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Development Of Food Guide Pyramid For Individuals With Achondroplasia

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DEVELOPMENT OF FOOD GUIDE PYRAMID FOR INDIVIDUALS WITH ACHONDROPLASIA

by

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AN ABSTRACT OF THE THESIS OF

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MAJOR PROFESSOR: Dr. Sara Long Roth

Previous studies have developed food guide pyramids for different populations. However, no study has developed a food guide pyramid for individuals with achondroplasia. This study used the USDA's food guide pyramid, RDA/DRI, and 2010 Dietary Guidelines to develop a food guide pyramid for individuals with achondroplasia.

Although food guide pyramids for different populations exist, there was a lack of nutritional guidelines geared towards individuals with achondroplasia. As this population continues to increase (1 of 26,000), the need for nutrition information increases too. Individuals with ACH are at risk of being overweight or obese just like average sized adults; and with being the height of a child and age of an adult, it can be more of a challenge to maintain a healthy body weight. This indicates how much of a need there is for food guide pyramid for individuals with achondroplasia.

Results will benefit individuals with achondroplasia along with parents, physicians, registered dietitians, and other health professionals associated with individuals with achondroplasia. Development of food guide pyramid for individuals with ACH could help develop food guide pyramids for other types of dwarfisms.

DEDICATION

For my parents, Mike and Lois, having been there for everything to support and encourage my dreams. You have always encouraged me to work hard and do my best. Also, I would like to thank you for believing me that I can overcome any obstacles or challenges I may come across in my life. Thank you for your support and encouragement from start to finish.

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CHAPTER 1

INTRODUCTION

Background

Achondroplasia (ACH), the most common type of dwarfism of skeletal dysplasia, is an autosomal dominant disorder, which means a child has a 50 percent chance of inheriting the gene from a parent (1). ACH occurs in approximately 1 in 26,000 births (1), and almost 80 percent occurs from new spontaneous mutations, and are born to parents of average height (2). ACH arises from a mutation in the FGFR3 gene whose primary responsibility is developing and maintaining bone and brain tissue (2). Mutations in this gene cause protein to be overly active thereby interfering with skeletal development and bone growth (2).

The word achondroplasia means "without cartilage formation" (2). However, the problem is not in forming cartilage, but converting cartilage into bone called ossification (2). This affects the long growth bones (2). Limbs, especially upper arms and legs, are shorter than the trunk; therefore, ACH is considered a disproportionate short stature (1).

The main characteristic of ACH is a relatively long trunk with shortened upper arms and thighs (3). Other features include a large head with a prominent forehead, flattened bridge of the nose, and short hands with stubby fingers (3). Most children with ACH have delayed motor milestones, otitis media, and bowing of the lower legs (4). More serious health problems are hydrocephalus, sleep apnea, and kyphosis (4). The average height of an adult with ACH is four feet tall; thus, the term "Little People or LP" issued to refer to those with ACH (1).

Statement of the Problem

Obesity is a common occurrence in individuals with ACH. In the past, many LP hoped that by eating, their bones would grow. LP now realize lack of calories was not a factor in their lack of bone grown. According to Hoover-Fong (5), between 13 and 43 percent of adults with ACH are obese.

Excessive body weight can worsen pre-existing health problems such as sleep apnea and lumbosacral spinal stenosis (5). It can also lead to early cardiovascular mortality (6). Overweight or obesity also means wear and tear on joints which are already overstrained and may cause the need for knee or hip replacements in one's late twenties or early thirties (7). Causes of obesity are uncertain. It may have to do with the underlying metabolic defect in individuals with ACH, or may be related to excessive caloric intake and/or lack of physical activity. Obesity could be due to less body area to distribute a greater body mass. Overall, LP have a survival rate of 10 years less than the general population (1). LP should have opportunity to have an optimal life as average-sized adults.

Need for the Study

Some types of disproportionate short statures have more problems with weight than others. This is especially true of individuals with ACH. Nutritional guidelines developed specifically for individuals with ACH are absent. Development of a food guide pyramid for individuals with ACH is important because many of these individuals have struggled with trying to lose weight, or maintain a healthy weight, and are frustrated. Is this due to a lack of nutritional information pertaining solely to this group?

As the population of LP/ACH continues to increase, need for nutrition information becomes more important. There is confusion as to the definition of a balanced diet for LP. Should they follow the food guide pyramid for kids, or the food guide pyramid for the general population? In reality, the answer is neither. LP adults and LP children do not fit the norm when considering weight and height. LP adults have stopped growing as well as their metabolism slows the same as an average sized adult. When an average sized individual decides to lose weight, the recommendation is to decrease caloric intake while consuming a balanced, nutritious diet and increase exercise. LP must rely more on controlling caloric intake because increased exercise can lead to excessive wear and tear on their strained joints. To maintain a balanced and nutritious diet, LP need to learn to choose nutrient-dense foods based on recommendations specifically geared to them.

Purpose of the Study

The purpose of this study was to develop a *Food Guide Pyramid for Individuals with Achondroplasia*.

Research Objectives

1. To determine the structure and dietary needs of a food guide pyramid for individuals with achondroplasia
2. To develop a *Food Guide Pyramid for Individuals with Achondroplasia.*

Definition of Terms

For the purpose of this study, the following terms will be defined as follows:

Achondroplasia (ACH): The most common form of short limb dwarfism (1).

Basal metabolic rate (BMR)/resting metabolic rate (RMR): The amount of calories calculated based on the amount of energy consumed at rest in a temperate environment and the body in a state post-absorbent (8).

FGFR3: Gene provides instructions for making a protein called fibroblast growth factor receptor 3 and the protein is involved in the development and maintenance of bone and brain tissue (2).

Food Guide Pyramid (FGP): Graphic representation of nutrition guidelines for adults in the shape of a pyramid.

Hydrocephalus: A buildup of fluid inside the skull, leading to brain swelling (9).

Kyphosis: A curving of the spine that causes a bowing or rounding of the back, which leads to a hunchback or slouching posture (10).

Little People (LP): A term used to refer to people with dwarfism, a genetic or medical condition that results in short stature, usually 4'10" or less in adulthood (11).

Obesity: An adult who has a BMI of 30 or higher (12).

Otitis Media: An inflammation of the middle ear, usually caused by bacteria, that occurs when fluid builds up behind the eardrum known as ear infection (13).

Overweight: An adult who has a BMI between 25 and 29.9 (12).

Skeletal dysplasia: A group of congenital abnormalities of the bone and cartilage that are characterized by short stature (14).

Sleep Apnea: Occurs when a person stops breathing for short periods during sleep (15).

CHAPTER 2

REVIEW OF THE LITERATURE

Introduction

The purpose of this study was to develop a *Food Guide Pyramid for Individuals with Achondroplasia*. The goal was to provide nutritional guidelines to individuals with ACH, their parents, physicians, registered dietitians, and other health professionals. Health problems, metabolic and nutrient needs, and development of and principles involved in developing a food guide pyramid for individuals with ACH are discussed in this chapter.

Health Problems Associated with Individuals with Achondroplasia

Obesity

Overweight and obesity are common problems among individuals with ACH, often appearing in early childhood. As cited in Hetch (6), 10 percent of these individuals younger than 18 years old were found to be obese. According to Hoover-Fong's findings (5), 13 to 43 percent of adults with ACH are obese. Just as an average sized adult, being an overweight individual with ACH increases risk of high blood pressure, heart disease, stroke, diabetes, osteoporosis, and cancer (6).

Sleep Apnea

Individuals with ACH have an increased risk of experiencing sleep apnea, which occurs when a person stops breathing for short periods during sleep (15). Sleep apnea in individuals with ACH may be related to midface abnormalities that obstruct airways during sleep (15).

Lumbosacral Spinal Stenosis

The most common complication for adults with ACH is lumbosacral spinal stenosis, which is the narrowing of the spinal canal in the lower spine (4). Abnormally short and thickened pedicles that reduce the distance across the spinal canal may occur in individuals with ACH (4). This complication may worsen if the LP is overweight or obese because this condition puts pressure on the spinal cord and may cause pain and/or numbness in the legs (4).

Arthritis and Bowed Legs

Individuals with ACH also have an increased risk of developing arthritis, which causes pain and inflammation of the joints. Due to overactive FGFR3 protein in individuals with ACH, the amount of bone formed from cartilage is drastically limited (2). Additionally, a progressive development of bowed legs may be experienced and can cause mobility issues (2).

Metabolic Needs Associated with Individuals with Achondroplasia

Body Fat

There are several methods to estimate body fat mass, but there is no single measurement method that is error free. A healthy percent of body fat for average sized men ranges from 13-21 percent and average sized women ranges from 23-31 percent (16). When body fat exceeds 22 percent in young men, 25 percent in men over age 40, 32 percent in young women, and 35 percent in women over age of 40, health problems typically develop (16). Equations developed in Owen's study derived from using a combination of measurements taken from skinfold thickness, body circumferences, and/or skeletal lengths to predict body fat of individuals with ACH gave a 95 percent confidence level that result in overestimated or underestimated

determined body fat by 14 percent to 52 percent for those with ACH (17). Another study found children with ACH had a mean body fat percentage of 23.98 +/-10.09 with a range of 4.62-39.63 (18). Body fat percentage was higher in children with ACH (18). However, no rigorous studies of body fat have been completed in the population.

