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Georgia State University

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This thesis, THE USE OF INDIRECT CALORIMETRY TO ACCURATELY ASSESS ENERGY NEEDS IN MEMBERS OF THE GEORGIA STATE UNIVERISTY STUDENT RECREATION CENTER AND A COMPARISON OF NUTRITION SERVICES AVAILABLE TO STUDENTS ON URBAN COLLEGE CAMPUSES, by Leslie S. Knapp was prepared under the direction of the Master's Thesis Advisory Committee. It is accepted by the committee members in partial fulfillment of the requirements for the degree Master of Science in the Byrdine F. Lewis School of Nursing and Health Professions, Georgia State University. The Master's Thesis Advisory Committee, as representatives of the faculty, certify that this thesis has met all standards of excellence and scholarship as determined by the faculty.

Sarah T. Henes, PhD, RD, LD
Committee Chair

Barbara Hopkins, MMSc, RD, LD
Committee Member

Caroline L. Dotts, MSA, ACSM HFS
Committee Member

Date

AUTHOR'S STATEMENT

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Leslie S. Knapp
3676 School Street
Chamblee, GA 30341

The director of this thesis is:

Sarah T. Henes, PhD, RD, LD
Assistant Professor
Department of Nutrition
Byrdine F. Lewis School of Nursing and Health Professions
Georgia State University
Atlanta, Georgia 30302

VITA

Leslie S. Knapp

ADDRESS: 3676 School St.
Chamblee, GA 30341

EDUCATION: M.S. 2014 Georgia State University
Health Sciences – Nutrition
B.B.A. 2005 Western Michigan University
Business Administration
B.A. 2005 Western Michigan University
Public Relations

PROFESSIONAL EXPERIENCE:

- Dining Hall Nutritionist 2013-2014
Piedmont & Patton Dining Halls
Georgia State University, Atlanta, GA
- Server 2007-2012
Seasons 52 Fresh Grill & Wine Bar, Atlanta, GA

PROFESSIONAL SOCIETIES AND ORGANIZATIONS:

- Academy of Nutrition and Dietetics 2013-present
- Greater Atlanta Dietetic Association 2013-present

ABSTRACT

THE USE OF INDIRECT CALORIMETRY TO ACCURATELY ASSESS ENERGY NEEDS IN MEMBERS OF THE GEORGIA STATE UNIVERSITY STUDENT RECREATION CENTER AND A COMPARISON OF NUTRITION SERVICES AVAILABLE TO STUDENTS ON URBAN COLLEGE CAMPUSES

by
Leslie S. Knapp

Background: The greatest increase in obesity rates have been seen with young adults in college due to their unhealthy dietary habits and behaviors. Interventions at this life stage may reduce the development of obesity related health concerns. There is an evident need for nutrition and lifestyle interventions yet there is limited research on the implementation of comprehensive nutrition programs for college students.

Objective: This research study has a dual focus. We aim (1) to describe nutrition services offered through the Georgia State University Student Recreation Center to include nutrition assessment in a college population. Specifically, measured energy needs (Korr ReeVue™ Portable Indirect Calorimeter) were compared with estimated energy needs (predictive equations) and nutrition software (BioEx Nutrition Maker Software© Plus 2.0). In addition, this study aims (2) to survey what types of nutrition services are offered by campus recreation centers that are part of the Urban 13 research-sharing institutions.

Methods: (1) Twenty-three healthy weight (n=8) and overweight/obese (n=15) 18 -37 year old males (n=11) and females (n=12) that were members of the Georgia State University student recreation center and had undergone indirect calorimetry. Paired samples t-tests were used to compare the means of measured resting metabolic rate

(RMR) with RMR estimated from the Harris-Benedict and Mifflin-St. Jeor equations. Measured and estimated RMR were used to calculate total energy expenditure (TEE). Paired sample t-tests were also used to compare the means of each calculated TEE. A p-value ≤ 0.05 defined significance. (2) The 21 campus recreation centers of the Urban 13 were asked to complete a five-question survey by email or phone. Survey results were tabulated based on result frequencies.

Results: (1) A statistical significance ($p < 0.003$) was found when comparing the means of measured RMR (1627 ± 393 kcal/day) with RMR estimated with the Harris Benedict equation (1781 ± 321 kcal/day). Significant differences ($p < 0.001$) were found between TEE calculated via measured RMR (2153 ± 534 kcal/day) and TEE calculated with estimated RMR via the Harris-Benedict equation (2354 ± 420 kcal/day) and Nutrition Maker© Plus 2.0 (2623 ± 582 kcal/day). Results were not statistically significant when comparing the means ($p=0.308$) of measured RMR (1626 ± 393 kcal/day) with RMR estimated with the Mifflin-St. Jeor equation (1677 ± 287 kcal/day), or between the means ($p=0.317$) of calculated TEE from measured RMR (2153 ± 534 kcal/day) and the Mifflin St-Jeor equation (2218 ± 381 kcal/day). (2) Of the 21 schools evaluated, seven stated nutrition services were provided through the campus recreation center. Of the seven schools, five staff an RD at the recreation center, and two schools, including Georgia State University, staff an RD and offer indirect calorimetry.

Conclusions: To our knowledge, this is the first study to describe nutrition services offered at a campus recreation center. In the absence of indirect calorimetry, the Mifflin-St. Jeor equation is the best method to estimate energy needs for a college population. Nutrition services provided by an RD are limited at campus recreation centers of the

Urban 13. Furthermore, only two campuses, including Georgia State University, provide nutrition assessment via indirect calorimetry.

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RECREATION CENTER AND A COMPARISON OF NUTRITION SERVICES
AVAILABLE TO STUDENTS ON URBAN COLLEGE CAMPUSES

by
Leslie S. Knapp

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ABBREVIATIONS

CDC	Center for Disease Control and Prevention
CVD	Cardiovascular Disease
IC	Indirect Calorimetry
Georgia State	Georgia State University
RD	Registered Dietitian
NA	Nutrition Assessment
NC	Nutrition Counseling
NE	Nutrition Education
NCP	Nutrition Care Process
IG	Intervention Group
CG	Control Group
SF-36	Short Form Health Survey
NQoL	Nutrition Quality of Life
BMI	Body Mass Index
SLT	Social Learning Theory
HDL	High-Density Lipoprotein
LDL	Low-Density Lipoprotein
TG	Triglyceride
GA	Graduate Assistant
IOM	Institute of Medicine Estimated Energy Requirement Equation
TEE	Total Energy Expenditure

kcal/day	Kilocalories per Day
BMR	Basal Metabolic Rate
PA	Physical Activity
RMR	Resting Metabolic Rate
PAF	Physical Activity Factors
CO ₂	Carbon Dioxide
O ₂	Oxygen
kg	Kilograms
cm	Centimeters
DRI	Dietary Reference Intake
EER	Estimated Energy Requirements
PAL	Physical Activity Level
SPSS	Statistical Package for the Social Sciences
N	Sample Size
SD	Standard Deviation

CHAPTER I

THE USE OF INDIRECT CALORIMETRY TO ACCURATELY ASSESS ENERGY NEEDS IN MEMBERS OF THE GEORGIA STATE UNIVERSITY STUDENT RECREATION CENTER AND A COMPARISON OF NUTRITION SERVICES AVAILABLE TO STUDENTS ON URBAN COLLEGE CAMPUSES

INTRODUCTION

Topic and Problem

In the United States, obesity and the associated health consequences have produced an estimated annual medical cost of \$147 billion dollars in 2008.¹ Regrettably, obesity continues to be a common diagnosis with severe health implications. In 2009-2010, the Centers for Disease Control and Prevention (CDC) cited that 69.2 percent of adults age 20 years and over were overweight or obese.^{2,3} Being overweight¹ or obese² increases the risk of developing chronic disease including cardiovascular disease (CVD), type 2 diabetes and some cancers.¹ Excess weight can also lead to the development of hypertension, dyslipidemia, stroke, sleep apnea, respiratory problems and liver disease.¹ Shockingly, individuals as young as 18 years of age have reported risk factors associated with chronic disease, specifically CVD and type 2 diabetes.⁴ Recently, young adults of college-age, defined as those 18-24 years of age, have had the greatest increase in obesity prevalence.^{4,5} In 2006, a National College Health Assessment Survey of over 80,000 college students found one-third of respondents to be overweight or obese based on self-reported height and weight.⁴ In response to this growing problem, research supports a

¹ Overweight is determined by a Body Mass Index ≥ 25 kg/m^{2,3}

² Obese is determined by a Body Mass Index ≥ 30 kg/m^{2,3}

need for personalized information, individualized risk assessments and the promotion of healthy lifestyles in this population.^{4,5}

