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Supplements contamination; a real enemy in physical activity & sports

Abstract

Dietary supplements encompass a huge amount of substances, from macronutrients such as proteins and carbohydrates to smaller exogenous (e.g., herbal extracts, vitamins) or endogenous (e.g., creatine, β-hydroxy- β-methylbutyrate, β-alanine) molecules. However, contamination is a serious problem that must be faced to avoid public health issues.

Keywords: dietary supplements, contamination, sports nutrition, doping, health

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Abbreviations: DS, dietary supplements; AAS, androgenic anabolic steroids; EED, estrogenic endocrine disruptors; GMP, good manufacturing practices; DHEA, dehydroepiandrosterone

Introduction

Dietary Supplements (DS) are added to the habitual diet in order to improve wellness, increase cognitive function, augment energy levels, accelerate post-exercise recovery, and promote fat loss, among others statements. Thus, DS might be used to improve sports performance, prevent injury and speed up physiological adaptations in a given situation; however, there are few of them with enough evidence and scientific background, which added to high popularity and low regulation, creates a perfect scenario for industry scam in a business with profits of thousands of million dollars. In this sense, this review aims to present some issues regarding dietary supplementation, specifically contamination, and some advice to recreational and elite athletes.

Non-desirable substances in dietary supplements

It has been shown that several dietary supplements (DS) present contaminants that unscrupulously are not reported in nutritional label. Hence, supplement contamination as a concept emerges, where positive doping can be present due to the small but real risk of consuming DS and introduce forbidden substances (WADA; World Anti-Doping Agency). Many studies have reported androgenic anabolic steroids (AAS), also called pro-hormones, which are not declared in DS label.[1,2] Generally, gas chromatography coupled to mass spectrometry (GC-MS) is used to quantify the concentration of substances that are not present in label; for example, Table 1 summarizes some pro-hormones found in van der Merwe et al.[1] research after analyzing some DS.

Some other forbidden substances can be found in DS, such as ephedra, sibutramine, clenbuterol, hormonal peptides, methylhexanamine, and even molecules that have not been described chemically. Noteworthy, AAS concentration range is from 0.01µg/g to 19 µg/g of product (e.g., positive doping is considered in >1µg of norandrosterone).[2] For Cole et al.,[3] and other authors,[4] contamination takes place due to several, accidental or intentional, reasons such us; contaminants present in raw material, low-quality fabrication process (contamination because of share equipment or inappropriate cleaning), transport disturbance (including packaging and storage), different concentration in the product (fraud and Nutrition misinformation), and conscious contamination to increase efficacy. Accidental or intentional contamination has been verified with sample analysis in different DS brands; in here, we can realize the vast range of mistake and fraud in some commercial products, as Muñoz[5] published in 2014 (Figure 1).

Melamine (C3H6N6 - PUBCHEM ID: 7955) is a chemical compound with various amine group (-NH2). This substance is used to commit fraud as a non-protein source of nitrogen in DS.[6] In addition, several side effects have been reported after melamine consumption (e.g., nephrolithiasis, chronic renal inflammation, bladder cancer). Modified image from: Muñoz M[5] Universidad Politécnica de Madrid.[5]

Recently, Deldicque et al.[7] published a review article in which include potential risks after consuming DS, highlighting a high percentage (≈90%) of contamination due to Estrogenic Endocrine Disruptors (EED), melamine (50%) and higenamine. In general, EED are defined as exogenous substances that interfere with production, secretion, transport, metabolism, receptor union, biologic action, or elimination of hormones responsible for maintain homeostasis and development.[8] According to Serrano et al (2001), hormonal effects of EED may be due to:

i. Mimicking,

ii. Antagonical mechanisms,

iii. Synthesis and metabolic alterations of hormone kinetics, and

iv. Hormone receptor disturbances.

High contamination with EED encompass from 17-β-estradiol, dioxins, bisphenol A, phthalate esters, polychlorinated biphenyls.[9] Most of side effects of EED take place in puberty, a period of drastic physiological changes (growth, gonadal maturation, etc.),

where estrogens play a key role. Thus, similar structure of EED to estrogens allow them to bind and activate estrogen receptors, which cause premature puberty. For example, exposition to dichlorodiphenyltrichloroethane, an EED, is associated with early menarche in young female athletes.[10]

Contamination of DS with pro-hormones is prevalent in countries like Holland (25.8%), Austria (22.7%), United Kingdom (18.8%) and United States of America (18.8%). Additionally, 21.2% of contamination was found from companies commercializing AAS, while 9.6% in factories that no commercialize pro-hormones.[2,11]

Table 1 Prohormones founds in dietary supplements. Taken from: van der Merwe et al.[1]

Supplement no	Listed on label	Found	µg/capsule mean (range)
5	19-nor-4-androstenedione	19-nor-4-androstenedione	
6	DHEA Pregnenolone	DHEA	
7	DHEA	DHEA	
14	DHEA	DHEA	
19A*	Branched-chain amino acids	DHEA 4-androstenedione	0.76 (0.67–0.85) 1.64 (1.35–1.94)
19B*	Branched-chain amino acids	DHEA 4-androstenedione	14.00 (7.40–17.80) 8.21 (4.10–12.90)
20A*	HMB	4-androstenedione 19-nor-4-androstenedione	0.16 (0.10–0.35) 16.5 (8.40–31.80)
20B*	HMB	No banned substance	
22	DHEA 4-androstenedione Tribulus Terrestris	DHEA 4-androstenedione	
24	DHEA	DHEA	

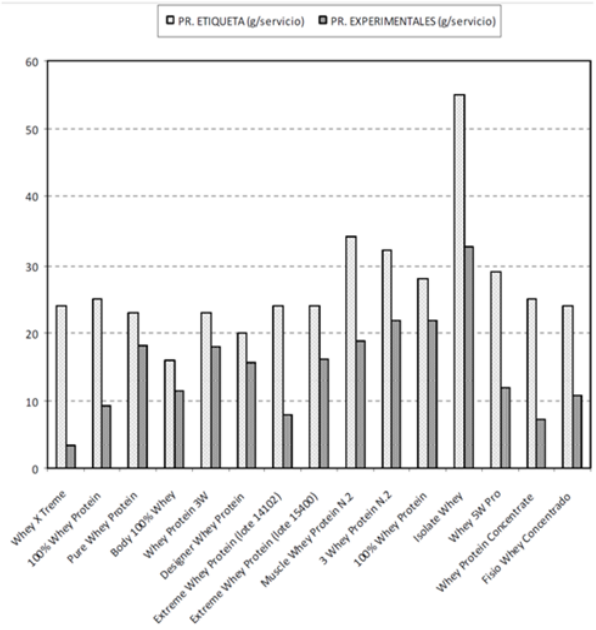

Figure 1 Batch of protein supplements with higher fraud index.

Conclusion

Taking into account the popularity of DS,[12,13] control measures must be taken in sports and physically active community.[14] Firstly, evaluate if supplementation is required. Second, if it is needed, check the DS classification systems that are based on scientific evidence. In fact, position stand from different international organizations should be considered; such as International Society of Sports Nutrition,[15] American College of Sports Medicine,[16] Academy of Nutrition and Dietetics, Dietitians of Canada, Australian Institute of Sports,[17] International Olympic Committee,[18] Federación Española de Medicina del Deporte.[19]

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Conflicts of interest

The authors declare no conflicts of interest related to this article.

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