Basal Metabolic Rate (BMR)/Resting Metabolic Rate (RMR)

There has been limited assessment of methods in addressing BMR/RMR in individuals with ACH (17). In Owen's study (17), measured RMR for individuals with ACH were 962kcal/24h to 1823 kcal/24h which indicated individuals with ACH have distinctively greater resting caloric requirements per unit body weight when compared to average sized adults' RMR of male ranges from 1500-1800kcal/day and female ranges from 1200-1450kcal/day (19). However, even though RMR is higher per unit body weight in adults with ACH, obesity among adults with ACH is about twice of the average sized adults (17). In calculating RMR, the Mifflin-St. Jeor equation is more likely than other equations to estimate correctly RMR to be within 10 percent of measured BMR and has the narrowest error range (20). Owen used indirect calorimetry for measuring the RMR of individuals with ACH, which was calculated using sums of protein and nonprotein calories oxidized (17). Results for women with ACH was a RMR of 862kcal/24hr +/- 12.026, and for men with ACH was a RMR of 1010kcal/24hr +/- 12.026 (16). Caloric needs of men and women with ACH are similar to those of average sized adults when based on weight and height. Resting metabolic rate may be overestimated or underestimated by 21 percent to 34 percent with a 95 percent confidence level based only on weight, sex, and age (17). As revealed in Owen's study of RMR, there are estimation differences in each equation when calculating RMR (Appendix A).

An alternative explanation for greater resting caloric requirements per unit body weight in people with ACH may be due to relative difference in the organ masses (17). Human organs can be arbitrarily classified into high (brain and liver), moderate (skeletal muscle), and low (adipose tissue) energy-requiring tissue (17). A portion of total resting energy expenditure is derived from the metabolic rate of internal organs (21). Between average sized adults and adults with ACH, large variances can occur, not because of major differences in high energy-requirements for the brain and liver; instead, because of large differences in the amount of moderate energy-requirements of skeletal muscle mass and in the amount of low energy-requirements of adipose tissue mass (22). Individuals with ACH in Owen's study (17) had disproportionately small extremities and disproportionately enlarged central nervous systems. The brain and liver make up about four percent of total body weight in average sized adults, but are responsible for approximately 40 percent of RMR (17). The remaining body tissue mass, with majority consumed by the tissue of the extremities, is responsible for the remaining 60 percent of the RMR (17). Individuals with ACH with disproportionately small extremities may have higher energy requirements for the brain and liver (17). This might explain higher resting metabolic rates in regards to their small sized bodies.

Nutrient Needs of Individuals with Achondroplasia

Paucity of Information

Articles about obesity do not state exactly how to reverse obesity besides nutrition counseling and/or consultation with a dietitian (23). Annie Yahner, a Registered Dietitian, and a Little Person with the Skeletal Dysplasia Center at Akron Children's Hospital in Akron, Ohio

stated she has no set dietary guidelines to follow when counseling her LP patients (A. Yahner, personal communication, March 25, 2011).

Need for a Food Guide Pyramid

Weight-for-height-and-age growth curves (Appendix B) and an age-appropriate body mass index are available for individuals with ACH (5, 7). Yahner uses weight-for-height-and-age growth curves for her LP patients; however, she has no dietary guidelines specifically for them (A. Yahner, personal communication, March 25, 2011). Yahner bases nutritional needs on growth curves and encourages healthy eating habits using her two-thirds rule; individuals with ACH should consume two-thirds less than average-sized individuals (A. Yahner, personal communication, March 25, 2011). Research indicates obesity is a common problem among individuals with ACH, and weight control and nutrition are recommended (23). Due to the physical stature of individuals with ACH, assessment of nutritional needs presents physicians and health care providers with an interesting dilemma of how to provide adequate nutrition needs to improve the health of ACH patients (24).

Development of a *Food Guide Pyramid for Individuals with Achondroplasia*

Purpose of Food Guide Pyramid for Achondroplasia

The primary purpose of developing a Food Guide Pyramid for Individuals with *Achondroplasia* is to focus on helping them maintain a healthy weight for their height. There is confusion as to what a balanced diet for individuals with ACH is because they are adults having the stature of a child ranging from about 45 to 57 inches (1). Individuals with ACH have stopped growing and their metabolism slows just the same as an average-sized adult. According to Owen's study (17), the BMR of adults with ACH ranged from 962kcal/24h to 1823 kcal/24h.

Food Guide Pyramids for Other Populations

There are food guides available for different populations based upon specific nutrient needs and/or age group, which include children, the general population, older adults, and vegetarians (25, 26, 27). All four food guides contain information needed to meet nutrient needs of that specific group. For example, the FGP for the general population concentrates on the importance of fruits and vegetables. The FGP for older adults emphasizes the importance of drinking enough water throughout the day, and the FGP for vegetarians shows how one can eat a healthy diet without consumption of animal products (25, 26, 27).

History/Purpose of USDA Food Guide Pyramid

Historical objectives of food guides have been to translate dietary standards and recommendations into simple nutrition education tools that are useful to consumers (28). In development of food guides, the USDA has used a variety of data sources. These data include information from the U.S. nutrition status, nutritional standards, food consumption practices, food availability, food composition, and food costs (28). In 1916, the USDA published their first "food guide" based on what was known about nutritional needs and food composition (28). Today, the food guidance system is known as the Food Guide Pyramid or MyPlate.

Principles of Developing a Food Guide Pyramid

Development of food guides was based on five steps. Philosophical and nutritional goals and food consumption data were used to develop the USDA's food guide (29). Developmental steps were as follows:

Step 1: Establishment of nutritional goals

Step 2: Definition of food groups

Step 3: Assignment of serving sizes

1. Typical serving sizes
2. Ease of use
3. Nutrient content
4. Tradition

Step 4: Determination of nutrient profiles

Step 5: Determination of the number of servings

Step 1: Establishment of nutritional goals

In order to develop a food guide, the first process was to establish the goals. The eight philosophical goals of the USDA's new food guide were based on a study of the evolution of food guides and on a needs assessment of the community (29).

1. Promote overall health and well-being.
2. Base on up-to-date nutrition research on recommended intakes of nutrients and other food components.
3. Focus on total diet rather than a foundation or core diet.
4. Must be useful to target audience and should build on previous guides.
5. Should meet its nutritional goals in realistic manner.
6. Allow maximum flexibility for consumers to eat in a way that suits their taste and lifestyle while meeting nutritional criteria.
7. Demonstrate a practical way to meet nutritional needs.
8. The food guide should be evolutionary, which means that a new food guide should build on the successful elements of previous guides.

The USDA established adequacy goals for energy, protein, and vitamins and minerals in which the Recommended Dietary Allowance (RDA) was used (28). Goals for moderation of the intake of fat, saturated fat, cholesterol, sodium, and added sugars were based on the 2010 Dietary Guidelines (30).

Step 2: Definition of food groups

The next step was to categorize groups and subgroups of foods. This focused on usefulness to consumers such as common foods used in meals. In addition, it considered how food groups were grouped in past food guides (29).

Step 3: Assignment of serving sizes

To determine serving sizes for each food group, four factors were considered in establishing serving sizes (29).

1. Typical serving sizes: Typical serving sizes were based on median serving sizes as reported in USDA food consumption surveys (29).
2. Ease of use: Food guides need to be easy to understand for the consumer to feel comfortable using it. Serving size chosen was a unit of measure, which consumers could easily multiply, or divide to represent the amount they actually eat (29). Common household units (cups, ounces) and easily recognizable units (such as a slice of bread or a median piece of fruit) were chosen to use as measurements for the food groups (29).
3. Nutrient content: Nutrient content lists nutrients in each food; so, different types of foods could provide the same type of nutrient for the same food group. For example, serving sizes for the milk, yogurt, and cheese group were specified as amounts

approximately equivalent in calcium content to 1 cup of milk. A 1/2 cup of cooked vegetables provide about the same amount of nutrients as 1 cup of raw leafy vegetables (29).

4. Tradition: Type of foods consumers eat has not really changed from past food guides, so the concept is kept the same. Serving size amounts are also similar to those that have been in food guides for many years. This shows that food guides have a tradition in the serving size of foods (29).

