PHYSICAL, BEHAVIORAL, PSYCHOLOGICAL, AND METABOLOMIC PREDICTORS OF WEIGHT AND ADIPOSITY CHANGE IN YOUNG ADULTS

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PHYSICAL, BEHAVIORAL, PSYCHOLOGICAL, AND METABOLOMIC PREDICTORS OF WEIGHT AND ADIPOSITY CHANGE IN YOUNG ADULTS

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Background: Weight gain in young adults during the first year of college tends to track into later adulthood, contributing to risk for adult overweight/obesity. Identification of predictors of weight gain and adiposity change, considering population subgroup differences, could lead to effective prevention strategies.

Methods: In the context of a prospective study design of college freshmen with repeated measures of anthropometry and adiposity (measured via dual energy x-ray absorptiometry), over one academic year, we evaluated multiple independent variables as potential predictors of weight gain and adiposity, testing for effect modification by sex. We also compared the metabolome between participants who increased in three markers of central adiposity over the year vs. those with stable adiposity.

Results: 264 freshmen (50% female, characteristics representative of the Class of 2015) participated; 65% (N = 173) completed follow-up 8-9 months later, at the end of the academic year. Weight gain was ~ 2 kg overall; among the 75% who gained at least 0.5 kg over the year, weight increased 5.6%, on average. Leaner body habitus at the start of college (leaner adiposity and anthropometrics) was associated with greater weight gain and weight gain risk in regression analyses. We observed a significant sex x physical activity interaction ($P_{interaction} = 0.049$) such that, higher baseline physical activity

predicted greater weight gain among females. Investigation of psychological factors, including eating competence, restraint, and overeating due to emotional or external cues, as predictors of changes in adiposity and weight were generally null; however, there was a consistent and statistically significant stress x sex interaction such that greater stress at the start of college was significantly associated with increases in weight, waist circumference and BMI among males. Metabolomics investigation results showed baseline plasma concentrations of meso-erythritol and fructose, two dietary sweeteners, were respectively 15- and 2-fold greater among participants who subsequently experienced increased central adiposity, compared to participants who maintained a stable adiposity phenotype.

Conclusions: Weight gain during the first year of university is common, and leaner body habitus at the beginning of college was associated with greater weight gain. There were meaningful sex differences in predictors of weight gain: higher self-reported baseline physical activity in females only and, higher self-reported baseline stress in males only, were both associated with greater weight gain. Higher frequency of dining hall use during the freshman year, and higher blood concentration of meso-erythritol were also significant predictors.

BIOGRAPHICAL SKETCH

Katie Carín Hootman was born in Eau Claire, Wisconsin and grew up with a love of the outdoors and spending summers with her family on Lake Winnebago. Katie enjoyed playing sports, traveling, and cooking and she developed an enduring interest in nutrition and health. She attended the University of Wisconsin – Stevens Point where she concentrated her studies in economics and foreign language before transitioning to dietetics and nutrition. She received the Chancellor's Leadership Medallion Award for her leadership, scholarship and service, and graduated *Cum Laude*, majoring in Dietetics.

From Stevens Point, Katie relocated to Buffalo, New York to pursue the Dietetic Internship Program at the State University of New York – Buffalo; she became a Registered Dietitian in 2008. Katie earned the Master of Science in Clinical Nutrition from SUNY – Buffalo in 2010. Her graduate work investigated dietary phytoestrogen exposure in relation to breast cancer tumor characteristics at Roswell Park Cancer Institute in Buffalo and through this work she further developed her dietetics skillset and gained meaningful experience in epidemiology and clinical research.

Katie joined the Division of Nutritional Sciences at Cornell University in 2010 to pursue the PhD in Nutritional Sciences with emphases in human nutrition, epidemiology and integrative human physiology. From 2011-2014 Katie was selected as

a predoctoral fellow in Translational Nutrition Research supported by the National Research Service Award, Institutional Training Grant, funded by the National Institute for Diabetes and Digestive Diseases. Through her graduate research and mentorship at Cornell, she completed invaluable training in epidemiologic research methods, longitudinal research, pathophysiology of chronic disease, as well as university teaching experience in clinical nutrition and epidemiology. Katie aims to pursue a career in which she utilizes her experience in dietetics, training clinical and epidemiologic research, as well as her passion for human nutrition and physiology.

DEDICATIONS

- I dedicate this work to all of the educators in my life, from throughout my life.

- To my family, especially my parents June and Scott, who live inspired lives of dedication, creativity and connection. Your support, encouragement and unconditional love have helped me every step of the way.

- To my sister, Mariah, who shows me how sensitivity, tact and organization are invaluable personal qualities.

- Will, I dedicate this work to you. Our adventures together have brought me abundant joy and laughter along with meaningful lessons about courage, trust, communication, and perseverance. Together we learned about partnership, risk and love. This work is dedicated to you for all the lessons we have learned from one another, learned together, and learned in parallel. You inspire me to hope, to adventure, and to live well with a light heart.

- To my friends and loved ones, those far and near, old and new. I continue to learn so much from each of you; thank you for being authentic, supportive, kind, and fun.

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I would also like to thank the numerous staff members, graduate students and undergraduate volunteers who devoted their time and effort to the EnHANCE Study. In particular, Brenda Daniels-Tibke and Vicky Simon were absolutely invaluable to our study. In addition, I am grateful for the EnHANCE participants and their engagement that made the study very special.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

BF%	total body fat percent
BMI	body mass index, BMI = body mass (kg)/height $(m)^2$
BCAA	branched-chain amino acid
CI	confidence interval
Cm	centimeter
FFQ	food frequency questionnaire
FMI	fat mass index, FMI = fat mass (kg)/height $(m)^2$
HbA1c	hemoglobin A1c, glycosylated hemoglobin
HC	hip circumference
Kcal	kilocalorie
Kg	kilogram
LDL	low density lipoprotein
M	meter
MET	metabolic equivalent
PA	physical activity
SP	study participant
SOP	standard operating procedure
TF%	truncal fat percent
VLDL	very low density lipoprotein
WC	waist circumference

CHAPTER ONE

INTRODUCTION

This year, an estimated 3.3 million U.S. high school graduates will enroll in postsecondary education as first-time college freshmen [1], marking the transition from living dependently among family and/or guardian(s) in adolescence to living relatively autonomously as young adults. This transition period is characterized by self-directed changes in health behaviors [2, 3] and has been identified as a critical period for excessive weight gain [4]. Nationally representative data from 1996 and 2001 show obesity prevalence doubled among adolescents transitioning to young adulthood over that time, increasing from 11% to 22% [5]; more recent data from the National Health and Nutrition Examination Survey indicate approximately 35% of Americans, aged 12-19 years, were overweight or obese in 2012 [6]. Overweight and obesity is defined as body weight that is greater than a level expected to be healthy for a given height and the standard metric for classifying weight status as underweight, normal, overweight, or obese is the body mass index (BMI), calculated as the ratio of weight (kg) to stature (m) squared.

The transition to college is unique: college freshmen gain weight more rapidly than their non-matriculated counterparts [7], gaining approximately 2 kg over the first year of college, on average [8]. Furthermore, freshman weight gain is common, occurring

in about 75% of freshmen, regardless of attendance at public or private institutions [9] and freshman weight gain contributes to a weight gain of approximately 3 kg, on average, over the entire college experience [10, 11].

Weight gain in college contributes to the trajectory of weight in later adulthood, thereby contributing to long-term risk for obesity and related co-morbidities [12]. A growing body of scientific evidence identifies excessive adipose tissue, not necessarily gross body weight, as the culprit for increased cardiometabolic risk because it is an active endocrine and paracrine organ [13] that releases bioactive factors that influence inflammation, blood lipids, and insulin resistance [14]. In the obese range of BMI (≥ 30 kg/m^2), there is a well-established linear relation of BMI with increased morbidity and mortality, but in the range of BMI < 30 the association is less consistent [15, 16]. In men and women with normal BMI, the prevalence of the components of the metabolic syndrome and the prevalence of cardiovascular disease vary by body fat percentage [17], indicating the importance of body fatness, particularly within the normal range for BMI. Tracking weight gain and BMI in the college years is not a specific enough indicator of health risk because the distribution of weight gain between fat and lean mass anatomical compartments is not reflected in gross body weight, and it is precisely this distribution that is most indicative of the health risks associated with excessive adiposity [18]. The accumulation of adipose tissue, particularly intra-abdominal (visceral) fat, in a young population is expected to set a trajectory favoring the development of cardiovascular

and/or metabolic disease in adulthood. It is critical to consider body composition, not merely stature and weight, when evaluating college age populations. Despite three decades of research on college weight gain, excessive weight gain during the freshman transition persists. Our research aimed to identify predictors of weight gain and adiposity change among first-year students pursuing post-secondary education at Cornell University.

Prior research has implicated numerous factors in freshman weight gain including dietary intake, initial weight [19], psychological stress [8], snacking habits [20], physical inactivity [21, 22], alcohol consumption [23] and residence on campus [24]. Many studies draw limited conclusions due to self-reported anthropometry data [25-27], single sex samples [28-30], short study duration and/or limited sample size [23, 31, 32]. In studies where both sexes are represented, evidence suggests males tend to gain 2- to 3-fold more weight than females [32, 33], although the body of evidence for sex differences is inconsistent [26, 34, 35]. Previous research in this area has not led to effective mainstream solutions preventing excessive weight gain in the U.S. population of first year university students and knowledge gaps persist regarding sex differences in the experience of weight and body composition changes.

In addition to work characterizing physical, dietary, and behavioral factors associated with weight gain, recent advances in research methodologies have catalyzed the emergence of the systematic study of circulating metabolites, also known as

metabolomics, for applied health research. Metabolomic profiling has identified causal effects of weight gain on multiple blood metabolites, including elevation of branched chain amino acids (BCAAs), very low density lipoprotein (VLDL) [36-38], triglycerides [36, 38], C-reactive protein [37, 38], and insulin-like growth factor [38]. In this body of evidence, hyperlipidemia and elevated branched chain amino acid profiles have also been associated with increased insulin resistance in addition to weight gain and obesity. While previous research explored the effect of weight change on the metabolome, questions about whether and how specific metabolites associate with subsequent changes in weight and adiposity remain unanswered. Our study addressed this knowledge gap by investigating metabolomic predictors of incident changes in central adiposity.

Overview of Research Aims

This dissertation explores predictors of weight and adiposity change among university freshmen studied just prior to arrival on campus through the end of the academic year. Each specific aim is centered around a core research question of whether and how a set of potential independent variables present at the start of college associate with changes in weight and adiposity and how associations may differ between population subgroups. As a whole, this dissertation describes physical, behavioral, psychological, and metabolomic predictors of college weight gain and adiposity

provides insight into interdisciplinary translational research.

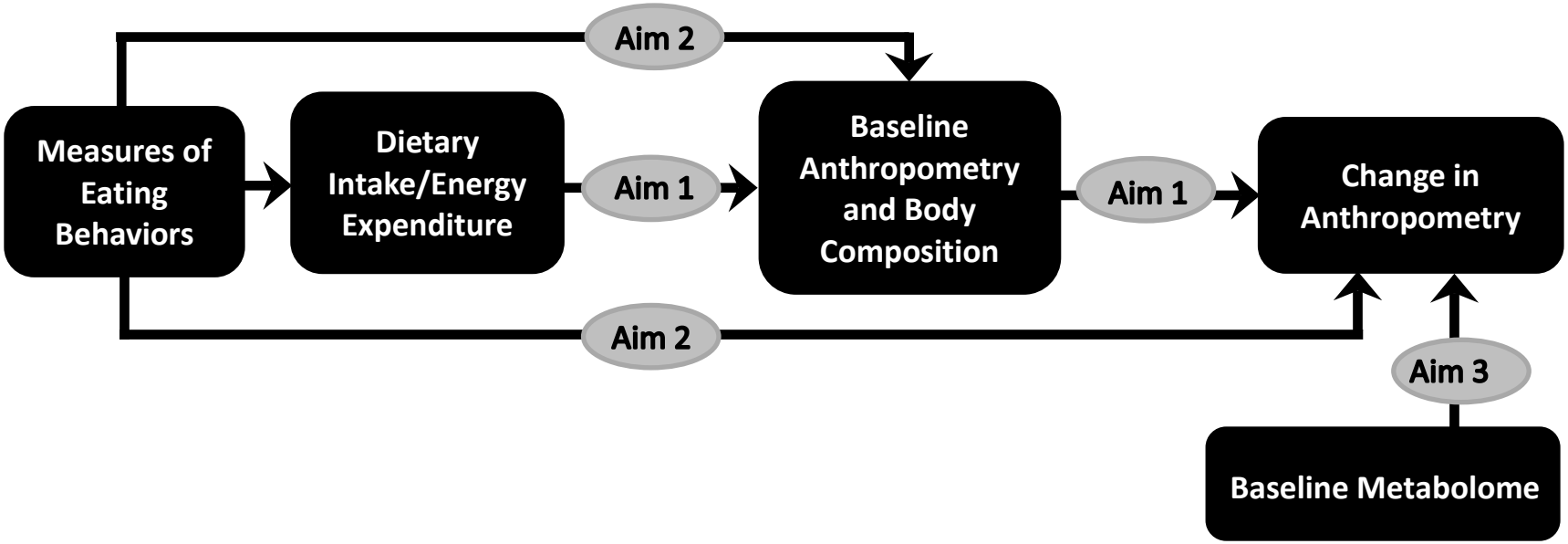
Aim 1: Investigate dietary intake, energy balance factors and physical activity in relation to changes in anthropometry and body composition over the first year of college in a large, mixed-sex sample using gold-standard dual-energy X-ray absorptiometry (DXA) measurements. We hypothesized weight gain varies by gender, depends on baseline anthropometry and that relative adiposity increases over the year in those gaining weight. In this study we also examined differences in body habitus changes experienced by males compared to females as well as comparing participants who gained more than 0.5 kg to those who gained less, maintained weight, or lost weight. Results for this research aim are described in Chapter 2.

Aim 2: Investigate psychological constructs related to eating behavior and energy balance factors in relation to anthropometry outcomes in the cohort of freshmen. Given the transition to college is characterized by shifting attitudes and behavior, we designed this study to examine baseline psychological and behavioral factors related to anthropometric changes during the first semester, a relatively short, yet meaningful period for weight change in the context of the freshman experience. We hypothesized that greater stress, greater disinhibited eating, less eating

competence, and greater emotional eating would predict greater weight gain in the first semester. Results for this research aim are described in Chapter 3.

Aim 3: Investigate the association between the baseline blood metabolome and incident changes in central adiposity over the first year of college. We used longitudinal anthropometry and body composition data to classify participants who increased in weight, waist circumference and truncal adiposity (measured by DXA) and those who remained relatively stable on those measures. We compared the baseline metabolome between the central adiposity phenotype and the stable adiposity phenotype. In addition, we compared the baseline metabolome in two other groups defined by the baseline distribution of usual glycemia, an indicator of glucose metabolism and cardiometabolic disease risk. Results for this research aim are described in Chapter 4.

Figure 1.1 Conceptual framework for the dissertation specific aims



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CHAPTER TWO

LONGITUDINAL CHANGES IN ANTHROPOMETRY AND BODY COMPOSITION IN UNIVERSITY FRESHMEN

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Running Title: Freshmen Year Weight and Adiposity Change

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Authorship: PAC, KCH and KAG designed the study, carried out the study, and managed and analyzed the data; KCH and PAC drafted the manuscript, and all authors edited the manuscript.

ABSTRACT

Background: Weight gain in early adulthood is associated with increased risk of adult overweight/obesity. We investigated factors associated with weight gain during the first year of college, and explored differences by sex. To address the need for objective quantification of adiposity change, we used dual energy X-ray absorptiometry (DXA).

Methods: We conducted a prospective cohort study of a representative sample of college students (N = 264), with repeated assessments of anthropometry, DXA-defined body composition, physical activity, and dietary intake. We investigated absolute change in weight and weight gain (defined as gaining >0.5kg) over the academic year (9 months) in least squares and logistic regression models, respectively.

Results: 172 participants completed follow-up and 75% gained >0.5kg in weight. There were negligible changes in linear growth in both sexes. Mean weight gain was 2.1 kg (SD 3.0); males and females gained 2.3 kg (SD 3.2) and 2.0 kg (SD 3.2), respectively. DXA-estimated adiposity increased 1.0% (SD 1.9); males and females increased 1.3% (SD 1.6) and 0.7% (SD 2.2), respectively. Among the participants gaining weight, there was a 5.6% increase in weight and a 1.6% increase in body fat. Males increased in weight and waist circumference primarily in the first semester, while females increased in both semesters. Leaner DXA-defined body composition at baseline was consistently associated with greater weight gain (P-values 0.029–0.049). Higher baseline physical activity was associated with greater weight gain in female participants only.

Conclusions: Overall, findings were consistent for continuous weight change and odds of weight gain. Freshman weight gain is common and reflects increased adiposity. Leaner body composition entering college was associated with greater gain in weight.

Introduction

For many of the approximately 3 million U.S. high school graduates who enroll in university directly after high school [1], the first year of university is a transition period bridging the adolescent experience of family-centered dependent living and independent living as young adults. The phenomenon of freshman weight gain, first introduced by Hovell et al. [2], occurs in about 75% of first year students, regardless of attendance at a public or private institution, according to recent prospective studies [3, 4]. A meta-analysis [5] of 24 studies (pooled N = 3,401) reported an average weight change of +1.75 kg (95% CI: 1.73-1.78 kg) during freshman year. Mean weight gain during four years of university is about 3 kg [6, 7], and, while gain in some studies is 2- to 3-fold greater in males [8, 9], the evidence for sex differences is inconsistent [4, 10, 11].

Past research suggests an association of dietary intake, initial weight [12], psychological stress [5], snacking habits [13], physical inactivity [14, 15], alcohol consumption [16] and residence on campus [17] with weight gain during the freshman year. Many studies draw limited conclusions due to inclusion of a single sex [18, 19], short study duration and/or limited sample size [16].

Weight gain during the freshman year is predictive of weight gain over all years of university [6] and the adult trajectory [8, 20], thus it contributes to long-term risk of overweight, obesity and associated co-morbidities. More immediate risks may exist given evidence that, among young people with a normal body mass index (BMI),

weight gain is associated with changes in risk-related metabolic biomarkers [21]. Even in the context of a normal BMI, excess adiposity increases health risks [22, 23], and at a given BMI, greater central adiposity is associated with an increased prevalence of dyslipidemia, hypertension, metabolic syndrome, and type 2 diabetes mellitus [24, 25]. In both adolescents and adults, a larger waist circumference is associated with a 5.5- to 16.5-fold increased odds of metabolic syndrome [26], and an increase of a few pounds in visceral adipose tissue in young, lean, healthy adults is associated with endothelial dysfunction [21], an early marker of cardiovascular risk. Despite the understanding that accretion of adipose tissue is the main determinant of adverse outcomes (26), the majority of published studies of weight gain do not consider body composition change.

Optimal strategies to prevent gain in weight and adiposity during the transition from home to university remain elusive [27], and there is a need for research that extends beyond the first semester, uses gold standard measurement of body composition such as dual energy X-ray absorptiometry (DXA), examines sex differences, and investigates differences between freshmen who gain weight and those who do not. In a random sample of college freshmen, we addressed these gaps by investigating the association of baseline body composition, anthropometry, and behaviors related to energy balance with changes in anthropometry and body composition in a random sample of university freshmen followed for one academic year.

Methods

Study Design and Participants

We conducted a one-year prospective cohort study of university freshmen matriculated at a largely residential University in the northeastern U.S. Students ≥ 18 years of age in the class of 2015 were eligible and 1001 students were randomly selected and contacted via email for study participation prior to arrival on campus. Of the students invited to participate, approximately 500 accessed the electronic materials describing the study; half (264) enrolled in the study and participated in the baseline data collection. Baseline data included a battery of electronic questionnaires administered in the month prior to the participant's relocation to campus in addition to an in-person study visit within the participants' first few days on campus for assessments of body composition via DXA and anthropometry. Follow-up visits were completed by 65% (172) of the sample, and included anthropometric assessments at the end of the first semester (mean 14.1 weeks from baseline [SD 1.1]) and at the end of the academic year (mean 34.8 weeks from baseline [SD 1.5]). The initial sample was 50% female, and the distribution by country of origin (domestic vs. international) and College of matriculation was representative of the incoming class of 2015. This study was conducted according to the guidelines in the Declaration of Helsinki, and all procedures involving human subjects were approved by the Cornell University Institutional Review Board for Human Participants Research. Written informed consent

was obtained from all participants.

Questionnaire Data

Web-based self-administered questionnaires collected information on usual diet (Diet History Questionnaire, DHQII, [28] NCI, Rockville, MD; baseline and end of year) and physical activity (Global Physical Activity Questionnaire, GPAQ, [29] WHO, Geneva, Switzerland; baseline, mid-year, end of year). The DHQII assessed usual consumption of 134 food and beverage items, based on standard portion sizes, over the past year. The validity of the DHQII is assumed to be similar to that of the DHQ [28] given minimal modifications. The GPAQ assessed the intensity, duration, and frequency of physical activity during work, recreation, and transportation in a recent typical week. To obtain a composite metric of daily activity, a metabolic equivalent (MET) value [30] of physical activity was assigned to each intensity level. The MET is a unit of relative energy expenditure (amount of energy expended for activity is divided by the amount of energy expended at rest): 1 MET corresponds to energy expenditure at rest, 4-6.9 METs corresponds to moderate intensity physical activity, and ≥7 METs corresponds to vigorous activity. MET hours/day were calculated using data on the number of hours/week in each activity at each level of intensity.

Dining Hall Data

University housing regulations require all freshmen to reside on campus and to enroll in a meal plan, and dining halls are accessed using student ID cards. When a student enters the dining hall, the ID card is 'swiped' through a card reader. We computed the average number of card swipes/day for each participant for the fall and spring semesters to obtain an objective estimate of meals/day.

Physical Measurements

Trained personnel measured weight, height, waist circumference, and hip circumference on participants within the first three days on campus, at mid-year, and at the end of the academic year. Before each data collection, anthropometrists completed at least one interactive training session and were evaluated for accurate technique and measurement reliability. Participants wore minimal, light clothing at each visit and measurements used standardized, calibrated instruments. Anthropometrists took two repeated measurements of height (stadiometer, Shorr Productions, Olney, MD) and weight (digital scale, Seca, Chino, CA). Three repeated measurements of waist and hip circumference were taken using a steel measuring tape (Lufkin, Apex, NC). All analyses used an average of these values.

An experienced, licensed radiologic technician conducted whole body scans to estimate body composition, using dual energy X-ray absorptiometry (DXA, QDR4500 fan beam densitometer, total body fat percent precision 1% [31], Hologic Inc., Bedford,

MA). DXA scans were completed in the first and last months of the academic year; the primary derived variables were total body fat percent (BF%), truncal fat percent (TF%), and fat mass index (FMI, the ratio of fat mass [kg] to height [m^2]).

Statistical Analysis

In order to gauge the similarities of our sample to the greater population of young adults in the US, we applied publically available statistical programs from the Centers for Disease Control and Prevention [32] to the anthropometric data from this study to generate participant z-scores for BMI-for-age, height-for-age, and weight-for-age. We used logistic and linear regression methods to investigate baseline factors associated with weight gain for categorical and continuous weight change, respectively. In logistic models, weight gain was defined as an increase in body weight >0.5 kg over the academic year; the 'no weight gain' group experienced either weight loss or <0.5 kg weight gain over the year. The threshold for the weight gain definition was set to capture true weight gain, an increase outside the error range of the calibrated electronic scale. To consider and account for potentially confounding factors in our analyses, fully adjusted statistical models considered sex, baseline anthropometry, body composition (total body fat%), diet (energy intake and total fat [% kcal]), and energy expenditure (physical activity, and sedentary time).

We evaluated differences in participant characteristics using the chi-square test

and Student's t-test; when underlying statistical assumptions were not met, we used nonparametric tests. All analyses used Statistical Analysis Systems statistical software package versions 9.3 and 9.4 (SAS Institute, Cary, NC, USA) with two-sided tests and $P<0.05$ as the threshold for statistical significance.

Results

Study Sample

Of the 264 participants enrolled in the study, 9% (N = 23) *only* completed online forms prior to arrival on campus, 26% (N = 69) completed only the baseline visit or only a mid-year visit, and 65% (N = 172) had complete follow-up, with measurements at baseline and at the end of the academic year. Participants with complete follow-up comprise the main analytical group. Characteristics at the baseline were comparable between the 264 enrolled participants and the 172 participants with complete follow-up (**Table 2.1**), with the exception that females were slightly more likely to complete the final visit. The 92 participants with incomplete follow-up included 60% males (versus 45% in the analytical group); the 69 (75% of 92) with baseline anthropometry data had slightly higher baseline weight and adiposity compared to participants with complete follow-up (Supplemental Table 2S.1). Mean percentiles, computed from z-scores, for weight-for-age, BMI-for-age, and height-for-age were 51.9%, 48.3%, and 52.9%, respectively, indicating this sample was similar to age- and sex-specific U.S. national

averages for anthropometric health indicators.

Descriptive Analysis of Changes in Anthropometry and Body Composition

The average weight gain over the academic year was 2.1 kg (SD 3.0); males and females gained an average of 2.3 (SD 3.2) and 2.0 kg (SD 2.9), respectively. DXA estimated adiposity change, change in BF%, was 1.0% (SD 1.9) overall, and 1.3% (SD 1.6) and 0.7% (SD 2.2) in males and females, respectively. 75% of the sample (N = 129) gained > 0.5 kg in weight and 43 participants did not gain weight (19 males; 24 females). Among participants who did not gain weight, 27 (63%; 13 males, 14 females) lost >0.5 kg and 16 had stable weight (within +/- 0.5 kg of baseline weight) over the academic year, and this group experienced a negative and/or no change in the majority of anthropometric measurements. Self-reported medical history at the study baseline was similar across weight change strata.

On average, participants who gained weight over the academic year experienced a 5.6% increase in weight, a 3 cm increase in waist circumference, a 1.1-unit increase in BMI, and a 0.6-unit increase in FMI. Based on the DXA body composition measurements, 94% of participants who gained weight increased in adiposity, and the increase in adiposity accounted for 69% and 66% of the weight increase in males and females, respectively. Among participants who gained weight, the mean ratio of fat mass (kg) to fat free mass (kg) increased significantly, from 0.26 to 0.29 ($p<0.0001$, data

not shown), indicating an increase in adiposity relative to lean mass.

The participants who subsequently gained weight had, on average, lower starting values for waist circumference (P = 0.029), BMI (P = 0.033) and FMI (P = 0.049) compared to those who did not gain weight (**Table 2.2**). Students with subsequent weight gain (vs. those without weight gain) tended to be at a lower percentile of BMI-for-age (43.3 vs. 53.5; P = 0.03) and weight-for-age (47.4 vs. 56.5; P = 0.07), but did not differ significantly on height-for-age at baseline (52.1 vs. 51.4; P = 0.93). There was little to no difference between weight change groups in daily exercise, sedentary time and dietary intake at study baseline. Mean alcohol intake, as a percentage of energy consumed, was negligible at < 2% in all groups at the beginning and end of the year.

Sex-specific changes in Body Composition and Energy Expenditure

In the first semester, the absolute increases in males who gained weight were of greater magnitude; thus, males gained approximately 1 kg more weight (P = 0.019) and increased about 1 cm more in waist circumference (P = 0.044) compared to females (**Table 2.3**). Although both sexes gained the majority of weight in the first semester, females had a greater percentage increase in weight in the second semester compared to males (1.2% vs. 0.4%). Anthropometric changes over the academic year were similar by sex among those who gained weight, with the exception that females increased more in hip circumference (P = 0.027). In participants who did not gain weight, the changes in

anthropometry in the first semester were negligible for both sexes, and over the academic year changes were small in magnitude and tended to be negative (thus, slightly lower values at the end of the year).

Males who gained weight reported a *decrease* in physical activity and a concomitant increase in sedentary time over the academic year, whereas females who gained weight reported an *increase* in physical activity (p=0.037; **Table 2.3**) and no change in sedentary time. On average participants reported lower energy intake (kcal/day) at the end of the academic year, compared to data from the summer prior to college entrance, regardless of weight gain status. Paradoxically, this decrease in reported energy intake was 1.5- to 2.5-fold greater among participants who gained weight (both sexes), compared to those who did not gain weight. The mean daily frequency of dining hall meals, measured by card swipes/day, during the first and second semesters did not differ by weight gain status, and there was little to no association between card swipes/day and change in weight over the year. Despite little variation in the average count of mealcard swipes per day, objective data on the total frequency of mealtime in the all-you-care-to-eat dining facilities, measured by the count of electronic card swipes required for dining access, showed a significant positive association between frequency of dining hall meals and changes in weight, BMI and waist circumference over the year; one standard deviation change in the count of mealcard swipes over the year was associated with 0.6 kg change in weight (P = 0.0314), 0.2 kg/m^2 change in BMI (P = 0.0447), and

0.5 cm change in waist circumference (P = 0.0436), after adjusting for sex and baseline anthropometry (data not shown).

