Factors influencing dietary supplements use 25
- Sources of information 27
- Theories used to study dietary supplements use 28
  - The Gateway Theory 28
  - The Theory of Planned Behavior 29
  - Additional theories 30
  - Theories used in the present research 30
  - Rationale of the study 31

Purpose of the study 32
Chapter 2 – Finalized manuscript (to be submitted to the Journal of Sport and Exercise Psychology) 33
Factors influencing dietary supplements use help identifying athletes with risky behaviors ... 33
Introduction 35
Methods 36
Results 38
Discussion 46
Chapter 3 – Discussion 55
References 63
Appendices 77
Varsity athletes' dietary supplements use habits description and factors describing this use . 77
Questionnaire description 81

List of tables

Table 1

Prevalence of dietary supplement consumption in male and female athletes

List of abbreviations

DS : Dietary supplements

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Chapter 1 – Introduction

Sports performances progressed swiftly in the last decades as illustrated by the tremendous improvement of different world records, such as the men 100m sprint world record which was lowered by 0.21 seconds during a 20 years span (World Athletics, 2020) or the men swimming 50 meter freestyle record which was lowered by 1.50 seconds over 24 years (FINA, 2020). This trend toward faster world records can be explained by various factors. Improvements in training methods can partly explain that progression (Lippi, Banfi, Favaloro, Rittweger, & Maffulli, 2008). Polarized training (Orie, Hofman, de Koning, & Foster, 2014) and block periodization (Issurin, 2010) are examples of such methods that were popularized in the last decades. Another factor that could explain some of the improvements seen in world records is the important development in training load monitoring which can be used to reduce injuries and improve performances (Bourdon et al., 2017).

However, this quest toward continuous improvements is also fueled by important changes in technology that affect sports performances. Full-body swimsuits, movable handles in rowing, fiber pole in pole vaulting and the use of hypoxic chambers are just a few examples of technological changes that had great impacts on sports performances. According to the research published by de Koning (2010), half of the progress of skating world records is attributed to technological changes. In his systematic review, Dyer (2015) identified many other technological changes that profoundly impacted sports performances.

The creation of multidisciplinary sports sciences teams surrounding the athletes also emerged in the last decades bringing its load of challenges and potential benefits (C. Reid, Stewart, & Thorne, 2004). The nutritionist often plays a role in those teams and works with the athletes to optimize performance and recovery through nutrition. In this context, dietary supplements (DS) came under the spotlight as an acceptable and efficient tool to improve performance.

DS in the context of elite sports have been extensively studied. However, comparisons between studies have often been limited due to the conflicting definitions of DS used by different research groups. Indeed, substances classified as DS varied among research groups and therefore

influenced reported results such as the prevalence and the perception of DS use among athletes. This issue and the methodological challenges it created are highlighted by Ina Garthe and Ronald J Maughan (2018). In their article, the definitions used by the US Food and Drug Administration and the somewhat similar definition used by the European Food Safety Authority are presented. Another definition that is widely used and recommended in the meta-analysis of Joseph J Knapik et al. (2016) is the definition proposed by the Dietary Supplement Health and Education Act (DSHEA) of 1994 which defines a DS in the following way: "… 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 botanicals, an amino acid, a dietary substance for use by man to supplement the diet by increasing the total daily intake, or a concentrate, metabolite, constituent, extract, or combinations of these ingredients." Health Canada does not provide a definition of dietary supplements, but it defined natural health products in its 2004 *Natural Health Products Regulations* (Health Canada, 2004) *as "*a substance set out in Schedule 1 [a list including mainly vitamins, mineral, herbal extracts and probiotic] or a combination of substances in which all the medicinal ingredients are substances set out in Schedule 1, a homeopathic medicine or a traditional medicine, that is manufactured, sold or represented for use in

a) the diagnosis, treatment, mitigation or prevention of a disease, disorder or abnormal physical state or its symptoms in humans;
b) restoring or correcting organic functions in humans; or
c) modifying organic functions in humans, such as modifying those functions in a manner that maintains or promotes health."

As mentioned by Ronald J Maughan et al. (2018), this definition does not depict accurately what a DS is since it mentions that it should be used in conjunction with a healthy diet which is not necessarily a sine qua non condition. This group of experts assembled by the Medical and Scientific Commission of the International Olympic Committee proposed the following alternative definition of a DS that is more complete: "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. Furthermore, we can recognize that dietary supplements come in many forms, including:

1. (a) Functional foods: foods, enriched with additional nutrients or components outside their typical nutrient composition (e.g. mineral- and vitamin-fortified, as well as nutrient-enriched foods)
2. (b) Formulated foods and sports foods: products providing energy and nutrients in a more convenient form than normal foods for general nutrition support (e.g. liquid meal replacements) or for targeted use around exercise (e.g., sports drinks, gels, bars)
3. (c) Single nutrients and other components of foods or herbal products provided in isolated or concentrated forms
4. (d) Multi-ingredient products containing various combinations of those products described above that target similar outcomes."

As suggested by Joseph J Knapik et al. (2016), the use of a common and standard DS definition would ease the comparisons between different studies and improve the knowledge around DS. The latest definition presented above is the one used in the present study.

Prevalence

In a study published in 2011, Bailey and al. reported that more than 50% of the American population consumed at least one DS while 10% of the population consumed more than five different DS. In a more recent study (2016), Kantor and al. revealed than 52% of the American adults consumed DS in the previous 30 days and they confirmed the historical stability in DS consumption and in the proportion of users consuming 4 or more different types of DS among the American population. Furthermore, according to McArdle (2018), in the United States only, the market size of DS exceeded 40 billion dollars in 2017. In 2026, the global market share of the DS industry is expected to reach 211 billion USD (Acumen, 2019). The situation is similar in Australia, where 43.2% of adults claimed to have used DS in the previous two weeks (O'Brien, Malacova, Sherriff, & Black, 2017). These results show that the use of DS is common among the general population.

The trend among athletes reflects the situation observed in the general population. Indeed, the data published in a meta-analysis published by Joseph J Knapik et al. (2016) showed that 70% of elite athletes use DS. In agreement with that number, a study conducted with Canadian athletes reported that 87% of athletes used DS (Lun, Erdman, Fung, & Reimer, 2012). Those athletes used on average three different DS products. Ina Garthe and Ronald J Maughan (2018) also reported a high level of prevalence among athletes, but they also report a high variability among different samples with a prevalence rate ranging between 40% and 100% highlighting the necessity of using a standardized DS definition and of interpreting the data in light of the context-specific situations. Maughan, Depiesse, and Geyer (2007) studied the prevalence of DS use among international track and field athletes participating at the World Championship and found that 85% of the respondents claimed to have consumed DS with some differences between genders and events. An older study on DS consumption in Canadian athletes during the Olympic Games reported that 69% of the athletes used DS during the Atlanta Games and 74% during the Sydney Games (Huang, Johnson, & Pipe, 2006). K. A. Erdman, T. S. Fung, and R. A. Reimer (2006) reported that 88% of Canadian elite athletes used DS in the previous six months. The prevalence reported by Giannopoulou, Noutsos, Apostolidis, Bayios, and Nassis (2013) was lower at 37%, but differences in the sample composition and the time frame considered relatively to studies previously mentioned may explain this different result.

Hence, widespread use of DS observed in the general population seems to be reflected and be even more important among elite athletes. Furthermore, considering the data presented above, there are no signs that DS consumption among elite athletes will decrease in the near future.

Benefits associated with dietary supplements consumption

Considering the widespread use of DS, one of the first questions that arise is whether DS provide evidence-based benefits that can be translated to performance improvements in athletes.

DS benefits on strength and lean mass increase have been extensively shown by various research groups (Kerksick et al., 2018; Peeling, Castell, Derave, de Hon, & Burke, 2019; Rawson, Miles, & Larson-Meyer, 2018). According to those researches, creatine, essential amino acids and protein all have been shown to increase power, strength and lean mass in an athletic population. In

addition, the use of sodium bicarbonate as an ergogenic aid to improve sports performance has also been studied in another meta-analysis (Peart, Siegler, & Vince, 2012). Sodium bicarbonate has been shown to lead to moderate improvement in performance in various sports such as cycling, swimming and running, but this improvement was much smaller when elite athletes were studied. Furthermore, the occurrence of gastrointestinal side effects is a factor to consider when using this substance.

Certain DS can also improve performances for athletes having specific deficits while providing little benefits for athletes without a deficit (Ronald J Maughan et al., 2018). For example, R. P. Heaney (2008) described the benefits provided by vitamin D supplements for people with a deficit. Larson-Meyer and Willis (2010) also mentioned the numerous negative impacts that a vitamin D deficiency among athletes can have on performance, such as decreased bone density and musculoskeletal pain and an increase in illness occurrences. Those symptoms could be alleviated with nutritional changes including supplementation. A study published in 2016 (Thomas, Erdman, & Burke) showed the benefits of iron supplementation among iron deficient athletes while also highlighting the benefits of calcium supplements on bone health for athletes with low energy availability.

Some DS, such as probiotics, have been shown to mitigate various health issues without providing further direct benefits to sports performance (Pyne, West, Cox, & Cripps, 2015). A recent review suggests that a thoughtful use of those DS could help the athletes in achieving higher sports performance (Francavilla, Bongiovanni, Todaro, Di Pietro, & Francavilla, 2017). This could be achieved by reducing the illness frequency or the severity of the symptoms associated with those illnesses.

Carbohydrate supplements in the forms of drinks, gel or candies have also been studied for benefits on sports performance as shown by various meta-analyses (McCartney, Desbrow, & Irwin, 2018; Pöchmüller, Schwingshackl, Colombani, & Hoffmann, 2016; Vandenbogaerde & Hopkins, 2011). According to those studies, carbohydrate supplementation improved time-to-exhaustion tests, time trials, mean power output and recovery. A recent review published by Ronald J Maughan et al. (2018) details the impacts of caffeine, nitrate, such as beetroot juice, and

beta-alanine supplements on sports performances while highlighting some possible side effects. It is also important to note that the benefits of the different DS previously mentioned are dependent on the duration of the event, the type of sport and the variability in individuals' responses to DS consumption. Therefore, the use of DS should be tailored to the individual's objectives, which can be influenced by the type of sports and its requirements.

In summary, the existing scientific literature supports the benefits provided by certain DS over performance and health when specific contexts and needs are met.

Risks associated with dietary supplements consumption

Physical adverse effects

As mentioned above, some DS have well-proven benefits for the athletes. However, these are not risk-free. Some DS have side effects that could counterweight their benefits. For example, it has been shown that caffeine supplements may lead to nausea (Ronald J Maughan et al., 2018) or jitters (Burke, 2008). Consuming large doses of caffeine supplements can also lead to sleep impairments, which could be detrimental to sports performances (Ronald J Maughan et al., 2018). Furthermore, caffeine withdrawal can cause headaches, fatigues and mood shifts (Graham, 2001). It is also important to note that there are important inter-individual differences in the effects of caffeine supplements, since some people are non-responders (Burke, 2008).

