Bodybuilding supplementation and tooth decay

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IN BRIEF

- Raises awareness of the increasing consumption of bodybuilding supplements amongst amateur competitors/enthusiasts.
- Describes which supplements might be consumed and their sugar content.
- Discusses how dental professionals can help recognise patients at an increased risk of developing dental caries and provides advice on how to better manage them.

GENERAL

Supplementation is a key component in bodybuilding and is increasingly being used by amateur weight lifters and enthusiasts to build their ideal bodies. Bodybuilding supplements are advertised to provide nutrients needed to help optimise muscle building but they can contain high amounts of sugar. Supplement users are consuming these products, while not being aware of their high sugar content, putting them at a higher risk of developing dental caries. It is important for dental professionals to recognise the increased risk for supplement users and to raise awareness, provide appropriate preventative advice and be knowledgeable of alternative products to help bodybuilders reach their goals, without increasing the risk of dental caries.

INTRODUCTION

Body image and self-consciousness are common advertising targets, with sexual imagery being used in 20% of advertisements in magazines such as *Cosmopolitan*, *Redbook* and *Esquire*.[1] The world of bodybuilding and fitness has followed this trend, with magazines such as *Men's health*, *Men's fitness*, *Flex* magazine, and *Muscle and fitness* selling almost 300,000 copies in the first half of 2014 in the UK.[2] These magazines are full of models with idealised bodies constantly feeding into the thinking that this is how we should want to look; then, on the following page there will be an advertisement by a sponsor promoting their muscle building supplement to help you achieve that look, thereby changing the readers' self-concept and lowering their self-esteem.[3]

The global sport nutrition industry was worth £3 billion in 2009, grew to £4.9 billion in 2012 and is estimated to rise to £8 billion by 2017.[4,5] This highly lucrative industry boasts hundreds of products all of which are advertised to help the reader achieve the body they always wanted. Products categories include all-in-ones, amino acids, creatine, energy and endurance, isotonic and hydration, meal support, meal replacements, nitric oxide, post-workout shakes, pre-workout, protein and protein bars all of which offer ample individual products.[6] Supplements such as whey protein, creatine, beta-alanine and branched chain amino acids can be taken alongside daily nutrition, resistance training and cardiovascular training to help increase muscle size, strength and recovery.[7,8]

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Refereed Paper
Accepted 10 June 2015
DOI: 10.1038/sj.bdj.2015.521

SUPPLEMENTS: CONSUMPTION PATTERNS AND MECHANISM

To optimise muscle hypertrophy and strength, weight lifters need to consume 1.4–2.0 g of protein per kilogram and 44–50 kcal per kilogram of bodyweight daily.[9,10] This means a person weighing 75 kg would need to consume up to 150 g of protein to optimise muscle gains. Some authors have even suggested protein consumption ranges of 2.3–3.1 g/kg of lean body weight for leaner bodybuilders who are in a calorific deficit, such as those getting ready to compete.[11] This large amount of protein can be accounted for by the consumption of protein from a variety of dietary sources including animal and plant proteins as well as supplements.[12] Nutritional supplements containing carbohydrates, protein, vitamins and minerals are used in a variety of sporting fields to boost athlete's recommended daily allowance of nutrients, as well as to boost performance.[13]

Supplements are easy to take pre-, intra- and post-exercise/resistance training and this maybe the reason for their widespread use. Supplements can help increase endurance, for example during endurance training, glycogen is gradually depleted making it more difficult to continue, consuming a carbohydrate supplement can help improve endurance as well as helping to replenish glycogen stores which can aid recovery.[13,14]

Resistance training has an anabolic effect on skeletal muscle and thus stimulates muscle protein synthesis; however, at the same time it also further stimulates protein breakdown resulting in an overall negative protein balance.[15,16] By consuming nutrients, specifically high quality protein which is rich in essential amino acids, the balance shifts in favour of muscle protein synthesis due to the increase of amino acid availability and the overall positive protein balance.[17]