Baseline Characteristics and Weight Gain (>0.5 kg) in the First Year of College

In findings that paralleled model-free comparisons, lower baseline levels of BMI, FMI, waist circumference, BF%, and TF% were statistically significantly associated with greater odds of gaining weight over the first year of college (**Table 2.4**). For example, a one-unit lower BMI at baseline was associated with an 11% greater odds of gaining weight in freshman year [odds ratio (OR) 0.89; 95% CI 0.80, 0.99]. When models were adjusted for sex, associations were similar for baseline BMI and waist circumference and stronger in magnitude for the body composition indicators. We considered the interaction of each variable with sex and detected a statistically significant interaction between sex and physical activity ($P_{interaction} = 0.041$); among females, a one-unit *greater* MET·hr/d physical activity at study baseline was associated with a 10% greater odds of gaining weight, but there was little to no association of baseline physical activity and subsequent weight gain in males.

The findings were similar when weight gain was modeled as a continuous outcome, particularly for the DXA body composition indicators. Leaner body composition at the study baseline was associated with greater absolute amount of weight gain over the year; baseline waist circumference (P = 0.038), BF% (P = 0.009), and

TF% (P = 0.024) were all inversely and statistically significantly associated with weight gain. The interaction between sex and physical activity was statistically significant in the fully adjusted model (P = 0.049). Thus, among females only, a one-unit *greater* MET·hr/d of baseline physical activity was associated with 0.11 kg increase in weight over the year; there was no association in males.

Sensitivity Analyses

To address possible misclassification of weight gain, we conducted a sensitivity analysis limiting our consideration to the top 25% of the weight gain distribution (weight gain defined as gain of >4.45 kg over the year; Supplement Tables 2S.2 and 2S.3). Over the academic year, the top 25% of the weight gain distribution experienced the following increases: 9.8% (SD 2.6) in weight, 2 units (SD 0.6) in BMI, 0.5 cm (SD 0.7) in height, 2.7% (SD 1.5) in total body fat, 3.1% (SD 1.9) in truncal fat, and 5.3 cm (SD 2.2) in waist circumference. In analyses comparing the top gainers to non-gainers, the interaction between gender and baseline physical activity persisted; thus, among females higher *baseline* physical activity was associated with greater odds of weight gain (for females, OR 1.13, 95% CI 1.02, 1.25). Also, in models of continuous weight change, there was a statistically significant interaction ($P_{interaction}$=0.073), and each additional MET·hr/d of baseline physical activity was associated with 0.09 kg increase in weight over the year in females only (data not shown). The pattern of *change* in physical activity

over the year showed that both male and females in the top quarter of the weight gain distribution reported a decrease in physical activity (with stable daily sedentary time, Supplement Table 4S). In this sensitivity analysis of participants experiencing extreme weight gain, there was little to no evidence of association of leaner body habitus at baseline with subsequent weight gain.

Excessive Adiposity: BMI Versus DXA Classifications

In this large sample of healthy young adults we explored two methods to classify excess adiposity: BMI (cutoff for excess adiposity $\geq$25) and DXA-derived BF% (cutoff >20% males, >30% females) (Supplement Table 5S). At the study baseline there was moderate agreement (Kappa statistic=0.49) between the classifications. Considering the BF% classification as the gold standard, 16 participants (8% of total) were classified as having excessive adiposity according to BF%, but not BMI, and may comprise a subgroup of "normal weight obese" [22].

Discussion

This study investigated the association of baseline body composition, anthropometry, and behaviors related to energy balance with changes in anthropometry and body composition during the first year of university. Leaner body composition at the start of college, estimated by DXA, was associated with both the

odds of weight gain and the magnitude of gain. We found a statistically significant interaction between sex and baseline physical activity such that females who subsequently gained weight reported *higher* baseline physical activity; in males there was little to no association between baseline physical activity and subsequent weight gain. Among participants gaining weight, males increased in anthropometric indices primarily in the first semester whereas female participants increased in both semesters.

Nine prior longitudinal studies, which evaluated sex differences in weight change in the first year of college, reported mixed findings. In four studies over the first year of college, males gained more weight than females [3, 16, 33, 34] while the remaining five studies showed no difference by sex [3, 4, 10-12]. Our findings indicate study duration may contribute to reported inconsistencies, a concept supported by recent evidence from college weight gain studies showing there is a positive correlation [$r = 0.40$, $P < 0.01$ in $N = 3,309$] between study duration and weight gain [5]. We observed males gaining more weight than females in the first semester, which is consistent with three studies reporting greater weight gain in males over the first semester [9, 16, 35]; however, there was little difference in the absolute amount of weight gain by sex over the full academic year, which is also similar to one prior with long enough study duration to compare weight change by sex after the first semester and again at the end of the first year of university[16], as we have done.

The association of baseline adiposity and subsequent weight gain is inconsistent in

prior studies. Among six studies addressing this question, two [36, 37] reported a positive association of baseline BMI with weight gain, one [38] reported no association, two [9, 39] reported an inverse association, and one[16] reported an inverse association using DXA estimated BF%. We found an inverse association using DXA estimated body composition, thus our findings agree with the one prior study (N = 29) that also used DXA [16] The DXA body composition indicators are more accurate adiposity estimates in young adults [40], which are expected to provide an unbiased estimate of the association of body habitus and subsequent weight gain.

Our study shows that both male and female participants who gained weight also increased body adiposity. The only prior study to use DXA longitudinally to assess body composition changes in first year students reported body fat increases in males only [16]. A U.S. study of a mixed-sex sample of freshmen, which used bioelectrical impedance to estimate body composition, reported a BF% increase of 2.2% (SD 2.7) and 1.8% (SD 3.2) in males and females, respectively [41], similar to our findings. A similar study of first year students conducted at multiple universities in the UK (N = 250) [12] reported small but significant gains in weight (0.8 kg, SD 2.1) and adiposity, measured via bioelectrical impedance (fat mass increased 0.9 kg, SD 1.9), after the first three months of the first term, but no significant increase in weight or adiposity over one year. Continued research to characterize young adult weight and adiposity changes are warranted to better understand these phenomena and to effectively target strategies to

reduce unhealthy weight gain risk and improve adult health.

The mean anthropometric characteristics of our sample were within normal limits at the study baseline. Nevertheless, 75% of participants gained weight, similar to prior reports of college-based studies [3, 4]. This prospective longitudinal cohort study included young adults who were in the freshman transition at one university during one time period, thus there was no comparison group of students outside this condition. For comparison to an outside group, we used nationally representative data to compute age- and sex-specific anthropometric z-scores, and found the sample characteristics were similar to population medians from 2000 [41]. Furthermore, 2000 CDC growth chart data (the most recent nationally representative data available on anthropometric trajectories specific to age and sex) [42] show the median expected weight gain for 18 year olds over an academic year is about 1.1 kg for males and 0.7 kg for females. In our study, male and female participants who gained weight increased by 3.6 kg and 3.2 kg, respectively, which is in excess of expected trajectories, arguing that change in weight is not simply reflecting maturation. Our finding of no change in linear growth further supports this claim. Furthermore 94% of the participants who gained weight increased in adiposity, measured by gold-standard DXA, with adipose gain accounting for about two-thirds of total weight gain, similar to past reports in this age-group [34].

There was little evidence to support an association of either energy intake and/or

dietary macronutrient factors with the change in body composition. There was no difference in total energy intake at study baseline between weight gain status groups; over the year, all participants reported a decrease in kcal/day, with the greatest decrease reported by participants who gained weight. These findings may reflect selective under-reporting of dietary intake, the challenge of accurately reporting dietary intake in the context of institutional dining, and/or a true effort by students experiencing weight gain to limit dietary intake at the end of the year to lose weight. The frequency of eating in a dining hall was < 2 meals/day in all subgroups, and while we expected participants to supplement their dining hall meals with other food, no information on other food sources was available, limiting our consideration of dietary intake. Despite limited data available on specific food choices, All international students with complete follow-up (N = 12) gained weight over the year, while ~75% of domestic students gained weight (N = 117), but it was not possible to identify differential explanatory factors given the small sample size.

Two methods for classifying excessive adiposity, BMI and BF%, showed a moderate level of agreement in this population. Although BMI is a reasonable proxy for body composition in the general population of adults, it may not perform as well in young adults [40]. Individuals with a normal BMI, but a BF% exceeding healthy sex-specific thresholds may be at risk for the development of adverse cardiometabolic changes, and our findings suggest about 6-8% of the sample fit this pattern [21].

We acknowledge several limitations including the lack of data on race/ethnicity, which was not included on study questionnaires; the study sample is assumed to be representative of the incoming class of 2015 where 20.1% self-identify as under-represented minorities. Also, while the sample was representative of the population of incoming students and at about the median on body habitus compared to national reference data, our results may not generalize to all college freshmen in the U.S. given campus-specific demographic characteristics and/or other features relevant to weight change may differ. Although data on family socioeconomic status (SES) indicators was unavailable in this study, it is reasonable to assume that the transition into the residential college environment with compulsory enrollment in the campus dining meal plan neutralizes the SES differential, because residence conditions and food availability are common to all freshmen. Participants lost to follow-up tended to be male, and had a higher starting weight, BMI and waist circumference compared to the sample with complete follow-up. If all participants who dropped out went on to gain weight then the trend for gainers to be leaner at baseline would be attenuated, but we cannot assess the degree to which this possible bias affects the findings. This study has important strengths including: body composition estimated by repeated DXA, repeated measurements of anthropometry, the use of well-defined protocols administered by trained staff, the large sample size, and the focus on within-person body composition change in subgroups defined by weight gain status.

In our analyses we distinguished between participants who gained weight during the first year of college and those who did not, using the threshold of weight change >0.5 kg to classify weight gain status. Prior research in this area [5] typically defined weight gain as any positive change in weight, but we set our threshold for weight gain to exceed the measurement error of the scale used in this study. Although this is expected to improve the classification of true weight gain, misclassification may yet affect our findings. We addressed this by also considering continuous outcomes, which were in complete agreement with categorical outcome models. Evidence from a sensitivity analyses limited to extreme weight gainers (top 25% of distribution, >4.45kg gain) supported the finding that females with higher physical activity at the beginning of the year are at increased risk for weight gain, but a leaner body habitus at baseline did not predict weight gain in this group. The more extreme weight gain outcome in the sensitivity analysis may be driven by other factors.

Conclusion

First year students followed prospectively from the summer prior to college through the end of the academic year, measured with DXA and anthropometry, gained an average of 2 kg, 75% gained weight, and those gaining weight experienced a 5.6% increase in weight and a 1.6% increase in body fat. Weight gain reflected gain in adiposity, as confirmed by gold standard DXA findings. In females only, higher self-

reported physical activity at the beginning of the year was associated with greater weight gain, and in both sexes leaner body composition at the beginning of the year was associated with greater weight gain in both categorical and continuous models. Further research investigating the relation of adiposity change to cardiometabolic risk in normal weight individuals is needed to explore the physiologic consequences of body composition changes in this age group.

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Table 2.1 Participant characteristics at the study baseline, August 2011, by completeness of participation

Baseline Characteristics	All Participants N=264*		Participants With Follow-Up N=172†	
Sex (% female)	49.6		54.7	
Nationality (% non-U.S.)	7.2		7.0	
	Mean	**SD**	**Mean**	**SD**
Age (years)	18.1	0.3	18.1	0.2
Weight (kg)	63.9	12.2	62.7	11.6
Body mass index (kg/m^2)	22.0	3.1	21.7	3.0
Waist circumference (cm)	73.1	8.3	72.4	7.9
Hip circumference (cm)	96.0	7.3	95.5	7.3
Total body fat (%)	21.2	7.4	20.9	7.3
Fat mass index (kg/ m^2)	4.8	2.2	4.7	2.1
Total physical activity (MET·hr/d)	10.2	10.9	9.8	9.3
Sedentary time (hr/d)	6.3	2.9	6.6	2.9
Usual energy intake (kcal/d)	2034	778	2081	784
Carbohydrate (% total kcal)‡	48.9	7.4	48.7	7.5
Protein (% total kcal)‡	16.2	3.1	16.2	3.2
Fat (% total kcal)‡	32.4	6.4	32.7	6.4

* Sample size varies slightly by variable due to missing data; N > 235 except for energy intake (N = 196)

† Sample size at final follow-up varies slightly by variable due to missing data; N >163, except for energy intake (N = 137)

‡ Mean percent of energy from alcohol consumption < 1% at both follow-up points; macronutrient total does not sum to 100% due to rounding

Table 2.2 Participant characteristics (N = 172 participants with complete follow-up) at the study baseline, stratified by weight gain over the academic year (> 0.5 kg vs. no weight gain)*

Baseline Characteristics	Weight Gain N=129		No Weight Gain N=43		P-Value†
Sex (% female)	54.3		55.8		0.860
Nationality (% non-U.S.)	9.3		0		**0.038**
	Mean	**SD**	**Mean**	**SD**	
Age (years)	18.1	0.3	18.0	0.2	0.565
Weight (kg)	61.9	11.6	65.0	11.4	0.107
Height (cm)	169.5	9.6	169.4	9.0	0.961
Body mass index (kg/m^2)	21.4	2.8	22.6	3.5	**0.033**
Waist circumference (cm)	71.6	7.3	74.8	9.1	**0.029**
Hip circumference (cm)	95.0	7.3	96.9	7.3	0.130
Total body fat (%)	20.2	7.0	22.9	8.1	0.066
Truncal body fat (%)	16.6	6.9	19.5	8.2	0.072
Lean body mass (%)	79.8	7.0	77.1	8.1	0.066
Fat mass index (kg/m^2)	4.5	1.9	5.4	2.5	**0.049**
Total physical activity (MET·hr/d)	10.4	9.7	7.8	7.8	0.169
Sedentary time (hr/d)	6.7	2.9	6.1	3.1	0.228
Usual energy intake (kcal/d)‡	2093	853	2042	516	0.773
Carbohydrate (% total kcal)	49.2	7.5	46.9	7.1	0.180
Protein (% total kcal)	16.0	3.2	16.7	3.0	0.275
Fat (% total kcal)	32.3	6.5	33.9	6.2	0.203

* Sample size varied slightly by variable due to missing data; N > 122 for weight gain group and N > 39 for no weight gain group for all variables except for 4 dietary intake variables (N = 106 and 31, respectively)

† Statistical significance of difference based on two-sample Student's t-test for variables meeting underlying assumptions; otherwise, statistical significance based on Wilcoxon Signed Rank non-parametric test (P < 0.05 **bolded**)

‡ Mean percent of energy from alcohol intake was < 1% in both groups

Table 2.3 Sex-specific change* in body composition and energy expenditure, during first semester and academic year; mean change in each characteristic and the corresponding standard deviation are shown by sex within weight change groups

	Participants Gaining > 0.5kg†			No Weight Gain†	
	Males N=59	Females N=70		Males N=19	Females N=24
First Semester Change*	Mean (SD)	Mean (SD)	P-Value‡	Mean (SD)	Mean (SD)
Anthropometry					
Weight (kg)	3.4 (2.5)	2.4 (1.9)	**0.019**	0.2 (1.8)	-0.5 (1.9)
Weight (% change)	5.2 (3.8)	4.4 (3.5)	0.264	0.4 (2.6)	-0.6 (3.1)
Height (cm)	0.0 (0.6)	0.2 (0.5)	**0.010**	-0.1 (0.5)	0.2 (0.6)
BMI (kg/m^2)	1.1 (0.8)	0.9 (0.7)	0.090	0.1 (0.6)	-0.2 (0.8)
Waist circumference (cm)	3.4 (3.2)	2.4 (2.5)	**0.044**	0.7 (2.2)	-0.1 (2.0)
Hip circumference (cm)	1.8 (3.4)	2.4 (2.6)	0.337	0.1 (3.7)	-0.7 (2.7)
Energy Expenditure					
Total PA (MET·hr/day)	0.1 (8.4)	2.3 (11.8)	0.057	-2.3 (10.4)	6.7 (11.3)
Sedentary time (hr/day)	0.4 (3.9)	0.4 (3.1)	0.954	0.1 (4.2)	1.5 (3.6)
Academic Year Change*					
Anthropometry					
Weight (kg)	3.6 (2.2)	3.2 (2.0)	0.361	-1.7 (2.2)	-1.6 (2.0)
Weight (% change)	5.5 (3.4)	5.6 (3.3)	0.701	-2.3 (3.0)	-2.6 (3.0)
Height (cm)	0.3 (0.7)	0.5 (0.6)	0.092	0.3 (0.7)	0.4 (0.5)
BMI (kg/m^2)	1.1 (0.7)	1.1 (0.7)	0.976	-0.6 (0.8)	-0.7 (0.8)
Waist circumference (cm)	2.9 (2.2)	3.1 (2.4)	0.700	-0.8 (2.9)	-0.9 (2.8)
Hip circumference (cm)	1.5 (2.4)	2.6 (3.0)	**0.027**	-1.5 (3.5)	-2.1 (2.6)
Body Composition					
Total body fat (%)	1.8 (1.2)	1.5 (1.8)	0.327	-0.3 (1.5)	-1.4 (1.6)
Truncal fat (%)	2.0 (1.3)	1.7 (2.3)	0.255	-0.3 (1.5)	-1.8 (1.9)
Lean body mass (%)	-1.8 (1.2)	-1.5 (1.8)	0.327	0.3 (1.5)	1.4 (1.6)
FMI (kg/m^2)	0.5 (0.4)	0.6 (0.6)	0.683	-0.2 (0.4)	-0.5 (0.5)
Energy Expenditure					
Total PA (MET·hr/day)	-2.3 (8.8)	1.5 (14.2)	**0.037**	-1.0 (13.1)	6.1 (7.9)
Sedentary time (hr/day)	1.2 (3.0)	0.2 (3.5)	0.138	0.8 (3.2)	1.7 (3.8)

(table continues on the next page)

	Participants Gaining > 0.5kg†			No Weight Gain†	
	Males N=59	Females N=70		Males N=19	Females N=24
First Semester Change*	Mean (SD)	Mean (SD)	P-Value‡	Mean (SD)	Mean (SD)
Diet					
Energy intake (kcal/day)	-484 (1040)	-363 (873)	0.264	-204 (764)	-131 (566)
Carbohydrate (% total kcal)	-0.1 (9.0)	-0.1 (6.9)	0.714	1.7 (5.4)	-1.5 (4.6)
Protein (% total kcal)	-0.7 (4.1)	-0.7 (2.9)	0.499	-1.2 (2.1)	-0.4 (3.4)
Fat (% total kcal)	-0.2 (5.4)	0.3 (6.6)	0.403	-1.4 (3.7)	1.4 (4.2)
Dining hall frequency (swipes/day)§	-0.1 (0.3)	-0.1 (0.2)	0.911	-0.2 (0.4)	-0.1 (0.2)

Abbreviations: BMI, body mass index; FMI, fat mass index; PA, physical activity

*First semester change is the difference between the measurement at the end of first semester and baseline (14.07 wks [SD 1.09]); academic year change is the difference between the measurement at the end of spring semester and the baseline (34.8 weeks [SD 1.48]).

† N varies slightly by variable: FFQ-derived diet composition variables had the lowest response rate (males N = 28, females N = 40)

‡ Statistical significance of sex difference based on two-sample Student's t-test for variables meeting the underlying assumptions of the test, otherwise, significance based on Wilcoxon Signed Rank non-parametric test ($P < 0.05$ **bolded**)

§The difference between the average count of card swipes per day in the spring semester and that of fall semester

Table 2.4 Logistic regression models estimating the relation of baseline characteristics to risk of weight gain over the first year of college (dichotomous outcome defined as gaining >0.5 kg vs. no gain)

Baseline Characteristics	**Model I, unadjusted***		**Model II, sex adjusted†**		**Model III, fully adjusted §**	
Anthropometry	**Odds Ratio**	**95% CI**	**Odds Ratio**	**95% CI**	**Odds Ratio**	**95% CI**
BMI (kg/ m^2)	**0.89‡**	**0.80, 0.99**	**0.89**	**0.80, 0.99**	0.96	0.75, 1.22
WC (cm)	**0.95**	**0.91, 0.99**	**0.95**	**0.90, 0.99**	0.88	0.78, 1.00
HC (cm)	0.97	0.92, 1.01	0.97	0.92, 1.01	1.01	0.87, 1.18
Body Composition						
BF (%)	0.95	0.91, 1.0	**0.91**	**0.84, 0.97**	0.89	0.80, 1.00
TF (%)	0.95	0.91, 1.0	**0.93**	**0.88, 0.98**	0.94	0.86, 1.02
FMI (kg/ m^2)	**0.83**	**0.71, 0.98**	**0.78**	**0.65, 0.95**	0.79	0.57, 1.09
Energy Expenditure						
Total PA (MET·hr/d)	1.04	0.99, 1.08	Males: 0.99‡ **Females: 1.10‡**	0.93, 1.05 **1.01, 1.19**	Males: 0.96‡ **Females: 1.10‡**	0.88, 1.04 **1.00, 1.21**
Sedentary time (hr/d)	1.07	0.95, 1.21	1.07	0.95, 1.21	1.12	0.95, 1.32
Diet						
Usual energy intake (kcal/d)	1.00	1.00, 1.00	1.00	1.00, 1.00	1.00	1.00, 1.00
Carbohydrate (% total kcal)	1.05	1.00, 1.11	1.05	1.00, 1.11	1.04	0.98, 1.11
Protein (% total kcal)	0.93	0.83, 1.06	0.94	0.83, 1.06	0.91	0.79, 1.05
Total fat (% total kcal)	0.96	0.90, 1.02	0.96	0.90, 1.02	0.98	0.91, 1.05

Abbreviations: BMI, body mass index; WC, waist circumference; HC, hip circumference; BF, body fat; TF, truncal fat; FMI, fat mass index; PA, physical activity

* No variables other than the single variable listed were included in unadjusted model

† Model was adjusted for sex, and sex by 'variable' interaction was tested and included

if statistically significant
‡ The P-value for estimates shown in bold was < 0.05; the sex by physical activity interaction P = 0.0409, thus model estimates shown are sex-specific
§ For each anthropometry and body composition variable models were adjusted for sex, baseline weight, baseline diet (energy intake and total fat [% kcal]), and energy expenditure (physical activity, sex by physical activity interaction, and sedentary time). All other models (for energy expenditure and diet variables) also adjusted for total body fat percent.

Table 2.5 Linear regression models estimating the association of baseline characteristics with subsequent weight gain (continuous outcome, kg) over one academic year.

	Model I, adjusted for sex *			Model II, fully adjusted†		
Baseline Characteristics	**β**	**95% CI**	**P-value**	**β**	**95% CI**	**P-value**
Anthropometry						
Weight (kg)	-0.02	-0.06, 0.03	0.494	0.02	-0.04, 0.08	0.537
BMI (kg/m^2)	-0.07	-0.22, 0.08	0.379	0.03	-0.30, 0.36	0.854
WC (cm)	**-0.07**	**-0.13, -0.00**	**0.038**‡	**-0.21**	**-0.36, -0.06**	**0.007**
HC (cm)	-0.03	-0.09, 0.04	0.425	0.03	-0.20, 0.25	0.833
Body Composition						
Total BF (%)	**-0.12**	**-0.21, -0.03**	**0.009**	**-0.17**	**-0.30, -0.04**	**0.013**
TF (%)	**-0.09**	**-0.17, -0.01**	**0.024**	**-0.11**	**-0.22, -0.00**	**0.050**
FMI (kg/m^2)	-0.26	-0.51, 0.00	0.054	-0.35	-0.76, 0.07	0.107
Energy Expenditure						
Total PA (MET·hr/d)‡	Males: 0.14	-0.78, 1.06	0.769	Males: -0.03	-0.13, 0.08	0.601
	Females: -0.14	-1.06, 0.78	0.769	**Females: 0.11**	**0.01, 0.20**	**0.026**
Sedentary time (hr/d)	0.008	-0.15, 0.17	0.922	0.05	-0.14, 0.24	0.603
Diet						
Usual energy intake (kcal/d)	0.00	-0.00, 0.00	0.674	0.05	-0.14, 0.24	0.603
Carbohydrate (% total kcal)	0.02	-0.06, 0.09	0.665	0.00	-0.00, 0.00	0.901
Protein (% total kcal)	0.052	-0.11, 0.22	0.541	0.01	-0.06, 0.08	0.755
Fat (% total kcal)	-0.045	-0.13, 0.04	0.276	0.03	-0.14, 0.20	0.736

Abbreviations: BMI, body mass index; WC, waist circumference; HC, hip circumference; BF, body fat; TF, truncal fat; FMI, fat mass index; PA, physical activity

* Model I for each variable, in separate models, adjusted for sex; sex by physical activity interaction was tested, but only included if statistically significant.
† For each anthropometry and body composition variable, models were adjusted for sex, baseline weight, baseline diet (energy intake and total fat [% kcal]), baseline energy expenditure (physical activity, sex by physical activity interaction, and sedentary time). All other models (for energy expenditure and diet variables) also adjusted for total body fat percent.
‡ P-values < 0.05 and associated parameters are in bold, and in model I the P-value for the sex by physical activity interaction = 0.8510; in model II, P-value for interaction=0.0486, interaction beta coefficient = -0.135 (males 1; females 0), and thus both models shown accounting for sex interaction

SUPPLEMENT

LONGITUDINAL CHANGES IN ANTHROPOMETRY AND BODY COMPOSITION IN UNIVERSITY FRESHMEN

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Table 2S.1 Baseline characteristics of participants with incomplete follow-up compared to participants with complete follow-up

Characteristic	Participants with Incomplete Follow-Up N=92		Participants With Complete Follow-Up N=172		P-Value*
Gender (% female)	40.2		54.7		**0.025**
Nationality (% non-U.S.)	7.6		7.0		0.850
	Mean	**SD**	**Mean**	**SD**	
Age (years)	18.1	0.3	18.1	0.2	0.546
Weight (kg)	66.8	13.2	62.7	11.6	**0.018**
Body mass index (kg/m^2)	22.6	3.1	21.7	3.0	**0.011**
Waist circumference (cm)	74.9	8.9	72.4	7.9	**0.016**
Hip circumference (cm)	97.3	7.3	95.5	7.3	0.074
Total body fat (%)	22.2	7.8	20.9	7.3	0.308
Fat mass index (kg/ m^2)	5.2	2.8	4.7	2.1	0.229
Total physical activity (MET·hr/d)‡	11.4	13.9	9.8	9.3	0.879
Sedentary time (hr/d)	5.8	2.8	6.6	2.9	0.079
Usual energy intake (kcal/d)	1925	760	2081	784	0.210
Carbohydrate (% total kcal)‡	49.4	7.3	48.7	7.5	0.443
Protein (% total kcal)‡	16.1	2.8	16.2	3.2	0.856
Fat (% total kcal)‡	31.6	6.1	32.7	6.4	0.282

*Statistical significance was from a two-sample Student's t-test for variables meeting the underlying assumptions of the test, otherwise, statistical significance was from the Wilcoxon Signed Rank non-parametric test (P < 0.05 **bolded**)

†Mean percent of energy from alcohol consumption <1% in both groups; macronutrient total does not sum to 100% due to rounding

Table 2S.2 Comparison of the baseline characteristics of participants in the top 25% versus bottom 75% of the weight gain distribution*

Characteristic	Top 25% N=32		Bottom 75% N=97		P-Value†
Gender (% female)	46.9		56.7		0.333
Nationality (% non-U.S.)	12.5		8.3		0.491‡
	Mean	**SD**	**Mean**	**SD**	
Age (years)	18.1	0.3	18.1	0.2	0.462
Weight (kg)	67.0	14.0	60.3	10.3	**0.016**
Height (cm)	171.6	9.5	168.8	9.6	0.158
Body mass index (kg/m^2)	22.6	3.6	21.0	2.4	**0.015**
Waist circumference (cm)	74.1	8.6	70.8	6.7	**0.025**
Hip circumference (cm)	97.1	8.6	94.4	6.8	0.071
Total body fat (%)	20.7	8.5	20.0	6.5	0.643
Truncal body fat (%)	18.0	8.5	16.2	6.3	0.579
Fat free mass (%)	79.3	8.5	80.0	6.5	0.643
Fat mass index (kg/m^2)	5.0	2.5	4.4	1.7	0.435
Total physical activity (MET·hr/d)	11.1	9.4	10.2	9.8	0.572
Sedentary time (hr/d)	6.5	3.2	6.8	2.8	0.634
Usual energy intake (kcal/d)	2149	715	2076	895	0.711
Energy from carbohydrate (%)	47.3	7.3	49.8	7.6	**0.047**
Energy from protein (%)	16.7	3.9	15.8	3.0	0.321
Energy from fat (%)	33.1	6.2	32.1	6.6	0.499
Energy from alcohol (%)	1.8	3.4	0.5	1.2	0.063

* 75% of all participants with complete follow-up gain weight, hence N = 129, and the top 25% of the weight gain distribution gained more than 4.45kg over the academic year.