Sodium bicarbonate is another DS that has sports performance benefits supported by strong scientific evidence while at the same time having side effects that can be detrimental to performances. Gastrointestinal issues are a well-documented side effect associated with the consumption of sodium bicarbonate (Burke & Pyne, 2007). Even if some strategies have been proposed to reduce the likeliness of gastrointestinal problems, this side effect can limit the effectiveness of such a supplement in a real-world setting.

It is also important to keep in mind that the benefits provided by some DS apply in a certain context while they can impair performances in another sport setting. For example, creatine, as discussed above, can increase muscular strength and power. However, the use of creatine is also linked to a body mass increase mainly caused by water retention (Ronald J Maughan et al., 2018)

which could decrease sports performances where body mass plays an important role, such as distance running.

Furthermore, the swift development of new DS makes it hard to monitor effectively all the DS products on the market. Indeed, DS containing hydroxycitric acid had to be withdrawn from the market after they had direct impacts of health by causing liver toxicity, cardiovascular problems, and seizures (Ronald J Maughan et al., 2018) illustrating once again the risk associated with the consumption of DS. Dietary supplements containing ephedrine alkaloids adulterated were also banned from the market in 2004 by the US Food and Drug Administration due to their severe cardiovascular side effects (US Food and Drug Administration, 2004).

Contaminated dietary supplements

Apart from the side effects directly associated with certain DS, yet another risk faced by athletes using DS is the risk of consuming a DS contaminated with a substance banned by the World Anti-Doping Agency, which could lead to a positive anti-doping test results. In the recent years, many athletes who failed an anti-doping control test blamed it on tainted DS such as sprint legends Asafa Powell and Tyson Gay. However, unintended doping does not exempt the athlete of their responsibilities since the athlete is “strictly liable” for the consequences of a positive test caused by a mislabeled DS.

In a paper published in 2017 (Martínez-Sanz et al., 2017), it was reported that the rate of contamination among DS products ranged between 12% to 58%. Another report by Simon Outram and Bob Stewart (2015) found a rate of contamination varying between 10 and 15% of DS products tested. Furthermore, according to the same research group, between 6.4% and 8.8% of the positive doping control tests can be attributed to contaminated supplements. Even if the rate of DS contamination varies greatly among published reports, it remains high enough to represent a risk for the consumers.

Some tools were made available to the athletes in order to reduce the risk of consuming a contaminated DS product. One of the ways to manage this risk is to use DS products that are

certified by reliable independent third-party organizations, such as NSF International (Akabas et al., 2016). However, even if the products are certified, the athlete still bears the responsibility of a positive anti-doping test result. Furthermore, the costs associated with those certifications can be prohibitive for some smaller DS companies (Akabas et al., 2016). Therefore, certified supplements may not always be easily accessible.

Transition from dietary supplements to prohibited substances

Another deleterious aspect associated with the consumption of DS which was brought forward is the hypothesis that DS users would be more prone to use prohibited substances than athletes not consuming DS (S. Backhouse, Whitaker, & Petróczi, 2013; Lambros Lazuras, Vassilis Barkoukis, & Haralambos Tsorbatzoudis, 2015). Indeed, S. Backhouse et al. (2013) reported that DS users are significantly more likely to use prohibited substances than non-DS users. Furthermore, they found that DS users exhibited more positive attitudes toward doping while having greater beliefs that doping is effective. DS users were also more favorable of competing in an environment where doping was allowed. Without claiming a causal relationship between the use of DS and prohibited substances, other research teams also observed a greater use of prohibited substances among DS users (Fabio Lucidi et al., 2008; Papadopoulos, Skalkidis, Parkkari, & Petridou, 2006).

Reasons for using dietary supplements

Acknowledging the variety of benefits that can be provided through the consumption of DS while keeping in mind the associated risks, the rationale behind athletes' consumption can be multilayered.

Some reasons are commonly reported by athletes to justify their use of DS in the literature reviews. Increasing sports performance is obviously a reason that is often cited by athletes (Ina Garthe & Ronald J Maughan, 2018). However, athletes also provide more specific answers such as maintaining or increasing strength, increasing endurance and training load, and improving recovery (Ina Garthe & Ronald J Maughan, 2018). Those reasons mainly focus on improving performances, but other reasons were also cited to improve health. For example, avoiding

sickness, improving the immune system, preventing deficiencies or compensating for a poor diet are frequently reported reasons for consuming DS (Ina Garthe & Ronald J Maughan, 2018).

In the study published by Lun et al. (2012) with elite Canadian athletes, maintaining health and preventing nutritional deficiency were the most cited reasons for consuming DS followed by increasing energy and improving recovery. Those results are coherent with the data published earlier by Kelly Anne Erdman, Tak S Fung, and Raylene A Reimer (2006) who studied elite Canadian athletes as well.

Factors influencing dietary supplements use

Acknowledging the risks and the side effects associated with the consumption of DS, it would be interesting to target interventions toward athletes presenting higher probabilities of using DS. Various factors that influence DS use have already been identified and those factors would help build a profile of the athletes exhibiting higher odds of consuming DS. The impact of gender on DS use is conflicting among different studies (Erdman, Fung, Doyle-Baker, Verhoef, & Reimer, 2007). Joseph J Knapik et al. (2016) did not report significant differences between the prevalence of DS use among male and female. However, they indicated that even if the same proportion of males and females used DS, the types of DS used varied among genders. In addition, gender-related differences in the reasons why DS are consumed were observed by different research teams. Indeed, Joseph J Knapik et al. (2016) reported that male athletes claim using DS for strength and/or muscle mass gain more often than female athletes. This is in accordance with the results presented by Erdman et al. (2007) who also claimed that perceived or diagnosed medical deficiencies is a reason more often mentioned by females than males.

The athletes' level of performance also influences DS consumption as reported in many studies. Joseph J Knapik et al. (2016) reported a higher prevalence of DS use among elite athletes compared to non-elite athletes. Kelly Anne Erdman et al. (2006) and Giannopoulou et al. (2013) also reached the same conclusion when discriminating between athletes of different levels. As reported by Fréchette (2009), the difference between elite and non-elite athletes is not limited

to the prevalence of DS use, but also to the number of different DS consumed by a single athlete, which was on average of six different types of DS for elite athletes while it was only two for varsity athletes. The age of athlete also influences the probability of using DS as older athletes are more likely to use DS (Braun et al., 2009; Erdman et al., 2007; Maughan et al., 2007).

As one of the reasons mentioned for using DS is recovery (Erdman et al., 2007), some researchers hypothesized that the amount of time spent training could influence the use of DS. Giannopoulou et al. (2013) found that athletes with a higher training volume were more likely to use DS than athletes with lower training volume. This is in accordance with the results published by Lun et al. (2012) for elite Canadian athletes. Along these lines, Fréchette (2009) reported that athletes training more than 25 hours per week used on average seven different types of DS while athletes training between six to ten hours per week used on average two different types of DS.

Researchers were also interested in differences between athletes specialized in different types of sports. Lun et al. (2012) classified the sports as “power sports” (i.e., sprinting and ice hockey), which have long rest periods between effort bouts, “intermittent sports” (i.e., volleyball and basketball) that were more continuous than power sports, “judged sports” and “endurance sports”. According to their study, athletes in power and endurance sports were most likely to use DS. Giannopoulou et al. (2013) observed a difference between athletes in individual sports and team sports. A larger proportion of athletes practicing an individual sport consumed DS than the athletes involved in a team sport. Huang et al. (2006) also reported significant differences in DS consumption across different sports.

Education influences prohibited substance consumption patterns. Papadopoulos et al. (2006) highlighted the fact that a lower prevalence of prohibited substances consumption was reported in biomedical school as compared to non-biomedical school student-athletes. The researchers hypothesized that this could be due to their higher knowledge of health risks. If this hypothesis was true, this could influence how athletes with different academic background perceive and use DS as well. However, Kantor et al. (2016) showed that the use of DS was more common among people with a higher degree of education compared to less educated people in the general population. Dalia El Khoury et al. (2019) showed that being enrolled in the Bachelor of Applied

Science program was negatively associated with DS consumption. Conflicting results such as those present an opportunity to investigate the relation between education and the decision-making process of consuming DS and prohibited substances.

Sources of information

Another dimension worth considering is where do athletes get their information about DS. The resources available to athletes differ considerably depending on their level of performance and sports environment, which in turn could influence the range of information sources consulted by the athletes.

Braun et al. (2009), reported that the main sources of information used by athletes were family (34%), coaches (26%) and physicians (24%). Those results may not be surprising since the sample in that research consisted of young athletes (16.6 ±3.0 years of age). However, those results are in line with the ones published by Lun et al. (2012) who studied elite Canadian athletes and found out that the main information sources were family and friends (19.8%), strength trainers (13.5%) and teammates (10.8%). In the same study, only 6.7% of the athletes mentioned that they were concerned with the reliability of the information sources. Giannopoulou et al. (2013) reported that coaches (35%), physicians (29.5%), and nutritionists (15%) were the most cited sources of information. However, they also found that the information sources consulted by athletes were affected by the athletes' training volume, performance level and national team selection. Maughan et al. (2007) found that health professionals (53%), coaches (28%) and personal research (22%) were the most frequently reported information sources. The high reliance on health professionals in the aforementioned study can possibly be explained by the population studied which was track and field national team athletes who possibly have great access to such professionals. Those discrepancies in the preferred information sources highlight the fact that the sources used are context-specific and may be influenced by various factors.

Those conflicting results highlight the interest of obtaining more data in different contexts. Furthermore, the fact that even when reliable resources were available, athletes did not always

use them raise the issue of awareness among athletes. This hypothesis is coherent with the observation that even when nutritionists were available athletes preferred using other sources of information such as their coaches and their family or friends for reasons that could be as trivial as the physical appearance of the nutritionist (Lovell, Parker, & Slater, 2013).

Theories used to study dietary supplements use

Various theories have been used to study substances use. Some of those theories were used as foundations to research conducted on DS or prohibited substance consumption in sports. The Gateway Theory (S. Backhouse et al., 2013; Hildebrandt, Harty, & Langenbucher, 2012; Karazsia, Crowther, & Galioto, 2013), the Theory of Planned Behavior (S. Backhouse et al., 2013; Conner, Kirk, Cade, & Barrett, 2001; Dalia El Khoury et al., 2019; Fabio Lucidi et al., 2008; McDermott et al., 2015), the Social Cognitive Theory (O'Dea, 2003; Ring & Kavussanu, 2018; Zelli, Mallia, & Lucidi, 2010), and the Bioecological Theory (Johnson, 2011) are such examples. The present study relies on the Gateway Theory (Kandel, 1975) and the Theory of Planned Behavior (Ajzen, 1991).