Step 4: Determination of nutrient profiles

Determination of nutritional contribution expected from each food group is the difficult part in development of the food guide. Composites and nutrient profiles must be conducted for the food groups and subgroups (28). As noted by Davis (28), a composite reflects the frequency with which foods in a group or subgroup are consumed based on food consumption surveys. Nutrient profiles represent quantities of nutrients and other components one would expect to obtain, on average, from a serving of food from each food group and subgroup (29). In developing nutrient profiles for the five major food groups and their subgroups, two key assumptions were made. First, forms of foods were those in their lowest amounts of fat and added sugars (28). Second, nutrients added by fortification of foods such as breakfast cereals were not included in nutrient profiles to avoid relying on them to meet nutrient needs (28).

These nutrient profiles are based on the philosophical goal of flexibility for the new food guide. This shows consumers how to obtain needed nutrients while allowing maximum flexibility in choosing sources of fat and added sugars within their fat and calorie limits. Development of food patterns also included the minimum number of servings from each food group that would provide necessary protein, vitamins, and minerals for consumers (29). These

most nutrient-dense foods were used to assemble diet patterns at three targeted calorie levels—1,600, 2,200, and 2,800 (28). This helped show consumers there is flexibility in the maximum and minimum number of servings from different choices of foods to obtain still the adequate nutrients in their diet.

Step 5: Determination of the number of servings

Finally, the number of servings recommended for each food group had to be determined in order to establish a food guide. Determination of amounts of each food group to include in the food guide was a two-phase process. The first phase focused on concerns about nutrient adequacy (28). Nutrient adequacy means the number of nutrients obtained from the foods. This involved determining the number of servings from each nutrient food group and subgroup needed to meet the nutritional goals for protein, vitamins, and minerals. The second phase focused on concerns about moderation (28). This involved focusing on food components for which moderation is a concern. For example, if the population consumed a lot of red meats, then it is best to not recommend consuming high amounts of saturated fat per day. Therefore, not only does nutrient adequacy to meet consumer's dietary needs need to be considered, but also how often the consumer actually consumes food from that food group needs to be taken into account (28).

Summary

This review of the literature describes how overweight and obesity is a common problem among individuals with ACH and can lead to an early death (1, 11). Other health problems associated with individuals with ACH are sleep apnea, bowed legs, arthritis, and lumbosacral spinal stenosis (2, 4, 6, 15).

Growth curves are available for individuals with ACH, but there are no dietary guidelines specifically for them. Because of the health problems and different metabolic needs associated with individuals with ACH, parents, registered dietitians, physicians, and other health care providers along with individuals with ACH are in need of nutritional guidelines. The main purpose of a food guide is to interpret dietary standards and recommendations into simple nutrition guidelines that are useful to consumers.

Developing a FGP for individuals with ACH will utilize the same five basic steps as the USDA's food guide. Hopefully, a FGP designed for individuals with ACH will provide information to maintain an ideal weight for their height.

CHAPTER 3

METHODS

Purpose of the Study

The purpose of this study was to develop a *Food Guide Pyramid for Individuals with Achondroplasia*.

Research Objectives

1. To determine the structure and dietary needs of a food guide pyramid for individuals with achondroplasia
2. To develop a *Food Guide Pyramid for Individuals with Achondroplasia.*

Research Design

The design of this study is a modified action research design of developing a *Food Guide Pyramid for Individuals with Achondroplasia*. A modified action research design is identifying the problem, gathering data, and developing a plan but not putting it into action and reflecting on the plan. The main data needed for this study included RMR data from Owen's study (17) information pertaining to development of the USDA's FGP, and Dietary Guidelines for Americans 2010.

Identified Users

A FGP was designed for individuals with ACH as well as parents, registered dietitians, physicians, and other health professionals. ACH is a type of disproportionate short stature, and

is the most common of the skeletal dysplasia (1). A *Food Guide Pyramid for Individuals with Achondroplasia* will be beneficial to them since obesity is a common problem.

Limitations

The main limitation of this study was the limited amount of research conducted in regards to LP and/or ACH. Broken down into subgroups, this included limited or no information on dietary guidelines, obesity, basal metabolic rate/resting metabolic rate, and energy needs regarding LP and/or ACH. Additionally, research that has been conducted contained a small sample size of 27 individuals (17).

Assumptions

The assumption of this study was that Owen's calculations regarding the RMR are still accurate.

Procedures

The overall process used to develop the FGP for individuals with ACH used the same process used in development of food intake patterns for the MyPyramid food guidance system. Five phases used to develop the FGP for individuals with ACH (31):

1. Identify appropriate energy levels for development of the *Food Guide Pyramid for Individuals with Achondroplasia*.
2. Identify nutritional goals for food intake patterns.
3. Establish food groupings.

4. Determine amounts of nutrients that would be obtained by from each food group and subgroup.
5. Determine the recommended amount of servings for each food group by evaluating nutrients level in each pattern against nutritional goals.

Establishing Energy Levels

Energy levels were established by Owen (Appendix C) using indirect calorimetry to measure RMR (17). These data (Appendix C) were used to establish energy levels of 1000, 1400, and 1800-calorie meal plans for the FGP. This was done by assessing RMR and finding the lowest, middle, and highest RMR of the group, which then established the energy levels of 1000, 1400, and 1800-calorie meal plans.

Establishing Nutritional Goals

The next step was to determine nutritional goals for the 1000, 1400, and 1800-calorie meal plans. These nutritional goals, which consist of the moderation goals and the nutrient adequacy (Appendix D), were based on the Dietary Reference Intake (DRI) and 2010 Dietary Guidelines recommendations (30, 31). Protein was calculated by multiplying total kcals by 10-35 percent (32). Carbohydrates were calculated by multiplying total kcals by 45-65 percent. This is the recommended percentage of calories that should come from carbohydrates out of the total calories, and subtracting that number from the total kcals (32). For moderation goals:

1. Sodium intake limited to less than 1,500 milligrams (mg).
2. Less than 10 percent of calories from saturated fats.
3. Less than 300 mg per day of dietary cholesterol.
4. Trans fat consumption kept as low as possible.

5. Reduce intake of calories from solid fats and added sugars.
6. Limit consumption of alcohol.
7. Limit intake of foods that contain refined grains.

These moderation goals were based on the 2010 Dietary Guidelines (30, 31). For nutrient adequacy, protein, vitamins, and minerals are to be 100% of Recommended Dietary Allowance (RDA) for sex/age groups over two years of age, and total fiber should be 14 grams per 1000 calories (30). Nutrient adequacy was based on the RDA or Adequate Intake (AI) set by the Institute of Medicine (IOM) (33).

Establishing Food Groupings

Establishment of food groupings for the FGP was retained from the FGP for the general population. The five major food groups included grains, vegetables, fruits, dairy, and protein. Subgroups within the grains are whole grains and refined grains, and subgroups within the vegetables are dark-green vegetables, orange vegetables, starchy vegetables, and other vegetables.

Identifying Nutrient Contributions from Each Food Group

To determine the 1000, 1400, and 1800 calorie meal plans, nutrient profiles for each food group and subgroup were used. Nutrient profiles of each composite for each food group and subgroup are presented in Appendix E (33).

Determining Recommended Amounts from Each Food Group

Determining recommended amounts from each food group began with the 1000, 1400, and 1800 calorie levels based on the RMR from Owen's study (17). Nutrient profiles were used as guidance to meet nutritional goals. Amounts of each food group were adjusted to which food

groups could most reasonably provide the nutrients. The 1000, 1400, and 1800 calorie meal plans were developed in accordance to the recommended amounts for each food group while still meeting nutritional goals. Each food group was expressed in whole or half cups, or ounce equivalents for consumers to be able to understand and use the tool efficiently. The recommended amount for each food group is shown in the FGP meal plans for individuals with ACH, Appendix F.

CHAPTER 4

RESULTS

Introduction

The purpose of this study was to develop a *Food Guide Pyramid for Individuals with Achondroplasia*. The goal was to provide nutritional guidelines to individuals with ACH, parents, doctors, registered dietitians, and other health professionals.

Collection Procedures

Set energy levels of 1000, 1400, and 1800 calories were used for meal plans. This was accomplished by assessing RMR data from Owens (Appendix C) and finding the lowest, middle, and highest RMR of the group. After taking into account nutrient profiles compared to nutrient goals and establishing food groupings, the Exchange List for Diabetes (34) was used to calculate the number of servings for each food group. Then, the number of exchange servings was translated into the number of FGP serving size (Appendix G). MyPyramid was used to check for any nutrient deficiencies for energy levels of 1000, 1400, and 1800 calories respectively. The FGP meal plans for individuals with ACH are shown in Appendix F. Finally, a Food Guide Pyramid for Individuals with ACH was developed (Figure 1).

