A Novel 'Food Lists' App to Promote Weight Loss, Improve Diet Quality,

and Strengthen Diet Adherence: the Foodmindr Study

by

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ABSTRACT

Background Smartphone diet tracking applications (apps) are increasing in popularity but may not adequately address the important concerns of proper intake and of diet quality. Two novel weight loss apps were designed based on the popular dietary frameworks: MyPlate and FoodLists. MyPlate, the dietary guidelines put forth by the U.S. government, encourages a balanced diet from five primary food groups, but does not specify intake limits. The Food Lists set upper intake limits on all food groups except vegetables, and these guidelines extend to include fats, sweets, and alcohol.

Objective The purpose of this randomized controlled trial was to determine whether adherence to a weight loss app providing intake limits and more food group detail (the Food Lists app) facilitated more weight loss and better diet quality than adherence to a weight loss app based on the MyPlate platform. An additional objective was to examine whether higher app adherence would lead to greater weight loss.

Design Thirty seven adults from a campus population were recruited, randomized, and instructed to follow either the Food Lists app (N=20) or the MyPlate app (N=17) for eight weeks. Subjects received one 15 minute session of diet and app training at baseline, and their use of the app was tracked daily. Body mass was measured at baseline and post-test.

Participants/setting Healthy adults from a university campus population in downtown Phoenix, Arizona with BMI 24 to 40, medically stable, and who owned a smartphone.

Main outcome measures Outcome measures included weight change, days of adherence, and diet quality change. Secondary measures included BMI, fat %, and waist circumference.

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Statistical analysis Descriptive statistics (means and standard errors); Repeated measures ANOVAs analyzing weight, diet quality, and BMI; Pearson and Spearman correlations analyzing adherence and weight loss.

Results Repeated measures ANOVAs and correlations revealed no significant mean differences in primary outcome variables of weight loss, adherence, or diet quality (P=0.140; P=0.790; P=0.278). However, there was a significant mean reduction of BMI favoring the group using the Food Lists app (P=0.041).

Conclusion The findings strengthen the idea that intake limits and food group detail may be associated with weight loss. Further investigation is warranted to determine whether longer use of the Food Lists app can produce more significant dieting successes and encourage healthier behavioral outcomes.

DEDICATION

I wish to thank my wonderful family for your love, support, and understanding. Dad, you

have been my biggest fan throughout my academic journey and that means the world to

me. Mom, you are a good listener and I appreciate you checking in with me about my

progress. Brendon, you experienced this process first-hand and I appreciate your advice

and expertise.

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CHAPTER 1

INTRODUCTION

Overweight and obesity are major health issues worldwide. The World Health

Organization (WHO) estimates there are 1.4 billion overweight worldwide; 11% are

obese.[1] Many weight loss strategies have been attempted, including diets, medications,

technologies, and surgeries. Dieting is especially popular. Diets are typically easy to

start, can quickly yield results, and may be relatively inexpensive to follow. Dieting is

big business in America. For example, Amazon.com offers approximately 11,000

weight-loss related book titles.[2]

Mobile technology is also a growing industry. In less than a decade, smartphones

have become ubiquitous companions to nearly half the US population. Increasingly,

Americans are adopting smartphones as their always-connected companions.

Smartphones and the applications (apps) that run on them improve people's lives. Users

appreciate the conveniences afforded by these devices. They feel more connected, and

more informed.[3] Phone calls and text messages aside, Internet access, in the form of apps

and websites, is the most popular feature of smartphones, especially with users under age

30. Nearly three quarters of all smartphone owners are using apps or websites to check

weather, read news, or play games.[3]

There are apps to address every aspect of life, including diet tracking and weight

loss. Over the past decade, thousands of diet-related apps and websites have been

launched. A search of the Apple iTunes app store alone by the keyword "diet" returned

over 500 results (September, 2014).[4] Exact download counts are difficult to ascertain but

the following appeared among the iPhone's highest rated diet tracking apps: Calorie

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Counter & Diet Tracker by MyFitnessPal, "Lose It!", My Diet Coach, MyPlate Calorie Tracker LITE, Calorie Counter and Diet Tracker by About, Inc. These apps varied greatly by feature and usability. Some offered only basic food logging while others allowed users to watch instructional videos, track workouts, and find recipes.

Smartphones show promise of being effective tools for diet tracking and weight loss. Recent research has shown mobile device use can help increase diet adherence. Adhering to a healthy diet is critical for weight loss and weight maintenance.[5] Unfortunately, while many apps may assist users in losing weight or recording meals, few if any are addressing the equally important concern of diet quality.[6]

In theory, eating a healthful diet should be easy. Two respected methods for encouraging diet quality are the USDA's MyPlate and the American Diabetes Association's Food Lists for Diabetes. Launched in 2011, MyPlate was intended to address the shortcomings of the Food Pyramid, released by the U.S. government in 1992. One of the primary improvements was a more intuitive, plate graphic. Dietary Guidelines for Americans 2010 encourages consumptions of fruits, vegetables, whole grains, and protein, while reducing saturated fat intake. The plate schema helps encourage more fruit and vegetable consumption. The sectional design also reminds persons to choose foods from all groups to achieve a balanced diet.[7-9]

The Food Lists for Diabetes was developed in 1950 by the American Diabetes Association and the American Dietetic Association (now the Academy of Nutrition and Dietetics) to help diabetics track daily carbohydrate intakes (formerly termed "exchange lists" or "exchange system"). This system works by segmenting foods into six main groups: starches, fruits, vegetables, milk, protein, and fats. Each group has specific

serving characteristics. For example, a single starch serving contains 15 grams of carbohydrate, zero to one gram of fat, and 80 calories. Most popular foods have established serving sizes. For instance, one slice of white bread is one starch serving. With a little practice this system allows for easy accounting of food groups, macronutrients, and fats.[10-12]

Although the Food Lists for Diabetes was initially intended for the management of diabetes, it has since been demonstrated to be effective at promoting weight loss.[10-12] Perhaps more importantly, dieters following this system are more likely to choose healthy foods.[13] It is this combination of weight loss and diet quality that makes the Food Lists for Diabetes a well-respected nutritional framework.[10-12] Nevertheless, no prior study had examined the efficacy of using an electronic Food Lists for Diabetes tracker.

This study measured diet quality by administering a modified version of the Rapid Eating Assessment for Patients Short Version (REAP-S) questionnaire. This survey provides a quick and effective means for appraising consumption the major food groups: fruits, grains, vegetables, milk, and protein. It also estimates intakes of cholesterol, fat, fiber, and sugar.[14] Select questions from the What We Eat in America 1994 – 1996 Diet and Health Knowledge Questionnaire (DHKQ) were also used. The DHKQ questions were selected for their similarity to the REAP-S questions and their focus on healthy dietary behavior choices.

Weight loss is rarely maintained after a study ends. Diet adherence is crucial. Subjects prefer to use mobile technology for tracking diets. As of September 2014, the Apple iTunes store offers several apps based on the MyPlate framework. However, there are no apps for tracking daily, per meal intake of the Food Lists for Diabetes food

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categories. Given the strengths of the Food Lists, a derivative app may provide a

nutritional trifecta: increased weight loss, diet quality and diet adherence.

Purpose of Study

The purpose of this randomized controlled trial was to compare two novel

smartphone diet apps. The Food List was modeled on the American Diabetes

Association's Food Lists eating plan. The other app, "MyPlate" (MyPlate), was based on

the United States Department of Agriculture's MyPlate recommendations. Both plans

have core guidelines for consumption of vegetables, fruits, grains, protein, and dairy.

MyPlate adds an oils group on its web site but not in its visual diagram. Food Lists

includes fats, sweets, and alcohol in all primary consumer guides. MyPlate simply

encourages followers to eat a variety of its five food groups. It sets lower limit intake

goals; but does not include upper limits. The Food Lists framework sets upper intake

limits on all food groups except vegetables. These limits are based on the user's

established daily caloric intake goal.

This study intervention consisted of assigning subjects to either the Food Lists

app group or the MyPlate app group. Subjects used their designated app to track food

intake over an eight week period. It was anticipated that the Food Lists app would

facilitate greater diet weight loss, diet quality, and adherence. Success in all three

categories could make it possible to deliver simple, affordable diet tracking software to a

much larger consumer population. Both apps were hosted on a web server and targeted

to run on mobile web browsers utilized by smartphones. Thus, the apps were compatible

with all major brands of mobile operating systems: Apple iPhone, Google Android, and

Windows Phone. While not encouraged during this study, the apps could also be accessed from tablets, laptops, and desktop computers.

Investigating diet quality was an important aspect of this study. A study by Wharton et al. found smartphones could promote diet adherence but diet quality showed no significant change; it actually appeared to worsen.[6] A recent search of the iTunes store found no apps that specifically demonstrate an ability to quantify the ongoing nutritional quality of a person's diet.[4] The Food Lists and MyPlate apps were developed specifically for this trial by the investigator (CS) and carefully reflect these two scientifically validated systems of healthful eating.

Research Aim and Hypotheses

1. Compared to the U.S. government's MyPlate eating guidelines, a diet intervention that specifies more food groups and imposes caloric limits will increase weight loss in a campus sample of adult smartphone users during an eight week period in Phoenix, AZ.

2. Greater daily app adherence will lead to greater weight loss in a campus sample of adult smartphone users during an eight week period in Phoenix, AZ.

3. Compared to the U.S. government's MyPlate eating guidelines, a diet intervention that includes more food groups and imposes caloric limits will increase diet quality in a campus sample of adult smartphone users during an eight week period in Phoenix, AZ.

Definition of Terms

1. Android: a computer operating system (OS) developed by Google to run on mobile platforms such as tablets and smartphones.

2. Diet adherence: in this study adherence was the number of days of app usage. On any given day, a subject was considered to have used the app if at least one entry of food group(s) was recorded. Maximum possible adherence was 56 days.

3. Diet quality: for the purpose of this study diet quality was measured using nine questions from the Rapid Eating Assessment for Patients short version (REAP-S) questionnaire, plus eight questions from the What We Eat in America 1994 – 1996 Diet and Health Knowledge Questionnaire (DHKQ).

4. Food Lists for Diabetes: a framework for meal planning that segments foods into six main categories: starches, fruits, vegetables, milk, protein, and fats. Prior to 2014 it was referred to as the Exchange Lists or Diabetes.

5. Mifflin-St Jeor: an equation for estimating resting energy expenditure (REE).

6. Smartphone: a cell phone that is more advanced and powerful than traditional keypad-only phones. Features include Internet access, built-in GPS, and high-resolution cameras. Smartphones can run compact software programs known as "apps".

7. Web app: a dynamic, data-driven website that runs inside a web browser. Unlike native smartphone apps, web apps are generally not limited to a specific web browser or operating system.

Delimitations and Limitations

Participants were recruited from Arizona State University's population of students, faculty, and staff. The age range was 18 to 75 years. Subjects needed daily access to a smartphone capable of accessing the Internet and running the Food Lists app or MyPlate app. Persons were accepted if body mass index (BMI) was ≥ 24. Most subjects were overweight or obese. Those with type 2 diabetes were allowed to participate if blood glucose was well-controlled. Subjects on doctor-prescribed medications were permitted on a case-by-case basis. For any prescription, the subject needed to be medically stable for the prior three months.

The primary limitation of both apps was their experimental nature. Both were developed just prior to the study so time for testing and debugging was limited. The web-based nature of the apps may not have provide the same degree of fluidness experienced seen in more mature software.

Lack of compliance was also a possibility. As with any self-reported diet, some persons could have intentionally or unintentionally misreported their intakes. Participants were trained in proper use of either MyPlate or the Food Lists for Diabetes, as well as their respective app. However, achieving comfort with these eating systems may have taken subjects varying amounts of practice and this study was only eight weeks long.