The Gateway Theory

The Gateway Theory was developed by Kandel in 1975. Kandel studied the use of legal and illegal drugs among adolescents and observed a sequential pattern in which users start by consuming legal drugs such as alcohol or cigarettes and then move on to marijuana and other illegal drugs afterward. Wells and McGee (2008) showed that the stage process described above was seen among a large sample of participants in New Zealand. Other research teams found a similar transition between legal and illegal substances while specifying that the order of the stages could vary (Degenhardt et al., 2010; L. W. Reid, Elifson, & Sterk, 2007). Furthermore, external variables were shown to influence this transition, such as social norms (Mayet, Legleye, Falissard, & Chau, 2012), differences in access and attitude toward the legal drugs among countries (Degenhardt et al., 2010), the age of drug use onset (Degenhardt et al., 2010; L. W. Reid et al., 2007), and experiencing problems with police, friends and parents during childhood (Melberg, Jones, & Bretteville-Jensen, 2010). The study published by Nkansah-Amankra and Minelli (2016) showed inconsistent relations between the use of legal drugs and illegal drugs over longer periods during adulthood. Most of the aforementioned studies showed a relation between legal and illegal

substances use while highlighting the need to consider context-specific variables, such social norms, access to the drugs, childhood situation and age at the onset of drug use.

The Theory of Planned Behavior

The Theory of Planned Behavior was developed by Ajzen (1991) and represents an extension of the Theory of Reasoned Action (Fishbein & Ajzen, 1975, 1980). According to the Theory of Planned Behavior, behavior is dependent on individual's motivations (their intentions) and their perception of ability to produce such behaviors (perceived behavioral control). Intentions are influenced by one's attitude toward the behavior, subjective norms and perceived behavioral control as well.

According to Ajzen (1991), perceived behavioral control is similar to the Bandura's concept of self-efficacy (Albert Bandura, 1977, 1982) by representing individuals' judgment about how well they can produce the behavior required in certain situations. To produce a behavior, individuals have to believe that they have the resources and the volitional control to produce such a behavior. An illustration of this concept would be an athlete feeling knowledgeable enough about DS and being able to buy them, who could then decide to consume DS or not. The attitude toward the behavior represents the positive or negative evaluation of the behavior in question (Ajzen, 1991). For example, an athlete could display a negative attitude toward DS by associating their consumption with cheating. Generally, if an individual displays a favorable attitude toward a behavior, the intention to produce the behavior should be higher. Finally, subjective norms represent the perceived social pressure to produce the given behavior. For example, the influence of significant others, such as teammates or coaches, could influence the decision of an athlete to use DS.

Although this theory has been extensively used to study DS and prohibited substance consumption (Duncan & Hallward, 2019; Hurst, Kavussanu, Boardley, & Ring, 2019; Ntoumanis, Ng, Barkoukis, & Backhouse, 2015), it faced many criticisms (Sniehotta, Presseau, & Araújo-Soares, 2014) that led researchers to integrate additional components to the original theory to better understand the different variables influencing the decision-making process underlying substance consumption. For example, descriptive norms have been added to the traditional Theory of Planned Behavior to deepen the understanding of the social environment's influence

on DS consumption (S. Backhouse et al., 2013). Descriptive norms represent one's perception about the fact that other people perform a certain behavior. As an illustration of this concept applied to substances use, Andrea Petroczi et al. (2010) showed that the prevalence estimates of prohibited substances use among athletes was higher for self-confessed users of prohibited substances compared to non-users. This research team explained this difference with the False Consensus Effect where people involved in behavior that does not follow the accepted social norms rationalize their behavior by overestimating the proportion of people engaged in the same behavior (Petróczi, Mazanov, Nepusz, Backhouse, & Naughton, 2008).

Additional theories

As mentioned above, other theories have been used to understand the use of DS or prohibited substances among athletes. The Social Cognitive Theory (O'Dea, 2003; Ring & Kavussanu, 2018; Zelli et al., 2010) has been used to study how athletes develop moral norms from various sources, such observations of others, explicit directions, and reinforcement and punishment. The complex interactions between the actual behavior, personal factors, such as cognitions, and the social environment are studied to understand how athletes appraise a behavior and decide to produce it.

The Bioecological Theory, which was initially developed by Bronfenbrenner (2001), has also been used to explore substances consumption (Johnson, 2011). This theory suggests that an individual's decision to consume prohibited substances is influenced by the interactions between his feelings, appraisal of the behaviors produced and his thoughts. However, the theory posits that those components depend on the person's genotype which comes from his biological parents. Therefore, the individual's development over time represents both the influence of the social environment and biological development.

Theories used in the present research

In the current research, the combination of the Theory of Planned Behavior and the Gateway Theory provides a theoretical framework to understand the decision-making process underlying DS consumption and the relationship between DS and prohibited substances use as well. As mentioned earlier, various research teams (S. Backhouse et al., 2013; Fabio Lucidi et al.,

2008; Papadopoulos et al., 2006) showed that DS users were more likely to consume prohibited substances by sharing more favorable attitude toward prohibited substances or by displaying descriptive norms that suggest that DS users would be more lenient toward prohibited substances. However, it is important to mention that doping behaviors are context-specific and need to be considered as part of a culture which can change in function of the events and demands faced by the athletes during their career (Denis Hauw, 2013).

Rationale of the study

The high prevalence of DS use among both recreative and elite athletes and the risks associated with such consumption highlight the importance of expanding our understanding of the decision-making process of consuming DS. Furthermore, the wide variety of information sources used by athletes and the various factors influencing DS consumption suggest that this process can only be fully understood if the specific social context in which the athletes evolved is considered. This is demonstrated by the conflicting results reported in studies where the age, the level, the nationality, the gender and the sport of the athletes differ.

Those conflicting results also highlight the need to have a research design complete enough to identify the sources of those discrepancies and to verify if they are present in a large sample of athletes. Many of the studies cited above such as those published by Goulet, Valois, Buist, and M. (2010) and F. Lucidi, Mallia, and Zelli (2015) relied extensively on questionnaires to collect information on DS consumption among athletes. Through the use of questionnaires, those researchers have been able to study large samples of athletes, but the use of questionnaires limit the in-depth understanding of the participants' experience by limiting their answer to the themes included in the questionnaires (F. Lucidi et al., 2015). Furthermore, the large variability in the results reported by studies using questionnaires highlight the need to include additional tools to understand this variability's sources. Not as popular as quantitative research, qualitative research has still been used in the last few years to study prohibited substances consumption and the mechanisms underlying this consumption among athletes (Boardley, Grix, & Harkin, 2014). The generalizability of the results provided by those studies is limited by the small size of the samples

used in those studies. Therefore, a mixed-methods study appears as an alternative combining the advantages of quantitative and qualitative studies while offsetting the respective drawbacks.

Purpose of the study

Supported by the aforementioned theoretical framework, the purpose of the present mixed-methods study is to collect information about DS consumption among Canadian varsity and elite athletes in order to better understand the decision-making process underlying DS consumption among athletes and the risky behaviors associated with this phenomenon. Improving the knowledge surrounding DS consumption could offer practitioners useful tools to ensure that DS are used effectively and safely by athletes to optimize their performances and improve their health. The results provided by such a research could also guide sport federations and governmental organizations in developing educational programs to minimize the risks associated by DS consumption, such as experiencing adverse side effects or transitioning toward prohibited substances.

The following chapter features the research article that will be submitted for publication whose research population was varsity athletes. It is followed by a general discussion in which comparisons to elite athletes are made on the basis of preliminary data of an ongoing study.

Chapter 2 – Finalized manuscript (to be submitted to the Journal of Sport and Exercise Psychology)

Factors influencing dietary supplements use help identifying athletes with risky behaviors

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Abstract

Despite evidence-based benefits, dietary supplements (DS) use has proven a risk for transitioning toward prohibited substances or even failing an anti-doping control test due to contamination. A sequential mixed-method research design was used to explore the factors affecting the decision-making process underlying the use of DS. Varsity athletes (n=10) participated to semi-structured interviews and/or completed a survey (n=162). The interviews were thematically analyzed and the survey support the analysis. Our main findings indicate that the following factors are associated with risky DS consumption: 1) being a male; 2) not being enrolled in a health-related university program; 3) not having received education regarding DS; 4) not having experienced significant benefits while consuming DS; 5) consuming creatine and/or 6) consuming more than 3 different DS. Targeting the most vulnerable segment of this population based on those identified factors could prove effective to reduce DS consumption risks.

Key words: Mixed-methods, Theory of Planned Behavior, Gateway Theory, Doping

Introduction

Dietary supplements (DS) are defined 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"* (R. J. Maughan et al., 2018). The use of DS has spread among the general public with the market size increasing quickly (McArdle, 2018; O'Brien, Malacova, Sherriff, & Black, 2017). DS consumption is striking among elite athletes as well with 70% of this population consuming DS (J. J. Knapik et al., 2016), a rate that has been surpassed by Canadian athletes among whom the reported consumption of DS rises to 87% (Lun et al., 2012). While some DS have well-proven benefits sought by elite athletes (e.g., increasing exercise time to fatigue, power output, strength and lean mass), their use is not risk-free. Indeed, certain DS may have long-term negative effects on health (R. J. Maughan et al., 2018) and may even lead to positive doping tests due to contamination with prohibited substances (S. Outram & B. Stewart, 2015). Moreover, following the premises of the escalation hypothesis based on the Gateway Theory (Kandel, 1975), evidence suggests that DS consumption could lead to doping (S. H. Backhouse, Whitaker, & Petroczi, 2013; Barkoukis, Lazuras, Lucidi, & Tsorbatzoudis, 2015; L. Lazuras, V. Barkoukis, & H. Tsorbatzoudis, 2015).

To gain a better insight of the athletes' decision-making process regarding the use of DS and prohibited substances, some researchers used the Theory of planned behavior (Ajzen, 1991). According to this theory, an individual's intention is the better predictor of enacted behavior and is modulated by attitude (e.g., appraisal of a given behavior), subjective norms (e.g., perceived social pressure exerted by significant others), and perceived behavioral control (e.g. the perception of how well an individual can perform a volitional behavior). Regarding doping, athletes' attitudes and perceived behavioral control were found to be associated with their intention to use prohibited substances (Goulet et al., 2010; L. Lazuras et al., 2015). While enlightening, these studies have mostly relied on questionnaires that constrained participants' responses to stipulated options, which may have limited unveiling alternative explanations (F. Lucidi et al., 2015) and capturing participants' viewpoints (D. Hauw, 2013). Furthermore, the data collected via questionnaires often present high variability within published work because of the

specificity of the studied populations thereby limiting their generalizability (J. J. Knapik et al., 2016).

Qualitative research emerged as an alternative to counteract the limitations pointed out above. For example, Boardley et al. (2014) conducted a study in which they exemplified how moral disengagement mechanisms were implemented by athletes consuming prohibited substances. Aligned with the Gateway theory (Kandel, 1975), some athletes acknowledged a transition from DS to prohibited substances when experiencing plateaus in training performances (Boardley et al., 2014). Also, this study portrayed how athletes handled close networks' influence and to whom they confided their doping behavior. Thus, qualitative research allowed to better depict human agency (A. Bandura, 2006).