Significance

College students experience the pressures of independent, hurried lifestyles and the stress of college life.⁵ It is unsurprising that, of all age groups, college-aged adults have some of the poorest dietary and lifestyle habits: consumption of large-portioned, calorie-dense foods; frequent fast-food consumption; unbalanced diets, limited consumption of fruits and vegetables; and insufficient physical activity.^{5,6} For example, nine out of ten students eat fewer than five servings of fruits and vegetables per day, while six out of ten students participate in physical activity of vigorous³ or moderate⁴ intensity less than three days per week.⁸ Additionally, the hurried lifestyle of college students leads to the frequent purchase of foods around campus, a behavior which is positively associated with skipping meals and an increase in fast-food intake.⁶ Similarly, it has been discovered that college students who purchase food on or around campus commonly make unhealthy dietary choices, primarily choosing high-fat and high-sugar foods, based on their surrounding environment.⁶ These activities not only increase the risk for the development of unhealthy eating behaviors, but are also primary contributors to weight gain, negative dietary influences, obesity, and a poor nutrition quality of life.^{5,6}

Purpose and Research Questions

The greatest increase in obesity rates have been seen with young adults in college due to their unhealthy dietary habits and behaviors.^{4,5,8} The college years are a critical

³ Vigorous intensity physical activity include activities that burn more than six times as much energy per minute as sitting quietly.⁷

⁴ Moderate intensity physical activity include activities that burn three to six times as much energy per minute as sitting quietly.⁷

time to shape adult behaviors, especially dietary, exercise, and lifestyle behaviors. Interventions at this life stage may reduce the development of obesity and obesity-related health concerns.^{9,10} Nutrition interventions have been found to have an impactful and effective outcome in changing the dietary behaviors of college students, suggesting a need for nutrition programs on college campuses.¹¹ There is an evident need for nutrition and lifestyle interventions yet there is limited research on the implementation of comprehensive nutrition programs for college students.^{4,5}

This research study has a dual focus: 1) compare measured energy needs using indirect calorimetry (IC) with estimated energy needs (predictive equations) and nutrition software in a college population, and 2) describe the types of nutrition services offered by campus recreation centers at urban universities similar to Georgia State University (Georgia State). We hypothesize that predictive equations and nutrition software will over-estimate calorie needs when compared with metabolic testing.

CHAPTER II

REVIEW OF LITERATURE

Defining Nutrition Services

The Academy of Nutrition and Dietetics and the Society for Nutrition Education suggest that school-based nutrition services include “policies that link nutrition education, child nutrition programs, a healthful school environment, and community involvement promoting healthful eating and physical activity.”¹² Although nutrition services can include a wide range of activities, those performed by a registered dietitian (RD) include, the nutrition assessment (NA), nutrition counseling (NC), and nutrition education (NE), which are fundamental components to the nutrition care process (NCP). The NCP is a critical and systematic approach used by nutrition professionals (registered dietitians or nutritionist) to address nutrition related problems and provide high quality nutrition care.¹³

An NA is defined as “a systematic process of obtaining, verifying, and interpreting data in order to make decisions about the nature and cause of nutrition-related problems,” and is the first step of the NCP.¹³ Part of an NA involves asking an individual questions about lifestyle, environment, and dietary intake. The information collected provides important insight into an individual’s health and nutritional status.¹³ The next step in the NCP is the nutrition diagnosis, or the main nutrition-related problem. The third step is the nutrition intervention, which is a formulated nutrition plan of action.

The final step is the nutrition monitoring and evaluation to evaluate and measure outcomes.¹³

While the NA helps the nutrition professional establish nutritional care needs for an individual, NC aims to assist an individual in making beneficial diet and lifestyle changes.¹³ During NC, an RD provides supported self-care to the client by working with the client to set goals and developing a collaborative relationship to motivate healthy changes.¹³

NE includes a group of learning techniques focused on the adaptation of healthy eating and lifestyle behaviors.⁵ A literature review by Lin et al (2011) found NE as an effective method to improve students' dietary habits and their understanding of overall health.¹¹ NE is commonly used to provide healthy lifestyle information to a variety of populations, and yet this type of intervention is seldom offered to college students.¹¹

Dali et al (2014) conducted a longitudinal nutrition education intervention study with 380 undergraduate students.⁵ Participants were randomized into two groups: the intervention group (IG) and the control group (CG). Over a six-month period, researchers promoted three key messages via lectures, brochures, and text messages to the IG students: 1) always be healthy 2) eat moderately and 3) live the future. The researchers administered a short form 36 health survey (SF-36) and a nutrition quality of life (NQoL) instrument before and after the intervention to evaluate the efficacy of their nutritional education intervention.⁵ The SF-36 measured concepts such as *Physical Functioning, Bodily-Pain, and Mental Health*, while the NQoL instrument assessed *Food Impact, Self Image, Psychological Factors, Social / Interpersonal Factors, Physical Functioning, and Self-Efficacy*.⁵ The findings noted improvements in NQoL

scores with the IG between pre-intervention and post-intervention periods.⁵ Significant improvements were found between the IG and CG in the *Food Impact* ($p = 0.001$), *Social / Interpersonal* ($p = 0.008$), *Physical Functioning* ($p = 0.001$), and *Overall NQoL* ($p = 0.001$) domains.⁵ These findings agree with the literature that establishes nutrition education as an effective method in health promotion and disease prevention programs to build nutrition knowledge and improve nutrient intakes.⁵

Nutrition Services on College Campuses

Nationwide, campus services offer numerous programs to support students through emotional issues, such as substance use or sexuality.⁸ Surprisingly, nutrition services are often not available to students to assist them towards changing their poor nutrition behaviors and dealing with the emotional issues that lead to obesity.⁸ Providing college students with university-supported nutrition programs can help promote a healthy weight status, improve eating habits and diminish the incidence of overweight and obesity.¹⁴ Furthermore, these programs could be designed to include a weight reduction component to help students focus on reducing their dietary intake, increasing their frequency of physical activity and modifying their behavior/lifestyle choices.¹⁵

King et al (2013) explored the efficacy of nutrition programs among college students.¹⁴ The researchers commented that colleges could provide an opportune setting for health promotion programs to develop and encourage students' health knowledge, attitudes, and behaviors.¹⁴ The authors recommended that college health programs focus on individual, social and environmental factors to effectively overcome obesity among college students.¹⁴ Future health programs should promote the development of students'

abilities to prepare healthy foods, how to plan ahead for healthy eating, and promote physical activity and nutrition.¹⁴

Kelly et al (2013) performed a systematic review to evaluate nutrition and dietary interventions in college and university settings.¹⁶ The researchers concluded that a variety of intervention styles may improve the dietary behaviors of college students and suggested that future programs include in-person interventions and techniques such as self-regulation, self-monitoring, and goal setting to maximize outcomes of future of dietary interventions with college students.¹⁶

Importance of Nutrition Services on College Campuses

Combining personal training and nutrition services at a campus recreation center may provide students with an individualized, healthy lifestyle program that will encourage healthy and responsible eating habits and physical activity.

In 2012 Fuglestad et al explored lifestyle patterns such as diet, physical activity, and recent weight loss in addition to changes in body mass index (BMI).¹⁷ Their findings stated consuming less calories and exercising more were effective behavioral patterns for weight control and reducing the risk for obesity.¹⁷ The food environment on a college campus plays a large role in students' overall dietary consumption. A study by Pellitier et al (2013) found students commonly make unhealthy food/beverages choices when purchasing food in the campus area.⁶ The authors stated that these unhealthy choices contribute to the student's unhealthy diet and weight gain, however dietary intake can improve through healthful interventions in college settings.⁶ Inspiring healthful eating habits and behaviors are the main goals of nutritional support, thus demonstrating the benefit of nutrition services for college students.

Brawley et al (2012) conducted an intervention study with obese adults, which was driven by the social learning theory (SLT) and group-mediated interactions.¹⁸ According to SLT, behaviors are influenced by the environment, cognitions and observations.¹⁹ The researchers created three intervention groups: a physical activity group (walking), a physical activity and weight loss group (walking + a dietary intervention with an RD), and a successful aging education control group (lecture series). Both the physical activity and physical activity and weight loss groups contained a group-mediated component. The physical activity and weight loss group showed more improvement in weight loss and improvements in mobility after the intervention.¹⁸ This study highlights the importance of group-mediated counseling interventions to facilitate maintenance behaviors in adults.¹⁸ This evidence-based research supports the notion that personal training paired with nutrition services could provide a collaborative group-mediated intervention to students, offering success in promoting prolonged healthy behaviors. Despite the promising results from this multiple-group intervention, minimal studies have been conducted comparing multiple interventions from different health disciplines.¹⁸

Nutrition Services at Georgia State University

In 2000 the Fitness Center at the Georgia State University Student Recreation Center began offering lipid testing twice a semester.²⁰ Each person received a five-page document with his or her lipid profile, which included total cholesterol, high-density lipoprotein (HDL), low-density lipoprotein (LDL), and triglyceride (TG) measurements. Additionally, a fasting blood glucose level was provided. These reports triggered requests for nutrition consults for in-depth nutrition advice and help with managing blood

lipid levels.²⁰ As this service grew in popularity, a need for consistent nutrition services became apparent. In order to handle the increased demand for nutrition consults, the Georgia State University Fitness Center partnered with the Georgia State University Department of Nutrition to create a graduate assistant (GA) position. In addition, a part-time registered dietitian (RD) was hired to supervise and mentor coordinated program graduate nutrition students as they completed their supervised practice hours at the Georgia State Student Recreation Center Fitness Center.²⁰ Currently, the facility has an RD and graduate students from the Department of Nutrition who meet with students and recreation center members to perform nutrition assessments. The nutrition GA also performs initial assessments and conducts follow-ups.²⁰ This assistantship provides tuition coverage and stipend, which is funded through the Department of Recreational Services. The Student Recreation Center Fitness Center also staffs personal trainers that are GAs working towards graduate degrees in Exercise Science through the Department of Kinesiology and Health.²⁰

