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WEIGHT MANAGEMENT RELATED FACTORS AND HEALTHY  
BEHAVIORS IN ADULTS

BY

SUMADHURI PAMARTHI

A dissertation submitted in partial fulfillment of the requirements for the

Doctor of Philosophy

Major in Nutrition and Exercise Sciences

South Dakota State University

2018

WEIGHT MANAGEMENT RELATED FACTORS AND HEALTHY  
BEHAVIORS IN ADULTS

SUMADHURI PAMARTHI

This dissertation is approved as a creditable and independent investigation by a candidate for the Doctor of Philosophy in Nutrition and Exercise Science degree and is acceptable for meeting the dissertation requirements for this degree. Acceptance of this does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

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## ACKNOWLEDGEMENTS

I convey my earnest appreciation and thankfulness to my advisor Dr. Lacey Arneson McCormack for her unremitting support and trust in me all through my Ph.D. study and the research. Her expertise, persistence, and inspiration have enormously assisted me in all aspects of my scholastic and professional life. I am always grateful to her for challenging me with tasks that needed higher level intellect and for giving me the opportunity to work in multiple projects that has tremendously helped me widen my research skills from various perspectives.

In addition to my advisor, I am thankful to other members of my Ph.D. committee: Dr. Kendra Kattelman (Head, Department of Nutrition and Exercise Sciences), Dr. Jessica Meendering, Dr. Nancy Lyons, and Dr. Debra Spear for their critical evaluation, insightful comments, encouragement, and support in all directions. I am also thankful to Dr. Jill Thorngren, (Dean-Education and Human Sciences) and Dr. Matt Vukovich (Associate Dean for Research) for their constant support and encouragement for overall student's growth and success.

I am also grateful to my research collaborators for all the projects that I had the privilege of working with: Dr. Kendra Kattelman, Dr. Jessica Meendering, Dr. Greg Heiberger, Dr. Eduardo Haurte, Dr. Novotny Jennifer,

Dr. Teresa Binkley, Dr. Andrea Bjornstead, Dr. Amber Letcher, Dr. Suzanne Stluka, Mrs. Mary Gengler, Mrs. Karly's Wells for their support and research. I also thank librarian Mrs. Mary Kraljic for her timely help.

My sincere thanks and admiration go to all my mentors throughout my academic career for contributing to my growth and success as an overall professional in some way. My special thanks to Dr. Sally Weerts for her continued belief in me with her unconditional support all through the years. I whole heartedly thank all my family and friends for their intellectual discussions on the subject matter, guidance and for believing in me with their unconditional support always. I especially thank my Mother and Brother for all the sacrifices, priceless love, and unconditional support they shower on me. I could not have attained this milestone without them by my side.

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## ABBREVIATIONS

NCI DSQ:	National Cancer Institute Dietary Screen questionnaire
NIH FV:	National Institute of Health Fruit and Vegetable Screener
IPAQ:	International Physical Activity Questionnaire Algorithm
EBBS:	Exercise Benefit and Barrier Scale
DXA:	Dual-X-ray-Absorptiometry
PA:	Physical Activity
FV:	Fruit and Vegetable
SD:	Standard Deviation
SE:	Standard Error
M:	Mean

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ABSTRACT

WEIGHT MANAGEMENT RELATED FACTORS AND HEALTHY  
BEHAVIORS IN ADULTS

SUMADHURI PAMARTHI

2018

Obesity is an ongoing global pandemic that affects more than one in three adults in the United States. Being overweight or obese also increases the risk of chronic health conditions. Weight management does not only center on immediate weight loss but also on the proper maintenance of an appropriate body weight over the years. Methods of weight management include eating a healthy diet and meeting physical activity guidelines. Such weight management practices are important to ensure that the people suffering from obesity can decrease risks of morbidity or even mortality. Nevertheless, unhealthy weight management strategies might lead to unintended health consequences. A healthy eating plan and regular physical activity will aid in weight maintenance. However, other related aspects need to be considered as well to design effective weight management interventions. Therefore, the purpose of this dissertation is to discover relatively unexplored weight management related factors to help advance our knowledge in this area and to open new frontiers for research.

This dissertation walks through a body of unexplored translational research work related to weight management that contributes to the ever-growing field of obesity prevention. The dissertation utilizes data from USDA GetFRUVED project and Sanford Successful Weight Management project. Research has shown the need for improved dietary behaviors among young adults. The dietary habits among young adults were explored to determine if there is an association with farmers' market use utilizing the National Cancer Institute (NCI) fruit vegetable intake screener, and National Institute of Health (NIH) dietary intake screener. Of the known influences on Physical activity levels, the Physical activity perceptions are the least understood area. The Physical activity levels and its perceived benefits and barriers were explored using International Physical Activity Questionnaire (IPAQ) algorithm scores and Exercise Benefit Barrier Scales (EBBS). Further, body composition changes that vary with age and weight change are of concern, especially among older adults. The studies reporting such changes in elderly participating in commercial weight management programs were explored using PUBMED. Together the findings from this dissertation will help to design more precise weight management interventions than what currently exists to combat the obesity pandemic.

**Keywords:** Obesity, Weight Management, Body Composition, Diet, Physical Activity, Perceived benefits/barriers, NCI FV, NIH DSQ, IPAQ, EBBS.

## **CHAPTER 1. INTRODUCTION AND DISSERTATION ORGANIZATION**

### **1.1. Obesity and Weight Management in Health**

The problem of obesity can be observed in every country of the global world including America where 40% of the overall American population fits aptly into being obese.<sup>1</sup> If these patterns remain, by 2030 a projected 38% of the global adult population will be overweight and another 20% will be obese.<sup>2</sup> In the USA, the most dismal forecasts point to over 85% of adults being overweight or obese by 2030.<sup>3</sup> Weight loss is important to ensure that the people suffering from obesity can be assured of decreasing their risks of losing their lives.<sup>1,4</sup> It is well known that people who have normal body-mass index (BMI) can survive for a long period of time in comparison with people having obesity (>30) as the risks for the survival of the latter are twice that of the former.<sup>5</sup> Diabetes, cancers and cardiovascular diseases which are the top leading causes of deaths in U.S can be acquired if obesity is not treated appropriately.<sup>6</sup> According to other research studies the trend of an increased death rate due to cardiovascular diseases can be observed in individuals who had been obese when they had been adolescents.<sup>7</sup> If any individual loses 5% weight when he or she is obese, then such a weight loss can be beneficial for the individual as the individual can get rid of certain complications associated with obesity.<sup>8</sup> Obesity has been considered to be chronic in most Americans as per the American Medical Association.<sup>9</sup> Weight loss is being targeted by several American citizens and has become a trend in America.<sup>10</sup>

Nearly half of Americans are attempting to lose weight.<sup>11</sup> Quantifiable trials have stated abundant short-term wellbeing benefits related with weight loss counting declines in blood pressure and triglycerides, improvements in lipoprotein sub fractions and insulin response, and improved respiratory function.<sup>12,13</sup> Weight loss has long-term benefits for the health of the patients like the improvement of blood flow as well as less chances of mortality arising from the acquiring and persistence of cardiovascular diseases.<sup>14,15</sup> However, the biggest challenge following weight loss is maintaining weight loss and limiting weight regain.<sup>16, 17,18</sup> A cohort study of 4000 adults age  $\geq 18$  years by National Weight Control Registry, reported that those who have lost at least 13.6 kg (30 pounds) and kept it off at least a year, have found that the most common dietary strategies by 87.5% of them reporting is restricting certain foods, 44% reported limiting quantities and about 43% reported counting calories for weight loss along with high levels of Physical Activity (PA) approximately an hour of daily moderate-intensity such as brisk walking to be the most common reported.<sup>17,18</sup> A accelerometer study measuring PA among U.S citizens reported the prevalence of meeting PA recommendations decreases with age from childhood since 42% have meet the recommendations (60min/day), to 8% in adolescents (60min/day) and only 5% among adults (30min/day). Gender wise males were reported to be more active than their counter parts.<sup>19</sup> Further, a study reported that majority of adults aren't meeting the recommended intake of 2-3 cup servings a day for fruits and vegetables.<sup>20</sup>

## 1.2. Weight Management Practices and Importance

Weight management is the course of accepting long-term lifestyle alteration to preserve a healthy body weight based on an individual's age, gender, and height.<sup>21</sup> Methods of weight management include eating a healthy diet and increasing PA levels. Diverse weight management practices embraced by individuals are connected with numerous aspects such as age and gender,<sup>22, 23, 24</sup> education level,<sup>25</sup> marital status,<sup>26</sup> socioeconomic status,<sup>27</sup> peer pressure, and health issues.<sup>10</sup> It also, appeared from the review that only women's marital roles appear to affect their perceived and desired weight, signifying that marital status and gender variances could be considered while designing weight management interventions.<sup>26</sup> Further, individuals with high income appeared more likely to identify being as overweight and were extra likely to attempt weight control.<sup>27</sup> Nevertheless, unhealthy weight management strategies might lead to inhibited growth, nutrient deficits, infections, major eating disorders, amplified threats of osteoporosis, and anemia.<sup>28</sup> It has been observed in various studies that female individuals are more prone towards controlling their body weight by applying faulty practices such as excessive PA, slimming belts or tablets, purging or smoking for weight loss or the conventional attitude of starving.<sup>29,30</sup> These malpractices can result in ever-increasing risks of osteoporosis and anemia in adults.<sup>28</sup> This shows the fact that people indulge in wrong and convenient practices more in order to achieve their desired goals instead of visiting dietitians. This situation calls for immediate measure to awaken the people off their misconceptions about diet. A review article explained that successful weight maintenance relates to instant initial weight loss and goal

fulfillment, an energetic lifestyle, self-monitored weight-related behaviors, regular food intake patterns which include breakfast and healthier eating, and control over eating behavior.<sup>31</sup>

Weight management does not only center on immediate weight loss but also on the proper maintenance of an appropriate body weight over the years. A successful weight management  $\geq 1$  year is the sustained weight loss of  $\geq 5\%$  of body weight or a drop-in body mass index by  $\geq 1$  units.<sup>32</sup> Modification of lifestyle is treading the path to success and those who have already conformed to these measures have started securing results.<sup>33</sup> Implementation of adequate measures would result in the establishment and maintenance of a positive body image through healthy and proper eating habits.<sup>33</sup> Moreover, the “Obesogenic” food environment is also at the target of many health experts on the basis of the fact that the present food environment has made it almost impossible to dive into the choicest of healthy food.<sup>33</sup> But basic normative changes and guidance of the experts can make people transcend all the adversities related to weight management. Awareness should spread from the basic platform of schools. It is high time that educators and curriculum framers provide adequate space to this concern for discussion in the classroom. Additionally, promotional campaigns can be highly instrumental in establishing appropriate beliefs, attitudes and behaviors associated with positive and negative body image, weight control and several eating disorders. In the present era, teacher training institutions also have integrated these facts inducing knowledge so that in all possible ways, awareness can be spread to lead the world to proper health. The importance of weight

management practices among young and adult population across the globe remains invincible. Given the ability of such practices to impact on the fine balance between health and disease, it is reasonable to tailor novel strategies to prevent obesity and associated comorbidities through weight management interventions.

### **1.3. Weight management interventions worldwide & Awareness**

It has become evident that the percentage of females are mounting in reducing their calorie intake visiting dietitians and consuming natural herbs and teas with the expectation of gaining a perfect body shape and a healthy body.<sup>10,34</sup> While many factors affect this aspiration marital status was stated to be the most influential one.<sup>10,34</sup> Moreover, adults with diabetes also reportedly do not rely on the informal information regarding nutrient balance in the body.<sup>10</sup> Awareness is, therefore, the key to success in case of gaining health by defeating obesity and related diseases. People of all ages should be taught that there are innumerable multidisciplinary health care units where renowned and efficient dietitians stay present to resolve the health issues related to obesity. Consultation is the most prospective approach towards defeating this plaguing disease.