The widespread use of DS among athletes, their possible performance benefits, the risks of contamination and/or adverse side effects altogether highlight the importance of studying DS consumption. With the purpose of better understanding the factors associated with the decision-making process underlying DS consumption in varsity athletes, a mixed-methods study was designed.

Methods

Study design

A sequential mixed methods study was designed (QUAL → QUANT) (Teddlie & Tashakkori, 2009), to thoroughly study DS consumption (F. Lucidi et al., 2015; Petróczi, 2013). This approach was used to get a deeper understanding of athletes' perception toward DS use in order to build a tailored questionnaire applicable to a larger population. The present study was reviewed and approved by the university ethics research council.

Qualitative data

Participants and data collection procedures. Following the exploratory nature of the study, varsity athletes from the swimming and the track and field team, two individual sports

teams that were available at the time the study was conducted, were recruited. Open-ended semi-structured interviews (Kvale & Brinkmann, 2009) were conducted to collect information related to the participant's sports background (i.e., sports experience, environment, goals), explore participant's viewpoints of DS (i.e., perceived reasons and risks of using DS, potential link between the use of DS and prohibited substances) and the influence of the athletes' social environment on their consumption of DS. The interview guide is available in the supplementary material section. The interview was piloted with one athlete and adjustments were done to ensure the flow of the conversation.

Data analysis. Interviews were transcribed verbatim and an exploratory analysis (Guest, MacQueen, & Namey, 2012) was conducted. Each interview was read and key segments that responded to the research interest were identified by SM. Guided by the Theory of Planned Behavior (Ajzen, 1991), Lazuras' work (L. Lazuras et al., 2015) and the Gateway Theory (Kandel, 1975), SM supported by SP, developed a preliminary coding system looking at identifying a possible relationship between DS and prohibited substances. RB and MLP double-coded, compared, and discussed the coding system. The inter-observer reliability was validated with an 88.7% inter-coder agreement followed by a 95% back-coding agreement that was carried out by SM. The analysis of the interviews was supported by MaxQDA software (VERBI GmbH, Germany, version 2018.2).

Quantitative data

Participants and data collection procedures. A convenience sampling technique (Teddlie & Yu, 2007) was used. After having obtained the agreement of the coaches, all varsity athletes from the university were invited to volunteer for this study by responding to a questionnaire.

Evidence coming from the interviews deemed to be crucial to assess reasons underlying DS consumption at a larger scale was used to develop the questionnaire. The qualitative data was used to identify the information needed during the quantitative phase of the research. Therefore, questionnaires used by previous research teams and new items were integrated to develop the questionnaire used in the current research. The questionnaire included the following four main sections that aimed at assessing key features of DS consumption: 1) *socio-demographic and sports*

background information: including items based on the questionnaire used by Erdman, Fund and Reimer (2006) 2) *participant's use of DS*: including items based on the aforementioned questionnaire and additional items to assess the quantity, frequency and yearly variations of the different DS consumed, retail sources used, perceived authenticity of DS, impact of stopping DS consumption, the sources of information and the social pressure perceived by the participants; 3) *perception of prohibited substances*: including the French Performance Enhancement Attitude Scale (PEAS) validated earlier by Hauw, Crettaz von Roten, Mohamed, and Antonini Philippe (2016), as well as two items on the perceived prevalence of prohibited substance consumption, which reflect descriptive norms (R. B. Cialdini, R. R. Reno, & C. A. Kallgren, 1990); and 4) *knowledge of DS:* including 11 items previously validated (Trakman, Forsyth, Hoye, & Belski, 2017) and four items added by the present research group to evaluate participants' knowledge of DS. A more detailed description of the questionnaire is available in the supplementary material section.

Data analysis. Questionnaires' data was checked for normality using the D'Agostino & Pearson-K squared test. Results guided the decisions about the use of parametric or nonparametric statistical tests to analyze the data. The Mann-Whitney-Wilcoxon Test was used to compare difference in the Performance Enhancement Attitude Scale (PEAS) score (Petróczi & Aidman, 2009) and Likert scales while chi-squared test was used to compare frequency of DS users in relationship to gender, academic programs and other variables. For normally distributed data such as knowledge score, Student's T-test was used to compare categorical variables (e.g., gender and DS use). The data analyses were performed using the open-source software "*R*" (RStudio, version 1.2.5033).

Results

Participants' characteristics

The interviewed participants were varsity athletes (N=10; n=5 men, n= 5 women; age: 22.5±5.5 years) from the swimming and track and field varsity teams. All the interviews were conducted in French. Questionnaire respondents (N=162) were members of varsity teams

representing nine different sports. Four respondents were excluded because they were under the age of eighteen. A table describing the participants' characteristics is available in the supplementary materials section.

Participants' perception of DS consumption

The interviews, conducted in a private room at the university to avoid distractions, lasted on average 40 minutes. Seven (out of 10) participants consumed DS in the twelve months before the interview whereas none of them declared using prohibited substances. Featured quotes exemplify athletes' perceptions of DS consumption. Pseudonyms are used to preserve athletes' confidentiality.

"If it helps, why not trying it?" Athletes mentioned a large variety of reasons to consume DS, such as improving recovery or performance, avoiding nutritional deficits, easing recovery from injuries, limiting weight loss, or enhancing alertness. All these reasons responded to a main goal: DS are worth taking if they improve athletes' health or performance. Athletes shared that using DS and experiencing little or no benefits could lead athletes to stop using DS or transition toward prohibited substances in order to fulfill their objectives depending on their attitude toward prohibited substances and how they perceive them in relation to DS. They added that consuming DS for a reason that can be fulfilled using prohibited substances, such as performance improvement, could increase the likelihood of this transition. Indeed, improving sports performance through DS consumption would then ease the use of prohibited substances which would be considered as the next step to improve performances. Consuming DS to improve health or performance was worded by Lisa as follows: "That's why I take supplements […] which can probably improve my global health and my physical health." On the contrary, Brian mentioned: "Clearly, recovering... it's the main reason. BGL [name of another supplement], it's really for my performance during training and competitions."

After using DS, athletes evaluated the gap between the effects of DS consumption versus their expectations. A mismatch resulting from this comparison led athletes to stop using DS, as stated by Laura: "[…] I didn't feel... I didn't see any results showing that it was beneficial or harmful." Athletes also mentioned that an alternative response would be to consider

transitioning toward prohibited substances. For example, Jennifer mentioned the following: “Personally, I think that if an athlete sees a big difference when he takes supplements, he might be tempted to take something else […] if at a certain point he sees that it [supplement] doesn’t do anything anymore.” Paul shared a similar point of view: “I cut 0.4 [seconds] over 50m. What is the next step?” Daniel also communicated the same idea: “You see that supplements help you. So why not try the other thing [prohibited substances] as well?”

Building on this idea, athletes mentioned that the reason behind DS use could ease or impede the transition toward prohibited substances. Nancy said: “I guess, it depends on why you take it [talking about the probability of an athlete transitioning from DS to prohibited substance]. If it’s to solve a problem, I would say no... but if it’s really to improve your performance, I would say yes.” Lisa also mentioned the idea that being motivated only by performance could lead an athlete toward prohibited substances: “[…] when the athlete becomes so focused on sports performance […] I think that it can lead […] to wanting to try something else to be the best and be at the top.” Daniel exposed the same dichotomy between health and performance: “For sure in sports, performance is the objective to follow. Some athletes will do anything to reach it, even harm their health.” According to the interviewed participants, athletes who highly value performance and choose to consume DS to improve it would be more likely to transition toward prohibited substances.

Performing without cheating. The attitude held toward DS seemed to differ between DS consumers and non-consumers. The former, generally, considered DS merely as any other tools to improve performance while non-users raised concerns about their safety and their adverse side effects and reported having negative perception of DS. This different perception of DS between DS users and non-users was not reflected in their perception toward prohibited substances. Indeed, both DS users and non-users shared common concerns and negative views toward prohibited substances.

Daniel, a DS user, mentioned “Basically, according to the list, if it’s legal, well... it’s legal. It is not us who decide what is legal or not. So, as long as it’s legal and you consume... and it’s good for your health, well... I think it’s correct.” However, non-DS users, shared concerns about the

consequences of DS use. For instance, Michelle illustrated how the contamination risk influences how she considers DS: "[…] That's what is a little scary. Now, I don't know... We take supplements, but how much we do have to take and what do we have to take is really difficult here." In addition, Laura added that there is a negative connotation surrounding DS: "There seems to be a negative aspect to the word dietary supplement […] I have the impression that we... Well, that I perceive it negatively." Laura and Michelle also mentioned the possibility that DS might cause negative changes, such as unwanted weight gain, as a reason for holding doubts and fears toward DS.

However, both DS users and non-users shared similar concerns toward using prohibited substances. Indeed, Brian, a DS user, mentioned that "[…] I think that it's a big line to cross... The gateway is not as if... I don't think that it's the same thing as recreational drugs and harder drugs." Lisa, a DS user as well, mentioned the difference in the magnitude of the substances' effects to illustrate the differences between DS and prohibited substances: "It [DS] doesn't have an impact as important as prohibited substances […] I know that it is not because of that that I perform well. I'm able to make the distinction between the two. As for prohibited substance, it is not banned for anything […] it can give an advantage to certain athletes and that's why I don't want to try this."

The tremendous social environment's influence on the athlete. Most athletes shared having received pressure from their social environment to consume DS; however, they disagreed on how this pressure influenced their behavior. Athletes mentioned that perceiving prohibited substance consumption as a common behavior from members of their social environment could ease the transition toward using them. They also mentioned the team's role in providing an athlete with the means to dope effectively and safely without getting caught; nevertheless, athletes' personal or moral norms were also mentioned as having an impact on the probability of this transition.

While some athletes shared that their coaches insisted that they should consume DS (e.g., "By obligation […] from one of my coaches." [Laura]); other athletes explained that this was not their case (e.g., "My coach will never coerce me to take some [DS]. He explains that it's really up to me, that it's my decision that he respects totally, but also that it cannot harm me. He strongly

advises them." [Lisa]). We can see though, that the coach's words tend to be heard, even if they are not aligned with the athlete's position. Thus, receiving pressure from the social environment to consume DS could lead athletes to engage in prohibited substances consumption, a fact confirmed by Richard:

> If it's really your coach and your entourage that force you to take it [DS] and you don't really know why, then yes, you could stray away and take stuff like that [prohibited substances].

Nancy completed this idea by saying the following: "Personally, I would say to educate the staff more than the athletes because I think that it would be more effective […] in order for drugs non-consumption to be the norm."

