Preventive Medicine Reports 23 (2021) 101504

Contents lists available at ScienceDirect

Preventive Medicine Reports

journal homepage: www.elsevier.com/locate/pmedr

A content analysis of marketing on the packages of dietary supplements for weight loss and muscle building

Sophia V. Hua [a,*], Brigitte Granger [b], Kelly Bauer [c], Christina A. Roberto [d]

[a] Department of Nutrition, Harvard T. H. Chan School of Public Health, Boston, MA 02115, United States
[b] Supporti, LLC, 665 Huntington Ave., Building 2, Room 320, 300 Lenora Street #667, Seattle, WA 98121, United States
[c] Division of Hematology and Oncology, Department of Medicine, University of California at San Francisco Helen Diller Family Comprehensive Cancer Center, 550 16th Street, Mission Hall, San Francisco, CA 94158, United States
[d] Department of Medical Ethics and Health Policy, University of Pennsylvania Perelman School of Medicine, 423 Guardian Dr., Blockley Hall, Philadelphia, PA 19104, United States

ARTICLE INFO

Keywords:
Weight loss
Muscle building
Dietary supplements
Marketing
Consumer health information

ABSTRACT

Most dietary supplements for weight loss and muscle growth lack scientific evidence in support of product claims and contain ingredients that can be harmful to health. Many people, however, still use these products. This paper aims to address a gap in the knowledge of the number and types of marketing claims appearing on dietary supplements for weight loss and muscle building and how they relate to the presence of an FDA disclaimer. We identified all products (n = 110) found in the weight loss and muscle building section of three stores (a pharmacy, supermarket, and superstore) in the Boston, MA area during 2013. We performed a content analysis to assess the presence of marketing claims displayed on product packaging, including claims about weight loss, safety, quality, and scientific evidence. Warnings and the FDA disclaimer were also coded. We found that, on average, products displayed 6.5 claims. Among weight loss- and muscle building- related claims, claims about reducing weight, BMI, or body fat were most common (60.9%), followed by protein claims (40.0%). Nearly half of the products made claims that scientific research supported product use. Products with the FDA disclaimer (53.6%) or a warning for vulnerable populations (56.4%) had a higher average number of claims compared to products without the disclaimer or warning ($p < 0.001$). Dietary supplements for weight loss and muscle building displayed many marketing claims promising weight loss despite a lack of scientific evidence that such products can be used safely and effectively. Greater FDA regulation of these marketing claims are needed.

1. Introduction

National surveys consistently report that about half of Americans want to lose weight (Reinhart, 2019), but weight loss can be an elusive goal (Brownell, 2010). It is therefore not surprising that many people turn to dietary supplements for weight loss, which are often marketed as fast, simple, and easy ways to lose weight (Gibson-Moore, 2010). In one survey, 34% of adults in a nationally representative sample reported making a serious weight loss attempt using an over-the-counter supplement such as an appetite suppressant, weight loss product, or herbal product (Pillitteri et al., 2008), and about five percent of high schoolers reported using diet pills to lose weight (Kann et al., 2014).

Abuse of over-the-counter diet products for weight control is growing among men and women spanning racial, ethnic, and socioeconomic groups (Kann et al., 2014; Blanck et al., 2007). These trends are problematic as a majority of studies evaluating dietary supplements for weight loss find that they are ineffective at producing the promised results (Laddu et al., 2011; Maunder et al., 2020), have no effect beyond placebos (Gibson-Moore, 2010), and may cause harm (Geller et al., 2015; Zheng and Navarro, 2015; Or et al., 2019). Such products can encourage unhealthy weight loss practices, and individuals with anorexia nervosa and bulimia nervosa are at particular risk of misusing them (Hackett and Krska, 2012). Product ingredients can lead to serious health consequences, including heart palpitations, hemorrhagic stroke, and sudden cardiac arrest (Venhuis et al., 2014; Cohen et al., 2015; Eliason et al., 2012). One study estimated that over 20,000 emergency department visits per year were attributable to dietary supplements, with approximately 25% of those attributed to weight loss

* Corresponding author.
E-mail address: sophiahua@g.harvard.edu (S.V. Hua).

https://doi.org/10.1016/j.pmedr.2021.101504
Received 12 April 2021; Received in revised form 14 June 2021; Accepted 19 July 2021
Available online 23 July 2021

products (Geller et al., 2015). Additionally, diet product claims may exacerbate unrealistic standards of weight and weight loss (Pirsch et al., 2013).

