ABSTRACT

Comparison of Selected Micronutrient Intakes
Between Flexible Dieting and Strict Dieting Bodybuilders

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The purpose of this study was to provide a descriptive assessment of the nutritional habits of competitive bodybuilders, specifically in relation to vitamin and mineral intakes. Data from 41 subjects (30 males and 11 females) were used in analyses. Participants completed a comprehensive food frequency questionnaire and diets were analyzed using a computer system. Males consumed less than the RDA of vitamin A, vitamin D, vitamin E, potassium, and dietary fiber. Females consumed less than the RDA for vitamin A, vitamin D, vitamin E, potassium, dietary fiber, and iron. There were no significant differences between male flexible and strict dieting bodybuilders when mean nutrient intakes were compared. For females, flexible dieters consumed significantly greater amounts of several nutrients. A large proportion of individuals from all groups consumed less than the recommended amounts of several of the micronutrients. Therefore, competitive bodybuilders should be advised to take their micronutrition into greater consideration.

Comparison of Selected Micronutrient Intakes
Between Flexible Dieting and Strict Dieting Bodybuilders

by

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DEDICATION

To my mother, for ingraining a strong work ethic in me and to anyone who believes that strong work ethic, not talent, is the key to success.

CHAPTER ONE

Introduction

Bodybuilding as a sport has become increasingly popular in recent years and is expected to continue growing (Helms, Aragon, & Fitschen, 2014). In the United States alone, there were over 200 amateur bodybuilding contests held in 2015 in just one of many organizations (Gilbert, 2016). Specifically, it has been the introduction of less extreme categories such as figure/physique, sports/fitness, and swimsuit/bikini that has attracted a great number of new competitors and spectators. For example, greater participation by females in competitions has been evident (Dutton, Laura, & others, 1989; Kennedy, 2008).

Competitive bodybuilding is unique in that participants in the sport are judged by appearance rather than performance. Through rigorous diet and training practices, a bodybuilder aims to achieve not only a muscular physique, but one that is also symmetrical and well-proportioned (Heyward, Sandoval, & Colville, 1989). To maximize muscle definition, subcutaneous fat levels must be minimal, and body composition is a primary concern for bodybuilders. The average body fat percentage of bodybuilders has been reported between 5% and 10% for males and 10% and 15% for females (Bamman, Hunter, Newton, Roney, & Khaled, 1993; Bazzarre, Kleiner, & Ainsworth, 1992; Heyward et al., 1989; Newton, Hunter, Bammon, & Roney, 1993; Withers et al., 1997).

Bodybuilders typically weight train 6-9 hours a week, 4-6 days a week. Some bodybuilders also engage in cardiovascular exercise for an average of 20 minutes, 3-5 times per week (Sandoval, Heyward, & Lyons, 1989). In addition, despite the evolution of bodybuilding and the addition of new divisions, a commitment to dietary practices remains a central component of competition preparation across all categories. However, due to the expansion of bodybuilding to include greater than just a relatively small number of individuals, new dietary approaches have recently become popularized. For example, a new "flexible dieting" strategy, popularly known in the bodybuilding community as "if it fits your macros" or "IIFYM," has become widespread (Salter, 2016). In contrast to the rigid, restriction-based dieting traditionally followed by bodybuilders, IIFYM is a nutrition system that instead focuses on monitoring individual macronutrient intake, with less regard for the specific foods consumed.

While many common dietary strategies practiced by bodybuilders have been evaluated by empirical research, others lack scientific scrutiny (Cho, Lee, & Kim, 2007). It is important to note that a bodybuilder's diet changes significantly from the offseason to pre-competition. In general, it has been reported that the total energy consumption of bodybuilders meets or exceeds the recommended dietary allowance (RDA) in the offseason, but is less than the RDA in the pre-competition diet (Sandoval & Heyward, 1991). In terms of macronutrient breakdown, bodybuilders' carbohydrate intakes are usually less than the RDA, and protein intakes can be up to 3 times greater than the RDA or more (Sandoval & Heyward, 1991). The average relative percentages of energy intake have been reported to range between 40 and 50% for carbohydrate, 25-35% for fat, and 20-25% for protein (Sandoval & Heyward, 1991).

While macronutrients are a hot topic amongst bodybuilders, micronutrients (vitamins and minerals) are often overlooked. It is known from the National Health and

Nutrition Examination Survey (NHANES) that more than 50% of adults in the United States are lacking in at least five essential micronutrients, including vitamins D, E, A, omega-3 fatty acids, and magnesium (Wallace, McBurney, & Fulgoni, 2014). However, it is mostly unknown whether the micronutrient intake of bodybuilders is different from the general population.

Definition of Terms and Abbreviations

For the purpose of clarification, the following definitions of terms and abbreviations were accepted for this study.

RDA: Recommended Dietary Allowances, the daily dietary intake level of a nutrient considered sufficient to meet the requirements of 97.5% of healthy individuals in each life-stage and sex group (Fink & Mikesky, 2013).

AI: Adequate Intake, when there is insufficient evidence to establish an RDA, this is used as an estimate of the amount of a nutrient individuals typically need to be healthy, based on research or observation (Fink & Mikesky, 2013).

UL: Tolerable upper intake levels, the highest level of daily nutrient consumption that is considered to be safe for, and cause no side effects in, 97.5% of healthy individuals in each life-stage and sex group (Fink & Mikesky, 2013).

FFQ: Food Frequency Questionnaire, a limited checklist of foods and beverages with a frequency response section for subjects to report how often each item was consumed over a specified period of time (Salvini et al., 1989).

DHQ-II: Diet History Questionnaire, Version 2.0, a semi-quantitative FFQ which uses an embedded question approach, collecting portion size information (National Cancer Institute, 2010).

Diet*Calc: A computer software that can be used to analyze DHQ-II data, generating nutrient and food group intake estimates (National Cancer Institute, 2012).

Purpose of the Study

Minimal research has been reported which explores the micronutrient intakes of bodybuilders. These measures are important because there is a great potential for micronutrient inadequacies and deficiencies in this population. The importance of micronutrients for both optimal performance as well as optimal health is indubitable, so realizing a lack of adequate intake would be the first step in designing an intervention to target this population.

The following null hypothesis was tested at the .05 level of significance: population 1 (flexible dieters) and population 2 (strict dieters) consume the same mean amount of each micronutrient against the alternative that flexible dieters consume, on average, a higher amount of each micronutrient.

Specific Study Objectives

The specific objectives of the study are:

1. To assess selected micronutrient intakes of bodybuilders.
2. To compare the intakes of those who follow flexible dieting and those who follow traditional, strict dieting regimens.