Athletes also mentioned the impact of indirect social pressure on the decision to use prohibited substances. Daniel explained that believing that other athletes use prohibited substances could lead them to do the same: "Maybe if you see competitors who take some [prohibited substances], well you tell yourself if he takes some why shouldn't I in order to level the field to try to compete against them." Furthermore, some athletes shared a pragmatic point of view by explaining that doping effectively and safely is nearly impossible without the help of a well-developed support team knowledgeable about prohibited substances: "At the international level, I think that it is essential for someone who dopes to be supervised regarding the use of [prohibited] substances and for the training planning around the use of those substances... So, it's really the environment, which has a much bigger role than the athlete who just follows what he's being told. His role is to perform in competition and train." (Edward). Along those lines, another athlete mentioned: "[…] You need a huge organization, because no one will dope thinking that he will be caught the day after, that is for sure." (Brian).

Finally, athletes referred to the interaction between their personal (moral) norms and their decision-making process. For example, Daniel said the following: "It all depends on your entourage and your values." Lisa added: "I believe that it [consuming prohibited substances] removes all the merit and I would tell myself... that all the work I do, all the training sessions, all

the effort I put in, in the end, it is not because of that that I perform well. It's because of the substance I take. So, I don't want to... I don't want my sport to become that […]"

Athletes' sport background

Out of the 158 eligible participants who completed the questionnaire in approximately 25 min, 51% were females. Athletes have been competing for 8.5±4.2 years and most trained between 11 and 15 hours weekly. Most athletes (86%) competed at the provincial and national level while the remaining competed internationally (14%). Most of the athletes (67%) practiced a team sport while the remaining practiced either an individual sport (28%) and a small proportion practiced tennis (4%) which was analyzed separately due to its possible individual or dual nature.

Dietary supplements consumption habits. More than ninety percent (143/158) of varsity athletes reported having consumed DS in the last twelve months. The prevalence was similar between males (89.6%) and female athletes (91.4%). Even when highly popular sport drinks were withdrawn from the descriptive statistics analyses, the prevalence of DS users still reached 84.8%. However, the different types of DS consumed was higher in males than in females (respectively 3.8 and 2.9, p=0.0068). The consumption of two DS was different between both sexes (table I). Indeed, more male athletes reported consuming protein supplements (p=0.0213) and creatine (p=0.0000).

According to the data collected from the questionnaires, 67.8% (97/143) of the DS users mentioned modifying their consumption habits during the year. The main change occurs during the "off season" which is generally referred as the period when the athletes do not have structured training sessions with their teams. It is usually used as a transition between two competitive years. Indeed, 63.9% (62/97) of the athletes that modified their habits during the year mentioned doing it during the "off season". Of those, two thirds (64.5%; 40/62) mentioned that their consumption decreases or stops during the off-season. On the contrary, some athletes (35.5%; 22/62) indicated that they increase it during the "off season" mainly to increase body weight or in response to an increase in the volume of resistance training during this period. Another reported behavior (13.0%; 8/62) is that the DS consumption is increased to help recovery when the training load increases.

Athletes' sources of information and knowledge regarding DS. Nutritionists were ranked within the three most important sources of information by 82.3% of the participants ahead of physicians (64.6%) and pharmacists (39.9%). Coaches were only the seventh most important source of information on a similar level as teammates. Academic study programs, either health-oriented or not, affected athletes' responses. Health studies included all the academic programs offered by the Faculties of Medicine, Nursing or Pharmacy. Athletes studying in health programs ranked nutritionists (97.4% vs 77.5%, p= 0.0107) and pharmacists (55.3% vs 35.0%, p=0.0420) higher as their three most important sources of information compared to athletes enrolled in non-health-oriented programs. With regards to the most effective ways to be instructed, athletes ranked individual meetings with a professional (76.0%), group presentations (57.6%) and mobile application (56.3%) among their three most preferred methods.

In the sample, 81.7% of the participants were aware that they had access to a sport nutritional service offered by the athletic department. While considering important to consult a reliable source of nutritional information (mean = 4.65; 5-point scale ranging from 1 [*not important*], to 5 [*very important]*), only 3.7% of the athletes met with the university sports nutritionist. Another important finding is that most (88.0%) athletes knew the anti-doping rule stating that the athlete is the sole responsible in case he/she fails an anti-doping control test. However, only 26.0% of DS users claimed to be able to name a dietary supplement certification agency whereas in fact, few (10.5%) were able to name such an organization accurately.

The data collected from the questionnaire shed light regarding the influence of the social environment. Few (11.4%) athletes reported having been under pressure to consume DS during their career. Furthermore, there was no difference in the prevalence (p=0.3018) or in the number of different types of DS consumed (p=0.0875) either participants received pressure to consume DS or not. When expressed, social pressure came mostly from teammates, family members, then friends. Coaches were only reported in fourth place.

Regarding the general nutrition knowledge of DS, athletes having followed a workshop on DS had better knowledge scores than athletes that had not followed such a workshop (43.5±18.3% vs 36.7±19.7%, p=0.0330). In addition, athletes enrolled in a health program had

better knowledge scores (49.1±17.4%) compared to athletes from other academic programs (35.8±19.0%; p=0.0002). Athletes participating in an individual sport also had better knowledge than athletes in a team sport (respectively, 50.7±21.3% vs 35.3±16.2%, p=0.0 where a higher score represents better knowledge of DS).

Factors affecting prohibited substances' consumption The PEAS score was used to evaluate the attitude held by questionnaire participants toward doping and performance enhancement tools. Participants' average score was low (27.1±8.3) considering that it ranges between 17 and 102. A low score means that participants hold generally unfavorable views toward prohibited substances and performance enhancement tools. This negative attitude toward prohibited substances was similar among all participants. Indeed, gender (p=0.0908), having followed a workshop on DS (p=0.1015) or being enrolled in a health program (p=0.3055) did not affect this score. Interestingly, there was no difference in the PEAS score between DS users and non-users (27.0±8.2 vs 27.7±9.8; p=0.8726).

The influence of the athletes' sports goal on the possible transition from DS to prohibited substances was evaluated. One open-ended item asked participants to share their dream or long-term objective in sport. Answers were then categorized as extrinsic or intrinsic goals to determine if athletes driven by extrinsic goals such as making a national team or winning a medal at the Olympic Games would be more likely to use DS or more open to use prohibited substances. This variable did not discriminate for the prevalence of DS use (p=0.3841), the number of DS consumed (p=0.9837) nor the PEAS score (p=0.3309).

Through the analysis of the interview data, the perception of prevalence, reflective of the descriptive norms, was mentioned as a factor influencing the decision to consume DS or prohibited substances. This finding is supported by the questionnaire data, since athletes consuming more than three different types of DS estimated that a larger proportion of their teammates used prohibited substances as compared to athletes using three DS or less (16.1% vs 6.4%, p=0.0073).

Finally, certain questionnaire items provided more information about the perception of behavioral control provided by DS consumption for performance improvement. Indeed, even if

the use of DS was common among participants, they believed that stopping their consumption of DS would have little or no impact on their athletic performances (mean = 2.48; 5-point scale ranging from 1 [*decrease in performance*], to 5 [*increase in performance])*. This raises an interrogation about why athletes consume DS even if they hold the belief that it does not lead to significant changes in performances.

Discussion

The present data helps improve the understanding of the decision-making process underlying DS consumption in varsity athletes and the relationship between DS and prohibited substance consumption. The high prevalence of DS consumption among the participants highlights the importance of this phenomenon. Males consumed significantly more different DS products than females including creatine and protein. Interviewed participants raised the idea that the reasons underlying DS consumption, health or performance oriented, could influence the probability of consuming prohibited substances. Furthermore, non-DS users, in contrast to DS users, shared fears regarding DS impact on their body and expressed a negative perception of DS. In addition, estimating that many teammates or competitors consume prohibited substances could lead an athlete to use those substances himself. Indeed, athletes consuming more than three different DS had a higher perception of prevalence of prohibited substances consumption among their teammates highlighting the possible link between those substances. However, interviews also indicate that the transition from DS to prohibited substance could be impeded by the lack of resources to consume those substances safely and effectively and by the individual's personal norms. Both DS users and non-users displayed a negative attitude toward prohibited substances. Indeed, interviewed participants mentioned the health risks associated with the consumption of prohibited substances and their perception that using them would be cheating and against their values.

Most participants mentioned that stopping DS consumption would not have an important impact on their performances. According to the data collected from the interviews, observing little or no performance benefits from consuming DS could lead athletes to stop consuming them

or looking for an alternative providing greater benefits, such as prohibited substances. Therefore, the participants in such a situation would have to decide in response to this absence of benefits. Whereas coaches were not influential regarding DS consumption, interviews revealed that teammates could influence DS and prohibited substance consumption. Indeed, observing a teammate or a competitor consuming a substance could lead an athlete toward using the same substances in order to level the field between them.

Being enrolled in a health program, practicing an individual sport, and having followed a DS workshop were associated with higher DS knowledge. Of interest, a large majority of participants knew that athletes are the sole responsible when failing an anti-doping control test, but few participants were able to accurately name supplement certification agencies. Those results are in line with the concerns shared during interviews regarding contamination risk. In addition, even if most participants ranked nutritionist as the most important sources of information, considered individual meetings with a professional as the most effective way to be instructed about DS, and knew that they had access to a sport nutritional service, only very few of them met with the nutritionist provided to them.

The prevalence reported in the current study is in line with studies on Canadian athletes (K. A. Erdman et al., 2006; Kristiansen, Levy-Milne, Barr, & Flint, 2005; Lun et al., 2012; J. A. Parnell, K. Wiens, & K. A. Erdman, 2015; Wiens et al., 2014). The higher proportion of males consuming proteins and creatine, two DS that have been shown to present higher risk of contamination (I. Garthe & R. J. Maughan, 2018), is coherent with previous studies (K. Diehl et al., 2012; Fraczek, Warzecha, Tyrala, & Pieta, 2006; J. J. Knapik et al., 2016; Wiens et al., 2014).