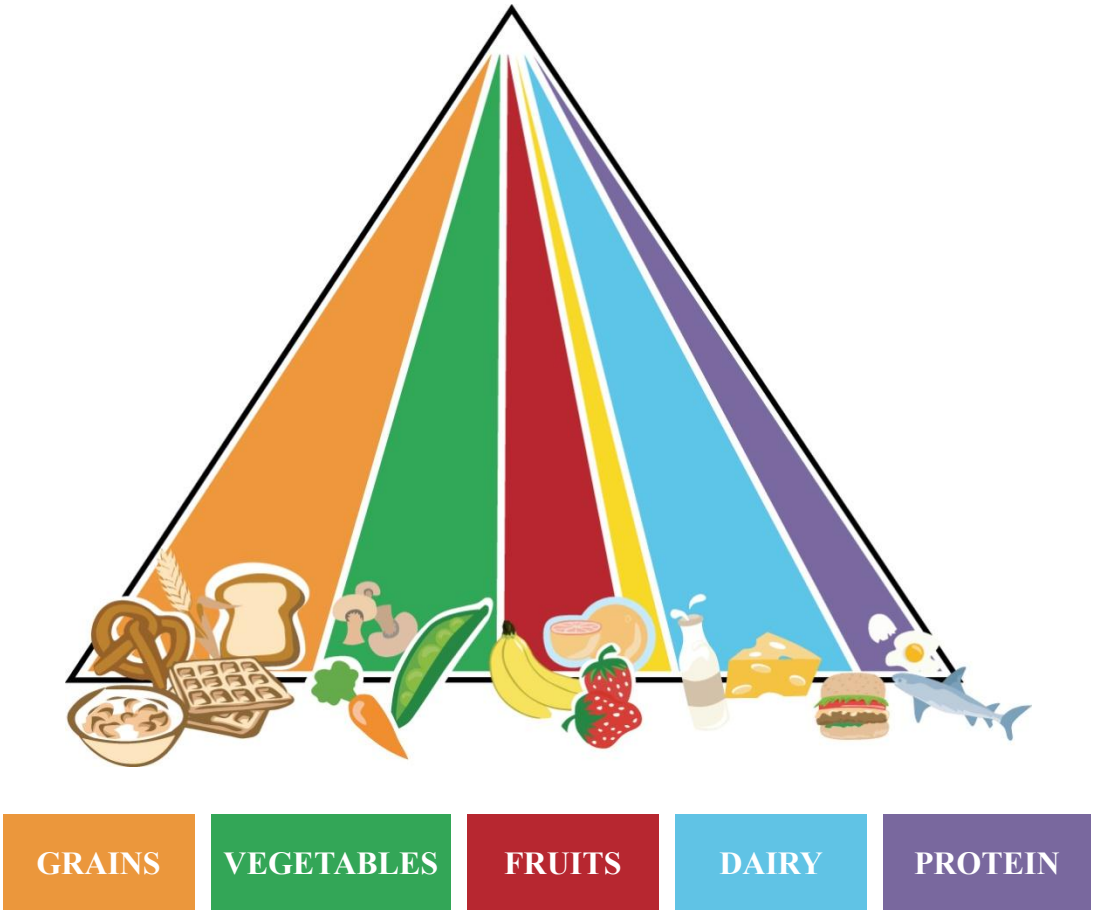

Figure 1. *Food Guide Pyramid for Individuals with Achondroplasia*

Data Summary

The FGP meal plans for 1000, 1400, and 1800 calorie meal plans are shown in Table 1. Each meal plan contains the five major food groups: grains, vegetables, fruits, dairy, and protein. Servings from the fruit, vegetables, and dairy group in the 1000 and 1400 calorie meal plan were the only food group decreased compared to the FGP for the general population. Overall, the *Food Guide Pyramid for Individuals with Achondroplasia* contains the same concept as the FGP for general population, which is to provide nutritional needs for individuals with ACH.

Table 1. **Food Guide Pyramid Meal Plans for Individuals with ACH**

Energy Level (kcals)	Food Group	Number of Exchange Servings	Estimated Total Serving Size
1000	Grains	4	4 oz.
	Vegetables	2	1 cup cooked, 2 cups fresh
	Fruits	3	1 ½ cups
	Dairy	1	1 cup
	Protein	4	4 oz.
1400	Grains	6	6 oz.
	Vegetables	2	1 cup cooked, 2 cups fresh
	Fruits	3	1 ½ cups
	Dairy	2	2 cups
	Protein	5	5 oz.
1800	Grains	7	7 oz.
	Vegetables	4	2 cups cooked, 4 cups fresh
	Fruits	4	2 cups
	Dairy	3	3 cups
	Protein	6	6 oz.

Comparison of Food Guide Pyramid for General Population and Food Guide Pyramid for Individuals with ACH

The food guide pyramid for the general population and the *Food Guide Pyramid for Individuals with Achondroplasia* are both in the form of a pyramid, nutritional needs are both based on the RDA/DRI and 2010 Dietary Guidelines, and both food guide pyramids contained the same five food groupings. The *Food Guide Pyramid for Individuals with Achondroplasia* actually has about the same number of servings as the food guide pyramid for general population. The number of servings from the fruit, vegetables, and dairy group in the 1000 and 1400-calorie meal plan were the only food groups that was decreased to meet the lower calorie meal plans. Overall, both of these food guide pyramids contain the same concept as to provide dietary guidelines for each intended population.

Analysis of Research Objectives

Two main objectives were stated at the beginning of this study.

1. To determine the structure and dietary needs of a food guide pyramid for individuals with achondroplasia

   The structure of the *Food Guide Pyramid for Individuals with Achondroplasia* was based on the FGP for the general population. Resting metabolic rates from Owen's data were used to develop the calorie meal plans. Dietary needs were developed using RDA/DRI, 2010 Dietary Guidelines, and the calorie intake levels, which were used to determine the number of servings for each food group.

2. To develop a food guide pyramid for individuals with achondroplasia

Development of a *Food Guide Pyramid for Individuals with Achondroplasia* was based on RMR data from Owen's study (16) to establish the 1000, 1400, and 1800 calorie meal plans. Nutrient goals were established based on RDA/DRI and 2010 Dietary Guidelines. Then, nutrient profiles were compared to the nutrient goals to establish food groupings. Exchanges Lists for Diabetes (33) was used to assess the number of servings for energy levels of 1000, 1400, and 1800 calories. The number of exchange servings was translated into the number of FGP serving size (Appendix G).

Importance of the Food Guide Pyramid for Individuals with Achondroplasia

A *Food Guide Pyramid for Individuals with Achondroplasia* can be used to help improve daily lives of those with ACH by having a dietary guideline for healthy eating. Knowing amounts from each food group according to calorie intake level, individuals with ACH may be able to lessen pre-existing health problems such as heart disease, hypertension, diabetes, and obesity. Excessive weight can decrease mobility, which, because of their genetic disorder, can be a challenge on a daily basis. By eating nutritious, balanced meals, individuals with ACH might better control their weight, have less stress on their joints, and increase their lifespan.

Promotion of Food Guide Pyramid for Individuals with Achondroplasia

Promotion of a *Food Guide Pyramid for Individuals with Achondroplasia* can be distributed through different medias such as online, print, and presentations to the public. Online promotion can be conducted through an existing national dwarfism community website such as Little People of America (www.lpaonline.org). Also, e-mails can be sent to the 14 districts and the 70 chapters located throughout the United States. The *LPA Today* magazine and the *Journal of the Academy of Nutrition and Dietetics* are print sources that can be used to promote the *Food Guide Pyramid for Individuals with Achondroplasia*. Flyers or pamphlets can be distributed to registered dietitians, skeletal dysplasia clinics, and other health professionals. Presentations can be made at district or chapter meetings, annual Little People Association National Convention, and annual Academy of Nutrition and Dietetics Food and Nutrition Conference and Exhibition.

CHAPTER 5

SUMMARY, CONCLUSION, AND RECOMMENDATIONS

Introduction

The purpose of this study was to develop a *Food Guide Pyramid for Individuals with Achondroplasia*. The goal was to provide nutritional guidelines to individuals with ACH, parents, physicians, registered dietitians, and other health professionals.

Summary

Achondroplasia (ACH) is the most common type of dwarfism of the skeletal dysplasia, occurring in approximately 1 in 26,000 births (1). Average height of an adult with ACH is four feet tall; thus, the term "Little People or LP" (1) is used to refer to those with ACH. Obesity is a common occurrence of individuals with ACH but the causes are uncertain. It may have to do with the underlying metabolic defect in individuals with ACH, or may be related to excessive caloric intake and/or lack of physical activity. Obesity could be due to less body area to distribute a greater body mass. Nutritional guidelines developed specifically for individuals with ACH are absent. The purpose of this study was to develop a *Food Guide Pyramid for Individuals with Achondroplasia*. Two research objectives in this study:

1. To determine the structure and dietary needs of a Food Guide Pyramid for Individuals with achondroplasia
2. To develop a *Food Guide Pyramid for Individuals with Achondroplasia.*

The overall process used to develop the *Food Guide Pyramid for Individuals with Achondroplasia* uses the same process used in the development of food intake patterns for the MyPyramid food guidance system. RMR used to determine the set energy levels of 1000, 1400, and 1800 calories were based on Owen's study (17). Then, these energy levels were used to develop the meal plans. Nutrient profiles were compared to the nutrient goals to establishing food groupings. Then, the Exchange Lists for Diabetes (33) was used to assess portions sizes for energy levels of 1000, 1400, and 1800 calories. Next, the number of exchange servings was translated into the number of FGP serving size (Appendix G). The FGP meal plans for individuals with ACH are shown in Appendix F. Finally, a food guide pyramid for individuals with ACH was developed (Appendix H).