CHAPTER TWO

Review of Literature

A recent review of the scientific literature (Helms et al., 2014) relevant to nutrition and bodybuilding competition preparation identified that several previous studies (Bazzarre, Kleiner, & Litchford, 1990; Kleiner, Bazzarre, & Ainsworth, 1994; Sandoval & Heyward, 1991; Sandoval et al., 1989; Walberg-Rankin, Edmonds, & Gwazdauskas, 1993) have reported deficiencies in intakes of micronutrients, such as vitamin D, calcium, zinc, magnesium, and iron in dieting bodybuilders. The authors of the review noted that since all of these studies were published nearly two to three decades ago, future studies are needed to determine the prevalence of these deficiencies in current day bodybuilding. Likewise, the results of another recent systematic review of the literature describing dietary intake practices of competitive bodybuilders, reporting on 18 manuscripts and 385 participants, indicated that the existing research is dated and of poor quality (Spendlove et al., 2015). Notably, most of the research was published between 1980 and 1990, with only three studies published since 2010. Further, the methodological quality of the studies was evaluated as poor.

Bodybuilders are a group known for extreme diet practices as well as a commitment to dietary manipulation (Apong, 2013). Many of the traditional strategies that have been long practiced by successful competitors, such as peri-workout protein consumption and frequent dosing of the macronutrient throughout the day, have only recently been gaining scientific support (Areta et al., 2013; Cribb, Williams, Carey, &

Hayes, 2006). Further, many of these strategies are emulated by other athletes and the general public and incorporated into their own dietary practices (Goston & Correia, 2010). Notably, however, some of the dietary ideologies common in bodybuilding have not had their efficacy confirmed by scientific research, and some may even be detrimental to health (Grunewald & Bailey, 1993). For example, in some studies analyzing dietary intake practices of competitive bodybuilders, reported micronutrient intakes were extremely high due to excessive supplementation, often reaching values up to 1000% of the RDA and well above the UL (Faber & Benadé, 1987; Heyward et al., 1989; Linseisen, Metges, & Wolfram, 1993; Newton et al., 1993). More studies, however, have shown that bodybuilders, especially females, may be at high risk for micronutrient deficiencies. For example, Kleiner et al. (1994) showed that female bodybuilders were only consuming 52% of the RDA for calcium and 76% of the RDA for zinc. Likewise, Bazzarre et al. (1990) reported female bodybuilders to be consuming only 38% of the RDA for calcium. Finally, Newton et al. (1993) reported that female bodybuilders were below 70% of the RDA for folic acid, vitamin E, calcium, potassium, and zinc.

Flexible Dieting vs. Traditional Dieting

Most of the research on traditional bodybuilding diets describe the diets as "repetitive and monotonous," with limited food selections, little variety among and within food groups, and little variability (Kleiner et al., 1994; Sandoval & Heyward, 1991). These diets are typically restrictive in nature, often only including foods such as whole eggs, water-packed tuna, skinless chicken breasts, protein shakes, fish, lean beef, broccoli, bananas, brown rice, oats, and rice cakes. As early as 1991, a study suggested that in contrast to these repetitive and uninteresting diets, bodybuilders should instead use the Exchange System for meal planning to add variety to their diet without altering the relative distribution of macronutrients (Sandoval & Heyward, 1991). This is exactly the basis for the new flexible dieting trend, which was started by a few competitive bodybuilders who grew tired of eating bland food when dieting for a contest (Salter, 2016). In flexible dieting, no foods are "off-limits" as long as certain daily macronutrient targets are met.

One advantage of flexible dieting is that since there is no food or food group elimination, there is less chance for falling into a "yo-yo dieting" cycle, where cheating on one's diet can lead an individual to end up back at their original weight or heavier. Instead, presumably because flexible dieting teaches moderation and inclusion, research has shown that people following flexible dieting may have lower BMIs, greater feelings of self-control, and less psychological stress related to weight and food intake (Timko & Perone, 2005). Likewise, studies have shown individuals who engage in rigid dieting strategies to show symptoms of eating disorders, mood disturbances, excessive concern with body size/shape, increased incidences of overeating and binge eating, and higher levels of depression and anxiety (Smith, Williamson, Bray, & Ryan, 1999; Stewart, Williamson, & White, 2002).

However, there are also disadvantages to flexible dieting. For example, many individuals who follow flexible dieting opt for empty calories over nutrient-dense foods too often, and many times they do not incorporate a variety of fruits and vegetables into their diet (Salter, 2016). Therefore, with the majority of the focus on macronutrients, they may be consuming too little micronutrients. Second, flexible dieters may find themselves counting low quality proteins towards their total protein score, which will lead to missing out on key essential amino acids critical for optimal muscle hypertrophy (Salter, 2016). Likewise, while a flexible dieter may treat all carbohydrates as equal, there is a great amount of evidence to suggest that the source, timing, and amount of carbohydrates are all important for energy, performance, recovery, and health (Jenkins et al., 2002). Finally, individuals practicing flexible dieting may be consuming fewer essential fats that have been shown to improve health and promote leaner body compositions (Hill, Buckley, Murphy, & Howe, 2007; Simopoulos, 2008).

Importance of Micronutrients

Micronutrients include the organic vitamin compounds as well as the inorganic minerals that the body requires in much smaller amounts than the macronutrients. Vitamins and minerals are essential because they cannot be synthesized by the body in sufficient amounts to support important functions, and therefore must be consumed in foods (Stipanuk & Caudill, 2013). While much is known about the importance of micronutrients for different body functions, the role that micronutrients play in sport performance is unclear (Fink & Mikesky, 2013). However, it is widely believed that adequate vitamin and mineral intake is important for peak performance (Fink & Mikesky, 2013). Even if the performance effect may not be well-established, there is evidence that certain athlete populations are more prone to nutrient deficiencies, thus justifying a greater emphasis on specific micronutrients (Schwenk & Costley, 2002). In addition, there is evidence that there may be a potential for an increased need for certain antioxidant vitamins for individuals who engage in high-intensity exercise, which can increase oxidative stress (Urso & Clarkson, 2003).

There are thirteen essential vitamins, with varying functions such as acting as catalysts and cofactors in chemical reactions, or serving as precursors for different processes and for the development of various compounds (Stipanuk & Caudill, 2013). Vitamins are categorized as either water-soluble (B complex vitamins and C) or fat-soluble (A, D, E, and K). The B-vitamins and vitamins A, C, D, and E are especially important for strength athletes (Fink & Mikesky, 2013; Ivy & Portman, 2004).