People tend to set inappropriate weight loss goals that aim at very rapid and effective weight loss no matter where they are from.<sup>35</sup> This makes them adopt diverse practices by evaluating the effectiveness of those preventive or reductive measures. Adequate knowledge on any subject is necessary in order make progress towards results and in this regard adequate nutrition knowledge is the key to success.<sup>35</sup> The competence of the dietitians and the conviction of the affected individuals can

effectively and gradually bring forth aspired results if the obese people conform to the cost and the reimbursement policies of the doctor.<sup>35</sup> It is evident from the evaluation of various results of the studies that weight management techniques happen to encompass long term techniques promoting healthy eating habits and effective PA on a regular basis.<sup>35</sup>

#### **1.4. Weight Management Healthy Practices & Gaps**

Managing weight by adopting weight management techniques like regular exercising or maintaining a proper diet can be useful for individuals who wish to be healthy overall for a long period of time.<sup>36</sup> Individuals must develop healthy habits to get rid of excessive fat and weight in their bodies. People must understand that their weight must be compatible with their heights, their genders as well as with their specific ages.<sup>36</sup> If the human genome is considered in the past 3 decades, it can be observed that it has remained the same.<sup>37</sup> Hence, it is evident that people are becoming obese because of environmental influences, social habits, personal habits and peer influences.<sup>37</sup> There is less of spending of the specific amounts of energy and calories by the global individuals because of living life with gadgets and digital tools.<sup>37</sup> Many studies have associated sedentary behavior, including passive transportation, with weight gain.<sup>38-40</sup> People are using cars, vehicles, etc. for moving to and from small distances.<sup>37</sup> Therefore, the result as per recent research studies reporting a past 50yr trend among Americans becoming more obese was attributed to failure to spend the least 100 kcal for their work purposes.<sup>41</sup> Finland is another country where the decrease of energy spending can be observed to be about 50 kcal in the past 50 years.<sup>42</sup> Similarly, 360 kcal

is the amount of energy spending which is not being spent by those working at home in America<sup>43</sup> and that this trend had been reported to be observed from the year of 1960.<sup>37,43</sup>

Appropriate nutrition and PA counter numerous diseases, including various cancers and obesity.<sup>44</sup> Healthy lifestyles among young adults lead to numerous psychosocial and behavioral protective factors.<sup>45</sup> Acquiring information on how and why to take up a healthy lifestyle is an essential growth need and a significant device for managing challenges occurring by the existing obesity epidemic.<sup>46-48</sup> It is vital to note that health behaviors are developed all the way through life with immense highlighting on the earlier stages of life.<sup>46</sup> The emerging adulthood is recognized as a time for excess weight gain.<sup>49</sup> During this period people tend to practice higher education, live without help and begin to build verdicts relating to their dietary habits and PA.<sup>47, 48</sup> Psychosomatic elements in the academy setting, which may reason the launching of disordered eating, comprise individual characteristics and role change, inadequate PA, dining hall food, and the accessibility and the ease of snacking on junk food.<sup>49- 51</sup> This stage, across starting late adolescence to early adulthood, is a critical phase as behaviors passed into later life are shaped.<sup>52</sup> Regrettably, poor dietary habits and declining levels of PA are coexisting currently.<sup>53-57</sup> In addition, a decision made by college students throughout this period often leads to the acceptance of damaging practices that prolong into adulthood.<sup>58,48</sup> Nevertheless, with behavior alteration promotion, healthy dietary behavior is achievable during this phase.<sup>59</sup> Thus, as healthy behaviors persist to form throughout the crucial years spent in practicing high

education, intervention at this stage may have a long-lasting impact on health promotion, weight management and disease prevention.<sup>60</sup>

Regular PA is linked to improved physical and mental health benefits, and the promotion of PA is now a top public health priority.<sup>61,62</sup> PA offers benefits at any age and regardless of prior PA history.<sup>63</sup> In spite of the many health benefits of regular PA, there are barriers to achieving sufficient levels of PA.<sup>64</sup> As per Shook et al., it has been observed that there have been higher food cravings for individuals with low levels of PA in comparison with the benchmark set by the standardized level of PA as per the theory.<sup>65</sup> Exercising voluntarily is something which is important when energy spending is considered. This is because of the aspect that the individuals getting involved in voluntary PA can be one of the major components of consideration of this voluntary act being an essential discretionary component.<sup>65</sup> This aspect of PA voluntarily by the individuals will make an impact and influence on energy balance. According to Hankinson et al., (2010) it is important to understand that after observing cases of individuals for more than 20 years of prospective study, it has been found that it is quite difficult for women to keep up high levels of PA.<sup>66</sup> Another observation was that when individuals were active during these 20 years of prospective study, they did not gain much weight. However, the individuals who were inactive tended to gain more weight and this was obvious.<sup>66</sup>

Motivational internal barriers to PA were reported to be predominate in developed countries.<sup>67,68</sup> Personal and environmental perception of barriers has a reverse relationship to PA and is reported to vary based on socio-demographic

characteristics of individual.<sup>69,71</sup> Although the perception of barriers is strongly related to PA during leisure time, this perception was reported to vary by gender.<sup>72,73</sup> Added culturally specific PA perceptions have significant inference for the design and success of PA programs.<sup>74</sup> Despite the importance on understanding the PA perceptions such context among those participating in weight management programs are among the least understood of the known influences on PA.<sup>75</sup> The conceptualization of such PA perceptions in this context comprise a relatively new area of research.

Obesity also varies with age. Aging is related with damage of body's skeletal muscle mass, and up until the age of seventy this is also accompanied with growth in body fat mass.<sup>74</sup> During this wearing out process, fat is rearranged centrally from the extremities to the trunk of the body. Bodily indices of the aging tip to advanced growth in the body fat, but also stimulate the damage of fat-free muscle mass resulting in decreased muscle function and fall related injuries.<sup>75</sup> A study indicated that with weight change, particularly among older men relatively more significant loss in lean body mass was reported with weight loss than was gained in other individuals who had a weight gain.<sup>76</sup> These findings suggested that a cycle of weight loss with subsequent weight regain, results in more sarcopenia condition than if the body weight had preserved. Further, literature review revealed that roughly one-quarter of all weight loss in older adults through deliberate weight loss interventions is fat-free mass.<sup>77</sup> These dissimilarities among others necessitate consideration when approaching weight management in older versus young adults.

A review conducted to determine the efficacy and cost-effectiveness of commercial and organized self-help weight loss programs in the USA from 1966 to 2003yr publicized that with the exemption of one trial of Weight Watchers, the confirmation to backing up the use of the key commercial and self-help weight loss programs are suboptimal.<sup>78</sup> The study warranted the need of controlled trials to draw conclusions on the efficacy of these of such programs.<sup>78</sup> In contrast with the current popularity tending towards online weight management program most of the earlier investigation in this area has focused on programs established by researchers<sup>79-82</sup> while only few studies have estimated the weight losses produced and strategies to improve such programs. One of the important strategy associated with weight loss among the successful weight loss programs that was revealed in the methodical reviews and meta-analyses have is the systematic self-monitoring of body weight and effective behavioral strategies for weight loss.<sup>83-86</sup> Providing feedback as the other strategy to enhance the value of self-monitoring has proven to facilitate weight loss in both commercial<sup>87</sup> and research-based online weight loss programs.<sup>88</sup>

### **1.5. Weight management programs and research needs**

What is unclear and underreported is the weight management programs claiming weight loss results such body weight loss whether from the body fat or the body muscle mass. Understanding this would help tailor weight management interventions to older adults and prevent undesirable outcomes in this group due to involuntary weight loss. Also understanding PA behaviors and perceptions among individuals who have successfully lost weight versus those who have not among those participating in

such weight management programs is unclear and yet to be explored. This explanation would help better tailor the weight loss efforts for enhancing positive results and perhaps maintenance. Nutrition and PA are closely related to health, and behaviors of first-year students could be improved. The university setting is an important and strategic place to promote healthy lifestyle practices such as weight management because many students are in their young adulthood (18-25y) which may be a prime period for affecting weight-related changes, understanding the possible associations with their nutrition and PA behaviors for weight management could therefore have a large avoidable burden of chronic disease.

Understanding how the use of farmers' market among young adults on college campuses and dietary/PA behavior associations has nutrition implications which has not yet been explored could lead to new directions for the future research towards decreasing the burden of chronic health disorders among populations and likewise, its alleviated results on the health care expenditure. Each of these gaps are explored and addressed as three separate chapters in this thesis.

### **1.6. Weight management review summary & Dissertation Hypothesis**

In summary obesity is a global pandemic; being overweight or obese also increases the risk of most of all chronic health conditions. A healthy eating plan and meeting PA guidelines will help lose weight and keep it off over the long term. The literature related to understanding various components and aspects of commercial weight loss programs is still unclear. Understanding some critical questions in this area that need focus is likely to help understand the unanswered aspects so far. The current study

proposes the focus on weight management among adults in varied aspects to fill in the existing gaps on enhancing dietary behaviors among young adults; understanding PA perceptions on PA levels and weight loss in adults and body composition related changes in elderly among those participating in commercial weight management programs will set the stage for future work regarding tailored weight management interventions among adults. Some of the critical questions in this context that need to be explored are mentioned below. Proper understanding of which could help open new frontiers for further research in this aspect.

**Hypothesis:**

**Study 1 Purpose:** To determine the associations between self-reported frequency of farmers' market use among young adults and dietary patterns. We hypothesize that those young adults using farmers' market may have better dietary patterns than those who do not. Proper understanding of this critical information can help cultivate and sustain healthy behaviors in this group.

**Study2 Purpose:** To examine self-reported PA behaviors and perceptions among individuals enrolled in a proprietary meal replacement program who have successfully lost weight versus those who have not. We hypothesize that PA levels and PA perceived benefits and barriers are associated to clinical significant weight loss. Those who have successfully lost weight would have reported higher PA levels than those who weren't successful losing weight. Understanding the association will set the stage for future work regarding enhancing the existing adult weight management interventions.

**Study 3 Purpose:** The purpose of this narrative review was to evaluate and synthesize the literature on studies reporting body composition changes in terms of lean mass among older adults participating in the U.S commercial weight management programs. This research will elucidate critical information regarding how a diet plan designed for adults may impact older adults in terms of weight management and will indicate additional factors potentially necessary to consider for better customization of the program for the older adults. The nature of response variation that occurs among these age groups is the critical component.

### **1.7. Dissertation Organization**

The dissertation research has yielded five chapters. The first chapter is a thorough review on weight management and existing gaps leading to the dissertation hypothesis. Chapters 2, 3 and 4 are potential articles for publications. Chapter 5 summarizes the research findings of the entire work presented in the thesis. Each chapter provides with an abstract and specific literature review. Future implications were also included, and references are provided at end of each chapter. All the tables belonging to the same chapter are provided before references of each chapter. The AMA referencing style was followed throughout the thesis.

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## CHAPTER 2. SELF-REPORTED FREQUENCY OF SHOPPING AT FARMERS' MARKETS AND ASSOCIATION WITH DIET AMONG YOUNG ADULTS

### 2.1. ABSTRACT

**Background** Chronic diseases like diabetes, obesity, and cardiovascular disease have been consistently linked with poor dietary behavior. Emerging adulthood has the potential to not only persuade the health status by practicing healthy eating behaviors that will lead to numerous psychosocial and behavioral protective factors for their own but also for next generations. Hence, it is essential to promote healthy eating behaviors among young adults throughout a diversity of possibilities and farmers' markets might be one of those potential ways, as they have been shown to do so in other populations.

**Objective** To determine the associations between self-reported frequency of farmers' market use among young adults and dietary patterns.

**Design/participants** A cross-sectional survey evaluation of (n=1,118) college freshmen with suboptimal FV consumption from eight US universities.

**Main outcome measures** Participants completed the National Cancer Institute Fruit and Vegetable Screener and questions about farmers' market use.