† Statistical significance of difference based on two-sample Student's t-test for variables meeting underlying assumptions of the test, otherwise, statistical significance based on Wilcoxon Signed Rank non-parametric test ($P < 0.05$ **bolded**).

‡ P-value from two-sided Fisher's Exact Test provided because one cell count < 5

Table 2S.3 Average change in body composition and energy expenditure for two time periods during the first year of college for participants in the top 25% of the weight gain distribution compared to the rest of the sample, stratified by gender

	Top 25%			Bottom 75%	
First Semester Change*	**Males N=17 Mean (SD)**	**Females N=15 Mean (SD)**	**P-Value†**	**Males N=42 Mean (SD)**	**Females N=55 Mean (SD)**
Anthropometry					
Weight (kg)	5.9 (1.4)	4.3 (1.9)	**0.017**	2.5 (2.2)	2.0 (1.6)
Weight (% change)	8.3 (2.5)	7.2 (3.2)	0.314	4.0 (3.6)	3.7 (3.1)
Height (cm)	0.0 (0.7)	0.1 (0.4)	0.725	0.0 (0.6)	0.3 (0.5)
BMI (kg/m^2)	1.9 (0.5)	1.6 (0.7)	0.164	0.8 (0.7)	0.7 (0.6)
WC (cm)	6.0 (3.1)	4.2 (2.9)	0.119	2.4 (2.6)	1.9 (2.1)
HC (cm)	4.2 (2.5)	4.2 (2.6)	0.948	0.9 (3.2)	1.9 (2.4)
Energy Expenditure					
Total PA (MET·hr/day)	2.8 (8.2)	2.6 (13.7)	0.975	-0.8 (8.4)	2.2 (11.4)
Sedentary time (hr/day)	0.1 (2.7)	0.7 (4.0)	0.657	0.5 (4.2)	0.3 (2.8)
Academic Year Change*					
Anthropometry					
Weight (kg)	6.5 (1.4)	6.2 (1.4)	0.167	2.5 (1.1)	2.4 (1.2)
Weight (% change)	9.5 (3.1)	10.1 (2.4)	0.542	3.8 (1.8)	4.4 (2.3)
Height (cm)	0.4 (0.8)	0.6 (0.7)	0.392	0.3 (0.6)	0.5 (0.6)
BMI (kg/m^2)	2.0 (0.6)	2.1 (0.5)	0.700	0.7 (0.4)	0.8 (0.5)
WC (cm)	4.9 (1.9)	5.6 (2.6)	0.415	2.1 (1.7)	2.4 (1.9)
HC (cm)	3.6 (1.9)	5.1 (2.7)	**0.046**	0.7 (2.1)	1.9 (2.7)
Body Composition					
Total BF (%)	2.9 (1.0)	2.6 (1.9)	0.671	1.4 (1.0)	1.2 (1.7)
TF (%)	3.3 (1.4)	2.9 (2.4)	0.563	1.6 (1.0)	1.4 (2.2)
Lean body mass (%)	-2.9 (1.0)	-2.6 (1.9)	0.671	-1.4 (1.0)	-1.2 (1.7)
Fat mass index (kg/m^2)	1.0 (0.5)	1.2 (0.5)	0.223	0.4 (0.3)	0.4 (0.4)
Energy Expenditure					
Total PA (MET·hr/day)	-0.8 (6.5)	-2.1 (15.7)	0.807	-2.8 (9.5)	2.5 (13.7)
Sedentary time (hr/day)	0 (2.6)	-0.4 (3.5)	0.799	1.6 (3.1)	0.3 (3.5)

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	Top 25%			Bottom 75%	
	Males N=17 Mean (SD)	**Females N=15 Mean (SD)**	**P-Value†**	**Males N=42 Mean (SD)**	**Females N=55 Mean (SD)**
Diet					
Energy intake (kcal/day)	-383 (648)	-419 (1057)	0.940	-518 (1153)	-351 (848)
Carbohydrate (% total kcal)	-4.6 (11.1)	4.3 (10.8)	0.271	1.4 (7.9)	-1.0 (5.6)
Protein (% total kcal)	0.1 (6.7)	-1.0 (4.2)	0.802	-1.0 (3.0)	-0.6 (2.7)
Fat (% total kcal)	0.9 (6.4)	-5.3 (10.6)	0.149	-0.5 (5.1)	1.4 (4.8)
Dining hall frequency (swipes/day) ‡	-0.1 (0.2)	-0.2 (0.2)	**0.047**	-0.2 (0.3)	-0.1 (0.2)

Abbreviations: BMI, body mass index; WC, waist circumference; HC, hip circumference; BF, body fat; TF, truncal fat; FMI, fat mass index; PA, physical activity
*First semester change is the difference between the measurement at the end of first semester and baseline; academic year change is the difference between the measurement collected at the end of spring semester and the baseline.
†Statistical significance of gender difference based on two-sample Student's t-test for variables meeting the underlying assumptions of the test, otherwise, significance based on Wilcoxon Signed Rank non-parametric test ($P < 0.05$ **bolded**)
‡The difference between the average count of card swipes per day in the spring semester and that of fall semester

Table 2S.4 Excessive adiposity by body mass index (BMI ≥ 25 vs. else) versus body fat percent (BF% >20 for males, BF% > 30 for females* [43]), at the baseline and at the end of the study period

		Excessive Adiposity by BMI	
Study Baseline (N=207†)		**Yes**	**No**
Excessive Adiposity by BF%	**Yes**	15 (7%)	16 (8%)
	No	8 (4%)	168 (81%)
End of Study (N = 151‡)		**Yes**	**No**
Excessive Adiposity by BF%	**Yes**	18 (12%)	9 (6%)
	No	8 (5%)	116 (77%)

*Cut-points for excessive adiposity defined by BF% vary between studies, with a range of 20-25% in males and 30-35% in females [43]; we chose the lower bound due to the young age of participants

† Study baseline N = 264; however, N = 57 (22%) had missing data on BF% and/or BMI; Kappa = 0.49

‡ End of study N = 172; however, N = 21 (12%) with missing data on BF% and/or BMI; Kappa = 0.61

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CHAPTER THREE

STRESS AND PSYCHOLOGICAL CONSTRUCTS RELATED TO EATING BEHAVIOR ARE ASSOCIATED WITH ANTHROPOMETRY AND BODY COMPOSITION IN YOUNG ADULTS

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ABSTRACT

Background: The transition to college is associated with weight gain in 75% of freshmen, but the relations between behavioral indicators of eating and anthropometric outcomes are unclear.

Methods: In a longitudinal study aimed to investigate psychological and behavioral predictors of anthropometric outcomes during the college transition, the Three Factor Eating Questionnaire (TFEQ), Satter Eating Competence Inventory, and Perceived Stress Scale (PSS) were administered to 264 participants within one month prior to starting college as freshmen at a large, residential U.S. university. Body composition was assessed via dual energy x-ray absorptiometry (DXA) at baseline; anthropometry [weight, height, waist circumference] was measured at the beginning and end of the first semester. Ordinary least squares regression was used to test psychological constructs as predictors of baseline body composition and anthropometry, and anthropometric change.

Results: 264 participants contribute some or all baseline data, 91% (N = 241) completed baseline anthropometry, and 66% (N = 173) completed follow-up. Compared to males, females had greater perceived stress, total TFEQ scores, emotional eating (EE) and cognitive restraint sub-scores ($P < 0.05$) at the beginning and end of the semester. In sex-adjusted linear regression models of baseline weight, BMI, waist circumference, and adiposity, total TFEQ score and the disinhibited eating (DE) and EE sub-scores were

positively associated ($P < 0.05$) with baseline anthropometry and adiposity. TFEQ scores had little or no relation with anthropometric change over the first semester, however, there was a positive association between baseline stress and subsequent changes in weight and waist circumference among males ($P < 0.05$).

Conclusion: Greater baseline stress was associated with weight gain and increased waist circumference among males. Overall, disinhibited and emotional eating scores were positively associated with weight, BMI and waist circumference at the beginning of freshman year, but did not predict change in these anthropometric indicators over the first semester.

Introduction

US surveys indicate that about 40% of young adults aged 18-24 years are overweight or obese, defined as body mass index (BMI) >25 kg/m^2 [1]. The transition from adolescence and living at home to college life is a critical period for the establishment of health-related behaviors, and this transition is widely experienced given that about 18 million students attend American colleges and universities annually as undergraduates [2]. Excessive weight gain during college is well documented [3-5] and weight gain early in the college years is associated with weight gain over the full university experience [6]. First year weight gain is accompanied by an average increase in total body adiposity of about 1% [5]. Whether small changes in adiposity are important remains a critical question given evidence that increased adiposity in young adults with normal BMI is associated with increased risk of adverse changes in cardiometabolic biomarkers [7].

Many studies describe freshman weight gain and two recent meta-analyses estimated the mean weight gain during freshman year is 1.5-1.8 kg [3, 5] and weight gain occurs in 75% of first-year students [8, 9]. Previous studies have investigated a variety of determinants of freshman weight gain, including access to on-campus dining facilities [10, 11], physical activity [12], alcohol consumption [13, 14], snacking habits [11], dieting behavior [15], gender [8, 9, 16-21], race/ethnicity [22], and residence type [23, 24].

Psychological constructs, such as dietary restraint and the behavioral tendency to overeat due to emotional cues or stress, shape eating behaviors in college students and

are associated with freshman weight gain [25-28] and with cross-sectional anthropometric measurements of freshmen [29-31]. In a recent qualitative study of the psycho-behavioral factors related to eating in college students [32] perceived stress and emotional eating were associated with overeating among women, while boredom and anxiety were the key factors associated with overeating in men. Past studies investigating the relation between psychological and behavioral constructs and anthropometric outcomes in college are diverse in the parameterization of constructs (choice of constructs and how the construct is assessed), and in the analytic approach (descriptive versus hypothesis-driven). Inferences from past studies are limited by consideration of only a single sex [29, 33], small samples [27, 28, 34], and by the use of self-reported anthropometry data [16, 31, 35-37].

Given the transition to college is characterized by changing attitudes and shifting interpersonal influences [4], we investigated the hypotheses that higher stress, less competent eating, more disinhibited eating, and more emotional eating would all be associated with greater weight gain. We studied psycho-behavioral attributes measured just prior to college arrival with weight change over the student's first semester on campus, to minimize the influence of reverse causality. Given variation in the specified psycho-behavioral attributes by gender [39-44] , we investigated whether the psycho-behavioral construct—weight change associations differed by gender. For comparability to past studies, we also assessed cross-sectional associations of psycho-behavioral construct—body habitus at the study baseline.

Methods

Study Design and Participants

We conducted a longitudinal prospective cohort study over the first year of college (July 2011-June 2012) in participants ≥ 18 years of age at a large university in the northeastern United States. 1001 students were identified via stratified random sampling and invited to participate via email. Approximately half of those approached accessed online materials describing the study, and about half of those (N = 264) enrolled and participated in the baseline data collection. All participants provided written informed consent and the study methods were approved by the Cornell University Institutional Review Board for Human Participants Research.

Physical Measures

Trained personnel measured anthropometry (weight, height, waist circumference, hip circumference) of participants within the first three days on campus and at the end of the first semester (mean 14.1 weeks from baseline [SD 1.1]). Before each data collection, anthropometrists completed at least one interactive training session and were evaluated for accurate technique and measurement reliability. Measurements were collected using standardized, calibrated instruments and participants wore minimal, light clothing at each visit. Anthropometrists took two repeated measurements of height (stadiometer; Shorr Productions, Olney, MD) and weight (digital scale; Seca, Chino,

CA), and three repeated measurements of waist and hip circumference using steel measuring tape (Lufkin, Apex, NC). Averages of the repeated measures from each data collection visit were used in the analyses. An experienced, licensed radiologic technician conducted whole body scans to estimate body composition, using dual energy x-ray absorptiometry (DXA, QDR4500 fan beam densitometer, Hologic Inc., Bedford, MA, pooled precision 1.16%) at the beginning of the first semester to determine baseline total body fat percent (BF%), truncal fat percent (TF%), and fat mass index [FMI, the ratio of fat mass (kg) to height (m^2)].

Questionnaire Data

Self-administered electronic questionnaires were completed prior to the participant's arrival on campus to assess usual diet (Diet History Questionnaire, DHQII [45]) and physical activity (Global Physical Activity Questionnaire, GPAQ [46]) The DHQII is a food frequency questionnaire (FFQ), which assessed usual consumption of 134 food and beverage items, based on standard portion sizes, over the past year. The validity of the DHQII is assumed to be similar to that of the DHQ [45] given minimal modifications. The GPAQ assessed the intensity, duration, and frequency of physical activity during work, recreation, and transportation in a recent typical week and was administered at the beginning and end of the semester. For the self-reported physical activities, a metabolic equivalent (MET) value [47] was assigned to each activity per level of intensity to obtain a

composite metric of physical activity, reflecting both duration and intensity of physical activity. Arithmetically, the metabolic equivalent is the amount of energy expended for a particular activity that is divided by the amount of energy expended at rest. The resulting metric conveys energy expenditure relative to the resting state: 1 MET corresponds to energy expenditure at rest, 4-6.9 METs corresponds to moderate intensity physical activity, and ≥7 METs corresponds to vigorous activity. MET hours/day were calculated using data on the number of hours/week in each activity at each level of intensity.

Psychological constructs related to eating were assessed via questionnaire at baseline and end of the first semester using the Satter Eating Competence Inventory [48], the Perceived Stress Scale [49]), and the Three Factor Eating Questionnaire [50] (assessed cognitive restraint, disinhibition, and emotional eating). The total score for the Satter Eating Competence Inventory (ecSI), which is a 16-item validated questionnaire [48, 51] with excellent test-retest reliability [52], conveys the degree to which a respondent has a positive attitude and flexible approach toward feeding him- or herself healthfully. Eating competence includes questions about internal regulation cues, contextual skills for procuring nutritious foods, acceptance of a variety of foods, and the level of comfort with and enjoyment from eating. The total score ranges from 0-48 and a score of 32 or greater is used to define eating competence [41, 48]; eating competence was considered as both a continuous and a dichotomous (competent yes/no) variable.

The Perceived Stress Scale (PSS) is a well-established instrument [49, 53] that measures the subjective report of stressfulness of life situations in the previous month. The PSS, which is a 10-item questionnaire with Likert-scale responses and a score range of 0-40, has excellent validity and reliability [49, 53, 54]. Scores are typically compared between groups and there are not established dichotomous cut points for stress.

The Three Factor Eating Questionnaire (TFEQ) was initially developed in the mid-1980s [55], but the instrument was truncated and re-validated recently [50, 56, 57]. We used the 18-item version, which assessed three psychological domains related to eating behavior: restraint, disinhibited eating (DE), and emotional eating (EE). Restraint reflects the personal choice to limit food intake to control weight, DE reflects the tendency overeat or lose control of how much is consumed, and EE is the degree to which emotions drive consumption. Given differences in the number of questions per domain, and to compensate for unanswered questions, raw scores are transformed [50] to yield values on a scale of 0-100 such that greater values indicate a greater degree of restraint, DE or EE.

Dining Hall Data

All freshmen lived on-campus, which is standard at the university, and they are obligated to enroll in a meal plan for the on-campus dining halls. To enter dining halls, the student's ID card is 'swiped' through an electronic card reader and we used the

frequency of card swipes/day and the total number of days the ID card was swiped during the fall semester as objective indicators of eating behavior.

Statistical Analyses

In bivariate analyses, we evaluated differences in participant characteristics using the chi-square test and Student's t-test; when underlying statistical assumptions were not met, we used nonparametric tests. Multivariate analyses used ordinary least squares regression models to characterize the relation between each psychological construct score and anthropometric outcomes, in separate models, adjusted for sex and testing for effect modification by sex in each model. In models for longitudinal change in the anthropometric indicators (where outcomes were change in weight, change in BMI, and change in waist circumference), the baseline weight, BMI and waist circumference, respectively, was also included in the model. All analyses used Statistical Analysis Systems statistical software package (version 9.4, SAS Institute, Cary, NC, USA) with two-sided tests and $P < 0.05$ as the threshold for statistical significance.

Results

Sample Characteristics

The study enrolled 264 participants; 91.3% were included in the cross-sectional analysis at baseline (N = 241) due to missing data on the baseline anthropometry

assessment. Mean age was 18.1 years (SD 0.3) and the sample distribution was similar to the distribution for the full class of 2015 on sex, college of matriculation, and country of origin (domestic vs. international). The longitudinal analyses included participants who completed follow-up at the end of first semester (N=173; 66%). Participants who completed follow-up were similar to participants lost to follow-up (Supplemental Table 1), with the exception that dropouts had minor differences in dietary intake, and tendencies towards lower eating competence and greater weight, BMI, and waist circumference at study baseline.

Descriptive Data on Psychological Constructs

There were consistent sex differences in psychological construct scores at the beginning and end of the semester (Table 1) such that the total TFEQ and the domain scores for restraint and emotional eating were higher in females at baseline and at the end of the first semester. Eating competence was higher in males at the beginning of the study, but the difference by sex was not statistically significant at follow-up. There was no evidence of a sex difference in the proportion of participants classified as competent eaters (ecSI score ≥ 32). Perceived stress was similar in males and females at the beginning of the semester, but at follow-up females reported significantly greater stress than their male counterparts. Sex differences in anthropometrics and body composition were evident and anticipated due to biological differences. There were no significant

sex differences either at baseline or at the end of the first semester for energy expenditure indicators.

Cross-Sectional Associations of Psychological Constructs and Body Habitus

At the beginning of the freshman year, total TFEQ and the domain scores for disinhibited and emotional eating were positively and statistically significantly associated with anthropometry and body composition, after adjusting for sex (Table 2). For example, one point higher on TFEQ was associated with 0.24 kg higher body weight, and one standard deviation (1 SD = 8.0) higher TFEQ was associated with 1.9 kg higher body weight. The associations of disinhibited and emotional eating were consistently associated across multiple indicators of body habitus including weight, BMI, waist circumference, and DXA-derived fat mass index. Effect modification by sex was tested for all variables, and statistically significant effect modification was evident for stress—body habitus associations. Stress was consistently inversely associated with baseline weight and waist circumference in females; conversely, in males, the stress—body habitus association was consistently positive.

We explored the association of variables related to energy balance, including food intake, physical activity and dining hall use, for their possible relation with anthropometry and body composition at the start of college. Physical activity, particularly vigorous physical activity, was consistently inversely associated with DXA-

derived indicators of body adiposity, although no associations were detected with anthropometric measures (Supplemental Table 2).

Longitudinal Associations of Psychological Constructs with Change in Body Habitus

There were no significant associations of the psychological constructs with change in weight, BMI, or waist circumference in models adjusted for sex and starting anthropometry (Table 3). However, we found consistent and statistically significant effect modification by sex for the perceived stress—body habitus association for all three anthropometric outcomes. Thus, males who were one standard deviation higher on baseline stress (1 SD = 6.7 among males) had a 0.8 kg greater change in weight, a 0.3 kg/m^2 greater change in BMI, and a 1.1 cm greater change in WC over the first semester of college. Similar to our cross-sectional findings, all stress—body habitus change associations in women were negative, indicating inverse associations.

Other energy balance factors were investigated as predictors of longitudinal change in body habitus assessed by anthropometry. The frequency of eating in the 'all-you-care-to-eat' on-campus dining halls was associated with positive changes in weight and waist circumference (Table 4).Participants who swiped one standard deviation more often during the semester (1 SD = 37.5) gained about 0.6 kg more in weight, 0.2 kg/m^2 more in BMI, and increased about 0.5 cm more in waist circumference.

Discussion

Weight gain during the college years is common [3, 38], tends to occur relatively rapidly early in college [8], and excess weight gained in college sets a trajectory that continues into adulthood [38]. Understanding the extrinsic and intrinsic factors that affect energy balance, which leads to weight and adiposity gain is important to guide the development of prevention strategies for the college years. We investigated stress, restrained eating, disinhibited [over]eating, and emotional [over]eating in relation to weight, BMI, and waist circumference change in the first semester. In males only, greater stress at baseline was associated with greater increases in all three anthropometric indicators. All associations were opposite in direction in females. In both males and females, the frequency of dining hall use was also positively associated with all change in weight, BMI and waist circumference in the first semester of college. At the baseline of the study, we noted consistent positive cross-sectional associations of disinhibited and emotional eating with body habitus assessed by both anthropometry and DXA.

Boyce *et al*. [27] investigated the relation of perceived stress with freshman weight change and reported a positive association for freshmen with BMI >25 kg/m^2 and a negative association for freshmen with low/normal BMI. We found no evidence for a baseline BMI – stress interaction in models of weight change. Stress could contribute to weight gain differently in the sexes through differential effect on dietary intake or on

internal hormonal regulators of energy utilization. In a recent study of stress and dietary behaviors among college freshmen [44], Papier *et al.* reported sex differences in the relation between stress level and dietary pattern; greater stress was a stronger predictor of unhealthy food intake in males compared to females. In addition, there is some evidence of sex differences in the hormonal stress response, as indicated by increased circulating free cortisol, a biomarker of activation of the hypothalamic-pituitary-adrenal axis [58]. Psychological stress from achievement challenges (i.e. exams) induced a greater cortisol response in young adults males compared to females, although females had a greater cortisol response to social rejection challenges compared to males [39, 59]. A large study (N = 396) of stress in first year college students [14] reported a greater change in the proportion of males who were stressed by academic challenges (70% of males reported stress at the beginning of the year vs. 87% at year's end, difference $P < 0.001$) in comparison to females (85% of females reported stress at the beginning of the year vs. 93% at year's end, difference $P < 0.01$).

Results from this study did not show an association between restraint, or overeating due to external or emotional cues, and changes in weight or adiposity. Similar to our findings, a recent study of first-year university students across four universities in the United Kingdom [26] reported no association between restraint, disinhibition, or emotional eating and body weight change over 3 or 12 months. In contrast, the same study reported change in FMI was predicted by baseline disinhibition score from the

TFEQ after 3 months ($\beta = 0.29$, $P < 0.0001$) and 12 months ($\beta = 0.28$, $P < 0.01$) of follow-up. We did not observe that association in our data from modeling baseline disinhibition construct score as a predictor of FMI change (adjusting for baseline FMI and sex) with FMI change calculated as the end of the year FMI measurement minus the FMI measurement at the beginning of the year ($\beta = -0.006$, $P = 0.059$, data not shown). We were unable to assess body composition via DXA after 3 months of follow-up for comparison; however, the different results for the association between disinhibition and FMI change over longer follow-up could be due differences in the populations studied wherein there may be true differences in the meaning of low/high disinhibited eating score and regarding how that construct manifests in behavior and may contribute to FMI; also differences in the method of adiposity measurements (bioelectrical impedance vs. DXA) and differences the underlying distributions of FMI in the population understudy could also explain the inconsistent results.

The primary outcome, first semester weight gain, was selected because it accounts for most of the weight gained during the first year of college [19, 20] and weight gain in the first year is greater than the average annual weight gain during the subsequent years of college [5, 38]. The finding of no significant association between restraint at the start of college and subsequent weight change observed in this sample agrees with reports from with prior studies of freshmen/sophomores [33, 35]. Another study of adolescents and young adults also reported no significant association between

restraint score from the TFEQ and adiposity change measured by sum of skin folds thickness [61]; but higher restraint has been shown to associated with weight gain when it has been interpreted in conjunction with other factors including on-campus residence [25] and self-esteem [28], two exposures irrelevant (all participants resided on-campus) or unmeasured (self-esteem) in the current study.

While we found consistent and positive cross-sectional associations of the disinhibited and emotional eating with weight, waist circumference, BMI, and FMI at the study baseline, there was no evidence for longitudinal associations. Possible explanations for this discrepancy include: 1) no true association exists, 2) the instruments assessing the psychological factors are not sensitive enough to capture the behaviors or attitudes that drive weight and adiposity gain, or 3) the significant cross-sectional findings are explained by reverse causality such that higher weight, BMI, waist circumference leads to more emotional and disinhibited eating. It is not possible to determine which explanation is correct, and further research implementing longitudinal, repeated exposure and outcome assessments could provide clarification.

Previous findings from a large French cohort [61] found TFEQ constructs to be significantly positively associated with BMI cross-sectionally in adults (aged 31-67 years), but not in youth aged 14-24 years. Our finding that females had higher TFEQ construct scores than males is consistent with findings in adults reported by the Quebec Family Study[40], although the same study reported no evidence of sex differences in

TFEQ constructs among adolescents [62]. As a whole, these findings suggest the hypothesis that sex differences in restraint, disinhibited eating, and/or emotional eating emerge in the transition to adulthood.

Strengths of the study include the use of anthropometry and body composition measurements that were collected by trained study staff using an established protocol within an equipped clinical research facility. The use of DXA-derived measures of adiposity meant that baseline cross-sectional associations evident in anthropometric indicators could be confirmed with more accurate body composition indicators. Furthermore, unlike BMI, FMI is a height-scaled index of adiposity that is not confounded by lean body mass. An additional strength is that this hypothesis-driven research was conducted in a study sample representative of the incoming freshmen class with a sample of sufficient size to evaluate effect modification by sex. A limitation is that findings based on students from one University may not generalize to the population of all young adults experiencing the college transition.

In conclusion, psychological constructs, including eating competence, restrained eating, disinhibited eating, emotional eating, and perceived stress were associated with anthropometry and adiposity at the baseline of the study. Perceived stress showed an association with subsequent changes in anthropometry in males only, such that greater stress at the start of college predicted greater increases in weight, BMI and waist circumference. The sex-specific association between stress and weight gain could be

related to a greater stress response to academic challenge among males compared to females and/or to a sex-specific influence of stress on food intake and energy balance factors.