CHAPTER 2

REVIEW OF LITERATURE

Overweight and Obesity

The problem of overweight and obesity has baffled researchers for many decades.[1] Science has attempted many solutions including diets,[5] medications,[15] technologies,[6] and even surgeries.[16] It is for good reason that researchers have made such efforts. Internationally, the number of obese persons doubled since 1980. An estimated 1.4 billion of the world's adult population are overweight (BMI $\geq$ 25) and 11% are obese (BMI $\geq$ 30). Obese women outnumber men by a two-to-one margin. Globally, more deaths are caused by overweight than underweight. The concern is not limited to adults. In 2012 there were 40 million overweight children (< 5 y) worldwide.[1]

Excess weight brings with it a list of potential health issues. Hypertension, cardiovascular disease (CVD), dyslipidemia, and type 2 diabetes are some of the risks associated with overweight and obesity. The term "metabolic syndrome" is an umbrella term relating to several risk factors associated with obesity and insulin resistance. Glucose intolerance, atherosclerotic CVD, and type 2 diabetes are some of the associated risks.[17] The World Health Organization (WHO) defines metabolic syndrome as insulin resistance plus the presence of at least two risk thresholds in these categories: body weight, lipid concentration, blood pressure, and glucose status.[1] At-risk body weight is a waist-to-hip ratio greater than 0.90 and 0.85 for men and women respectively; or a BMI greater than 30. Triacylglycerols (TG) greater than 150 mg/dL for either sex are considered unhealthy as are concentrations of HDL-C less than 35 mg/dL for men, or less

than 39 mg/dL for women. A blood pressure of greater than 140/90 mm Hg indicates risk. An impaired glucose tolerance test (IGT), impaired glucose fasting (IFT), or diagnosis of type 2 diabetes mellitus are risk factors.[17]

Those overweight and obese individuals who manage to elude metabolic syndrome are not necessarily traveling along a safer health trajectory. Persons with excess body fat may develop a variety of comorbidities. There is a positive correlation between BMI and expression of gastroesophageal reflux disease (GERD) symptoms. GERD is a condition in which the lower esophageal sphincter allows stomach acid to renter the esophagus. It is characterized by regurgitation of stomach acid, sometimes referred to as "heartburn". Among those with GERD, additional weight gain can increase frequency and severity of symptoms, while a decrease in BMI can diminish GERD symptoms.[18,19]

Obstructive sleep apnea (OSA) is another chronic disease strongly correlated with obesity. OSA is characterized by obstruction of the upper respiratory tract. Increased adipose tissue compresses the soft tissue in the pharynx. This in turn leads to hypoventilation and decreased oxygen in the blood. OSA can increase a person's risk of developing hypertension, type 2 diabetes, and CVD.[20,21]

While a positive relationship between obesity and OSA seems likely, research is yet unable to describe the specific manner in which excessive bodyweight results in OSA. One explanation is that excess fatty deposits around the upper respiratory tract cause physical changes to the airway. Obesity may promote an imbalance in respiratory drive verses load, and may result in hypoxemia.[20]

OSA is thought to affect approximately 12 million Americans. Increased fat deposits in the neck and abdominal regions may be correlated with higher incidence of OSA.[20] Early diagnosis can be difficult because obese subjects with OSA may initially be asymptomatic.[20] As obesity increases, OSA symptoms become more severe, making diagnosis easier by health clinicians.[20,21]

Some cancers have been directly linked to an elevated BMI.[1,22] The American Cancer Society began a prospective cohort study of over 1 million subjects in 1982. Results published two decades later found extreme obesity (BMI > 40) was correlated with a 50 percent greater incidence of all cancer-related deaths. Elevated BMI increased a subject's risk of many types of cancers including those of the colon and rectum, esophagus, gallbladder, kidney, liver, and pancreas.[22]

Even when overweight persons manage to avoid chronic disease, increased adiposity may make them more predisposed to developing issues with mobility.[1] Carrying more body weight may cause muscle and tendon strain, bone stress, and in some cases osteoarthritis.[1,23] For instance, many studies have reported a positive association between obesity and incidences of radiographic osteoarthritis (ROA) of the knee. However, the relationship is less clear in the case of overweight and ROA.[24]

In the absence of any disease or physical disability, an overweight person may still face a stigma associated with his or her condition. This can lead to depression and other psychological issues. A growing body of evidence suggests those who manage to lose weight will eventually gain it back. More importantly, this pattern known as "yo-yo dieting" may be metabolically unhealthy, especially when the cycle is repeated. Weight loss causes physiological changes as the body attempts to maintain homeostasis; a return

to its "normal" weight. Hormone levels change as the body adjusts to its new

physiology. Some researchers believe attempting weight loss for better health is too high

a price to pay. They call into question the ethics of pushing overweight and obese

individuals toward a goal that is, more often than not, unsustainable.[25]

Weight Loss

Throughout the years a myriad of diets have emerged in attempt to solve

America's weight puzzle. From passing fads to science-based frameworks, there is no

shortage of diets to assist individuals with losing weight. A search of "diet" books at

Amazon.com brought back over 11,000 titles related to weight loss (September 2014).[2]

Obviously, science cannot hope to assess each division of such a staggering volume but

some diets have been studied in detail. Atkins and Ornish are two such popular

mainstream diets. They present an interesting contrast in that Atkins eschews

carbohydrate consumption while Ornish seeks to limit fat intake.[5,26,27]

The Atkins diet limits carbohydrates in favor of proteins and fats. Supporters

claim this high protein, high fat diet has advantages.[26] It is a ketogenic way of eating.

When the body is starved of carbohydrates, free blood glucose drops and alternative

energy sources must be found. Glycogen stores in liver and muscle are quickly depleted.

If glucose is not reintroduced into circulation the body begins to produce ketone bodies.

Ketosis is an alternate energy-producing pathway that utilizes fatty acids and ketogenic

amino acids. It is less efficient than breaking down glucose. Since the Atkins diet is low

in carbohydrate but high in fat and protein, it can easily place the body into a state of

ketosis.[28] This type of diet may have clinical uses in treating epilepsy and other inborn

errors of metabolism but its efficacy for long-term weight loss in healthy adults has been called into question.[5,28,29] Another potential drawback of the Atkins diet is the high intakes of fat and protein make it nearly impossible for a strict vegetarianism to follow. It might be possible to for a pesco-vegetarian or ovo-vegetarian to follow a modified Atkins diet.[26]

By contrast, the Ornish program of eating advocates low fat and low cholesterol intakes. Saturated fats are to be especially avoided. These criteria essentially exclude most, if not all, meat from a person's diet. To some extent, this makes Ornish a vegetarian regimen. Consuming egg whites and nonfat dairy is perfectly acceptable. Most energy in this diet comes from carbohydrates. According to Ornish, a typical American diet may contain a 30:25:45 ratio of carbohydrate, protein and fat. The suggested Ornish ratio is 70:20:10. Complex carbohydrates are recommended, in part due to their high fiber content. The low protein content of the diet is addressed by paying special attention to mixing complimentary varieties of protein sources, such as eating beans with rice. This helps achieve complete protein intake, thereby ensuring the body is able to metabolize sufficient amounts of amino acids, enzymes and other building blocks needed for normal function.[27]

Most sources of fats and oils including meats, nuts, chocolate, and avocados are disallowed under the Ornish system. Unsaturated fat is permitted in small amounts such as the use of cooking oil. Oils containing omega-3 essential fatty acids can also be used. Interestingly, the traditional Ornish diet does not place a specific limit on calories. Supporters tout the flexibility this diet provides its followers in planning meals and

addressing daily schedule constraints. The diet has also been shown to lower cholesterol and reverse the effects of atherosclerosis.[27]

For purposes of a comparison, the Atkins and Ornish frameworks might be placed on the consumer or "fad" side of a diet spectrum. They carry the names of the individual medical doctors by whom they were created.[26,27] The two other eating plans previously mentioned, Food Lists for Diabetes and MyPlate, would then fall on the "scientific" side the continuum. These evidence-based frameworks were developed by multidisciplinary teams of researchers at government and private agencies. MyPlate was developed by the United States Department of Agriculture (USDA). The Food Lists for Diabetes was developed by the American Diabetes Association (ADA) and the Academy of Nutrition and Dietetics.[9,10] Note, this is not a scientific comparison but merely an illustration of the disparate dieting strategies for controlling weight. All four have been shown to be successful in clinical weight loss studies. Following any may help a subject to decrease caloric intake, lower LDL cholesterol, and increase HDL cholesterol.[5,6]

The diet comparisons were a useful exercise to narrow focus of the current investigation and assisted with choosing which app technologies this study would evaluate. Food Lists for Diabetes and MyPlate are maintained by broad agencies with large amounts of stakeholders. Much research exists related to these evidenced-based frameworks. Their popularity in research provides a degree of legitimacy. The two frameworks are also built around a concept of food categories or groups. Each provides a simple method for choosing foods, calculating intakes, and recording progress.[7-9,12,30] These similarities make the two eating plans well-matched for purposes of comparing

related smartphone apps. With these comparative qualities in mind, the Food Lists for Diabetes and MyPlate were chosen as the focal diets for this study.

To better appreciate the role of MyPlate in the modern American diet and understand how the policy makers and nutrition professionals arrived at MyPlate, it is useful to review the history of this eating framework. The U.S. government's earliest attempts at codifying dietary advice date back to the late nineteenth century. The USDA first published dietary guidelines in the *Farmer's Bulletin* in 1894. Written by W.O. Atwater, the prescient manuscript was somewhat sparse because it predated the discovery of essential vitamins and minerals. What it did contain were intake recommendations of carbohydrates, proteins, fats, and "mineral matter" (ash). The recommendations only accounted for adult males but Atwater's work laid the scientific underpinnings for recognizing that food affects health.[31]

Almost 20 years later, the USDA created its first true dietary framework: *Food for Young Children*. Published in 1916, this pamphlet described five food groups: cereals, fruits and vegetables, meats and milk, fats and fatty foods, and sugar and sugary foods. This was quickly followed in 1917 with *How to Select Foods*. This manual contained the same five food groups but was geared toward the remainder of the population. It provided recommendations to households as to which types of foods should be consumed on a weekly basis in order to achieve "protective" benefits. Both guides were used well into the early 1930's. In 1933 the USDA added a "buying guide" to help shoppers select foods that would fulfill their household's weekly nutritional needs.[31]

The first Recommended Daily Allowances (RDAs) were published in 1941. They included six essential vitamins: A and D, ascorbic acid (vitamin C), niacin, riboflavin, and thiamin. Protein, calcium, iron, and calories were also included. Around this same time the USDA also created the Basic Seven food guide which was published as insert in the *National Wartime Food Guide*. The intent of this guide was to promote eating foods that would provide consumers with the RDAs. The initial guide did not contain suggested servings sizes but it was reworked in 1946 to show general quantities of servings from each food group. Unfortunately, the revision did not contain specifics about serving sizes.[31]

In 1956, Basic Seven was replaced by the Basic Four. The new guide emphasized eating sufficient amounts of foods from four groups: fruits, vegetables, meats, and milk. These recommendations remained in place until the 1970's. Over these two decades, research began to show a correlation between poor dietary habits and increased health risks such as heart disease and stroke. It is interesting to note that up until this time all of the U.S. government's guidance had been focused on getting people to eat enough, as opposed to eating only enough. The distinction may appear minor but was likely unintuitive for typical consumers. This may explain why, during this time period, some Americans were overeating.[31]

Thus, it was that during the 1970s the USDA pivoted from a message of consuming plenty of food to a message of message of moderation; a directive to avoid eating too much. The new goals were finally codified with the publication of *Food* in 1979. This report included a new food guide named Hassle-Free Daily Food Guide (also known as the Hassle-Free Guide to a Better Diet), which was an updated version of the

Basic Four food guide. However, unlike the Basic Four, the Hassle-Free Daily Food

Guide included fats, sugars, and alcohol. The overarching message of the new guide was

that eating in moderation could lower one's risk of disease. Americans were encouraged

to regulate their intakes of calories, fat, salt, and sugar. Around this same time, in 1980

the USDA issued the first version of *Dietary Guidelines for Americans*. Consumers were

encouraged to eat a variety of foods, and to limit saturated fat, cholesterol and sodium.

Interestingly, these guides did not specify quantities. Still, the message was clearly

moving beyond the "foundational diet" of past decades to a more holistic way of eating in

which food choices were made based on meeting nutrient needs and lowering risk of

diseases associated with excess dietary intake.[9,31]

The USDA's eating recommendations underwent much iteration from the 1940s

through the 1980s. Most were accompanied by some form of visual schema (typically a

circle shape) in an attempt to make the advice easier for consumers to understand and

adopt.[9] *A Pattern for Daily Food Choices* was no exception. Introduced in 1984, this

guide depicted food choices as a wheel with six main sections: fruits; vegetables; fish,

meat, poultry and fats; dairy; grains; alcohol. This guide emphasized adequate intake and

eating in moderation. Three tiers of daily caloric intakes were provided. The intake

amounts and grouping of foods paved the way for the subsequent *Food Guide

Pyramid*.[9,31]

By 1980s the rate at which the USDA had begun updating and releasing food

guidance on a much more frequent schedule. Throughout these releases, into the early

1990s, *A Pattern for Daily Food Choices* remained a core set of dietary principles.