Protein supplements

Whey protein is a good example of a high quality protein source as it contains high levels of essential and branch chain amino acids. It is quickly digested and, due to its excellent bioavailability, elicits a rapid increase in plasma amino acids leading to rapid protein synthesis.[18,19] Alongside whey protein the other most popular protein supplement is casein, which also has a full amino acid profile and stimulates muscle protein synthesis. However, casein is more slowly digested and absorbed leading to a more moderate and prolonged increase in plasma amino acids.[19] Between the two, whey protein has been found to stimulate muscle protein synthesis to a greater degree than casein.[18] Protein supplementation before and after resistance training has been shown to stimulate and increase muscle protein synthesis.[20-22]

Carbohydrate supplements

Carbohydrate are consumed near to or during training periods to reduce muscle protein

breakdown and increase muscle protein synthesis.[23] When taken with protein, fast acting carbohydrates such as maltodextrin, glucose and dextrose can accelerate muscle protein synthesis through the action of insulin which has known anabolic and anti-catabolic properties.[24-26] Carbohydrate supplementation before and during high volume training can also help maintain muscle glycogen levels leading to better performance as well as quicker recovery due to enhanced re-synthesis of muscle glycogen.[27]

However, this is an issue of contention with some studies disputing the muscle hypertrophy benefits of carbohydrate consumption during or around training. Figueiredo *et al.* have reviewed the evidence supporting carbohydrate supplementation in addition to protein supplementation after resistance training for the specific purpose of increasing muscle mass.[28] They found one study citing supportive data from *in vitro* cell culture models where it was possible to exclude insulin entirely. Therefore, the results were not necessarily transferable to *in vivo* conditions without consideration of the differences.[28] The authors agreed that insulin was needed to increase protein synthesis when amino acid delivery was increased but that even very low levels of insulin were able to work with leucine (an amino acid which has the greatest influence on protein synthesis) to enable protein synthesis. They also mentioned that leucine itself had the ability to stimulate insulin secretion and that most of the studies on protein supplementation also reported a marked increase in insulin levels after ingestion.[29,30]

Staples *et al.*[31] found that the addition of 50 g of maltodextrin to 25 g of whey isolate did not increase the muscle protein balance post exercise. Therefore, the benefit of carbohydrate supplementation for the purpose of muscle hypertrophy around resistance training appears to be a very grey area, which currently lacks the necessary data to make evidence-based recommendations. It is certainly of greater importance for endurance rather than strength and muscle hypertrophy goals.[32]

Pre-workout supplements

Pre-workout supplements is a new category of sports supplements which have been developed to optimise nutrient delivery before exercise/training.[33] Pre-workout supplements are not only used by bodybuilders but also by athletes and strength competitors with the aim of increasing energy availability, promote vasodilation and positively affect exercise capacity.[33,34] They are made up of a combination of ingredients which can include stimulants (eg caffeine), energy-producing agents (eg creatine), agents that act as hydrogen ion buffers (eg beta-alanine), protein recovery nutrients (eg amino acids), antioxidants, nitric oxide precursors (eg arginine) and energy boosters (eg citrulline malate).[34,35] Caffeine which perhaps is the most commonly consumed pre-workout stimulant by bodybuilders has been shown to support an improvement in strength and endurance training, alongside creatine which has also been shown to improve high intensity training performance.[36,37]

Indeed, individual ingredients have a beneficial effect when taken in the correct dosages but most consumer products contain a combination of ingredients at low ineffective dosages.[34] For example, nitric-oxide-based, pre-workout supplements have been developed and claim to promote vasodilation and increased blood flow due to the increase in nitric oxide following the intake of L-arginine.[38] L-arginine is indeed the precursor to nitric oxide biosynthesis which in turn is associated with increased vasodilation; however, most of the evidence from which this rationale is based is in relation to using intravenous L-arginine at much higher doses and not oral L-arginine at much lower doses which is often found in pre-workout products and has no effect on vasodilation/enhanced blood flow.[39-41] Some companies who develop and market pre-workout supplements even claim that a single use of their product will give the consumer a muscle 'pump' which is completely unsubstantiated.[34]