People may be using these products, in part, because they do not realize they are not well regulated by the government. About half of Americans in a nationally representative survey and over 60% of college students in another study incorrectly believe that all dietary supplements must be approved for safety and efficacy before being sold to the public, as is the case for over-the-counter and prescription drugs (Pillitteri et al., 2008; Dodge et al., 2011). In reality, dietary supplements for weight loss and muscle building are regulated through the Dietary Supplement Health and Education Act (DSHEA) of 1994 (Dietary Supplement Health and Education Act, 1994). A product is regulated by the U.S. Food and Drug Administration (FDA) as a drug if it makes disease claims about treating, preventing, or curing a specific disease (Office of Inspector General, 2012). Instead, most dietary supplements make claims about a product's structural or functional effects ("structure/function claims") on the human body without a disease-related claim. When such structure/function claims appear (e.g., curbs appetite to help with weight loss[19]), DSHEA requires products to also display the following prominently placed and bolded disclaimer: *"These statements have not been evaluated by the Food and Drug Administration. This product is not intended to diagnose, treat, cure or prevent any disease"* (Dietary Supplement Health and Education Act, 1994). Manufacturers are not required to test the safety of their products before going to market and are allowed to make truthful and not misleading structure/function claims based on their own internal evidence (Dietary supplements, 2012). Problematically, a study examining the structure/function claims on dietary supplement print ads found that many of these claims, such as "rebuilds joints", mimic health claims, which may cause consumers to believe these dietary supplements are curative (Avery et al., 2017). In 2012, the U.S. Department of Health and Human Services Office of Inspector General (OIG) conducted an audit of dietary supplements due to increased concerns regarding the use of structure/functions claims combined with the FDA's lack of authority to evaluate these claims prior to them going to market. This audit included 60 weight loss dietary supplements, all of which had at least one structure/function claim, with ~7% not displaying the required FDA disclaimer (Office of Inspector General, 2012). More concerning is that a larger proportion of the products (18%) included health claims on their labels (e.g. "Adequate calcium may reduce the risk of osteoporosis.") (Office of Inspector General, 2012).

The FDA only has the authority to stop the sale of dietary supplements after they are marketed if either the labeling includes unauthorized claims or enough consumers report adverse effects. In a study of dietary supplement recalls in the U.S., 27% of the 237 recalled dietary supplements were for weight loss, while 31% were for bodybuilding (Harel et al., 2013). All were recalled due to unapproved drug ingredients. Despite such recalls, prohibited substances are still found in these products (Cohen et al., 2021).

Although previous studies have investigated weight loss advertising, including print media and online ads (Avery et al., 2017; Ethan et al., 2016; Kruger, 2012), there have been few comprehensive studies examining a range of marketing strategies and claims appearing on the product packaging of dietary supplements for weight loss and muscle building. Therefore, the aims of this study were to build on the 2012 OIG report by: 1) documenting the prevalence of potentially misleading advertising claims on a larger sample of dietary supplements for weight loss and muscle building, and 2) examining whether the number of marketing claims is associated with the presence of warnings for vulnerable populations and the FDA disclaimer. We hypothesized that the presence of the FDA disclaimer or other warnings would be associated with a greater number of marketing claims because companies may either feel greater license to make claims given the disclaimer or try to compensate for the disclaimer with additional claims (Loewenstein et al., 2012). This research can help inform efforts by the FDA to protect the public from misleading marketing practices on dietary supplements for weight loss and muscle building (U.S. Food & Drug Administration, 2019).