**Statistical analyses performed** A linear regression model was used to evaluate the relationship between farmers' market use and young adult dietary patterns.

**Results** High farmers' market use was reported by 16% of which 72% were female and 62% Caucasians. The mean BMI of all participants was  $24.1 \pm 4.3$ . Linear regression for farmers' market use and dietary behaviors resulted in significance. FV

consumption was significantly higher among high FM users (3.3 CE) compared to low farmers' users (2.2 CE). Additional analysis of dietary intake and farmers' market use revealed significance for whole grain intake (3.3Oz), among high farmers' market users to those low users at (3Oz); and whole grain bread intake (5Oz) among high farmer' market use to those low users at (4.3 Oz).

**Conclusions** Our analysis suggests that farmer's market use may help cultivate healthy eating behaviors such as enhanced FV intake among young adults.

## **2.2. INTRODUCTION**

Emerging adulthood is recognized as a time for excess weight gain.<sup>1</sup> Prior studies specific to young adult dietary patterns have revealed excess intake of dietary fat, cholesterol and sodium and insufficient intakes of vital micronutrients, such as calcium, iron, zinc, folate, and vitamins A, B6 and C.<sup>2-9</sup> Further, healthy people 2020 nation's health status report to date informed no change in obesity rates nor any increase in intake of fruit and vegetable intake. However, it reported worsened mental health outcomes concerned with major depressive episodes among adolescents and young adults.<sup>10</sup> Healthy lifestyles among young adults lead to numerous psychosocial and behavioral protective factors.<sup>11</sup> It is vital to note that health behaviors are developed all the way through life with immense highlighting on the earlier stages of life.<sup>12</sup> Growing evidence with regards to FV intake in association to better mental health with a lower incidence of depression and anxiety cases reported have also been well documented.<sup>13-18</sup> Perhaps it is essential to promote the acceptance of healthy eating behaviors among young adults throughout a diversity of possibilities. Farmers'

markets have proven to increase FV intake among other populations so, counting the encouragement of FV intake via increasing their availability by use of farmers' market could be one potential means to cultivate healthy eating among young adults.

Fruit and vegetable (FV) intake is key to achieving a well-balanced diet.<sup>19-22</sup> Studies have stated that intake of fruit and vegetables in young adulthood might guard individuals against future excess weight gain, chronic diseases and related mortality.<sup>2-5,23-32</sup> However, over 90% of women and similarly high proportions of men aged 19-30 years do not meet recommendations for FV intake.<sup>7,8</sup> The current national recommendations for young adults (19 to 30y) for FV intake is at least 2-3 cups per day.<sup>6</sup> Exploratory studies investigating effects on FV intake during young adulthood are limited.<sup>1,9,10,12</sup> Farmers' market can be one promotional tool to improve access to FV and to advance population health and lessen population health disparities potentially.<sup>1,6,12,33-36</sup>

Farm strategies, including farmers' markets, have been recommended by the Centers for Disease Control and Prevention (CDC) as an approach to raise fruit and vegetable intake through increasing accessibility and affordability of fresh fruit and vegetables.<sup>18,37</sup> Previous studies have reported the farmers' market use and dietary associations in the context of socioeconomic status, education, minority groups, rural and urban settings.<sup>35-45,46-51,52-58</sup> studies were focused on health-related outcomes such as BMI and dietary behaviors such as FV intake.<sup>35-45,46-51,52-58</sup> Further, few studies took this further and reported in an actual number of FV servings daily ( $\geq 5$ ) among those who utilized farmers' markets.<sup>50,59</sup> Despite large numbers of farmers' markets

available in the United States, little is known about their associations on dietary intake in general,<sup>42</sup> and is fairly a new area to be explored in specific to young adults.

Farmers' markets may be a feasible way to improve population-level healthy food consumption behaviors.

Majority of studies have focused on youth-based gardening programs, farmers' market nutrition programs for Special Supplemental Nutrition Program for women, infants, and children participants, the influence of farmers' market programs for elderly, and on community gardens.<sup>18,33, 35-45,46-51,52-58,58-61</sup> The likelihood and efficiency of use of farmers' market stay unknown due to the need for proper available valuation research. Understanding this existing gap in the literature will not only open avenues to explore future possibilities of research in this area but also will help enhance the current weight management efforts. This study will do so by providing insight into the association between dietary intake and farmers' market use among young adults, which will, in turn, serve as the basis for developing strategies to direct and enhance current weight management efforts. Therefore, the purpose of the current cross-sectional study is to examine the association between self-reported farmers' market use and dietary behaviors among young adults. We hypothesized a positive association between farmers' market use and healthful dietary behaviors among young adults.

## **2.3. MATERIALS AND METHODS**

### *Study Overview*

The secondary analysis of cross-sectional data examining self-reported farmers'

market shopping frequency and dietary intake is a sub-study of the Get your Fruits and Vegetables (GetFRUVED) project, which is a US Department of Agriculture multi-institutional research grant to prevent excess weight gain among young adults by encouraging healthy behaviors. Baseline data from all the participating institutions in the study were utilized for data analysis. Data were obtained during fall 2015 year from each of the eight institutions after IRB approval and after obtaining written consent from participants.

### ***Participants Recruitment and Enrollment***

For the original study, freshmen age  $\geq 18$  yrs were recruited by email, flyers, and advertising at various campus events. Data were collected in the first academic year onsite at each campus. A short survey was administered to screen for eligibility. To be eligible for participation, individuals needed to be a first-year student age  $\geq 18$  yrs that consumed  $< 2$  cup equivalents of fruits or  $< 3$  cup equivalents of vegetables. One additional criterion from the following list also needed to be met: BMI  $\geq 25$ , first-generation college student, have a parent who is overweight or obese, be of a low-income background, or a racial minority group. All the other study procedures were completed after receiving informed consent from participants.

### ***Measures***

Participants completed electronic surveys that assessed bodily measurements, lifestyle, and health-related questionnaires through a protected web-based platform. A total of 1,154 eligible surveys made the baseline data. Incomplete surveys (21), and no response surveys (15) were excluded from analysis leaving (n=1,118) for data

analysis. As part of the survey, participants self-reported demographic information including race, ethnicity, sex, GPA, work status, scholarship status, PELL financial aid, and vegetarian status. Participants also indicated frequency of shopping at farmers' markets by answering the question, "When in season, how often do you shop at farmer's markets?" which included the following Likert scale responses of 6 choices beginning with 1 Barely ever to never; Rarely (25%); Sometimes (50%); Often (75%); & Almost always. Data were dichotomized into 'high' farmers' market use for those who replied often and almost always and 'low' farmers' market use for those who responded as barely, rarely, and sometimes. Work status of participants was grouped as doing some kind of work for those who reported 1hr to >40hrs as opposed to those not doing any work reporting as zero hrs. Fruit and vegetable intake was assessed using the National Cancer Institute's (NCI) FV screener, which is a 19-item survey that captures intake of 10 categories of fruits and vegetables intake in terms of both consumption frequency and amount (in cups) over the past month.<sup>63-67</sup> As a part of normal data processing study responses were then converted to cup equivalents for data analysis and total combined fruit and vegetable cup equivalent value intake is presented in the analysis. The other diet variables whole grain, whole grain bread, red meat, cheese, milk were collected using the National Cancer Institute DSQ and were scored per instructions.<sup>67,66</sup> The NCI Fat screener of 17 items was used and scored for fat intake in past 12 months.<sup>68</sup> The NCI FV screener participant's responses have been validated.<sup>63,66,69</sup> Measured height in centimeters and weight in kilograms were used to calculate the BMI of each study participant.

### *Data Analysis*

All data were analyzed using STATA version 15. Chi-squared tests and t-tests were used to determine differences in demographic characteristics between high and low farmer's market usage groups. Linear regression was used to determine the relationship between farmers' market use and diet outcome variables while controlling for race, ethnicity, work status, and being vegetarian as these variables differed significantly between high and low FM use. The study statistical significance was set at  $P \leq 0.05$ . Marginal means for all diet outcomes by farmers' market usage group are also presented.

### **2.4. RESULTS**

Of the 1,118 freshmen participants included in this study, 16% (n=178) reported high farmers' market use of which 72% (n=122) were females and 62% (n=109) were Caucasians. Characteristic of participants grouped by Farmers' market high use and low market use are shown in Table 1. A Chi-square analysis was run on demographic variables and farmers' market use yielded significant differences for ethnicity, race, work status & being vegetarian) so, these were controlled in the further analysis.

The primary outcome variable FV consumption was significantly higher among high FM users (3.3 CE) compared to low farmers' users (2.2 CE). Additional analysis of dietary intake and farmers' market use revealed significance for Whole Grain intake (3.3Oz), among high farmers' market users to those low users at (3Oz); and Whole Grain bread intake (5Oz) among high farmers' market use to those low users at (4.3Oz). No-significance was reported for Fat intake ( $P=0.995$ ); Red meat

intake ( $P=0.269$ ); Cheese ( $p= 0.669$ ) & Milk ( $P= 0.779$ ) intake. Marginal means for all diet outcomes and farmers' market use is shown in Table 2.

## 2.5. DISCUSSION

Emerging adulthood is recognized as a time for excess weight gain.<sup>1</sup> This stage, starting late adolescence to early adulthood, is a critical phase as behaviors that are passed on into later life are shaped here.<sup>26</sup> Regrettably, poor dietary habits are overriding currently.<sup>27-31</sup> Promoting healthy dietary behaviors during this phase of life is very critical for public health.<sup>20</sup> Intake of fruit and vegetables in young adulthood might guard individuals against future excess weight gain, better mental health, chronic diseases and related mortality.<sup>2-5, 13-18, 23-32</sup> The limited ~~existing~~ research signifies that the greater part of college students eat less than the daily recommended servings of FV intake.<sup>43</sup> Further, the use of farmers' markets has been documented as one promotional tool to increase access to FV intake.<sup>51</sup> All these reasons highlighted the need for present study. The purpose of this cross-sectional study was to examine the association between self-reported farmers' market use and dietary behaviors among young adults. We hypothesized a positive association between farmers' market use and healthful dietary behaviors among young adults. Our study findings supported the initial hypotheses by revealing a significant association for high farmers' market use and FV, Whole grain and Whole grain bread intake.

The study's primary outcome FV consumption was significantly higher among high FM users (3.3 CE) compared to low farmers' users (2.2 CE). Our study findings were similar to other study findings in this context conducted among other

populations.<sup>43,64,70</sup> It means that those who utilized farmers' market had more FV intake and that farmers' market use may be further encouraged to make improved dietary choices on their own. Additional analysis revealed significance for Whole Grain intake (3.3Oz), among high farmers' market users to those low users at (3Oz); and Whole Grain bread intake (5Oz) among high farmers' market use to those low users at (4.3Oz). These results aren't surprising as farmers' market were expected to enhance healthy dietary choices. For these are the typical food groups sold at farmers' market<sup>71</sup> and that improving diets in this food groups, in general, are associated with a plethora of physical and mental health benefits.<sup>2,3,23-32,4,72,5,13-18</sup> Thus enhancing intake from these food groups would be beneficial to achieve public health goals to combat obesity and related co-morbidities.

We did not find any significance for red meat, fat, milk, and cheese intake to farmers' market usage. As we are aware of typical foods sold at the farmers' market are fresh whole fruit and vegetables, herbs, whole grain, baked foods such as whole grain bread, jams, jellies, and eggs.<sup>71</sup> Dairy products such as cheese, butter, raw milk, pickles, pies, canned home goods and meat, game, poultry all need prior permit to be sold.<sup>71</sup> This adds additional sales price to these products sold, so this could be one of the reasons that may explain why these products didn't yield any significant relationship with farmers' market use. One another explanation may be knowledge about making healthy food choices, for instance, avoid opting for red meat intake, or whole milk intake over lean meat and reduced-fat milk. Also, it could be that those using farmers' markets are more interested in choosing healthier diets. Regardless of

the explored associations on farmers' market use and dietary behaviors among young adults we acknowledge that the timeframe of the question posed to explore farmers' market use association would have influenced the number reporting farmers' market use; additionally, there may be students who take part in an on-campus meal plan may have limited their purchases at farmers' markets in both the scenarios the study findings may have been influenced.