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Table 3.1 Characteristics at the beginning and end of the first semester, by sex

Characteristics	Baseline N=241				End of Fall Semester N=173			
	Females N=125		Males N=116		Females N=93		Males N=80	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Psycho-behavioral Constructs								
Total TFEQ†	40.2**	7.4	35.2**	7.7	40.8**	7.2	34.8**	7.6
Cognitive Restraint ††	46.5**	21.8	31.3**	23.4	48.4**	20.6	33.9**	20.7
Disinhibited Eating ††	37.8	18.6	34.6	18.3	38.5*	16.1	32.0*	16.4
Emotional Eating ††	39.5**	24.3	25.2**	25.0	42.0**	24.5	22.9**	22.4
Eating Competence	31.5*	7.2	33.8*	6.3	32.2	7.0	33.3	6.6
Perceived Stress	15.1	5.5	14.2	6.7	17.9**	6.4	14.7**	7.8
Anthropometry								
Weight (kg)	58.2**	9.8	70.0**	11.6	59.4**	9.6	71.6**	10.4
Body mass index (kg/m^2)	21.5**	3.0	22.4**	3.1	22.1*	3.0	22.9*	2.7
Waist circumference (cm)	69.9**	7.0	76.6**	8.1	71.4**	7.2	78.5**	7.1
Hip circumference (cm)	96.2	7.3	95.8	7.4	97.5	6.9	96.6	6.3
Body Composition (DXA)								
Total body fat (%)	26.0**	5.5	15.7**	5.2				
Truncal body fat (%)	21.5**	6.4	13.3**	5.9				
Fat mass index (fat mass, kg/ht, m^2)	5.8**	2.0	3.7**	1.8				
Energy Expenditure								
Total physical activity (MET·hr/d)‡	9.8	10.1	10.4	11.0	11.7	9.4	9.6	7.1
Sedentary time (hr/d)	6.2	2.9	6.5	3.0	7.1	3.4	7.4	3.7
Moderate intensity PA (hr/wk)	6.8	9.6	6.4	8.2	4.9	5.9	3.6	4.6
Vigorous intensity PA (hr/wk)	3.9	5.4	4.9	6.7	3.2	5.5	2.7	4.2

(table continues on the next page)

Characteristics	Baseline N=241				End of Fall Semester N=173			
	Females N=125		Males N=116		Females N=93		Males N=80	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Dietary Intake								
Self-reported total meals/d	3.0	0.6	2.9	0.6	2.6	0.7	2.6	0.6
Self-reported total snacks/d	2.5	1.4	2.3	1.7	2.4**	1.3	1.7**	1.0
Usual energy intake (kcal/d)	1797**	727	2305**	751				
Energy from carbohydrate (%)	48.6	7.2	49.1	7.6				
Energy from protein (%)	16.2	3.1	16.1	3.1				
Energy from fat (%)	32.6	6.5	32.2	6.1				
Fall Dining Hall Frequency (semester cumulative)								
Visits per day during fall semester (average swipes/day)					1.5**	0.3	1.7**	0.3
Total dining hall visits during fall semester (total swipe count)					130.3**	35.3	150.5**	39.5
Total days of dining hall use (count of days swiped)					83.5**	11.8	88.5**	11.6

*P < 0.05 and **P ≤ 0.01; sex differences were tested using Student's t-test for variables meeting the underlying assumptions of the test, otherwise, the Wilcoxon Signed Rank test was used; all tests were two-sided

† Total TFEQ score is based on summing raw data values, and ranges from 0 - 76

††In contrast to the total TFEQ score, domain scores are transformed and each domain ranges from 0-100

Shaded cells indicate variables that were not measured at time-point

Table 3.2 Cross-sectional association of psychological factors with anthropometry (Table 3.2A) and adiposity (Table 3.2B) at baseline estimated using least squares regression modeling*

3.2.A Anthropometric outcomes

Psycho-behavioral Constructs	**Baseline weight**				**Baseline BMI**				**Baseline WC**			
	β	**95% CI**		**P**	**β**	**95% CI**		**P**	**β**	**95% CI**		**P**
Total TFEQ (raw)	**0.24**	**0.01**	**0.46**	**0.042**	**0.08**	**0.01**	**0.14**	**0.017**	0.14	-0.02	0.30	0.086
Cognitive Restraint	-0.04	-0.11	0.02	0.206	-0.01	-0.03	0.01	0.270	-0.04	-0.09	0.00	0.077
Disinhibited Eating	**0.14**	**0.05**	**0.23**	**0.003**	**0.04**	**0.02**	**0.07**	**0.002**	**0.10**	**0.03**	**0.16**	**0.004**
Emotional Eating	**0.08**	**0.02**	**0.14**	**0.014**	**0.03**	**0.01**	**0.05**	**0.001**	**0.06**	**0.02**	**0.11**	**0.006**
Eating Competence	-0.09	-0.32	0.14	0.451	**M -0.12** F 0.05	**-0.23** -0.04	**-0.01** 0.14	**0.028** 0.265	-0.03	-0.20	0.14	0.733
Perceived Stress **	M 0.34 **F -0.54**	-0.01 **-0.93**	0.69 **-0.16**	0.061 **0.007**	M 0.09 F -0.10	-0.01 -0.22	0.19 0.01	0.091 0.081	M 0.21 **F -0.32**	-0.04 **-0.60**	0.47 **-0.04**	0.102 **0.029**

*N = 173 with complete anthropometry data; all models adjusted sex

**The P-values for the sex x perceived stress interaction terms were 0.0012, 0.0157, and 0.0068 for weight, BMI and WC, respectively.

3.2.B Adiposity outcomes measured by DXA*

Psycho-behavioral Constructs	**Baseline BF%**				**Baseline FMI**			
	β	**95% CI**		**P**	**β**	**95% CI**		**P**
Total TFEQ (raw)	0.06	-0.05	0.18	0.282	0.04	0.00	0.08	0.076
Cognitive Restraint	0.00	-0.04	0.03	0.800	-0.01	-0.02	0.01	0.415
Disinhibited Eating	0.03	-0.02	0.08	0.242	**0.02**	**0.00**	**0.04**	**0.023**
Emotional Eating	0.02	-0.01	0.06	0.155	**0.01**	**0.00**	**0.03**	**0.014**
Eating Competence	-0.03	-0.15	0.09	0.618	-0.01	-0.05	0.03	0.734
Perceived Stress**	0.05	-0.09	0.19	0.491	0.01	-0.04	0.06	0.718

*N = 173 with complete data; all models adjusted sex

**The P-values for the sex x perceived stress interaction terms were 0.3878 and 0.1099 and for BF% and FMI, respectively.

Table 3.3 Association of baseline psycho-behavioral constructs with longitudinal change in the first semester, adjusted for sex and baseline anthropometry, and estimated using least squares regression modeling (N=173)

Psycho-behavioral Constructs	**Weight Change**				**BMI Change**				**WC Change**			
	β	**95% CI**		**P**	**β**	**95% CI**		**P**	**β**	**95% CI**		**P**
Total TFEQ (raw)	-0.021	-0.076	0.035	0.463	-0.008	-0.027	0.012	0.436	-0.019	-0.082	0.044	0.557
Cognitive Restraint	-0.007	-0.023	0.010	0.421	-0.002	-0.008	0.004	0.439	-0.017	-0.035	0.002	0.083
Disinhibited Eating	-0.005	-0.028	0.018	0.692	-0.003	-0.011	0.005	0.519	0.003	-0.023	0.029	0.832
Emotional Eating	-0.001	-0.017	0.014	0.870	0.001	-0.005	0.006	0.840	0.007	-0.011	0.025	0.437
Eating Competence	-0.007	-0.062	0.048	0.811	0.000	-0.020	0.019	0.988	-0.004	-0.066	0.059	0.913
Perceived Stress *	**M 0.118**	**0.034**	**0.202**	**0.007**	**M 0.039**	**0.009**	**0.069**	**0.011**	**M 0.162**	**0.066**	**0.257**	**0.001**
	F -0.28	-0.123	0.066	0.554	F -0.005	-0.038	0.028	0.777	F -0.073	-0.178	0.033	0.181

*Sex-stratified coefficients are shown for perceived stress, and the P-values for the sex x perceived stress interaction terms were 0.0268, 0.0572 and 0.0017 for weight, BMI and WC, respectively

Table 3.4 Association of baseline energy balance factors with longitudinal anthropometric change over the first semester, adjusted for sex and baseline anthropometry, using least squares regression modeling (N=173)

	Weight Change				BMI Change				WC Change			
Characteristics	**β**	**95% CI**		**P**	**β**	**95% CI**		**P**	**β**	**95% CI**		**P**
Total physical activity (MET·hr/d)‡	0.011	-0.025	0.047	0.541	0.003	-0.009	0.016	0.596	0.015	-0.026	0.056	0.478
Sedentary time (hr/d)	0.004	-0.121	0.129	0.952	0.007	-0.037	0.050	0.767	-0.007	-0.148	0.133	0.919
Moderate intensity PA (hrs/wk)	-0.008	-0.051	0.035	0.723	-0.005	-0.020	0.011	0.556	-0.007	-0.056	0.042	0.770
Vigorous intensity PA (hrs/wk)	0.029	-0.031	0.089	0.339	0.011	-0.010	0.032	0.295	0.043	-0.024	0.111	0.210
Usual energy intake (kcal/d)	0.000	-0.001	0.001	0.910	0.000	0.000	0.000	0.923	0.000	-0.001	0.001	0.782
Energy from carbohydrate (%)	0.021	-0.036	0.078	0.475	0.008	-0.012	0.028	0.435	0.001	-0.066	0.068	0.981
Energy from protein (%)	0.020	-0.113	0.153	0.766	0.015	-0.032	0.062	0.539	0.048	-0.108	0.204	0.549
Energy from fat (%)	-0.031	-0.098	0.036	0.360	-0.013	-0.036	0.011	0.289	-0.011	-0.089	0.068	0.792
Self-reported total meals/d	0.503	-0.076	1.081	0.091	0.161	-0.045	0.367	0.127	0.365	-0.299	1.028	0.283
Self-reported total snacks/d	-0.048	-0.283	0.186	0.687	-0.019	-0.103	0.064	0.652	-0.028	-0.297	0.241	0.840
Visits per day during fall semester (average swipes/day)	**1.822**	**0.516**	**3.129**	**0.007**	**0.581**	**0.124**	**1.039**	**0.014**	1.433	-0.067	2.933	0.063
Total dining hall visits during fall semester (total swipe count)	**0.016**	**0.006**	**0.025**	**0.002**	**0.005**	**0.002**	**0.009**	**0.004**	**0.013**	**0.002**	**0.024**	**0.022**
Total days of dining hall use (count of days swiped)	**0.046**	**0.015**	**0.077**	**0.004**	**0.015**	**0.005**	**0.026**	**0.006**	**0.044**	**0.009**	**0.080**	**0.016**

SUPPLEMENT

STRESS AND PSYCHOLOGICAL CONSTRUCTS RELATED TO EATING BEHAVIOR ARE ASSOCIATED WITH ANTHROPOMETRY AND BODY COMPOSITION IN YOUNG ADULTS

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Contents:

Table 3S.1 Baseline characteristics among those with complete follow-up and those who were lost to follow-up in this sample of college freshmen

Characteristic	Complete Follow-Up N=173		Incomplete Follow-Up N=91		
Psycho-behavioral Constructs	**Mean**	**SD**	**Mean**	**SD**	**P-value***
Total TFEQ (raw; max 76)	37.3	7.3	38.5	9.2	0.346
Cognitive Restraint *	38.9	23.5	40.0	24.9	0.690
Disinhibited Eating *	35.0	16.7	38.6	21.6	0.247
Emotional Eating *	31.6	25.1	32.4	27.1	0.963
Eating Competence	33.0	6.9	31.5	6.6	0.085
Perceived Stress	14.7	5.9	14.3	6.6	0.517
Anthropometry					
Weight (kg)	63.0	11.6	66.2	13.5	0.092
Body mass index (kg/m^2)	21.8	3.0	22.4	3.4	0.070
Waist circumference (cm)	72.6	7.8	74.6	9.3	0.073
Hip circumference (cm)	95.6	7.1	97.1	7.8	0.212
Body Composition (DXA)					
Total body fat (%)	20.9	7.5	22.4	7.3	0.253
Truncal body fat (%)	17.4	7.5	18.8	7.2	0.196
Fat mass index (fat mass, kg/ht, m^2)	4.7	2.1	5.2	2.5	0.225
Energy Expenditure					
Total physical activity (MET·hr/d)‡	10.1	10.4	10.5	12.0	0.725
Sedentary time (hr/d)	6.6	3.0	5.8	2.8	0.100
Moderate intensity PA (hr/wk)	6.7	8.7	5.8	9.1	0.186
Vigorous intensity PA (hr/wk)	4.4	6.1	5.1	8.2	0.814
Dietary Intake					
Self-reported total meals/d	2.9	0.6	3.0	0.7	0.911
Self-reported total snacks/d	2.3	1.6	2.4	1.4	0.423
Usual energy intake (kcal/d)	2104	806	1854	674	0.071
Energy from carbohydrate (%)	48.4	7.4	50.3	7.5	0.102
Energy from protein (%)	16.2	3.1	16.0	3.0	0.658

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Characteristic	Complete Follow-Up N=173		Incomplete Follow-Up N=91		
	Mean	**SD**	**Mean**	**SD**	**P-value***
Energy from fat (%)	33.0	6.3	30.8	6.2	**0.026**
Energy from alcohol (%)	0.8	1.9	1.3	2.5	**0.027**
Fall Dining Hall Frequency					
Visits per day during fall semester (average swipes/day)	1.6	0.3	1.6	0.3	0.406
Total dining hall visits during fall semester (total swipe count)	139.6	38.6	131.1	38.6	0.126
Total days of dining hall use (count of days swiped)	85.8	11.9	82.1	13.4	**0.018**

* Differences were tested using Student's t-test for variables meeting the underlying assumptions of the test, otherwise, the Wilcoxon Signed Rank test was used; all tests were two-sided.

Table 3S.2 Cross-sectional association of energy balance variables with baseline anthropometry (Table 3.2A) and DXA-derived body composition indicators (Table 3.2B) in college freshmen*

3S.2.A Anthropometry outcomes

	Baseline weight				**Baseline BMI**				**Baseline WC**			
Baseline Characteristics	**β**	**95% CI**		**P**	**β**	**95% CI**		**P**	**β**	**95% CI**		**P**
Total physical activity (MET·hr/d)**	0.00	-0.14	0.13	0.963	-0.02	-0.06	0.01	0.225	-0.06	-0.15	0.04	0.237
Sedentary time (hr/d)	-0.25	-0.73	0.22	0.293	-0.03	-0.16	0.11	0.696	-0.01	-0.35	0.32	0.953
Moderate intensity PA (hr/wk)	0.02	-0.14	0.17	0.845	-0.03	-0.07	0.01	0.188	-0.07	-0.18	0.04	0.219
Vigorous intensity PA (hr/wk)	-0.01	-0.24	0.22	0.962	-0.02	-0.08	0.05	0.619	-0.04	-0.20	0.13	0.665
Usual energy intake (kcal/d)**	0.00	0.00	0.00	0.297	0.00	0.00	0.00	0.851	0.00	0.00	0.00	0.539
Energy from carbohydrate (%)	-0.17	-0.38	0.04	0.120	M 0.03 **F -0.09**	-0.05 **-0.17**	0.12 **-0.01**	0.428 **0.037**	M 0.08 **F -0.22**	-0.13 **-0.42**	0.29 **-0.01**	0.461 **0.041**
Energy from protein (%)	-0.14	-0.64	0.37	0.601	-0.03	-0.17	0.11	0.692	**M -0.61** F 0.17	**-1.14** -0.31	**-0.09** 0.65	**0.023** 0.483
Energy from fat (%)	**0.30**	**0.06**	**0.55**	**0.015**	0.06	-0.01	0.13	0.077	0.17	0.00	0.34	0.057
Self-reported total meals/d	0.48	-1.75	2.70	0.673	-0.01	-0.65	0.63	0.975	-0.19	-1.76	1.38	0.815
Self-reported total snacks/d	0.23	-0.70	1.17	0.623	0.15	-0.11	0.42	0.260	0.31	-0.35	0.97	0.357

*Analyses include participants with some or all baseline data (N = 264)

**Estimates appear as zero when actual non-zero estimates were rounded to two decimals

3S.2.B Adiposity outcomes measured by DXA

	Baseline BF%				Baseline FMI			
Baseline Characteristics	**β**	**95% CI**		**P**	**β**	**95% CI**		**P**
Total physical activity (MET·hr/d)	**-0.13**	**-0.20**	**-0.06**	**0.001**	**-0.04**	**-0.04**	**-0.01**	**0.010**
Sedentary time (hr/d)	0.11	-0.14	0.36	0.409	0.03	0.02	0.12	0.530
Moderate intensity PA (hr/wk)	-0.07	-0.15	0.01	0.093	-0.02	-0.03	0.01	0.151
Vigorous intensity PA (hr/wk)	**-0.24**	**-0.36**	**-0.12**	**<0.001**	**-0.06**	**-0.07**	**-0.02**	**0.008**
Usual energy intake (kcal/d)*	0.00	0.00	0.00	0.255	0.00	0.00	0.00	0.532
Energy from carbohydrate (%)	-0.02	-0.13	0.09	0.695	-0.01	-0.02	0.03	0.562
Energy from protein (%)	-0.18	-0.44	0.07	0.161	-0.05	-0.06	0.04	0.270
Energy from fat (%)	0.12	-0.01	0.24	0.065	0.04	0.04	0.09	0.068
Self-reported total meals/d	**-1.25**	**-2.46**	**-0.04**	**0.044**	-0.28	-0.33	0.16	0.209
Self-reported total snacks/d	-0.23	-0.72	0.26	0.366	0.03	0.01	0.21	0.765

*Estimates appear as zero when actual non-zero estimates were rounded to two decimals

CHAPTER FOUR

METABOLOMIC MARKERS ASSOCIATED WITH CENTRAL ADIPOSITY GAIN IN YOUNG ADULTS

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Key words: metabolomics, freshman weight, body composition, cohort study, weight gain

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Running Title: Metabolic profile of freshmen year adiposity change

Conflicts of Interest: None

Authorship: PAC, KCH and KAG designed and carried out the cohort study, and

managed and analyzed the data; PAC, KCH, KH and JPT devised the pooling scheme for blood samples for metabolomics; KH and JPT completed the metabolomic assays; PAC, KCH, PJS, KH, JPT and LB analyzed and interpreted all data; KCH, JPT, KH, LSB, and PAC drafted the manuscript, and all coauthors edited and approved the manuscript.

ABSTRACT

Background: The metabolome reflects a multitude of internal exposures, including healthy and perturbed metabolic activity. We conducted a discovery-based analysis to identify metabolomic markers associated with the incidence of adiposity gain in young adults.

Methods: In a nine month prospective cohort study of college freshmen (N = 264; mean age 18.1 years [SD 0.3]), we collected blood samples during the first 3 days on campus, and we measured body habitus using both anthropometry and dual-energy x-ray absorptiometry (DXA) at the beginning and end of the academic year. Plasma aliquots from individual participants were combined into phenotype-specific pools, as follows: a) participants who increased in central adiposity (N = 66; 47% female); b) participants with no change in adiposity (N = 16; 56% female); c) participants with hemoglobin A1c (HbA1c) > 5.05%; and, d) participants with HbA1c < 4.92%. All pools were assayed in triplicate using GC-MS, chromatograms were analyzed using MetaboliteDetector, and normalized metabolite levels were compared between pools using Welch's t-test. To confirm findings, the assays were repeated using freshly prepared pools and an optimized assay method, and metabolites that were statistically significantly different also were quantified in targeted assays.

Results: Participants with incident central adiposity gain differed from participants with no change in adiposity; five metabolites reached the nominal significance

threshold ($P < 0.05$) and one metabolite, meso-erythritol, reached the significance threshold correcting for multiple testing (nominal $P = 0.0004$, FDR Q-value = 0.0435). In further assays to quantify meso-erythritol concentrations, there was a 15-fold higher concentration in participants with incident central adiposity gain compared to participants with no change in adiposity. In participants with higher HbA1c (> 5.05%) the concentration of meso-erythritol was 21-fold higher compared to participants with lower HbA1c (nominal P-value = 0.0024).

Discussion: Blood meso-erythritol is associated with intake of erythritol, which is a low-calorie sweetener added to commercial foodstuffs. Starting levels of this biological marker were associated with incident gain in central adiposity in college freshmen.

Introduction

In fall 2015, an estimated 3.3 million high school graduates will enroll in postsecondary education as first-time college freshmen [1], and the transition to a residential college environment is associated with weight gain. About 75% of students experience weight gain during this transition [2, 3], but there have been few efforts to identify biomarkers of risk that could lead to improving prevention efforts. Twin studies of obesity [4] confirm that monozygotic twins discordant for BMI begin to diverge at about age 18, corresponding to a time in life when environment shifts, and further underscoring the importance of young adulthood in the lifetime trajectory of adiposity. The young adult age range presents an important opportunity for prevention [5].

Existing observational research on young adults focuses on behavioral/environmental risk factors for adipose gain, with few studies reporting biological markers in relation to either cross-sectional and/or longitudinal changes in adiposity or body weight. A recent overview of intervention studies to prevent weight gain in young adults [6] identified 37 studies; the majority assessed diet, physical activity and behaviors, only 10 studies directly measured changes in weight, body mass index (BMI; weight, kg/height, m^2) and/or body composition, and none of the studies measured biological markers. Existing prediction or risk scores integrate across the various domains contributing to weight gain risk, including demographic,

anthropometric, behavioral, psychological, diet-related, and physical activity [7], but existing risk scores do not incorporate biological markers.

Metabolomics approaches, which study the final downstream products of the complex interactions among genetic, environmental, and pharmacologic influences, have been used to study obesity as a phenotype, but few prior studies investigate metabolite profiles that are predictive of risk of weight gain in young adults who are not currently overweight or obese. A recent paper [8] investigated the metabolic signature associated with adiposity and adiposity change in participants aged 16 to 39 years. This study focused on a pre-specified set of 67 metabolites, including lipoproteins, inflammatory markers, fatty acids and glycolysis precursors. Branched-chain amino acids, lipoprotein-related metabolites, and glycolysis-related metabolites were all positively associated with change in BMI. Prior studies in older adults also identified the branched-chain amino acid (BCAA)-related signature, and reported an increase in leucine/isoleucine and valine in obese compared to non-obese individuals [4, 9-11]. Furthermore, experimental research using metabolomic profiling has identified causal effects of weight gain on multiple blood metabolites, including elevation of BCAAs, very low density lipoprotein (VLDL) [8, 10, 12], triacylglycerol [10], C-reactive protein [8, 10], and insulin-like growth factor [10]. Findings regarding the effects of weight change on the metabolome are interesting; however, research exploring how changes in weight and the human adiposity phenotype depend on antecedent metabolomic

markers represents a knowledge gap that we address with this research.

We investigated the relation of the metabolome to incident adiposity gain in young adults over the first year of college. Our primary analysis used discovery-based approaches, thus we sought to discover novel metabolites associated with incident adiposity gain. Based on past findings, we hypothesized that branched chain amino acids would be associated with gain in adiposity.

Methods

Study Sample

The study used data from a recently completed longitudinal cohort study of college freshmen residing on-campus during their freshman year (2011-12) at a university in the Northeastern United States. Study participants were selected through stratified random sampling of the incoming freshman class to recruit equal numbers of males and females, and to represent the characteristics of the full incoming class. Participants were aged 18-19 years, about 50% were female, and at the study baseline about 10.5% were overweight (defined as BMI > 25).

Collection of Participant Data

All relevant data were collected during participant study visits to the Human Metabolic Research Unit (HMRU) at Cornell University. Anthropometric

measurements, including height, weight, waist and hip circumferences measured using standardized methods and plasma for metabolomics were collected per protocol by trained research staff within the participants' first three days on-campus, and again near the end of the academic year, 8-9 months later. Participants were not required to fast prior to phlebotomy. Adiposity, measured via dual energy x-ray absorptiometry (DXA, Hologic Inc., Bedford, MA), was assessed within the first two weeks of the academic year and again at the end of the academic year.

Processing and storing of blood samples was conducted using rigorous protocols; all samples were kept on ice, centrifuged immediately following collection, divided into aliquots, and immediately stored at -80°C. Hemoglobin A1c (HbA1c), a marker of usual glycemia and long-term glycemic control, was measured in whole blood using Dimension Xpand Plus Integrated Chemistry System (Siemens Corporation, Germany). After the year was completed, and phenotypes were determined, baseline blood aliquots were identified and pooled, as described below, and plasma aliquots of each pool were express-shipped on dry ice for metabolomics assays conducted at the Centre for Systems Biomedicine, University of Luxembourg.

For this discovery-based study, we defined phenotypes related to cardiometabolic risk indicators and then created pools of individual blood samples for metabolomics analysis. The following pools were created: 1) incident central adiposity gain defined by changes in all three indicators: weight increase > 0.5 kg, DXA truncal

adiposity increase > 200 g, and waist circumference increase > 0.5 cm (N = 66); 2) stable adiposity phenotype defined by minimal changes in these measurements (N = 16); 3) HbA1c in the top 25% of baseline distribution (corresponds to HbA1c >5.505%, or about 36-40 nmol/mol; N = 21), and 4) HbA1c in the bottom 10% of baseline distribution (corresponds to HbA1c <4.920%, or about 25-30 nmol/mol; N = 7). To investigate dose-response associations, we created sub-pools. For the HbA1c groups, subpools were defined by the median of the distribution of individual values in each pool, and individual blood aliquots were combined to form two sub-pools for each group. For the incident central adiposity gain pool, the group was divided into 3 subgroups based on 'dose' of central adiposity change (supplemental methods), and individual blood aliquots were combined to form 3 sub-pools.

Data Collection: Metabolomics

Metabolite extraction and chemical derivatization was followed by gas chromatography-mass spectrophotometry (GC-MS), yielding high-dimensional data that were input to the MetaboliteDetector software [13] and subsequently analyzed using R Studio statistical software. All samples were assayed in triplicate to provide estimates of technical variation. Prior to statistical analysis, metabolite levels were normalized, (every metabolite level divided by the mean signal of the same metabolite level in a pooled sample of two measured pools chronologically close to the measured sample).

Firstly, we conducted a non-targeted metabolomics assay of pooled samples from the four groups. Approximately 305 metabolites were measured in each sample. Secondly, an optimized assay was designed based on the first set of findings, and starting over with freshly prepared pools, we assayed the four original groups and the sub-pools defined above to confirm the signals. We considered signals that persisted to be replicated and validated. Thirdly, we ran targeted, quantitative assays on the subset of metabolites of interest. (See Supplemental Methods for further details)

Following discovery analyses, quantitative concentrations of metabolites of interest were assayed. For this purpose, known amounts of [^{13}C] stable-isotope labeled analogues of metabolites were spiked into the extraction fluid (methanol/water) used for metabolite extraction. The stable-isotope labeled metabolites exhibit the same characteristics in terms of degradation and derivatization efficiency, but their molecular mass shifts (for example, by 5 and 6 atomic units for valine and leucine/isoleucine, respectively). Using GC-MS, the abundance of the spiked and labeled metabolites can be separated from the endogenous, unlabeled metabolites originating from the plasma. Finally, both signals, in combination with a calibration measurement, can be used for a one-point quantification to accurately determine absolute metabolite levels in the plasma samples.

Statistical Analysis

To determine the association of the metabolome with the phenotypes, we used a discovery based approach to identify metabolites associated with the phenotype and accounted for multiple testing by calculating false discovery rate (FDR) Q-values [14]; the threshold of 0.2 for the FDR Q-value was set *a priori*. The metabolome in plasma samples from the study baseline was compared between two groups in two separate comparisons. We compared the metabolome between participants with incident central adiposity gain over the follow-up vs. participants who were stable on adiposity indicators. We also compared the metabolome between participants with higher HbA1c (HbA1c > 5.05%) at the study baseline vs. participants with lower HbA1c (HbA1c < 4.9%). Welch's t-test was used to compare metabolite levels and yielded a nominal P-value, which was adjusted for multiple comparisons to yield the FDR Q-value. Discovery, replication and quantitative assay results were analyzed using the same methods.

Results

Sample Description

In a longitudinal study of 264 freshmen members of the Class of 2015, 65% of participants had data available at both the beginning and the end of the academic year. The 75% of students who gained weight (>0.5 kg) over the year experienced a 3.6% increase in body weight.

Among participants with complete follow-up data, there were no participants with medical history of diabetes, other cardiometabolic disease, or insulin use. Sixty-six participants had incident central adiposity gain; over the 9 month follow-up these participants experienced a 4.0 kg (SD 2.0 kg) increase in weight, a 3.9 cm (SD 2.0 cm) increase in waist circumference, and a 2.6% (SD 1.5) increase in truncal adiposity (measured by DXA). In contrast, 16 participants were stable on the adiposity indicators; on average, their weight change was 0.6 kg (SD 1.1), waist circumference change was 0.4 cm (SD 1.7), and DXA-derived truncal adiposity change was -0.1% (SD 0.5).

Given this sample was young and healthy, the HBA1c levels at the start of college were expected to be within normal limits (defined as 4.0-6.0% for ages ≥ 18 years). We used a distributional approach to define two phenotype groups, as follows: the top 25% of the baseline HbA1c distribution (N = 21, HbA1c > 5.05%; mean 5.66% [SD 0.18]) was compared to the bottom 10% (N = 7, HbA1c < 4.92%; mean 4.80% [SD 0.084]).

At the baseline of the study, the phenotype groups were similar in age and DXA-derived adiposity indicators and anthropometry measurements (**Table 1**). The higher usual HbA1c group and the group with incident central adiposity gain tended to weigh slightly more than the other groups at the beginning of the study. Each of the phenotype groups was near the population median on weight-for-age (range 45th-52nd percentile), slightly above the population median on height-for-age (52nd-60th percentiles), and, thus, on average below the population median on BMI-for-age (38th-

48th percentiles).

Metabolites Predictive of Incident Central Adiposity Gain Phenotype

The semi-quantitative level of five metabolites differed between the stable adiposity group and the incident central adiposity gain group at a nominal $P < 0.05$ (Table 2). The difference in one metabolite, meso-erythritol (nominal P-value = 0.0004; FDR Q-value = 0.0435), reached the FDR Q-value threshold for statistical significance, and the concentration of meso-erythritol was 13.4-fold greater in the baseline pooled blood aliquots from participants with incident central adiposity gain compared to pooled blood aliquots from participants who maintained a stable adiposity phenotype. There were suggestive findings for fructose and an unidentified metabolite, and the differences between the phenotype pools were near the significance threshold after adjusting for multiple comparisons (both nominal P-values = 0.006, FDR Q-values = 0.23).