2. Methods

Two research assistants collected data on dietary supplements for weight loss and muscle building from May to November 2013 at a CVS Pharmacy, Shaw's supermarket, and a Target superstore in the Boston, Massachusetts, USA metropolitan area. DSHEA defines dietary supplements as "*a product (other than tobacco) intended to supplement the diet that bears or contains one or more of the following dietary ingredients: a vitamin; a mineral; an herb or other botanical; an amino acid; a dietary substance for use by man to supplement the diet by increasing the total dietary intake; or a concentrate, metabolite, constituent, extract, or combination of any ingredient described*". Although dietary supplements are supposed to display Supplement Facts panels instead of Nutrition Facts panels, if the item was located in the weight loss and muscle building aisles and met the DSHEA definition of a supplement, we included it in our sample regardless of whether it had a Supplement or Nutrition Facts panel.

Research assistants recorded all available unique pills, shakes, powders, and bars in the weight loss and muscle building store aisles; diet products appearing elsewhere in the stores were not included. Only one flavor was recorded for products with multiple flavors. Out-of-stock products and products that made no specific references to weight or body (e.g., energy pills, general nutrition shakes and snack bars) were excluded. We obtained data on 111 products, but one was dropped due to incomplete coding data. The final analytic sample included 110 products. Research assistants photographed all sides of each product in the store.

The research team reviewed the types of marketing appearing on each product to inform the development of a codebook (available upon request), which was used to perform a content analysis of the package marketing. Weight loss- and muscle building- related claims appearing on the products were categorized as: cleansing (e.g., detoxifying), weight loss mechanisms (e.g., block carbohydrates), weight loss results (e.g., reduce body fat), wellbeing (e.g., increases energy), or nutrient claims (e.g., low calorie). We also examined whether the packaging had claims that referenced scientific studies and if there were warning labels. Table 1 displays all claim themes with examples. Research assistants also recorded the product's form (e.g., pill, shake, bar) and price per dose.

Thirty-five percent of the sample (n = 39) were randomly selected and double coded to determine inter-rater reliability. All included variables had a kappa coefficient of 0.80 or higher or a percent agreement greater than 97% (indicating only one disagreement between two coders). Percent agreement was included in the analyses as a check on kappa, which can yield very low reliability coefficients for variables with high agreement (Feinstein and Cicchetti, 1990). The remaining products were divided between the two researchers and coded individually. We excluded 14 claims that did not meet our reliability criteria (one mechanism claim, three results claims, one wellbeing claim, four nutrient claims, and five non-weight loss/other marketing claims). All other claims were included in the analyses. See Table 1.

3. Statistical analyses

We present descriptive statistics summarizing the frequency of different claim types and the mean number of claims per package. We also report the number of products that displayed an FDA disclaimer informing consumers when claims on a product have not been approved by the FDA and/or a warning that the product was not safe for vulnerable populations (i.e., children or pregnant women). Using t-tests, we examined whether the presence of the FDA disclaimer and the presence of a warning for vulnerable populations were associated with more overall claims or specific types of claims on a product. We hypothesized that the presence of a disclaimer or warning would be associated with an

Table 1
Categories[a] and claims assessed on the packaging of weight loss and muscle building dietary supplements found in three stores in Boston, Massachusetts.

Weight Loss- & Muscle Building- Related Claims	
Cleansing Claims	
	Eliminate excess water/waste/matter, "flush"
	Reduce bloating/puffiness
	Detoxifying
	Cleansing/clean/purifying
Mechanism Claims	
	Suppresses hunger, keeps you full or satisfied, decreases appetite, curbs cravings
	Burn/block calories
	Increase/boosts metabolism or says "thermogenic"
Results Claims	
	Reduce body fat, BMI, or promotes weight loss
	Money back guarantee; guarantees success, "or your money back"
	Fast, easy simple, quick weight loss
	Increase muscle mass
	Tones, sculpts, leans
	Get fit
	Lose >5lbs per week (in writing or charts)
	Rids stubborn fat or lose last 5 lbs
Wellbeing claims	
	Improves mental performance, alertness, focus
	Supports or improves mood, makes you happy, feel good
	Reduces stress
	Boosts self-esteem or confidence
	Helps immunity or combats illness, makes you happy
Nutrient Claims (outside of nutrition facts)	
	Low carb, no carb, # grams of carbs
	Low sugar, sugar free, # grams of sugar
	High protein, # grams of protein
	Low calorie, # calories
	High fiber, # grams of fiber, kind of fiber
Non-Weight Loss Claims/Other Marketing	
	Performance claims (e.g., quick, fast-acting, etc.)
	Side effect descriptions
	Claims about scientific research findings
	FDA approved
	Product endorsement (e.g., by a physician)
	Product testimonials
	Product awards
	Ingredients includes "blends" (e.g., muscle building blend)
	Website link