Specifically, five of the eight vitamins that make up the B-vitamin complex (thiamin, or B1, riboflavin, or B2, niacin, or B3, pyridoxine, or B6, folic acid, or B9, and cyanocobalamin, or B12) are essential for releasing energy from the macronutrients (Stipanuk & Caudill, 2013). Further, pyridoxine is involved in protein synthesis, and cyanocobalamin and folic acid are vital for cellular reproduction and red blood cell synthesis (Fink & Mikesky, 2013; Ivy & Portman, 2004). Of the B-vitamins, folic acid is of most concern, as it has been shown to be the one for which the greatest amount of individuals have inadequate intake levels (Bailey et al., 2010). In contrast to the other B vitamins that are prevalent in many protein-rich foods, folic acid is found in the greatest abundance in green leafy vegetables (Stipanuk & Caudill, 2013). Folic acid is especially important for females as well, because a sufficient intake of folic acid before and during pregnancy can prevent major birth defects (Green, 2002). The RDA and/or AI for the B vitamins for adults are as follows: thiamin, 1.2 mg per day for males and 1.1 mg per day for females; riboflavin, 1.3 mg per day for males and 1.1 mg per day for females; niacin, 16 mg per day for males and 14 mg per day for females; pyridoxine, 1.3 mg per day for both males and females; cobalamin, 2.4 micrograms per day for both males and females (mcg); and folic acid, 400 mcg per day for both males and females (Fink & Mikesky, 2013).

Vitamin C plays a wide variety of roles in the human body, and is actually the only vitamin present in every cell of the body (Stipanuk & Caudill, 2013). These include structural functions, such as its role in collagen formation, as well as antioxidant functions like free radical neutralization. Notably, free radical damage is a major factor in aging and in the development of degenerative diseases such as cancer (Stipanuk & Caudill, 2013). Vitamin C may also play a role in blunting the release of cortisol, a catabolic hormone that is released during strenuous workouts (Thompson et al., 2001). Further, as the body's utilization of oxygen increases with exercise, athletes may require more vitamin C than sedentary individuals (Maughan, 1999). The RDA is 90 mg per day for males and 75 mg per day for females (Fink & Mikesky, 2013).

Vitamin A is especially important for athletes due to its function in cell differentiation, which is critical for tissue repair (Fink & Mikesky, 2013). The RDA for vitamin A for adult males is 900 mcg retinol activity equivalent (RAE) per day and for females is 700 mcg RAE per day (Fink & Mikesky, 2013). Further, another crucial vitamin for athletes is vitamin D, which has traditionally been understood to play an important role via its function of maintaining normal blood levels of calcium, essential to the formation and maintenance of strong bones (Fink & Mikesky, 2013; Ivy & Portman, 2004). Since weightlifters are exposed to extreme forces, vitamin D may play an especially important role for this population for keeping their bones healthy and mineral-dense. In addition, vitamin D has recently been suggested to impact muscle strength in athletes as well (Chiang, Ismaeel, Griffis, & Weems, 2016). The RDA for vitamin D is set at 600 IU per day for adult athletes (Fink & Mikesky, 2013).

The last vitamin of particular relevance to bodybuilders is vitamin E. Like vitamin C, vitamin E serves an important role as an antioxidant. Further, vitamin E may accelerate post-workout recovery by limiting the loss of muscle proteins, reducing inflammation, and reducing muscle soreness (Sacheck, Milbury, Cannon, Roubenoff, & Blumberg, 2003; Urso & Clarkson, 2003). The RDA for vitamin E is 15 mg per day for men and women (Fink & Mikesky, 2013).

The most important minerals for bodybuilders are calcium, iron, phosphorous, zinc, magnesium, potassium, and sodium (Fink & Mikesky, 2013). Calcium plays a critical role in bone health as well as in muscle contraction, muscle growth, the regulation of muscle glycogen breakdown, and carbohydrate oxidation during exercise (Fink & Mikesky, 2013; Ivy & Portman, 2004). The RDA for calcium for men and women is 1000 mg per day (Fink & Mikesky, 2013). For optimal calcium absorption, an individual must consume 1 mg of magnesium for every 2 g of calcium (Stipanuk & Caudill, 2013). In addition, over 300 enzymes require the presence of magnesium for catalytic action, including all enzymes utilizing or synthesizing ATP and those using nucleotides to synthesize DNA and RNA (Stipanuk & Caudill, 2013). Magnesium is also involved in reactions involving nerve transmission and muscle contraction, and the RDA is set at 320 mg per day for females and 420 mg per day for males (Fink & Mikesky, 2013). Zinc is also a mineral that is a constituent of over 300 enzymes (Stipanuk & Caudill, 2013). In addition, zinc plays roles in tissue repair and maintenance, can raise testosterone levels, and is therefore considered an anabolic mineral (Fink & Mikesky, 2013; Ivy & Portman, 2004). The RDA for zinc has been established at 11 mg per day for men and 8 mg per day for women (Fink & Mikesky, 2013).

Iron is necessary for hemoglobin formation, the oxygen-carrying compound in red blood cells. It is therefore a critical nutrient for aerobic metabolism. Iron deficiencies are relatively common in female athletes, as females tend to consume less iron in their diets, and menstruation further increases iron losses. High levels of activity also increase iron requirements, so female athletes are at a higher risk of anemia (Santolo, Stel, Banfi, Gonano, & Cauci, 2008). The RDA for iron is 8 mg per day for men and 18 mg per day for women (Fink & Mikesky, 2013).

Phosphorous is important because it is a constituent of both sources of energy for maximum-intensity efforts, ATP and creatine phosphate (Ivy & Portman, 2004; Stipanuk & Caudill, 2013). The RDA for phosphorous is 700 mg per day for men and women (Fink & Mikesky, 2013). Next, potassium is an electrolyte mineral, necessary for nerve transmission, muscle contraction, and for the formation of glycogen. In addition, potassium plays a key role in maintaining cardiovascular function (Stipanuk & Caudill, 2013). Excessive potassium losses can lead to muscle cramping and heat intolerance as well, and the AI for potassium is set at 4700 mg per day for both men and women (Fink & Mikesky, 2013; Ivy & Portman, 2004).

Finally, sodium is an electrolyte that plays a key role in maintaining fluid balance and facilitating muscle contraction and relaxation, transporting nutrients into cells, and nerve impulse transmission (Stipanuk & Caudill, 2013). While sodium intakes of the general population are well over the UL, bodybuilders often consume diets extremely low in this minerals (Steen, 1991). The current AI for sodium is 1500 mg.

While the concern with micronutrients is usually ensuring an adequate intake, excessive intakes, usually as a result of megadoses of supplements, is also an important issue to consider. For example, high amounts of vitamin C and E supplementation have been shown to interfere with exercise-induced signaling in muscle cells, (Paulsen et al., 2014) and excessive amounts of other vitamins, such as the fat-soluble vitamin A, can even be fatal (Fink & Mikesky, 2013). Therefore, helping athletes meet the RDA for vitamins and minerals from food sources appears to be the most prudent current recommendation, as supplementing with vitamins and minerals in amounts greater than the RDA to improve performance has not shown any ergogenic value (Fink & Mikesky, 2013).