However, despite the frequency of publications, *A Pattern for Daily Food Choices* never

achieved wide-spread public consciousness. Finally, in 1992, the USDA dropped its often-used wheel-shaped designs in favor of a pyramid figure. The Food Guide Pyramid was a system of eating that emphasized grains, fruits, vegetables, meats and dairy, with only parsimonious amounts of fats, oils and sweets. This guide was a step in the right direction but it had several shortcomings. The graphical design of the Pyramid was a tiered schema. It assigned grains the largest portion of the diagram and placed them at them bottom. Fruits and vegetables occupied equal halves of the tier above grains; dairy and meats were next. Fats, oils and sweets provided the tip of the Pyramid.[9,31,32]

The Food Guide Pyramid was widely adopted by health and nutrition professionals, educators, and the food industry. It received widespread media coverage. The Pyramid was seen on TV, posters, and food labeling and packaging; the latter due partly to the Nutrition Labeling and Education Act of 1990 (NLEA). Many textbooks have devoted sections to discussing the Pyramid. The Pyramid became the most widely recognized nutrition icon of its time. Three years after its inception, two thirds of adults reported being familiar with the Pyramid. The tool distinguished itself from predecessors. It was a tangible, proportional graphic that depicted the importance of a plant-based diet. More importantly, its message was rooted in evidenced based research.[9,31,32]

However, the pyramid was not without its detractors. The Pyramid's described ratio of meats was smaller than those of vegetables, fruits, and grains. This caused controversy and political backlash. The meat industry lobby had managed to block passage of an earlier version of the pyramid, the 1991 Eating Right Pyramid.[32] Some nutrition professionals also resisted the new design. There were concerns that foods were

not sufficiently assigned to groups, and that serving sizes were not well-established. Furthermore, they argued that "good" foods were not sufficiently differentiated from "bad" foods.[33] The Pyramid did not make clear that some daily serving amounts were recommended upper limits (as with the case of meats), not suggested intakes. The layout failed to emphasize the importance of fruits and vegetables, as well as overall dietary variety. The redesigned shape – pyramid vs. circle – did not take the opportunity to delineate good fats from bad. By grouping all fats at the top, one might assume all were to be avoided. For some health and industry professionals, these issues reduced the tool's usefulness when planning healthy meals. Suffice it to say, much controversy surrounded the creation and implementation of the Food Guide Pyramid but it remains one of America's most recognized nutritional emblems.[9,31-33]

In 2005, in conjunction with *Dietary Guidelines for Americans, 2005*, the USDA released an improved pyramid version named MyPyramid. This guide emphasized five food groups: grains, vegetables, fruits, milk, meat and beans. The Pyramid graphic was redrawn to better emphasize healthy ratios of the food groups. Each group was color-coded and occupied a vertical sector of the Pyramid, some being wider at the bottom than others. Fats, sugars and salt were relegated to the noticeably thinnest segment. Another improvement over the 1992 design was an emphasis on physical activity. The MyPyramid graphic depicted a person climbing stairs up the side of the pyramid.[34] Although the Pyramid system had been improved, its main objective was unchanged. The Pyramid told persons what to eat, and how much to eat. It was an instructional tool.[8]

The success of the food pyramids was difficult to substantiate. Some of America's eating behaviors were not improving. For example, between 1970 and 1994

the country's consumption of saturated fat and total fat from dairy remained unchanged.[31]

Another confounding factor is national programs often need years, if not decades, to show determinate impact.[8] Meanwhile, in the period from 1992 to 2010, body mass (BMI) continued to increase, as measured on a worldwide basis.[1,35,36] This seeming incongruity may confound judgments made about the effectiveness of a large public program. Furthermore, when positive nationwide results are achieved they can appear small in comparison to those seen in controlled research environments.[37] This is unfortunate because at a national level public attitudes toward food need not change dramatically to have significant effects. If the average American dinned out one less day per month it may not produce headlines but that difference may reflect a measurable shift in the behaviors of the populace.[8] It is also possible that some public health behavior changes occur through related avenues, not initial government intervention. A theoretical example might be the increased media saturation of weight loss issues and growing societal favoritism toward thinness (and stigma of overweight). These forces have certainly affected the eating behaviors of many Americans.[8,37]

After more than a century of dietary framework iterations, MyPlate is the most recent USDA food pattern. Released in 2011, it was based on the *Dietary Guidelines for Americans, 2010* (DGA). MyPlate debuted a new plate graphic that includes suggested food group proportions. One half of the plate contains vegetables and fruits. Grains and proteins occupy the other half, with the former having a slightly larger zone. Dairy is symbolized by a glass of milk beside the plate. In addition to the graphical guidance, the framework is accompanied by healthy eating tips gleaned from DGA. These include recommendations to consume whole grains, drink one percent milk, and eat proteins from

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a variety of sources including meat, seafood and beans. As with MyPyramid, MyPlate also includes a physical activity component, though it is not represented in the new graphic.[7]

Unlike MyPlate, which stemmed from efforts to improve the diets of all Americans, the Food Lists for Diabetes diet was initially conceived to assist diabetics. It was engineered to aid in the planning and tracking of daily carbohydrate intakes to control blood glucose. The diet recognizes all foods contain one or more types of macronutrients: carbohydrates, protein, and fat. Foods are categorized by their primary macronutrient content.[10,11]

The Food Lists classification scheme allows foods to be more easily comparable due to their similar amounts of macronutrients and calories; food choices become "exchangeable". For example, a slice of bread may contain some protein and fat, but most of its calories come from carbohydrates. The carbohydrate group contains the subcategories of starch, fruit, milk, sweets, and non-starchy vegetables. A serving size has been determined for each food group or subcategory. A serving contains a specific amount of carbohydrate, protein, fat, and calories. For example, one serving of fruit has 15 grams of carbohydrate, zero protein, zero fat, and 60 calories.[10-12]

Food Lists recommends a carbohydrate ratio of 50% to 55% of total calories, placing it between the guidelines of Atkins and Ornish.[10,26,27] Food Lists goes one step further and highlights foods containing more than three grams of fiber. Conversely, some foods garner special warnings. Foods containing more than 480 milligrams of sodium (or combination foods containing over 600 mg) are flagged. Likewise, those high in fat must be counted as one extra fat exchange.[10,12]

Food Lists has been a highly successful tool in the management of diabetes. It is frequently used by diabetes educators and has led to the authoring of numerous books and menu plans.[10] Although the Food Lists was first developed for people with diabetes, it has been used successfully in weight loss studies.[6]

Diet Quality

In a rudimentary way, the well-known adage "one is what one eats" quickly summarizes the idea of diet quality. A true definition is much broader in scope. The term diet quality includes concepts such as nutrient values, meal portions, eating habits, food variety, and food group balance. Diet quality is affected by a person's environment, socioeconomic status, education level, and personal behaviors and attitudes toward food.[7,14,38] A high quality diet may offer protection against CVD, hypertension, type 2 diabetes, and some forms of cancer.[1,7,39,40] Persons with health dietary behaviors may also reduce their risks of contracting foodborne illnesses.[7]

At its core, weight loss appears to be a matter of simple arithmetic. Consume less energy than expended and weight loss should occur. However, this equation does not address the nutritional value of what is eaten. If calories are sufficiently reduced, a subject could lose weight eating ice cream and potato chips. Such a diet would also cause malnourishment. This is perhaps a puerile example but it underlies the importance of a nutritious diet in any weight loss routine. Research has shown that persons who assemble meals based on MyPlate and the DGA tend to make healthier food choices.[41] The Food Lists for Diabetes is also an evidenced-based method for achieving weight loss.[13]

The Wharton et al. study illustrated the benefit of using the Food Lists diet to simultaneously achieve weight loss and diet quality. In that study the "Lose It!" (LI) app group was allowed to consume any food while the Food Lists group was directed to follow the diet's guidelines. Both groups lost weight. However, only the Food Lists group showed an improvement in diet quality. The diet quality of the LI group actually declined. In essence the LI group was only counting calories.[6] The problem with most existing weight loss apps is they do not include a diet quality component. The Food Lists and MyPlate apps have diet quality built in because they are based scientifically sound frameworks for healthful eating.[8,10]

Diet quality can be measured in many ways. Food diaries are popular with small studies and short time frames. Larger studies and retrospective research often use food frequency questionnaires. Indexes and surveys are also popular tools for quantifying quality of intake. The Healthy Eating Index (HEI) is a complex instrument that measures how well a person's intake meets United States federal guidelines, and was used in the Wharton et al. study.[6,42,43] The HEI is comprised of twelve dietary components: nine "adequacy" and 3 "moderation". Adequacy components include total fruits, total fruit, total vegetables, whole grains, dairy, and seafood and plant proteins. Refined grains, sodium, and empty calories make up the moderation components. The HEI includes guidelines for scoring intakes of each component. Scores are determined by segregating intakes into food groups in accordance with the USDA's Food Patterns and 2010 DGA. A higher overall score equates to a healthier diet.[43]

By comparison, the Rapid Eating and Activity Assessment Participants Short Version (REAP-S) is an extremely simple, validated tool consisting of a mere 16

questions. The REAP-S has been shown to be accurate at gauging intakes of fruit, vegetables, dairy, and fats. It can also approximate levels of intakes for cholesterol, fiber and sugar. One possible shortcoming of the REAP-S is its inability to approximate a subject's meat intake.[14]

Adherence

It is not enough to eat healthfully on occasion, nor is it sufficient to select only low-fat foods if such foods are not consumed in moderation. Successful weight loss and weight maintenance requires rigorous and constant adherence to caloric and nutrient goals. Of course, for most persons these are difficult goals indeed.[25] The 11,000 diet books available at Amazon attest to America's tumultuous relationship with food and bodyweight.[2] Surely the purchasers of these books have the best intentions. Many readers probably lose weight. Unfortunately, most are likely to gain it back. Sustained weight loss is an elusive goal for most overweight or obese individuals. History has shown that no matter how well guidelines may be constructed, their effects can only reach so far. A diet is only sustained by personal effort. As noted previously, the Food Guide Pyramid, MyPlate, and Food Lists have the potential to be effective eating frameworks.[8,12,44] Following any of these diets with caloric restrictions may facilitate weight loss and weight maintenance.[5-7,13,45] The success of any of these plans relies on the individual's unrelenting commitment. Adherence is a key component of sustained weight loss.[5,25,45]

In fact, weight loss is dependent less on the diet specifics than on the follower's devotion to its guidelines. At face value, it may appear weight loss simply requires

consuming fewer calories than energy expended. However, the second law of thermodynamics suggests appearances are not always what they seem; not all calories are created equally.[46] Research has shown that people can lose weight following "fad" diets. The upside to following a mainstream diet plan might be its social acceptance and connectedness.[5,27,47,48] For example, Weight Watchers staffs local offices in many large cities where the company provides dieters with resources and facilitates group meetings. A Google search of "Weight Watchers" revealed three offices in Phoenix, AZ (September 2014). This interaction may help dieters build peer support for their weight goals.[5,27,47,48]

On the other hand, diet popularity is not a panacea. The more unique the fad, the less likely a person is to maintain it.[5] The Atkins and Ornish diets may test the patience of a dieter's palate.[26,27] Many dieters do not possess the willpower to live without carbs for weeks or months at a time. The same may also be true for a diet that heavily restricts fat intake, such as the Ornish eating plan. Attempting an unbalanced method of eating does not appear to lend itself to a high level of long-term adherence.[25] In a study by Dansinger et al. the Atkins and Ornish diet intervention groups experienced one-year attrition of 47% and 50% respectively. By comparison, total attrition in the study's Weight Watchers and Zone Diet groups was only 35%.[5]

Of course, health professionals would be correct to argue the healthfulness of a diet should be considered. Evidence-based diets are perhaps more conducive to long-term adherence.[6] What is more, these dieters reap benefits beyond body mass reduction. Following balanced, low fat, low sodium diets such as those encouraged by Food Lists

and MyPlate can lower a person's risk at heart disease, hypertension, and some cancers.[5,45,48]

Given the benefits of adherence, it is logical to ask why it ebbs over time. Even persons with the best intentions tend to decrease dietary adherence as weeks or months pass. The subjects with the longest staying power will tend to lose the most weight. Yet, even when rewarded with initial success, most people are destined to regain any lost weight.[5,25,48] Life goes back to "normal" once a participant leaves the structured environment of a research investigation. Participants face many hurdles sticking with their new routine. After the study ends, diets can be complicated to follow, tracking progress can be difficult, and social support may taper off.[49]

Another possible explanation is a person's feelings toward a behavior intervention may change over time. There are costs involved with any behavior change. Behavior change takes effort. A person must expend mental or physical energy. New patterns and practices may require extra time commitments. There are, hopefully, perceived benefits that outweigh the costs. When undertaking a change the behavior is new and different from the norm. This may provide a sense of adventure. There may be excitement when noticing initial improvements. The person is more likely to continue a diet as long as its perceived benefits (weight loss, health improvements, etc.) outweigh the investments (food changes, time, money, etc.). However, this delicate balance often shifts when dieters enter the weight maintenance stage. The novelty has worn off. Frequent, measurable improvements in weight loss have stopped. Now the cost/benefit equation suddenly becomes much more difficult to justify. Willpower subsides and dieters relapse.[25,48]