For a fee, the Georgia State University Fitness Center at the student recreation center offers students and recreation center members a variety of packages.²¹ The fitness packages offer an assessment performed by a personal trainer that includes an American College of Sports Medicine Health History Screening and Risk Stratification, blood pressure and resting heart rate screening, sub-max cardiorespiratory testing via treadmill or bike test, body fat composition using a seven-site skinfold test, muscular endurance, flexibility testing, cholesterol testing, and individualized one-on-one training sessions.²¹ Components of the nutrition packages include an evaluation of a two-day food diary with BioEx Nutrition Maker© Software Plus 2.0, IC testing with the Korr ReeVue™ Portable

Indirect Calorimeter, cholesterol testing, and a one hour nutrition consultation with two, 30 minute follow-up sessions with the nutrition GA or RD.²¹ Clients have the option of purchasing a combined training and nutrition package.^{22,23}

Importance of an Accurate Assessment of Energy Needs

Assessing individual energy needs is a principal component of nutrition practice.²⁴ An accurate assessment of energy needs is important to develop an effective nutrition care plan and to prevent undesirable outcomes such as weight gain or weight loss, depending on the nutrition goals established by the client.²⁵ The nutrition assessment (NA) is individualized and includes collecting information on anthropometrics, diet history, client history, biochemical data, and it also evaluates individual energy needs. Energy needs are estimated by predictive equations or measured by IC. A predictive equation is commonly used as a low-cost method for estimating energy needs that can be calculated by hand or by using nutrition software programs.²⁶ Some of the most popular equations are the Harris-Benedict equation, the Mifflin-St Jeor equation, and the Institute of Medicine (IOM) estimated energy requirement equation, or IOM.²⁵ Although these predictive equations are frequently used in practice, there is a great deal of discrepancy with their outcomes.²⁵ According to the Academy of Nutrition and Dietetics, indirect calorimetry is recommended as the best method to assess energy needs.²⁶ IC is a distinctive component of the nutritional assessment package at Georgia State.

Total Energy Expenditure

Total energy expenditure (TEE) is the total amount of calories used by an individual each day and is measured in kilocalories per day (kcal/day).²⁴ TEE is

comprised of three components: basal metabolic rate (BMR), physical activity (PA) and the thermic effect of food.²⁴ BMR, the largest component of TEE, is defined as the minimum amount of energy required for the body to perform basic physiological processes.^{24,26} BMR can be affected by age, body composition, gender, stress, fasting, starvation, caffeine, smoking, hormones and lack of sleep.²⁴ PA is the most varied component of TEE and can be a significant contributor to weight loss or weight gain.²⁴ PA represents energy expended and is dependent upon muscle mass, body weight and the type of activity.²⁴ The third and smallest component of TEE is the thermic effect of food, which is an estimation of the energy required for the body to process food and is proportional to the amount of food consumed.²⁴

The method to measure BMR is exacting and requires strict testing conditions such as a temperature controlled room and a long fasting period.^{24,26} Therefore, resting metabolic rate (RMR) is commonly used to measure energy expenditure, and although RMR measurements are slightly higher than BMR, testing conditions are less stringent and more apt to “real-world” conditions.^{24,26} To quantify average daily energy needs, TEE is calculated by multiplying RMR by a physical activity factor (PAF).²⁷ A PAF is associated with physical activity level that combines the level of intensity and the frequency of the exercise.²⁴

Methods to Measure and Estimate RMR

In nutrition practice, an accurate estimation of energy needs is important for the NA to design an effective nutrition intervention and to prevent undesired nutrition outcomes based on client goals.²⁵ There are several techniques to assess RMR including

IC, the Harris-Benedict, and Mifflin-St. Jeor predictive equations. The Institute of Medicine equations and electronic methods calculate total TEE.

Indirect Calorimetry

Indirect Calorimetry (IC) has been proven as an effective method for measuring energy needs in healthy populations and is the recommended method to assess energy needs by The Academy of Nutrition and Dietetics.^{26,28} IC is a noninvasive procedure that measures respiratory gas exchange, specifically the amount of carbon dioxide (CO₂) output and oxygen (O₂) input while an individual respire through a tube, canopy hood, or fitted mask while at rest.²⁸ Although metabolic carts are considered the gold standard for measuring RMR, they are expensive and time consuming.²⁹ Additionally, these carts are large, difficult to maneuver, and require technical expertise to maintain and operate the cart.³⁰ In response to these drawbacks, portable indirect calorimeters were developed as a method for measuring RMR in a clinical setting. These devices are affordable, lightweight, transportable, convenient, and easy to use on many patients.²⁹ Portable metabolic systems can provide an affordable method for measuring RMR that is practical for the office and clinical settings. The ReeVue™ Portable Indirect Calorimeter is an example of a portable indirect calorimeter that has been validated in an adult population, which measures O₂ consumption.³¹ When assessing RMR, portable calorimeters are more accurate than predictive equations based on gender, age, and ethnicity.³²

When portable indirect calorimeters have been compared with predictive equations, the literature reflects mostly negative outcomes. Spears et al (2009) compared popular predictive equations (the Harris-Benedict equation, the Mifflin-St. Jeor equation, and the Institute of Medicine equation) with a portable indirect calorimeter in a group of

obese women.³³ The results found discrepancies between measured RMR via handheld IC and estimated RMR via predictive equations.³³ Specifically, only 37% - 46% of the estimated RMR values were within 10% of her measured values.³³ Frankenfield et al (2005) stated that errors in estimating RMR via predictive equations would be eliminated with IC.²⁵

Predictive Equations

Predictive equations are commonly used in nutrition practice to estimate energy needs. Some of the most commonly used are the Harris-Benedict equation, the Mifflin-St Jeor equation, and the IOM equation. Electronic methods, such as nutrition software and mobile applications, also estimate calorie needs using the predictive equations listed above. Predictive equations estimate RMR using variables such as gender, body weight, height, and age.³⁴ These equations are free, time-effective and fairly easy to use; however, Frankenfield et al (2005) emphasized the importance of clinical judgment when accepting RMR results from predictive equations.²⁵

The Harris-Benedict Equation

In 1919 the Harris-Benedict equation was developed to establish a standardized method to estimate BMR for people in a variety of disease states.³⁵ The equation is gender dependent and uses actual body weight in kilograms (kg), height in centimeters (cm), and age in years.²⁶ However, as clinical practice has evolved, the Harris-Benedict equation is now used to estimate RMR. The clinician selects a physical activity factor (PAF) based on the individual's level of physical activity to determine an estimated daily TEE.²⁴

The Harris-Benedict equation has been extensively validated by many researchers and it remains one of the most widely used methods for researchers and clinicians to estimate RMR.^{27,35} Despite its popularity, studies have continuously shown the Harris-Benedict equation to be an inaccurate estimation of energy needs. When compared to Mifflin-St. Jeor equation and IOM, the Harris-Benedict equation was found to be the most biased equation towards overestimating energy needs.³⁶ In 2008, a study by Amirkalali et al found the Harris-Benedict equation to be the most accurate when compared to the Mifflin-St. Jeor equation, however 39% of patients had an unacceptably high error in RMR.³⁷ The Harris-Benedict equation has also been shown to overestimate RMR anywhere from 5-15% in healthy populations of men and women.^{27,37} Therefore, this equation may not be appropriate for all patients, specifically those who are obese.^{27,35,37}

The Mifflin-St. Jeor Equation

When IC is not available, the Academy of Nutrition and Dietetics identifies the Mifflin-St. Jeor equation as the most appropriate equation for predicting metabolic rate in non-obese and obese healthy people.³⁶ Similar to Harris-Benedict equation, the Mifflin-St. Jeor equation uses gender, actual body weight (kg), height (cm), and age (years) to compute RMR.³⁶

Frankenfield et al (2005) evaluated predictive equations and their RMR results in healthy non-obese and obese adults.²⁵ This review concluded that the Mifflin-St. Jeor equation estimated RMR within 10% of measured RMR, which was better than the Harris-Benedict and IOM equations.²⁵ When estimating energy needs in non-obese individuals, it was found to have the highest accuracy rates.³⁶ The Mifflin-St. Jeor

equation was also found to underestimate energy needs versus overestimating energy needs.²⁵ Frankenfield et al (2013) explored the accuracy of predictive equations and stated the Mifflin-St. Jeor equation was established as a useful method to predict RMR in ambulatory adults of various body sizes.³⁶ Furthermore, Frankenfield et al (2013) also noted a need for the Mifflin-St. Jeor equation to be validated before it is adopted for clinical use.³⁶