The findings from this study are consistent with the literature review stating farmers' market as a tool to promote healthy behaviors among populations.<sup>1,6,12,18,33-36,39,62,73</sup> Interventions to increase the accessibility and affordability of FV have reported increasing fruit and vegetable intake both in the short and long term.<sup>42,47</sup> Thus, increased access and affordability may likely to enhance farmers' market use among these subjects. Acquiring information on how and why to take up a healthy lifestyle is an essential growth need and a significant device for managing challenges occurring by the existing obesity epidemic.<sup>4,6,12</sup> The farmers' markets use in connection to increasing FV intake was shown to advance population health and lessen population health disparities potentially.<sup>35,45,60,61,74</sup> Hence perhaps nutrition education could be one other component to keep populations motivated to practice farmers' market use in relation to make healthy dietary choices. One barrier identified by most of the studies was lack of or limited access to farmers' market.<sup>41,51-53,75</sup> Policies and ecological changes for increasing accessibility to healthy foods are recommended as potential solutions to combat the obesity epidemic.<sup>12</sup> Many federal programs are in place to encourage the use of farmers' market through vouchers/incentives for

increasing FV consumption, among varied population groups.<sup>38,46,47,54-56</sup> Providing with similar incentives such as vouchers to purchase healthy foods at the farmers' markets may help enhance the current intervention efforts and may be one potential solution to combat the obesity epidemic. Nevertheless, nothing to date "especially targeting towards young adults" is in place within this regard. Similar efforts aiming to enhance farmers' market use among this age group is required. As this may ultimately help enhance the public health efforts to achieve and enhance healthy dietary behaviors among populations.

This study's findings provided insights towards how to encourage and enhance healthy dietary habits among young adults. Research has also constantly shown that self-reported usage and improved access to farmers' market enhances the increased FV intake<sup>1,6,12,18,33-36,39,62,73</sup> and with better weight-related outcomes among children and adults.<sup>12,44</sup> Thus use of farmers' markets should be promoted among this age group to encourage healthy dietary behaviors. Overall, the study results support the study hypothesis that farmers' markets can be one potential tool to enhance healthy dietary behaviors among young adults.

### ***Strengths/limitations***

The study is a cross-sectional self-reported FM usage, so, there could be a high potential for recall bias. The study design does not permit to established causality. However, the study validated tools for assessing diet. We did not ask if an FM was available, we just asked if they shopped at one in self-reported data survey. Additionally, most study participants being female and Caucasians, so this would

compromise the generalizability of study findings. To combat these limitation statistical measures were taken controlling for these confounding variables in our analyses. This study has several strengths, first, being the large sample size and that the study sample is from different geographic locations and demographically different educational institution enabling a well-represented study group of interest. Secondly that it is one first study that explored this relationship specific to young adults which is an important move not only towards opening new frontiers in the research area but also for enhancing healthy behaviors to achieve public health goals.

## **2.6. FUTURE DIRECTIONS**

Future research should focus on having a longitudinal data with diverse sample representation. This will help us to establish a causal relationship and to generalize study findings to a great extent. Also, focusing on collecting qualitative data as opposed to survey data will help further the generalizability of the findings and, will help with designing and developing effective interventions. University campuses can be one potential site to branch farmers' market, thus to increase accessibility.<sup>41</sup> Collaborative and partnership efforts between universities and local community wellness groups can help bring in farmers' markets on campus thus increasing its accessibility.

## **2.7. CONCLUSIONS**

Farmers' market use is positively associated with FV intake, whole grain, and whole grain bread intake. Promoting farmers' market use among young adults could be one effective public health preventive tool to encourage and enhance FV intake. The

institution and community wellness programs should work to provide some monetary incentives as vouchers directed towards purchasing healthy foods at farmers' markets and may work towards increasing this accessibility on campus and in the local community. These collaborative extended efforts to make farmers' market accessible and affordable may help establish and maintain healthy eating behaviors thus promoting health through the lifespan and is likely to help combat the obesity epidemic.

**Table 2.1** Demographics of study population for those with high farmers' market use & those not.

<b>Variables</b>	<b>Farmers' market use High (n=178) 16%</b>	<b>Farmers' market use Low (n=940) 84%</b>	<b>(P-value≤.05)</b>
<b>Sex</b>			0.118
Male	48 (28%)	294 (34%)	
Female	122(72%)	560 (66%)	
<b>Race</b>			<b>0.038</b>
Caucasians	109(62%)	490(54%)	
Non-Caucasians	66(38%)	421(46%)	
<b>Hispanic or Latino</b>			<b>0.005</b>
Yes	19(11%)	185(20%)	
No	156(89%)	744(80%)	
<b>Relationship Status</b>			0.225
Committed	111(64%)	630(69%)	
Not-Committed	62(36%)	285(31%)	
<b>BMI</b>			0.544
Underweight ( $\leq 18.5$ )	9 (5%)	30(3%)	
Normal weight (18.5-24.9)	99 (56%)	556 (59%)	
Overweight (25-29.9)	50 (28%)	243(26%)	
Obese ( $\geq 30$ )	20 (11%)	111(12%)	
<b>Scholarship</b>			0.295
Yes	126(72%)	696 (76%)	

No	49(28%)	223(24%)	
<b>Pell Aid</b>			0.150
Yes	53(14%)	338(86%)	
No	112(17%)	551(83%)	
<b>Working</b>			<b>0.036</b>
Yes	58(34%)	238(26%)	
No	115(66%)	684(74%)	
<b>Vegetarian</b>			<b>0.002</b>
Yes	20(11%)	48 (5%)	
No	155(89%)	880(95%)	

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**Table 2.2.** Marginal means of all diet outcomes and farmers' market use from a Linear Regression model controlled for race, ethnicity, work status and being vegetarian ( $P \leq 0.05$ )

<b>Diet outcome</b>	<b>FM high User M<math>\pm</math>SE</b>	<b>FM Low-User M<math>\pm</math>SE</b>	<b>P-value</b>
<b>FV (CE)</b>	3.3 $\pm$ .16	2.2 $\pm$ .08	<b>0.000</b>
<b>Whole Grain (Oz)</b>	3.3 $\pm$ .14	3.0 $\pm$ .06	<b>0.016</b>
<b>Whole Grain Bread (Oz)</b>	5.0 $\pm$ .16	4.3 $\pm$ .06	<b>0.001</b>
<b>Fat (g)</b>	30 $\pm$ .17	30 $\pm$ .07	0.995
<b>Red meat (Oz)</b>	5.0 $\pm$ .13	5.0 $\pm$ .05	0.269
<b>Milk (CE)</b>	5.1 $\pm$ .19	5.0 $\pm$ .08	0.779
<b>Cheese (Oz)</b>	6.0 $\pm$ .13	6.0 $\pm$ .05	0.669

**Note:** CE= Cup Equivalents; g=grams; Oz- Ounce equivalents

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## **CHAPTER 3. PERCEIVED BENEFITS OF AND BARRIERS TO PHYSICAL ACTIVITY AMONG ADULTS PARTICIPATING IN A PROPRIETARY WEIGHT MANAGEMENT PROGRAM**

### **3.1. ABSTRACT**

**Background** Physical Activity (PA) is linked to improved physical and mental health benefits, and the promotion of physical activity is now a top public health priority.

Physical activity perceptions play a key mediator role in the number of people engaging in PA. However, it is the least understood area among the known influences on physical activity. Public health PA activity goals can be achieved by exploring PA benefits/barriers and addressing PA barriers for future possibilities. Health coaching as one efficient cost-effective resource may help overcome perceived PA barriers to enhance current weight management interventions.

**Objective** To examine self-reported physical activity behaviors and perceptions among individuals enrolled in a proprietary meal replacement program who have successfully lost weight versus those who have not.

**Design/participants** A cross-sectional survey evaluation of (n=1,256) current/past proprietary weight management program members  $\geq 18$  yrs.

**Main outcome measures** Participants completed the IPAQ and PA perceptions survey data.

**Statistical analyses performed** A logistic regression model was used to evaluate the relationship between Clinically Significant Weight Loss (CSWL), PA activity levels and PA perceptions.

**Results** The odds of CSWL were lower among those with higher scores for perceived PA barriers (OR=0.68, p-value=0.01). The odds of CSWL were lower among those with higher scores for time expenditure barrier sub-scale (OR=0.76, p-value=0.01). There was no difference in odds of CSWL between low vs high PA (OR=1.4, p-value= 0.53) and low vs moderate PA (OR=1.2, p-value= 0.68) and no difference in odds of CSWL between low and higher scores for overall perceived PA benefits (OR=1.2, p-value= 0.68).

**Conclusions** Our analysis suggests working towards minimizing perceived PA barriers to achieve CSWL may help enhance current adult weight management interventions.

### **3.2. INTRODUCTION**

Regular physical activity (PA) is linked to improved physical and mental health benefits, and the promotion of PA is now a top public health priority.<sup>1,2</sup> Sufficient levels of routine PA can support weight control efforts.<sup>3</sup> Despite this, PA levels are low globally and are associated with the leading causes of death.<sup>4,5</sup> In particular, women report less PA with obese women being the most inactive.<sup>6,7</sup> PA promotion is influenced by variables at and beyond the individual level and there is an interplay of individual, group, ecological and policy level variables<sup>8,9</sup> Scientific studies advancing our knowledge by investigating any of the factors that are likely to influence PA behaviors are needed.<sup>10</sup> PA perceptions are one such variable that plays a key role in whether or not people engage in PA.<sup>8,11–23,24,25</sup> There is a need for understanding the PA benefit/barriers to overcome the limited evidence and to enhance current PA promotion efforts and primary prevention strategies.<sup>26,27</sup> Additionally, studies state that health

coaches are an efficient, cost-effective resource in weight management interventions and are shown to improve participant attendance and enhance PA participation through increased motivation.<sup>28–32 33–40</sup> Health coaching may help address perceived PA barriers through increased motivation to overcome such underlying PA variables and such coaching makes effective interventions to enhance PA to achieve public health PA goals.