If a diet's perceived benefits decrease or stop altogether then perhaps the cost side of the equation might be reduced. For example, Weight Watchers uses group support which can ease an individual's urge to cheat.[50] Frameworks such as Food lists and MyPlate allow many more food choices (in moderation) than those of Atkins and Ornish. The increased selection can help reduce monotony and increase meal palatability.[5,48] Along these same lines, providing dieters with pre-planned meals may ease the burden of compliance. Weight Watchers uses a system of points similar to Food Lists. Points or exchanges reduce the complexity of food selection by abstracting calories, carbohydrates, fats, and proteins. Foods are more easily compared and evaluated.[50] Once a dieter learns the initial rules under these systems, building a meal becomes more "plug-and-play".[5,10-12] Kendall et al. compared use of a "diet guide" (nutrient based regimen) with the Food Lists diet. Subjects initially spent less time per day working with exchanges than with the diet guide (16 minutes verses 25 minutes). Although this gap narrowed over time, it illustrates the advantage of removing complexity from meal planning. In addition, group participation was shown to be important in helping the nutrient-based group learn their regimen.[30]

Santosa et al. illustrates another example of how lowering cost of participation can increase adherence and overall weight loss. The Food Lists diet was combined with exercise, motivational counseling, and group support. Forty out of 42 subjects completed the 20-week study. The mean weight loss at 20 weeks was 11.7 ± 2.5 kg. Four interventions were used: exercise, counseling, motivational techniques, and a diet based on Food Lists. The exercise and counseling components required minimal staff interaction. All interventions were mostly self-directed. This suggests that use of

motivational techniques and Food Lists guidelines may have been responsible for improving diet adherence.[13]

Adding variation to a diet routine may also increase long-term adherence by reducing boredom. Most persons who diet will succeed in losing some amount of weight; at least their initial efforts will be positive. Over time boredom may set in. Research shows that most if not all weight is regained, typically within a few years.[25,48,51,52] A novel method of mixed behavior interventions holds promise of overcoming diet ennui.[51,52] This could entail frequent (weekly or monthly) changes to education, exercise, journaling, and other interventions related to adhering to a meal plan. Breaks from the above interventions might even further variety. For example, a subject may attend a food class and keep a journal during the first month, start a new exercise routine in the fourth to sixth weeks, and then have no counselor directives between weeks six and eight.[51,52]

With the advent of personal technology devices, self-monitoring has become an increasing popular activity. Perhaps technology holds promise of improving diet adherence. What if a dieter could keep an intervention easily at his or her fingertips? Handheld, personal devices such as smartphones are constant companions to most Americans. Recall, the Wharton et al. study did not reveal app usage to be any better at weight loss than traditional journal entry. However, the study's app group did show a statistically significant improvement in diet adherence.[6]

A vital key to extended weight loss success is how well one adheres to his or her chosen method. This is where mobile devices and smartphone apps are holding promise of improvements over traditional, paper-based food logs. In terms of health

interventions, people prefer to engage with personal technology. Furthermore, they will engage for a longer period of time, making it more likely to continue weight loss or weight maintenance intervention.[49]

Mobile devices such as PDAs and smartphones allow dieters to "cut the cord" with traditional in-person nutrition counselors. This in turn could lower costs. One of the first studies to demonstrate this effect was Spring et al. 2013. All subjects attended regular weight counseling. The intervention group was additionally given a PDA-based weight loss app for the duration of the 12 month study. The intervention group lost 3.9 kg more than the counseling only group.[49] Similarly, Burke et al. 2011 used PDA interventions to increase weight loss and improve diet adherence. Sixty three percent of subjects using a PDA-based, weight-loss app shed $\geq 5\%$ of their body weight. This was a significant improvement over the 46% success rate seen in the paper-only group. Perhaps more importantly, adherence to self-monitoring (weekly app/log entries) was significantly greater ($P < 0.01$) for the PDA group (2.7) versus the paper group (2.2).[53] The advantages of self-monitoring with mobile devices was also seen in a study by Wang et al. 2012. The one year study employed three types of self-monitoring: paper journal, PDA, and PDA plus feedback message (PDA+FB). All three groups lost an equivalent amount of weight ($P > 0.05$). However, adherence to weekly self-monitoring in the PDA (58 weeks) and PDA+FB (72 weeks) groups was much greater than in the paper journal group (34 weeks) ($P < 0.001$).[54]

Technology

Society is undergoing a rapid saturation of personal devices (smartphones and tablets) and personalized services (social media and apps). This technological evolvement brings with it the potential to improve healthcare delivery. However, there is much room for improvement. Progressively more consumers are accessing the Internet from mobile devices instead of desktop PCs.[3] This has led to a reprioritizing of software development. There has been a shift from traditional PC-based software to mobile-based software. Websites are being optimized to run on the smaller screens of smartphones and tablets. This is not technological whim. An increasing amount of Internet traffic is originating from mobile devices.[55]

"Responsive design" describes a website that is engineered to render a pleasant user experience on a variety of devices and screen sizes. A responsive website works as well on a desktop PC as it does for a smartphone or tablet. Traditional flat, widescreen computer monitors have no trouble displaying webpages of any width or depth. When a user does encounter a particularly wide or deep webpage it is a simple matter of using the mouse or keyboard to navigate to other parts of the screen.[55]

However, on the smaller screens of tablets and phones the same oversized webpage can prove disconcerting. Mobile devices put screen real estate at a premium; every pixel counts. Each website must strike a balance between providing as much of the PC-based content as possible, while maintaining a high degree of accessibility for mobile users. The best responsive websites are almost indistinguishable from native phone apps.[55]

Since the inception of the iPhone in 2007 the fast pace of smartphone adoption has given rise to a rapid expansion of native mobile apps and responsive web apps.[3,55] At the same time, obesity rates in the United States appear to be leveling off. Americans' waistlines may no longer be growing but during this same time frame their appetites for smartphones have been insatiable.[35,56,57]

Although thousands of weight loss apps exist, the effectiveness of most has never been tested. Perhaps the closest science has come to evaluating a truly portable software platform is through examinations of weight loss software running on personal digital assistants (PDA).[53,58] Unfortunately, in these studies the PDAs were temporary, loaned devices as opposed to peripherals fully integrated into the subjects' lifestyles such as smartphones. The PDA studies were in some ways obsolete even before their publications. The first smartphone-specific weight loss app study was finally published in September 2014.[6] Given the pervasiveness of smartphone use, the paucity of literature regarding their utility for weight loss is somewhat surprising.

As previously mentioned, adherence is critical to any successful weight loss program. The method used need not be fancy. Pen and paper work equally as well as smartphones.[6] However, when given a choice, the majority of persons attempting weight loss will prefer a phone app over traditional written food logs.[6,49]

The FoodMindr Food Lists and MyPlate apps were developed to leverage a smartphone owner's preference to use apps for routine health tracking. The apps seek to be a convenient technology one can use to manage a diet. The MyPlate app mimics the MyPlate graphical guide. The Food Lists app works much the same as a paper Food

Lists for Diabetes worksheet. It displays the same inputs as shown in the American Diabetes Association's *Choose Your Foods* booklet.[12]

The puzzle of weight loss and weigh maintenance has stymied researchers for many decades. Many strategies have evolved over time in an attempt to address these issues. Current weight loss strategies are still incomplete. Even when weight is lost, it is often eventually regained. The best-intentioned, most nutritious diets are of little consolation if weight loss cannot be sustained. Adherence plays a pivotal role in truly long-term success.[25] Diet quality is another piece of the puzzle. After all, a person may lose weight eating candy bars and potato chips. No weight loss intervention should come with a cost of lower diet quality. The Food Lists and MyPlate eating plans have been shown to facilitate weight loss and provide nutritious diets.[10,11,13] Research has revealed that a technology based intervention can be more effective when it is considered accessible by the subject.[6] Having the Food Lists app readily available 24-hours-per-day might be the added catalyst dieters need. An app that could facilitate increases in weight loss, diet adherence and diet quality would be an intervention trifecta.

CHAPTER 3

METHODS

Participants and Study Design

This study recruited healthy, weight stable adults from the Arizona State University campus population. All subjects were between the ages of 18 and 65. Potential subjects were solicited between December 15, 2014 and January 15, 2015 using ASU email distribution lists, campus flyers, campus class presentations, and word-of-mouth. Interested parties were referred to a SurveyMonkey questionnaire which asked initial screening questions and collected contact information.

Sample size was determined by reviewing two similar-sized, technology-based weight loss studies (Table 1).[6,59] In addition, one study of diet quality data (n = 34) from ASU's labs was referenced (Table 2). Sample size calculations were based on parallel study design and used a significance level of 0.5, and a power of 0.8.

Spring et al. used PDAs to track dietary intakes of overweight and obese adults aged 18 to 65 years old (n = 34). The study ran for 12 months and the PDA group's mean weight loss was 9.7 ± 2 lb (9.9 lb at the third month). Wharton et al. followed healthy adults aged 18 to 65 (n per group range 13 to 19) for eight weeks using the "Lose It!" iPhone app. This group experienced weight loss of 3.5 ± 1.0 lb.[6] Both studies analyzed weight loss and took other anthropometric measurements. The average weight loss in these two studies was 6.6 ± 2.8 lb. The time frame of this study was be eight weeks. Thus, substantial weight loss (or gain) was not anticipated. It was estimated that Food Lists subjects would achieve a final mean weight loss ≥ 4.0 lb.

The calculated sample sizes based on Spring et al. and Wharton et al. were three and 19 respectively. The calculated sizes are quite different and may be explained by the greater weight loss shown by Spring et al. This study reported almost three times more weight loss than Wharton et al., but had a much smaller relative standard deviation. Thus, a smaller computed sample size was to be expected from the Spring et al data. The averaged calculated sample size was 11 subjects. ASU's diet quality data had a mean score of 4 ± 3.1 and the calculated sample size was 22 participants. With these comparisons in mind, the FoodMindr study sought to recruit 30 – 40 subjects. This would provide 15 – 20 subjects per group and allow for attrition and exclusions.

Table 1. Sample size calculations based on weight loss variable

Author	Year	Weight (lb)	SD (lb)	n per Group	Calc n per Group	Age Range	Subject State	Test
Spring et al.	2013	9.7	2	34	3	28 - 86	BMI 25 - 40; < 181 kg	Anthropometric measurements
Wharton et al.	2014	3.5	3.6	12	19	18 - 65	BMI 25 - 40; weight stable	Bal beam scale; waist circum.
Average		6.6	2.8	23	11	21 - 67		

Table 2. Sample size calculations based on diet quality variable (REAP-S)

Author	Year	Mean	SD	n per Group	Calc n per Group	Age Range	Subject State	Test
Bliss	2014	4	3.1	34	22	n/a	Healthy adults	REAP-S

Inclusion criteria were weight stable, healthy men and women, ages 18 – 65, who were non-competing athletes. Subject BMI was required to be ≥ 24. A maximum BMI limit was not enforced. Persons with type 2 diabetes and controlled blood glucose were accepted. This was verified during visit #1 via the administered health history

questionnaire and subject interview. Subjects taking prescription medications were evaluated on a case-by-case basis. The subject must have been taking the medication for at least three months without adverse health effects. Participants were required to be owners/users of a web-enabled smartphone capable of running the FoodMindr app. Exclusion criteria were cancers, and other substantial health issues. Persons revealing alcohol abuse or other illicit drug use were excluded. All types of eating disorders were excluded. Females were asked about regular menstrual cycles and if they planning to become pregnant during the study. Those with irregular cycles or pregnancy plans were excluded.

For this parallel study the qualified participant pool was stratified by gender, age, and BMI and randomized into either the Food Lists or MyPlate group by coin toss. Subjects were scheduled to meet with ASU researchers for visit 1 (week 1) lasting ~30 minutes. First, inclusion and exclusion criteria were reviewed. Subjects were given a general overview of the study and estimated time commitments. At that time the subjects were asked to sign the consent form (Appendix B) and complete a health history questionnaire. Subjects were given a Qualtrics survey (qualtrics.com) which consisted of selected questions from the REAP-S survey and the What We Eat in America 1994 – 1996 Diet and Health Knowledge Questionnaire.

Subjects removed their shoes and socks for a weight reading on a calibrated Tanita scale (Tanita Corporation, Tokyo, Japan), and height measurement on a stadiometer. Waist circumference was measured at the navel (above clothing) using a Gulick tape measure (FitnessMart, Gays Mills, WI). BMI was calculated. For subjects in the Food Lists group, the Mifflin-St. Jeor equation was used to compute basal metabolic

rate, which was multiplied by an activity factor (1.2) to determine a personalized caloric intake. The subject was then assigned to one of four caloric ranges (Appendix C). Per USDA MyPlate guidelines, subjects in the MyPlate group were assigned daily intake goals based on age and gender (Appendix C). During this initial visit app and diet training was conducted by a qualified research professional. Participants were provided with complimentary print handouts with tips for following their respective app. No further contact was initiated with subjects until the fourth week. A reminder email was sent to each subject at week four reminding the subject to record daily intakes. A second email was sent on week six to schedule the follow up visit.