We took six metabolites forward to complete quantitative assays, including meso-erythritol, fructose, lactic acid and 3 branched-chain amino acids (Table 4). The signal for meso-erythritol was confirmed, and this metabolite had a 14.7-fold higher concentration in the pooled samples of participants experiencing incident central adiposity gain compared to participants with stable adiposity (60.77 vs. 4.12 μmol/L, P-value < 0.0001). The concentration of fructose was 2.2-fold greater in the baseline pooled

blood aliquots from participants with incident central adiposity gain compared to the stable adiposity group. The concentrations of leucine, isoleucine and valine were higher in the incident central adiposity gain phenotype group, but these findings did not reach statistical thresholds (nominal P-values all exceeded 0.5).

Finally, we refined the phenotype of incident central adiposity gain to investigate dose-response patterns for the metabolites of interest. The concentration of meso-erythritol varied by tertiles of the central adiposity score (**Figure 1**), but there was no trend in the stable adiposity phenotype sub-groups. The highest meso-erythritol concentration was in the lowest central adiposity change sub-group (composite score ≤ 5, N = 26), and the trend indicated lower meso-erythritol with greater central adiposity change.

Metabolite Profile Associated with Higher Usual Glycemia Phenotype

We also compared the metabolomic profile between phenotype groups defined by higher versus lower usual glycemia using HbA1c concentrations at the study baseline (Table 3). The group with higher usual glycemia had 22-fold greater concentration of meso-erythritol (nominal P-value = 1.5E-06; FDR Q-value = 0.0002) and about half the concentration of fructose (nominal P-value = 0.0006; FDR Q-value = 0.0302) compared to the lower usual glycemia phenotype. Findings were suggestive for the branched-chain amino acids, and for all metabolites concentrations were higher in the higher usual

glycemia group; valine and leucine differences reached the nominal P-value threshold, but not the Q-value threshold, and isoleucine differences were consistent in direction though not statistically significant (P-value = 0.0620, FDR Q-value = 0.6155).

Based on these findings, we took six metabolites forward to quantitative assays, including meso-erythritol, fructose, lactic acid, valine, leucine, and isoleucine. Meso-erythritol concentration was 20.6-fold greater in the higher usual glycemia group (105.62 vs. 5.12 μmol/L, P = 0.0024). Fructose and lactic acid had significantly lower concentrations in the higher usual glycemia group, with nominal P-values supporting an association. The branched-chain amino acids tested showed associations in the same direction. Thus, the metabolite concentration was higher in the higher usual glycemia group; these differences did not reach statistical significance thresholds, but the results were suggestive.

In a further analysis of the dose-response, both usual glycemia phenotype groups were split in half at the median and the quantitative assay was repeated in the four resulting pools (**Figure 1**). Meso-erythritol concentrations were about the same in the two halves of the lower usual glycemia group, but in the higher usual glycemia subgroup, meso-erythritol was higher in the top 12.5% of the baseline HbA1c distribution (HbA1c ≥ 5.64 %).

Discussion

We conducted a discovery-based, non-targeted metabolomics study to determine differences in the baseline metabolome between college freshmen with incident central adiposity gain and those with stable adiposity. We sought to identify a metabolic profile predictive of adverse changes in body habitus, specifically incident gain in central adiposity, which is a phenotype with known cardiometabolic risk [15, 16]. We found consistent differences for meso-erythritol and fructose over several analytic steps that indicated overall positive associations between those metabolites and incident central adiposity gain in young adults. We also found the concentration of meso-erythritol was higher in the group with higher usual glycemia compared to lower usual glycemia. Conversely, fructose and lactic acid metabolites had lower blood concentrations in the higher usual glycemia group. The concentrations of BCAAs (isoleucine, leucine, and valine) did not differ between the central adiposity phenotype groups, but these metabolites had higher concentrations in the higher usual glycemia phenotype group. BCAAs reportedly perturb insulin signaling [17] and experimental feeding of BCAAs, with and without concurrent high fat diet, contributes to insulin resistance in animal models [10].

In the examination of subgroups of the incident central adiposity gain group, we compared the concentration of erythritol across three levels of central adiposity gain, defined by the degree of change. We observed the greatest concentration of meso-erythritol in the subgroup with the least degree of central adiposity change. These data

provide some evidence of a stepwise relationship between erythritol and central adiposity gain and the inverse relation observed (greatest erythritol observed in the group with the least change) may indicate that erythritol is associated with susceptibility to increases in central adiposity, but not to the magnitude of central adiposity change. Replication of this study is needed to verify the relationship. Also, future research characterizing specific foods or food groups that contribute to exogenous erythritol exposure could improve the understanding of erythritol exposure, and lead to a better understanding of factors contributing to endogenous erythritol concentration, increased adiposity, or both.

Erythritol is a sugar alcohol that occurs naturally in foods, including wine, sake, soy sauce, pear, and watermelon; it is 60-80% as sweet as sucrose, and it is an approved low-calorie sweetener food additive [18, 19]. U.S. survey data estimates that the typical intake of erythritol is about 1 g/day [20]. Erythritol is a 4 carbon polyol and up to 90% of the ingested quantity is rapidly absorbed through the gut lumen [21], with the unabsorbed fraction possibly [22] subject to fermentation by gut microbes [18, 20]. Clinical feeding studies of 10-80 g of isotope-labeled erythritol show 78-92% of the dose is excreted in urine within 24-48 hours. In animal models plasma erythritol levels peak approximately 30-60 minutes post-ingestion, with 99% disappearance from the plasma within 24 hours [23]. Erythritol exists endogenously in human tissues, with plasma levels approximately 9.8 μmol/L [24], but one study claims that endogenous production of

erythritol is null [21]. Given recent interest in sugar substitutes [25] and artificial sweeteners [26] in relation to cardiometabolic disease risk, further research is needed to investigate erythritol with regard to endogenous production, metabolism, and possible effects on metabolic pathways related to cardiometabolic risk. **Figure 2** shows pathways that include erythritol or erythrose, the end-product of erythritol metabolism [27], and highlights connections among the cluster of metabolites (erythritol, fructose, lactate, leucine, valine) we found to be associated with central adiposity gain and usual glycemia.

No past studies are directly comparable to our study, and few studies of young adult weight gain include biomarkers or look for predictive metabolomic profiles. Wurtz et al. [8] investigated 82 pre-specified metabolites to understand the causal effect of BMI and of adiposity change on the metabolome in a large consortium-based study of 16 to 39 year olds. They identified causal associations of BMI change with changes in lipid-related, inflammation-related and BCAA metabolites. Prior research also has reported an association of artificial sweeteners with both metabolic dysfunction [28] and with weight gain [29, 30], but these studies were based on consumption, and conclusions are likely to be affected by both confounding and reverse causality (persons already gaining weight choose to consume artificially sweetened beverages to prevent further weight gain). Several recent studies suggest that the biological mechanisms for the artificial sweetener—weight gain association relates to gut microbiota metabolism [31].

We also found higher baseline concentration of plasma fructose was associated with the incident central adiposity gain phenotype. Fructose is a normal component of the human diet and is naturally concentrated in sweet fruits, although fructose is also extracted from corn, beets and cane and concentrated for use as a sweetener. Diets high in fructose have been shown to induce insulin resistance in humans and animals under experimental conditions [32], and the fructose monosaccharide molecule has been shown to enter the glycolysis pathway as an energy substrate, past the primary rate-limiting step, with preferential conversion to lipid in the liver [33]. The possible causal link between fructose intake and human weight gain is controversial [34] and we could not identify any published studies that used metabolomics to study the relation of fructose with subsequent weight gain. We also found higher lactic acid concentrations in the incident central adiposity gain phenotype, and this finding may be driven by the fructose finding given evidence from isotopic tracer studies of fructose, which show that approximately one-fourth of ingested fructose is converted to lactic acid within hours [35].

Previous studies have used metabolomic approaches to construct metabolic 'fingerprints' associated with obesity. Studies have repeatedly shown higher concentrations of branched-chain amino acids with obesity [8, 36, 37] across all age ranges and with risk for insulin resistance in adolescents [37]. In our study, concentrations of BCAAs were higher in the higher usual glycemia phenotype group, supporting

previous studies that implicate BCAAs in long-term glucose economy. No differences in concentration were found in the incident central adiposity gain vs stable adiposity phenotype groups suggesting that increased BCAAs in circulation are not predictive of adiposity gain, but are associated with existing excess adiposity.

A limitation of this work is the use of pools of plasma for all comparisons because it is possible that a subset of the individuals within a pool drives the overall levels of metabolites measured in the pool. A pooling approach was adopted because it offered a cost-effect strategy to investigate the relation between the metabolome and complex phenotypes in an understudied population for this discovery-based analysis. In addition, pooling is advantageous to reduce overall variation when the biological variation between individual samples is greater than the technical variation between replicate assays from the same pool [38]. In this study, we had information on technical variation (pool replicates), but we had no information on biological variability among individual samples. The FDR-corrected statistical tests presented herein are not as robust as tests that account for both biological and technical variation [38]. However, the consistency of the meso-erythritol results in both the central adiposity and usual glycemia comparisons lend strength to the findings, and the cluster of metabolites has biological plausibility.

The interpretation of these data may be affected by the use of non-fasted blood samples. Future research using a protocol requiring fasting would resolve this

weakness by removing the possible contribution of dietary erythritol to plasma erythritol in seeking to understand the predictive association with subsequent central adiposity gain.

This pool-based study delivers two unique results about metabolite abundance related to usual glycemia and longitudinal increase in central adiposity measures. The two pools in each comparison are mutually exclusive, but there is minor overlap across the two comparisons, albeit minor (for example, 12 of the 66 participants with central adiposity gain are also in the higher usual glycemia group). Strengths of this work include a large sample representative of University freshmen, longitudinal data to define the phenotype using both anthropometry and gold-standard DXA methods, and the use of rigorous protocols for all data collection.

In conclusion, we found a positive association between circulating levels of meso-erythritol at the study baseline and the incidence of central adiposity gain in non-obese adults aged 18 years of age studied over 9 months. Further research is needed to understand the meaning of these findings. Research to identify metabolic profiles that predict changes in adiposity in early adulthood present a unique opportunity to identify novel targets for prevention, which are very important given the well-known difficulty of losing weight once it is gained.

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Table 4.1 Baseline characteristics by phenotype group*

	Phenotype Groups			
Characteristic	Incident Central Adiposity N=66	Stable Weight and Adiposity N=16	Higher Usual Glycemia N=21	Lower Usual Glycemia N=7
Demographics:				
Sex (% female)	47.0	56.3	57.1	71.4
Nationality (% US)	90.9	93.8	90.5	85.7
Age, years	18.1 (0.3)	18.1 (0.3)	18.0 (0.2)	18.0 (0)
Anthropometry:				
Weight, kg	64.2 (12.7)	60.9 (12.3)	63.3 (12.4)	59.4 (12.3)
Height, cm	171.3 (10.9)	169.7 (8.6)	169.3 (8.8)	168.9 (11.2)
Body Mass Index, kg/m^2	21.8 (3.2)	21.0 (2.4)	22.0 (3.1)	20.6 (1.6)
Waist Circumference, cm	72.4 (7.6)	71.8 (8.2)	72.0 (7.8)	70.1 (5.7)
Hip Circumference, cm	95.6 (7.8)	94.1 (6.3)	95.3 (6.7)	94.4 (7)
Weight-for-Age, percentile	50.3 (27.4)	45.2 (27.5)	51.8 (24.5)	45.8 (27.5)
Height-for-Age, percentile	55.3 (30.1)	54.6 (31.6)	52.1 (32.4)	59.5 (30.6)
BMI-for-Age, percentile	44.8 (27.1)	39.0 (23.3)	48.5 (23.4)	38.5 (18.4)
Body Composition (DXA):				
Total Body Fat %	19.1 (7.3)	20.4 (6.6)	20.6 (8.1)	20.4 (6.6)
Truncal Body Fat %	15.9 (7.3)	16.5 (6.3)	17.3 (8.3)	15.8 (6.7)
Fat Mass Index, kg/m^2**	4.4 (2.2)	4.4 (1.6)	4.7 (2.2)	4.3 (1.3)
Usual Blood Glucose				
Glycosylated hemoglobin, %	5.30 (0.27)	5.36 (0.37)	5.67 (0.16)	4.81 (0.07)

Abbreviations: dual-energy x-ray absorptiometry (DXA)

*Values shown are Mean (SD) unless otherwise noted

**Fat Mass Index numerator is the mass of total body adipose

Table 4.2 Comparison of semi-quantitative metabolite level* in the central adiposity gain group versus the stable weight and adiposity group; metabolites with nominal P-value < 0.05

	Phenotype				
	Incident Central Adiposity	Stable Adiposity			
Metabolite:	**Mean**	**Mean**	**T-Statistic**	**Nominal P-value**	**FDR Q-value**
Meso-Erythritol	0.1395	0.0104	47.30	**0.0004**	**0.0435**
Metabolite 1742**	0.0184	0.0079	7.08	**0.0060**	0.2280
Fructose	0.0587	0.0271	10.83	**0.0064**	0.2280
Metabolite 1297**	0.0097	0.0135	-5.497	**0.0120**	0.3216
Metabolite 2470**	0.0089	0.0060	5.498	**0.0308**	0.6600

*metabolite semi-quantitative findings are reported for the optimized assay, which validated results based on the first pass assay using a non-targeted approach
**unknown metabolites, with arbitrary numbering system

Table 4.3 Comparison of semi-quantitative* metabolite level in the higher versus lower usual glycemia groups; metabolites with nominal P-value < 0.05

	Phenotype				
	Higher Usual Glycemia	**Lower Usual Glycemia**			
Metabolite:	**Mean**	**Mean**	**T-Statistic**	**Nominal P-value**	**FDR Q-value**
Meso-Erythritol	0.2768	0.0124	165.43	**1.51E-06**	**0.00016**
Fructose	0.0504	0.1162	-16.734	**0.0006**	**0.03015**
Octadecenoic Acid	0.2033	0.2837	-5.3393	**0.0227**	0.55551
Lactic Acid	1.9870	2.7210	-8.5887	**0.0233**	0.55551
Glycerol	0.1400	0.1814	-9.4625	**0.0260**	0.55551
Valine	0.4357	0.3497	4.3149	**0.0430**	0.56474
Metabolite 1175**	0.0943	0.1539	-7.9110	**0.0468**	0.56474
Metabolite 2278**	0.0959	0.1168	-3.2985	**0.0471**	0.56474
Leucine	0.2157	0.1585	3.5326	**0.0475**	0.56474

*metabolite semi-quantitative findings are reported for the optimized assay, which validated results based on the first pass assay using a non-targeted approach
**unknown metabolites, with arbitrary numbering system

Table 4.4 Metabolite quantification* for incident central adiposity phenotype compared to stable adiposity phenotype groups (nominal P-values)

	Increased Central Adiposity		Stable Adiposity		
Metabolite	**Mean***	**SE**	**Mean***	**SE**	**Nominal P-Value**
Meso-Erythritol	60.77	3.14	4.12	0.00	**<0.0001**
Fructose	46.18	0.92	27.77	1.60	**0.0022**
Isoleucine	47.62	0.95	45.12	4.47	0.6392
Lactic Acid	1547.21	5.07	1422.93	20.75	**0.0283**
Leucine	78.74	2.48	75.45	9.15	0.7614
Valine	152.95	6.23	143.97	11.76	0.5483

* concentration (μmol/L)

Table 4.5 Metabolite quantification* for higher usual glycemia phenotype compared to lower usual glycemia phenotype (nominal P-values)

	Higher Usual Glycemia		Lower Usual Glycemia		
Metabolite	**Mean***	**SE**	**Mean***	**SE**	**Nominal P-Value**
Meso-Erythritol	105.62	1.44	5.12	0.07	**0.0024**
Fructose	42.62	3.24	76.62	6.67	**0.0444**
Isoleucine	52.64	3.49	42.52	3.21	0.0996
Lactic Acid	1499.10	18.94	1909.41	39.11	**0.0088**
Leucine	86.50	7.65	67.16	6.28	0.1458
Valine	160.28	9.63	129.15	5.89	0.0702

* concentration (μmol/L)

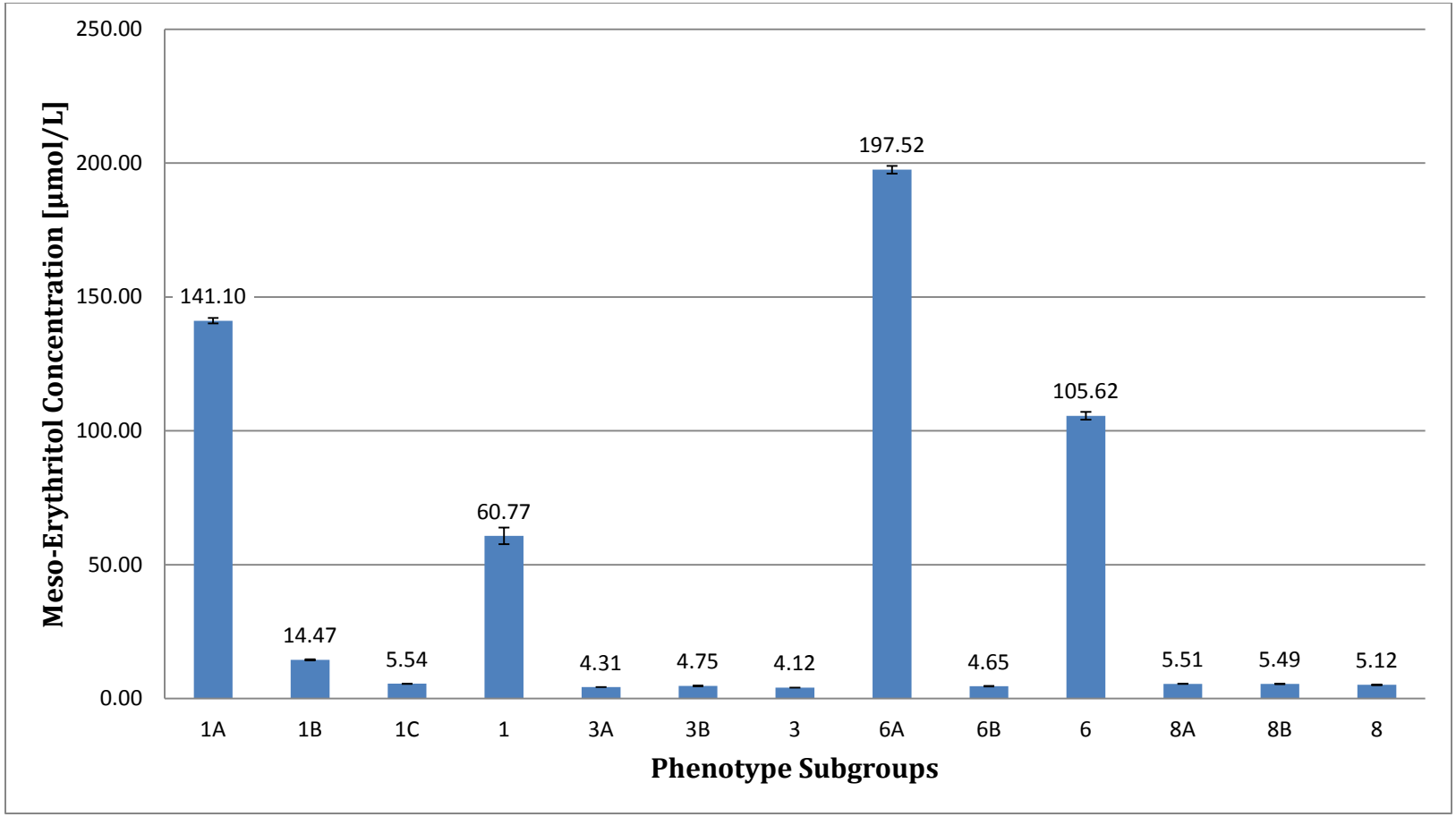

Figure 4.1 Quantification of meso-erythritol by phenotype pool, and by phenotype sub-group pools, as follows:
Group 1: all incident central adiposity gain, with 1A, 1B and 1C denoting low, middle and high amount of central adiposity change (scores ≤ 5, N = 26; 6-7, N = 24; and >7, N = 16, respectively)
Group 3: all stable adiposity, with 3A and 3B denoting above and below the median (4.5)
Group 6: higher usual glycemia at baseline, with 6A and 6B denoting above and below median (HbA1c, 5.64%)
Group 8: lower usual glycemia at basline, with 8A and 8B denoting above and below median (4.85)

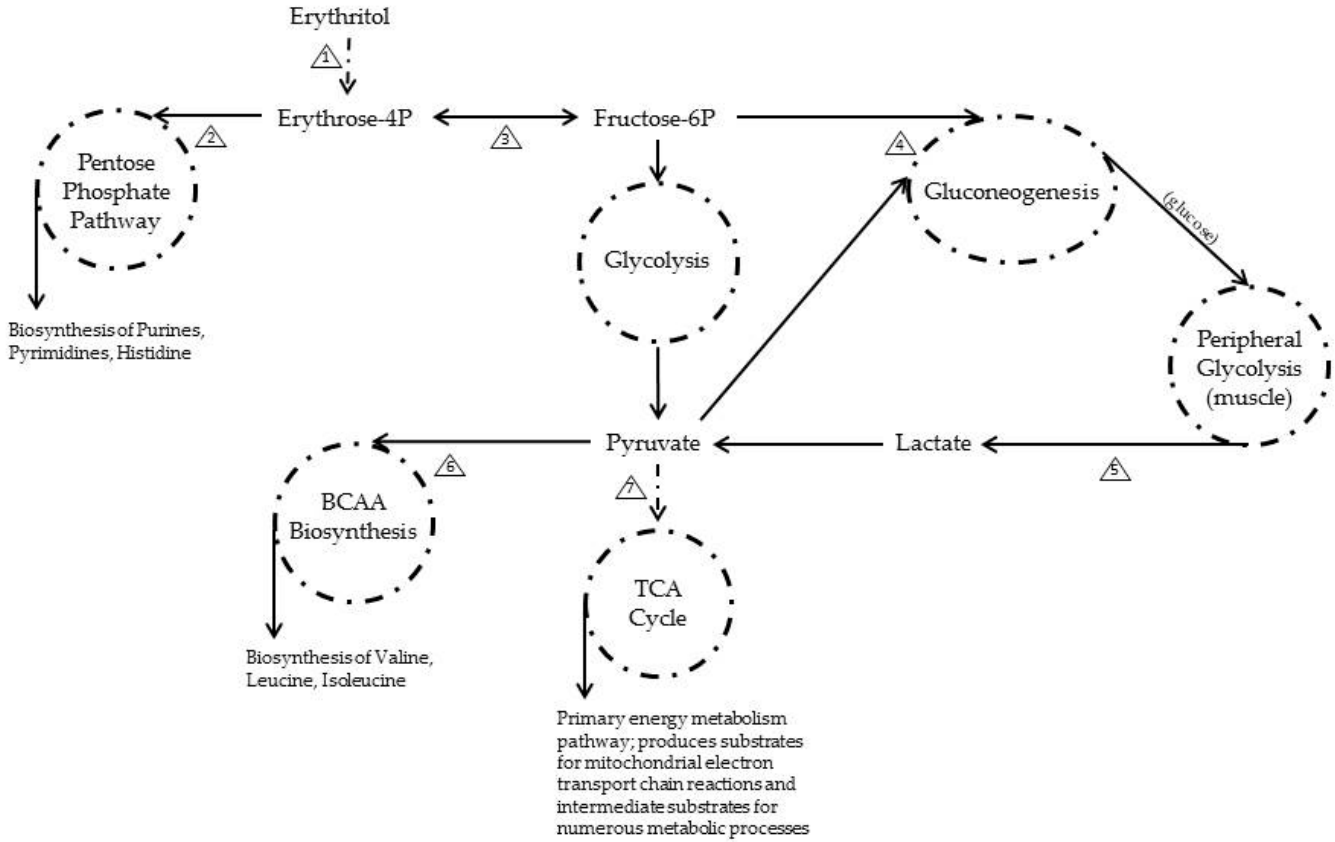

Figure 4.2 Metabolic pathways involving erythritol, fructose, and lactic acid substrates.
Dashed lines represent pathways with intermediate compounds not shown; solid lines represent direct pathway input.
Abbreviations: Erythrose-4P, D-erythrose-4 phosphate; Fructose-6P, fructose-6 phosphate; TCA cycle, tricarboxylic acid cycle; BCAA, branched-chain amino acid.
Triangles identify the main reference for the pathways shown: 1. Barbier et al., 2014; 2. Kyoto Encyclopedia of Genes and Genomes Database (KEGG) Phosphate Pentose Pathway; 3. KEGG Overview of Biosynthetic Pathways; 4. KEGG Glycolysis/Gluconeogenesis Pathway; 5. Gropper SS, Smith JL, Groff JL (Eds.): Advanced Nutrition and Human Metabolism. Belmont, California: Thomson Wadsworth; 2005; 6. KEGG Pyruvate Metabolism Pathway; 7. KEGG TCA (Citrate) Cycle

SUPPLEMENT

METABOLOMIC MARKERS ASSOCIATED WITH CENTRAL ADIPOSITY GAIN IN YOUNG ADULTS

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**starred last authors

Online Supplement
Contents:

Supplemental Methods

We assigned sex-specific tertiles scores of 1, 2 or 3 for the changes in weight, waist circumference, and truncal adiposity, and we summed the tertile scores for each indicator to create an overall phenotype score (minimum score 3, indicating the participant was in the lowest tertile of change on all 3 indicators of adipose change, maximum 9, indicating the participant was in the highest tertile of change on all 3 indicators of adiposity change). The three subgroups of the incident central adiposity gain group were defined by tertiles of the composite score to investigate the potential for dose-response between the concentration of a metabolomic marker and phenotype.

All GC-MS assays were performed on an Agilent 6890 gas chromatograph equipped with a DB-35MS capillary column. The GC is coupled to an Agilent 5975C MS equipped with an electron impact (EI) ionization source operating at 70 eV. The mass spectrometer source is heated to 230°C and the quadrupole to 150°C. To avoid analytical noise originating from variations in metabolite derivatization, a Gerstel Multipurpose Sampler performed an online derivatization. This automated derivatization procedure ensures that all samples are processed identically. Dried metabolite extracts in GC glass vials were mixed with 15 μl of 2% methoxyamine hydrochloride in pyridine (MOX, Fisher Scientific) and incubated at 40°C. After 30 minutes, 15 μl of MSTFA (2,2,2-trifluoro-N-methyl-N-trimethylsilyl-acetamide; Machery Nagel, Inc.) were added and the mixture was further incubated for 30 min at

40° C. The detector was operated in scan mode and the Gerstel Multipurpose Sampler injects 1 μl of derivatized sample in the GC sample inlet. With the injection set to splitless mode, helium was used as the carrier gas (flow rate 1 ml/min). The GC oven was maintained at 80°C for 6 minutes prior to increasing to 300°C (heating rate 6°C/min). Thereafter, the temperature was increased to 325°C for 4 min (heating rate 10°C/min). Run-time per sample was 59 minutes; derivatization requiring additional hour as the autosampler optimized timing by derivatizing the next sample while the first was measured.

CHAPTER FIVE

CONCLUSIONS

The aims of this dissertation framed the investigation of predictors of weight and adiposity change in young adults during the first year of college, a critical period of personal transition where weight gain is common. This work incorporates disciplines of nutrition, epidemiology, behavioral psychology, integrative physiology and metabolomics to address questions about the risk factors for and the etiology of young adult-onset weight gain during the widely experienced transition to college. We investigated physical, behavioral, psychological, and metabolomic factors in relation to weight and body composition outcomes, exploring differences across sex and phenotype-specific subgroups.

For the first aim, we studied the longitudinal changes in anthropometry and body composition in young adults, and investigated the associations of dietary intake, energy balance factors, such as physical activity and sedentary time, and physical characteristics using ordinary least squared regression methods. Three quarters of the sample gained at least 0.5 kg, with overall average weight gain of about 2 kg. Closer examination of outcomes by weight gain status revealed that freshmen who gained weight over the year experienced a 5.6% increase in weight. Interestingly, the group who did not gain weight lost about 1.6 kg, on average, but included a subgroup who were stable and a subgroup who lost weight; these groups were too small to pursue

further subgroup analyses. Overall, a leaner body habitus at baseline (lower BMI and waist circumference and lower adiposity as measured by DXA) was associated with greater weight gain. The drivers of this association need to be studied in further research, and several testable hypotheses are suggested. The finding may be driven by changes in habits related to leanness prior to starting college; for example, an increase in the amount of food usually consumed at a meal, which may change during the college transition, may play a role. Alternatively, freshmen who are leaner at the start of college may be less physically mature and weight accretion may represent continued maturation. The finding of negligible linear growth in this sample does not support this second hypothesis. Also, the weight gain observed in this study exceeded expectations based on normal growth/maturation patterns derived from nationally representative age- and sex-specific references [1], indicating that the magnitude of weight gain observed among those who gained weight may represent a pathological antecedent to adult-onset overweight/obesity.