The current data shows that the athletes are more aware of the risks of contamination than what was reported in previous studies (Braun et al., 2009; Whitehouse & Lawlis, 2017). Regarding knowledge, S. Heaney, O'Connor, Michael, Gifford, and Naughton (2011) also found that practicing an individual sport was associated with significant higher nutrition knowledge of DS. A higher level of education or majoring in nutrition has previously been associated with better nutrition or DS knowledge (S. Heaney et al., 2011; Trakman, Forsyth, Devlin, & Belski, 2016). The most effective tools, identified in the current study, to communicate information about DS or

nutrition to the athletes (individual meeting and group presentation) converge with results published by other research teams (Lun et al., 2012; Wiens et al., 2014). According to the present data, athletes consuming more than three DS estimated that a larger proportion of their teammates used prohibited substances, which has been associated by other research teams with a higher risk of using prohibited substances (Barkoukis et al., 2015; A. Petroczi, Mazanov, Nepusz, Backhouse, & Naughton, 2008) in accordance with the influence of descriptive norms on intention formation (R. B. Cialdini et al., 1990). This characteristic could ease the transition from DS to prohibited substances as proposed by the Gateway Theory (S. H. Backhouse et al., 2013; Barkoukis et al., 2015; L. Lazuras et al., 2015). Furthermore, other research groups (Boardley et al., 2014; Mazanov, Huybers, & Connor, 2011) already raised the idea of identifying moments during which the athletes are more vulnerable to considering prohibited substances. In the present research, those moments are when an athlete experiences a performance plateau or goes through an important training load increase. Those data reflect the influence of the sport social context on moral behavior. Indeed, having an antisocial moral climate, such as promoting cheating behaviors through prohibited substances consumption, was associated with immoral behavior highlighting the importance of social environment on the decision-making process (Spruit, Kavussanu, Smit, & IJntema, 2019). A previous research group (Hurst, Kavussanu, et al., 2019) suggested that athletes' perception of DS effectiveness could influence the likelihood of transitioning toward prohibited substances. They found that athletes believing strongly in the effectiveness of DS could transition more easily toward prohibited substances. The current data offers an explanation for the athletes at the other end of the spectrum, athletes consuming DS to improve performance, but experiencing little to no benefits. Those athletes would be more likely to transition toward prohibited substances in the hope of finding an effective way that helps them achieve their goals. Considering that the proportion of DS contaminated by prohibited substances ranges between 6.4 and 25% of DS (Eichner & Tygart, 2016; Mathews, 2018; S. Outram & B. Stewart, 2015; A. Petroczi, Taylor, & Naughton, 2011), athletes would benefit to be better informed about ways to reduce the risk of consuming contaminated DS.

The current data could be used to identify athletes displaying at-risk DS consumption. This would allow targeting subsets of the athletic population that could benefit the most from

educational interventions since nutrition knowledge has been shown to be a protective factor against prohibited substance use (Kondric, Sekulic, Uljevic, Gabrilo, & Zvan, 2013; Sekulic et al., 2017). An effective educational intervention could then target: 1) men, 2) athletes who have not followed a workshop about DS, 3) athletes enrolled in an academic program outside of the health field, 4) athletes consuming more than three DS, 5) athletes consuming creatine, or 5) athletes experiencing plateaus in performances or going through a swift increase in training load. Individual meetings with nutritionists should be integrated in such interventions when feasible while technological tools could be used to reach a larger number of athletes. The *Athletes Training and Learning to Avoid Steroids Program* (ATLAS) and *Athletes Targeting Healthy Exercise and Nutrition Alternatives (ATHENA)* have been used to reduce drug use among high school athletes (Elliot et al., 1996; Goldberg & Elliot, 2005; LeCroy & Mann, 2008). The data presented earlier suggest that some foundations of those programs could be used to inform athletes about DS risks as well. For example, considering that the social environment, especially the teammates, influences the decision-making process underlying DS consumption, peer-led programs leveraging older athletes' experience could prove useful (Goldberg & Elliot, 2005). Presenting athletes with alternatives to unhealthy substances use could also be a major component of future education programs as demonstrated by positive outcomes in drug use prevention program (Tobler, 1992). Those programs should also include follow-up interventions since those seem necessary to ensure knowledge and behavior modification retention (Bates et al., 2019; Hurst, Ring, & Kavussanu, 2019). Further research could explore the changes in DS consumption in association with improvement in DS knowledge to evaluate more thoroughly the importance of interventions aimed at improving athletes' knowledge of DS.

The findings provided by the present mixed-methods study design shed light over the design of what could be an efficient education intervention to increase athletes' knowledge and awareness of DS while reducing their risk of transitioning toward prohibited substances or consuming contaminated DS relying on the TPB (Ajzen, 1991). It is worth mentioning that even if TPB is the dominant theory used to study the decision-making process underlying prohibited substances and DS consumption (S. H. Backhouse et al., 2013; D. El Khoury et al., 2019; Fabio Lucidi et al., 2008), this theory received many criticisms. For example, it fails to account for

external variables (e.g. age, socio-economic status, environmental characteristics) that have been shown to impact behavior when TPB predictors are controlled for (Sniehotta et al., 2013). Furthermore, TPB considers behavior as the result of a rational and intentional process while previous studies (Whitaker, Long, Petróczi, & Backhouse, 2014) found that decision-making process underlying doping may not be fully intentional. Relying on the TPB for future research may ease comparing results with existing literature, but additional theories could be used to overcome TPB's limitations (Sniehotta et al., 2014).

Furthermore, the results presented in the present study are specific to the sample studied. Even if the varsity structure includes athletes of different levels and age groups, it would have been informative to study the reality of athletes training and competing in different structures, such as national training centers. Furthermore, certain subsections of the questionnaire were designed for the sample studied and were not previously validated. Using a fully validated questionnaire such as the one proposed by D. El Khoury et al. (2019) would be an interesting avenue to consider. Future studies should also include items about temptation to use prohibited substances under specific situations and perception of DS use prevalence to help researchers better understand the relationship between DS and prohibited substances.

In conclusion, DS consumption is widespread among varsity athletes and some athlete subsets display at-risk behaviors related to DS consumption. Instead of offering standardized education programs to athletes, it would be better to offer resource-intensive educational interventions to athletes more vulnerable to transitioning toward prohibited substances or displaying at-risk DS consumption. This could be an interesting avenue to have a meaningful impact on athletes more at risk of failing an anti-doping control test or transitioning toward prohibited substances.

Despite evidence-based benefits, dietary supplements (DS) use has proven a risk for transitioning toward prohibited substances or even failing an anti-doping control test due to contamination. A sequential mixed-method research design was used to explore the factors affecting the decision-making process underlying the use of DS. Varsity athletes (n=10) participated to semi-structured

interviews and/or completed a survey (n=162). The interviews were thematically analyzed and the survey support the analysis. Our main findings indicate that the following factors are associated with risky DS consumption: 1) being a male; 2) not being enrolled in a health-related university program; 3) not having received education regarding DS; 4) not having experienced significant benefits while consuming DS; 5) consuming creatine and/or 6) consuming more than 3 different DS. Targeting the most vulnerable segment of this population based on those identified factors could prove effective to reduce DS consumption risks.

Declaration of interest

The authors declare that they have no conflicts of interests. The authors alone are responsible for the content and writing of the article.

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Table 1

Prevalence of dietary supplement consumption in male and female athletes

Dietary supplements	All athletes		Male athletes		Female athletes		P-value
	n	%	*n*	%	*n*	%	
Sport drinks	129	81.7	66	85.7	63	77.8	0.2790
Protein supplements	91	57.6	52	67.5	39	48.2	0.0213
Vitamin D	53	33.5	28	36.4	25	30.9	0.5733
Energy drinks	43	27.2	24	31.2	19	23.5	0.3629
Caffeine	42	26.6	21	27.3	21	25.9	0.9909
Iron	33	20.9	15	19.5	18	22.2	0.8197
Vitamin C	32	20.3	19	24.7	13	16.1	0.2499
Multivitamins and minerals	31	19.6	18	23.4	13	16.1	0.3376
Medicinal herbs	19	12.0	10	13.0	9	11.1	0.9063
Creatine	15	9.49	15	19.5	0	0	0.0000
Sodium bicarbonate	2	1.27	1	1.30	1	1.23	1

Note. A p-value, calculated with a chi-squared test, smaller than 0.05 was used to determine a significant gender effect.

Table 2

Questionnaire participants' characteristics

Sports	All athletes		Male athletes		Female athletes	
	n	%	*n*	%	*n*	%
Soccer	35	22.2	23	29.9	12	14.8
Rugby	27	17.1	0	0	27	33.3
Volleyball	24	15.2	15	19.5	9	11.1
Track and field	23	14.6	15	19.5	8	9.9
Swimming	19	12.0	13	16.9	6	7.41
Cheerleading	15	9.5	3	3.9	12	14.8
Tennis	7	4.4	3	3.9	4	4.9
Football	5	3.2	5	6.5	0	0
Alpine skiing	3	1.9	0	0	3	3.7
Total	158	100	77	100	81	100

Chapter 3 – Discussion

The aim of the current research is to better understand DS consumption habits among varsity athletes and explore the risky behaviors linked with those habits and methods to mitigate their consequences. The research paper presented above allows the identification of some characteristics displayed by athletes facing higher risks associated with DS consumption, such as consuming contaminated DS or transitioning toward prohibited substances. The data collected during this research also led to recommendations regarding the most effective ways to provide athletes with information to reduce those risks. However, as mentioned earlier, it would be interesting to verify if the aforementioned characteristics and tools suggested to mitigate them could be applied to athletes competing at a higher level. Investigating the situation among elite athletes could provide a different perspective since previous studies have already shown differences in DS consumption among elite and recreative athletes (Kelly Anne Erdman et al., 2006; Joseph J Knapik et al., 2016; Ronald J Maughan et al., 2018). Therefore, the tools to reduce the risks associated with DS consumption and the characteristics identifying risky behaviors may also be different according to the competition level. Furthermore, elite athletes, typically, have access to a wider range of resources, such as on-site nutritionists and full-time coaches which could magnify those differences.

To explore the situation among elite athletes, the process used by the present research group with varsity athletes was replicated with elite athletes. Through nutritionists working at a Canadian national training center, elite athletes (N=7, n= 3 men, n= 4 women, age= 25.6±5.6 years) were recruited from the national boxing (n=3), gymnastics (n=1), fencing (n=1), and speed-skating (n=1) teams to participate in semi-structured interviews. Afterward, additional elite athletes (N=37) were recruited to complete a questionnaire similar to the one completed by varsity athletes. One questionnaire participant was excluded because he was under the age of eighteen. To be eligible to participate in this research, participants had to be a member of the national training team and had to be training at the national training center. The small sample size can be explained by the fact that the research with elite athletes is part of an ongoing study

and more athletes will be recruited. However, it still provided preliminary results that can help comprehend how elite athletes differ from varsity athletes in regard to DS consumption.

Regarding DS consumption habits, elite athletes exhibited similar profile to varsity athletes. Indeed, 92% of elite athletes consumed DS, prevalence nearly identical to the one found among varsity athletes (91%). The similar prevalence of DS use observed among elite and varsity athletes in the present research differs from previously reported data where higher performance level was associated with a larger prevalence of DS consumption (Giannopoulou et al., 2013; Ronald J Maughan et al., 2018). However, a smaller proportion of elite athletes consumed sports drinks (61% vs 82%, p=0.0076) and energy drink (8% vs 27%, p=0.0167) while a larger proportion of elite athletes consumed iron supplements (44% vs 21%, p=0.0034) compared to varsity athletes. Therefore, even if similar overall prevalence was observed between varsity and elite athletes in the present research, differences could still be observed in consumption patterns.