Instrument

A food frequency questionnaire (FFQ) is a limited checklist of foods and beverages with a response section that includes the frequency of consumption so that subjects can report how often each item was consumed over a specified period of time (Cade, Burley, Warm, Thompson, & Margetts, 2004). Advantages of FFQs are that they are able to rank subjects according to their intake and that they give a representation of individuals' habitual intakes; they are therefore especially preferable for measuring the intake of nutrients with high day-to-day variability (Cade et al., 2004). Limitations of FFQs include the retrospective nature of the instrument, which necessitates a reliability on the respondent's memory. However, bodybuilders are typically very self-aware of their diets and often have been consuming the same foods for years (Lankford & Campbell, 2012). Further, FFQs can be less sensitive to measures of absolute intake for specific nutrients, and groupings of foods may not correspond to the respondents' perceptions (Cade et al., 2004).

The Diet History Questionnaire (DHQ) is a FFQ developed by the Risk Factor Assessment Branch (RFAB) of the National Cancer Institute (NCI). The original DHQ, the DHQ-I was designed based on cognitive research findings and had 124 food items, including both portion size and dietary supplement questions. The food list and nutrient/food group database are based on national dietary data from the NHANES data collection (National Cancer Institute). The updated version, the DHQ-II, was used for this study. The DHQ-II has a food list that has been updated based on more recent dietary data and contains 134 food items and 8 dietary supplement questions (National Cancer Institute, 2010). There are four different versions of the DHQ-II, differing by time frame and portion size questions. For this study, the version asking about dietary intake over the past month with portion size questions was used. While the DHQ-II has not been validated due to only minimal modifications to the food list and nutrient database of the DHQ-I, data from two studies showed that the DHQ-I provided reasonable nutrient estimates (Subar et al., 2001; Thompson et al., 2002). In addition, FFQs in general have been shown to provide valid information on intake for micronutrients, and are considered an acceptable method of assessing vitamin and mineral intake (Henríquez-Sánchez et al., 2009; Jacques et al., 1993; Streppel et al., 2013).

CHAPTER THREE

Methodology

The major purpose of this study was to assess selected micronutrient intakes of competitive bodybuilders using the DHQ-II and to compare the intakes of those who follow flexible dieting and those who follow traditional, strict dieting.

The specific objectives of the study were as follows:

1. To determine the mean intake of each selected micronutrient for all males and females.
2. To determine the proportion of individuals in each group that meets the recommended daily intake for each micronutrient.
3. To compare the intakes of those who follow flexible dieting and those who follow traditional, strict dieting regimens.

Subject Selection

Approval to conduct the study was obtained from the Institutional Review Board (IRB) of Baylor University in Waco, Texas. The subjects for the study were both male and female competitive bodybuilders, ages 18-50. Exclusion was based on bodybuilders outside the selected age range and those who had never competed and/or were not currently in contest preparation. Subjects were recruited online from the social media outlets of Facebook and Instagram. Recruitment involved obtaining the e-mail addresses of subjects that agreed to share this information. Recruitment text was in English only. The subjects were e-mailed a preliminary survey beginning with an Internet consent text question (APPENDIX A). Each respondent was given a study ID, numbered BBS001-BBS041. The passwords for each ID were randomly generated by the DHQ-II system. The questionnaires were all anonymous, and no names or any identification information were obtained. The only personal information asked for was gender and age. Once assigned a respondent ID, subjects were no longer linked to their individual e-mails.

Instrument

The FFQ has been established as an acceptable method of assessing micronutrient intake, and this has been proven to be true for athletes as well (Heaney, O'Connor, Gifford, & Naughton, 2010; Henríquez-Sánchez et al., 2009; Jacques et al., 1993). For this study, the DHQ-II was selected because it is a semi-quantitative FFQ, which collects portion size information, and has been shown to provide reasonable nutrient estimates, as good as or superior to those of other instruments (Subar et al., 2001; Thompson et al., 2002). A sample copy of the DHQ-II is provided in APPENDIX B. Another strength of the DHQ-II for this particular study is the inclusion of the dietary supplement questions since bodybuilders are a group known to frequently use dietary supplements (Sobal & Marquart, 1994).

Data Analysis

Means, standard deviations (SDs), and ranges were calculated in order to describe the population characteristics. The mean intake of each micronutrient for males and females was determined based on the Diet*Calc analysis. The proportion of individuals in each population that met the RDA for each micronutrient was also determined. Further, a pooled *t*-test can be used to test two population means from independent samples, pooling the data to calculate variability (Maddox, 2016, p. 141). The assumptions of normality and equal population variances were verified prior to analysis. The null hypothesis that population 1 (flexible dieters) and population 2 (strict dieters) consume the same mean amount of each micronutrient was tested against the alternative that strict dieters consume, on average, a higher amount of each micronutrient, or vice-versa (H_0: $\mu_2 = \mu_1$; H_a: $\mu_2 > \mu_1$ or H_a: $\mu_2 < \mu_1$). Outliers (>1.5 of the interquartile range [IQR]) were eliminated for each micronutrient. The level of significance was set at .05 to allow the researcher only a 5 out of 100 chance of committing a Type I error, "rejecting a null hypothesis that is really true" (Maddox, 2016, p. 116). Based on a (1-beta) of 0.8, an alpha of 5%, and using data previously recorded for bodybuilder micronutrient intakes, the sample size suggested to detect a difference was n=16.

In order to assure accuracy and economize time spent in analysis, the JMP computer software was used for all data analyses (SAS Institute, Cary NC).

Procedure

Subjects were first e-mailed a preliminary survey obtaining information about their dieting style (flexible vs. strict), whether or not they have a coach, and their competition history. Next, the subjects received a second e-mail (APPENDIX C) with a link to the DHQ-II's respondent site as well as log-in information. Subjects were informed that they do not have to complete the whole questionnaire at once, as answers are saved. The subjects were further contacted only in the case on an incomplete questionnaire with a follow-up e-mail (APPENDIX D), reminding them of the incomplete status and kindly requesting its completion.

CHAPTER FOUR

Results and Conclusions

In total, 90 subjects were sent the questionnaire, out of which 44 completed it (response rate = 48.89%). Three individuals were excluded from analyses due to several of their nutrient intake values falling as outliers. Thirty males and 11 females (n = 41) were included in the final analyses. Of the 41 subjects, 21 practiced flexible dieting, and 20 practiced traditional, strict dieting. The mean age of the 41 subjects was 29.1 years (SD = 6.9), and ages ranged from 20 to 50 years old. Subject characteristics are summarized in Table 1.

Table 1. Subject characteristics.

Variable	Males (n = 30)	Females (n = 11)
Dieting style		
Flexible	14	7
Strict	16	4
Age (years)	29.3 (7.0)	28.8 (7.3)
Number of competitions	5.0 (7.7)	5.6 (5.3)
Number of wins	3.4 (4.8)	2.4 (2.6)
Coaching		
Coached	9	5
No coach/self-coached	21	6

Note. Data presented as mean (SD) when applicable.