The Institute of Medicine Equation

To create awareness to the growing prevalence of overweight and obesity, The Institute of Medicine (IOM) of The National Academies created the Dietary Reference Intake (DRI) for average dietary intake for weight maintenance, or the Estimated Energy Requirement (EER).³⁸ EER is estimated using an equation to predict an individual's energy expenditure based on a variety of factors.³⁹ There are a series of equations for different age groups and genders, but the adult equation is based on an individual's energy intake, energy expenditure, gender, weight, height, and physical activity, which is associated with a physical activity level (PAL).³⁸

The IOM is based on a large population with attention to the association with metabolic rate and body size.³⁶ Yet when analyzed by the Academy of Nutrition and Dietetics in 2003, the IOM equation was not recommended for calculating energy needs due to lack of validation work.³⁶ When compared with common predictive equations, the IOM and the Harris-Benedict equation had lower accuracy rates for estimating energy needs than the Mifflin-St. Jeor equation.³⁶ Furthermore, the IOM was more likely to overestimate energy needs and had the widest error distribution of all the predictive equations.³⁶

Electronic Methods of Measuring Energy Needs

Total energy needs can also be estimated by various software packages, such as Nutrition Maker© or NutriBase©. These programs often use the aforementioned predictive equations to assess individual energy needs based on height, weight, age, gender and reported physical activity. However, estimated energy needs for an individual may vary depending on which program is used. MyFitnessPal is a popular mobile application that estimates calorie needs electronically using the Mifflin-St Jeor predictive equation.⁴⁰ As previously noted, this can lead to an inaccurate estimation of calorie needs.

Review of Literature Summary

There is a clear problem in the college-aged population with unhealthy dietary and lifestyle habits.^{5,14} The literature supports a need for university-supported nutrition programs for college students to improve dietary intake, develop nutrition knowledge and attitudes, and motivate behavior change.^{6,14-16} Despite the apparent need for these programs, research detailing the implementation or description of comprehensive nutrition programs at a college or university is limited.^{4,5}

A critical part of nutrition practice includes the effective measurement of energy needs so an effectual nutrition intervention can be designed.²⁵ Many studies have compared methods to measure (indirect calorimetry) or estimate (predictive equations) energy needs in youth and adult populations.^{26,37} However, there does not appear to be research comparing different methods to measure or estimate energy needs (i.e. indirect calorimetry, predictive equations, nutrition software) in a college population.

With the main goal of describing the nutrition services offered at the Georgia State Student Recreation Center and using IC to measure energy needs, we discovered another gap in the literature. There does not appear to be any literature documenting or comparing the types of nutrition services are offered to college-aged students or who administers these nutrition services.

CHAPTER III

METHODS

This research study has a dual focus: 1) support use of IC to accurately measure energy needs of the members of a campus recreation center, and 2) evaluate the availability of nutrition services offered through campus recreation centers at urban institutions.

Nutrition Assessment at the Georgia State University Student Recreation Center

Members of the Georgia State University Student Recreation Center that have signed up for a nutrition package complete a nutrition assessment form that includes anthropometric information, medical history, family medical history, physical activity, medications, and a two-day food diary. The RD or the GA analyzes the assessment data (age, height, weight and physical activity) using BioEx Nutrition Maker© Software Plus 2.0 to calculate the individual's total energy expenditure (TEE) in kilocalories per day (kcal/day).

Indirect Calorimetry at the Georgia State University Student Recreation Center

The nutrition assessment form, including the two-day food diary, must be completed before an individual can undergo indirect calorimetry testing. To minimize the thermic affect of food, each individual is asked to refrain from eating or drinking any liquid, besides water, from 12:00am the night before and up until test time. It is also requested that medications are not taken prior to testing. Once it is confirmed that the individual has not consumed food, liquids, or medications, they are asked to sit and relax

motionless in the testing chair. The Korr ReeVue™ Portable Indirect Calorimeter is calibrated and the logistics of the testing are explained to the participant. The participant is asked to place nose plugs over his or her nostrils, and then are handed the IC tubing with the attached mouthpiece. They are instructed to breath steadily through the tube as the RD or GA conducts the testing. The indirect calorimeter uses the first two minutes to calibrates based on the person's breathing. In total, the average IC test takes about 10 minutes, however, based on how effectively the person is breathing, the test may run longer. After each 30 second increment, the ReeVue™ Portable Indirect Calorimeter will produce a measured RMR amount. At the completion of the test, an average measured RMR value in kcal/day is produced.

Participants to Compare Indirect Calorimetry, Predictive Equations, and Nutrition Maker© Plus 2.0

The study sample was comprised of members of the Georgia State Student Recreation Center who had undergone IC testing from January 2013-April 2014. Additional inclusion factors included: ≥ 18 years of age; members of Georgia State University Student Recreation Center; paid for a nutrition package that included IC, finished a two-day food diary and general assessment; and had completed IC testing.

Research Design to Compare Indirect Calorimetry, Predictive Equations, and Nutrition Maker© Plus 2.0

The goal of the research analysis was to compare energy needs calculated from the Harris-Benedict equation, the Mifflin-St. Jeor equation, the IOM equation, and BioEx Nutrition Maker© Plus 2.0 with the measured energy needs from the Korr ReeVue™ Portable Indirect Calorimeter test in a college population.

This study performed a retrospective chart review with the sample group. Each chart contained a nutrition assessment questionnaire containing self-reported anthropometric data and results from the indirect calorimetry test. The participant's age, gender, height, weight, activity level, and measured RMR via IC were acquired from each chart. Participant's BMI (kg/m^2) was calculated using self-reported height and weight. The RMR (kcal/day) for each participant was also estimated using the Harris-Benedict and the Mifflin-St. Jeor energy equations as shown in Table 1.

Table 1. Predictive Equations to Estimate Energy Needs

Equations used to Calculate Estimated Resting Metabolic Rate in kcal/day^{27,35,38}	
The Harris-Benedict Equation	
Male	$\text{RMR} = 66.47 + 13.75 \times W + 5.0 \times H - 6.8 \times A$
Female	$\text{RMR} = 655 + 9.6 \times W + 1.8 \times H - 4.7 \times A$
The Mifflin-St. Jeor Equation	
Male	$\text{RMR} = \text{Weight}(10) + \text{Height}(6.25) - \text{Age}(5) - 5$
Female	$\text{RMR} = \text{Weight}(10) + \text{Height}(6.25) - \text{Age}(5) - 161$
Equation Used to Calculate Estimated Total Energy Expenditure	
The Institute of Medicine Equation	
Male	$\text{TEE} = 662 - (9.53 \times \text{age}[\text{y}]) + \text{PA} \times \{(15.91 \times \text{weight}[\text{kg}]) + (539.6 \times \text{height}[\text{m}])\}$
Female	$\text{TEE} = 354 - (6.91 \times \text{age}[\text{y}]) + \text{PA} \times \{(9.36 \times \text{weight}[\text{kg}]) + (726 \times \text{height}[\text{m}])\}$

An appropriate physical activity factor (PAF) was determined for each participant based on self-reported activity level and clinical judgment. The same PAF value was multiplied by RMR from indirect calorimetry, the Harris-Benedict equation, and the Mifflin-St. Jeor equation to estimate TEE for weight maintenance, as shown in Table 2.

Table 2. Physical Activity Values

Physical Activity Values
Physical Activity Factors for Indirect Calorimetry, the Mifflin-St. Jeor Equation, and the Harris-Benedict Equation
<ul style="list-style-type: none"> • Sedentary (1.25) - Little to no Exercise/Sports, burning minimal kcal/day in addition to activities of independent living • Lightly Active (1.375) - Light exercise/Sports 1-3 days a week, burning approximately 590 kcal/day in addition to activities of independent living • Moderately Active (1.550) - Moderate Exercise/Sports 3-5 days a week, burning approximately 870 kcal/day in addition to activities of independent living • Very Active (1.725) - Hard exercise/Sports 6-7 days a week, burning approximately 1150 kcal/day in addition to activities of independent living
Physical Activity Levels (Physical Activity Values) for the Institute of Medicine Equation⁴¹
<p>For Men:</p> <ul style="list-style-type: none"> • Sedentary (1.0) - When $1.0 \leq \text{PAL} < 1.4$ - Activities that are required for independent living⁵ • Low Active (1.12) - When $1.4 \leq \text{PAL} < 1.6$ - Physical activities equivalent to walking 2 miles a day at the rate of 3-4 miles/hour in addition to activities of independent living⁵ • Active (1.27) - When $1.6 \leq \text{PAL} < 1.9$ - Physical activities equivalent to walking 7 miles at the rate of 3-4 miles/hour in addition to activities of independent living⁵ • Very Active (1.54) - When $1.9 \leq \text{PAL} < 2.5$ - Physical activities equivalent to walking 17 miles at the rate of 3-4 miles/hour in addition to activities of independent living⁵ <p>For Women:</p> <ul style="list-style-type: none"> • Sedentary (1.0) - When $1.0 \leq \text{PAL} < 1.4$ - Activities that are required for independent living⁵ • Low Active (1.14) - When $1.4 \leq \text{PAL} < 1.6$ - Physical activities equivalent to walking 2 miles a day at the rate of 3-4 miles/hour in addition to activities of independent living⁵ • Active (1.27) - When $1.6 \leq \text{PAL} < 1.9$ - Physical activities equivalent to walking 7 miles at the rate of 3-4 miles/hour in addition to activities of independent living⁵ • Very Active (1.54) - When $1.9 \leq \text{PAL} < 2.5$ - Physical activities equivalent to walking 17 miles at the rate of 3-4 miles/hour in addition to activities of independent living⁵