The REAP-S survey evolved out of the Rapid Eating and Activity Assessment for Patients (REAP) tool developed by the Nutrition Academic Award Program. Studies validated the 31-question REAP to be an accurate tool for assessing an individual's dietary intake.[14,38] However, when counseling in a clinical setting time is often at a premium. The REAP-S contains only 16 questions. Most were taken directly from the REAP but several were rewritten. First year medical students at the Albert Einstein College of Medicine participated in a validation study of the questionnaire. To validate the REAP-S, the students were given the survey along with the highly-validated Block 1998 Food Frequency Questionnaire. Statistical analysis showed high correlations between the two tests. The resulting product gives practitioners fast method for assessing an individual's nutritional intake and for screening certain risk factors such as pre-diabetes. The survey can be administered using booklets with optical reader answer sheets, or on a computer.[14] During their first visit, subjects were given a modified

version of the REAP-S questionnaire containing nine of the original 13 Likert scale questions.

The What We Eat in America 1994 – 1996 Diet and Health Knowledge Questionnaire survey was conducted by the USDA to analyze eating behaviors of Americans. At ~20 printed pages, the survey is quite extensive. The FoodMindr study selected eight "category C" questions similar to REAP-S for inclusion in the Qualtrics survey.

After the initial visit, the subjects recorded their daily food intakes using their assigned intervention app over the course of eight weeks. For the MyPlate group, the process consisted of recording food group servings corresponding to the MyPlate graphic. For example, if a subject consumed one slice of toast and two cups of milk for breakfast this would entail tapping the MyPlate icon, entering a "1" in the Grains text box, a "2" in the "Dairy" text box, and clicking the "Save Changes" button. The subject would then be returned to the status page where progress meters would show their current status toward daily MyPlate goals. The subject could make updates any time throughout the day. Each evening (12:01 am) the app automatically archived the previous day's data and presented a new, empty log screen. The app and data were hosted in a data center (winhost.com) which allowed the subjects to enter updates any time throughout the following 24 hour period (Appendix D).

A similar workflow was used by the Food Lists Group. Quantities of food group servings were input into app. The only differences were the app included eight food categories and all except vegetables displayed intake limits. To enter the breakfast described above the subject would tap the Starch row and enter "1", tap the Milk row and

enter "2", and tap the "Save Changes" button. The subject was returned to the status screen where progress toward intake limits was shown. App hosting and data storage were identical to the MyPlate app(Appendix D).

The data entry steps were repeated daily for eight weeks (56 d). Both groups were permitted to contact an ASU researcher in case of meal plan questions or technical support issues. At the end of the study (week 8) the subjects returned to the ASU research lab for post assessments. The subjects removed their shoes and socks prior to being weighed on a calibrated Tanita scale. Height was not re-measured. A second Qualtrics survey was administered. The survey dietary questions were identical to the first visit and six questions regarding app usage experience were added. Participants were also given an exit survey. Participants were asked to provide opinions of the app used, comments about the study, and any additional feedback they desired to share. A $25.00 gift card was awarded during this visit. This was the second and final visit. No other direct subject involvement was required.

This study was approved by the Institutional Review Board at Arizona State University (Appendix A) prior to any recruitment of subjects and all participants provided written informed consent (Appendix B) at the initial visit.