Results

Males consumed an average of 2577.2 (SD = 955.1) Calories, with values ranging from 1585 – 4944 Calories. In terms of the macronutrients, average fat intake was 83.6 g (SD = 41.3), average carbohydrate intake was 324.4 g (SD = 105.2), and average protein intake was 163.4 g (SD = 70.4). Of the vitamins and minerals assessed in this study, males consumed less than the RDA/AI of vitamin A, vitamin D, vitamin E, and potassium. In addition, dietary fiber was below current recommendations for fiber intake. Nutrient data for the males are summarized in Table 2.

Table 2. Dietary intake in men.

Nutrient	Reported Intake	RDA/AI	% RDA/AI met
Fiber	26.9 (12.9) g	38 g	70.8%
Vitamin A	776.4 (418.3) mcg	900 mcg	86.3%
Vitamin D	372.3 (574.0) IU	600 IU	62.05%
Vitamin E	13.9 (8.3) mg	15 mg	92.7%
Vitamin C	165.7 (118.8) mg	90 mg	184.1%
Thiamin	1.4 (1.0) mg	1.2 mg	200.0%
Riboflavin	4.0 (1.3) mg	1.3 mg	307.7%
Niacin	51.7 (28.5) mg	16 mg	323.1%
Pyridoxine	4.2 (1.9) mg	1.3 mg	323.1%
Folic acid	774.4 (401.5) mcg	400 mcg	193.6%
Cobalamin	9.6 (5.3) mcg	2.4 mcg	400.0%
Calcium	1609.4 (523.5) mg	1000 mg	160.9%
Phosphorous	2129.0 (915.2) mg	700 mg	304.1%
Magnesium	591.9 (770.9) mg	420 mg	140.9%
Iron	26.5 (13.0) mg	8 mg	331.2%
Zinc	19.0 (8.8) mg	11 mg	172.7%
Sodium	4670.7 (2232.8) mg	1500 mg	311.4%
Potassium	4413.2 (1774.4) mg	4700 mg	93.9%

Note. Data presented as mean (SD) when applicable.

While some of the nutrients were consumed at levels up to 400% of the RDA/AI, none of the intake values were near the UL, and therefore there appeared to be no potential for any adverse effects related to toxicity for any of the nutrients.

Females consumed an average of 1794.8 (SD = 453.1) Calories, with values ranging from 1072 to 2256 Calories. The mean fat intake for all females in this study was 58.3 g (SD = 23.1), the mean carbohydrate intake was 217.8 g (SD = 85.9), and the mean protein intake was 103.8 g (SD = 35.7). Of the vitamins and minerals assessed, females consumed less than the RDA/AI for vitamin A, vitamin D, vitamin E, iron, and potassium. Dietary fiber was also below recommendations for fiber intake. Nutrient data for the females are summarized in Table 3.

Table 3. Dietary intake in women.

Nutrient	Reported Intake	RDA/AI	% RDA/AI met
Fiber	21.1 (6.0) g	25 g	84.4%
Vitamin A	465.3 (248.6) mcg	700 mcg	66.5%
Vitamin D	216.4 (260.9) IU	600 IU	36.1%
Vitamin E	8.6 (2.7) mg	15 mg	57.3%
Vitamin C	134.9 (66.1) mg	75 mg	179.9%
Thiamin	1.5 (0.4) mg	1.1 mg	136.4%
Riboflavin	2.9 (0.8) mg	1.1 mg	263.6%
Niacin	35.5 (9.2) mg	14 mg	253.6%
Pyridoxine	3.1 (0.9) mg	1.3 mg	238.5%
Folic acid	483.8 (155.1) mcg	400 mcg	121.0%
Cobalamin	7.2 (3.6) mcg	2.4 mcg	300.0%
Calcium	1034.5 (138.0) mg	1000 mg	103.5%
Phosphorous	1443.8 (370.8) mg	700 mg	206.3%
Magnesium	414.8 (96.7) mg	320 mg	129.6%
Iron	15.6 (4.3) mg	18 mg	86.7%
Zinc	12.3 (4.3) mg	8 mg	153.8%
Sodium	3585.1 (920.1) mg	1500 mg	239.0%
Potassium	3678.5 (1214.8) mg	4700 mg	78.3%

Note. Data presented as mean (SD) when applicable.

There were no significant differences between male flexible and strict dieting bodybuilders when mean nutrient intakes were compared. However, in the strict dieting group, average intakes were higher for all nutrients, and a greater proportion of individuals met the RDA/AI. Table 4 highlights the differences in nutrient consumption between the two groups.

For females, the opposite was shown, with strict dieters consuming less, on average, of each nutrient. In fact, for protein, vitamin E, vitamin C, and sodium, the difference was significant ($P < 0.05$). In addition, for folic acid, phosphorous, magnesium, and iron, there was a trend ($P = 0.06 - 0.08$) for greater consumption within the flexible dieting group.

Table 4. Comparison of intakes between flexible and strict dieting males.

Nutrient	Flexible Dieters (Fl)	Strict Dieters (Str)	*P*-value	Proportion Below RDA/AI
Calories	2490.2 (899.2)	2644.9 (1045.0)	0.38	N/A
Fat	84.0 (34.2) g	84.3 (42.3) g	0.51	N/A
Carbohydrate	316.9 (101.6) g	330.1 (113.7) g	0.41	N/A
Protein	161.4 (29.6) g	169.1 (66.9) g	0.21	N/A
Fiber	25.5 (17.9) g	28.0 (8.2) g	0.36	Fl: 9/14 Str: 10/16
Vitamin A	771.3 (434.9) mcg	780.4 (431.5) mcg	0.48	Fl: 8/14 Str: 7/16
Vitamin D	304.5 (607.4) IU	388.2 (516.5) IU	0.14	Fl: 10/14 Str: 12/16
Vitamin E	11.9 (9.1) mg	15.4 (7.8) mg	0.21	Fl: 10/14 Str: 7/16
Vitamin C	156.2 (146.2) mg	173.0 (101.4) mg	0.40	Fl: 7/14 Str: 1/16
Thiamin	2.3 (1.1) mg	2.4 (0.9) mg	0.45	Fl: 1/14 Str: 0/16
Riboflavin	3.9 (1.6) mg	4.0 (1.2) mg	0.46	Fl: 0/14 Str: 0/16
Niacin	46.8 (21.3) mg	55.6 (33.9) mg	0.28	Fl: 0/14 Str: 0/16
Pyridoxine	4.1 (2.1) mg	4.2 (1.9) mg	0.46	Fl: 0/14 Str: 0/16
Folic acid	705.1 (515.6) mcg	828.2 (309.0) mcg	0.28	Fl: 6/14 Str: 2/16
Cobalamin	9.2 (4.3) mcg	9.9 (6.2) mcg	0.40	Fl: 0/14 Str: 1/16
Calcium	1548.8 (670.1) mg	1656.6 (413.9) mg	0.35	Fl: 4/14 Str: 0/16
Phosphorous	2020.4 (932.2) mg	2213.4 (949.0) mg	0.35	Fl: 0/14 Str: 0/16
Magnesium	515.6 (281.5) mg	651.2 (262.9) mg	0.17	Fl: 7/14 Str: 3/16
Iron	24.1 (14.5) mg	28.3 (12.3) mg	0.27	Fl: 0/14 Str: 0/16
Zinc	18.4 (9.4) mg	19.5 (8.8) mg	0.41	Fl: 1/14 Str: 0/16
Sodium	4488.7 (2077.8) mg	4812.2 (2461.3) mg	0.39	Fl: 0/14 Str: 0/16
Potassium	4095.5 (2203.4) mg	4660.4 (1451.0) mg	0.27	Fl: 10/14 Str: 5/16

Note. Data presented as mean (SD) when applicable, *P*-value is for pooled *t*-test, testing H_0: $\mu_2 = \mu_1$ against H_a: $\mu_2 > \mu_1$, proportion below RDA/AI refers to the number of individuals in each population not meeting RDA/AI for each nutrient out of total population.