⁵ For an adult weighing 70 kg⁴¹

Client Activity Levels for Nutrition Maker© Plus 2.0 Software
<ul style="list-style-type: none"> • Very Light - One day or less a week of aerobic or active exercise (i.e. sitting, standing, □driving, cooking, sleeping, lying down, or re□ding) • Light - 2-3 days a week of aerobic or active exercise (i.e. light cycling or walking for 30 minutes or less about 3 times a week) • Moderate - 3-5 days a week of aerobic or active exercise (i.e. jogging, cycling, swimming, aerobics for 30-60 minutes about 5 times a week) • Heavy - More than 5 days a week of aerobic or active exercise (i.e. construction work, marathon training, intense workouts for 60 minutes or more at least 6 times a week)

A physical activity (PA) value is used in the IOM equation to estimate TEE. This value is associated with a physical activity level (PAL) based on frequency and intensity of exercise, as shown in Table 2. Researchers matched the PAF used to estimate TEE with IC, the Harris-Benedict, and Mifflin-St. Jeor equation within a PAL range, and the corresponding PA value was selected to calculate TEE using the IOM equations.

Researchers also estimated TEE using Nutrition Maker© Plus 2.0 by entering each participant's age, height, and weight, and a client activity level comparable to the PAF and PA used for IC and the predictive equations. Client activity levels are outlined in Table 2.

Statistical Methods to Compare Indirect Calormetry, Predictive Equations, and Nutrition Maker© Plus 2.0

The data were analyzed using Statistical Package for the Social Sciences (SPSS) Version 21.0. Data including gender, age, weight, BMI, PAF, and RMR assessed with the ReeVue™ portable indirect calorimeter, the Harris-Benedict equation, and the Mifflin-St. Jeor equation were described using frequency analysis. The Kolmogorov-Smirnov/Shapiro-Wilk test for normality determined the data to be normally distributed. A paired samples t-test was used to compare the mean measured RMR with RMR

estimated with those of the Harris-Benedict and Mifflin-St. Jeor equations. Separate paired t-tests were also used to compare the means of TEE calculated with measured and estimated RMR as well as the means of TEE calculated with the IOM equation and Nutrition Maker© Plus 2.0. Two independent sample t-tests were conducted, one to compare TEE between the Healthy (BMI 18.5 - 24.9 kg/m²) and Overweight BMI (BMI >25.0 kg/m²) groups and another to compare measured RMR between males and females.¹ A p-value ≤ 0.05 defined significance.

Evaluation of Nutrition Services of the Urban 13

Twenty-one schools that comprise the Urban 13 research-sharing institutions were evaluated for the type, location, and administration of nutrition services they provide for students. The Urban 13 is group of 21 research-sharing public universities and colleges based in major metropolitan areas across the United States.^{21,42} All of the 21 schools, including Georgia State University, were included in the study based on their geographical location, student demographics and campus recreation centers.

Research Design to Evaluate Nutrition Services of the Urban 13

The goal of this research assessment was to evaluate the types of nutrition services offered through campus recreations centers at urban institutions comparable to Georgia State.

Contact information for directors, assistant directors, managers and coordinators of the campus recreation centers were gathered from each university's or college's campus recreation website. A contact from each of the campus recreation centers was administered a five-question survey either by email or phone. Survey results were tabulated based on result frequencies. Table 3 includes the questions used for the survey.

Nutrition services are not provided by the campus recreation centers at The University of Missouri-St. Louis, University of Missouri- Kansas City, City College of New York, Indiana University-Purdue University-Indianapolis, University of Toledo, and Wayne State University. A review of each institution's website provided information about the types of nutrition services offered and by whom.

Table 3. Survey to Evaluate Nutrition Services offered by Campus Recreation Centers of the Urban 13

Survey to Evaluate Nutrition Services offered by Campus Recreation Centers of the Urban 13
1) Are nutrition services offered through your university's recreation center?
2) If so, what types of services are offered? (For example, nutrition counseling or nutrition assessments)
3) Does a Registered Dietitian (RD) provide nutrition services through your recreation center?
4) If so, what types of services does the RD provide?
5) Is metabolic testing, or indirect calorimetry, offered to the students through the student recreation center?

CHAPTER IV

RESULTS

Results from Comparison of Indirect Calorimetry, Predictive Equations, and Nutrition Maker© Plus 2.0

Characteristics of the sample population are shown in Table 4 and Table 5. Of the 23 participants (n=23), a majority were female (52.2%) and were overweight or obese (65.2%) with a BMI >25 kg/m². Participants above the defined college-age of 18-24 were included in the sample population to represent the increase in students over the age of 25 enrolled in higher education institutions.⁴³ Characteristics of the sample and PAF/PAL statistics are shown in Table 6.

Table 4. Sample Population Group Characteristics

Variable	N (%)
Gender	
Male	11 (47.8)
Female	12 (52.2)
BMI	
Healthy BMI	8 (34.8)
Overweight - Obese BMI	15 (65.2)

Table 5. Sample Population Anthropometrics

Variable	Mean ± Standard Deviation (SD)	Range
Age (years)	24.8 ± 5.2	18 - 37
Weight (pounds)	181.2 ± 50.1	120 - 294
BMI (kg/m²)	28.3 ± 7.6	18.4 - 46.0

Table 6. Mean and Frequency of Physical Activity Values

Statistics	PAF	PA
Mean ± SD	1.33 ± .14	1.06 ± .10
Range	1.250 - 1.725	1.00 – 1.27
PAF/PAL Value (Frequency)	1.250 (14) 1.300 (3) 1.375 (2) 1.400 (1) 1.550 (1) 1.725 (2)	1.00 (16) 1.12 (1) 1.14 (3) 1.27 (3)

Table 7. Comparison of Measured RMR and Estimated RMR

RMR Method	Mean ± SD (kcal/day)	Range (kcal/day)
Indirect Calorimetry	1627 ± 393	1066 - 2376
Harris-Benedict	1781 ± 321	1389 - 2583
Mifflin-St. Jeor	1678 ± 287	1301 - 2315

Table 7 describes the mean RMR in kilocalories per day (kcal/day). A statistical significance ($p < 0.003$) was found when comparing the means of measured RMR (1627

± 393 kcal/day) with estimated RMR from the Harris-Benedict equation (1781 ± 321 kcal/day). When comparing the means of measured RMR (1626 ± 393 kcal/day) and estimated RMR from the Mifflin-St. Jeor equation (1677 ± 287 kcal/day), results were not statistically significant ($p=0.308$); however, there was a strong, positive correlation between the means (0.81).

Indirect calorimetry measures RMR, while predictive equations (the Harris-Benedict and the Mifflin-St. Jeor equations) estimate RMR. A physical activity factor is multiplied by measured RMR or estimated RMR to calculate TEE. The IOM equation estimates TEE since physical activity is included in the equation. Nutrition Maker© Plus 2.0 uses the Mifflin-St. Jeor equation with a client activity value to calculate TEE. Therefore, measured RMR and estimated RMR can be compared, and calculated TEE from IC, predictive equations and Nutrition Maker© Plus 2.0 can be compared.

Table 8. Comparison of Measured TEE and Estimated TEE

Methods	Average TEE Means \pm SD (kcal/day)	Difference in Means compared to IC (kcal)	Range (kcal/day)
Methods to Measure RMR and Estimate TEE			
Indirect Calorimetry	2153 \pm 534	0	1423 - 3147
Methods to Estimate RMR and Estimate TEE			
The Harris-Benedict Equation	2354 \pm 420	202	1784 - 3229
The Mifflin St. Jeor Equation	2218 \pm 381	66	1683 - 2894
Methods to Estimate TEE			
The Institute of Medicine Equation	2542 \pm 462	390	1941 - 3465
Nutrition Maker© Plus 2.0 Software	2623 \pm 582	471	1854 - 4127

Table 8 describes the method for calculation and the average mean TEE compared to the mean IC standard. When TEE means were compared, the IC (2153 ± 534 kcal/day) and the Harris-Benedict equation (2354 ± 420 kcal) had a strong, positive correlation (0.84) and a significant difference was found between the means ($p < 0.001$). TEE calculated from measured RMR (2153 ± 534 kcal/day) and the Mifflin St-Jeor equation (2218 ± 381 kcal/day) did not show statistical significance ($p=0.317$). A significant difference ($p < 0.001$) was found between the TEE means of IC (2153 ± 534 kcal/day) and the IOM equation (2542 ± 461 kcal/day) and between the TEE means ($p < 0.001$) of IC (2153 ± 534 kcal/day) and Nutrition Maker© Plus 2.0 (2623 ± 582 kcal/day).