Analysis of these data also revealed an interaction of sex and physical activity which showed that a higher baseline physical activity was associated with a greater weight gain in females only. In women who gained weight there was not a precipitous drop in physical activity during the transition to college; indeed among women gaining weight MET·hr/day increased 1.5 units over the academic year. Together these findings argue that the association of higher baseline physical activity with subsequent weight

gain is not driven by a decline in physical activity. Other hypotheses that could be explored to further understand this finding include the hypothesis that activity drives greater appetite and/or compensatory over-consumption, leading to increased food intake, possibly related to the wide availability of a variety of choices at the all-you-care-to-eat on-campus dining facilities.

Future research should consider sex differences in the trajectory of weight and body composition in young adults due to evidence that baseline factors, such as physical activity, are differentially associated with weight gain in males and females. More detailed methods for measuring physical activity, such as wearable personal activity monitors or objective data on the frequency of fitness center visits, would be important to reduce measurement error and to more allow a more unbiased estimate of how the dose, duration, and/or frequency of physical activity contributes to body habitus outcomes in college, including weight gain, staying stable and weight loss.

In the second research aim, we explored the association of psychological constructs, including stress, eating competence, dietary restraint, and overeating due to emotional or external cues, at the beginning of college with anthropometric change over the first semester. By investigating sex differences, we found a significant positive association between perceived stress at the start of college and subsequent increases in weight, BMI and waist circumference among males. Why would a baseline stress—subsequent weight/adiposity gain be limited to males? There may be sex differences in

the stress response to different types of stimuli [2]; males with greater baseline stress may respond to an academically intensive college transition by shifting their food choices toward processed, energy dense, unhealthful foods [3]. We also used a novel, objective measure of dietary intake, which was based on the electronic meal card system at campus-dining halls. All metrics from the meal card data (average number of 'swipes' per day, total number of meals, and total number of days swiped) showed positive associations with changes in weight, BMI, and waist circumference. A prior study of Cornell freshmen reported that consuming meals at the dining facilities on-campus (at which students are offered a wide variety of cuisines and allowed to consume *ad libitum* during mealtime) was associated with longer mealtime, greater feeling of 'fullness' , and eating larger meals [4], which is consistent with our finding. While we found consistent cross-sectional associations between eating competence, restraint, disinhibited eating or emotional eating and prevalent body habitus measures, similar to other studies, we did not show an association with longitudinal change in body habitus. Thus, cross-sectional associations may not represent a causal association, and these psychological constructs may not be etiologic factors in weight gain.

Further research is needed to understand the stress – weight/BMI/waist circumference association among males in the college transition. Future studies should aim to collect richer data on stress stimuli and coping strategies to determine whether there are triggers for stress that are unique to male freshmen, while also studying how

stressors change over time. Replicating our study in a different cohort of freshman in a context that is relatively less academically challenging would elucidate the role of academic responsibilities as a stressor related to weight gain. Further research would be strengthened by incorporating biomarkers of the stress response, such as free cortisol [5], in order to gather information on internal markers of the dose of stress and develop testable hypotheses related to biologically plausible mechanisms underlying the relation between stress stimuli, markers of internal stress response, and increases in weight and adiposity. Future research incorporating objective measurements of intake, for example, electronic use and purchase data, as well as methods that allow for meal- and food-level assessment, such as photographic food records of the meal before and after intake, are needed to better understand the role of more dining hall visits in relation to change in body habitus over time.

In the third aim we completed a prospective investigation of metabolomic markers in baseline blood samples in relation to incident central adiposity gain in young adults. We identified significantly greater baseline plasma concentrations of meso-erythritol, lactic acid and fructose in the group of participants with incident increases in weight, waist circumference, and truncal adiposity over the academic year, compared to the group of participants who remained relatively stable on adiposity measures. Compared to glucose, fructose preferentially contributes to hepatic lipogenesis [6], and the presence higher fructose in plasma suggests fructose is readily

available for hepatic metabolism and may plausibly contribute to central adiposity.

Future work replicating our findings in another cohort of young adults, with the examination of group- and individual-level metabolomics data, is needed to verify the predictive association of fructose, meso-erythritol, and lactate with gains in adiposity. Meso-erythritol is associated with intake of erythritol, a low-calorie dietary sweetener added to a wide variety of commercial foodstuffs including sugar substitutes, candy, dairy products, baked goods, and beverages. Our observation of significantly greater meso-erythritol among young adults with subsequent central adiposity gain, compared to stable adiposity, and of greater meso-erythritol among participants in the top quartile of baseline usual glycemia (HbA1c > 5.50%), vs. the bottom of the distribution (HbA1c > 4.92%) is provocative because these data suggest meso-erythritol could be a novel biomarker associated with cardiometabolic risk in young adults. The erythritol results also suggest three questions that need to be addressed in future research: first, is there endogenous production of meso-erythritol ; second, is meso-erythritol metabolized into other compounds, and third, does erythritol relate to adiposity gain by playing a role in glucose economy and metabolism.

The research described in this dissertation was based on a prospective cohort study designed to address current gaps in the scientific understanding of the predictors of weight and adiposity change in young adults. This study was conducted with rigor and the quality of measurement and reduction in bias lends strength to the findings.

Excessive weight and adiposity gain in the transition to college is documented [7, 8], but prior work in this area has not yet produced effective prevention strategies. This interdisciplinary work advances previous research by seeking to identify predictors of incident weight and adiposity gain. In summary, the main findings showed that a leaner body composition, a higher self-reported physical activity in females only, a higher level of self-reported stress in males only, a higher frequency of dining hall use during the freshman year, and a higher blood concentration of meso-erythritol were all significant predictors of adiposity gain. The development of excessive adiposity over the trajectory of adulthood is arguably the most significant public health problem facing the U.S., and this work provides new information about at-risk population subgroups, interacting conditions, and potential risk factors for adult-onset overweight/obesity.

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CHAPTER SIX

APPENDIX

TABLE OF CONTENTS

APPENDIX FORWARD: About the EnHANCE Study Operations Manual

Appended to this dissertation are the components of the EnHANCE Study Operations Manual collaboratively co-authored by Pat Cassano, Katie Hootman, Sarah Shapiro, and Brenda Daniels-Tibke in 2011, prior to the start of the study. The EnHANCE Study Operations Manual has been modified from its original format as a PDF portfolio for inclusion herein, and as such, includes documentation from multiple sources regarding study background information, personnel training, data collection methods and safety, equipment, questionnaires, and standard operating procedures.

SECTION 1: EnHANCE Communications

- Recruitment and Enrollment
- Approach Letter
- Follow-Up Communication
- Study Brochure and Bookmark

Recruitment and Enrollment

The design of this research is a longitudinal cohort study of college freshmen who reside on campus during their first year at Cornell University. Study participants will be selected through stratified random sampling of the incoming freshmen class at Cornell University prior to arriving in August, 2011, with a goal of 50-80% participation (note recent surveys of students at Cornell cite 50% acceptance rate, but freshmen tend to participate at slightly higher levels). Recruitment will occur after the students accept university enrollment and before they move to campus. The sampling will be stratified to recruit equal numbers of males and females and to equally represent each of the major colleges within Cornell. This sampling is meant to represent the larger population of freshmen at Cornell, a culturally, ethnically and racially diverse population. We expect to achieve a diverse sample with our sampling method. The study duration will span approximately 12 months, from June-July prior to freshman year to June at the end of the participant's freshman experience. The first questionnaires will be administered via internet during the summer, prior to the beginning of the fall term. On arrival at Cornell University, blood samples will be collected within the first three days, and these will be archived in a biospecimen repository. Three additional brief in-person visits will be conducted over the year, and the majority of data will be collected via web-based interfaces.

APPROACH LETTER FRONT SIDE

Cornell University
Division of Nutritional Sciences

Date
Name
Address

Dear *Student's Name*,

We would like to invite you to participate in a new study that will help understand how the college experience affects health outcomes in Cornell freshmen. The study is called **EnHANCE,** which stands for "**E**ngaging **H**ealth**, A**griculture and **N**utrition through the **C**ornell **E**xperience". The EnHANCE pilot study will enroll 400 incoming students from the Cornell graduating class of 2015. The pilot study will pave the way for the full study, to take place in the next two years, when we plan to invite the full class of about 3,000 students. Profs. Patricia A. Cassano and Patrick Stover from Cornell University are the lead researchers on this study, and they are working in collaboration with the Centers for Disease Control and the Cayuga Medical Center, Ithaca, NY. The pilot study is funded by Cornell University.

We are doing this study because there is a need to understand factors related to changes in weight and body composition during the college years, and how such changes affect metabolism and risk of chronic diseases like diabetes and high blood pressure. Ultimately, we would like to identify ways to prevent unhealthy weight change in young adults and promote wellness into later adulthood. Your participation in EnHANCE is completely voluntary. As a participant in the EnHANCE Pilot Study, you will learn first-hand about biomedical research, and you will have the chance to attend special events for study participants. Your participation is highly valued because understanding the factors affecting the health of college-aged students depends on the willingness of the freshmen we contact to get involved. We will send you an email in the coming week, which provides a link to the study website, further details about what participation entails, and a link to web-based registration for the study if you choose to participate.

We have included a bookmark that provides some links for the EnHANCE study, and we hope you enjoy the red and white theme! Answers to questions you may have about EnHANCE are provided on the back of this letter. If you have other questions about this study, please feel free to contact Prof. Cassano at pac6@cornell.edu, enhance@cornell.edu or 607-255-7551.

We welcome your participation in EnHANCE, and we wish you well as you prepare for your transition to Cornell.

On behalf of the EnHANCE Study team,
Sincerely,

Patricia A. Cassano, Ph.D.
Associate Professor

APPROACH LETTER BACK SIDE

Engaging Health, Agriculture and Nutrition through the Cornell Experience, EnHANCE

What kinds of scientific questions will this study answer?

- The EnHANCE Pilot Study will observe the changes in diet, body weight, body measurements, and markers of metabolism during the freshman year.
- Based on these observations, the study will investigate the factors that lead to unhealthy changes in weight and/or metabolism in the first year of college.
- The EnHANCE study will use the data from the class of 2015 to understand the factors associated with unhealthy weight gain during college, and with changes in metabolism that may signify risk of chronic diseases later in life.

Who is eligible for the study? We selected a sample of 800 Cornell students, at random, from the full roster of entering freshmen. You were selected as part of the sample, hence we are inviting your participation in the study.

Can you tell me more about what my participation will involve? If you join the EnHANCE study, you will be asked to: 1. Take web-based surveys that ask about diet, eating habits, medical history, and lifestyle habits such as alcohol and cigarette use, sleeping habits and stress, 2. Visit for four in-person appointments (beginning and end of each semester) to provide a small sample of blood and to be measured on weight, height and a few body circumferences, 3. Visit for two DXA scans (beginning and end of the year), to assess lean and fat tissues in the body, 4. Sign a consent that gives the researchers access to some of your University records including your college, your dormitory assignment, and your dining purchases.

How can I be sure that my information will be confidential? All the information you provide will be kept strictly confidential as required by law and will be used exclusively for research purposes. Only key research staff will have access to any identifying information, and your name will never be used in any publications from this study. Your participation is voluntary and you may skip questions that you do not want to answer, or refuse any procedures you do not wish to complete without any penalty. You will receive a consent form to sign describing the study, and your rights as a participant.

Are there any costs involved, and how much time does the study take? The EnHANCE study will never ask you for money; the contribution of your time is valuable to us. Participating in the study will take about 12 hours of your time spread out over the academic

year, or about 6 hours per semester.

Why is it important for me to participate in this study? Your participation is important because studies like EnHANCE depend on volunteers like you to provide information that will help identify prevention strategies during the collegiate years to assure optimal health throughout adulthood.

What kind of future contacts will occur? After your freshman year we will not contact you further.

Can I find out about the results of the study? Although we will not provide you with information about your individual health, we will share a summary report of the study with you via the EnHANCE website, and we will publish our new findings in scientific journals. Your participation may or may not help you directly, however it will help improve the health of your generation and future generations.

Follow-Up Contact During Recruitment

Within two weeks of mailing approach letters via postal mail, electronic communication will be initiated to the prospective participant's Cornell email address. This contact will be administered by the Survey Research Institute at Cornell University. Email follow-up will reference the approach letter, inform the prospective participant of the purpose of EnHANCE and details of study participation, and offer a link to the first consent document.

Email Contact

In the event that prospective participants do not respond to the first electronic follow-up email, up to five additional emails will be sent to offer the opportunity to participate in EnHANCE; if the prospective participant does not respond to any of those contact attempts, their recruitment pursuit will be discontinued.

Frequently Asked Questions (FAQ)

A list of FAQ and answers will be available electronically on the EnHANCE website (www.enhance.cornell.edu) and partly incorporated into the brochure and approach letters. The electronic list will be updated as needed throughout the study.

Brochure and Bookmark

Engage

Public Science

In NY State, the US and around the world citizens are engaged in the quest to discover answers to some of society's pressing questions.

A famous example of public participation in science is the Framingham Heart Study, which follows the health of citizens residing in Framingham, Massachusetts in 1948 and two subsequent generations.

At Cornell, a recent example is the Genetic Ancestry Project, which enrolled student volunteers to participate in National Geographic's Genographic Project.

EnHANCE is a new example of citizen science that relies on the participation of volunteers to advance understanding of health transitions in young adulthood.

Answers to Questions

1. How much time does it take to be in the study?

Participation in EnHANCE will take about 12 hours over the entire year (6 hours each semester). Scheduling is flexible, and surveys are online for students to complete at their convenience.

2. How are data collected?

Web-based surveys, in-person visits, and existing University records are used to collect data.

3. What kinds of information does the study gather?

EnHANCE will collect data on food intake, eating habits, physical activity, body measurements, and will measure metabolic indicators in blood samples collected periodically from participants.

3. Does the study benefit me directly?

We will not provide you with specific information about your individual health, but we will give you summary information about the study.

www.enhance.nutrition.cornell.edu

contact: Prof. Patricia A. Cassano
pac6@cornell.edu; 607 255 7551

EnHANCE

Engaging Health, Agriculture and Nutrition through the Cornell Experince

Learn. Participate. Contribute.

What is EnHANCE?

What will I learn?

How can I participate?

What will it contribute?

What is EnHANCE?

LEARN

EnHANCE is an initiative of the Division of Nutritional Sciences, Cornell University.

The goal of EnHANCE is to understand how the transition to the college environment affects changes in diet, weight and metabolism.

The study of a random sample of the Class of 2015 will set the stage for a second, larger study that will start with freshmen and continue for all four years of college and beyond.

Through EnHANCE students will learn more about the links between diet, physical activity and health outcomes including weight gain, diabetes and hypertension.

"Tell me what you eat and I will tell you what you are"

Brillat-Savarin, A.

PARTICIPATE

What information will I need to provide as an EnHANCE participant?

Participants complete web-based surveys and in-person visits. The majority of data is collected via web-based surveys.

The study will collect information about diet, eating habits, lifestyle, physical activity, physical measurements, and markers of metabolism measured in blood samples.

Why was I invited to participate?

Each student invited to participate was chosen at random from the Class of 2015.

The study would like to achieve a good balance across the Cornell colleges and majors to represent Cornell's diverse student body.

CONTRIBUTE

EnHANCE will contribute to understanding how the transition to college affects changes in weight, body fat, and markers of metabolism in the blood.

Scientists will use what we learn from the EnHANCE study to devise strategies to maintain health and well-being through the college years and beyond.

Feeding your mind and body at Cornell University

The Division of Nutritional Sciences is introducing a new Cornell research study called **EnHANCE** (Engaging Health, Agriculture and Nutrition through the Cornell Experience).

EnHANCE will study how the body changes during the college years, and how diet and physical activity affect these changes.

We invite you to learn more by visiting www.enhance.nutrition.cornell.edu

or

by sending an email to enhance@cornell.edu

SECTION 2: **Responsible Research Conduct and Participant Informed Consent**

- Human Subjects Protection in Research Training
- EnHANCE Study Consent Forms:
  - General Consent Form
  - Biospecimen Consent Form
  - FERPA Consent Form
  - DXA Consent Form
- Data Collection Plan

Human Subjects Protection in Research Training of All Study Personnel

As required by the IRB, all personnel involved in this study are required to complete Training for Research with Human Participants. As of May 2010, the Office of Research Integrity and Assurance (ORIA) at Cornell University began using the Collaborative Institutional Training Initiative (CITI) Program for web-based training in the ethical conduct of research with human participants. Thus, all investigators (Profs. Stover and Cassano), and all research personnel, will be required to complete this training at the Cornell University IRB website using netid and password access (www.irb.cornell.edu/training/citi). Additional training by members of the EnHANCE Study Research Team of study personnel who obtain informed consent from participants will also be conducted prior to the start of the in-person study visits. Additional training for personnel who collect anthropometry, biospecimes, and/or adiposity data will also be conducted per protocol of the Human Metabolic Research Unit.

GENERAL CONSENT FORM

Cornell University
Division of Nutritional Sciences

We are asking you to participate in a research study. This form is designed to give you information about this study. We will describe this study to you and answer any of your questions.

Project Title: "Engaging Health, Agriculture and Nutrition through the Cornell Experience (**EnHANCE**) Pilot Study"

Principal Investigator: Professor Patricia A. Cassano
Division of Nutritional Sciences
Phone: 607-255-7551; email pac6@cornell.edu or enhance@cornell.edu

You are a prospective participant in the Engaging Health, Agriculture and Nutrition through the Cornell Experience (EnHANCE) Pilot Study. EnHANCE is a cohort study (a type of research study that follows people over time) looking at the long-term effects of college students' diet and lifestyle habits on overall health. You are being asked to join the pilot study for EnHANCE; a pilot study is completed ahead of the full study to pave the way. In a future year, all Cornell Freshmen will be invited to join the EnHANCE study. The funding and leadership for EnHANCE is from Cornell University and the Division of Nutritional Sciences, Cornell University. We are partnering with the Centers for Disease Control, Atlanta, GA and the Cayuga Medical Center, Ithaca, NY in designing and conducting the study.

WHY IS THIS STUDY BEING DONE?

The purpose of the study is to understand the transition from high school to the university environment and how independent decisions about nutrition and activity affect health outcomes in college-aged students. The EnHANCE study is important because we will learn how the transition from home to college affects eating behaviors, dietary patterns, and related lifestyle choices such as activity and sleep, and how these factors are related to changes in health and well-being.

The health indicators being studied by EnHANCE include weight, body fat, and markers of metabolism measured in the blood. The overarching goal of the EnHANCE study is to contribute to evidence that will identify prevention strategies that could be used during the college years to assure long-term health and well-being throughout later adult years.

Research studies like this one depend on voluntary participation. There are many examples of such studies: for example, a recent Cornell study on ancestry enrolled about 200 undergraduates who provided a sample of saliva so that genetic markers of ancestry could be measured. If you are not interested in participating in the EnHANCE study there is no penalty to you; your participation is completely voluntary and it is up to you to decide if you would like to be in the study.

WHAT WILL WE ASK YOU TO DO?

If you consent to participate in the EnHANCE study, we will ask you to complete the following:

1. Surveys completed electronically on the study website
    - Surveys address medical history, food intake, eating habits, sleep habits, stressful events, and other lifestyle factors such as physical activity, cigarette smoking and alcohol use patterns
    - Surveys can be completed at the participant's convenience, following an electronic invitation
    - Surveys can be started and stopped, so that if you get interrupted you may return to continue

2. An in-person visit at the beginning and end of each semester, thus four times during your freshman year
    - Visits will be scheduled; the first visit will be during the first two days on campus, other visits will be scheduled at your convenience
    - During each visit, body measurements will be completed including height, weight and circumference measurements
    - A small amount of venous blood will be collected at each visit to measure metabolic indicators that are used in research studies.

- For about 100 students, we will also collect a single saliva sample and/or a single finger stick blood sample at the first visit only.

3. A separate in-person visit at the beginning and the end of the school year to complete a measurement of body composition known as a DXA scan
    - A separate consent form will describe this in more detail

4. Information from academic records on your college, dormitory assignment, number of roommates and other aspects of your living arrangements including meal plan and dining purchases will be obtained from existing University records to save you time
    - A separate consent form will describe this in more detail

All in-person visits take place at the Human Metabolic Research Unit (HMRU), Martha Van Rensselaer Hall. The blood markers we measure provide information for research purposes. Physicians do not routinely measure most of these blood markers, and thus, in this research study we will not report any laboratory values back to you. However, we will make you aware of routine screening markers that your primary care physician could measure in your blood so that you can obtain information if you wish.

Participation in the EnHANCE pilot study will take about 6 hours per semester, or about 12 hours over the entire year. Roughly, the time (in hours) is distributed as follows: during summer- 1¾, August- 1, September- ½, October- ½, November- ½, December- 1½, January- 1, February- ½, March- ½, April- 1¾, May- 1½.

Additional consent forms for use of biological specimens, the DXA scan, and obtaining access to some of your University records will be reviewed with you when you arrive at Cornell and visit the Human Metabolic Research Unit for your first in-person appointment.

ARE THERE BENEFITS TO TAKING PART IN THE STUDY?

There are no personal benefits from taking part in this study other than contributing your time and effort to assist in research. We will provide you with an overall summary report at the end of the study, and this report will describe the data on the group of study participants without any individual identifiers. These summary data may be of interest to

you in putting your personal experiences during freshman year into perspective. Also, the information learned from this study will contribute to our understanding of dietary patterns of college-aged students and this information will help us prevent changes in weight that lead to changes in health.

WHAT ARE THE RISKS OF THE STUDY?

There are no specific risks from participating in the web-based questionnaire portion of the EnHANCE study. When we draw your blood, there is a small risk that you may have some bruising on your arm. Other risks that are associated with drawing blood include fainting or feeling dizzy, and a slight risk of infection, but these are rare and trained personnel will monitor your recovery should this occur. There are no known specific risks of an individual DXA scan. The theoretical risk of ionizing radiation contributing to cancer is cumulative and based on one's total exposures over time.

WHAT IS A DXA SCAN?

A Dual X-ray Absorptiometry (DXA) Scan uses low-dose x-ray to capture images of the body. The DXA scan will provide researchers with a highly accurate measurement of the amount and distribution of the fat and lean tissue in your body. The DXA scan is being performed strictly for research purposes and no physician will review the results of your scan. This procedure is limited to the assessment of body composition and therefore does not provide diagnosis of any medical conditions.

Having a DXA scan involves:

- Lying still on the bed of the DXA scanner and having a whole-body scan taken over the course of about 6 minutes.
- You must be able to lie still and breathe normally over these 6 minutes.
- You will be asked to wear a gown for the procedure only if your own clothes have metal components such as zippers, clasps or underwire.
- Because the DXA involves some radiation exposure, all female participants will be provided with a urine pregnancy test kit at the HMRU and will be asked to perform this pregnancy test prior to undergoing the scan. Although the low level of exposure is not harmful to body organs, the risk to a developing fetus are uncertain.

A NYS Licensed Technologist will administer scans, and scans will only be performed in non-pregnant women and men. There are several other reasons why someone may not be eligible to have a DXA as well as factors that can influence the accuracy of the test. The researchers will provide you with an additional information sheet on DXA so you will be made aware of these issues prior to the scan. You will be asked to fill out an additional consent form on the day of the DXA scan.

WILL I RECEIVE SPECIFIC INFORMATION ABOUT MY HEALTH FROM THE STUDY?

The EnHANCE pilot study will use your biological specimens to measure blood markers that are used in research, such as leptin, cholesterol, hemoglobin A1c and others. The majority of the information is not clinical information used by physicians, and you will not be provided with any of the data from the study. We will produce summary reports of all participants, with no identifying information, and these reports will be shared with you. At any time, you may talk to your primary care physician about performing various blood tests related to nutritional status and/or disease risk if you are interested, and we will provide you with information about this during the in-person visits.

WHAT IF I DON'T WANT TO BE IN THE STUDY, BUT I WANT INFORMATION ABOUT MY HEALTH?

Some of the measurements and blood markers we will study are things your primary physician could also measure. Thus, you could seek some similar information about your health during a routine visit with your doctor. Our study website gives you links where you may learn more about health and disease prevention in young adults.

WHAT ARE THE COSTS?

There are no costs to participate in this study, beyond the time you take to complete the in-person visits and web-based questionnaires. In the highly unlikely event of injury or illness resulting from this study, medical treatment will be provided at usual charge. No funds have been set aside to compensate you in the event of injury. You or your insurance company will be charged for continuing medical care and/or hospitalization.

WILL MY TIME BE REIMBURSED OR WILL I BE PAID TO BE IN THE STUDY?

Your time will not be compensated, but we will offer you a small amount of money to defray the costs of being in the study. At the first visit, you will receive $10, and assuming you remain in the study to the final study visit, in May 2012 you will receive $20. At five times over the course of the year, all students who have completed the data collection up to that point will be entered into a raffle to win a $50 bonus.

HOW MANY PEOPLE WILL TAKE PART IN THE STUDY AND HOW LONG IS THE STUDY?

About 400 students will take part in the EnHANCE pilot study. These students will be selected at random from the incoming class of 2015. The EnHANCE pilot study is a one-year study, which starts in mid-July 2011 and ends in May 2012.

WHAT ABOUT CONFIDENTIALITY?

All data will be held in the strictest confidence on secure research computers, and no data files will be linked to your personal identifiers. Only a few key EnHANCE staff members will have access to your personal information, such as your full name and your email address, and these data will be kept under lock and key. The EnHANCE investigators will use unique ID numbers for each participant to identify the information for each individual in the study. The EnHANCE investigators will not have any of your personal information in their study data files. If we publish the information we learn from this study in a scientific journal, you will not be identified by name or in any other way.

WHAT ARE MY RIGHTS AS A PARTICIPANT?

Taking part in the EnHANCE study is completely voluntary. You may choose not to participate in this study, and, in that case, there are no consequences to you at all. You may also choose to participate in the study, but decline some aspects of the study. In that case, there is also no consequence or penalty. You may choose not to join the study, and you may leave the study at any time. Leaving the study will not result in any penalty. In the event that you decide to stop participating in the study, we encourage you to talk to the EnHANCE research staff so that we can learn more about your decision. No faculty who teach you in class are directly involved in this pilot study.

WHOM DO I CALL IF I HAVE QUESTIONS OR PROBLEMS?

The person in charge of this study is Prof. Patricia A. Cassano at Cornell University. Prof. Cassano leads the EnHANCE research team.
For questions about the study or a research-related injury, contact Prof. Cassano at *607-255-7551* OR *PAC6@CORNELL.EDU* OR *ENHANCE@CORNELL.EDU*.
Alternatively, if you are reading this and have questions after usual business hours, please click the box online that says "I have a question that's not answered here" and you will be prompted to send a message directly to the researchers with the option to provide your phone number to have the researchers call you back to answer your questions.

Additionally, if you have any questions or concerns regarding your rights as a subject in this study, you may contact the *Institutional Review Board (IRB)* at *607-255-5138* or access their website at http://www.irb.cornell.edu. You may also report your concerns or complaints anonymously through Ethicspoint (www.hotline.cornell.edu) or by calling toll free at *1-866-293-3077*. Ethicspoint is an independent organization that serves as a liaison between the University and the person bringing the complaint so that anonymity can be ensured.

WHERE CAN I GET MORE INFORMATION?

Please visit the following website for more information about the study, and for links to more general websites that provide information about the college experience and wellness.

www.enhance.nutrition.cornell.edu

You will get a copy of this form via email for your records.

SIGNATURE

You are deciding whether or not to take part in the EnHANCE study. By clicking 'accept', it means that you have decided to volunteer to take part in this study, you have read and understood all of the information on this form, and you are 18 years of age or older. Feel free to ask any questions you have about the study before signing. If you have questions, please use the contact information above to have your questions addressed.

Participant Name _____Date _____

BIOSPECIMEN CONSENT FORM

Cornell University
Division of Nutritional Sciences

Consent Form for Use of Specimens Collected by the EnHANCE Pilot Study For Future Research

We are asking you about the future use of your specimens in research studies. This form is designed to give you information about this topic. We will review this information with you and answer any of your questions.