The PA perceived barriers and benefits are constantly cited in literature as two key cognitive mediator variables for improved PA participation.<sup>41,42</sup> PA perceived benefits are described as a person's assessment of the potential gains for performing PA, for instance, improved fitness related with engaging in a certain health behavior such as achieving CSWL, or enhanced cardiac performance.<sup>42–44</sup> While PA perceived barriers are described as a person's assessment of potential obstacles' for instance time constraint that prevent them from engaging in the healthy behavior.<sup>42–44</sup> These variables have been included in several health behavior models,<sup>25,42,45</sup> most frequently the health belief model.<sup>42,25,45–47</sup> The perception of barriers to PA has increased in developed countries, and at present, PA is practiced mainly during leisure time.<sup>11</sup> A 2017 review on PA perceptions that examined personal and ecological factors stated the need for primary prospective studies to be able to establish the various motives for PA and associations of these motives with PA.<sup>8</sup> Personal and environmental perception of barriers has an reverse relationship to PA and is reported to vary based on socio-demographic characteristics of the individual.<sup>11,13</sup> The perception of barriers is strongly related to PA during leisure time, and among those trying to lose weight this

perception was reported to vary by gender and age.<sup>14,22,48-51,52</sup> The studies on PA perceptions among weight management interventions reported PA perceived benefits in adult women to be: improved physical health,<sup>53</sup> mood lift,<sup>53</sup> more often perceiving to perform vigorous PA,<sup>54</sup> and perceived PA barriers to be time constraints,<sup>53,54</sup> and the enjoyment of PA.<sup>53</sup> While studies on PA perceptions among adult men in weight management interventions reported PA perceived benefits to be physical health and appearance,<sup>55,56</sup> social inclusion,<sup>55</sup> stress relief<sup>55</sup> and improved fitness<sup>55,56</sup> and perceived barriers as peer influence,<sup>55</sup> cost,<sup>55</sup> time management,<sup>55,56</sup> feelings of inferiority<sup>55</sup> and family upbringing.<sup>55</sup> In addition in one study lifestyle coaches documented barriers and approaches to PA after each lifestyle session targeting weight management reported that PA barriers in obese women were notably associated with access, injury, time managing, mental and social cues, and weather.<sup>57</sup> While among other study participants holidays and internal cues were noted as added variables to the stated ones in this context.<sup>57</sup> The study also reported that these barriers were reported to be less in the group that had intervened by lifestyle coaching.<sup>57</sup> We did not find any study that had worked to explore similar associations among those in commercial weight management programs. Preventive strategies to overcome such perceived PA barriers, such as health coaching, time managing, efforts to promote social contact during PA as enjoyment and community integration, are critical to accomplishing national PA recommendations.<sup>26,27,34,57,58</sup>

Understanding PA perceptions and their impact on continued engagement in PA among those in commercial weight management practices would direct us to

overcome perceived barriers to help make the most effective PA interventions. In general, from the literature review, it appeared that this is the least understood area of the known influences on PA in weight management practices. The conceptualization of such PA perceptions among those in commercial weight management programs comprises a relatively new area of research and will lead to the possibility of future possibilities for research in this area. Health coaching can help individuals adopt healthy behaviors,<sup>28-32 33-40</sup> enhance self-management strategies,<sup>59,60</sup> increase PA participation,<sup>61</sup> and improve weight loss.<sup>62</sup> Thus, health coaching can be a tool to address the perceived PA barriers to achieve public health PA goals. This study is an attempt to provide some insights into the associations between CSWL, PA levels and perceived PA benefits/barriers among those in a proprietary weight management program. We hypothesize that high PA levels and perceived PA benefits/barriers are significantly associated for those with CSWL.

### **3.3. MATERIALS AND METHODS**

#### ***Study Overview***

This secondary analysis of cross-sectional data examining physical activity benefits/barriers is part of a study aiming to identify a comprehensive list of barriers to and facilitators, of weight management among participants in a proprietary meal replacement program that incorporates health coaching. In the original study, an electronic survey was administered to 20,000 current/past proprietary weight management participants  $\geq 18$  yrs during spring 2015. The survey collected information including demographics, physical activity participation (IPAQ), and

PA perceived benefits. The study obtained IRB approval from SDSU and the Health care system related with funding for the project. Data was obtained upon written consent from participants.

### ***Participants Recruitment and Enrollment***

Of the total 20,000 electronic surveys that were sent 2,365 surveys were completed. All current/past proprietary weight management participants  $\geq 18$  yrs were eligible for the study. Three reminder emails about participation with the survey link were sent out by the program staff.

### ***Measures***

Out of the 2,365 surveys that were received a total of 932 were omitted from the analysis for either missing data (530), duplicate data (235) or for zero time for survey entry (167). In addition, we have decided to exclude data if the program length is less than one month (124) and more than a year (22) to avoid the outliers which may confound the analysis. We have also decided to exclude non-Caucasians (22) from our analysis because race has been associated with weight outcomes added, to which our sample size was very small to be included. We grouped our analysis by CSWL that omitted (9) missing data. Thus, the final sample size for our data analysis was 1,256. Eight demographic variables were included in the survey including age, gender, race, ethnicity, educational, employment, marital and income status. All the data for the study was self-reported on the questionnaire. The questions from the Exercise Benefits Barriers Scale (EBBS) were used to assess perceived PA benefits/barriers.<sup>6,50,63,64</sup> The 29 items in benefit scale were grouped in 5 domains

as life enhancement, physical performance, psychological outlook, social interaction, and preventative health.<sup>6,50,63,64</sup> While the 14 barrier items were grouped into 4 domains of exercise milieu; time expenditure; physical exertion and family discouragement.<sup>6,50,63,64</sup> This is very similar to the measures taken in other PA perception studies or to the studies that have validated the use of EBB scale for similar study purposes.<sup>6,50,63,64</sup><sup>65</sup> Each of the benefit and barriers items offered a Likert scale response choice of 4 options with 1 being 'strongly disagree'; 'disagree'; 'agree'; to 4 being 'strongly agree.' The questions grouped under each subscale was based on EBB scale that was then summed in to total and divided by the number of total questions in each subscale to obtain each subscale total score.

Information about PA levels among study participants was obtained using the International Physical Activity Questionnaire (IPAQ) long form,<sup>66</sup> which categorizes individuals as having either High, Moderate or Low levels of PA based on IPAQ long scoring<sup>56</sup> form which is validated for use from a number of other studies that have been tested and reported for validity.<sup>56,67-69</sup> Further self-reported height and weight was used to calculate the Clinical Significant Weight Loss (CSWL) in the analysis and is interpreted as  $\geq 10\%$  of body weight to their present weight status in contrast to the weight at program start date.<sup>70,71</sup> Data were then dichotomized into those who achieved CSWL and those who did not.

### ***Data Analysis***

All data were analyzed using STATA version 15. Chi-squared tests and t-tests were used to determine differences between CSWL, and Non-CSWL to understand and

control for variables that which are likely to influence analysis. Age and sex were controlled in all our analysis. There was no difference in odds of CSWL between low vs high PA (OR=1.4, p-value= 0.53) and low vs moderate PA (OR=1.2, p-value= 0.68) and no difference in odds of CSWL between low and higher scores for overall perceived PA benefits (OR=1.2, p-value= 0.68). The odds of CSWL were lower among those with higher scores for perceived PA barriers (OR=0.68, p-value=0.01). The odds of CSWL were lower among those with higher scores for time expenditure barrier sub-scale (OR=0.76, p-value=0.01). The study statistical significance was set at  $P \leq 0.05$ .

### **3.1. RESULTS**

In the study sample 1,256 a total of 71% (n=897) achieved CSWL with 70% (749) females, 71% Caucasians (886) and 72% (618) of those reported high physical activity levels in this group. Characteristics of all study participants grouped by CSWL and No-CSWL are shown in Table 1. There was no difference in odds of CSWL between low vs high PA (OR=1.4, p-value= 0.53) and low vs moderate PA (OR=1.2, p-value= 0.68). The summary t-test means and standard errors for perceived PA benefit/barrier subscales for CSWL and Non-CSWL groups along with P-values from logistic regression controlled for age and sex are presented in Table2. There was no difference in odds of CSWL between low and higher scores for overall perceived PA benefits (OR=1.2, p-value= 0.68). The odds of CSWL were lower among those with higher scores for perceived PA barriers (OR=0.68, p-value=0.01). The odds of CSWL were lower among those with higher scores for time expenditure

barrier sub-scale (OR=0.76, p-value=0.01). A Linear Regression run controlled for age and gender detailing subscale breakout is presented for perceived benefits in Table 3 and for barriers in Table 4.

### **3.2. DISCUSSION**

Having sufficient PA levels is an important behavior for health and wellness.<sup>72</sup> The significance of reducing PA barriers parallels with current policies intended at improving public PA levels,<sup>26,27,73,74</sup> and corresponds with a review of fifty studies on health behavior changes where perceived barriers were the major solitary influential predictors of health behavior.<sup>75</sup> Despite, this there is lack of detailed understanding of PA perceived barriers in research<sup>26</sup> especially among women<sup>76,77</sup> and none available among commercial weight management program participants. So, our study proposed to provide some insights into the associations between CSWL, PA levels and perceived PA benefits/barriers among those in a proprietary weight management program. Our findings report that the odds of CSWL were lower among those with higher scores for perceived PA barriers (OR=0.68, p-value=0.01) and the odds of CSWL were lower among those with higher scores for the time expenditure barrier sub-scale (OR=0.76, p-value=0.01).

Our analysis did not reveal any association between odds of CSWL and self-reported PA levels. One possible explanation could be that the focus of the proprietary weight management program in this study is primarily on diet and participants are discouraged from PA in initial phases. With no emphasis on PA by the current program for its participants, it is not surprising that our analysis did not

reveal any significant association for CSWL and Non-CSWL groups to PA levels. Regardless of high levels of PA self-reported by participants in the study that could have resulted from recall bias, and/or reporting bias by study subjects, we are aware that weight loss isn't possible without actual engagement in PA. The meal replacement program that the participants utilized in this study talks about how much PA participants should get so they are aware of needed PA. This could be one reason to explain participants overreporting their PA as they all know they should be doing PA, so they are reporting they are doing it. Earlier studies have documented self-reported PA is overreported and especially so after an intervention when subjects are learning they should be doing PA and how much they should be doing.<sup>95</sup> Not to overlook diet as another key moderator in weight management,<sup>78,79</sup> it may be a factor that may have some influence in the program under study to explain any significant differences among CSWL if present. Nevertheless, most studies focused on achieving significant weight loss outcome have attributed the results to the synergistic effects of diet and PA interventions as opposed to either one of these alone.<sup>80,81</sup> It isn't very applicable for the program in this study as it is focused on diet alone. Future studies can explore analysis for PA and diet variables separately and together for synergistic effects for CSWL groups among proprietary weight management programs to understand unexplored patterns if present where applicable.

There was no difference in the odds of CSWL between low and higher scores for overall perceived PA benefits. This could be because everyone, regardless of weight status, knows the benefits of PA. The EBBS scale framed questions for

benefits are general information of PA benefits which most of the individuals are aware of, so it is certain that we wouldn't find any differences for perceived PA benefits scale and CSWL groups. However, our study reported the odds of CSWL to be lower among those with higher scores for perceived PA barriers (OR=0.68, p-value=0.01). This is consistent with other studies that have usually focused on addressing PA perceived barriers to achieve weight loss as opposed to benefits.<sup>12,73,74,82,83</sup> The barriers are what can really tell us why someone may not have achieved CSWL. If participants are perceiving lots of barriers to PA, regardless of what they report for PA levels, they are less likely to engage in PA. Our study is cross-sectional, so temporality is an issue. We don't know if someone had barriers to PA and then didn't achieve CSWL or if they didn't achieve CSWL and therefore perceive barriers to PA. Our analysis reporting no significance for PA perceived benefits while revealing significance for PA barriers alone may be because the questionnaire uses the word "exercise" rather than PA and that people may have interpreted this differently and this could have influenced our results. Regardless, the current weight management program and wellness efforts can be enhanced by helping participants overcome such perceived barriers.<sup>26,27,34,57,58</sup> Health coaches as heightened in research findings earlier are one effective resource to keep participants motivated and to enhance self-efficacy.<sup>33-40</sup> Health coaches can conduct group sessions to keep participants motivated. They can also act as a constant support to build participant self-efficacy through social networks and interactions. Community networks and wellness programs may also be integrated for the long-term success of

such efforts. Overall by focusing on reducing perceived barriers as opposed to promoting perceived benefits alone by health coaches is likely to help enhance the current weight management program's success.

Further, a detailed analysis of subscale revealed significance for time expenditure subscale. The odds of CSWL were lower among those with higher scores for time expenditure barrier sub-scale (OR=0.76, p-value=0.01). This finding is consistent with the prior study findings,<sup>49, 84, 69, 58,82,85-89</sup> as time expenditure is the most common reported perceived barrier in literature studies regardless of age and gender. Health coaches can help identify time slots that work better for the participants and help direct them with the activities that fit within the time slot. They can also conduct classes for time management skill learning. Further, linear regression yielded significance for people feeling embarrassed to exercise within Exercise Milieu barrier Sub-scale but not for perceiving exercise tiers within the Physical Exertion barrier Sub-scale as was shown in t-test. Regardless, these two were the other common factors reported in the majority of studies next to lack of time.<sup>90-93</sup> This is certain because people often feel embarrassed to exercise since they get concerned about the perceived external judgment of their body size by others. People complaining about getting tired is also not uncommon; health coaches can intervene to help keep these participants motivated by making PA a fun process as opposed to perceived routine and by emphasizing on the long-term PA benefits.