A statistically significant difference ($p < 0.001$) was found between the TEE calculated from measured RMR (2153 ± 534 kcal/day) and the IOM equation (2542 ± 461 kcal/day), the Harris-Benedict equation (2354 ± 420) and the IOM equation (2542 ± 461 kcal/day), and the Mifflin-St. Jeor equation (2218 ± 381 kcal/day) and the IOM equation (2542 ± 461 kcal/day). However, there was not a significant difference ($p=0.142$) between the TEE means of Nutrition Maker© Plus 2.0 (2623 ± 582 kcal/day) and IOM (2542 ± 461 kcal/day).

There was a statistically significant difference ($p=0.05$) between the RMR means of IC (kcal/day) when comparing the Healthy BMI (1402 ± 369 kcal/day) and the Overweight BMI (1746 ± 361 kcal/day) groups. When comparing measured RMR between genders, there was a significant difference ($p=0.001$) between the males (1896 ± 358 kcal/day) and females (1380 ± 231 kcal/day).

Results from the Urban 13 Survey

Seventeen of the 21 schools (n=21) provide nutrition services for students on campus or through the campus recreation center. Results from the survey are shown in Table 9 – Table 11. Seven of those 17 schools provide nutrition services on campus, and four provide nutrition services on campus with an RD, as shown in Table 9.

Table 9. Nutrition Services Offered on Campus

Schools that Provide Nutrition Services on Campus	
Institution & Recreation Center (City, State)	Description of Nutrition Services
University of Memphis Student Recreation and Fitness Center (Memphis, TN)	Health services provides nutrition services to students.
University of Houston Campus Recreation Center (Houston, TX)	Basic nutrition counseling is offered through the campus wellness division via nutrition interns.
University of Illinois at Chicago Student Recreation Facility (Chicago, IL)	The campus wellness center provides nutrition services, however, the recreation center does offer basic nutrition education.
Virginia Commonwealth University MCV Campus Recreation & Aquatic Center (Richmond, VA)	The wellness resource center provides nutrition services with a certified nutritionist.
University of Missouri – St. Louis - Mark Twain Athletic & Fitness Center (St. Louis, MO)	The university offers health & wellness education through the Health, Wellness and Counseling Services. Topics covered include diabetes and nutrition assessments and self-management skills and are not offered by an RD. ^{44,45}
Indiana University – Purdue University – Indianapolis Campus Recreation (Indianapolis, IN)	The Division of Student Affairs offers Health & Wellness Promotion to provide students with general nutrition information. ⁴⁶ An employee with a Master's of Science coordinates the program, with the help of peer educators. ⁴⁷ It was noted that nutrition services are not offered through the recreation center as the facility is not owned by recreation, but shared with recreation, athletics, and academics.
Wayne State University Mort Harris Recreation & Fitness Center	Wayne State University's Campus Health Center provides Wellness Counseling and

(Detroit, MI)	Health Promotion (nutrition, exercise, and weight management) as well as Health Education Programming for student organizations. ⁴⁸ It is not clear if an RD provides these services.
Schools that Provide Nutrition Services on Campus by an RD	
Institution & Recreation Center (City, State)	Description of Nutrition Services
University of Pittsburgh Baierl Student Recreation Center (Pittsburgh, PA)	Nutrition services are offered through student health services by an RD.
Temple University Recreation Independence Blue Cross Recreation Center, Pearson McGonigle Halls, and Temple University Fitness Facility (Philadelphia, PA)	Nutrition services by an RD are offered out of the wellness resource center and through Sodexo Food Services who operates food services on campus.
University of Massachusetts – Boston Beacon Fitness Center (Boston, MA)	Sodexo, who operates campus food services, provides free services by an RD.
Portland State University Campus Recreation Center (Portland, OR)	Portland State University Health Services offers nutrition counseling with an RD. ⁴⁹ The university also provides Intuitive Eating Groups to build self-trust with eating decisions and a resource page of books, articles, websites and blogs with nutrition information. ⁴⁹ In the past, an RD from the health and counseling center has hosted a “nutrition drop-in” at the campus recreation center.

As indicated in Table 10, seven schools offer nutrition services through the campus recreation center. Five of those schools have an RD that provides the nutrition services through the recreation center, and two of the schools (University of Cincinnati and Georgia State University) offer IC with an RD.

Table 10. Nutrition Services Offered by Campus Recreation Centers

Schools that Provide Nutrition Services at a Campus Recreation Center	
Institution & Recreation Center (City, State)	Description of Nutrition Services
Florida Agricultural & Mechanical	A DPD student provides basic nutrition

University Recreation Center (Tallahassee, FL)	education, conducts diet assessments with the assistance of electronic applications (MyFitnessPal) and performs BMI and body fat measurements.
University of Alabama at Birmingham Campus Recreation (Birmingham, AL)	Health coaching, which includes exercise plans, examples of healthy foods/meals, assistance with grocery shopping, fitness assessments and body fat testing are provided to students at the campus recreation center.
Schools that Provide Nutrition Services at a Campus Recreation Center with an RD	
Institution & Recreation Center (City, State)	Description of Nutrition Services
Cleveland State University Recreation Center (Cleveland, OH)	An RD provides: nutrition counseling, nutrition assessments, aids in developing personal nutrition plans, and general nutrition education.
University of New Orleans Recreation & Fitness Center (New Orleans, LA)	An RD provides: nutrition counseling, meal planning and nutrition advice. The RD is part-time and meets with clients by appointment only.
University of Wisconsin – Milwaukee University Recreation Building (Milwaukee, WI)	RDs provide one-on-one nutrition consultations, as well as support health fairs and the Stepping Forward Weight Loss Program.
Schools that Provide Nutrition Services at a Campus Recreation Center with an RD and Offer Indirect Calorimetry	
Institution & Recreation Center (City, State)	Description of Nutrition Services
University of Cincinnati Campus Recreation Center (Cincinnati, OH)	An RD provides RMR testing with The BodyGem® Indirect Calorimeter, nutrition coaching, nutrition education classes & presentations, and grocery store tours.
Georgia State University Student Recreation Center (Atlanta, GA)	The Student Recreation Center offers personal training, nutrition services, and RMR testing with The Korr ReeVue™ Portable Indirect Calorimeter. An RD provides nutrition assessments (including IC testing), nutrition coaching, and nutrition education. A graduate assistant (GA) nutritionist and Coordinated Program Graduate Nutrition Students assist with nutrition education and IC.

Table 11 displays the three schools that offered general nutrition information to students through websites or links on the university or college webpage. The websites did not provide information about specific nutrition services (i.e. nutrition assessments or nutrition counseling), but instead provided online nutrition information or nutrition activities on campus. Appendix A provides the direct responses from the contacts of the Urban 13 survey.

Table 11. Nutrition Information Offered Online and on Campus

Schools that offer Nutrition Information Online and Nutrition Activities on Campus	
Institution & Recreation Center (City, State)	Description of Nutrition Information
University of Missouri – Kansas City Swinney Recreation Center (Kansas City, MO)	The Outreach and Extension Website provides nutrition education and links to other nutrition sites (American Diabetic Association, Mayo Clinic). ⁵⁰ Based on a search on the University of Missouri Kansas City website, it appears nutrition support such as weight loss diet or eating healthfully may be offered through Sodexo Dining Services. ⁵¹ However, the link to the food services nutrition webpage was not active. ⁵²
City College of New York Wingate Fitness Center (New York, NY)	The City College of New York offers the Healthy Monday Campaign to students. This includes weekly table events by peer health educators that focus on nutrition, fitness, and sexual health. ⁵³ Student Health Services also offers Health Initiatives links to nutritional information including eating healthy and sugary drink handouts and www.choosemyplate.gov . ⁵⁴
University of Toledo Student Recreation Center (Toledo, OH)	The University of Toledo provides a nutrition podcast through the Dining and Hospitality Services. ⁵⁵ Health Services also provides support for eating disorders, however no nutrition services were found on a search of the website. ⁵⁶

A web search was performed to assess which schools offered personal training services at the campus recreation center. Nineteen of the 21 Urban 13 schools offered a personal training component through their recreation centers.^{21,44,57-73} Personal training services could not be found on the websites of City College of New York or Indiana University - Purdue University – Indianapolis

CHAPTER V
DISCUSSION AND CONCLUSIONS

Implications from the Comparison of Indirect Calorimetry, Predictive Equations, and Nutrition Maker© Plus 2.0

Our analysis discovered a significant difference between the means of measured resting metabolic rate (RMR) and the estimated RMR from the Harris-Benedict equation, but there was not a significant difference between the means of measured RMR and estimated RMR from the Mifflin-St. Jeor equation. It is interesting to note that total energy expenditure (TEE) estimated by the IOM equation and Nutrition Maker© Plus 2.0 both significantly over-estimated energy needs when compared with TEE that was calculated by multiplying measured RMR and an appropriate activity factor.