Fig. 1: Flowchart of study progression and data collection

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┌─────────────────────────────────────────────────────────────┐
│    Email SurveyMonkey questionnaire link to ASU distribution │
└─────────────────────────────────────────────────────────────┘
                             │
                             ▼
        ┌─────────────────────────────────────────┐
        │       Survey respondents (n = 75 goal)   │
        └─────────────────────────────────────────┘
                             │
                             ▼
        ┌─────────────────────────────────────────┐
        │   Did not meet screening criteria (n = 25)│
        └─────────────────────────────────────────┘
                             │
                             ▼
        ┌─────────────────────────────────────────┐
        │  Stratify; randomize to Food Lists or MyPlate│
        └─────────────────────────────────────────┘
                     │               │
                     ▼               ▼
```

Week 1: (Visit #1) Inclusion (n = 37)
1. Consent form; HHQ
2. Qualtrics survey
3. Stadiometer height
4. Tanita weight and fat %
5. Waist circumference
6. Mifflin-St. Jeor calculation (Food Lists)
7. Diet and app training

Excluded
1. Opted out (n = 5)
2. Lost to follow up (n = 3)

Weeks 1 – 8: Both groups entered daily dietary intake into assigned app. Daily data uploads. One investigator contact via email at midpoint.

Week 8: (Visit #2) – Post-study data collection (n = 29)
1. Tanita weight and fat %
2. Waist circumference
3. Qualtrics survey
4. $25 gift card

Dependent Variables

The primary objective of this study was to examine the effect of using a Food Lists app to facilitate increased weight loss, improved diet quality, and greater diet adherence. All measurements, except height, were taken twice: once before the study began (week 1) and once after the study ended (week 8).

Diet adherence was measured in days of app usage. The primary investigator (CS) queried the FoodMindr database to count each user's food log entries. The total possible days of app usage was 56.

Diet quality was measured using selected questions from the Rapid Eating Assessment for Patients short version (REAP-S) questionnaire and the What We Eat in America 1994 – 1996 Diet and Health Knowledge Questionnaire. Only nine of the survey's 14 Likert scale questions were used during the first visit. This equated to a possible score range from 9 through 27. Answering "usually/often" was assigned three points, followed by "sometimes" with two points, and "rarely/never" as one point. Two questions regarding eating frequency and shopping habits were "yes" or "no" responses and were not counted in this study. The survey responses were coded in a manner that assigned higher scores to healthier responses. A higher total score indicated higher diet quality.[14,38]

Statistical Analysis

Results were expressed as the mean ± standard error (SE). Data were first tested for normality using Shapiro-Wilk test. If data were not normally distributed then nonparametric tests were used. Baseline data were analyzed using independent samples

t-tests, except for gender which was analyzed using a chi-squared test. Baseline and post-

test means were compared using repeated measures ANOVA. The relationship between

adherence and weight loss was examined using a Pearson correlation for all subjects and

Spearman correlation for group comparisons. $P < 0.05$ was considered significant when

assessing differences among variables. All data were analyzed using the Statistical

Package for Social Sciences (SPSS (PASW), version 22, IBM Corporation. Somers, NY).

CHAPTER 4

RESULTS

A survey (surveymonkey.com) was used to attract 280 prospects. Seventy four

met survey screening criteria and were invited via email to schedule the initial visit.

Thirty seven prospects did not reply to the invitation email or were lost to follow up

during this phase of the recruitment process. There other thirty seven subjects were

qualified for study inclusion and completed their first visit. Eight of these did not finish

the study (7 Food Lists and 1 MyPlate). The remaining twenty nine subjects recorded

daily food intake during an eight week period. There were no differences between

participants who completed the study (age, gender, height, BMI, REAP-S, DHKQ) and

those who did not. Group baseline values for age, gender, height, and weight did not

vary between groups (Table 3).

Repeated Measures and Correlations

A repeated measures ANOVA was used to analyze time and interaction for each

variable. As summarized in Table 4 and Figures 2, 4 - 6, there was no significant mean

difference in weight loss (P=0.113), diet quality (REAP-S P=0.053; DHKQ P=0.442), or

adherence (P=0.703) between groups. However, the Food Lists group lost some weight

and there was a significant mean difference in BMI between the Food Lists and MyPlate

groups (P=0.029; effect size = 0.145) (Table 4, Figure 3).

Adherence was measured in days of app usage over the eight week period and

was similar between groups (Food Lists = 73%; MyPlate = 70%). Using a Pearson

correlation for all 37 subjects, there was no significant association between adherence

and weight loss (r = -0.074; *P*=0.703) (Table 4, Figure 4). Due to the small sample size,

group-level associations were analyzed using a Spearman correlation. MyPlate showed

greater weight loss as adherence rose while Food Lists revealed weight gain. Still, the

association was not significant for Food Lists and MyPlate respectively (r = -0.204,

P=0.504; r = 0.124, *P*=0.649) (Table 4, Figure 5).

Quantitative and Qualitative Survey Data

Most participants found their respective app "enjoyable" or "very enjoyable"

(90%) and "easy" or "very easy" to use (93%).   The majority reported they were

"satisfied" or "very satisfied" with their overall app experience (93%) (Table 5). Several

MyPlate subjects felt the app was too basic. One participant commented "I think it is

good, but might be a bit too plain". The easy navigation was the most popular feature

(83%) (Table 6). No single feature or issue stood out as being consistently disliked

(Table 7). Still, 58% of participants did provide write-in dislikes. These comments

included the desire for more examples in the food guides, calls for a reminder function,

and inability to post-date log entries.

During the exit visit, subjects were given the opportunity to share any additional

feedback regarding their experiences with the Food Lists or MyPlate apps (Appendix E).

There were several recurrent themes. App ease of use was highlighted by four subjects.

One MyPlate subject commented "really liked how easy it was to pull up on my phone

and use it throughout the day". Four MyPlate subjects felt the app was too simple and

dissatisfaction about the app's lack of food group detail and missing intake limits. "I

think it was too general since it didn't track fats, alcohol, etc." wrote one of these

subjects. Another said "no indication if you were going overboard and eating too much…". Conversely, no Food Lists subject expressed these same concerns.

Five MyPlate subjects suggested their app should include some form of reminder feature to assist with adherence. One participant reflected "I think friendly emails or reminders to continue to log in would have helped". Greater diet awareness was a benefit shared by five subjects, both Food Lists and MyPlate. They felt their app helped to improve food habits and plan balanced meals. As one subject stated, using the app "…made me more mindful of the foods I was eating and how many extra servings I used to eat".

Of the seven subjects who did not complete the study, two were lost to follow up and five opted out. All subjects who opted out notified the lead investigator via email of their intent and justification for leaving the study (Appendix E). The general theme in these emails was a lack of adherence. "I did not use the phone app as often as I should have", read one of these emails. No opt out email mentioned any problems with using the app or difficulties in following the assigned diet.

A modified REAP-S score was obtained from using nine of the survey's Likert scale questions, for a possible high score of 27. Both groups mean scores showed slight improvement after eight weeks (P=0.053) (Table 4, Figure 5). Selected Likert scale questions from the We Eat in America 1994 – 1996 Diet and Health Knowledge Questionnaire also showed no significant mean change from baseline (Table 4, Figure 6).

Table 3. Baseline characteristics of study participants by app diet group[a]

	Food Lists	**MyPlate**	**Partial η^2**	*P*
Gender, m/f	3/10	4/12	NA[c]	0.904
Age, y	31.1 ± 2.7	28.3 ± 2.0	0.026	0.408
Height, in	64.6 ± 0.9	66.3 ± 0.9	0.058	0.210
Weight, lb	167.3 ± 8.4	188.6 ± 6.5	0.132	0.053
WC, in	38.7 ± 2.7	37.7 ± 0.9	0.008	0.638
Fat, %	32.7 ± 2.6	35.5 ± 2.0	0.026	0.405
BMI, kg/m^2	28.3 ± 1.0	30.1 ± 0.6	0.092	0.109
REAP-S score[a]	18.6 ± 0.9	20.4 ± 0.7	0.091	0.113
DHKQ score[b]	25.9 ± 1.2	24.2 ± 0.9	0.046	0.261

[a]REAP-S is the Rapid Eating Assessment for Participants, Short Version. Survey was modified; nine questions used; score range 9 - 27 with higher score = healthier dietary habits.
[b]DHKQ score is eight nutritional preference questions from the 1994-1996 Diet and Health Knowledge Questionnaire. Score range 8 - 32; higher score = healthier dietary habits.
[c]NA = not applicable.
Note: data are means ± standard error. P was obtained from univariate tests, except for gender, which came from chi-square.

Table 4. Means for variables with outcome change comparisons

| | Food Lists | | MyPlate | | | P values | | |
	Base line	Post-test	Basel ine	Post-test	Partial η^2	Time	Inter action	Group
Wt, lb	167.3 ± 8.4	165.0 ± 8.2	188.6 ± 6.5	188.5 ± 6.9	0.079	0.113	0.140	0.043
WC, in[a]	38.7 ± 2.7	35.2 ± 1.1	37.5 ± 0.9	37.8 ± 0.9	0.072	0.247	0.159	0.698
Fat, %[b]	32.7 ± 2.6	31.6 ± 2.6	35.5 ± 2.0	35.4 ± 2.0	0.095	0.067	0.104	0.036
BMI kg/m^2	28.3 ± 1.0	27.6 ± 1.0	30.1 ± 0.6	30.1 ± 0.7	0.145	0.029	0.041	0.069
REAP-S[a]	18.6 ± 0.9	20.5 ± 0.9	20.4 ± 0.7	21.0 ± 0.7	0.043	0.053	0.278	0.221
DHKQ[b]	25.9 ± 1.2	26.0 ± 1.0	24.9 ± 0.9	25.1 ± 0.9	0.016	0.442	0.519	0.320

| | # Days | | | | Correlation with Weight Loss | |
	Food Lists	My Plate	Partial η^2		r	P value
Adh[e]	40.5 ± 3.9	39.2 ± 3.2	0.003		-0.074	0.703

[a]WC for Food Lists at baseline was not normally distributed.

[b]Fat % for MyPlate at baseline was not normally distributed.

[c]REAP-S is the Rapid Eating Assessment for Participants, Short Version. Survey was modified; nine questions used; score range 9 - 27; higher score = healthier dietary habits.

[d]DHKQ score is eight nutritional preference questions from the 1994-1996 Diet and Health Knowledge Questionnaire. Score range 8 - 32; higher score = healthier dietary habits.

[e]Adherence is days of app use from 0 - 56 days.

Note: data are means ± standard error. P was obtained from repeated measures ANOVA, except for adherence, which came from Pearson correlation coefficient.

Table 5. Likert scale exit survey opinions of FoodMindr app experiences[a]

Answers	Food Lists	MyPlate	P value
Enjoyment			0.72
Very enjoyable	30.8	18.8	
Somewhat enjoyable	61.5	68.8	
Somewhat unenjoyable	0.0	6.3	
Unenjoyable	7.7	6.3	
Ease of Use			0.35
Very easy	38.5	43.8	
Easy	61.5	43.8	
Difficult	0.0	12.5	
Very difficult	0.0	0.0	
Overall Satisfaction			0.26
Very satisfied	38.5	18.8	
Satisfied	61.5	68.8	
Dissatisfied	0.0	12.5	
Very dissatisfied	0.0	0.0	

[a]Pearson chi-square tests. Some cells < 5 expected count.

Table 6. Features participants liked most about the FoodMindr application

Feature	Count[a]
Ease of login	13
Personalized name and caloric goal	7
Easy to navigate	24
Clear prompts	17
Good performance	8
Other (write in):	4

Food groups
Easy to use and record
I liked that it wasn't checking off the day, flexible enough to have more one day, less another
Gaining personal awareness of my eating habits

[a]Counts are number of subjects who answered from a multiple choice prompt.

Table 7. Features or issues participants disliked about the FoodMindr application

Response	Count[a]
Too slow	4
Did not work well on a small screen	1
Difficult to understand	3
Not visually appealing	2
Encountered too many bugs or errors	4
Other (write in):	18

> Too general
> Just couldn't go back to record the meals
> Made me log in every time
> Midnight cut off
> The plus and minus didn't work often
> Portion specifics were not there
> Wish it had more variety
> Lack of reminder function
> Difficult to use on desktop
> No chance to change if you had a mistake
> No issues
> Could not log in to enter food logs for days prior.
> Oversimplified.
> The midnight cut off was a challenge for me simply because I would forget to enter until after
> Mixed foods are hard to find a category for
> Could have sort of a reminder for the meals
> The food guide was very scarce
> Understand serving sizes

[a]Counts are number of subjects who answered from a multiple choice prompt.

Figure 2. Weight Change from Baseline
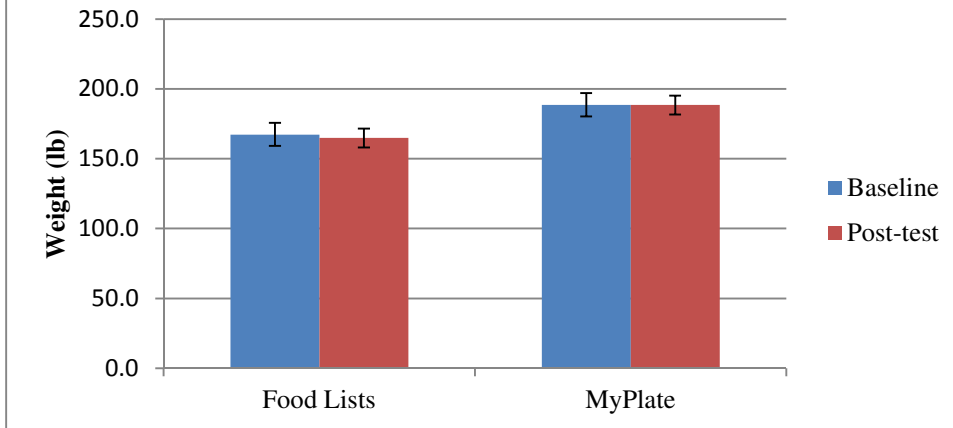
Values represent mean ± SE; repeated measures interaction *P*=0.140.

Figure 3. BMI Change from Baseline
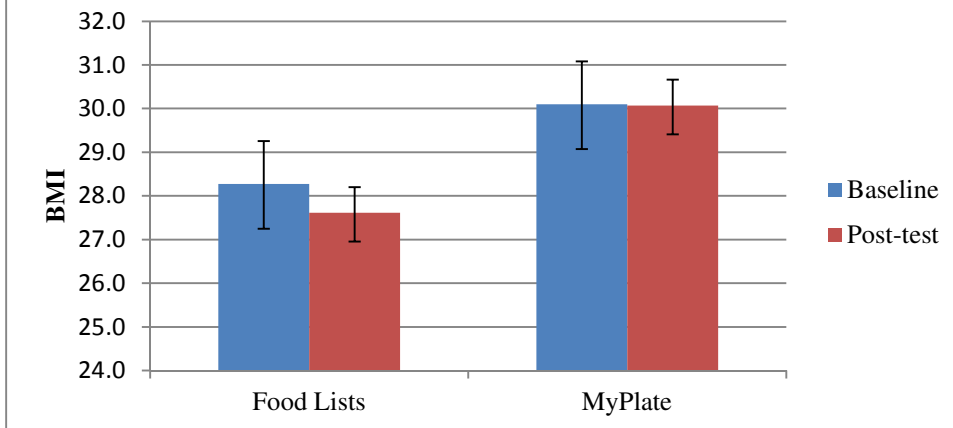
Values represent mean ± SE; repeated measures interaction *P*=0.041.

Figure 4. Overall Correlation of Adherence to Weight Change[a]
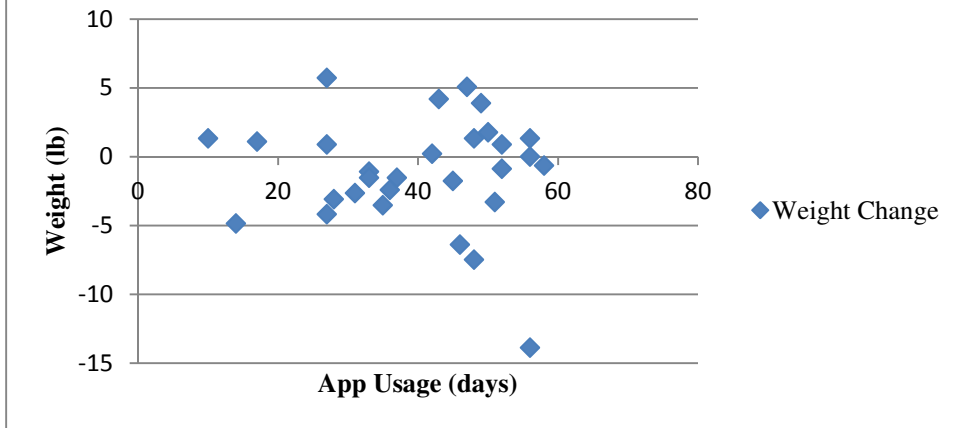
[a]Pearson correlation (r = -0.074; *P*=0.703)
Adherence is days of app use from 0 - 56 days.

Figure 5. Group Correlation of Adherence to Weight Change[a]
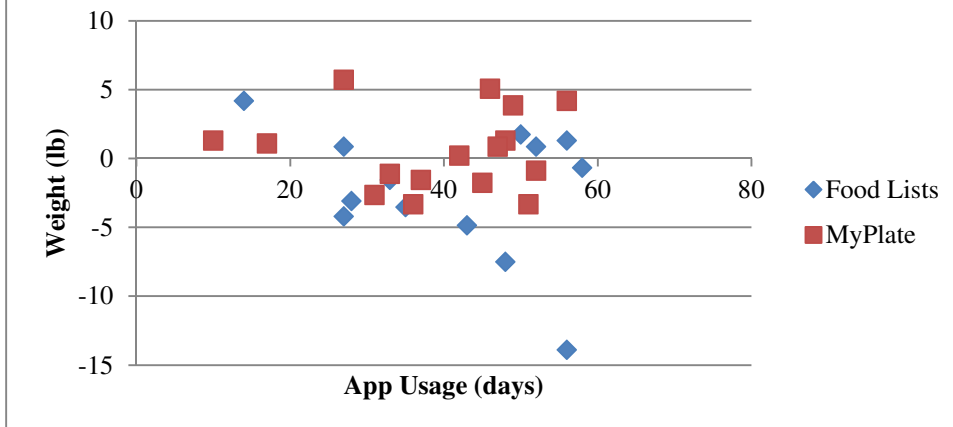
[a]Spearman correlation: Food Lists and MyPlate (r = -0.204, *P*=0.504; r = 0.124, *P*=0.649)
Note: adherence is days of app use from 0 - 56 days.

Figure 6. Modified REAP-S Change from Baseline[a]
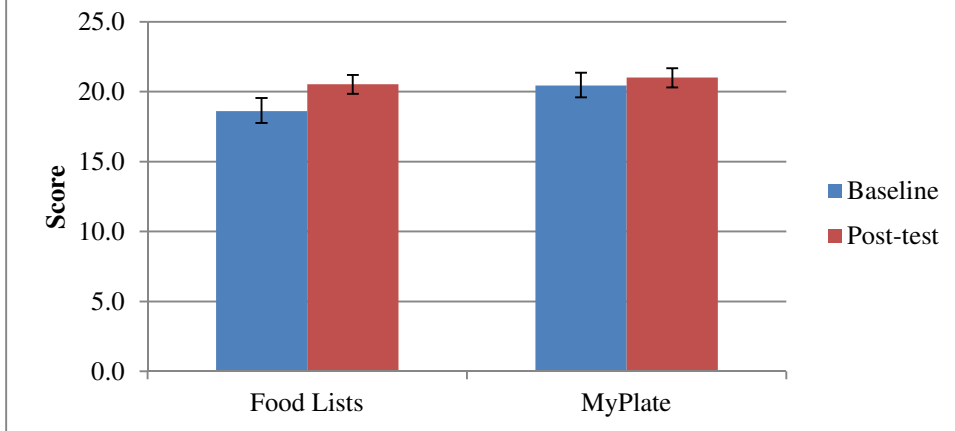
[a]REAP-S is the Rapid Eating Assessment for Participants, Short Version. Survey was modified; nine questions used; score range 9 - 27; higher score = healthier dietary habits.

Figure 7. Selected DHKQ Change from Baseline[a]
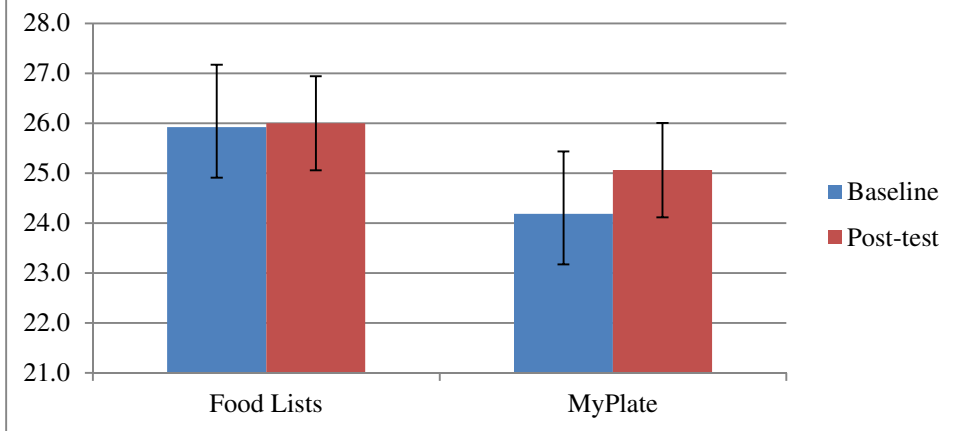
[a]DHKQ score is eight nutritional preference questions from the 1994-1996 Diet and Health Knowledge Questionnaire. Score range 8 - 32; higher score = healthier dietary habits.

Figure 7. Consort Flow Diagram