[a] The following variables did not meet inter-coder reliability and were not included in the final analysis: burn/block fat; burn/block carbohydrates; get thin or slim, reduce waistline, flat abs, belly fat; get the body you've always wanted; improve athletic performance increase endurance; increases energy or stamina, reduce fatigue or tiredness; low fat, fat free, # grams of fat; mentions caffeine; pure or natural, from nature, herbal, authentic, natural way to lose weight (except "natural flavors"); touts healthy ingredients excluding fiber (e.g., green tea, vitamins, berries); safety claims (e.g., statement that manufacturer is under strict quality control); descriptions of the product's functional mechanism ingredients; imagery (e.g., scientific images such as graphs, fruits/vegetables, scales); promotions (e.g., offer of something free).

increased number of claims on the product. All tests were two-tailed and based on a 0.05 significance level. We used the Benjamini-Hochberg procedure to correct for multiple testing. Statistical analyses were performed using Stata 16 statistical software package (StataCorp, 2019).

4. Results

On average, products had 6.5 (SD: 2.5) claims per package. Product prices ranged from $1.49 (an individually packaged protein bar) to $42.79 (a bottle of 56 pills). The median price per daily dose was $2.03 among the 71 products (64.5%) that listed a recommended maximum daily dosage. Nearly half (46.4%) of the products were categorized as pills (e.g., tablets, capsules), while the remaining half were nearly evenly distributed between bars (19.1%), liquids (including shakes or drops; 16.4%), and powders (13.6%). Five products (such as candy or tea bags) were categorized as "other." Thirty-four (30.9%) of the products were found in two or more stores, but each product was only coded once.

4.1. Weight loss- and muscle building-related claims

Among the weight loss- and muscle building- related claims, claims about reducing weight, BMI, or body fat were the most common (60.9%), followed by protein claims such as "high protein" (40.0%), and then claims about guaranteeing success (31.8%). About a quarter of all products included claims about quick weight loss, being low in calories, or boosts in metabolism. Table 2 lists the top ten most frequently observed weight loss- and muscle building- related claims in the sample.

4.2. Other marketing strategies

Forty-seven percent (n = 52) of products had claims about scientific research supporting product use. Twenty-seven percent of products (n = 30) made claims that described the product as "fast-acting," "long lasting," or "maximum strength", and 12.7% (n = 14) featured a person endorsing the product (e.g., celebrity, physician, company representative). Fourteen percent (n = 15) boasted awards on the package, such as being the number-one selling brand. Table 2 lists the top five most frequently used non-weight or muscle building- related marketing strategy.

4.3. FDA disclaimer

As summarized in Table 3, 53.6% (n = 59) of the products included the FDA disclaimer, which appeared either on the side or back of the package. Products with the disclaimer had a higher overall average number of claims (7.4 [SD: 2.5]) compared to products without the disclaimer (5.5 [SD: 2.0]; $p < 0.001$), and a higher average number of results claims (e.g., "quick weight loss" or "increase muscle mass") in particular (1.8 [SD: 0.8] vs. 0.8 [SD: 0.7]; $p < 0.001$). Products without the FDA disclaimer, however, had more nutrient claims (e.g., "low carb" or "low calorie") as compared to products with the disclaimer (2.2 [SD:1.2] vs. 0.08 [SD: 0.3]; $p < 0.001$). See Table 3.