These findings suggest that in the absence of IC, the Mifflin-St. Jeor equation would be a suitable substitute method to estimate RMR in a non-obese and obese college population. This is similar to other studies that suggest the Mifflin-St. Jeor equation, secondary to IC, is a useful predictor of RMR and is more likely than other equations to estimate RMR within 10% of measured RMR.^{25,36} Accuracy rates of the Mifflin-St. Jeor equation are lower in obese people versus non-obese people.³⁶

Significance of Physical Activity Values

A statistical significance was found between the TEE means of the IOM equation and the measured RMR with an activity factor and the estimated TEE from the Harris-Benedict and the Mifflin-St. Jeor equations. However, TEE results from the IOM

equation and Nutrition Maker© Plus 2.0 did not produce statistically significant differences between the means. IC, the Harris-Benedict equation, and the Mifflin-St. Jeor equation use a physical activity factor, where as the IOM equation uses a physical activity level. Nutrition Maker© Plus 2.0 uses the Mifflin-St. Jeor equation but uses its own client activity level. The differences in physical activity values and the statistically significant differences in these means suggests PAF versus a PAL plays a factor in estimating energy needs and may need to be further explored.

Comparison of Healthy, Overweight/Obese, and Gender Groups

A significant difference was found between the means of measured RMR in the Healthy (BMI 18.5 - 24.9 kg/m²) and the Overweight/Obese (BMI >25.0 kg/m²) groups. One would assume that because energy needs are correlated with height, weight, or total body mass, a larger person would need more calories. Estimating a high daily calorie intake for an overweight or obese person may cause them to eat too much, actually preventing desired weight loss. A significant difference was found between the means of measured RMR in the male and female gender groups. Although men generally need more calories than women, this difference suggests a variation with gender.

Importance of Accurately Assessing Energy Needs

Frakenfield et al (2005) stated “current calculation methods for estimating RMR have clinically important limitations, including undetectable differences from measured RMR.”²⁵ This agrees with our findings that there is disagreement between measured and estimated RMR values. Findings confirmed our hypothesis of predictive equations and nutrition software over-estimating calorie needs when compared to the standard of IC testing. As outlined in Table 8, overestimation of total calorie needs ranged from 65 kcal

– 470 kcal. An over- or under- estimation of energy needs could actually cause undesired weight changes. This re-emphasizes the importance of accurately assessing energy needs to establish a successful nutrition care plan.²⁵

Indirect calorimetry has been found as the most effective method to measure energy needs and it has been stated that errors in estimating RMR can be eliminated with IC.²⁵ Despite the clear importance of accurately assessing energy needs with IC, Georgia State University and the University of Cincinnati are the only two schools in the Urban 13 that provide indirect calorimetry testing. Ideally, more schools should aim to implement IC testing to improve the accuracy of nutrition assessments. If this is not attainable, the Mifflin-St. Jeor equation should be used to estimate RMR with a college population.

Importance of Clinical Judgment and Physical Activity Values

An important component of TEE is the physical activity value. IC and predictive equations (Harris-Benedict, Mifflin-St. Jeor) use a PAF to estimate total energy needs. Physical activity factors include a range of values from 1.20 – 1.725. The IOM equation estimated total energy needs by incorporating a physical activity value associated with a Physical Activity Level (PAL), which is representative of a range of physical activity factors depending on intensity and frequency of the exercise (i.e. sedentary to very active). Nutrition Maker© Plus 2.0, which uses the Mifflin-St. Jeor equation to calculate energy needs, uses its own range of predetermined client activity levels, based on the intensity of physical activity (i.e. very light active to heavy). Choosing an activity factor or level too high or too low has a direct affect on recommendations for TEE, which can

produce undesired results. This underlines the significance of clinical judgment by an RD when selecting a PAF or PAL.

Importance of a Registered Dietitians and Clinical Judgment

In most professions, a certified expert in the field is preferred to give the best care or service, which is also the case with nutrition. A registered dietitian (RD) is a credentialed professional in the field of nutrition, whose clinical judgment is important in assessing appropriate methods of energy needs, knowing the limitations of each method, and selecting PAF and PAL. An RD understands that calorie needs can be a range, not just a single number, and that calorie needs change each day and should be adjusted with weight changes. An RD's credentials allow for nutritional counseling to motivate behavior change and this expertise is also needed to effectively perform indirect calorimetry testing, nutrition assessments, nutrition counseling, and medical nutrition therapy.

Benefits of Pairing Personal Training and Nutrition Services at a Campus

Recreation Center

A collaborative and comprehensive approach to nutrition can be extremely advantageous for students at a campus recreation center to adopt healthy lifestyle behaviors. Despite literature supporting a need for nutrition and lifestyle interventions for college students, not all schools offer nutrition services to their students.^{4,5} Our research has shown there is a wide variation as to where these services are offered on campus as well as who administers the services and what types of services are provided.

Georgia State University's Student Recreation Center offers personal training services that include individual workout sessions and fitness assessments to evaluate

muscular endurance, muscular strength, flexibility, body composition, and cardiorespiratory health. The fitness assessments also evaluate a student's level of fitness, cardiovascular health, blood pressure, and cholesterol levels.

As previously mentioned, the Georgia State Student Recreation Center also offers a full list of nutrition services that would be offered in clinical practice. An RD, GA, and master's level nutrition students provide a thorough nutrition assessment, analysis of a two-day food diary, and IC testing. The RD also provides medical nutrition therapy and nutritional counseling. Pairing personal training with nutrition services at a recreation center provides a collaborative, team approach to health and wellness.

Interestingly, 19 of the 21 Urban 13 schools offered a personal training component through their recreation centers.^{21,44,57-73} Yet, only seven of the 21 schools surveyed provide nutrition services through the recreation center. Combining personal training and nutrition services together broadens the scope of health and nutrition problems that can be addressed, thereby providing students a multi-disciplined approach at one location. A recreation center is a place of health and fitness and most likely these are the goals of its members. Providing these services through the recreation center, versus a health or wellness center, promotes fitness and nutrition in one location and creates the ability to address nutrition-related concerns with members of the recreation center. The previously mentioned study by Brawley et al (2012) supports this notion that a group-mediated approach, including a physical activity component and a weight component (dietary intervention with an RD), can promote desirable improvements post-intervention.

Prevalence of Electronic Methods to Calculate Energy Needs

This study has shown that when compared to the standard of indirect calorimetry, Nutrition Maker© Plus 2.0 had the highest over-estimation of total energy expenditure by 471 kcal/day, suggesting this software program does not effectively estimate energy needs. Interestingly, Nutrition Maker© Plus 2.0 uses the Mifflin-St. Jeor equation and client activity levels to compute total energy needs. However, there was a significant difference between the means of Nutrition Maker© Plus 2.0 TEE and TEE calculated from the Mifflin-St. Jeor equation. The Mifflin-St. Jeor equation uses a defined range of PAF whereas Nutrition Maker© Plus 2.0 uses client activity levels with values that are not defined. The variation in TEE may be a result of the physical activity values and needs to be recognized when using electronic methods to estimate energy needs.

Software programs lack the clinical judgment of an RD. Frankenfield et al (2005) indicated the importance of clinical judgment when estimating energy needs by recommending nutrition practitioners to use clinical judgment to determine the best method to estimate energy requirement.²⁵ Not only is clinical judgment critical to selecting the correct method to estimate energy needs, it is also important to select an appropriate range of physical activity values.

Electronic applications have become a popular method for individuals to estimate their daily calorie needs. The MyFitnessPal application uses the Mifflin-St. Jeor equation to compute total energy needs. As with Nutrition Maker© Plus 2.0, MyFitnessPal also lacks clearly defined physical activity values and clinical judgment, which can lead to an inaccurate energy assessment.

Strengths, Weaknesses, and Suggestions for Future Studies

This study is original in that IC testing was done with a college population at a student recreation center. There does not appear to be any literature describing the comparison of measured energy needs to energy needs estimated with predictive equations or nutrition software in a college population, and to our knowledge there are not any studies that describe the use of indirect calorimetry in a college population at a campus recreation center. The sample population was diverse, with respect to genders and BMI status. In addition, this study appears to be the first to describe the implementation and operations of nutrition services in a campus recreation center and examine nutrition services offered by other urban campus recreation centers. This uniqueness is a strength of this study. The limitations of this study include a small sample size and anthropometric data that were self-reported.

In order to improve our knowledge of energy need assessments in a college population, further studies should be conducted to compare measured and estimated methods for TEE in other college populations; explore the significance of PAF and PAL when estimating energy needs; highlight the importance of clinical judgment by an RD when determining energy needs; and examine long-term benefits of personal training services and nutrition services with IC at college recreation centers, as there is limited research studying intervention methods with multiple health components being tested at the same time.¹⁸

Conclusions

To our knowledge, this is the first study to compare IC with predictive equations and nutrition software in a college population at a campus recreation center and to

describe nutrition services offered by urban campus recreation centers. In the absence of indirect calorimetry, the Mifflin-St. Jeor equation is the best method to estimate energy needs for a college population of healthy, overweight, and obese individuals. We found TEE based on estimated RMR and TEE from IOM and nutrition software often overestimate energy needs when compared to TEE calculated from measured RMR in this population. This study also illustrates the importance of clinical judgment when selecting PAF and PAL for energy needs. Furthermore, only two schools, Georgia State University and the University of Cincinnati, provide indirect calorimetry testing. Finally, we discovered that nutrition services provided by an RD are limited at campus recreation centers of the Urban 13.