Recent statistics published in Lancet 2016 on physical inactivity associated with compromising quality of life has a \$53.8 billion monetary cost estimated

globally in 2013.<sup>94</sup> This warrants the need for understanding underlying causes of PA inactivity and to address them to achieve public health goals. PA perceptions that help to explain PA behavior and PA environment relationships as known can play a key role in shaping the future research agenda and in linking research to tailor weight management interventions and practices. A proper understanding of perceived PA barriers will help enhance PA levels. Health coaches can help explore ways to overcome PA barriers through increased PA motivations, by enhancing time management skills, providing social and environmental supports, and tailoring weight management interventions for different subgroups of individuals.<sup>48-51</sup> Working along these lines may help decrease physical inactivity levels, and enhance the quality of life through improved weight-related outcomes.

### ***Strengths/Limitations***

This study provided some insights in to the unexplored area of PA benefits/barriers in commercial weight management participants that could help to enhance current weight management outcomes; the study has a large sample size for the target population; and finally, the study reported a detailed report of both benefits and barriers. The literature had suggested a need for future studies to design effective tailored interventions by addressing these variables.<sup>26,73,74</sup> Although most of the participants are females and Caucasians in our study which may act as limitation for generalizing the study findings however this is perceived to be a strength for this study as women were emphasized in literature not only for PA inactivity<sup>27,76</sup> but also for the need to understand differences in perceived PA benefits/barriers and PA.<sup>26,75,77</sup> One

limitation of our study is self-reported data to calculate CSWL and PA levels. Another is that we have no data on temporal relationship.

### **3.3. FUTURE DIRECTIONS**

Future research should focus on having a longitudinal study with diverse sample representation. This will help enhance causal inference and generalize study findings. This will also help explore patterns in the data. Accelerometric objective reading to collect PA levels will help obtain a more precise measure of PA levels. To enhance the validity of study findings measured height and weight as opposed to reported height and weight should be used to calculate CSWL. Focusing on collecting qualitative data in addition to quantitative data will allow a more in-depth understanding of the behavioral, emotional, and personality features within this less explored area. This will help guide with the design and development of effective tailored interventions. Overcoming physical inactivity is the current public health PA goal and studies exploring the underlying causes of physical inactivity are needed. Health coaches working towards minimizing perceived PA barriers may help enhance the current weight management intervention efforts and may be one potential solution to combat the obesity epidemic.

### **3.7. CONCLUSIONS**

Our analysis suggests that self-reported PA perceived barriers were less among those with CSWL than those in the Non-CSWL group. We did not find self-reported PA levels to differ among CSWL and Non-CSWL groups. The current weight management practices should target addressing PA perceived barriers while promoting PA perceived benefits to enhance PA levels among individuals. Health coaches as one

efficient cost-effective resource can help overcome perceived barriers to help enhance weight management outcomes. Some proven strategies like enhancing social interactions during PA, time management skill learning, working on integrating community social networks and making PA fun may work towards overcoming perceived PA barriers and enhance consistent PA participation. Efforts to target areas of improvement by health coaches are likely to help establish and maintain PA behaviors that will enhance weight-related outcomes in current weight management programs.

**Table 3.1.** Differences in participants (n=1256) demographics grouped by CSWL and No-CSWL

	<b>Clinically Sig wt. loss (n=897) 71%</b>	<b>Non- Clinically Sig wt. loss (n=359) 29%</b>	<b>p-value</b>
<b>Sex</b>			
Male	136(15%)	39(11%)	<b>0.047</b>
Female	749(85%)	315 (89%)	
<b>Race</b>			
Caucasians	886(71%)	356(29%)	
<b>Education</b>			
College Graduate or higher	488(55%)	190(53%)	0.173
Some College	317(35%)	142 (40%)	
High School or Less	90(10%)	26(7%)	
<b>Hispanic or Latino</b>			
Yes	11(1%)	4 (1%)	0.862
No	874(99%)	352(99%)	
<b>Marital Status</b>			
Divorced/Widowed/Separated/Never married	201(22%)	72 (20%)	0.396
Married/Living with Partner	708(78%)	294 (80%)	
<b>Income</b>			
\$30,000-79,999	319(36%)	141 (31%)	0.717
\$80,000-119,000	292(33%)	114 (26%)	
< \$30,000	51(6%)	114 (26%)	
≥\$120,000	217(25%)	78(17%)	
<b>Employed</b>			
Yes	779(87%)	315(88%)	0.596
No	115(13%)	42(12%)	

<b>Physical Activity level</b>			0.458
High level	618(69%)	235(66%)	
Moderate level	270(30%)	119(33%)	
Low level	9(1%)	5 (1%)	

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**Table 3.2.** Summary of PA perceived benefits & barriers subscales for those in CSWL & Non-CSWL groups run for t-test with logistic run OR & P-values controlled for age & sex. Score scale for PA benefits/barriers to range from a 4-point response.

	<b>CSWL M(SE)</b>	<b>Non- CSWL M(SE)</b>	<b>P-value</b>
<b>PA perceived Benefits</b>			
Life Enhancement	3.1±.01	3.1±.02	0.57
Physical Performance	3.3±.01	3.3±.02	0.52
Psychological Outlook	3.1 ±.01	3.1±.02	0.45
Social Interaction	2.5±.02	2.4±.03	0.26
Preventive Health	3.2±.01	3.2±.02	0.53
<b>All Benefit scales</b>	3.1±.01	3.1±.02	0.45
<b>PA perceived Barriers</b>			
Exercise Milieu	1.8±.01	1.9±.02	0.10
<b>Time Expenditure</b>	2.1±.02	2.2±.03	<b>0.01</b>
Physical Exertion	2.6±.02	2.6±.03	0.14
Family Subscale	1.9±.02	2.0±.03	0.30
<b>All Barrier scales</b>	2.0±.01	2.1±.02	<b>0.01</b>

\*Adapted from the EBBS.<sup>56, 57, 74, 95</sup>; M=Mean; SE= Standard Error; OR-Odds Ratio; P=≤0.05

**Table3.3** PA Benefit for each questionnaire item within subscales for those in CSWL & Non CSWL. Linear Regression ( $P \leq 0.05$ ). Score scale for PA benefits/barriers to range from a 4-point response.

<b>PA Benefit Sub-scale</b>	<b>CSWL M(SE)</b>	<b>Non- CSWL M(SE)</b>	<b>P-value</b>
<b>Life Enhancement Sub-scale</b>			
25: My disposition is improved by exercise	3.1±.02	3.1±.03	0.88
26: Exercising helps me sleep better at night	3.1 ±.02	3.1±.03	0.71
29: Exercise helps me decrease fatigue	3.0 ±.02	3.0 ±.03	0.87
32: Exercising improves my self-concept	3.2±.02	3.2±.03	0.79
34: Exercising increases my mental alertness	3.2±.02	3.1±.03	0.71
35: Exercise allows me to carry out normal activities without becoming tired	3.1±.01	3.1±.03	0.12
36: Exercise improves the quality of my work	3.0 ±.02	3.0±.03	0.77
41: Exercise improves overall body functioning for me	3.2 ±.01	3.2±.02	0.23
<b>Life Enhancement Subscale Total</b>	3.1±.01	3.1±.02	0.57
<b>Physical Performance Sub-scale</b>			
7: Exercise increases my muscle strength	3.4 ±.01	3.3±.02	0.59
15: Exercising increases my level of physical fitness	3.4 ±.01	3.4±.02	0.86
17: My muscle tone is improved with exercise.	3.3 ±.01	3.3±.03	0.42
18: Exercising improves functioning of my cardiovascular system.	3.4 ±.01	3.4±.02	0.49
22: Exercise increases my stamina	3.3±.01	3.3±.02	0.75
23: Exercise improves my flexibility	3.3±.01	3.2±.01	0.34
31: My physical endurance is improved by exercising	3.3±.01	3.3±.01	0.96

43: Exercise improves the way my body looks	3.4±.01	3.3±.02	0.31
<b>Physical Performance Subscale Total</b>	3.3±.01	3.3±.02	0.52
Psychological Outlook Sub-scale			
1: I enjoy exercise	2.8 ±.02	2.7±.04	0.49
2: Exercise decreases feelings of stress and tension for me	3.1±.02	3.2±.03	0.77
3: Exercise improves my mental health	3.2±.02	3.2±.03	0.96
8: Exercise gives me a sense of personal accomplishment	3.4±.02	3.3±.03	0.18
10: Exercising makes me feel relaxed	3.0 ±.02	3.0±.03	0.40
20: I have improved feelings of wellbeing from exercise	3.3±.02	3.2±.03	0.19
<b>Psychological Outlook Subscale Total</b>	3.1±.01	3.1±.02	0.46
Social Interaction Sub-scale			
11: Exercising lets me have contact with friends and persons I enjoy	2.5 ±.02	2.4±.04	0.31
30: Exercising is a good way for me to meet new people	2.4±.02	2.4±.04	0.89
38: Exercise is good entertainment for me	2.6±.02	2.5±.04	0.31
39: Exercising increases my acceptance by others	2.4±.02	2.3±.04	0.25
<b>Social Interaction Subscale Total</b>	2.5±.02	2.4±.03	0.26
Preventive Health Sub-scale			
5: I will prevent heart attacks by exercising	3.3±.02	3.3±.03	0.81
13: Exercising will keep me from having high blood pressure	3.2±.02	3.2±.03	0.79
27: I will live longer if I exercise	3.2±.01	3.3±.03	0.44
<b>Preventive Health Subscale Total</b>	3.2±.01	3.2±.02	0.53
<b>All Subscales Benefit items</b>	3.1±.01	3.1±.02	0.36

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\* Adapted from the EBBS<sup>56, 57, 74,95</sup>; M=mean; SE= Standard Error; P= $\leq$ 0.05

**Table 3.4.** PA Barrier for each questionnaire item within subscales for those in CSWL & Non-CSWL Linear Regression ( $P \leq 0.05$ ). Score scale for PA benefits/barriers to range from a 4-point response.