Among the females, a greater proportion of individuals in the flexible dieting group also met the RDA/AI for many nutrients. Table 5 summarizes the differences in nutrient consumption between the two groups. Combining males and females, there were no significant differences between flexible dieters and strict dieters in the consumption of any of the nutrients ($P > 0.05$ for all).

Finally, to assess whether any correlations existed between a sufficient intake of any of the nutrients and success as a competitor, a Mann-Whitney U-test was utilized. The independent variable for this test was either "at or above" (n_1) or "below" (n_2) the RDA for each nutrient, and the dependent variable was the number of competition wins. There existed a significant association only between consuming sufficient amounts of dietary fiber and greater competition wins ($U = 112$, $n_1=15$, $n_2=26$, $P = 0.001$).

Overall, the Calorie intakes and macronutrient distributions in this study were similar to those reported previously, with only the protein intakes lower than reported in most studies assessing dietary intakes in male bodybuilders. Previous studies also reported deficiencies in intakes of vitamin D, calcium, zinc, magnesium, and iron (Bazzarre et al., 1990; Kleiner et al., 1994; Sandoval & Heyward, 1991; Sandoval et al., 1989; Walberg-Rankin et al., 1993). However, these studies, in addition to much of the existing research on the dietary intake of bodybuilders have been described as "dated and of limited quality" (Spendlove et al., 2015). The results of this study identified potential concerns with vitamin A, vitamin D, vitamin E, potassium, dietary fiber, and iron for females.

Table 5. Comparison of intakes between flexible and strict dieting females.

Nutrient	Flexible Dieters (Fl)	Strict Dieters (Str)	*P*-value	Proportion Below RDA/AI
Calories	1964.9 (358.9)	1454.7 (541.4)	0.10	N/A
Fat	61.4 (16.5) g	52.0 (41.7) g	0.34	N/A
Carbohydrate	236.7 (104.2) g	179.9 (5.6) g	0.25	N/A
Protein	123.3 (22.9) g	64.8 (16.2) g	0.02*	N/A
Fiber	23.6 (5.3) g	16.0 (4.8) g	0.08	Fl: 3/7 Str: 4/4
Vitamin A	474.8 (312.2) mcg	446.3 (124.6) mcg	0.46	Fl: 5/7 Str: 4/4
Vitamin D	220.1 (40.4) IU	200.8 (94.6) IU	0.22	Fl: 6/7 Str: 3/4
Vitamin E	9.9 (2.1) mg	5.8 (1.2) mg	0.03*	Fl: 7/7 Str: 4/4
Vitamin C	169.5 (47.4) mg	65.5 (26.5) mg	0.02*	Fl: 0/7 Str: 2/4
Thiamin	1.6 (0.5) mg	1.2 (0.0) mg	0.17	Fl: 2/7 Str: 0/4
Riboflavin	2.7 (0.7) mg	3.2 (1.2) mg	0.73	Fl: 0/7 Str: 0/4
Niacin	37.5 (4.2) mg	31.6 (18.0) mg	0.26	Fl: 0/7 Str: 0/4
Pyridoxine	3.1 (0.8) mg	3.0 (1.6) mg	0.47	Fl: 0/7 Str: 0/4
Folic acid	553.5 (142.5) mcg	344.4 (33.9) mcg	0.06	Fl: 2/7 Str: 4/4
Cobalamin	7.2 (3.6) mcg	7.3 (5.0) mcg	0.51	Fl: 0/7 Str: 0/4
Calcium	1040.0 (177.3) mg	1023.5 (25.4) mg	0.45	Fl: 2/7 Str: 0/4
Phosphorous	1612.7 (323.6) mg	1105.9 (176.3) mg	0.06	Fl: 0/7 Str: 0/4
Magnesium	458.9 (48.3) mg	326.6 (128.0) mg	0.06	Fl: 0/7 Str: 1/4
Iron	17.4 (4.1) mg	11.9 (0.9) mg	0.08	Fl: 4/7 Str: 4/4
Zinc	13.9 (4.5) mg	9.2 (1.4) mg	0.12	Fl: 0/7 Str: 0/4
Sodium	4059.6 (397.0) mg	2635.9 (1028.3) mg	0.03*	Fl: 0/7 Str: 0/4
Potassium	4163.7 (1037.4) mg	2708.2 (1131.2) mg	0.10	Fl: 7/7 Str: 4/4

Note. Data presented as mean (SD) when applicable, *P*-value is for pooled *t*-test, testing H_0: $\mu_2 = \mu_1$ against H_a: $\mu_2 < \mu_1$, proportion below RDA/AI refers to the number of individuals in each population not meeting RDA/AI for each nutrient out of total population.

Conclusions and Implications

While male bodybuilders were shown to consume, on average, below the RDA of fiber, vitamin A, vitamin D, vitamin E, and potassium, the intakes of vitamin E and potassium were very close to the recommended amounts (92.7% and 93.9% of the RDA, respectively). Of greater concern were the intakes of vitamin A, vitamin D, and fiber. Notably, 57% of the flexible dieting males and 44% of the strict dieting males had intakes below the RDA for vitamin A, 71% of flexible dieting males and 75% of strict dieting males had intakes below the RDA for vitamin D, 71% of flexible dieting males and 31% of strict dieting males had intakes below the RDA for potassium, and 64% of flexible dieting males as well as 63% of strict dieting males consumed below the recommended amount of fiber. Male flexible dieters and strict dieters did not differ significantly in their consumption of any of the nutrients, although strict dieters consumed greater amounts of every vitamin and mineral assessed. Notably, while 50% of flexible dieting males consumed vitamin C at levels below the RDA, only 1 of the 16 males in the strict dieting group fell below the RDA for this vitamin. Similarly, while 71% of flexible dieting males consumed vitamin E at an amount below the RDA, only 44% of male strict dieters had intakes of vitamin E at lower levels than the RDA.