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APPENDIX

Responses from Contacts of the Urban 13 Campus Recreation Centers*

Survey Responses from the Urban 13	
Institution & Recreation Center (City, State)	Response to Survey Questions
University of Alabama at Birmingham Campus Recreation (Birmingham, AL)	<p>1. In the past two years we did offer nutrition services with an RD on staff, however we now no longer offer nutrition services through the RD.</p> <p>2. a. When we worked with the RD we offered nutrition counseling, assessments, body fat testing, weight management, counseling, analysis, BMI testing, food and exercise plans.</p> <p>b. Currently we offer Health Coaching where we are able to provide exercise plans and examples of healthy foods and meals to prepare and purchase. We offer one on one counseling through this where we will assist our members with grocery shopping, food journals, cooking swaps, weight management, fitness assessments, body fat testing.</p> <p>3. Not currently, but we had in the past two years</p> <p>4. Stated above with all of the services</p> <p>5. No</p>
University of Missouri – St. Louis - Mark Twain Athletic & Fitness Center (St. Louis, MO)	We do not offer this service.
University of Cincinnati Campus Recreation Center (Cincinnati, OH)	<p>1. Yes</p> <p>2. We offer nutrition coaching sessions as well as resting metabolic rate testing. We offer just the test and two types of follow-ups. One is a basic follow-up with meal plans and the other is a grocery store experience. We also offer the RMR test and a follow up as part of a Total Wellness package which consists of those 2 nutrition sessions and 8</p>

	<p>personal training sessions with nationally-certified personal trainers providing personal training.</p> <p>3. Yes</p> <p>4. He provides all of the above plus customized corporate or group lectures and presentations regarding nutrition.</p> <p>5. Yes, RMR via The Body Gem by Mircrolife. We offer it to students, and non-students as well.</p>
<p>University of Missouri – Kansas City Swinney Recreation Center (Kansas City, MO)</p>	<p>1. Not currently</p> <p>2. No</p> <p>3. No</p> <p>4. None</p> <p>5. No</p>
<p>Cleveland State University Recreation Center (Cleveland, OH)</p>	<p>1. Yes – Although a small program/service we offer in terms of how many people we are currently serving, we are offering nutrition services through our recreation center.</p> <p>2. The initial session with our RD generally serves as that assessment, with the option to purchase follow up packages to get the client moving forward with a plan. If they have utilized our services, purchased a plan they are also able to come back for a follow up session at a lower than the initial cost so that those individuals can continue to receive nutrition counseling as they seek to reach both their fitness and nutrition goals.</p> <p>3. Yes – although our website indicates we employ one RD, we have recently hired a second. In an attempt to further grow this service area, we have started to incorporate the knowledge of the RD in some of our fitness programming Iron Woman and Live Fit programs. As a part of participation in this program, each of the patrons will receive 1-2 sessions (depending on the particular program they are registered) with the RD. These costs are already built into the price, so it is not an additional charge to the patron at that time. With these continued changes, we were able to justify the hiring of a second RD to our staff.</p> <p>4. In theory – the RD is supposed to</p>

	<p>provide all of the services from the initial assessment session to continued nutrition counseling sessions to the follow up session. Some topics covered by the RD include:</p> <ul style="list-style-type: none"> - Develop a personalized nutrition plan -Assess the adequacy of your diet -Learn how to use diet to help prevent or treat chronic disease -Weight management -Learn how to eat healthy on the run and while eating out -Effective grocery store shopping -What to buy and what to avoid <p>I say in theory because we do have some knowledgeable Personal Trainers who also like to provide nutritional information to their clients. Preferably, all nutrition information would be coming from the RD; however, as a form of customer service, we probably won't ever get to the point where the Trainers are not providing some form of nutritional information.</p> <p>5. Not at this time.</p>
<p>University of New Orleans Recreation & Fitness Center (New Orleans, LA)</p>	<ol style="list-style-type: none"> 1. Yes. 2. Nutrition counseling with an RD 3. Yes, but she is not a full time staff member. She meets with clients by appointment only. 4. Nutrition counseling, meal planning, nutrition advice 5. No
<p>Florida Agricultural & Mechanical University Recreation Center (Tallahassee, FL)</p>	<p>The recreation center offers basic nutrition education, provided by a DPD student (has completed course work and is waiting on internship).</p> <ol style="list-style-type: none"> 1. Yes 2. Nutrition education – 3 day diet assessment, SuperTracker, MyFitnessPal, circumference, BMI, and body fat. 3. No 4. Nutrition education 5. No
<p>City College of New York Wingate Fitness Center (New York, NY)</p>	<p>No nutrition services are offered. The rec. center does provide basic nutrition education such as "healthy diet." No RD</p>

<p>Georgia State University Student Recreation Center (Atlanta, GA)</p>	<p>1. Yes 2. Nutrition Assessments, Nutrition Counseling, and Basic Nutrition Education 3. Yes, an RD, a GA Nutrition Student and Coordinated Program Nutrition Students 4. Nutrition Assessments & Nutrition Counseling, IC 5. Yes, with the Korr ReeVue™ Portable Indirect Calorimeter</p>
<p>University of Pittsburgh Baierl Student Recreation Center (Pittsburgh, PA)</p>	<p>No nutrition services. Services are offered through student health services by an RD.</p>
<p>University of Houston Campus Recreation Center (Houston, TX)</p>	<p>Our department does not currently offer any of the services you listed below. UH Wellness, which is a separate department, tries to secure nutrition interns each semester that are available to UH students for very basic nutrition counseling. As one of 5 departments within the Health and Wellness core in the Division of Student Affairs, we hope to eventually partner with others to add an RD or outsource services in the future, but that may be a few years away.</p>
<p>Portland State University Campus Recreation Center (Portland, OR)</p>	<p>1. NO 2. N/A 3. NO 4. N/A 5. NO I will note that we did have a dietitian from our Student Health and Counseling Center come to the Rec Center to host "nutrition drop-in hours" one hour per week for a couple terms. The turnout was not great but I honestly think this has to do with both the marketing and also who we have in the dietitian position right now. She isn't very good at reaching out to users in the facility and engaging with them so I think many patrons didn't feel comfortable approaching her.</p>
<p>University of Illinois at Chicago Student Recreation Facility (Chicago, IL)</p>	<p>We do not offer any specific nutrition services through Campus Recreation as the Wellness Center is a separate department on our campus, and they do some nutrition services. In Recreation, we do some</p>

	programming that touches on the importance of nutrition but we do not offer specific services or staff for nutrition counseling or assessments.
Temple University Recreation Independence Blue Cross Recreation Center, Pearson McGonigle Halls, and Temple University Fitness Facility (Philadelphia, PA)	<ol style="list-style-type: none"> 1. No 2. N/A 3. No 4. None 5. No <p>Nutrition services with registered dietitians are offered out of two areas on campus, the Sodexo Food Services area that manages the multiple food services areas in and around campus, and out of the Wellness resource center which does a hodge podge of student services. Both of these two 'offices' table at times in our recreation facilities to spread the word of their services and offerings.</p>
Indiana University – Purdue University – Indianapolis Campus Recreation (Indianapolis, IN)	<p>This should be brief: we do not own our own campus recreation facility –we are a shared facility between academics, athletics and us.</p> <ol style="list-style-type: none"> 1. No, we do not offer nutrition services on campus 2. NA 3. NA 4. NA 5. No
University of Toledo Student Recreation Center (Toledo, OH)	The University of Toledo does not provide nutrition services of any kind.
University of Massachusetts – Boston Beacon Fitness Center (Boston, MA)	Nutrition services are not offered through the recreation center. Sedexo – offers free services RD services, so students are referred to those dietitians.
Virginia Commonwealth University MCV Campus Recreation & Aquatic Center (Richmond, VA)	<ol style="list-style-type: none"> 1. We do not offer nutritional services through Recreational Sports. 4. We do collaborate with the Wellness Resource Center, which has certified nutritionists on staff. Their staff offers workshops in our facility once a semester. 5. We do no metabolic testing or indirect calorimetry at all.
University of Memphis Student Recreation and Fitness Center	1. Not through the recreation center, but through Health Services. We are

(Memphis, TN)	<p>considering that possibility due to comments/suggestions/inquiries by our students.</p> <ol style="list-style-type: none"> 2. Nutrition counseling 3. No 4. N/A 5. No. We only offer fitness assessments using BSDI Fitness Analyst software.
Wayne State University Mort Harris Recreation & Fitness Center (Detroit, MI)	We do not offer nutrition services.
University of Wisconsin – Milwaukee University Recreation Building (Milwaukee, WI)	<ol style="list-style-type: none"> 1. Yes, University Recreation offers Nutrition Services 2. We offer one-on-one nutrition consultations 3. We have 2 registered dietitians that also teach for the Nutritional Sciences program 4. Nutrition consultations, geared advice and nutrition plans, they also will offer nutrition workshops for our staff, help with health fairs and also help with other programs such as our Stepping Forward weight loss program (www.steppingforward.uwm.edu) 5. No

*All responses were quoted directly from each contact's answers to the email and phone survey.