Table 2
Ranking of most common weight loss- and muscle building-related claims and other marketing strategies on dietary supplement packaging on 110 diet products found in three stores in Boston, Massachusetts.

	Weight loss- & muscle building-related claims	% of products with claim
1	Reduce body fat, BMI, or promotes weight loss	60.9
2	High protein, # grams of protein	40.0
3	Money back guarantee; guarantees success, "or your money back"	31.8
4	Suppresses hunger, keeps you full or satisfied, decreases appetite, curbs cravings	30.0
5	Fast, easy simple, quick weight loss	25.5
6	Low calorie, # calories	26.4
7	Increase/boosts metabolism or says "thermogenic"	22.7
8	High fiber, # grams of fiber, kind of fiber	18.2
9	Low sugar/sugar free/# grams of sugar	16.4
10	Helps immunity, combats illness	10.9
	Other marketing strategies	
1	Side effect descriptions	60.9
2	Ingredients listed as blends (e.g. "muscle building blend")	51.8
3	Mention of science or research	47.3
4	Performance claims (e.g., fast acting)	27.3
5	Product endorsement	12.7

Table 3
Associations between FDA disclaimer or warnings for children and/or pregnant women and the number of packaging claims on weight loss/muscle building dietary supplements.

	Without FDA Disclaimer n = 51	With FDA Disclaimer n = 59	*t*-Statistic	Unadjusted *p*-value[a]	Without warning for vulnerable populations n = 48	With warning for vulnerable populations n = 62	*t*-Statistic	Unadjusted *p*-value[a]
Claim Category	Mean (SD)	Mean (SD)			Mean (SD)	Mean (SD)		
Total Claims	5.5 (2.0)	7.4 (2.5)	−4.3	**<0.001**	5.5 (2.0)	7.3 (2.5)	−4.2	**<0.001**
Weight Loss Claims	4.0 (1.6)	4.3 (2.1)	−0.9	0.355	4.0 (1.7)	4.3 (2.1)	−0.9	0.381
Cleansing Claims	0.1 (0.5)	0.3 (1.0)	−1.4	0.172	0.0 (0.0)	0.4 (1.0)	−2.5	0.014
Mechanism Claims	0.4 (0.5)	0.8 (0.9)	−2.4	0.019	0.5 (0.6)	0.7 (0.9)	−1.7	0.099
Results Claims	0.8 (0.7)	1.8 (0.8)	−7.2	**<0.001**	0.8 (0.7)	1.8 (0.8)	−6.6	**<0.001**
Wellbeing Claims	0.2 (0.4)	0.3 (0.5)	−1.1	0.265	0.2 (0.4)	0.2 (0.5)	−0.4	0.695
Nutrient Claims	2.2 (1.2)	0.08 (0.3)	12.7	**<0.001**	2.2 (1.3)	0.2 (0.7)	10.6	**<0.001**

[a] Bold indicates statistical significance after adjusting for multiple testing using the Benjamini-Hochberg procedure.

4.4. Warnings for children and/or pregnant and nursing women

Many packages (56.4%) indicated that vulnerable groups such as children and pregnant or nursing women should avoid using the product. Like the FDA disclaimer, the presence of these warnings was statistically significantly associated with a greater mean number of overall claims on the package (7.3 [SD: 2.5] vs. 5.5 [SD: 2.0]; $p < 0.001$). Products with these warnings were also more likely to have results claims [0.8 [SD:0.7] vs. 1.8 [SD: 0.8], $p < 0.001$], but as with the presence of an FDA disclaimer, were significantly less likely to have nutrient claims [2.2 [SD : 1.3] vs. 0.2 [SD : 0.7], $p < 0.001$]. See Table 3.

5. Discussion

The purpose of this study was to describe the different types and frequency of marketing claims found on the packaging of weight loss and muscle building dietary supplements. We found that on average, weight loss and muscle building products displayed approximately 6.5 claims per package, and these claims ranged from promises of easy weight loss to assurances of scientific evidence. Products with the FDA disclaimer or warnings for vulnerable groups displayed significantly more claims than products that did not have those disclosures.