<b>Perceived Barrier Items (n=14)</b>	<b>M(SD) CSWL</b>	<b>Non- CSWL M(SD)</b>	<b>P- value</b>
<b>Exercise Milieu Sub-scale</b>			
9: Places for me to exercise are too far away	2.0±.02	2.0±.04	0.29
12: I am too embarrassed to exercise	2.0±.02	2.0±.04	<b>0.02</b>
14: It costs too much money to exercise	2.0±.02	2.0±.03	0.20
16: Exercise facilities do not have convenient schedules for me	2.0±.02	2.0±.04	0.44
28: I think people in exercise clothes look funny	2.0±.02	2.0±.03	0.54
42: There are too few places for me to exercise	2.0±.02	2.0±.03	0.16
<b>Exercise Milieu Total Subscale</b>	2.0±.01	2.0±.02	0.10
<b>Time Expenditure Sub-scale</b>			
<b>4: Exercising takes too much of my time</b>	2.3±.02	2.4±.03	<b>0.02</b>
<b>24: Exercise takes too much time from family relationships</b>	2.0±.02	2.1±.03	<b>0.02</b>
<b>37: Exercise takes too much time from my family responsibilities</b>	2.0±.02	2.1±.04	<b>0.05</b>
<b>Time Expenditure Subscale Total</b>	2.1±.02	2.2±.03	<b>0.01</b>

Physical Exertion Sub-scale			
6: Exercise tires me	3.0±.02	3.0±.03	0.09
19: I am fatigued by exercise	2.4±.02	3.0±.03	0.51
40: Exercise is hard work for me	3.0±.02	3.0±.04	0.17
<b>Physical Exertion Sub-Scale Total</b>	<b>3.0±.02</b>	<b>3.0±.03</b>	<b>0.14</b>
Family Discouragement Sub-scale			
21: My spouse (or significant other) does not encourage exercising	2.0±.02	2.0±.03	0.41
33: My family members do not encourage me to exercise	2.0±.02	2.0±.04	0.34
<b>Family Subscale Total</b>	<b>2.0 ±.02</b>	<b>2.0±.04</b>	<b>0.30</b>
<b>All Subscales Barriers items</b>	<b>2.0±.01</b>	<b>2.1±.02</b>	<b>0.01</b>

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\* Adapted from the EBBS<sup>56, 57, 74, 95</sup>; M=mean; SE= Standard Error; P= $\leq$ 0.05

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**CHAPTER 4. WEIGHT LOSS AND BODY COMPOSITION CHANGES IN  
OLDER ADULTS USING COMMERCIAL WEIGHT MANAGEMENT  
PROGRAMS IN THE UNITED STATES: A NARRATIVE REVIEW**

**4.1. ABSTRACT**

Body composition changes that vary with age and with weight change are of concern especially among older adults participating in commercial weight loss programs. The health implications associated with weight loss in older adults relates to adverse health effects and even death. Commercial weight management practices claiming program efficacy in terms of achieving weight loss often fails to report in terms of body composition changes. The available research in this area is far limited to generalize the study findings across diverse groups. The purpose of the current review is to comprehend and evaluate the existing studies reporting body compositing changes in terms of lean mass among adults participating in the U.S commercial weight management programs. Understanding the guide of body weight and body-composition change across age groups in diverse populations and the variables that influence such change will help develop the most suitable point in a time efficient weight management approaches. Three studies were found that reported on body composition changes in terms of both lean mass and fat mass. Two studies had a good conservation of lean mass and included the outcomes during the maintenance phase. Age-appropriate tailored weight loss interventions to avoid adverse health effects can be possible through more studies on elderly for appropriate valuation of research. Future studies should focus on

including a high-quality assessment of body composition changes at all stages of weight management programs as this is important to provide a less confounded measure of the effectiveness of current interventions.

## 4.2. INTRODUCTION

Body composition is directly related to health<sup>1-3</sup> and is primarily comprised of lean mass and fat mass.<sup>1-3</sup> Body weight change as a result of a normal aging process or as a part of voluntary weight loss brings about changes in both fat and lean mass body composition.<sup>1-3</sup> A normal balance of body fat that varies with age and sex ( 9-19% - Men and 14%-25% in Women)<sup>4</sup> is associated with good health and longevity.<sup>1-3</sup> Excess fat in relation to lean mass can lead to health disorders.<sup>1-3</sup> As we age body not only experiences growth in the body fat,<sup>5,6</sup> but also experiences stimulated damage of lean muscle mass that results in decreased muscle function.<sup>5</sup> Added, to which the proportion of damage in lean mass is also influenced by a change in body weight.<sup>7,8</sup> Decline in lean muscle mass is associated with weakness, disability, and even death.<sup>5,6,9,10</sup> The precise evaluation of body composition changes is essential to estimate the contribution of fat mass and lean mass to overall body mass composition change as an evaluation of the efficiency of weight management interventions.<sup>1-3,11-13</sup>

The literature review revealed that roughly one-quarter of all weight loss in older adults through deliberate weight loss interventions is lean mass.<sup>14-20</sup> The studies have also stated the older age group's failure to preserve lean mass not only with weight loss<sup>7,8,13,19,21,22</sup> but also with weight change<sup>23</sup> that can result in adverse health conditions.<sup>8,13,19,21-23</sup> In comparison to other prolonged health conditions, there is a small literature base supporting the profits of weight loss in older adults.<sup>24-27</sup> With

regards to the younger group, numerous studies have reported age-related increases in body weight and fatness and decreases in lean mass after young adulthood.<sup>19,28-30</sup> A recent study exploring age-related decreases in lean mass reported that lean mass gets diminished rapidly among young adults and further worsens unusually with high loss among women and older adults.<sup>19</sup> This could be of concern particularly among those participating in weight loss programs. These dissimilarities among age groups and sex for body composition changes among others highlight the need for further research in this area and necessitates consideration when approaching for weight management practices in older versus young adults.

A cohort study conducted for four years exploring age-related associations between weight loss/gain and variations in lean Vs fat mass using DXA among older adults reported that men lost more lean mass with weight loss as opposed to women. For in both sexes those who had weight gain experienced less lean mass gain. Further, regardless of direction of weight change both men and women reported increase in fat mass as opposed to lean mass. The study results convey that weight loss among elderly has potential to advance sarcopenia.<sup>13</sup> Further, a systematic review that measured the effects of diet and physical activity intervention on lean mass changes in above normal weight young and older adults reported exercise as a powerful tool to achieve modest weight loss that will help conserve lean mass in both genders  $\geq 50$  yrs thus combating sarcopenia.<sup>31</sup> Earlier reviews and meta-analysis exploring intentional weight loss in older adults from lifestyle interventions that incorporated both diet and exercise have also stated a significant weight loss and improved clinical parameters in most of the

cases.<sup>32,33</sup> This affirms the importance of exercise as opposed to diet alone weight management interventions among elderly.

Numerous national institutions recommended reduced calorie diet, exercise and behavioral change gears as inclusive lifestyle weight management program for those above normal weight to achieve a clinically meaningful 5-10% weight loss within six months in there proposed weight management guidelines.<sup>34,35</sup> Proprietary and commercial weight management programs that have evidence of being safe and effective among those practicing within the above guidelines are supported for weight management practices among adults.<sup>35-41</sup> As per the available statistics on commercial weight management programs in the U.S., the recent one being in 2014 stated a projected spend of \$2.5 billion by Americans on these services.<sup>42,43</sup> Added the leading market share was said to be dominated by Weight Watchers, Nutri-System, and Jenny Craig.<sup>42-44</sup> How most of the existing commercial weight management practices differ from life- style intervention trials is that most of them focus on diet alone interventions.<sup>42-45</sup> Mostly an increased protein decreased fat and calorie diet.<sup>42-45</sup> The exercise is a powerful tool to combat sarcopenic obesity<sup>31,46</sup> and is not as much incorporated in these commercial practices. Although the number of commercial weight loss programs has increased the past reviews of these programs have exposed the lack of scientific, peer-reviewed data from most programs.<sup>47,48</sup>

Among commercial weight management practices, only a couple of studies reported in terms of lean mass body composition changes,<sup>38,49</sup> A 2015 systematic review on commercial or proprietary weight management programs among adults

included all randomized clinical trials that were  $\geq 12$  weeks and up to 12 months although reported weight loss none of these studies mentioned weight loss in terms of body composition changes fat Vs lean mass.<sup>43</sup> Other similar studies among adults  $\geq 18$ yr affirmed this lack of documentation in terms of lean mass changes among weight management programs.<sup>35,36,48</sup> Of the most available studies in this area very few are randomized controlled trials, very few reported weight loss in terms of clinically significant weight loss, only few in terms of lean mass changes, most reported lack of blinding, high attrition rates, lack of age differed variation in body composition changes in response to interventions and most of the current studies were in urban settings.<sup>35,36,38,43,48-50</sup> This further highlights the need for further research in this area. The known need and importance of expanding our understanding this less explored area if left unaddressed would be of public health concern. Determining body-composition changes in older adults participating in commercial weight management programs is needed due adverse health implications associated with inappropriate weight loss in this group. Further, research in this area will help to develop the most suitable point in a time efficient weight management approaches.

Research describing the lean mass changes and in between gender among elderly is challenging to synthesize because of lack of valid research in existing studies. The decrease of fat mass and conservation of lean mass should deliver maximal weight management benefits. This is essential to avoid adverse health conditions among elderly and must be further explored. Despite the challenges of synthesizing available research and scarcity of documented research in this area of body composition changes among commercial weight management elderly participants it is critical to understand what

about these practices that if unexplored may potentially harm populations and may lead to increased mortality. Therefore, the purpose of this narrative review was to evaluate and synthesize the literature on studies reporting body composition changes in terms of lean mass among older adults participating in the U.S commercial weight management programs.

### **4.3. METHODS**

PubMed was searched for peer-reviewed articles published from January 1, 2010, through June 30, 2018. Search terms included body composition, body composition changes, commercial weight management programs, weight loss programs, weight control programs, weight change, adults, older adults, younger adults, DXA Dual-energy X-ray absorptiometry, Magnetic Resonance Imaging (MRI), varied age groups, gender and age differences, proprietary meal replacement programs, commercial lifestyle intervention programs. Additional search terms were on top ten commercial weight management programs in the U.S <sup>43</sup> these were: Weight Watchers, Jenny Craig, Nutrisystem, Profile, Medi-fast, Opti fast, Atkins, Biggest Loser Club, e-Diets, HMR, Lose it! with a blend of any or of all the earlier terms. A snowball approach permitted the scrutiny of references in recognized articles, and in addition to more articles as relevant. Articles limiting to randomized controlled trial studies on commercial lifestyle weight management programs for general public in the United States reporting body composition changes in terms of lean mass changes among adults for at least 12 weeks were included in this review. The retrospective reviews, <sup>35,51</sup> systemic reviews<sup>43,48,52</sup> and others not meeting the inclusion criteria were excluded from the review.

#### 4.4. RESULTS

Overall only three studies met the search inclusion criteria.<sup>38,49,53</sup> All the randomized controlled trial studies reported outcomes in terms of both lean mass and fat mass changes.<sup>38,49,53</sup>

##### *Body composition changes outcome*

All the three studies reported body composition changes in terms of fat vs lean mass changes are summarized in Table 1. The studies that meet search inclusion criteria were on Medi-fast meal plan replacement program.<sup>38,49</sup> The program is a combination of weekly once counseling with diet and PA inclusive in it.<sup>38,49</sup> The Medi-fast meal plans are grouped as two major types of regular weight loss plans 4, 2 and 1 plan, that is suggested for older men  $\geq 65$  yrs or those who have individual behavioral preferences another plan is 5 and 1 plan which is somewhat higher calorie weight loss plan.<sup>35,38,49,51</sup> Irrespective all the meal plans were designed to provide sufficient protein to support retention of lean mass during weight loss.<sup>35,38,49,51</sup>

A 2010 study by Davis and colleagues was a forty-week randomized controlled trial conducted among 90 obese adults 18-65 yrs for a length of 16 and 24 weeks follow up period.<sup>38</sup> The weight management participants aligned either to a Medi-fast plan or an isocaloric diet plan to evaluate body weight, body composition, inflammatory and oxidative markers.<sup>38</sup> A decrease in body fat of 13.6% from baseline and 5.2% lean mass increase was reported for those in Medi-fast group while those in other arm reported a 2.7% decrease in body fat mass with no change in lean mass.<sup>38</sup> Inflammatory markers and oxidative stress indicators of study interest were reported to be improved in both

groups.<sup>38</sup> The study concludes the efficacy of Medi-fast in initial weight loss and improved body composition, inflammatory and oxidative stress markers.<sup>38</sup>

Shikany and colleagues randomized controlled trial among 120 obese participants aged 19–65 years, were either subjected to Medi-fast 5 and 1 plan arm or the reduced calorie diet plan.<sup>49</sup> The data was collected at 3 points of time (baseline, 26 and 52 weeks) on body weight and body composition changes were measured.<sup>49</sup> In comparison to baseline at 26 weeks a reduction in 7.5kg body weight loss, 6.4kg in body fat and decrease in 1.2kg lean mass was reported in Medi-fast group versus 3.8kg in body weight loss and 3.7kg reduction in body fat and 0.2kg lean mass was reported among participants in the other arm.<sup>49</sup> However, for lean mass percentage an increase with 2.9 in the Medi-fast group and 1.9 in another arm was reported.<sup>49</sup> Further, in comparison to baseline at 52 weeks a reduction in 4.7kg body weight loss, 4.1kg in body fat and increase in 0.6kg lean mass was reported in Medi-fast group versus a decrease in 1.9kg in body weight and 1.9kg reduction in body fat and no change in lean mass 0.0kg reported among participants in the other arm.<sup>49</sup> In terms of lean mass percentage increase in 1.9 in Medi-fast and 1.1 in another arm was reported.<sup>49</sup>

Beavers and colleagues 2015 study was a single blinded randomized controlled trial in a small sample size (n=24) conducted for a 12-week period in obese adults aged 60–79 yrs.<sup>53</sup> The study was intervened by a soy based Medi-fast meal replacement products in addition to prepared products. Body composition changes were measured using DXA.<sup>53</sup> The study reported no significant body composition changes.<sup>53</sup>

## 4.5. DISCUSSION

### Summary of Findings

Three articles were identified that compared body composition changes in a particular weight management program among adults.<sup>38,49,53</sup> Among the studies assessing body composition changes both used bioelectrical impedance to report changes in body composition.<sup>38,49</sup> The pilot study reported the use of DXA to measure body composition changes.<sup>53</sup> Females were the majority in all the three trials.<sup>38,49,53</sup> The randomized trial in a yearlong and relatively in greater sample size reported a significant decrease in fat mass and increase in lean mass.<sup>49</sup> Similarly, the other randomized trial on Medi-fast plan 5 and 1 reported a rise in the percent of lean mass by the end of the intervention.<sup>38</sup> The participants in two trials were  $\leq 65$  yrs<sup>38,49</sup> and for the pilot study participants were 60–79yr old.<sup>53</sup> This clearly states the need for having more randomized controlled trials in particular among older adults.