Sugar content

Glucose syrup, high fructose corn syrup, fructose, dextrose and maltodextrin are an example of the sugars found in bodybuilding supplements especially weight gainers and intra work carbohydrate drinks such as High5 energy source (16 g sugar and15 g fructose per serving), Mutant mass (34 g sugar per serving), USN muscle fuel anabolic (7.5 g sugar per serving), XL nutrition xtra protein & carbs (7.7 g sugar per serving), Optimum nutrition serious mass (21.3 g sugar per serving), Vyomax nutrition maxi carb energy drinks (27.5 g sugar per 500 ml bottle).[6,42] It is the sugars found in supplements which are of interest in this paper as consumers of these supplements, in pursuit of the advertised 'ideal body' can put themselves at an increased risk of dental caries.[43-45] The focus of this article is to describe the use of dietary supplements, their effect on dental health and to raise awareness to general dental practitioners (GDPs) and dental care professionals (DCPs).

Table 1 Table showing the sugar content of supplements around a typical workout day[6,42]

Product	Type	Sugar content (per serving)	Timing and no. of servings
Sci MX Whey Protein	Whey protein	4.9 g	Breakfast (1) and pre-workout (1)
Muscle Cell Tech Performance Series	Flavoured creatine	14.0 g	Post-work out (2)
MusclePharm Assault	Pre-Workout	2.0 g	Pre-workout (1)
Vyomax Nutrition Maxi Carb Energy Drink	Carbohydrate drink	27.5 g	Pre- and intra-workout (1-2)
CNP Professional Pro Recover	Post workout protein	44.0 g	Post-workout (1)
Optimum Nutrition 100% Gold Standard Casein protein	Casein protein	1.5 g	Before bed (1)

SUPPLEMENTS AND SUGAR CONTENT

In the preceding section of this paper, some of the evidence for bodybuilding supplementation and the timing of its consumption has been discussed. However, in reality it is not certain how many of the consumers of these supplements are actually aware or know about the evidence behind the claims made about supplements or the validity of these claims. Perhaps, these consumers are more likely to access bodybuilding supplement websites and view their 'evidence' or recommendations while they decide which products they wish to purchase.

The following are some of the recommendations made by a popular website[46] regarding supplement choice and timing. It's important to note that the regimen of supplementation can change and is not the same for everyone, some consumers supplement more or less than others and this can be dependent on their budget, convenience or simply, their preference.

1. Whey protein supplementation before and after a workout – a quarter gram of protein per pound of bodyweight – a 200 lb person would need to approximately 50 g of whey protein before and after a workout[46]
2. Consume fast digesting carbohydrates

Table 2 The sugar content of dietary supplements[6,42]

Product	Type	Sugar content (per serving in grams)
Optimum Nutrition 100% Natural Oats & Whey	Meal replacement	14.8
USN Whey & Oats	Meal replacement	9.0
USN Muscle Fuel STS	Meal replacement	4.4
CNP Professional Pro MR	Meal replacement	3.7
Muscle Pharm Combat Powder	Protein blend	2.0
BSN Syntha 6 EU	Whey protein	4.0
USN RTD Pure Protein Fuel 25	Whey protein	11.5
USN Pure Protein GF1	Whey protein	1.2
XL Nutrition Xtra Whey	Whey protein	3.8
Mutant Whey	Whey protein	1.0
PhD Nutrition Pharma Whey HT+	Whey protein	0.95
Optimum Nutrition 100% Gold Standard Whey	Whey protein	1.4
Optimum Nutrition 100% Gold Standard Casein Protein	Casein protein	1.5
USN Casein Night Time Protein	Casein protein	1.3
PhD Nutrition Casein	Casein protein	1.47
Mutant Micellar Casein	Casein protein	2.0
MusclePharm Combat Casein	Casein protein	1.0
High 5 Protein Recovery	Post workout	18.0
PhD Nutrition Recovery 2:1	Post workout	25.2
Kinetica 100% Recovery	Post workout	29.1
Optimum Nutrition Recover 2:1:1	Post workout	38.9
Universal Torrent	Post workout	26.0
Sci MX Recover 2:1 Isolate	Post workout	23.9
CNP Professional Pro Recover	Post workout	44.0
Dorian Yates Nox Pump	Pre-workout	0
USP Labs Jac3d Micro	Pre-workout	0
BPI 1.MR	Pre-workout	0
USN Hyperdrive N O	Pre-workout	0
BSN NO Xplode 3.0	Pre-workout	0
Grenade 50 Calibre	Pre-workout	0.6
MusclePharm Assault	Pre-workout	2.0
PhD Nutrition VMX2	Pre-workout	0.43
Optimum Nutrition Gold Standard Pre Workout	Pre-workout	0
Vyomax High Protein Oat Cookies	Protein bar	6.38
Sci MX Pro 2GO Duo Bar	Protein bar	11.4
Garnell Nutrition Protein Cookie	Protein bar	7.6
Grenade Reload Protein Flapjacks	Protein bar	8.1
Quest Nutrition Protein Bars	Protein bar	1.0
XL Nutrition High Protein Flapjacks	Protein bar	4.9