Discussion of Findings

The *Food Guide Pyramid for Individuals with Achondroplasia* is in the form of a pyramid to replicate the standard diagram of other FGPs. Dietary needs are based on the RDA/DRI and 2010 Dietary Guidelines, and contain the same five food groupings as FGP for the general population. The *Food Guide Pyramid for Individuals with Achondroplasia* has lower calorie meal plans reflecting the use of Owen's RMR research. Due to the lower calorie meal plans, the number of servings for some food groups was decreased. Overall, the *Food Guide Pyramid for Individuals with Achondroplasia* contains the same concept as the FGP for general population, which is to provide nutritional needs for individuals with ACH.

Conclusion

The *Food Guide Pyramid for Individuals with Achondroplasia* provides recommended daily dietary needs. These calorie meal plans were designed using RMR data from individuals with ACH in Owen's study (17). The *Food Guide Pyramid for Individuals with Achondroplasia* can be used by individuals with ACH, and also by parents, physicians, registered dietitians, and other health professionals involved with individuals with ACH.

Recommendations

Choose My Plate

The MyPyramid.org has been replaced with ChooseMyPlate.org. The guidelines are still based on the 2010 Dietary Guidelines. However, the food guide pyramid has been replaced with "Choose MyPlate." This information does not affect this study. "Choose my plate" might be a way visually for individuals to understand what their plate should look like while meeting their nutritional needs.

Physical Activity Level

One study measured physical activity of children and adolescents with ACH. The subjects with ACH had a mean energy expenditure of 5.3 mega-Joules per day, which is about 1266.7kcals/day (18). However, because of their unique physique, validity of the physical activity record is uncertain. Individuals with ACH might use more energy compared to average sized adults doing the same physical activity. Therefore, there is need for further research on the energy use of physical activity of individuals with ACH.

Nutrient Goals Being Met

Nutrient goals were set to ascertain individuals with ACH are getting the recommended nutrients on a daily basis. Depending on their food choices (Appendix I) or their meal plan allowance, individuals with ACH might not meet all nutrient goals. Appendices J, K, and L show how a sample meal plan for each 1000, 1400, and 1800 calorie meal plans meet nutrient goals. All three meal plans meet recommended calorie needs and number of servings for each food group. However, the three meal plans did show some nutrient deficiencies (Appendices J, K, and L). After consulting with a physician or registered dietitian, individuals with ACH might need supplements to meet specific nutrient goals if unable to obtain from food sources.

Implications for Research and Practice

Future research is needed to test the usefulness of the *Food Guide Pyramid for Individuals with Achondroplasia,* and improvements of the health status of individuals with ACH. Additionally, researchers can apply the same methods to develop food guide pyramids for other types of dwarfisms based on their dietary and nutritional needs.

Registered dietitians should be the main consultants for individuals with ACH who may be overweight/obese and even for those in the normal weight range by providing guidance in selection of the recommended nutrients pertaining to their needs.

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APPENDICES

Appendix A

Comparison of Owen's Resting Metabolic Rate and Resting Metabolic Rate Calculated using Harris-Benedict

and

Comparison of Owen's Resting Metabolic Rate and Resting Metabolic Rate Calculated using Mifflin-St. Jeor

Comparison of Owen's Resting Metabolic Rate* and Resting Metabolic Rate Calculated using Harris-Benedict

Dwarf No.	Owen's RMR (kcal/24hr)	Harris-Benedict	Difference
1	1028	1131.74	-103.74
2	962	1041.7	-79.7
3	1114	1210.32	-96.32
4	1071	1180.38	-109.38
5	1221	1247.94	-26.94
6	1405	1218.04	+186.96
7	1071	1178	-107
8	1054	1077.08	-23.08
9	1395	1251.94	+143.06
10	1190	1213.24	-23.24
11	1462	1265.06	+196.94
12	1399	1060.45	+338.55
13	1418	1105.22	+312.78
14	1208	1183.03	+24.97
15	1260	1224.28	+35.72
16	1591	1275.1	+315.9
17	1347	1292.89	+54.11
18	1410	1227.27	+182.73
19	1323	1303.61	+19.39
20	1375	1279.6	+95.4
21	1474	1343.99	+130.01
22	1611	1277.11	+333.89
23	1612	1353.32	+258.68
24	1694	1531.86	+162.14

*Modified from: Owen, O. E., Smalley, K. J., D'Alessio, D. A., et. al. Resting metabolic rate and body composition of achondroplastic dwarfs. *Medicine*. 1990; 69(1): 56-67.

Comparison of Owen's Resting Metabolic Rate* and Resting Metabolic Rate Calculated using Harris-Benedict (continued)

Dwarf No.	Owen's RMR (kcal/24hr)	Harris-Benedict	Difference
25	1823	1544.77	+278.23
26	1689	1608.89	+80.11
27	1694	1772.28	-78.28

*Modified from: Owen, O. E., Smalley, K. J., D'Alessio, D. A., et. al. Resting metabolic rate and body composition of achondroplastic dwarfs. *Medicine*. 1990; 69(1): 56-67.

Comparison of Owen's Resting Metabolic Rate* and Resting Metabolic Rate Calculated using Mifflin-St. Jeor

Dwarf No.	Owen's RMR (kcal/24hr)	Mifflin-St. Jeor	Difference
1	1028	901.75	+126.25
2	962	787.75	+174.25
3	1114	1006	+108
4	1071	929.5	+141.5
5	1221	1028	+193
6	1405	991.75	+413.25
7	1071	940.25	+130.75
8	1054	819.5	+234.5
9	1395	1054.25	+340.75
10	1190	973	+217
11	1462	1017.5	+444.5
12	1399	1195.25	+203.75
13	1418	1230	+188
14	1208	1250.75	-42.75
15	1260	1197.25	+62.75
16	1591	1284.25	+306.75
17	1347	1256.25	+90.75
18	1410	1293.25	+116.75
19	1323	1215.5	+107.5
20	1375	1276	+99
21	1474	1438	+36
22	1611	1444.75	+166.25
23	1612	1499.5	+112.5
24	1694	1605.25	+88.75

*Modified from: Owen, O. E., Smalley, K. J., D'Alessio, D. A., et. al. Resting metabolic rate and body composition of achondroplastic dwarfs. *Medicine*. 1990; 69(1): 56-67.

Comparison of Owen's Resting Metabolic Rate* and Resting Metabolic Rate Calculated using Mifflin-St. Jeor (continued)

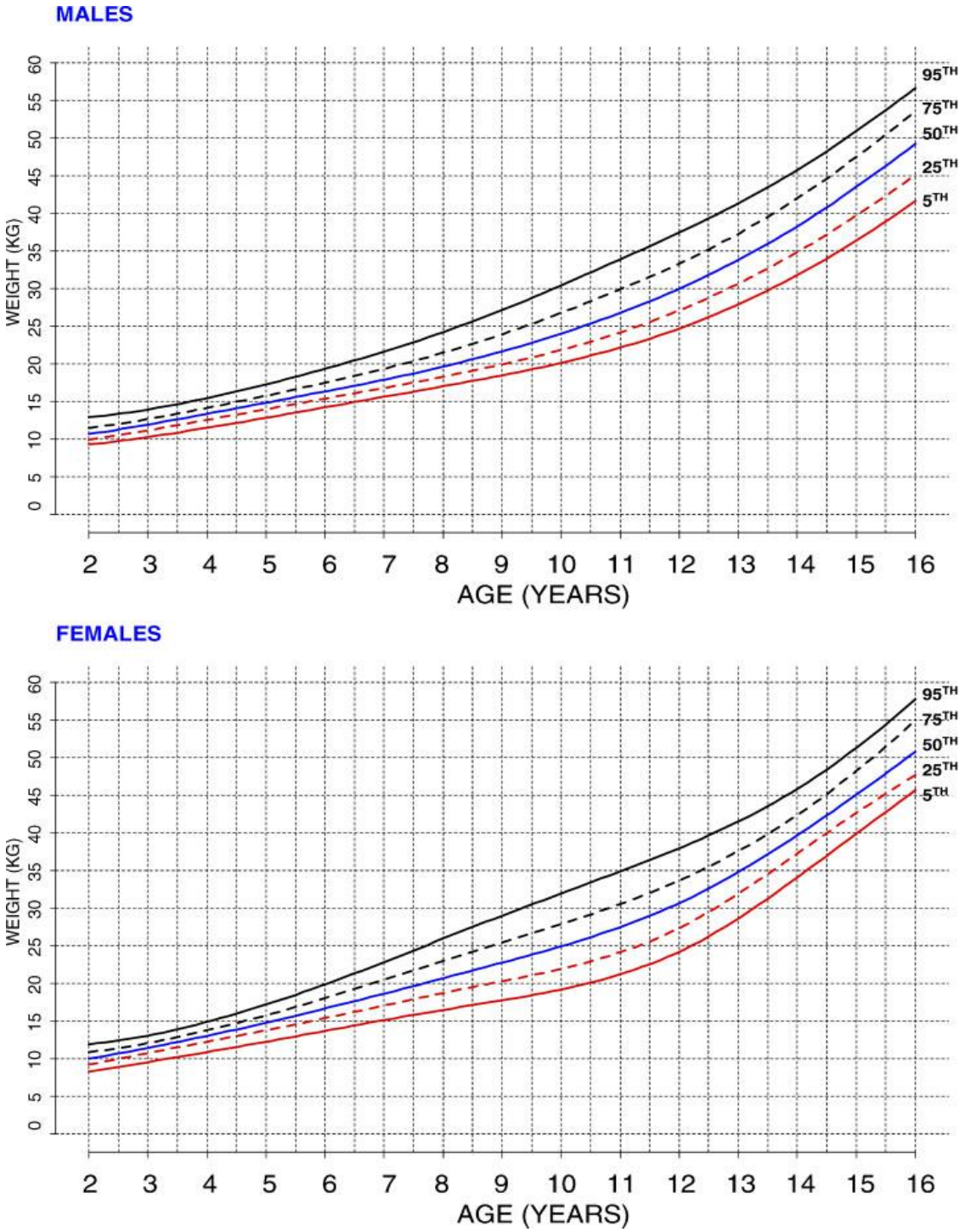
Dwarf No.	Owen's RMR (kcal/24hr)	Mifflin-St. Jeor	Difference
25	1823	1057.5	+765.5
26	1689	1116	+573
27	1694	1165.25	+528.75