While the data for females is limited by a smaller sample size, previous studies assessing vitamin and mineral intakes of female bodybuilders included only from 1 to 11 female subjects, with an average of 4 female subjects per study (Spendlove et al., 2015). In this study, females were shown to fall below the RDA for intakes of fiber, vitamin A, vitamin D, vitamin E, iron, and potassium. In general, females were at a much greater risk for deficiencies in the assessed nutrients. For example, average vitamin A consumption for females was only 66.5% of the RDA, average vitamin E intake was only 57.3% of the RDA, and average vitamin D intake was as low as 36.1% of the RDA.

When comparing nutrient intakes between flexible and strict dieting female bodybuilders, there were much greater differences observed. Flexible dieters consumed significantly greater amounts of vitamin E and vitamin C, and there were trends for greater consumption of phosphorous, magnesium, folic acid, and iron in the flexible dieting group as well. These differences were due to a large variation in the average amount of Calories consumed by each group. The average Calorie intake for the flexible dieting females was 1964.9 (SD = 358.9), while the strict dieting females consumed a mean of only 1454.7 (SD = 541.4) Calories. It is important to note that since only 4 strict dieting females were included in the assessment, only limited generalizations can be made to this population group. However, there was not a great amount of deviation among the 4 females, and the intake for all 4 females fell below 1528 Calories, which is likely lower than their actual Calorie requirements. Notably, a limitation of this study is the lack of data collection on body mass, which prevents any estimation of the actual requirements for these individuals. Likewise, without data on body mass, no recommendations can be made on the sufficiency of the macronutrient intakes. However, using information from previous studies (Spendlove et al., 2015), the average body mass of male bodybuilders has been reported as 83.7 (SD = 9.1) kg. Using this data, the male bodybuilders in this study may have been consuming too little protein, as the dietary protein requirement of male bodybuilders has been estimated to be around 2.2 g/kg (Bandegan, Courtney-Martin, Rafii, Pencharz, & Lemon, 2017). The average body mass of female bodybuilders has been reported as 54.2 (SD = 5.1) kg, which would put only the strict dieting females below their protein requirements.

Based on the results of this study, recommendations can be made for male and female bodybuilders to increase their intakes of vitamin A, vitamin D, vitamin E, potassium, and fiber. Vitamins A and E are important antioxidants, and a deficiency in vitamin E can also result in muscle weakness (Fink & Mikesky, 2013). While the intakes reported in this study may not be low enough to notice immediate deficiency symptoms, it is important to note that recent evidence suggests that chronically consuming inadequate intakes of vitamins and minerals may accelerate the degenerative diseases of aging and cause metabolic disruption (Ames, 2006). Likewise, there is evidence that some functions of micronutrients are restricted during shortages, and thus functions required for short-term survival take precedence over less essential functions (McCann & Ames, 2009). Given the plethora of roles that some vitamins and minerals play in the body, certain functions such as muscle strength may be limited for more important functions of the vitamin to be performed when serum levels are inadequate. Many experts now suggest that the current RDA for several of the vitamins and minerals should be raised, even for the common population (Ames, 2006). Realizing that athletes likely require even greater amounts of many of these micronutrients, it is evident that micronutrient malnutrition may be an important issue for this population.

Male bodybuilders can easily meet their vitamin A requirements by consuming greater amounts of sweet potatoes, carrots, and spinach, all common foods consumed by this group (Sandoval & Heyward, 1991). To increase their intake of vitamin E, bodybuilders can add a small amount of plant oils, such as corn, safflower, or sunflower oil to their diets (Stipanuk & Caudill, 2013).

While sodium intakes in this study were higher than recommended, moderately excessive sodium consumption is generally not an issue for athletes, as sodium is lost in sweat during exercise (Casa et al., 2000). However, bodybuilders can benefit from sodium restriction resulting in extracellular and subcutaneous volume deficit, and therefore better "definition" of muscle contours and structure (Bristschgi & Zünd, 1991). This would be more practical leading up to a competition, but a limitation of this study is that there was no assessment of whether individuals were in contest preparation or in offseason. Due to the high intakes of sodium, however, bodybuilders may need to increase their potassium intakes, as potassium counteracts the effects of sodium on blood pressure. This can be achieved by increasing consumption of potatoes, plain, nonfat yogurt, tomatoes, bananas, and spinach (Stipanuk & Caudill, 2013).

Vitamin D was the nutrient consumed at the lowest amounts compared to the RDA. Only 8 of the 30 males and 2 of the 11 females in this study consumed above the RDA for vitamin D. Interestingly, of the individuals who met the RDA for vitamin D, 70% were taking a vitamin D supplement. Vitamin D supplementation has been suggested to potentially have a positive impact on muscle strength (Chiang et al., 2016). However, as there are also potential issues with vitamin D toxicity, serum levels of vitamin D should be monitored prior to recommending supplementation. Notably, the RDA for vitamin D assumes that no vitamin D is available from synthesis from exposure to UVB radiation. However, since bodybuilders are a group that often takes part in tanning (Klein, 2007), this can also trigger the synthesis of the vitamin D precursor in the skin.

Dietary fiber, a complex carbohydrate, is mostly indigestible, and therefore provides no caloric or carbohydrate value when consumed. However, consuming sufficient amounts of fiber can be very important to the bodybuilder for regulating blood glucose levels. In addition, a high-fiber diet can also produce an increased satiety level that may aid in weight loss over time by reducing hunger, ultimately decreasing caloric intake (Stipanuk & Caudill, 2013). Only 63% of all the individuals in this study met the current recommendations for fiber intake. To increase fiber consumption, bodybuilders should eat more oats, barley, legumes, whole grain products, nuts, seeds, and vegetables. In this study, a very interesting correlation was noted between adequate fiber consumption and greater success as a bodybuilding competitor. However, it is important to note that there are several explanations for this. It is likely that competitors with greater experience have better knowledge in nutrition and are therefore paying attention to their dietary fiber intake. It also may be that more experienced competitors consume a greater amount of total Calories, and therefore greater amounts of dietary fiber as a result of the higher caloric intake. Still, the increased satiety and blood glucose regulation associated with fiber suggest that it may be of great importance to the success of a bodybuilding competitor. Notably, dietary fiber has been inversely associated with body fat (Slavin, 2005), and a low body fat percentage is essential to the success of a bodybuilding competitor. Dietary fiber is also critical for nourishing beneficial gut bacteria, and several of these microbes have been associated with better health as well as with improvements in glycemia and in body composition (Holscher et al., 2015; Marchesi et al., 2015).