Considering that elite athletes compete at a higher level and train more than varsity athletes (95% of elite athletes train more than 15 hours a week vs 30% for varsity athletes, p=0.0), it would be interesting to explore if elite athletes feel more pressure to perform and to consume DS in order to reach the expected performance level. Mike, an interviewed participant, shared his perception of pressure imposed by the national team: "We are always being told that we want medals […]. At a certain point, you start to think that if you don't get the medal, you will get cut from the team. That's what is happening. It's pressure from your sport, from your environment […]". Another participant also acknowledged being under pressure to perform, but not as bluntly as described above. Indeed, Lara shared: "We feel a bit the pressure […], but they [coaches] never tell us that if we don't perform well, we won't get financial support." The data from the questionnaire seems to corroborate the idea that pressure to perform does not translate to pressure to consume DS as only 20% of elite athletes shared having been under pressure from their social environment to consume DS. Even if this proportion is higher than the proportion among varsity athletes (11.4%), the difference is not statistically significant (p=0.1953). Interviewed participants also highlighted how the failed anti-doping control tests by other national team members impacted their social environment. Indeed, during the research timespan, a well-known national team member failed an anti-doping control test and blamed it

on contaminated DS. Claire mentioned, “We stopped [using those DS] because there was a case with a speed kayaker who took them […] As a precaution measure, we stopped [using them].” Rachel shared a similar point of view when asked if she has received pressure to consume DS from her social environment: “No. It would be the opposite of that […] We lost a Boxing Canada athlete a few months ago because he failed a doping test and that looks bad, you lose funding […]”. Those excerpts illustrate how positive anti-doping test results by national team members impact the social environment’s attitude toward DS. In contrast with the data reported in the present research, a study among Canadian athletes (Jill A Parnell, Kristin Wiens, & Kelly Anne Erdman, 2015) stated that 44% of their participants reported that their decision to consume DS was influenced by their social environment. The difference with present data can reflect a change in how the athletes’ supporting personnel views and manages DS consumption. This seems to be reflected by interviewed participants mentioning the impact recent anti-doping violations by national team members had on their social environment.

On the topic of DS information sources, interviewed participants unanimously shared that their coaches were not involved in managing their DS consumption. Six out of seven interviewed participants mentioned having regular meetings with a nutritionist. Coaches nearly systematically referred athletes toward their nutritionist instead of directly providing them with advice or getting involved. This was reflected by the interviewed participants who mentioned that their main sources of information regarding DS were the national team nutritionists and physicians. The data collected from the questionnaires support the importance of the team nutritionist and physician with, respectively, 98% and 83% of elite athletes that ranked them in their three most important sources of information regarding DS. The coach was ranked in the three most important sources of information by only 14% of the athletes. Therefore, elite and varsity athletes preferred sources of information seem to be similar.

Even if the preferred sources of information were similar for both populations, their accessibility differed greatly. Indeed, six out of seven elite athletes mentioned during the interviews that they had regular meetings with the national team nutritionist while only 4% of varsity athletes met with the nutritionist available through the athletics department. This seemed to influence how elite athletes select their DS. Indeed, elite athletes said that the nutritionist

either must approve or chose the DS for them. Along these lines, Mike said, “Before buying the product, I have to ask the nutritionist what she thinks about it.” Claire mentioned that “it was the nutritionist that did that [selecting what brand of DS they were going to use].” Those quotes illustrate the higher role of nutritionists in minimizing contamination risk with elite athletes compared to varsity athletes. Contrarily to data reported by other research teams (Denham, 2017; Katharina Diehl et al., 2012; Manore, Patton-Lopez, Meng, & Wong, 2017; Scofield & Unruh, 2006; Tawfik, El Koofy, & Moawad, 2016; Walsh, Cartwright, Corish, Sugrue, & Wood-Martin, 2011), athletes in the current research did not consider coaches as an important source of influence on their decision to consume DS. This is in line with a previous research conducted with elite Canadian athletes (Lun et al., 2012). The high reliance on coaches reported by previous research groups could be explained by the lower performance level and younger age of the athletes studied. Indeed, younger athletes or athletes performing at lower levels may not have easy access to resources such as physicians or nutritionists, which can lead them to rely more heavily on other sources of information.

Furthermore, elite athletes seemed to be well aware of the contamination risk of DS as all of the interviewed participants raised the issue during the interview. The knowledge score about DS was not significantly different between elite and varsity athletes (6.6 vs 5.8, p=0.0734), but some differences were significant regarding the knowledge of tools to reduce contamination risks. Indeed, a significantly higher proportion of elite athletes claimed to be able to name a DS certification agency compared to varsity athletes (50% vs 26%, p=0.0045). However, when asked to name such an agency, the proportion between the two populations was similar (8.3% for elite vs 10.5% for varsity athletes, p=0.8315) indicating that elite athletes are possibly overoptimistic regarding their knowledge of certification agencies. This optimism is translated as well in the certainty elite athletes have regarding the fact that the DS they consume are exempt of prohibited substances. Indeed, elite athletes have a higher certainty than varsity athletes (respectively 4.3 vs 3.9, p=0.0432; 1: Not certain that the DS are exempt of prohibited substances, 5: completely certain). The high reliance on national team nutritionists and physicians by elite athletes may have influenced their perception of their knowledge of DS certification organizations. Indeed, even if the knowledge of DS and certification agencies was similar among both populations, elite athletes

were more confident in their ability to name such agencies and that their DS were exempt of prohibited substances. The role of national team nutritionists in verifying that elite athletes consume only certified DS could explain the high level of confidence regarding the fact that their DS are exempt of prohibited substances.

Both varsity and elite athletes shared negative views toward prohibited substances. During the interviews, participants mentioned the important consequences of failing an anti-doping control could have on an athlete's career. Those consequences led Lara to question the veracity of the Gateway Theory applied to DS and prohibited substances: "If someone who doesn't practice any sport takes a hard drug, there aren't that many consequences. If someone [an athlete] takes steroids, for example, there would be bigger consequences." Furthermore, many interviewed participants questioned the Gateway Theory by saying that consuming prohibited substances would not be helpful because their sport involves a technical or tactical component that could not be improved by consuming prohibited substances contrarily to an individual or endurance sport. Jack expressed this view by saying: "In team sports, I'm really under the impression that there are fewer people taking prohibited substances because of the technical aspect." Peter shared a similar opinion: "It is not purely physical like track and field or similar sports. So, yes, dietary supplements and doping substances can help on the physical side, but it doesn't directly improve the results." The low PEAS score (26.9) calculated from the questionnaire data further supports the fact that elite athletes hold negative views toward prohibited substances. Elite athletes' perception of prevalence of prohibited substances use among competitors and teammates is lower than varsity athletes' perception. Indeed, elite athletes estimated that respectively 10% and 2% of their competitors and teammates use prohibited substances (vs 24% [p=0.0006] and 10.2% [p=0.0000] of varsity athletes). This result is interesting considering that varsity athletes compete at a lower level than elite athletes and the stakes are typically lower. Due to methodological and ethical issues, the prevalence of prohibited substances use among athletes reported in the literature varies greatly. However, the present elite athletes' estimate is on the low side of the literature data while varsity athletes' estimate is similar to what has been found with previous questionnaires (De Hon, Kuipers, & van Bottenburg, 2015; Faiss et al., 2020; Sottas et al., 2011; Striegel, Ulrich, & Simon, 2010). Finally, elite athletes have a stronger

belief that stopping DS consumption would impact their results negatively as compared to varsity athletes (respectively 2.1 vs 2.4, p=0.0255; [1: decrease in performance, 5: increase in performance]).

The similar consumption of DS among both populations studied in the present research and the higher perception of prevalence of prohibited substances use among varsity athletes highlight the importance of mitigating the risks of DS consumption among varsity athletes even if they compete at a lower level than elite athletes. In the current study, the involvement of the nutritionists and physicians was higher with elite athletes than it was with varsity athletes. The higher reliance on nutritionists and physicians by elite athletes might have been explained by better accessibility to those services. However, varsity athletes in the current research had access to those resources as well but decided not to use them. When those resources are available in a varsity context, coaches and athletic administrators should rely more extensively on those resources and use virtual tools to reach athletes when those resources are not available or cannot be offered to all the athletes as proposed in the present research paper.

With regards to the Theory of Planned Behavior (Ajzen, 1991), both elite and varsity athletes in the present research work exhibited low risk of transitioning toward prohibited substances. Indeed, both elite and varsity athletes displayed negative attitude toward prohibited substances. Furthermore, most of them claimed that they never received pressure from their social circle to consume DS or prohibited substances. Some of them even mentioned that their social environment advised them not to consume DS following the anti-doping control failure of other national team members. Those negative subjective norms toward prohibited substances consumption are coherent with the low estimates provided by elite athletes regarding the proportion of teammates and competitors that use prohibited substances. Therefore, descriptive norms (Robert B Cialdini, Raymond R Reno, & Carl A Kallgren, 1990) seem to indicate that the probability that athletes transition from DS to prohibited substance is low. However, as illustrated in the above research paper, subsets of the athlete population display at-risk characteristics that would ease this transition toward prohibited substances. Furthermore, the risk of consuming contaminated DS also presents serious threats that could be minimized by conducting tailored interventions with athletes.

In order to grasp athletes' attention and help them build trust toward better decision-making, elite athletes raised the importance of providing information about how DS can be used effectively instead of only focusing on their risks. They also requested legal and safe alternatives to prohibited substances as reported by previous research groups (James, Naughton, & Petróczi, 2010; Lambros Lazuras et al., 2015; Szabo, 2013; Whitaker, Petroczi, Backhouse, Long, & Nepusz, 2016) in order to decrease the probability of athletes transitioning toward prohibited substances. Those publications indicated that DS could fulfill this role. Furthermore, acknowledging the impact that national team members' anti-doping violations had on the athletes' social environment and athletes themselves, it seems worthwhile to illustrate the risks of DS and prohibited substances with examples that can relate to the athletes' own experiences. Indeed Lentillon-Kaestner, Hagger, and Hardcastle (2012) suggested using testimonies from athletes who used prohibited substances to prevent prohibited substances use. Therefore, it was hypothesized that using national team member anti-doping violation cases would make the message more "surprising and intense", which would lead to a heightened emotional reaction and reduce doping behaviors (Lentillon-Kaestner et al., 2012).

The data presented in the current study help provide a better understanding of the context surrounding DS consumption among varsity and elite athletes. However, in addition to the limitations mentioned in the above research paper, the number of elite athletes that completed the questionnaire limits the generalizability of the preliminary results regarding this population. Conducting the research during an Olympic year limited the research team's ability to reach a larger sample of athletes. Therefore, considering the competition calendar in order to reach a larger number of athletes would be important to make more meaningful comparisons between populations. Conducting interviews or focus groups, in a mixed-research design, with the national team staff, such as physicians, coaches, strength and conditioning coaches and nutritionists, could help better understanding how those professionals influence athletes' decision to consume DS and the issues associated with such consumption. This process could also be used with varsity support personnel in order to get a better understanding of their impact on athletes' decision-making process toward using DS and prohibited substances. Furthermore, futures studies could include items about the likelihood of consuming prohibited substances in

specific situations since the differences in the environment and the external constraints could affect the athletes' decision of consuming DS or prohibited substances. For example, the temptation to use these substances during the preparation for an important championship.