*Modified from: Owen, O. E., Smalley, K. J., D'Alessio, D. A., et. al. Resting metabolic rate and body composition of achondroplastic dwarfs. *Medicine*. 1990; 69(1): 56-67.

Appendix B

Weight for Age Growth Curves for Individuals with ACH with 5th, 25th, 50th, 75th, and 95th percentiles for males and females, 2–16 years

Weight for Age Growth Curves for Individuals with ACH with 5th, 25th, 50th, 75th, and 95th percentiles for males and females, 2–16 years



Referenced with permission from: Hoover-Fong, JE, McGready, J, Schulze, KJ, Barnes, H, Scott CI. Weight for age charts for children with achondroplasia. *Am. J Genetics*. 2007; 143: 2227-2235.

APPENDIX C

Summary of Anthropometric Data of Owen's Subjects and Measured Resting Metabolic Rate Compared to Calculated Resting Metabolic Rate

Summary of Anthropometric Data of Owen's Subjects and Measured Resting Metabolic Rate Compared to Calculated Resting Metabolic Rate

Dwarf No.	Gender (M/F)	Age (yr)	HT (cm)	WT (kg)	RMR (kcal/24hr)	Harris-Benedict	Mifflin-St. Jeor
1	F	26	127	39.9	1028	1131.74	901.75
2	F	48	123	42.0	962	1041.7	787.75
3	F	26	132	47.2	1114	1210.32	1006
4	F	31	122	48.3	1071	1180.38	929.5
5	F	19	128	48.4	1221	1247.94	1028
6	F	25	127	48.4	1405	1218.04	991.75
7	F	33	125	48.5	1071	1178	940.25
8	F	54	122	48.8	1054	1077.08	819.5
9	F	22	133	49.4	1395	1251.94	1054.25
10	F	28	124	49.9	1190	1213.24	973
11	F	33	122	58.1	1462	1265.06	1017.5
12	M	28	126	40.5	1399	1060.45	1195.25
13	M	33	136	42.6	1418	1105.22	1230
14	M	26	133	45.9	1208	1183.03	1250.75
15	M	29	133	50.4	1260	1224.28	1197.25
16	M	22	132	51.0	1591	1275.1	1284.25
17	M	23	135	51.7	1347	1292.89	1256.25
18	M	34	133	53.1	1410	1227.27	1293.25
19	M	32	145	53.3	1323	1303.61	1215.5
20	M	34	141	54.0	1375	1279.6	1276
21	M	23	137	54.7	1474	1343.99	1438
22	M	32	126	58.3	1611	1277.11	1444.75
23	M	41	128	67.6	1612	1353.32	1499.5

Modified from: Owen, O. E., Smalley, K. J., D'Alessio, D. A., et. al. Resting metabolic rate and body composition of achondroplastic dwarfs. *Medicine*. 1990; 69(1): 56-67.

Summary of Anthropometric Data of Owen's Subjects and Measured Resting Metabolic Rate Compared to Calculated Resting Metabolic Rate (continued)

Dwarf No.	Gender (M/F)	Age (yr)	HT (cm)	WT (kg)	RMR (kcal/24hr)	Harris-Benedict	Mifflin-St. Jeor
24	M	28	140	69.8	1694	1531.86	1605.25
25	M	30	139	72.1	1823	1544.77	1057.5
26	M	26	142	73.7	1689	1608.89	1116
27	M	40	137	94.4	1694	1772.28	1165.25

Modified from: Owen, O. E., Smalley, K. J., D'Alessio, D. A., et. al. Resting metabolic rate and body composition of achondroplastic dwarfs. *Medicine*. 1990; 69(1): 56-67.

APPENDIX D

Calculations of 1000, 1400, and 1800 Calories of Nutritional Goals Based on Dietary Reference Intakes and 2010 Dietary Guidelines Recommendations

Calculations of 1000, 1400, and 1800 Calories of Nutritional Goals Based on Dietary Reference Intakes and 2010 Dietary Guidelines Recommendations

Nutrient (units)	Source of goal[a]	1000	1400	1800
Macronutrients				
Protein (g)	RDA[b]	25-87.5	35-122.5	45-157.5
(% of calories)	AMDR[c]	10-35	10-35	10-35
Carbohydrate (g)	RDA	112.5-162.5	157.5-227.5	202.5-292.5
(% of calories)	AMDR	45-65	45-65	45-65
Total fiber (g)	IOM[d]	14	20	25
Total fat	RDA	22.2-38.8	31.1-54.4	40-70
(% of calories)	AMDR	20-35	20-35	20-35
Saturated fat (% of calories)	DG[e]	<10%	<10%	<10%
Linoleic acid (g)	AI[f]	11-17	11-17	11-17
(% of calories)	AMDR	5-10	5-10	5-10
α-Linolenic acid (g)	AI	1.1-1.6	1.1-1.6	1.1-1.6
(% of calories)	AMDR	0.6-1.2	0.6-1.2	0.6-1.2
Cholesterol (mg)	DG	<300	<300	<300
Minerals				
Calcium (mg)	RDA	1,000-1,300	1,000-1,300	1,000-1,300
Iron (mg)	RDA	8-18	8-18	8-18
Magnesium (mg)	RDA	310-420	310-420	310-420

Modified from: U.S. Department of Agriculture and U.S. Department of Health and Human Services. *Dietary Guidelines for Americans, 2010.* 7th Edition, pg. 76. Washington, DC: U.S. Government Printing Office, December 2010.

a Dietary Guidelines recommendations are used when no quantitative Dietary Reference Intake value is available; apply to ages 2 years and older.

b Recommended Dietary Allowance, IOM.

c Acceptable Macronutrient Distribution Range, IOM.

d 14 grams per 1,000 calories, IOM.

e Dietary Guidelines recommendation.

f Adequate Intake, IOM.

g Upper Limit, IOM.

h 1 mcg of vitamin D is equivalent to 40 IU.

AT = alpha-tocopherol; DFE = dietary folate equivalents; RAE = retinol activity equivalents.

Calculations of 1000, 1400, and 1800 Calories of Nutritional Goals Based on Dietary Reference Intakes and 2010 Dietary Guidelines Recommendations (continued)

Nutrient (units)	Source of goal[a]	1000	1400	1800
Phosphorus (mg)	RDA	700-1,250	700-1,250	700-1,250
Potassium (mg)	AI	4,700	4,700	4,700
Sodium (mg)	UL[g]	<1,500	<1,500	<1,500
Zinc (mg)	RDA	8-11	8-11	8-11
Copper (mcg)	RDA	900	900	900
Selenium (mcg)	RDA	55	55	55
Vitamins				
Vitamin A (mcg RAE)	RDA	700-900	700-900	700-900
Vitamin D[h] (mcg)	RDA	15	15	15
Vitamin E (mg AT)	RDA	15	15	15
Vitamin C (mg)	RDA	75-90	75-90	75-90
Thiamin (mg)	RDA	1.1-1.2	1.1.-1.2	1.1-1.2
Riboflavin (mg)	RDA	1.1-1.3	1.1-1.3	1.1-1.3
Niacin (mg)	RDA	14-16	14-16	14-16
Folate (mcg)	RDA	400	400	400
Vitamin B_6 (mg)	RDA	1.3-1.7	1.3-1.7	1.3-1.7
Vitamin B_{12} (mcg)	RDA	2.4	2.4	2.4
Choline (mg)	AI	425-550	425-550	425-550
Vitamin K (mcg)	AI	90-120	90-120	90-120

Modified from: U.S. Department of Agriculture and U.S. Department of Health and Human Services. *Dietary Guidelines for Americans, 2010.* 7th Edition, pg. 76. Washington, DC: U.S. Government Printing Office, December 2010.

a Dietary Guidelines recommendations are used when no quantitative Dietary Reference Intake value is available; apply to ages 2 years and older.

b Recommended Dietary Allowance, IOM.