The high number of claims found on these packages deserves attention. A U.S. OIG report revealed that documentation from many weight loss and immune support supplement manufacturers did not meet the FDA's criteria for competent and reliable evidence in support of packaging promises (Office of Inspector General, 2012). Many dietary supplements avoid accusations of false weight loss claims by including language explaining that the product can produce weight loss when combined with a reduced calorie diet and exercise. In addition, the number of these potentially misleading statements was greater when there was a disclaimer or warning. Prior studies on disclaimers have shown that including them may make companies feel more license to make unsubstantiated or biased claims (Loewenstein et al., 2012). Further, even when the FDA disclaimer appeared on the product packaging, it was relegated to the back and side of the product (not the front), so consumers may not even see it before purchasing or consuming the product. These findings suggest the FDA disclaimer should be required to appear on the front of all dietary supplement packaging in font that is accessible in size, style, and color so that it is easily visible to the consumer.

Greater regulation is needed for the content of the marketing claims appearing on weight loss and muscle building supplements. Nearly 95% of the supplements we examined had at least one statement related to weight loss, and almost half of the dietary supplements in our sample mentioned science or research on the package. Although we did not examine the research underlying each scientific claim made, in general, there is a lack of scientific evidence supporting the use of dietary supplements for weight loss and muscle building (Laddu et al., 2011; Maunder et al., 2020), and many of these products may have adverse side effects (Zheng and Navarro, 2015; Or et al., 2019). Regulations requiring these products to have rigorous scientific evidence supporting marketing claims may help protect consumers. In addition to these claims, 13% of the sampled products had an endorsement by a celebrity, physician, athlete, etc., which has been found to increase sales (Elberse and Verleun, 2012).

A recent study showed that of the dietary supplements identified by the FDA between 2007 through 2016 that were adulterated with banned or potentially unsafe ingredients, 41% were for weight loss and 12% were for muscle building (Tucker et al., 2018). These numbers are consistent with FDA's more recently published list of dietary supplements containing potentially dangerous ingredients, of which 35% are for weight loss and 8% are for muscle building (U.S. Food & Drug Administration, 2021). Research uncovering these issues has grown over the last 15 years (Maunder et al., 2020; Or et al., 2019; Eichner et al., 2016; Cohen et al., 2019), but there continues to be a lack of regulation that needs to be addressed.

This research study has several limitations. First, our data are from 2013, so our sample only partially reflects what is available in the marketplace today, though they are representative of the types of products that can be found. Of the products in our sample, 40.9% of them are captured in the NIH Dietary Supplement Label Database (DSLD), a database that lists dietary supplements sold in the U.S. We also searched each of the brand websites in 2021 for the products in our sample and found that 55.5% (n = 61) of them are still being offered. However, no study detailing the claims on weight loss and muscle building dietary supplements has been published since 2013. Second, our study is only able to show an association and not a causal relationship between the presence of the FDA disclaimer and more claims. Third, our sample only includes weight loss and muscle building products available at three stores in a relatively small geographic area, so we do not know if the results would generalize to the national market of these products. However, the stores we selected are large chain retailers that likely sell similar items store to store. Finally, we lack data from online retailers and if a popular product was out of stock, we were not able to code the marketing on its packaging.

The study also has several strengths. First, we assessed claims on nearly all dietary supplements for weight loss and muscle building available in three major chain retailers. Second, this is one of the first studies to provide detailed information about the types of marketing and claims appearing on these products. Third, this is the first study to show

how the presence of the FDA disclaimer and warning for vulnerable groups are associated with the number of claims shown on these dietary supplements.