Project Title: "Engaging Health, Agriculture and Nutrition through the Cornell Experience (**EnHANCE**) Pilot Study"

Principal Investigator: Professor Patricia A. Cassano
Division of Nutritional Sciences
Phone: 607-255-7551; email pac6@cornell.edu or enhance@cornell.edu

About Using Specimens for Research

You have been asked to allow a sample of your blood and saliva to be collected and then sent to a research laboratory for testing for the EnHANCE pilot study. The laboratory will measure blood markers for use in the EnHANCE study, and although a few of these markers are also measured by physicians, the investigators in this study are not physicians and we will not be giving you any clinical interpretation of the laboratory measurements on your sample. Thus, we will not report any information about your individual blood sample back to you. You already signed the web-based consent form for the EnHANCE study, and by signing you consented to the use of your sample by the EnHANCE study. If at any time you change your mind about this, please follow instructions below to contact the study.

This consent form asks about the use of your specimens for future research. We would like to keep some of the blood specimens for future research studies; in many research projects, while we have a clear idea of things we wish to measure now, new findings that are published by other researchers may suggest new markers that would be measured in future studies. If you agree, we will keep your specimens for use in future

research to learn more about metabolism, obesity, diabetes and other diseases. We will not collect any new specimens for this purpose, we are only asking about keeping unused materials for future research. The specific details about future uses are unknown at the current time. Below, we ask you a series of questions about the use of your specimens in future research studies.

Please read the question and answer sheet (attached) titled "How are Specimens Used for Research" to learn more. Research using your specimens will not help you directly. We will not put results of this research into your health records or give them to you or your doctor. But, research using your specimens may help identify strategies for disease prevention, and this information may ultimately contribute to optimizing health in the college years and beyond.

Things to Think About

By signing the web-based consent form for the EnHANCE study, you consented to the use of your sample by the EnHANCE study. If at any time you change your mind about this, please follow instructions below to contact the study. Now, we are asking you to decide whether or not we can use your specimens for future research. You may choose not to donate specimens for future research, while still participating in the EnHANCE study; there is no penalty to you if you do not wish your sample to be used in future studies. In that case, we will use your specimen for the EnHANCE study, but not for any future studies.

Also, if you decide that your specimens can be kept for research, you may change your mind at any time. Just contact us (instructions below) and let us know, and your specimens will no longer be used for future research.

The EnHANCE researchers will control all storage of samples, and will set up a process to review any proposed research projects that would use stored samples; in all future uses of your samples the research will only be allowed if it complies with all confidentiality requirements. In the future, researchers using your samples may need to know more about other data that we collected about your health. When we share these data, we will not provide any identifying information, such as your

name, address, or phone number. Only unique study ID numbers will be used, and these will not be traceable to your name or other individually identifiable information. Thus, complete confidentiality will be assured at all times.

Sometimes specimens are used for genetic research (research about diseases that are passed on in families). No results from genetic research will be put in your health records.

Your specimens will be used only for research and will not be sold. You may not request access to your sample in the future because your sample will not be linked to any identifying information. At this time, we do not have a time limit on storage of samples; freezers are able to preserve samples for future uses without degradation. The research done with your specimens may help to prevent diseases in the future.

Benefits
Research using stored specimens may help us learn about how to prevent or treat diabetes or other diseases.

Risks
There are few risks to you by allowing us to use your stored specimens. The only risk is that somehow identifying information will be given to someone else is extremely low, and this the risk is negligible. The EnHANCE research staff are committed to protect your records so that any identifying information, such as your name or email address, will be kept completely confidential at all times.

Please read each sentence below and think about your choice. After reading each sentence, check
"Yes" or "No."

---

1. My specimens may be kept for use in research to learn about, prevent, treat, or cure chronic diseases.
Yes ___No ___

2. My specimens may be kept for investigations to address other research questions (for example:
studies on stress or on other social or behavioral research)
Yes ___No ___

3. I permit the investigators of the EnHANCE study to extract RNA and DNA from my specimens to be analyzed for genetic information, understanding that the information will be kept confidential at all times.
Yes ___No ___

4. I permit my genetic/DNA samples and data to be used, for research purposes, by other qualified non-EnHANCE investigators who have met EnHANCE's standards for confidentiality.
Yes ___No ___

5. Someone from the EnHANCE study may contact me in the future to ask me to take part in more research.
Yes ___No ___

What are My Rights, and Who Answers My Questions?

If you have any questions, please let us know by asking during your in-person visit, or by contacting the study leader Professor Patricia A. Cassano at 697-255-7551, pac6@cornell.edu, or enhance@cornell.edu. If you have any questions or concerns regarding your rights as a subject in this study, you may contact the Institutional Review Board (IRB) at 607-255-5138 or access their website at http://www.irb.cornell.edu. You may also report your concerns or complaints anonymously through Ethicspoint (www.hotline.cornell.edu) or by calling toll free at 1-

866-293-3077. Ethicspoint is an independent organization that serves as a liaison between the University and the person bringing the complaint so that anonymity can be ensured.

What Do I Do if I Change My Mind?

If, after signing this form, you later decide to withdraw your specimens from all future use, please send a written withdrawal of consent to the EnHANCE Principal Investigator: Dr. Patricia A. Cassano, 209
Savage Hall, Division of Nutritional Sciences, Cornell University, Ithaca NY 14853.

SIGNATURE

Do you give us permission to use your blood or saliva for future research?
Please indicate if you agree to let us use your blood or tissue samples for future research. The above five questions help us to determine which type of future research is agreeable to you. You do not have to give permission to use your blood or saliva samples for future research to participate in other parts of this study. Please ask questions if you do not understand why we are asking for your permission to use your samples for future research.

I agree to allow use of my blood or tissue sample for future research. *Please check Yes or No.*

☐Yes – Please sign and date: ____

☐No

Supplemental Information About the Use of Specimens in Research

The below set of questions and answers will help you to understand how specimens are used for research.

Where do specimens come from?

A specimen may be from a blood sample or from saliva, or other body materials.

People who are trained to handle specimens and protect donors' rights make sure that the highest standards of quality control are followed by the EnHANCE study staff.

Why do people do research with specimens?

Research with specimens is important because it provides more direct information about changes in the functions in the body that lead to risk of disease. For example, the use of specimens in the EnHANCE study will tell us more about what causes some individuals to experience changes in weight and metabolism. Research using biological specimens can provide important clues about how to prevent, treat and cure diseases.

What type of research will be done with my specimen?

The EnHANCE study will use your specimens to understand whether changes in body composition during the freshman year of college are associated with changes in markers in the blood. Knowing the answer to this question is important because it will help to identify ways to prevent unhealthy weight gain in the first year of college. The future uses of your specimen are unknown at the current time.

Will I find out the results of the research using my specimen?

You will not receive any results for your individual specimen. The strength of the data on specimens is in the collective whole: thus, data on groups of individuals is the focus of the research. In the laboratory, to ensure the confidentiality of your sample, all personal information is removed and there is no way that laboratory workers can link a sample to

an individual. By removing your personal identifying information from the specimen, your privacy is preserved and your personal results will never be reported or linked to your name in any way.

Why do you need information from my health records?

In order to do research with your specimen, researchers also need to know other things about you. (For example: Are you male or female? How old are you? Have you ever smoked?) This helps researchers address questions about the causes of disease in populations. If your specimen is used in future research, other information would be given to the researcher; for example, that information may include your age, sex, race, diagnosis, and medical history.

Will my name be attached to the records that are given to the researcher?

No. Your name, address, phone number and anything else that could identify you will be removed before any data are shared with researchers. The researcher will not know who you are.

How am I protected?

The EnHANCE Study staff at Cornell University is in charge of making sure that information about you is kept confidential. The EnHANCE Study staff at Cornell University will take careful steps to prevent misuse of records. Your name, address, phone number and any other identifying information will never be associated with your specimen—a system of barcodes is used to label all specimens and the barcodes do not contain any information about your name, address, phone number or any other identifying information. Thus, it is essentially impossible for any research results to be linked to you or your family.

What if I have more questions?

If you have any questions or concerns regarding your rights as a subject in this study, you may contact the principal investigator of the study, Prof. Cassano at 607 255 7551 or pac6@cornell.edu or enhance@cornell.edu. You may also contact the Institutional

Review Board (IRB) at 607-255-5138 or access their website at http://www.irb.cornell.edu. You may also report your concerns or complaints anonymously through Ethicspoint (www.hotline.cornell.edu) or by calling toll free at 1-866-293-3077. Ethicspoint is an independent organization that serves as a liaison between Cornell University and the person bringing the complaint so that anonymity can be ensured.

FAMILY EDUCATIONAL RIGHTS AND PRIVACY ACT (FERPA)
CONSENT FORM

Student Consent for Access to Educational Records for Research Purposes

We are asking you to grant consent to use existing Cornell University records about you in the EnHANCE pilot study. This form is designed to give you information about this request to use your records. We will describe the request to you and answer any of your questions.

Project Title: " Engaging Health, Agriculture and nutrition through the Cornell Experience (**EnHANCE**) Pilot Study"

Principal Investigator: Professor Patricia A. Cassano
Division of Nutritional Sciences

Phone: 607--255--7551; email pac6@cornell.edu or enhance@cornell.edu

About Using Records for Research

The Family Educational Rights and Privacy Act (FERPA) assures certain rights to students concerning the privacy of, and access to, their education records. Records already contain information about you that would be of use to the EnHANCE Study. Very often, researchers seek to obtain information from records as a way of avoiding time consuming surveys because the records contain the information that the researchers need for a study.

You may choose to complete and submit this form, which allows the release of your education records as part of your participation in the EnHANCE study. For additional information, visit Cornell University Registrar's FERPA Information page at

http://registrar.sas.cornell.edu/Student/records.html or the U.S. Department of Education's website at www.ed.gov/policy/gen/guid/fpco/ferpa/index.html.

In the EnHANCE study, we wish to use existing University records to obtain information about your on--campus residence (dormitory, number of room--mates), your academic schedule (College, number of credits, GPA), and your purchases (meal plan, dining purchases).

What are My Rights, and Who Answers My Questions?

If you have any questions, please let us know by asking during your in--person visit, or by contacting the study leader Professor Patricia A. Cassano at 697--255--7551, pac6@cornell.edu, or enhance@cornell.edu. If you have any questions or concerns regarding your rights as a subject in this study, you may contact the Institutional Review Board (IRB) at 607--255--5138 or access their website at http://www.irb.cornell.edu. You may also report your concerns or complaints anonymously through Ethicspoint (www.hotline.cornell.edu) or by calling toll free at 1--866--293--3077. Ethicspoint is an independent organization that serves as a liaison between the University and the person bringing the complaint so that anonymity can be ensured.

What Do I Do if I Change My Mind?

If, after signing this form, you later decide to withdraw your consent about the use of your records, please send a written withdrawal of consent to the EnHANCE Principal Investigator: Dr. Patricia A. Cassano, 209 Savage Hall, Division of Nutritional Sciences, Cornell University, Ithaca NY 14853.

SIGNATURE

Do you give us permission to access information about your in existing University Records?

University Records to Be Released for Research Purposes (check all that you agree to release)

☐ **All records listed below**

	Fall 2011		**Spring 2012**
☐	Number of credit hours and other academic information	☐	Number of credit hours and other academic information
☐	On-campus residence information	☐	On-campus residence information
☐	Cornell mean plan selection	☐	Cornell mean plan selection
☐	Cornell ID card purchasing data	☐	Cornell ID card purchasing data
☐	College affiliation	☐	College affiliation

Or,

☐ I do not consent for anyone other than myself (the student) to access any of my Cornell University records listed above unless I give written permission at a later time.

I understand that (1) I have the right not to consent to the release of my education records, (2) I have the right to inspect any written records released pursuant to this Consent, and (3) I have the right to revoke this consent at any time by delivering a written revocation to the University Registrar or Prof. Cassano.

Participant Signature_____Date_____

DXA CONSENT FORM

Cornell University
Division of Nutritional Sciences

Engaging Health, Agriculture and Nutrition
EnHANCE
through the Cornell Experience

Information and Consent Form for Dual Energy X--Ray Absorptiometry (DXA) Scan for the EnHANCE Pilot Study

We are asking you to have a DXA scan for the study. This form is designed to give you information about this topic, and to ask for your consent for this procedure. We will review this information with you and answer any of your questions.

Project Title:"Engaging Health, Agriculture and Nutrition through the Cornell Experience (**EnHANCE**) Pilot Study"

Principal Investigator: Professor Patricia A. Cassano
Division of Nutritional Sciences
Phone: 607--255--7551; email pac6@cornell.edu or enhance@cornell.edu

What do you need to know about DXA scans?

Research conducted in the HMRU occasionally requires that bone density and/or body composition be obtained in human participants via DXA. This DXA scan is conducted in the HMRU DXA Lab which contains a Hologic Discovery--A DXA scanner that is capable of measuring site specific or whole body bone density, vertebral fracture risk and body composition. This unit also has the capacity to scan neonates for bone density and body composition.

DXA is a method used to measure body composition. This procedure uses x--rays that yield precise, high quality images of your body compartments (e.g., fat and muscle tissues) that involves exposure to very low amounts of x--ray radiation. For all radiation sources, the standard measure of radiation dose to our bodies is called the Sievert (Sv) or millisievert (mSv) where 1 Sv is equal to 1000 mSv. Every person is exposed daily to natural background radiation from sources like soil, rocks, radon, and natural radiation

in our bodies, the sun, and outer space. On average, a person in the United States receives about 3 mSv each year from natural background radiation, or about 0.01 mSv per day. When a person receives radiation as part of a research study at Cornell, their extra radiation dose is limited by Cornell to 1 mSv, which is the annual regulatory limit for the general public.

Examples of radiation dosage:

Annual Background Radiation	3 mSv	Mammogram	0.06 mSv
CAT scan	10 mSv	DXA AP spine scan	0.07 mSv
Chest X--ray	0.08 mSv	DXA Whole Body scan	0.01 – 0.04 mSv
Roundtrip Transatlantic Flight	0.08 mSv	DXA Infant Whole Body Scan	0.012 mSv

What are the risks of research radiation?

The amount of radiation exposure received in this study is below the levels that are thought to result in a significant risk of harmful effects. One possible indirect effect is an increase in the risk of cancer. The potential increase in the risk of cancer or potential increased risk of other adverse health consequences, from the low level of radiation used in this study is too small to be estimated accurately. If you have additional questions, please contact the research staff (information below) or Environmental Health & Safety at 607--255--8200 or visit the EH&S web site at http://www.ehs.cornell.edu/.

What is expected of you during the scan?

You must be able to lie still on a padded table and breathe normally for the duration of the scan, which is approximately 6 minutes. The table will move horizontally and vertically during the scan. You will be asked to remove jewelry, body piercings, clothing with zippers or metal buttons, etc. and to put on a gown or other unrestrictive clothing for the scan. You may bring your own unrestrictive clothing with you or if you prefer you can use one of the HMRU gowns.

Before you arrive for your scan at the Human Metabolic Research Unit (HMRU) it's important that you read this document and the attached questionnaire and consent form. The questionnaire and consent form should be completed immediately before your scan. The Consent Form must be signed in the presence of the Principal Investigator.

What kinds of results are available from the DXA scan?

The DXA machine will automatically generate a report of body composition for each scan. The analysis is based on a standard operating procedure for body composition analysis designed by the manufacturer of the DXA scanner. A radiologist does not read research scans, and you are not provided with any of the information from the scan. The scan is for research purposes only and will not be interpreted by a clinician.

What questions do you need to answer in preparation for the DXA scan?

- Pregnancy Testing: If you are a female student you will be asked to take a urine pregnancy test. The DXA technologist must obtain the results of the pregnancy test from you before administering the scan. The test will be performed immediately before your scan. If the test is positive, the DXA technician will not perform the scan.
- Recent Procedures: DXA should not be performed on participants who have had any procedure that included Iodine, Barium or Nuclear Medicine Isotopes within the last 7 days. Please inform us if this is the case.
- Surgery, Prosthetic Devices and Foreign Bodies: Since the body composition assessment involves a scan of the whole body, it is important to disclose any surgeries you may have had since they might impact the results of the DXA scan. For example, it is important to know if you have a prosthetic device, pacemaker leads, radioactive seeds, metal implants, or surgical staples. The same caution is also given to foreign bodies such as shrapnel and radio--opaque catheters or tubes.

Are there any other requirements?

- Calcium Supplements: Calcium supplements should not be taken the day before the exam because they may interfere with the accuracy of the results. Please refrain from taking calcium for 24 – 36 hours before the DXA scan.
- General Requirements for DXA Scans: Physical and hydration factors may affect the results of the scan and therefore, we ask that you ensure that you:
    - are able to lie still on a padded table and breathe normally for approximately 6 minutes;
    - weigh less than 450 pounds (204 kg);
    - wear clothing with no metal and remove all jewelry during the procedure;
    - refrain from heavy exercise 12 hours prior to study;
    - refrain from alcohol, nicotine, or caffeinated beverages 12 hours prior to study;
    - fast for at least 2 hours prior to scan with only light meals in the 10 hours prior to fasting
    - wear no deodorant or talcum powder the day of the exam, or remove it prior to scan. Please make every effort to meet these criteria since they are important for the accuracy of the scan.

Thank you!

Questionnaire and Consent for DXA

Please answer the questions below **just before your scheduled scan**. If you have any questions, please ask the Principal Investigator or the Licensed Radiologic Technologist that will be performing your scan.

Have you had any X--ray procedures within the last 7 days that used (check all rows yes or no):

Iodine		Yes		No
Barium		Yes		No
Nuclear Medicine Isotopes		Yes		No

Do you have any of the following medical devices in your body (check all rows yes or no):

Ostomy Devices		Yes		No
Prosthetic Devices		Yes		No
Surgical Devices		Yes		No
Pacemaker Leads		Yes		No
Radioactive Seeds		Yes		No
Radiopaque Catheters or Tubes		Yes		No

Do you have any of the following foreign objects in your body (check all rows yes or no):

Shrapnel, Buckshot		Yes		No

Metal of any Sort		Yes		No
Other – Please Specify		Yes		No

Have you engaged in any of these activities in the past 12 hours (check all rows yes or no):

Consumed Alcohol, Nicotine, or Caffeinated Beverages		Yes		No
Exercised Heavily		Yes		No
Taken Calcium Supplements		Yes		No

What are My Rights, and Who Answers My Questions?

If you have any questions, please let us know by asking during your in--person visit, or by contacting the study leader Professor Patricia A. Cassano at 697--255--7551, pac6@cornell.edu, or enhance@cornell.edu. If you have any questions or concerns regarding your rights as a subject in this study, you may contact the Institutional Review Board (IRB) at 607--255--5138 or access their website at http://www.irb.cornell.edu. You may also report your concerns or complaints anonymously through Ethicspoint (www.hotline.cornell.edu) or by calling toll free at 1--866--293--3077. Ethicspoint is an independent organization that serves as a liaison between the University and the person bringing the complaint so that anonymity can be ensured.

SIGNATURE

Do you agree to the DXA scan?

I have read the Information Sheet, have been encouraged to ask questions, and have received answers to my questions.

_____ _____

Name Date/Time

Official Use Only:

Weight	
Height	

I hereby certify that I have reviewed the pregnancy test for this patient and the test is negative.

_____ _____

Karla L. Golden
Radiologic
Technologist NYS
License Number
876128

Date/Time

Freshmen Cohort Pilot Study Data Collection Plan

	July/Aug at home (M-1)	Aug (M 0)	Sept (M 1)	Oct (M 2)	Nov (M 3)	Dec (M 4)	Jan (M 5)	Feb (M 6)	Mar (M 7)	Apr (M 8)	May (M 9)	Estimated Time for Data Collection Activities
Personal Information												Web--based, administered through Survey Research Institute (SRI), Cornell Univ.
Medical History/Family History	X										x	5--10 min
Participant Self--Report												web--based, administered through SRI, Cornell Univ.
Usual Dietary Intake (FFQ) (DHQ---- online form, NCI)	X									X		about 1 hour
24--hour Recall (ASA24----online form, NCI)			X	X	X	X	X	X	X	X	X	20--30 minutes
Eating Attitudes (eSatter) Three Factor	X					X					X	5--10 min
Eating Questionnaire Recent Physical	X					X					X	10--15 min
Activity (GPAQ) Lifestyle			X	X	X	X	X	X	X	X	X	GPAQ 10--15 min PPAQ 5 min
	X					X	X			X		15--20 min
Laboratory												Samples collected in--person at Human Metabolic Research Unit, CHE
Blood Collection		X				X	X				X	about 20 minutes/visit for 4 visits about
Saliva Collection		X										10 minutes, once for 100 students
FingerPrick Blood Spot Collection		X										about 2 minutes, once for 100 students
Anthropometry												Measurements made in--person at Human Metabolic Research Unit, CHE
Weight, Height		X				X	X				X	2 min/visit for 4 visits
DXA		X									X	20 min/visit for 2 visits
Waist and Hip Circumferences		X				X	X				X	5 min/visit for 4 visits
University Records												Data abstracted by SRI, Cornell Univ.
Demographic Data	X											
Dormitory Room		X					X					
Style Course		X					X					
Credits College,		X				X	X				X	
Major		X					X				X	
Food purchases with Cornell ID			X	X	X	X	X	X	X	X	X	

SECTION 3: Electronic Data Collection and Questionnaires

- Electronic Data Collection Management by the Survey Research Institute at Cornell University
- Dietary Intake: 24-hr Recall Fact Sheet
- Dietary Intake: Food Frequency Questionnaire
- Physical Activity Questionnaire
- Medical History Questionnaire
- Eating Attitudes Questionnaire
- Lifestyle Questionnaire
- Stress Questionnaire
- Anthropometry and Body Composition Data
- Student Records Data

Electronic Data Collection

Questionnaire data collection is a key component to EnHANCE. All questionnaires will be administered electronically. The Survey Research Institute (SRI) at Cornell University is equipped to administer electronic questionnaires for research purposes and EnHANCE questionnaire data will be collected and managed securely by SRI. Questionnaires allow the study participant to provide information about dietary habits, personal history, attitudes and perceptions and other important information in a standardized manner. To comprehensively evaluate the personal experience of EnHANCE participants, multiple questionnaires will be administered throughout the study.

Electronically Administered Questionnaires:

Dietary Intake

Two dietary intake assessments, developed and disseminated by the National Cancer Institute, will be used in the study, the "Automated Self-Administered 24 hour Dietary Recall", (ASA-24) which assesses dietary intake during one day, and the "Dietary History Questionnaire" (DHQ), which is a food frequency questionnaire assessing usual patterns of dietary intake over the past twelve month period. The ASA24 is a simple tool assessing food consumed over a 24 hour period, and takes about 20-30 minutes to complete. The DHQ comprises 134 food items and

8 dietary supplement questions and takes less than one hour to complete (exact time estimates for the online version are not published by NCI, but times sorter than one hour are expected especially in a highly computer literate population subgroup). Both questionnaires are administered through a web-based interface hosted by the National Cancer Institute, and using assigned study id numbers (no identifying information), participants will log into the EnHANCE Pilot study area on the NCI site to complete these questionnaires online. The timetable attached as an appendix to this application shows the questionnaires administered at each time point.

The following ASA24 Fact Sheet ASA-24 Fact Sheet was authored and published by the Division of Cancer Control and Population Sciences, National Cancer Institute (available online: http://riskfactor.cancer.gov/tools/instruments/asa24.htm)

Automated Self-Administered 24-Hour Dietary Recall (ASA24)

Applied Research Program

Background

Self-reported dietary assessment methods are commonly used to measure food intakes for dietary surveillance, nutritional epidemiology, clinical research, and intervention research.
Different methods have been used for different purposes, and each has advantages and disadvantages. For example:

1) **Dietary food records** (also called **diaries**) have been used to collect food intake data in real time, but they require highly motivated and literate respondents and are prone to biases attributable to respondents changing their diets on recording days. Documenting intake of all food items often leads to underreporting and/or undereating. If not automated, this method requires labor-intensive, expensive, and unstandardized data entry and coding.

2) The **food frequency questionnaire (FFQ)** is commonly used in large-scale epidemiologic research. It asks respondents about their intake frequency and portion size for a long list of food items. Self-administered by paper and pencil and scanned or administered electronically so that data are easily coded and analyzed, the FFQ's appeal is that it seeks to provide information on typical intake and can be administered quickly and cheaply. Its disadvantages are significant measurement error and bias for some nutrients, lack of comparability across studies using different instruments, and poor detail with respect to exactly what was consumed, preparation methods, and portion sizes.

2) The **interviewer-administered 24-hour recall** has long been regarded as the optimal dietary assessment method because it provides the highest-quality and least biased data for a single day. It allows detailed food and portion size information to be collected, and because the data are collected after consumption, this method does not affect a respondent's food choices on a given day. Data are relatively comparable across studies because the query format is open-ended. However, recalls have limitations related to memory and bias, and assessing usual intakes requires at least two administrations with statistical modeling. Because the recalls have always been administered by trained professionals, they are considered costly and impractical in research settings with large sample sizes and/or a need to collect data for multiple days.

The Automated Self-Administered 24-Hour Dietary Recall (ASA24)

The ASA24 system is a web-based software tool that enables automated and self-administered 24-hour dietary recalls.

The ASA24 can be used by researchers for epidemiologic, intervention, behavioral, or clinical research. Clinicians may also find it useful for diet assessment and nutrition counseling, and educators may find it to be a useful teaching tool.

The ASA24 consists of a Respondent application used by participants to enter recall data and a Researcher application used by researchers to manage study logistics and obtain data analyses.

The format and design of the Respondent application are modeled on the interviewer-administered Automated Multiple Pass Method (AMPM) 24-hour recall developed by the US Department of Agriculture (USDA). The AMPM uses multi-level food probes to accurately assess food types and amounts.

The Researcher application allows researchers, clinicians and teachers to register to use ASA24, obtain usernames and passwords used by participants to access the Respondent application, set parameters (e.g., number of recalls to be completed), monitor participant progress, and obtain nutrient and food group analyses. Beta versions of both applications are now available.

Features of ASA24

The Beta version of ASA24 uses state-of-the- art automated computer technology, including graphic enhancements, animated guide characters, and audio language/cues to enhance use in low-literacy populations.
Respondents select their intakes for the previous day from a food list that includes all foods available from the USDA's Food and Nutrient Database for Dietary Studies (FNDDS). Resulting data files include nutrients, foods, MyPyramid food groups, and variables to calculate Healthy Eating Index scores.

The software shows multiple portion sizes of foods to help respondents estimate portion size. It can quickly compute nutrient and food group estimates for each recall day.

ASA24 allows respondents to: access tutorials and help;

find foods to report by browsing through food groups or by typing and searching;

move or copy a food to a different meal;

edit a meal, increase reported food amounts, or correct double reports of a food; and

review a final list of the day's intake and a list of frequently forgotten foods, with options for the respondent to modify his/her food list.

The ASA24 does not provide automatic feedback to users; rather, researchers can obtain data files and contact users with any findings they choose to share.

Further Development of ASA24

A new graphical user interface for the respondent application is under development and is expected to be available in the summer of 2011. New features and functionality will include:

a new tutorial and help system, a supplement module,

a Spanish language version, and

an updated underlying database using version 4.0 of FNDDS and the most current version of the AMPM.

Evaluation of ASA24

The ASA24 underwent numerous small-scale cognitive and usability tests during development. Two larger validation studies will be undertaken in the fall of 2011.

In a large study of healthy, geographically diverse individuals, the nutrient/food group values of respondents completing ASA24 will be compared to those completing a standardized AMPM interviewer-administered 24HR recall.

In a smaller study, investigators will unobtrusively document food intakes as an objective measure of food intake for participants completing the ASA24 or a standard interviewer- administered recall. Analyses will assess differences in validity between the two types of recalls.

Accessing ASA24

Researchers, clinicians, and teachers can register to use the Beta version of ASA24 in a study, clinic, or classroom by visiting the Researcher site at https://asa24beta.westat.com/ResearcherSite.html. A demonstration version of the respondent application is also available at https://asa24.westat.com/index.htm. The demonstration version allows interested users to enter recall data using the automated system, but will not save any information or provide any dietary analyses.

For Further Information

ASA24 Respondent Site:
Amy Subar, PhD
Applied Research Program, DCCPS, NCI 6130 Executive Boulevard, EPN 4012
Bethesda, MD 20892-7344

Telephone: 301-594-0831
E-mail: subara@mail.nih.gov

ASA24 Researcher Site:
Sharon Kirkpatrick, PhD
Applied Research Program, DCCPS, NCI 6130 Executive Boulevard, EPN 4005
Bethesda, MD 20892-7344
Telephone: 301-435-1638
E-mail: kirkpatricksi@mail.nih.gov

For additional information and to view answers to frequently asked questions about ASA24, visit http://riskfactor.cancer.gov/tools/instruments/asa 24.htm

November 2010

Diet History Questionnaire II Food Frequency Questionnaire

The DHQ II was administered in the EnHANCE Study electronically; the first three pages of the paper version of the DHQ II, shown here, provide representation of the administered questionnaire assessing usual dietary intake.