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before and after workouts, the same amount as protein – 50 g of carbohydrates such as sucrose or dextrose should be consumed before and after workouts for a 200 lb person[46]

3. Take creatine 3–5 g before and after a workout.[46]

The above recommendations are just from one website, another popular website[47] also advised consuming a whey protein (20 g) in the morning and casein protein (20 g) before going to bed, as well as a pre-workout supplement a combination of vitamins, minerals and fish oil throughout the day. If you add these recommendations together one could easily consume supplements up to 8–9 times in a day (depending on what product is used), not including multivitamin, mineral and fish oil supplements. When individual products are assigned to this regimen, Table 1 shows what the breakdown can look like.

You can clearly see from Table 1 that the frequency and overall sugar consumption from supplements alone can be as high as 7–8 times a day with a total of 107.9 g of sugar daily, this can be even higher if the supplements are consumed in higher dosages. Post-workout carbohydrate drinks were not included in Table 1 because post workout protein powder already contained a substantial amount of glucose and sucrose to help aid recovery. The high and frequent consumption of sugar-containing supplements can clearly put the consumer at an increased risk of developing dental caries due to the dissolution of tooth substance by acid as a result of the metabolism of fermentable carbohydrates by oral bacteria.[48,49] The Stephan's curve shows how demineralisation occurs when the pH drops below 5.5 but then gradually begins to rise by the buffering action of saliva resulting in remineralisation.[50] However, due to the high frequency of sugar consumption throughout the day, the time between the decreases in pH is not enough to allow effective remineralisation to occur therefore increasing the likelihood of dental caries.[51]

There has been no meaningful research into bodybuilding supplementation and the possible link to increased tooth decay. However, Needleman *et al.*[52] did analyse the oral health of Olympic athletes in the 2012 London Games and found that out of 302 athletes, from 25 sports, 55% had evidence of cavities, 45% had tooth erosion and 76% had gum disease. The authors highlighted that caries risk and disease levels had been repeatedly found to be high in athletes and that this could be due to frequent carbohydrate consumption and reduced salivary flow.[53-55]

RECOMMENDATIONS

Why is this important for the general dental practitioner? The answer is simple, recognition of this new risk group allows dental healthcare professionals to raise awareness and deliver more targeted preventive advice, as well as being better informed of what caries risk group to place these patients in.

The following are some recommendations which dental healthcare professionals may wish to consider in managing and treating this new risk group:

1. Identify supplement users when taking social histories and making dietary enquires, recording what product is consumed, sugar content if possible and the frequency of consumption
2. Record any evidence of erosion as extrinsic acids can be found in sports drinks and citrus products which can lead to the progressive loss of dental hard tissue[56]
3. If the patient is deemed to be at a high risk of having dental caries, take six monthly posterior bitewing radiographs until no new active lesions are found or until the patient enters a new risk category[57]
4. Provide appropriate preventative advice and consider fluoride supplementation, such as fluoride varnish application and prescribing high strength fluoride tooth paste, as per the recommendations set in the Public Health England's *Delivering better oral health: an evidence-based toolkit for prevention (Third edition)*
5. Place patients in the appropriate risk category and re-call as per dental recall guidelines by NICE.