While there were no large differences between the nutrient intakes of males who follow flexible dieting compared to strict dieting, the greater proportion of individuals in the flexible dieting group who were not meeting the RDA for several nutrients suggests that this group should especially pay more attention to micronutrition. While the main focus of this group tends to be on the macronutrients (Salter, 2016), it is important for these individuals to track their vitamin and mineral intakes as well, ensuring they are consuming sufficient amounts of these essential nutrients. A practical application would be for a flexible dieter to ensure that even if a portion of his/her caloric intake is coming from processed sources, at least 70 to 80% is from whole food sources (Whitehead, 1995). Further, female bodybuilders should be advised to track their dietary intake to ensure they are consuming, first and foremost, a sufficient amount of Calories. Female athletes have been reported to regularly be in a negative caloric balance (Sanborn, Horea, Siemers, & Dieringer, 2000). In the American College of Sports Medicine's position stand, the tendency for female athletes to exhibit low energy availability and restrictive eating behaviors was identified as a special concern (Nattiv et al., 2007). The better nutritional status seen among flexible dieting females is likely due to greater knowledge of Calorie and macronutrient requirements and their tracking of food intake. Still, both groups would benefit from increasing their intakes of certain micronutrients such as vitamin E; in fact, 100% of all the females in this study had an intake below the RDA for vitamin E. Therefore, in general, both male and female flexible and strict dieting bodybuilders should be advised to take their micronutrition into greater consideration.

APPENDICES

APPENDIX A

Internet Consent Text and Preliminary Survey

My name is Ahmed Ismaeel, and I am a current graduate student in the Nutrition Science department at Baylor University. I am conducting a survey in the interest of gaining perspective on different dietary patterns used among bodybuilders.

Your voluntary participation is requested so we may learn more about the dietary behaviors of bodybuilders. The survey will take approximately 20 minutes to complete. Your name will not be recorded on the survey and your responses will be confidential. The data from this survey will be published as a portion of my Master's thesis. Again, your participation is voluntary, and you do not have to take part in this study if you do not want to do so. If you begin the study and then decide that you want to stop, you can do so whenever you wish.

If you have any questions about this project, please contact Dr. Suzy Weems 254-710-6003. Also, her address is One Bear Place 97346 Waco, TX 76798-7346. We will be glad to answer any questions you have.

Do you agree to the above terms? By clicking Yes, you consent that you are willing to answer the questions in this survey.

"I have been advised of the above information; I am age 18 or older; and I DO AGREE to participate in this study".

1. Does a coach of personal trainer design your diet for you?
   a. Yes
   b. No

2. Which of the following best describes your dieting style?
   a. Flexible dieting/ IIFYM (if it fits your macros)
   b. Strict/rigid (traditional bodybuilder diet)

APPENDIX B

DHQ-II Sample

This is a sample form. Do not use for scanning.

1. Over the past month, how often did you drink **carrot juice**?

☐ NEVER (GO TO QUESTION 2)

☐ 1 time in past month
☐ 2–3 times in past month
☐ 1–2 times per week
☐ 3–4 times per week
☐ 5–6 times per week
☐ 1 time per day
☐ 2–3 times per day
☐ 4–5 times per day
☐ 6 or more times per day

1a. Each time you drank **carrot juice**, how much did you usually drink?

☐ Less than ½ cup (4 ounces)
☐ ½ to 1¼ cups (4 to 10 ounces)
☐ More than 1¼ cups (10 ounces)

2. Over the past month, how often did you drink **tomato juice** or **other vegetable juice**? *(Please do not include carrot juice.)*

☐ NEVER (GO TO QUESTION 3)

☐ 1 time in past month
☐ 2–3 times in past month
☐ 1–2 times per week
☐ 3–4 times per week
☐ 5–6 times per week
☐ 1 time per day
☐ 2–3 times per day
☐ 4–5 times per day
☐ 6 or more times per day

2a. Each time you drank **tomato juice** or **other vegetable juice**, how much did you usually drink?

☐ Less than ¾ cup (6 ounces)
☐ ¾ to 1¼ cups (6 to 10 ounces)
☐ More than 1¼ cups (10 ounces)

3. Over the past month, how often did you drink **orange juice** or **grapefruit juice?**

☐ NEVER (GO TO QUESTION 4)

☐ 1 time in past month
☐ 2–3 times in past month
☐ 1–2 times per week
☐ 3–4 times per week
☐ 5–6 times per week
☐ 1 time per day
☐ 2–3 times per day
☐ 4–5 times per day
☐ 6 or more times per day

3a. Each time you drank **orange juice** or **grapefruit juice**, how much did you usually drink?

☐ Less than ¾ cup (6 ounces)
☐ ¾ to 1¼ cups (6 to 10 ounces)
☐ More than 1¼ cups (10 ounces)

Question 4 appears in the next column

3b. How often was the orange juice or grapefruit juice you drank **calcium-fortified**?

☐ Almost never or never
☐ About ¼ of the time
☐ About ½ of the time
☐ About ¾ of the time
☐ Almost always or always

4. Over the past month, how often did you drink **other 100% fruit juice** or **100% fruit juice mixtures** (such as apple, grape, pineapple, or others)?

☐ NEVER (GO TO QUESTION 5)

☐ 1 time in past month
☐ 2–3 times in past month
☐ 1–2 times per week
☐ 3–4 times per week
☐ 5–6 times per week
☐ 1 time per day
☐ 2–3 times per day
☐ 4–5 times per day
☐ 6 or more times per day

4a. Each time you drank **other 100% fruit juice** or **100% fruit juice mixtures**, how much did you usually drink?

☐ Less than ¾ cup (6 ounces)
☐ ¾ to 1½ cups (6 to 12 ounces)
☐ More than 1½ cups (12 ounces)

4b. How often were the other 100% fruit juice or 100% fruit juice mixtures you drank **calcium-fortified**?

☐ Almost never or never
☐ About ¼ of the time
☐ About ½ of the time
☐ About ¾ of the time
☐ Almost always or always

5. How often did you drink **other fruit drinks** (such as cranberry cocktail, Hi-C, lemonade, or Kool-Aid, diet or regular)?

☐ NEVER (GO TO QUESTION 6)

☐ 1 time in past month
☐ 2–3 times in past month
☐ 1–2 times per week
☐ 3–4 times per week
☐ 5–6 times per week
☐ 1 time per day
☐ 2–3 times per day
☐ 4–5 times per day
☐ 6 or more times per day

Question 6 appears on the next page

APPENDIX C

DHQ-II Instruction E-mail

Thank you very much for your interest in this study.

Here is the link you go to for the food frequency questionnaire:

https://appliedresearch.cancer.gov/dhq2.html.

Your respondent ID will be BBS___ and password will be ________. The study code is 1617. You do not have to complete the whole questionnaire at once! You can log in, complete a portion of it, log out and return to it later- the answers will be saved! The full questionnaire takes 15-20 minutes to complete. Once again, I thank you for your interest. Best of luck in your training and dieting!

APPENDIX D

Follow-up E-mail

Please note that the food frequency questionnaire is still not completed. We would really appreciate it if you could take the time to finish working on it when you get a chance, as you would help provide some really important information about our diets as competitive bodybuilders. Also please note that you may take your time and complete it at your own leisure- logging in and out of the program as you'd like!

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