6. Conclusion

The results of this study revealed that weight loss and muscle building supplements display a high number of marketing claims that have not been evaluated by the FDA. In addition, the presence of a hard-to-find FDA disclaimer was associated with more claims. For these reasons, we recommend the government require a disclaimer on all dietary supplements that is prominently displayed on the front of the packaging. An even better step would be to restrict the use of marketing claims on dietary supplements for weight loss and muscle building that are not supported by rigorous scientific evidence.

Funding

The funding section should read: This study was supported by a seed grant from the Robert Wood Johnson Foundation Health & Society Scholars program. Ms. Hua was supported by the National Research Service Award (training grant T32 DK 007703) from the National Institutes of Health (NIH). This paper is solely the responsibility of the author and does not necessarily represent the official views of the NIH.

CRediT authorship contribution statement

Sophia V. Hua: Formal analysis, Writing - original draft, Writing - review & editing, Visualization. **Brigitte Granger:** Investigation, Writing - review & editing. **Kelly Bauer:** Investigation, Writing - review & editing. **Christina A. Roberto:** Conceptualization, Methodology, Funding acquisition, Writing - review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

Avery, R.J., Eisenberg, M.D., Cantor, J.H., 2017. An examination of structure-function claims in dietary supplement advertising in the U.S.: 2003–2009. Prev. Med. 97, 86–92.

Blanck, H.M., Serdula, M.K., Gillespie, C., Galuska, D.A., Sharpe, P.A., Conway, J.M., Khan, L.K., Ainsworth, B.E., 2007. Use of nonprescription dietary supplements for weight loss is common among Americans. J Am Diet Assoc. 107 (3), 441–447.

Brownell, K.D., 2010. The humbling experience of treating obesity: should we persist or desist? Behav. Res. Ther. 48 (8), 717–719.

Cohen, P.A., Travis, J.C., Vanhee, C., Ohana, D., Venhuis, B.J., 2021. Nine prohibited stimulants found in sports and weight loss supplements: deterenol, phenpromethamine (Vonedrine), oxilofrine, octodrine, beta-methylphenylethylamine (BMPEA), 1,3-dimethylamylamine (1,3-DMAA), 1,4-dimethylamylamine (1,4-DMAA), 1,3-dimethylbutylamine (1,3-DMBA) and higenamine. Clin Toxicol (Phila). 1–7.

Cohen, P.A., Zeijlon, R., Nardin, R., Keizers, P.H., Venhuis, B., 2015. Hemorrhagic stroke probably caused by exercise combined with a sports supplement containing beta-methylphenyl-ethylamine (BMPEA): a case report. Ann. Intern. Med. 162 (12), 879–880.

Cohen, P.A., Travis, J.C., Keizers, P.H.J., Boyer, F.E., Venhuis, B.J., 2019. The stimulant higenamine in weight loss and sports supplements. Clin. Toxicol. (Phila). 57 (2), 125–130.

Dietary Supplement Health and Education Act of 1994. In: Congress r, ed. Pub. L. No. 103-4171994.

Dodge, T., Litt, D., Kaufman, A., 2011. Influence of the dietary supplement health and education act on consumer beliefs about the safety and effectiveness of dietary supplements. J. Health Commun. 16 (3), 230–244.

Eichner, S., Maguire, M., Shea, L.A., Fete, M.G., 2016. Banned and discouraged-use ingredients found in weight loss supplements. J. Am. Pharm. Assoc. 56 (5), 538–543.

Elberse, A., Verleun, J., 2012. The economic value of celebrity endorsements. J. Advertis. Res. 52 (2), 149–165.

Eliason, M.J., Eichner, A., Cancio, A., Bestervelt, L., Adams, B.D., Deuster, P.A., 2012. Case reports: death of active duty soldiers following ingestion of dietary supplements containing 1,3-dimethylamylamine (DMAA). Mil Med. 177 (12), 1455–1459.

Ethan, D., Basch, C.H., Hillyer, G.C., Berdnik, A., Huynh, M., 2016. An analysis of weight loss articles and advertisements in mainstream women's health and fitness magazines. Health Promot Perspect. 6 (2), 80–84.

Feinstein, A.R., Cicchetti, D.V., 1990. High agreement but low kappa: I. The problems of two paradoxes. J Clin Epidemiol. 43 (6), 543–549.