```
        ┌─────────────────────┐
        │  Completed survey   │
        │     n = 280         │────────┐
        └─────────────────────┘        │   ┌─────────────────────┐
                   │                    │   │     Ineligible      │
                   │                    └───│     n = 206         │
                   │                        │   Did not meet      │
                   │                        │ screening criteria  │
                   │                        └─────────────────────┘
        ┌─────────────────────┐
        │ Invited to participate │
        │      n = 74         │────────┐
        └─────────────────────┘        │   ┌─────────────────────┐
                   │                    │   │  Did not schedule   │
                   │                    └───│     n = 37          │
                   │                        │  Could not schedule │
                   │                        │ visit or declined invite │
                   │                        └─────────────────────┘
        ┌─────────────────────┐
        │    Randomized       │
        │     n = 37          │
        └─────────────────────┘
                   │
         ┌─────────┴─────────┐
   ┌───────────┐        ┌───────────┐
   │ Food Lists│        │  MyPlate  │
   │  n = 20   │        │  n = 17   │
   └───────────┘        └───────────┘
         │                    │
   ┌────────────────┐   ┌────────────────┐
   │ Opted out: n=5 │   │ Lost to follow up: │
   │Lost to follow  │   │    n = 1       │
   │ up: n = 2      │   │                │
   └────────────────┘   └────────────────┘
         │                    │
   ┌────────────────┐   ┌────────────────┐
   │Food Lists analyzed │ │MyPlate analyzed│
   │    n = 13      │   │    n = 16      │
   └────────────────┘   └────────────────┘
```
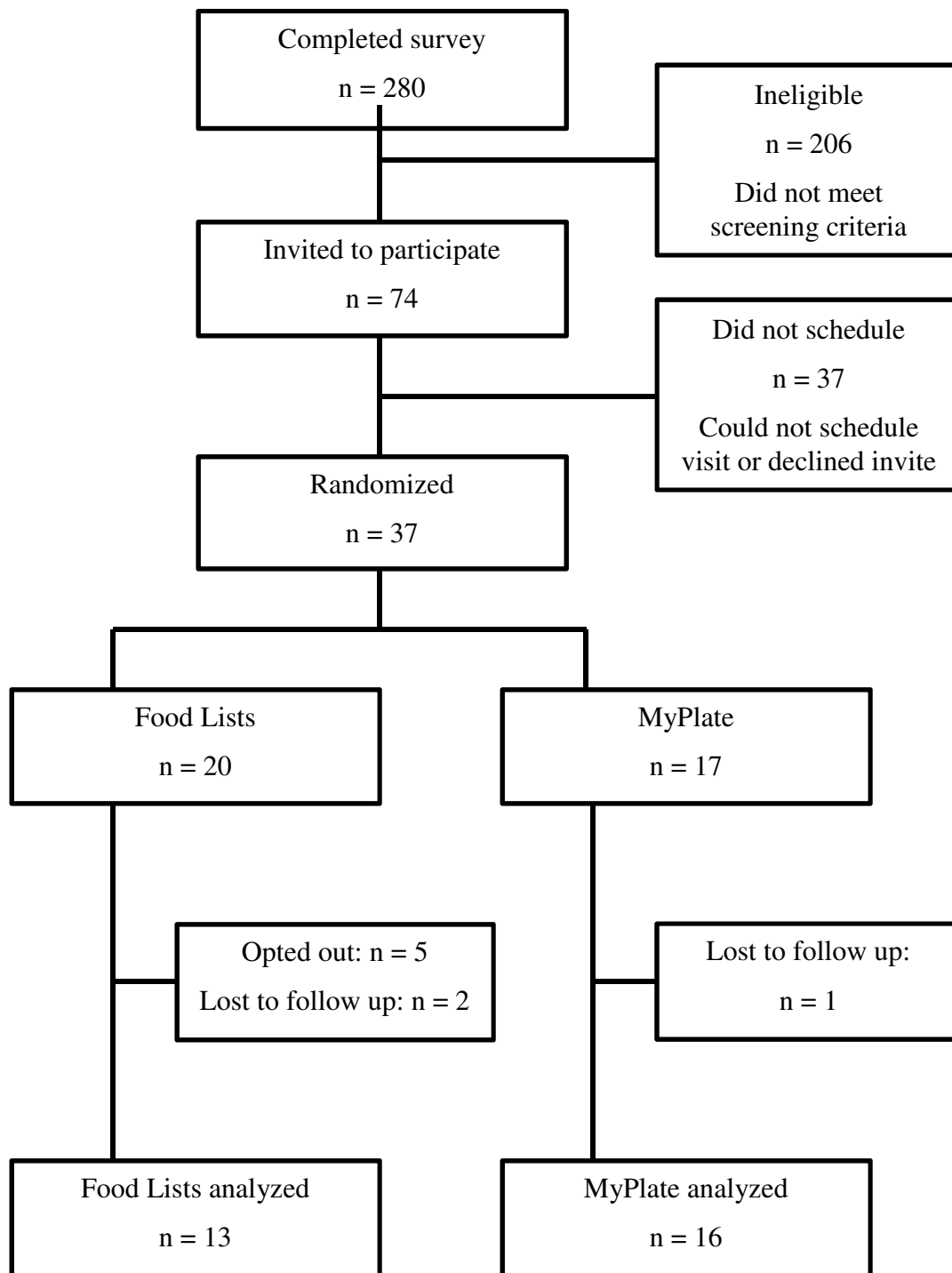
51

CHAPTER 5

DISCUSSION

Although the Food Lists group lost a modest amount weight (-2.3± lb) and the

MyPlate group experienced no appreciable weight loss (-0.1± lb), there was no

significant difference for weight change over time or between groups. However, the

subjects following the Food Lists diet improved their BMIs significantly more than

subjects following the MyPlate diet. This finding was additionally supported by an

adequate effect size (0.145). A $\geq$ 5% BMI reduction was seen in four out of thirteen

Food Lists participants while only a single MyPlate subject achieved this threshold.

Moreover, two Food Lists subjects lost enough weight to change their BMI category; one

from obese to overweight and one from overweight to normal weight. No MyPlate

subjects changed BMI categories.

This study's findings related to BMI are interesting for several reasons. First,

because the BMI calculation (weight/height^2) contains a height component it gives

context to weight changes. Height remains constant during weight change. By losing (or

gaining) weight subjects are necessarily changing their body compositions when viewed

through the lens of BMI.

Second, previous studies have noted positive correlations between low BMI and

successful long-term weight maintenance.[45,54,60] Participants in the National Weight

Control Registry who maintained weight loss for one decade decreased their BMI from

36.7 (obesity class II) to 25.1 (overweight).[60,61]

Third, a lower BMI may convey health benefits. Low BMI is correlated with

decreased risks of type 2 diabetes, hypertension, and cardiovascular disease.[62]

Epidemiological data from the Global Burden of Disease Study 2010 also revealed a positive association between BMI and atherosclerosis.[63] BMI > 25 is a risk factor for obstructive sleep apnea,[20] musculoskeletal injuries,[23] and some forms of osteoarthritis.[24] In a survey of Nurses' Health Study participants, frequency of gastroesophageal reflux disease (GERD) symptoms was positively correlated with higher BMI. Interestingly, this relationship was uninfluenced by variables such as smoking, alcohol consumption, and some GERD medications.[18] Very high BMI can also impact mental wellbeing. Major depression is found in 7% of persons having BMI $\geq$ 35 (with associated comorbidities) or BMI $\geq$ 40 (without comorbidities).[16] In the United States, bariatric surgery is typically recommended for persons with BMI $\geq$ 35 (with associated comorbidities) or BMI $\geq$ 40 (without comorbidities).[16]

Fourth, correlations between healthy dietary patterns and lower BMI have been noted.[45,46,64] Tucker et al.[65] found diets high in fruits, vegetables, and fiber were associated with lower subject BMIs. Persons who ate low-fat dairy and consumed little or no meat also had lower BMIs. It should be noted that similar patterns were encouraged by the Food Lists app which permitted unlimited vegetable intake but set limits on protein consumption.

This study's findings related to diet adherence were not significant. However, this outcome is nonetheless noteworthy. The Food Lists group had greater participatory burdens. Users were required to manage three more food groups than were tracked by MyPlate subjects. Learning and adhering to the Food Lists diet may have been more difficult.[66,67] With the exception of vegetables, the Food Lists group was urged to obey strict intake limits versus MyPlate's suggested goals. This type of diet rigidity can lead

to noncompliance.[5,29] The adherence data make Food List's equivalent performance against MyPlate all the more remarkable.

To be fair, both diets involve evidenced-based, salubrious eating patterns.[8,10] It is worth mentioning MyPlate subjects tracked fewer food groups yet maintained diet quality comparable to Food Lists followers. However, as mentioned previously, the leniency of the MyPlate requirements did not lead to greater adherence. In other words, both groups similarly consumed and adhered to healthful diets. These outcomes highlight a key study construct: limits versus goals. Subjects appear to have benefited more from strict limits than from suggested goals.

Technology played an important role in the FoodMindr study. The Food Lists and MyPlate apps were custom built to manifest a high degree of simplicity and usability. The primary daily tasks of recording meals and viewing current intake statuses each necessitated visiting one screen only. Contrast this with commercial apps such as "Lose It!" and "MyFitnessPal" which require users to first choose a meal (breakfast, lunch, etc.), and then select individual foods and quantities belonging to that meal. At this point in those apps, selecting a specific food may require additional searching.[68,69] An experienced Food Lists user can enter a meal within seconds. A MyFitnessPal user may take 1 – 2 minutes to record the same meal.[69] If the simpler Food Lists app can produce results equivalent to or better than "full-featured" apps, it might call into question the need for tracking additional detail when following a diet. This is a thought-provoking notion which could be addressed in future FoodMindr studies.

This study's relatively brief, eight-week time frame may help inform some of its outcomes. Previous weight-loss studies examining Food Lists, MyPlate, or similar diets

have not reported significant weight loss before 20 weeks.[5,13] App-centric weight loss interventions have also failed to show significant weight loss differences over short timeframes.[6,70] Extending the size and length of subsequent FoodMindr studies could help to accentuate weight loss differences between and within groups.

Changing one's eating behaviors and diet patterns takes time. Wing et al.[60] reviewed the National Weight Control Registry for successful strategies regarding weight loss maintenance. Diet quality was found to promote and maintain weight loss but only if adherence was maintained ≥ 1 year. Case in point, the eight-week Wharton et al.[6] study recorded decreased diet quality from its app group. That study used the commercially available "Lose It!" iPhone app. On the other hand, the FoodMindr study saw no decrease in diet quality over an eight-week duration. It is possible Food Lists or MyPlate could improve diet quality and adherence if the study time were extended.

The small group sizes posed a limitation. There could have been an increased risk of a type 2 statistical error in which group differences existed but were overlooked. In cases such as this, effect size can be calculated to quantify the difference. An effect size from 0.06 to 0.14 is considered moderate.[71] For the change in body weight, the repeated measures ANOVA subjects groups (P=0.140) was not significant and the effect size (0.079) was moderate. This analysis provides additional reassurance for the continued examination of Food Lists to promote weight loss.

Another potential problem with the samples was the higher number of Food Lists subject dropouts (7 vs. 1). A flaw in the random assignment methodology may be indicated here. Unfortunately, the exit surveys do little to explain the disparity in drop

rates. In fact, only one subject cited Food Lists app design or Food Lists diet as a withdrawal justification.

Another limitation of the study was its low external validity. The email listserv used to attract prospective subjects consisted primarily of students in ASU's School of Nutrition and Health Promotion. This population is predominately young adults with high school diplomas and some college experience. Many are exercise science or nutrition majors. Their socioeconomic statuses combined with their health-related interests do not represent the greater Phoenix population. On the other hand, there was good ecological validity (a component of external validity). The study design encouraged a realistic, real-world atmosphere. Subjects received minimal app training and diet instruction. Few constraints were placed on the subjects. During the intervention, subjects were left to their own volitions. Other than a single mid-point email, investigators made no attempt to remind subjects about app usage or diet adherence.

The MyPlate group's BMIs at baseline and post-test were almost indistinguishable. It calls into question whether this diet provides sufficient guidelines for weight loss. A successful eating framework should stipulate clear intake limits. MyPlate gives daily recommended intakes based on age and gender. However, it does not specifically instruct a dieter when to stop eating. MyPlate's focus on "recommended daily amounts" may not convey a sense of finite quantities.[72] Even worse, the use of goals could be misconstrued by laypersons as "more is better". After all, exceeding a goal is often a desirable outcome. A more encompassing level of diet detail may also be beneficial. The MyPlate logo displays five food groups. Its official website,

choosemyplate.gov, includes a sixth "oils" group. Yet, this food group is not mentioned in many of the downloadable materials. It is unknown what percentage of dieters might be aware of MyPlate's oil guidelines. By contrast, Food Lists outlines specific serving limits and utilizes eight primary food groups including fats, sweets, and alcohol.

Smartphone diet apps vary greatly in their complexity, feature set, and availability across platforms. This variety can make diet comparisons difficult. A key strength of this study was its custom-designed software. In this regard, the FoodMindr software may have provided improved usability as compared to more complex commercial apps. Researchers crafted the Food Lists and MyPlate app interfaces to be as identical as possible. Participants were allowed to use any web-enabled smartphone, regardless of brand or model. These methods diminished technology as a variable and allowed a more equitable comparison of diets.

A logical next step is to open FoodMindr to the general public. This would potentially allow for studying a large cohort. Ideally, anyone in the world would be able to participate. Although this could make most subject anthropometrics impossible, surveys might be used to examine a variety of topics. Diet behaviors, quality of life, sleep patterns, and happiness can all be measured through surveys.[3,49,57,60] This information could then be combined with app adherence and food intake data.

Although this study failed to reject its three null hypotheses, the resulting data contain interesting trends which warrant further investigation. Most promisingly, the reduction in BMI was significant. Given that BMI contains a height component, it provides useful insight into each group's weight loss performance, or lack thereof. The BMI data are encouraging for future investigations using FoodMindr. Also of interest is

the possibility that simply tracking food groups might be as effective as recording the minutia of dietary intake. In today's world of shortened attention spans, a faster diet app would likely be a popular tool.

The findings in the study support the concept that a diet with set intake limits and broader food group coverage may outperform one without such guidelines. The US government's current eating guidelines encourage balanced meals, but may not be sufficient for weight loss. Persons desiring to lose weight may benefit from additional dietary structure. With this in mind, mobile technologies are establishing themselves as useful tools for delivering dietary interventions. Furthermore, this study demonstrated that effective diet apps need not be fancy or platform specific. These findings will be of interest to nutrition professionals wanting simple, affordable dietary interventions.

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APPENDIX A

IRB APPROVAL

ASU Knowledge Enterprise Development

APPROVAL: EXPEDITED REVIEW

Carol Johnston
SNHP - Nutrition
602/827-2265 CAROL.JOHNSTON@asu.edu

Dear Carol Johnston:

On 2/2/2015 the ASU IRB reviewed the following protocol:

Type of Review:	Initial Study
Title:	A novel 'Food Lists' app to promote weight loss, improve diet quality, and strengthen diet adherence: the Foodmindr Study
Investigator:	Carol Johnston
IRB ID:	STUDY00002170
Category of review:	(4) Noninvasive procedures, (7)(b) Social science methods, (7)(a) Behavioral research
Funding:	None
Grant Title:	None
Grant ID:	None
Documents Reviewed:	• food list (app), Category: Participant materials (specific directions for them); • Consent, Category: Consent Form; • Protocol, Category: IRB Protocol; • Post trial survey, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • online survey, Category: Screening forms; • food list (MP), Category: Participant materials (specific directions for them); • Health history questionnaire, Category: Screening forms; Pre trial survey, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • Recruitment email, Category: Recruitment Materials;

The IRB approved the protocol from 2/2/2015 to 2/1/2016 inclusive. Three weeks before 2/1/2016 you are to submit a completed "FORM: Continuing Review (HRP-212)" and required attachments to request continuing approval or closure.

If continuing review approval is not granted before the expiration date of 2/1/2016 approval of this protocol expires on that date. When consent is appropriate, you must use final, watermarked versions available under the "Documents" tab in ERA-IRB.

In conducting this protocol you are required to follow the requirements listed in the INVESTIGATOR MANUAL (HRP-103).

Sincerely,

IRB Administrator

cc:
       Cameron Scholtz

APPENDIX B

SUBJECT CONSENT FORM

ASU School of Nutrition and Health Promotion: Smartphone App Weight Loss Study

Investigators
Dr. Carol Johnston, professor of nutrition
Cameron Scholtz graduate student of nutrition

Why am I being invited to take part in a research study?
We invite you to take part in a research study because the screening information you provided indicates you meet the minimum participation requirements.

Why is this research being done?
The current body of research contains only a handful of "app" related weight-loss interventions. In addition, it is still unclear to what extent food tracking apps may improve nutritional intake. This study seeks to determine whether a specific app can improve weight loss and diet quality.

How long will the research last?
This study will cover eight weeks. You will be asked to record your food intake each day. This is estimated to take approximately 15 minutes per day.

How many people will be studied?
We expect about 30 – 40 people here will participate in this research study.

What happens if I say yes, I want to be in this research?
It is up to you to decide whether or not to participate. If you participate, you are requested to record all foods consumed during the study's eight-week period. In addition, you will be asked to come to the ASU research lab once before the study begins and once when the study ends. During the first visit we will train you to use the app and to use a specific nutritional protocol. During both visits will measure your weight, waist circumference, and administer a very short survey about your eating habits. During the eight we study we will collect the food intake data that you enter into your smartphone (or other device you use for this study).

Timeline

1. Before study begins: you will visit the ASU research lab for body measurements and app instruction by a trained nutrition expert. This is estimated to take 30 minutes.
2. Weeks 1 through 8: you will record daily all foods eaten using your smartphone; about 10 – 15 minutes per day.
3. After study ends: you will visit the ASU research lab for body measurements and app instruction by a trained nutrition expert. This is estimated to take 30 minutes.

What happens if I say yes, but I change my mind later?
You can leave the research at any time it will not be held against you. ASU will retain the right to use any study data collected up to the point of your exit. If you decide to leave the research, there will be no adverse consequences. If you decide to leave the research, contact the investigator so that the investigator is aware of your exit.

Is there any way being in this study could be bad for me?
This study is noninvasive. It is unlikely to cause you any harm.

Will being in this study help me in any way?
The focus of this study is weight loss and diet quality. It is possible you will lose weight during the eight weeks. Moreover, you may notice an improvement in the nutritional quality of your diet.

What happens to the information collected for the research?
Efforts will be made to limit the use and disclosure of your personal information, including research study and medical records, to people who have a need to review this information. We cannot promise complete secrecy. Organizations that may inspect and copy your information include the IRB and other representatives of this organization.

What else do I need to know?

If you agree to take part in this research study, we will provide you with two $25 gift cards for your time and effort. You will receive one gift card during your initial visit and the other at your end visit. If you agree to participate in the study, then consent does not waive any of your legal rights. However, no funds have been set aside to compensate you in the event of injury.

Who can I talk to?

If you have questions, concerns, or complaints, or think the research has hurt you, talk to the research team at ASU.

Dr. Carol Johnston email: Carol.Johnston@asu.edu phone: (602)827-2265

Cameron Scholtz email: Cameron.Scholtz@asu.eduphone: (503) 515.3839

This research has been reviewed and approved by the Bioscience IRB ("IRB"). You may talk to them at (480) 965-6788 or research.integrity@asu.edu if:

- Your questions, concerns, or complaints are not being answered by the research team.
  You cannot reach the research team.
  You want to talk to someone besides the research team.
  You have questions about your rights as a research participant.
  You want to get information or provide input about this research.

Your signature documents your permission to take part in this research.

_____   _____
Signature of participant   Date

_____
Printed name of participant

_____   _____
Signature of person obtaining consent   Date

_____
Printed name of person obtaining consent

APPENDIX C

FOOD LISTS AND MYPLATE INTAKE GUIDELINES

Table 8. Food Lists intake tiers with guidelines

Kcal Range	Goal Vegetable	← Fat	Fruit	Milk	Limits Protein	Starch	Sweet	→ Alcohol
1500 kcal	4	2	2	3	6	6	1	1
1800 kcal	5	3	3	3	7	7	1	1
2100 kcal	5	3	3	3	8	9	1	1
2400 kcal	5	5	3	3	9	11	1	1

Subjects assigned to kcal tier using Miffin-St. Jeor calculation with 1.2 activity modifier.

Table 9. MyPlate intake tiers with guidelines

Age Range	Vegetable[a]	Dairy[a]	Fruit[a]	Grain[b]	Protein[b]
Females					
19 - 30	2.5	3	2	6	5.5
30 - 50	2.5	3	1.5	6	5
50+	2	3	1.5	5	5
Males					
19 - 30	3	3	2	8	5.5
30 - 50	3	3	2	7	6
50+	2.5	3	2	6	5.5

[a]Amounts are cups. Fruits and vegetables can be raw, cooked, canned, frozen, dried, or juice; whole, cut, or mashed. Vegetable group includes beans and peas.
[b]Ounce equivalents. Protein includes soy products, nuts and seeds.

APPENDIX D

FOODMINDR SCREEN SAMPLES

Food Lists app

FoodMindr ☰

Wed, July 15

Food Group	Progress	Goal
Vegetables ⭐	5	5
		Limit
Fats	2	3
Fruits 🛑	3	3
Milk	2	3
Starch 🛑	8	7
Protein	5	7
Sweets 🛑	1	1
Alcohol		1

Edit Food Log

🔲 🔒 foodmindr.com/Excha ↻ ⋯

MyPlate app

FoodMindr ☰

Wed, July 15

Food Group	Progress	Goal
Dairy	2	3
Fruits ⭐	3	2
Grains ⭐	8	7
Protein	5	6
Vegetables ⭐	5	3

Edit Food Log

🔲 🔒 foodmindr.com/MyPl ↻ ⋯

APPENDIX E

EXIT SURVEY DATA

Table 10. FoodMindr subject exit survey comments

Subject	Comments
1	I think it would be nicer as an app that doesn't require safari
2	Thy foodminer was good a good application. once I got an understand of the proper serving size and what a grain, and protein was. it was easy to use. I did encounter a few times that it did not record my inputs. it did however point out to me that I did not eat enough fruit. If there was a way to put in that you at 1 serving of chicken ant the app would make the proper inputs that was be a good feature.
4	I think friendly emails of reminders to continue to log in would have helped. I also think it was too general since it didn't track fats, alcohol, etc.
7	It went by food groups and not what type of food you ate, which made it easier to use.
8	I wish it gave me reminders or notifications telling me to log my food in.
9	This study helped me to eat leaner meats and to eat a variety of different food. By eating a variety of different foods you are less likely to get bored with a healthy diet.
10	[no response]
11	There would be times when I wouldn't follow my diet plan and I would eat something bad or fried and I wouldn't know how to track it in the app. Maybe there should be somewhere to track the bad stuff as well
12	Difficult with the midnight cut off (would miss entire day or even just dinner) / - If food did not fit in category, where do I put it (ex. alcohol, added sugar) / - No indication if you were going overboard and eating too much (theoretically could cons
14	Really liked how easy it was to pull up on my phone and use it throughout the day. Only negative thing I can think of is it was sometimes hard to decide where certain things set in the categories.
15	[no response]
16	I enjoyed the application and having to note everything i was eating and placing it in a category, I feel as if it made me more aware of what i was eating and what my habits were whether good or bad. / The one thing I though was that the recommendations of the My Plate may have been a little high, i felt it was hard for me to reach some of the goals because I felt as if i were over eating. Overall great application I definitely benefited from it. I wish there was a way to go back to the previous day and edit the intake, made it difficult for me to log when I was out of work past midnight.
18	I think it is good, but might be a bit too plain. I wasn't able to enter in sugar intake and some other things that I felt were a part of my diet. Maybe in the future they could add more to the application. Overall it is very simple and easy to use. I would also like if there was a way to put the application onto my phone instead of having to look it up online every time.
19	I enjoyed using the FoodmIndr. It helped me to plan and include all food groups in my diet. I especially like the stop sign.

20	There were many times that I forgot to use Foodmindr at the the end of the day. Prior to the study, I had not regularly used a food tracking application, so my adherence to the program decreased. About half way through the study, I set an alarm on my phone at 11pm (end of the day) to remind myself to use Foodmindr and that helped.
21	I wish there were more food examples in the food list
22	Difficult to know what constitutes a serving of meat & grains since it was a different measurement than fruits & veggies
23	[no response]
24	I like being able to log specific food more than servings of different types of food
25	This app was easy to use. It's a great way to track your diet.
27	[no response]
28	I realize that the app was created to follow the MyPlate guidelines, but due to the simplicity of the choices listed, anyone with "non-average" diet such as paleo, where animal dairy products are not consumed, will find that they are not technically meeting their daily dairy goals when they may be consuming an adequate amount of calcium and protein via other foods.
29	If there was an actual application for the phone instead of an online application, it would have been easier to track, and remember what i needed to eat more of.
30	It would be nice if one could go back and modify entries the day after. Many times I remembered to fill in my food choices after midnight (I'm a night owl) but by then it was too late.
32	This seems simple but I didn't like how I couldn't track my problem foods, like sugar, for instance.
34	Drinking protein or meal shakes does not reflect only one category because there are a plethora of nutrients found in them.
35	In the beginning was difficult to use because I was not used to eat and insert data on the app. Overall, the experience was good and I could improve my food habits.
36	I really enjoyed using the app. It made me mindful of the foods I was eating and how many extra servings I used to eat. It would be nice if this app was available in internet browser format for better ease of access.
37	[no response]

Table 11. Opt out emails received from Food Lists subjects

Subject	Email
3	I actually wanted to remove myself from the study. I did not use the phone app as often as I should have.
13	Certain circumstances have prevented me from updating my food log for the last couple days. That being said, I have decided to withdrawal my participation from the study to prevent further mishaps/error in the results. I appreciate your time and I apologize for any inconvenience.
31	I would like to withdrawal from your study. I did not to a sufficient job with keeping track on the app. I am berry sorry but hope the rest of your data come in as expected. Enjoy your day
33	I forgot to mention, I didn't go through with the app. I did modify my diet but I just kept slipping my mind so I stopped all together, That was back in March. I am so sorry, I hope it all worked out for you well!
39	Unfortunately I have not been keeping up with my food logging. Once I figured out that the actual entry was a placebo of sorts, and that your study was designed to see the effects of logging data on any program, I lost interest and quite often forgot to log. Had the calorie or food quantities been more detailed and actually important I probably would have been more religious in my data entry.