In conclusion, DS consumption is widespread among varsity and elite athletes who have relatively low knowledge of ways to reduce the risks associated with this consumption and how to optimize its benefits. As suggested in our research paper, more tailored interventions could be offered by targeting athletes that are more likely to display risky behaviors according to the aforementioned criteria. Finally, those interventions should provide athletes with information to optimize their DS use while minimizing its risks.

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Appendices

Varsity athletes' dietary supplements use habits description and factors describing this use

Interview guide

Explanation of the interview's process:

- The interview will be recorded, is that fine with you?
- The information will be confidential:

o A code will be used when we transcribe the interview.

- Have you fully understood the consent form? You have the right not to answer a question.
- Our goal is to learn, not to judge.
- I will take notes during the interviews to avoid interrupting you and make sure that I don't forget any valuable information. Are you comfortable with that?

Introduction- Sport background

· How and when did you start practicing your sport?

o Since when have you been practicing your sport competitively?

o How many university eligibility years have you used?

o What is the highest competition level that you have reached?

o How many hours per week do you spend practicing your sport (including gym workout, competition, etc.)?

o What program are you in?

o How many years old are you?

Supplements

A. Knowledge

· Have you already participated in a nutrition class or in dietary supplement workshops?

o If yes, was it useful?

· How would you define dietary supplements?

Here is the International Olympic Committee's definition:

A dietary supplement is 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.

It can take many forms, including:

a) Functional foods: foods enriched with additional nutrients or components outside their typical nutrient composition (e.g., mineral- and vitamin-fortified, as well as nutrient-enriched foods).

b) Formulated foods and sports foods: products providing energy and nutrients in a more convenient form than normal foods for general nutrition support (e.g., liquid meal replacements) or for targeted use around exercise (e.g., sports drinks, gels, bars).

c) Single nutrients and other components of foods or herbal products provided in isolated or concentrated forms.

d) Multi-ingredient products containing various combinations of those products described above that target similar outcomes.

B. Use

· Do you use or have you already used dietary supplements? If yes:

o What types of supplements do you use?

o What are the reasons for your use?

o What criteria do you use to choose the supplements?

- Do your dietary supplements use habits or patterns change during the year in function of the period of the year?
- Where do you buy your supplements?
  - Why do you buy them there?
  - What criteria do you use to choose this location?
  - Do the dietary supplements influence your training or recovery capacity?
- What are the reasons that explain which dietary supplements that you use actually? For example, do you have a special diet (religious, vegan, etc.) that has an impact on your nutrition? If yes: Is your dietary supplement use related to your diet? If yes: in which way?
- What are the side effects of the dietary supplements that you use?
- What information sources do you consult to choose which type of supplements to use?
  - What is the most efficient way to communication information to the athletes about dietary supplements?
  - Do you feel pressure from your social network to use dietary supplements? If yes, from whom? How is this pressure communicated to you?
  - Do the athletes talk freely about the supplements that they use among themselves?
  - According to you, what percentage of your competitors use dietary supplements?
  - According to you, what percentage of your teammates use dietary supplements?
  - If there's a difference between the numbers: Why is there a difference between those numbers?
  - Do you believe that athletes are more in need of using dietary supplements that the regular population?
  - Do you believe that supplement consumption is necessary to perform at a high level in your sport?

· There are contamination risks with dietary supplements. Do the performance benefits associated with dietary supplements exceed the risks associated with contamination?

o If there were no contamination risks and side effects, would you consume dietary supplements or would consume more or differently the supplements?

o What ways can you use to reduce contamination risks?

· What is your opinion regarding the statement that dietary supplements use can lead to doping substances use? Why?

o According to you, are there any dietary supplements that are in gray area between prohibited substances and legal dietary supplements?

o Do you know what organization publish the list of prohibited substance every year?

o Do you know any athletes that started by using dietary supplements and started to use prohibited substances? What is your opinion about that?

Conclusion

I asked all the questions I needed to learn more about your perspective based on your experience. Are there any additional elements that you consider important and that would like to talk about?

Thank you!

Questionnaire description

The questionnaire comprised the following four sections:

Socio-demographic and sports background information

This section included 14 multiple responses and open-ended response items. Two items related to the participant's level of competition and training load came from a validated questionnaire previously used with Canadian athletes (Erdman, Fund, and Reimer, 2006). Seven items collected commonly used information, such as age groups, academic programs, highest diploma obtained and gender. Five items were included to collect the participant's sport, number of years spent practicing this sport, athlete's identification level and sports objectives.

Participant's use of DS and sources of information

The section's first item asked if the participant consumed DS in the last 12 months. This time frame was selected to ensure that the whole competitive year was considered and thus account for possible variations in DS consumption through different training periods. If the participant had not consumed DS in the specified period, the section's items regarding DS consumption were skipped and he was sent to the second subsection regarding information sources. For DS users, the following multiple response item came from the questionnaire used in the first section (Erdman, Fund, and Reimer, 2006) and collected retail sources used by the participant to buy their DS. The rest of the section included four items that were repeated for all DS used by the participant. The first of those items was a 5-point Likert scale added by the current research team about the DS impact on sports performance (1: no effect, 5: very important effect). The second item was the multiple responses item from the previously mentioned questionnaire (Erdman, Fund, and Reimer, 2006) collecting the reasons underlying the DS use. "Cognition/alert level" and "weight/fat mass loss" were added while "medical deficiency" was removed since the values "health maintenance/prevent nutritional deficiencies" and "medical indications" already covered that reason. The third item was added by the current research team and was a multiple responses item regarding the frequency of consumption. Finally, the last item asked if the participant knows

if that substance could have side effect. If the participant answered yes, he is asked to write those side effects in an open-ended item. Those four items were repeated for eleven common DS used by varsity athletes according to the existing literature (Knapik et al., 2016; Erdman, Fund, and Reimer, 2006) and the data collected from the interviews. The participant was able to answer those questions for additional DS that were not included in the specified eleven DS. DS users answered an item added by the current team which was a Likert scale assessing their certainty regarding the possibility that the DS used contain prohibited substances (1: Not certain that the DS are exempt of prohibited substances, 5: completely certain). An open-ended item asked the athlete to explain the reasons explaining their answer to the previous item. The Likert scale assessing the participant's perception of the impact of stopping DS consumption on their performance (1: Would decrease my performance; 3: No impact on my performance; 5: Would improve my performance) used by Erdman, Fung, and Reimer (2006) was included. An additional yes/no item was included assessing if the participant's DS consumption habits changed during the training year. If so, the participant was asked to describe those changes in an open-ended question.

The last part of this section was completed by both DS users and non-users. Seven items out of twelve in this subsection came from the previously mentioned questionnaire (Erdman, Fund, and Reimer, 2006). The first item asked participants to select all information sources used to gather information about DS. The second item asked the participants to rank those information sources according to their perception of their importance. The third item was a 5-point Likert scale assessing how important it was for the participant to receive information about DS (1: not important, 3: more or less important, 5: very important). The fourth item asked the participants to rank in order of preference different tools to communicate information about DS. This item was slightly modified from the previously mentioned questionnaire to add the following options "Mobile application", "Social media post", and "mailing list". The fifth item was a multiple response item assessing what information would be the most useful about DS consumption. In the original questionnaire, this item was open-ended with many examples listed in the question. The format of this item was changed in the current questionnaire to be a multiple response item including the examples suggested in the original questionnaire with the possibility of adding

additional response. This was done to ease the task of the participants. The sixth item was a five-point Likert scale assessing the participant's perception of his nutrition quality (1: bad, 5: excellent). Finally, the last item coming from the previously mentioned questionnaire was a yes/no question asking the participant if he has ever followed a DS workshop. An additional item was included by the current research team based on the previous item assessing if the participant has ever followed a nutrition workshop. This item was added to assess differences in attending a DS workshop and a nutrition workshop. Another item added by the research team was a yes/no item assessing if the participants have access to a nutritionist within his university sports structure. Another item is a yes/no item assessing if he received pressure from its entourage to consume DS. If the participant answers yes, he is asked to identify the people from whom he received pressure. This section also included an item asking the participant if he knew what certification agencies certify DS and if so what were their names. Finally, a multiple response items asked the participants who is held responsible if an athlete fails a doping control. If the participants answered that the responsibility was shared, he was asked to explain who shared the responsibility.

Perception of prohibited substances

This section included the Performance Enhancement Attitude Scale (PEAS) which evaluates the attitude toward doping and performance enhancement drugs developed and validated by Petroczi et al. (2003). The PEAS is a questionnaire included 17 6-point Likert scale (1: strongly disagree, 6: strongly agree). In the current research, a French language version of the PEAS, translated and validated by Hauw et al. (2016) was used. The research team made minor changes to the items to ensure that it reflects Quebec's reality since the French language version was previously validated and used in France. Two additional numeric input items were added in this section assessing the participant's perception of prevalence of prohibited substance use among his teammates and competitors reflecting descriptive norms (Cialdini, Reno and Kallgrand, 1990).

Knowledge of DS

This section included 15 items to evaluate participants' knowledge of DS. Eleven of those items were developed and validated by Trakman et al. (2017). The items were translated by the research team into the French language according to Chen and Boore's (2009) recommendations. To ensure that the translation reflected the original English language items, six native English speakers, all of whom fluently speak French, were asked to translate the French items back into English. Those "double-translated" English items were compared to the original English items to make sure they conveyed the same meaning. Adjustments were made when needed. The objective of this section was to calculate a score reflecting the participants' knowledge of sports supplements.

Even if most questionnaire items were already validated by previous research teams, the questionnaire was tested for face validity to ensure that the questionnaire's items were unambiguous, and the content was relevant to the participants answering the survey (Taherdoost, 2016). A panel of experts composed of two certified nutritionists working with national sports teams and three university professors doing research on DS or doping behavior participated in this process. Seven athletes that were not included in the sample also answered the questionnaires to test validity. After this process, the wording of some items was modified to facilitate their understanding. Fourteen athletes were recruited to answer the last section of the questionnaire about DS knowledge to ensure that the items allow for discrimination between participants.

The internal consistency of the PEAS used in the current questionnaire evaluated with Cronbach's alpha was 0.814. This value is higher than the value found by Hauw et al. (2016), 0.71, when they validated the French version of the scale and it is higher than the cut-off value of 0.7 for an acceptable reliable scale (Nunally, 1994). The value found in the current study is in line with the values reported by a review published in 2009 (Petroczi, Aidman).

The internal consistency was also for the 15-item knowledge section was evaluated with Cronbach's alpha. The value of 0.745 is also above the acceptable threshold of 0.7 (Nunally, 1994). The Cronbach's alpha on the original eleven items used by Trakman et al. (2017) is 0.702. The four

items added in the current study increase Cronbach's alpha as expected by the Cronbach's alpha formula.

Bibliography for the questionnaire appendix

Nunnally, J. C. (1994). *Psychometric theory 3E*. Tata McGraw-Hill Education.