Geller, A.I., Shehab, N., Weidle, N.J., Lovegrove, M.C., Wolpert, B.J., Timbo, B.B., Mozersky, R.P., Budnitz, D.S., 2015. Emergency department visits for adverse events related to dietary supplements. N. Engl. J. Med. 373 (16), 1531–1540.

Gibson-Moore, H., 2010. Do slimming supplements work? Nutrit. Bull. 35 (4), 300–303.

Hackett, A., Krska, J., 2012. Is it time to regulate over-the-counter weight-loss formulations? Int. J. Pharm. Pract. 20 (3), 199–202.

Harel, Z., Harel, S., Wald, R., Mamdani, M., Bell, C.M., 2013. The frequency and characteristics of dietary supplement recalls in the United States. JAMA Intern. Med. 173 (10), 926–928.

Kann, L., Kinchen, S., Shanklin, S.L., et al., 2014. Youth risk behavior surveillance–United States, 2013. MMWR Suppl. 63 (4), 1–168.

Kruger, J., 2012. Weight loss advertisements on teen magazine websites. J. Adolescent Health 50 (2), S10.

Laddu, D., Dow, C., Hingle, M., Thomson, C., Going, S., 2011. A review of evidence-based strategies to treat obesity in adults. Nutr. Clin. Pract. 26 (5), 512–525.

Loewenstein, G., Sah, S., Cain, D.M., 2012. The unintended consequences of conflict of interest disclosure. JAMA 307 (7), 669–670.

Maunder, A., Bessell, E., Lauche, R., Adams, J., Sainsbury, A., Fuller, N.R., 2020. Effectiveness of herbal medicines for weight loss: a systematic review and meta-analysis of randomized controlled trials. Diabetes Obes. Metab. 22 (6), 891–903.

Dietary supplements: structure/function claims fails to meet federal requirements. Department of Health and Human Services Office of Inspector General;2012.

Or, F., Kim, Y., Simms, J., Austin, S.B., 2019. Taking stock of dietary supplements' harmful effects on children, adolescents, and young adults. J Adolesc Health. 65 (4), 455–461.

Pillitteri, J.L., Shiffman, S., Rohay, J.M., Harkins, A.M., Burton, S.L., Wadden, T.A., 2008. Use of dietary supplements for weight loss in the United States: results of a national survey. Obesity (Silver Spring). 16 (4), 790–796.

Pirsch, J.A., Grau, S.L., Polonsky, M.J., 2013. "Lose 30 lbs in 30 days": assigning responsibility for deceptive advertising of weight-loss products. J. Social Market.. 3 (1), 56–77.

Reinhart RJ. More Americans say they weight 200 lbs. or more this decade. 2019; https://news.gallup.com/poll/268847/americans-say-weigh-200-lbs-decade.aspx, 2020.

Tucker, J., Fischer, T., Upjohn, L., Mazzera, D., Kumar, M., 2018. Unapproved pharmaceutical ingredients included in dietary supplements associated with US Food and Drug Administration Warnings. JAMA Netw Open. 1 (6), e183337. https://doi.org/10.1001/jamanetworkopen.2018.3337.

Statement from FDA Commissioner Scott Gottlieb, M.D., on the agency's new efforts to strengthen regulation of dietary supplements by modernizing and reforming FDA's oversight [press release]. U.S. Food & Drug Administration: U.S. Food & Drug Administration, 2019.

U.S. Food & Drug Administation. Tainted Products Marketed as Dietary Supplements. 2021. Accessed May 20, 2021.

Venhuis, B., Keizers, P., van Riel, A., de Kaste, D., 2014. A cocktail of synthetic stimulants found in a dietary supplement associated with serious adverse events. Drug Test Anal. 6 (6), 578–581.

Zheng, E.X., Navarro, V.J., 2015. Liver injury from herbal, dietary, and weight loss supplements: a review. J. Clin. Transl. Hepatol. 3 (2), 93–98.