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d 14 grams per 1,000 calories, IOM.

e Dietary Guidelines recommendation.

f Adequate Intake, IOM.

g Upper Limit, IOM.

h 1 mcg of vitamin D is equivalent to 40 IU.

AT = alpha-tocopherol; DFE = dietary folate equivalents; RAE = retinol activity equivalents.

APPENDIX E

Nutrient Profiles for Food Group and Subgroup Composites

Nutrient Profiles for Food Group and Subgroup Composites

Nutrients, Unit Amount	**Fruits ½ cup**	**Dark-green vegetables ½ cup**	**Orange vegetables ½ cup**	**Dry Beans ½ cup**	**Starchy vegetables ½ cup**	**Other ½ cup**
Calories, kcal	59	20	32	114	73	18
Protein, g	0.7	1.6	0.7	8.0	1.7	0.9
CHO, g	14.7	3.9	7.4	19.2	16.8	3.9
Total fat, g	0.2	0.2	0.1	1.0	0.2	0.2
Sat. fat, g	0.03	0.04	0.03	0.16	0.03	0.03
Mono. fat, g	0.02	0.02	0.01	0.19	0.03	0.02
Poly. fat, g	0.05	0.10	0.08	0.49	0.08	0.08
Linoleic acid, g	0.03	0.03	0.07	0.38	0.07	0.06
α-Linolenic, g	0.01	0.07	0.00	0.12	0.01	0.02
Cholesterol, mg	0	0	0	0	0	0
Dietary fiber, g	1.1	2.1	2.1	6.0	1.7	1.1
Vit. A, µg RAE	16	167	554	0	2	13
Vit. E, mg AT	0.2	1.0	0.6	0.6	0.0	0.4
Vit. C, mg	25	30	5	0	6	9
Thiamin, mg	0.06	0.05	0.05	0.14	0.09	0.04
Riboflavin, mg	0.03	0.10	0.04	0.05	0.03	0.04
Niacin, mg	0.3	0.4	0.6	0.4	1.1	0.5
Vit. $B_{6,}$ mg	0.09	0.13	0.12	0.12	0.21	0.08
Folate, µg DFE	24	81	10	111	14	14
Vit. $B_{12,}$ µg	0.0	0.0	0.0	0.0	0.0	0.0
Calcium, mg	11	50	23	57	8	21
Phosphorus, mg	17	39	25	119	43	21
Magnesium, mg	12	25	9	46	19	10
Iron, mg	0.2	1.0	0.3	2.3	0.4	0.6
Zinc, mg	0.1	0.3	0.2	1.0	0.3	0.2
Copper, mg	0.06	0.07	0.03	0.21	0.13	0.06
Sodium, mg	3	30	41	3	5	57
Potassium, mg	213	229	214	363	286	162

Adopted from: Marcoe, K., Juan, W., Yamini, S., Carlson, A., Britten, P. Development of food group composites and nutrient profiles for the MyPyramid food guidance system. *J Nutr Educ Behav*. 2006; 38:S93-S107.

Nutrient Profiles for Food Group and Subgroup Composites (continued)

Nutrients, Unit Amount	**Whole grains 1 oz.**	**Refined grains 1 oz.**	**Meat & Beans 1 oz.**	**Milk 1 cup**	**Added Sugars 1 tsp**	**Oils 10 g**	**Solid Fats 10 g**
Calories, kcal	77	83	54	83	16	84	76
Protein, g	2.4	2.2	6.9	8.3	0	0.0	0.0
CHO, g	15.6	15.8	0.4	12.2	4.2	0.0	0.0
Total fat, g	1.1	1.1	2.6	0.2	0	9.5	8.5
Sat. fat, g	0.20	0.23	0.80	0.29	0	1.43	3.60
Mono. fat, g	0.33	0.39	1.09	0.12	0	3.27	3.27
Poly. fat, g	0.38	0.35	0.44	0.02	0	4.34	1.25
Linoleic acid, g	0.40	0.32	0.37	0.01	0	3.99	1.10
α-Linolenic, g	0.02	0.03	0.02	0.00	0	0.35	0.14
Cholesterol, mg	0.3	0.9	34.8	5.0	0	0	11.5
Dietary fiber, g	2.4	0.7	0.1	0.0	0	0.0	0.0
Vit. A, µg RAE	26	5	17	69	0	11	45
Vit. E, mg AT	0.1	0.1	0.2	0.0	0	1.4	0.4
Vit. C, mg	1	0	0	0	0	0	0
Thiamin, mg	0.13	0.14	0.06	0.11	0	0.00	0.00
Riboflavin, mg	0.11	0.10	0.07	0.45	0	0.00	0.00
Niacin, mg	1.4	1.4	1.6	0.2	0	0.00	0.00
Vit. $B_{6,}$ mg	0.14	0.06	0.09	0.00	0	0.00	0.00
Folate, µg DFE	50	59	5	12	0	0	0
Vit. $B_{12,}$ µg	0.2	0.1	0.6	1.3	0.00	0.00	0.00
Calcium, mg	26	30	6	306	0	0	1
Phosphorus, mg	85	33	63	247	0	0	1
Magnesium, mg	27	7	8	27	0	0	0
Iron, mg	1.8	1.2	0.5	01	0	0.0	0.0
Zinc, mg	0.9	0.2	1.0	1.0	0	0.0	0.0
Copper, mg	0.08	0.06	0.05	0.03	0	0.00	0.00
Sodium, mg	87	153	93	103	0	13	16
Potassium, mg	91	29	91	382	0	0	2

Adopted from: Marcoe, K., Juan, W., Yamini, S., Carlson, A., Britten, P. Development of food group composites and nutrient profiles for the MyPyramid food guidance system. *J Nutr Educ Behav*. 2006; 38:S93-S107.

APPENDIX F

FGP Meal Plans for Individuals with ACH

FGP Meal Plans for Individuals with ACH

Energy Level (kcals)	Food Group	Number of Exchange Servings	Estimated Total Serving Size
1000	Grains	4	4 oz.
	Vegetables	2	1 cup cooked, 2 cups fresh
	Fruits	3	1 ½ cups
	Dairy	1	1 cup
	Protein	4	4 oz.
1400	Grains	6	6 oz.
	Vegetables	2	1 cup cooked, 2 cups fresh
	Fruits	3	1 ½ cups
	Dairy	2	2 cups
	Protein	5	5 oz.
1800	Grains	7	7 oz.
	Vegetables	4	2 cups cooked, 4 cups fresh
	Fruits	4	2 cups
	Dairy	3	3 cups
	Protein	6	6 oz.

APPENDIX G

Recommended Serving Sizes per Exchange Serving

Recommended Serving Sizes per Exchange Serving

Food Groups	**Serving Sizes = 1 Exchange Serving**
Grains	½ cup of cooked cereal or grain 1/3 cup of cooked rice or pasta 1 oz. of bread product, such as 1 slice of bread ¾ oz. to 1 oz. of most snack foods
Vegetables	½ cup of cooked vegetables or vegetable juice 1 cup of raw vegetables
Fruits	½ cup of canned, fresh fruit, or unsweetened fruit juice 1 small fresh fruit (4 oz.) 2 tbsp. of dried fruit
Dairy	1 cup of milk 2/3 cup of yogurt (6 oz.)
Protein	1 oz. of cooked meat, poultry, or fish 1 tbsp. of peanut butter 1 oz. of cooked beans 1 egg

APPENDIX H

Food Guide Pyramid for Individuals with ACH

Food Guide Pyramid for Individuals with Achondroplasia

GRAINS	VEGETABLES	FRUITS	DAIRY	PROTEIN

Appendix I

Description of Food Groups and Recommendations for Food Selection

Description of Food Groups and Recommendations for Food Selection

Food group and examples of food items	**Recommendations**
Grains (wheat, corn, oats, rice, and millet) Grain products: bread, pasta, and tortillas	Select whole-wheat and whole-grain products.
Vegetables All vegetables	Emphasize leafy, green vegetables. Eat both cooked and raw vegetables.
Fruits All fruits	Emphasize fresh, whole fruit rather than juice.
Dairy Milk, yogurt, and cheese	Emphasize nonfat and low-fat products. If dairy is avoided, ensure that adequate sources of calcium, vitamin D, and vitamin B_{12} are consumed.
Protein Meat, poultry, fish, eggs, beans, and nuts	Emphasize lean cuts of meat.