The following advice and information can be given to patients as part of a wider preventive regimen in reducing the risk of dental caries as set forth in *Delivering better oral health: an evidence-based toolkit for prevention*:

1. Explain the role of sugar in tooth decay and how frequent consumption of sugar-containing supplements can put the patient at an increased risk of tooth decay
2. Advise the patient to chew sugar-free gum containing xylitol as this has anti-cariogenic effects and helps to stimulate saliva flow which in turns buffers acid, supporting remineralisation[58]
3. Advise the patient to avoid sugar-containing supplements within one hour of bed time as the salivary flow and buffering capacity is low/reduced at night[59]
4. Advise the patient to opt for low sugar or sugar-free supplements where possible, especially those containing sweeteners such stevia, sucralose and Acesulphame K which are calorie free and non-cariogenic[60,61]
5. Advise the patient to try and consume the majority of their macro nutrients from whole foods such as meats, grains, dairy, vegetables and nuts rather than supplements.

Table 2 The sugar content of dietary supplements[6,42]

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CNP Professional Pro Flapjacks	Protein bar	4.8
SNE True Gainer	Weight gainer	20.7
Universal Real Gains	Weight gainers	7.0
USN Muscle Fuel Mass	Weight gainers	22.9
Mutant Mass	Weight gainers	34.0
CNP Professional Pro Mass	Weight gainers	2.3
Reflex Nutrition Instant Mass Pro	Weight gainers	11.4
Arnold Schwarzenegger Iron Mass	Weight gainers	4.0
BSN True Mass 1200	Weight gainers	16.0
Muscletech Mass Tech	Weight gainers	8.0
Optimum Nutrition Serious Mass EU	Weight gainers	21.3
Dorian Yates Creagen Creatine	Flavoured creatine	6.0
USN Creatine Anabolic	Flavoured creatine	2.4
Optimum Nutrition Micronized Creatine Powder	Creatine powder	0
USN Creatine Transport	Flavoured creatine	0.2
Universal Creatine	Creatine powder	0
Sci MX Creatine Monohydrate	Creatine powder	0
Reflex Nutrition Creapure Creatine	Creatine powder	0
Primaforce CreaForm	Creatine power	0
PhD Nutrition Creatine	Creatine powder	0
Muscletech Cell Tech Performance Series	Flavoured creatine	14.0
High 5 Energy Source 2:1 Fructose	Energy powder	16.0
PhD Nutrition Battery +/-3	Energy power	26.2
Science In Sport GO Energy	Energy powder	3.5
Thornton & Ross Glucose Power	Energy powder	90.9 (per 100g)
Kinetica 100% Energy	Energy powder	14.6
EZ Fuel Energy Bar	Energy bar	20.6
Vyomax Nutrition Maxi Carb Energy Drink	Energy drink	27.5

It is important to say here that not all supplements are high in sugar or even contain sugar, just as not all supplement users will consume products with the same frequency or quantity as others. It is all dependant on the individual and the goals they wish to achieve. For example, the bodybuilder who is trying to reduce their body fat for a competition will aim to restrict their sugar intake and as a result reduce what supplements they take and often they take them with the option of switching to sugar-free versions. On the other hand if the bodybuilder is aiming to gain weight they will consume more calories and part of that regimen may involve consuming high calorie supplements which, as shown in the Table 2, can also be high in sugar. A lack of awareness of athletes in the study by Needleman *et al.*[52] highlights that the population may be unaware of the risks to the person's oral health. A detailed history including questions regarding supplements should therefore be routine.

CONCLUSIONS

From personal experience, regular supplement consumers I have treated commonly have active caries and are generally unaware of the effect of supplements on their dental health. Understanding the lifestyle and habits of our patients helps us to provide more holistic dental care better suited to the mould of our patients.

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