Although the number of commercial weight loss programs has increased, aligning with the results from past reviews of these programs we conclude the need for more scientific, peer-reviewed data from most programs.<sup>47,48</sup> It is also, important to note that two studies from our search have body composition data provided by using bioelectrical impedance<sup>38,49</sup> and one using DXA.<sup>53</sup> Literature review reveals there are several approaches that were used to measure body composition changes, all with changing degrees of reliability and validity.<sup>46</sup> The bioelectrical impedance measures are dependent on the ratio of body water electrolyte conduction per lean mass.<sup>64</sup> With age the body hydration levels vary and such variations are likely to increase error in reporting body composition changes.<sup>65-67</sup> It is apparent from our review that there is a

need for studies that utilized the use of DXA or full body MRI to measure body composition changes. The validation for this was to disregard other methods that depend on numerical norms of lean mass hydration and density which may be imprecise for overweight entities.<sup>54-56</sup> DXA or full body MRI approaches are extra sensitive to variations in lean body mass related to others.<sup>57-59</sup> Perhaps, there is a need for studies that use these approaches to increase the validity of the data analysis.

The studies in our review were diet and PA based interventions fitting the national recommendations for safe and effective lifestyle weight loss management practices.<sup>34-41</sup> which could be one possible explanation for having conserved or increased lean mass reported by these studies.<sup>38,49</sup> While one of the study did not revealed any significant association in the same program could be explained by more emphasis on diet alone.<sup>53</sup> Another possible explanation could be blinding and use of DXA that were absent in other two trials adds strength to this study findings as these approaches minimize bias in reporting results.<sup>53</sup> Historically weight management programs seemed to highlight diet alone in their practices.<sup>42-45</sup> Despite of well-established role of exercise in the weight change cycle among weight management programs.<sup>31,46</sup> The programs focused on weight management practices should incorporate a combination approach of diet and exercise as opposed to diet alone to achieve better possible weight related body composition change outcomes. The scientific studies documenting the changes in body composition by diet, exercise and for synergistic intervention effects at varied stages of weight changes among those participating commercial weight management programs aligning with previous work in this area will help enhance our understanding in this area.

The other common concerns among the majority of studies in this area were: Scarcity of studies that measured weight loss in terms of clinically significant weight loss, studies reporting in terms of lean mass changes, lack of blinding among trials, high attrition rates and that majority appeared to be conducted in urban settings.<sup>35,36,38,43,49,50</sup> Two of the three randomized trial studies from our review also lacked blinding.<sup>38,49</sup> Studies mainly conducted in urban settings would have received funding from weight management programs added to no blinding the validity of these studies need to be questioned.

Further, in the review, two retrospective chart reviews that reported results in terms of lean mass changes that have used biomedical impendence to do so were identified.<sup>35,51</sup> The retrospective electronic chart review by Coleman and colleagues among (n=310) above normal weight adult clients aged  $\geq 18$  yrs that followed Medi-fast 4,2, & 1 meal replacement plans at one of its twenty-one centers tested the effect of this program on weight loss, body composition and cardiometabolic risk factors grouping data to  $\leq 65$  yrs and  $\geq 65$  yrs.<sup>35</sup> The data was tested at 12, 24 weeks and for follow up at 34 weeks.<sup>35</sup> Both the group participants reported significant weight reductions with preservation of lean mass.<sup>35</sup> Additionally the analysis reported more loss in fat mass among male participants.<sup>35</sup> Such gender differences reporting lost in fat mass were earlier reported by other studies.<sup>60,61</sup> However randomized trials are required to affirm the extent of group response variations in commercial weight management practices.

Yet, another retrospective reviews by Coleman and colleagues retrospective electronic chart 2012 review (n = 185) to evaluate efficacy of Medi-fast meal plans in overweight and obese adults 18 yrs-70 yrs.<sup>51</sup> The study included (n = 446) subjects and

evaluated for post intervention changes in body weight, body composition with other health measures at 4,12 and 24 weeks.<sup>51</sup> The study reported that all visits together presented a decrease in 15% of body fat mass and an increase of 13.9% lean mass.<sup>51</sup> Both these retrospective reviews reported data from bioelectrical impedance.<sup>35,51</sup> This kind of studies limits the randomization and of having a control group included in the analysis.<sup>35,51</sup> Predefined windows for data points were set but because of missing data as a result of the high participant attrition rate at the given point the outcomes were available only for fewer study samples.<sup>35,51</sup> This has been a historical limitation for many commercial weight management studies conducted in general,<sup>43,50,52</sup> However more studies among adults with less attrition rates will give us some insights in to the underlying variables in commercial weight management practices.

Overall from the review it appears that the robust methodological research studies reporting in terms of body composition changes are lacking among elderly participating in weigh management programs. Gender varied response differences to weight management interventions that were reported in few studies seems inconclusive and warranties the need to be further explored. Having known the adverse health implications attached to unhealthy weight loss among elderly the scarcity of research in this area raises a potential public health threat. Most of the current commercial programs are intervened by diet alone focusing on incorporating exercise would help enhance weight outcomes. The need for more randomized clinical trials had been mentioned in earlier reviews and the present review adds to this by emphasizing on lack of studies not only in general but also to older adults. The current review reveals the additional gaps such as the need for appropriate designed methodological studies,

diverse study groups, use of more standardized robust measurements to indicate body composition changes and need for studies among elderly and for the studies in rural settings. Conserving lean mass is equally important as focusing on reducing fat mass in terms of attaining meaningful weight loss. The current weight management programs should aim towards conserving lean mass through a sex and age-appropriate intervention in elderly to achieve meaningful weight loss among program participants and to avoid adverse public health concerns in its absence.

#### **4.6. EVALUATION OF LITERATURE AND FUTURE RESEARCH NEEDS**

The results from these studies lay the groundwork for beginning to understand body composition changes among elderly in commercial weight management programs. The response variation based on age and gender differences within this group among these programs. The results from these studies in the review are from the same commercial program with most lacking blinding, thus there is a great potential for publication bias. Further because of the small sample size in most of the studies the results must be interpreted with caution, and care must be taken not to overgeneralize the study findings. Two studies reported a greater decrease in fat mass and reported conserved or increased percent lean mass among adults by the end of the intervention period.<sup>38,49</sup> One of the single blinded study using DXA in the same program reported no such significance intervention effect.<sup>53</sup> This type of data is very much useful to help show the existing need and to appropriately design studies that would fill in the existing gap and thereby to prevent possible public health concerns that may leave unaddressed if unexplored. Further, the need for more robust validation research in this area is also heightened in reviews.<sup>48-50</sup> The factor that may be explored as in one of the review is

reporting the analysis in terms of absolute lean mass<sup>35</sup> particularly among older adults<sup>35,51</sup> and the application of DXA to report body composition changes<sup>53</sup> blinding of the trials and need for randomized trials and prospective studies would enhance our understanding further in this area. The female group dominated both the studies in the review.<sup>35,38,49,51</sup> The relation of lean mass and fat mass to body composition changes as we age<sup>63</sup> hence there is a need for a more elderly groups to be considered for in future studies to understand the differing influence of commercial weight management practices. This review elucidates critical need for information regarding on how commercial weight management practices designed for adults may impact participants especially among older adults regarding weight management. The review also indicates additional factors potentially necessary to consider for better customization of the program for the older adults.

#### **4.7. CONCLUSIONS**

If a disparity exists in body composition changes across commercial weight management programs and among varied gender and age groups, it is expected that diet plan and exercise as a part of the weight management plan would be contributing factors and that it would differ between age groups. The research that currently exists on this topic is scarce and has a high potential for publication bias. This could be in part because most of them are limiting their reports in terms of weight loss which is perceived to be one a factor to show a program's efficacy. However, things like, how the data has been collected and in-depth analyzed for body composition changes among elderly and for gender differences within would give a clear idea and understanding on the areas of improvement to attain desirable results and to avoid adverse conditions in

elderly that may occur in its absence. Conserving lean mass along with reducing fat mass should be the priority of elderly weight management programs. The current weight management programs should aim towards preserving lean mass and work towards elderly tailored diet and exercise incorporated weight management interventions to achieve best weight related outcomes.

**Table 4.1. Summary of studies comparing body composition changes in commercial weight management programs**

Author, Year, reference	Study Size age	Design	Measure tools	Intervention	Comparison group	Body composition change Outcome	
						Fat Mass loss	Lean Mass
<b>Davis et.al., 2010</b> <sup>38</sup>	(n=90) 18-65yr	RCT	BI	Medi-fast 5&1 plan	Iso-caloric food-based plan ~1000 kilocalories (kcal) per day	2.9%↓	4.5%↑
<b>Shikany et.al., 2013</b> <sup>49</sup>	(n=120) 19-65yr	RCT	BI	Medi-fast 5&1 plan	Isoenergetic, food-based diet	-4.7 kg↓	1.9%↑
<b>Beavers et.al., 2015</b> <sup>53</sup>	(n=24)	RCT single blinded	DXA	Medi-fast meal replacement product	Non-soy-based protein meal replacement group	No signifi- cance change	No signifi- cance change

**RCT-Randomized control trial BI-bioelectrical Impedance; DXA-Dual X-ray Absorptiometry; ↓=decrease; ↑=increase**

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## CHAPTER5: CONCLUSIONS

The central theme of this work is around weight management in adults which is a relevant and timely topic given the prevalence of overweight and obesity today and the financial burden it places on individuals and the healthcare system. Our findings conclude that farmers' market use as a feasible tool may help enhance dietary eating behaviors among young adults. Perceived PA barriers are to be addressed while promoting PA benefits to enhance weight related outcomes among adults. Perhaps, health coaches can help address the perceived barriers to PA by improved motivation, self-efficacy and time managing skills. Furthermore, properly designed studies are required to understand body composition changes among elderly participating in commercial weight management programs. The current weight management practices among elderly should consider incorporating both diet and PA and have a tailored intervention in place for elderly to enhance weight loss related outcomes. The findings of this dissertation did set the stage for future work regarding the ways to enhance the existing weight management interventions and elucidated the critical information for future research by indicating potential factors necessary to be considered for better customization of the existing adult weight management interventions. Overall the work contributes by indicating ways to enhance current obesity prevention efforts and weight management strategies among adults as a step towards addressing the obesity pandemic.