Appendix J

Sample Plan for 1000 Calories Meal Plan

Recommended Number of Exchange Servings for each Food Group

Nutrient Composition of Sample Meal Plan

Sample Plan for 1000 Calories Meal Plan

Food	**Serving Size**	**Number of Exchange Servings**
Bran Flakes Cereal	½ cup	1
Banana	½	1
Skim Milk	8 oz.	1
100% Whole Wheat Bread	1 slice	1
Turkey, skinless	2 oz.	2
Carrots	1 cup	1
Apple	1 small	1
Mayo, reduced fat	1 Tbsp.	1
100% Whole Wheat Bread	1 slice	1
Brown Rice	1/3 cup	1
Chicken, skinless	2 oz.	2
Broccoli	½ cup, cooked	1
M & M's	8	1
Peanut Butter	1 Tbsp.	1

Recommended Number of Exchange Servings for each Food Group

Food Group	**Recommended Number of Exchange Servings**
Grains	4
Vegetables	2
Fruits	3
Dairy	1
Protein	4

Nutrient Composition of Sample Meal Plan

Nutrient	Intake	RDA/DRI
Exchange Calories/Actual Calories (kcals)[a]	1006	1000
Protein (gm)[a]	63	25-87.5
Carbohydrate (gm)[a]	135	112.5-162.5
Total Fiber (gm)[b]	20	14
Total Fat (gm)[b]	26.7	22.2-38.8
Total Fat (% of total calories)[b]	24	20-35
Saturated Fat (% of total calories)[b]	6	< 10
Monounsaturated Fat (% of total calories)[b]	9	**
Polyunsaturated Fat (% of total calories)[b]	6	**
Linoleic (omega 6) (gm)[b]	6	11-17
Alpha Linolenic (omega 3) (gm)[b]	0.5	1.1-1.6
Cholesterol (mg)[b]	97	< 300
Vitamin A (mcg RAE)[b]	1400	700-900
Vitamin C (mg)[b]	112	75-90
Vitamin E (mg a-TE)[b]	15	15
Thiamin (mg)[b]	1.7	1.1-1.2
Riboflavin (mg)[b]	2.3	1.1-1.3
Niacin (mg)[b]	34	14-16
Folate (mcg, DFE)[b]	644	400
Vitamin B6 (mg)[b]	3.1	1.3-1.7
Vitamin B12 (mcg)[b]	5.7	2.4
Calcium (mg)[b]	525	1000-1300
Phosphorus (mg)[b]	960	700-1250
Magnesium (mg)[b]	272	310-420
Iron (mg)[b]	18	8-18
Zinc (mg)[b]	16	8-11
Selenium (mcg)[b]	76	55
Potassium (mg)[b]	2166	4700
Sodium (mg)[b]	1139	< 1500

*Red represents Low compared to RDA/DRI

[a] Based on ADA Exchange Lists

[b] Based on MyPyramid

Appendix K

Sample Plan for 1400 Calories Meal Plan

Recommended Number of Exchange Servings for each Food Group

Nutrient Composition of Sample Meal Plan

Sample Plan for 1400 Calories Meal Plan

Food	**Serving Size**	**Number of Exchange Servings**
Oatmeal	1 packet	1
100% Whole Wheat Bread	1 slice	1
Banana	½	1
Skim Milk	8 oz.	1
Margarine	1 tsp.	1
100% Whole Wheat Bread	2 slices	2
Turkey, skinless	2 oz.	2
Grapes	15	1
Carrots	1 cup	1
Mayo, reduced-fat	1 Tbsp.	1
Chicken, skinless	3 oz.	3
Green Beans	1 cup	1
Animal Crackers	15	1
M&M's	10	1
Skim Milk	8 oz.	1

Recommended Number of Servings of each Food Group

Food Group	**Recommended Number of Exchange Servings**
Grains	6
Vegetables	2
Fruits	3
Dairy	2
Protein	5

Nutrient Composition of Sample Meal Plan

Nutrient	Intake	RDA/DRI
Exchange Calories/Actual Calories (kcals)[a]	1398	1400
Protein (gm)[a]	83	35-122.5
Carbohydrate (gm)[a]	202	157.5-227.5
Total Fiber (gm)[b]	22	20
Total Fat (gm)[b]	31.0	31.1-54.4
Total Fat (% of total calories)[b]	20	20-35
Saturated Fat (% of total calories)[b]	5	< 10
Monounsaturated Fat (% of total calories)[b]	8	**
Polyunsaturated Fat (% of total calories)[b]	5	**
Linoleic (omega 6) (gm)[b]	6	11-17
Alpha Linolenic (omega 3) (gm)[b]	0.8	1.1-1.6
Cholesterol (mg)[b]	125	< 300
Vitamin A (mcg RAE)[b]	1715	700-900
Vitamin C (mg)[b]	36	75-90
Vitamin E (mg a-TE)[b]	7	15
Thiamin (mg)[b]	1.4	1.1-1.2
Riboflavin (mg)[b]	2.1	1.1-1.3
Niacin (mg)[b]	28	14-16
Folate (mcg, DFE)[b]	352	400
Vitamin B6 (mg)[b]	2.2	1.3-1.7
Vitamin B12 (mcg)[b]	3.0	2.4
Calcium (mg)[b]	1000	1000-1300
Phosphorus (mg)[b]	1315	700-1250
Magnesium (mg)[b]	310	310-420
Iron (mg)[b]	12	8-18
Zinc (mg)[b]	8	8-11
Selenium (mcg)[b]	104	55
Potassium (mg)[b]	2723	4700
Sodium (mg)[b]	1598	< 1500

*Red represents Low compared to RDA/DRI

[a] Based on ADA Exchange Lists

[b] Based on MyPyramid

Appendix L

Sample Plan for 1800 Calories Meal Plan

Recommended Number of Exchange Servings for each Food Group

Nutrient Composition of Sample Meal Plan

Sample Plan for 1800 Calories Meal Plan

Food	**Serving Size**	**Number of Exchange Servings**
Oatmeal	1 packet	1
100% Whole Wheat Bread	2 slice	2
Banana	½	1
Skim Milk	8 oz.	1
Margarine, lower-fat spread	1 ½ Tbsp.	1 ½
100% Whole Wheat Bread	2 slices	2
Turkey, skinless	3 oz.	3
Grapes	15	1
Carrots	1 cup, cooked	1
Mayo, reduced fat	1 Tbsp.	1
Chicken, skinless	3 oz.	3
Applesauce	1 cup	2
Broccoli	1 cup, cooked	2
Animal Crackers	15	1
M&M's	10	1
Skim Milk	8 oz.	1
Yogurt, fat free	6 oz.	1

Recommended Number of Servings of each Food Group

Food Group	**Recommended Number of Exchange Servings**
Grains	7
Vegetables	4
Fruits	4
Dairy	3
Protein	6

Nutrient Composition of Sample Meal Plan

Nutrient	Intake	RDA/DRI
Exchange Calories/Actual Calories (kcals)[a]	1823	1800
Protein (gm)[a]	110	45-157.5
Carbohydrate (gm)[a]	247	202.5-292.5
Total Fiber (gm)[b]	28	25
Total Fat (gm)[b]	46.6	40-70
Total Fat (% of total calories)[b]	23	20-35
Saturated Fat (% of total calories)[b]	6	< 10
Monounsaturated Fat (% of total calories)[b]	9	**
Polyunsaturated Fat (% of total calories)[b]	6	**
Linoleic (omega 6) (gm)[b]	10	11-17
Alpha Linolenic (omega 3) (gm)[b]	1.7	1.1-1.6
Cholesterol (mg)[b]	149	< 300
Vitamin A (mcg RAE)[b]	2235	700-900
Vitamin C (mg)[b]	126	75-90
Vitamin E (mg a-TE)[b]	12	15
Thiamin (mg)[b]	1.7	1.1-1.2
Riboflavin (mg)[b]	2.8	1.1-1.3
Niacin (mg)[b]	31	14-16
Folate (mcg, DFE)[b]	523	400
Vitamin B6 (mg)[b]	2.9	1.3-1.7
Vitamin B12 (mcg)[b]	4.5	2.4
Calcium (mg)[b]	1495	1000-1300
Phosphorus (mg)[b]	1868	700-1250
Magnesium (mg)[b]	399	310-420
Iron (mg)[b]	14	8-18
Zinc (mg)[b]	12	8-11
Selenium (mcg)[b]	136	55
Potassium (mg)[b]	3797	4700
Sodium (mg)[b]	2518	< 1500

*Red represents Low compared to RDA/DRI

[a] Based on ADA Exchange Lists

[b] Based on MyPyramid

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