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

NATIONAL INSTITUTES OF HEALTH

Diet History Questionnaire II

GENERAL INSTRUCTIONS

- Answer each question as best you can. Estimate if you are not sure. A guess is better than leaving a blank.
- Use only a black ball-point pen. Do not use a pencil or felt-tip pen. Do not fold, staple, or tear the pages.
- Put an X in the box next to your answer.
- If you make any changes, cross out the incorrect answer and put an X in the box next to the correct answer. Also draw a circle around the correct answer.
- If you mark NEVER, NO, or DON'T KNOW for a question, please follow any arrows or instructions that direct you to the next question.

BEFORE TURNING THE PAGE, PLEASE COMPLETE THE FOLLOWING QUESTIONS.

Today's date:

MONTH	DAY		YEAR
☐ Jan	___ ___		☐ 2010
☐ Feb	☐0	☐0	☐ 2011
☐ Mar	☐1	☐1	☐ 2012
☐ Apr	☐2	☐2	☐ 2013
☐ May	☐3	☐3	☐ 2014
☐ Jun		☐4	☐ 2015
☐ Jul		☐5	☐ 2016
☐ Aug		☐6	☐ 2017
☐ Sep		☐7	☐ 2018
☐ Oct		☐8	☐ 2019
☐ Nov		☐9	☐ 2020
☐ Dec			

DHQ II PastYear

In what month were you born?

☐ Jan
☐ Feb
☐ Mar
☐ Apr
☐ May
☐ Jun
☐ Jul
☐ Aug
☐ Sep
☐ Oct
☐ Nov
☐ Dec

In what year were you born?

19 ___ ___

☐0	☐0
☐1	☐1
☐2	☐2
☐3	☐3
☐4	☐4
☐5	☐5
☐6	☐6
☐7	☐7
☐8	☐8
☐9	☐9

Are you male or female?

☐Male
☐Female

BAR CODE LABEL OR SUBJECT ID HERE

___ ___ ___ ___ ___ ___ ___ ___

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

1. Over the past 12 months, how often did you drink **carrot juice**?

- ☐ NEVER (GO TO QUESTION 2)
- ☐ 1 time per month or less
- ☐ 2–3 times per month
- ☐ 1–2 times per week
- ☐ 3–4 times per week
- ☐ 5–6 times per week
- ☐ 1 time per day
- ☐ 2–3 times per day
- ☐ 4–5 times per day
- ☐ 6 or more times per day

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

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

2. Over the past 12 months, how often did you drink **tomato juice** or **other vegetable juice**? *(Please do not include carrot juice.)*

- ☐ NEVER (GO TO QUESTION 3)
- ☐ 1 time per month or less
- ☐ 2–3 times per month
- ☐ 1–2 times per week
- ☐ 3–4 times per week
- ☐ 5–6 times per week
- ☐ 1 time per day
- ☐ 2–3 times per day
- ☐ 4–5 times per day
- ☐ 6 or more times per day

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

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

3. Over the past 12 months, how often did you drink **orange juice** or **grapefruit juice?**

- ☐ NEVER (GO TO QUESTION 4)
- ☐ 1 time per month or less
- ☐ 2–3 times per month
- ☐ 1–2 times per week
- ☐ 3–4 times per week
- ☐ 5–6 times per week
- ☐ 1 time per day
- ☐ 2–3 times per day
- ☐ 4–5 times per day
- ☐ 6 or more times per day

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

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

Question 4 appears in the next column

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

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

4. Over the past 12 months, how often did you drink **other 100% fruit juice** or **100% fruit juice mixtures** (such as apple, grape, pineapple, or others)?

- ☐ NEVER (GO TO QUESTION 5)
- ☐ 1 time per month or less
- ☐ 2–3 times per month
- ☐ 1–2 times per week
- ☐ 3–4 times per week
- ☐ 5–6 times per week
- ☐ 1 time per day
- ☐ 2–3 times per day
- ☐ 4–5 times per day
- ☐ 6 or more times per day

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

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

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

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

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

- ☐ NEVER (GO TO QUESTION 6)
- ☐ 1 time per month or less
- ☐ 2–3 times per month
- ☐ 1–2 times per week
- ☐ 3–4 times per week
- ☐ 5–6 times per week
- ☐ 1 time per day
- ☐ 2–3 times per day
- ☐ 4–5 times per day
- ☐ 6 or more times per day

Question 6 appears on the next page

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

Over the <u>past 12 months</u>...

5a. Each time you drank **fruit drinks**, how much did you usually drink?

- ☐ Less than 1 cup (8 ounces)
- ☐ 1 to 2 cups (8 to 16 ounces)
- ☐ More than 2 cups (16 ounces)

5b. How often were your fruit drinks **diet** or **sugar-free**?

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

6. How often did you drink **milk as a beverage** (NOT in coffee, NOT in cereal)? *(Please do not include chocolate milk and hot chocolate.)*

- ☐ NEVER (GO TO QUESTION 7)
- ☐ 1 time per month or less
- ☐ 2–3 times per month
- ☐ 1–2 times per week
- ☐ 3–4 times per week
- ☐ 5–6 times per week
- ☐ 1 time per day
- ☐ 2–3 times per day
- ☐ 4–5 times per day
- ☐ 6 or more times per day

6a. Each time you drank **milk as a beverage**, how much did you usually drink?

- ☐ Less than 1 cup (8 ounces)
- ☐ 1 to 1½ cups (8 to 12 ounces)
- ☐ More than 1½ cups (12 ounces)

6b. What kind of **milk** did you usually drink?

- ☐ Whole milk
- ☐ 2% fat milk
- ☐ 1 % fat milk
- ☐ Skim, nonfat, or ½% fat milk
- ☐ Soy milk
- ☐ Rice milk
- ☐ Other

7. How often did you drink **chocolate milk** (including hot chocolate)?

- ☐ NEVER (GO TO QUESTION 8)
- ☐ 1 time per month or less
- ☐ 2–3 times per month
- ☐ 1–2 times per week
- ☐ 3–4 times per week
- ☐ 5–6 times per week
- ☐ 1 time per day
- ☐ 2–3 times per day
- ☐ 4–5 times per day
- ☐ 6 or more times per day

Question 8 appears in the next column

7a. Each time you drank **chocolate milk**, how much did you usually drink?

- ☐ Less than 1 cup (8 ounces)
- ☐ 1 to 1½ cups (8 to 12 ounces)
- ☐ More than 1½ cups (12 ounces)

7b. How often was the chocolate milk **reduced-fat** or **fat-free**?

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

8. How often did you drink **meal replacement** or **high-protein beverages** (such as Instant Breakfast, Ensure, Slimfast, Sustacal or others)?

- ☐ NEVER (GO TO QUESTION 9)
- ☐ 1 time per month or less
- ☐ 2–3 times per month
- ☐ 1–2 times per week
- ☐ 3–4 times per week
- ☐ 5–6 times per week
- ☐ 1 time per day
- ☐ 2–3 times per day
- ☐ 4–5 times per day
- ☐ 6 or more times per day

8a. Each time you drank **meal replacement** or **high-protein beverages**, how much did you usually drink?

- ☐ Less than 1 cup (8 ounces)
- ☐ 1 to 1½ cups (8 to 12 ounces)
- ☐ More than 1½ cups (12 ounces)

9. Over the <u>past 12 months</u>, did you drink **soda** or **pop**?

- ☐ NO (GO TO QUESTION 10)
- ☐ YES

9a. How often did you drink **soda** or **pop IN THE SUMMER**?

- ☐ NEVER
- ☐ 1 time per month or less
- ☐ 2–3 times per month
- ☐ 1–2 times per week
- ☐ 3–4 times per week
- ☐ 5–6 times per week
- ☐ 1 time per day
- ☐ 2–3 times per day
- ☐ 4–5 times per day
- ☐ 6 or more times per day

Question 10 appears on the next page

Global Physical Activity Questionnaire

Physical activity will be assessed by the "Global Physical Activity Questionnaire" (GPAQ), which will be digitized and administered through the web-based interface managed by SRI. The GPQA comprises 16 questions about physical activity at work (relevant for student jobs), travel to and from places, recreational activities and sedentary behavior; the questionnaire is completed in about ten minutes. This questionnaire is supplemented by a short inventory of physical activity, comprised of seven question, developed for the College Alumnus Study by R. Paffenbarger; this questionnaire takes about ten minutes to complete, and is considered to be a better method for assessing regular activity in sports and exercise-related activity in comparison to the GPAQ. A recent NIH-funded program project grant assessing the best physical activity questionnaires for use in young to middle aged adults identified the combination of the GPAQ and the Paffenbarger as the best choice for high validity and reliability (C. Olson, DNS, personal communication). The two questionnaires take about
10 minutes to complete.

Global Physical Activity Questionnaire
(GPAQ)

Analysis Guide

Surveillance and Population-Based Prevention
Department of Chronic Diseases and Health Promotion
World Health Organization
20 Avenue Appia, 1211 Geneva 27, Switzerland
For further information: www.who.int/chp/steps

Global Physical Activity Questionnaire (GPAQ) Analysis Guide

Table of contents

1 Overview

Introduction

The Global Physical Activity Questionnaire was developed by WHO for physical activity surveillance in countries. It collects information on physical activity participation in three settings (or domains) as well as sedentary behaviour, comprising 16 questions (P1-P16). The domains are:

- Activity at work
- Travel to and from places
- Recreational activities

Using GPAQ

Prior to using GPAQ, you should review the question by question section. This section, which follows the actual questions, will guide the interviewer in asking the questions and recording responses.

When using GPAQ, all the questions must be asked. Skips of questions do ONLY apply to the corresponding day and time variables if P1, P4, P7, P10, or P13 have been answered negatively. Skipping any other questions or removing any of the domains will restrict the results that you will be able to calculate.

GPAQ version 1 and 2

This document provides information on version 2 of GPAQ. It is advised that you use version 2 of GPAQ.
If you have already used GPAQ version 1 and need advise on analysing this information, please refer to GPAQ version 1 section of this document (p. 9).

Calculating and cleaning physical activity data

This document includes information on how to clean and analyse GPAQ data in general as well as specifically with the statistical package EpiInfo.

The coding column of GPAQ version 2 is used as a reference for all the calculations. If you insert this questionnaire into another questionnaire, you may change the question numbers, but do not change the coding column.

Metabolic Equivalent (MET)

METs (Metabolic Equivalents) are commonly used to express the intensity of physical activities, and are also used for the analysis of GPAQ data.

MET is the ratio of a person's working metabolic rate relative to the resting metabolic rate. One MET is defined as the energy cost of sitting quietly, and is equivalent to a caloric consumption of 1 kcal/kg/hour. For the analysis of GPAQ data, existing guidelines have been adopted: It is estimated that, compared to sitting quietly, a person's caloric consumption is four times as high when being moderately active, and eight times as high when being vigorously active.

Therefore, when calculating a person's overall energy expenditure using GPAQ data, 4 METs get assigned to the time spent in moderate activities, and 8 METs to the time spent in vigorous activities.

2 GPAQ version 2

Physical Activity

Next I am going to ask you about the time you spend doing different types of physical activity in a typical week. Please answer these questions even if you do not consider yourself to be a physically active person.

Think first about the time you spend doing work. Think of work as the things that you have to do such as paid or unpaid work, study/training, household chores, harvesting food/crops, fishing or hunting for food, seeking employment. *[Insert other examples if needed].* In answering the following questions 'vigorous-intensity activities' are activities that require hard physical effort and cause large increases in breathing or heart rate, 'moderate-intensity activities' are activities that require moderate physical effort and cause small increases in breathing or heart rate.

	Questions	Response	Code
Activity at work			
1	Does your work involve vigorous-intensity activity that causes large increases in breathing or heart rate like *[carrying or lifting heavy loads, digging or construction work]* for at least 10 minutes continuously? *[INSERT EXAMPLES] (USE SHOWCARD)*	Yes 1 No 2 *If No, go to P 4*	P1
2	In a typical week, on how many days do you do vigorous-intensity activities as part of your work?	Number of days ⌊_⌋	P2
3	How much time do you spend doing vigorous-intensity activities at work on a typical day?	Hours : minutes ⌊_⌋⌊_⌋ : ⌊_⌋⌊_⌋ hrs mins	P3 (a-b)
4	Does your work involve moderate-intensity activity that causes small increases in breathing or heart rate such as brisk walking *[or carrying light loads]* for at least 10 minutes continuously? *[INSERT EXAMPLES] (USE SHOWCARD)*	Yes 1 No 2 *If No, go to P 7*	P4
5	In a typical week, on how many days do you do moderate-intensity activities as part of your work?	Number of days ⌊_⌋	P5
6	How much time do you spend doing moderate-intensity activities at work on a typical day?	Hours : minutes ⌊_⌋⌊_⌋ : ⌊_⌋⌊_⌋ hrs mins	P6 (a-b)
Travel to and from places			
The next questions exclude the physical activities at work that you have already mentioned. Now I would like to ask you about the usual way you travel to and from places. For example to work, for shopping, to market, to place of worship. [insert other examples if needed]			
7	Do you walk or use a bicycle (*pedal cycle*) for at least 10 minutes continuously to get to and from places?	Yes 1 No 2 *If No, go to P 10*	P7
8	In a typical week, on how many days do you walk or bicycle for at least 10 minutes continuously to get to and from places?	Number of days ⌊_⌋	P8
9	How much time do you spend walking or bicycling for travel on a typical day?	Hours : minutes ⌊_⌋⌊_⌋ : ⌊_⌋⌊_⌋ hrs mins	P9 (a-b)
Recreational activities			
The next questions exclude the work and transport activities that you have already mentioned. Now I would like to ask you about sports, fitness and recreational activities (leisure), [insert relevant terms].			
10	Do you do any vigorous-intensity sports, fitness or recreational (*leisure*) activities that cause large increases in breathing or heart rate like [*running or football,*] for at least 10 minutes continuously? *[INSERT EXAMPLES] (USE SHOWCARD)*	Yes 1 No 2 *If No, go to P 13*	P10
11	In a typical week, on how many days do you do vigorous-intensity sports, fitness or recreational (*leisure*) activities?	Number of days ⌊_⌋	P11
12	How much time do you spend doing vigorous-intensity sports, fitness or recreational activities on a typical day?	Hours : minutes ⌊_⌋⌊_⌋ : ⌊_⌋⌊_⌋ hrs mins	P12 (a-b)

Continued on next page

2 GPAQ version 2, Continued

Physical Activity (recreational activities) contd.			
Questions		**Response**	**Code**
13	Do you do any moderate-intensity sports, fitness or recreational (*leisure*) activities that causes a small increase in breathing or heart rate such as brisk walking,(*cycling, swimming, volleyball*)for at least 10 minutes continuously? *[INSERT EXAMPLES] (USE SHOWCARD)*	Yes 1 No 2 *If No, go to P16*	P13
14	In a typical week, on how many days do you do moderate-intensity sports, fitness or recreational (*leisure*) activities?	Number of days ⌊_⌋	P14
15	How much time do you spend doing moderate-intensity sports, fitness or recreational (*leisure*) activities on a typical day?	Hours : minutes ⌊_⌋⌊_⌋ : ⌊_⌋⌊_⌋ hrs mins	P15 (a-b)
Sedentary behaviour			
The following question is about sitting or reclining at work, at home, getting to and from places, or with friends including time spent [sitting at a desk, sitting with friends, travelling in car, bus, train, reading, playing cards or watching television], but do not include time spent sleeping. *[INSERT EXAMPLES] (USE SHOWCARD)*			
16	How much time do you usually spend sitting or reclining on a typical day?	Hours : minutes ⌊_⌋⌊_⌋ : ⌊_⌋⌊_⌋ hrs min s	P16 (a-b)

3 GPAQ Question by Question Guide

CORE: Physical Activity			
Next I am going to ask you about the time you spend doing different types of physical activity in a typical week. Please answer these questions even if you do not consider yourself to be a physically active person. There are various domains of activity which need to be included; work, activities in and around the home and garden, to get from place-to-place (transport-related) and recreation (discretionary or leisure-time) exercise or sports activities. This opening statement **should not** be omitted. *The respondent will have to think first about the time she/he spends doing work. Work includes things that he/she has to do such as paid or unpaid work, household chores, harvesting food, fishing or hunting for food, seeking employment. [Insert other examples if needed]* *In answering the following questions 'vigorous-intensity activities' are activities that require hard physical effort and cause large increases in breathing or heart rate, 'moderate-intensity activities' are activities that require moderate physical effort and cause small increases in breathing or heart rate.*			
Questions		**Response**	**Code**
Activity at work			
1	Does your work involve vigorous-intensity activity that causes large increases in breathing or heart rate like *[carrying or lifting heavy loads, digging or construction work]* for at least 10 minutes continuously? *Activities are regarded as vigorous intensity if they cause a large increase in breathing and/or heart rate.* *[INSERT EXAMPLES] (USE SHOWCARD)*	Yes 1 No 2 *If No, go to P 4*	P1
2	In a typical week, on how many days do you do vigorous-intensity activities as part of your work? *"Typical week" means a week when a person is doing vigorous intensity activities and not an average over a period* *Valid responses range from 1-7.*	Number of days ⌊_⌋	P2
3	How much time do you spend doing vigorous-intensity activities at work on a typical day? *Think of one day you can recall easily. Consider only those activities undertaken continuously for 10 minutes or more. Probe very high responses (over 4 hrs) to verify*	Hours : minutes ⌊_⌋⌊_⌋ : ⌊_⌋⌊_⌋ hrs mins	P3 (a-b)
4	Does your work involve moderate-intensity activity, that causes small increases in breathing or heart rate such as brisk walking *[or carrying light loads]* for at least 10 minutes continuously? *Activities are regarded as moderate intensity if they cause a small increase in breathing and/or heart rate.* *[INSERT EXAMPLES] (USE SHOWCARD)*	Yes 1 No 2 *If No, go to P 7*	P4
5	In a typical week, on how many days do you do moderate-intensity activities as part of your work? *Valid responses range from 1-7*	Number of days ⌊_⌋	P5
6	How much time do you spend doing moderate-intensity activities at work on a typical day? *Think of one day you can recall easily. Consider only those activities undertaken continuously for 10 minutes or more. Probe very high responses (over 4 hrs) to verify*	Hours : minutes ⌊_⌋⌊_⌋ : ⌊_⌋⌊_⌋ hrs mins	P6 (a-b)
Travel to and from places			
The next questions exclude the physical activities at work that you have already mentioned. Now I would like to ask you about the usual way you travel to and from places. For example to work, for shopping, to market, to place of worship. [insert other examples if needed] *The introductory statement to the following questions on transport-related physical activity is very important. It asks and helps the participant to now think about how they travel around getting from place-to-place. This statement **should not** be omitted.*			
7	Do you walk or use a bicycle (*pedal cycle*) for at least 10 minutes continuously to get to and from places? *Circle the appropriate response*	Yes 1 No 2 *If No, go to P 10*	P7
8	In a typical week, on how many days do you walk or bicycle for at least 10 minutes continuously to get to and from places? *Valid responses range from 1-7*	Number of days ⌊_⌋	P8

Continued on next page

3 GPAQ Question by Question Guide, Continued

9	How much time do you spend walking or bicycling for travel on a typical day? *Think of one day you can recall easily. Consider the total amount of time walking or bicycling for trips of 10 minutes or more. Probe very high responses (over 4 hrs) to verify.*	Hours : minutes ⌊_⌊_⌋ : ⌊_⌊_⌋ hrs mins	P9 (a-b)
Recreational activities			
The next questions exclude the work and transport activities that you have already mentioned. Now I would like to ask you about sports, fitness and recreational activities (leisure),[insert relevant terms]. *This introductory statement directs the participant to think about recreational activities. This can also be called discretionary or leisure time. It includes sports and exercise but is not limited to participation competitions. Activities reported should be done regularly and not just occasionally. It is important to focus on only recreational activities and not to include any activities already mentioned. This statement* ***should not*** *be omitted.*			
10	Do you do any vigorous-intensity sports, fitness or recreational (*leisure*) activities that cause large increases in breathing or heart rate like [*running or football,*] for at least 10 minutes continuously? *[INSERT EXAMPLES] (USE SHOWCARD)* ? *Activities are regarded as vigorous intensity if they cause a large increase in breathing and/or heart rate.*	Yes 1 No 2 *If No, go to P 13*	P10
11	In a typical week, on how many days do you do vigorous-intensity sports, fitness or recreational (*leisure*) activities? *Valid responses range from 1-7*	Number of days ⌊_⌋	P11
12	How much time do you spend doing vigorous-intensity sports, fitness or recreational activities on a typical day? *Think of one day you can recall easily. Consider the total amount of time doing vigorous recreational activities for periods of 10 minutes or more. Probe very high responses (over 4 hrs).*	Hours : minutes ⌊_⌊_⌋ : ⌊_⌊_⌋ hrs mins	P12 (a-b)
13	Do you do any moderate-intensity sports, fitness or recreational (*leisure*) activities that causes a small increase in breathing or heart rate such as brisk walking,(*cycling, swimming, volleyball*)for at least 10 minutes continuously? *Activities are regarded as moderate intensity if they cause a small increase in breathing and/or heart rate.* *[INSERT EXAMPLES] (USE SHOWCARD)*	Yes 1 No 2 *If No, go to P16*	P13
14	In a typical week, on how many days do you do moderate-intensity sports, fitness or recreational (*leisure*) activities? *Valid responses range from 1-7*	Number of days ⌊_⌋	P14
15	How much time do you spend doing moderate-intensity sports, fitness or recreational (*leisure*) activities on a typical day? *Think of one day you can recall easily. Consider the total amount of time doing moderate recreational activities for periods of 10 minutes or more. Probe very high responses (over 4 hrs).*	Hours : minutes ⌊_⌊_⌋ : ⌊_⌊_⌋ hrs mins	P15 (a-b)
Sedentary behaviour			
The following question is about sitting or reclining at work, at home, getting to and from places, or with friends including time spent [sitting at a desk, sitting with friends, travelling in car, bus, train, reading, playing cards or watching television], but do not include time spent sleeping. *[INSERT EXAMPLES] (USE SHOWCARD)*			
16	How much time do you usually spend sitting or reclining on a typical day? *Consider total time spent at work sitting, in an office, reading, watching television, using a computer, doing hand craft like knitting, resting etc. Do not include time spent sleeping.*	Hours : minutes ⌊_⌊_⌋ : ⌊_⌊_⌋ hrs min s	P16 (a-b)

4 Cleaning GPAQ data

Introduction

It is important to standardize the way in which the data collected are cleaned and analysed. Please use the guidelines below when cleaning and analysing your data.
The cleaning and analysis guidelines use the coding column in the questionnaire as an identifier.

Cleaning

You should clean all domains as a combined set. While some of the calculations of results use all the domains and others use only one of the domains, it is necessary that each respondent has an overall "clean" response to all physical activity questions. To be included in the analyses, each participant must have a valid response for at least one domain and have no invalid responses for any domains.

Check for the following for all the domains.

If…	Then…
Values in the hours column are 15, 30, 45, or 60	move them into the corresponding minutes variable, if the corresponding minutes variable is empty or zero (most likely a data recording error).
Maximum values: If for at least one "sub-domain" (vigorous work, moderate work, transport, vigorous recreation, or moderate recreation activity) the value of hours+minutes >16 hours	remove the case from all analyses.
If a respondent reports implausible values (eg., >7 days in any days column)	remove the case from all analyses.
If a respondent has inconsistent answers (eg., 0 days, but values >0 in the corresponding time variables)	remove the case from all analyses.
If one whole "sub-domain" (vigorous work, moderate work, transport, vigorous recreation, or moderate recreation activity) has missing values, but the other "sub-domains" are valid	include the case in the analysis, assuming no activity (0 days, 0 time) for this "sub-domain". That means that, as long as at least one "sub-domain" has valid answers, and all others are missing, this person will be included in analyses.

Notes

Overall, this cleaning method should result in the same denominator across all domains and all analyses.

For information on how to create P3, P6, P9, P12, and P15 see the Cleaning GPAQ with EpiInfo section at the end of this document (p. 12).

Continued on next page

Detailed cleaning instructions	There are detailed cleaning instructions on how to clean each variable in the Cleaning GPAQ with EpiInfo section of this document (p. 12). This section includes details on how to clean the variables and the associated EpiInfo code.

5 Cleaning data derived from GPAQ version 1

Introduction

GPAQ 1 is the first version of the Global Physical Activity Questionnaire. A reliability and validity study was conducted on GPAQ 1. The questionnaire was modified according to the results of this study, and resulted in GPAQ 2.

GPAQ 1 can be analysed in the same manner as GPAQ 2. Prior to using the analysis guidelines or the STEPS generic analysis syntax, most of the variables from GPAQ 1 need to be recoded.

Changes from GPAQ 2

For GPAQ 2, three questions have been removed from GPAQ 1. Two of these questions were filtering questions. The other one looked at the length of workdays. These three questions were:

- GPAQ1P1: Does your work involve mostly sitting or standing, with walking for no more than 10 minutes at a time?
- GPAQ1P6: How long is your typical work day?
- GPAQ1P9: Does your [*recreation, sport or leisure time*] involve mostly sitting, reclining, or standing, with no physical activity lasting more than 10 minutes at a time?

Recode GPAQ 1 to GPAQ 2

Please use the table below to recode your GPAQ 1 variables. Specific instructions for updating GPAQ 2 variables P1, P4, P10 and P13 using GPAQ1P1 and GPAQ1P6 follow.

GPAQ 1	GPAQ 2
P1	GPAQ1P1
P2	P1
P3a	P2
P3b	P3a (hrs) and P3b (min)
P4	P4
P5a	P5
P5b (hrs and mins)	P6a (hrs) and P6b (min)
P6	GPAQ1P6
P7	P7
P8a	P8
P8b	P9a (hrs) and P9b (min)
P9	GPAQ1P9
P10	P10
P11a	P11
P11b	P12a (hrs) and P12b (min)
P12	P13
P13a	P14
P13b	P15a (hrs) and P15b (min)
P14	P16a (hrs) and P16b (min)

Continued on next page

5 Cleaning data derived from GPAQ version 1, Continued

GPAQ1P1 Follow the instructions in the table below to update P1 and P4 using GPAQ1P1.

Step	Action
1	Confirm that the following recodes have been completed: **GPAQ 1 Code** / **GPAQ 2 Code** P1 / GPAQ1P1 P2 / P1
2	Create the following variables to store the original values: • P1orig • P4orig
3	Make P1orig and P4orig equal to the original P1 and P4 in your dataset (P1orig=P1 , P4orig=P4).
4	Update P1 and P4 with the following rule.

P1 Update	P4 Update
If GPAQ1P1=1 (yes) then P1=2 (no), otherwise P1 remains P1	If GPAQ1P1=1 (yes) then P4=2 (no), otherwise P4 remains P4

In EpiInfo:
 	
IF GPAQ1P1=1 THEN
P1=2
ELSE
P1=P1
END
	In EpiInfo:
	
	IF GPAQ1P1=1 THEN
	P4=2
	ELSE
	P4=P4
	END

GPAQ1P6 The variable for the question, "How long is your typical work day?", does not need to be coded into the dataset for the analysis of the GPAQ data.

Recode the variable to GPAQ1P6 and keep it in the original dataset.

Continued on next page

5 Cleaning data derived from GPAQ version 1, Continued

GPAQ1P9

Follow the instructions in the table below to update P10 and P13 using GPAQ1P9.

<table>
<tr><th>Step</th><th>Action</th></tr>
<tr><td>1</td><td>Confirm that the following recodes have been completed:
<table>
<tr><th>GPAQ 1 Code</th><th>GPAQ 2 Code</th></tr>
<tr><td>P9</td><td>GPAQ1P9</td></tr>
<tr><td>P12</td><td>P13</td></tr>
</table></td></tr>
<tr><td>2</td><td>Create variables:
• P10orig
• P13orig</td></tr>
<tr><td>3</td><td>Make P10orig and P13orig equal to the original P10 and P13 in your dataset (P10orig=P10 , P13orig=P13).</td></tr>
<tr><td>4</td><td>Update P10 and P13 with the following rule.
<table>
<tr><th>P10 Update</th><th>P13 Update</th></tr>
<tr><td>If GPAQ1P9=1 (yes) then P10=2 (no), otherwise P10 remains P10</td><td>If GPAQ1P9=1 (yes) then P13=2 (no), otherwise P13 remains P13</td></tr>
<tr><td>In EpiInfo:

If GPAQ1P9=1 THEN
P10=2
ELSE
P10=P10
END</td><td>In EpiInfo:

If GPAQ1P9=1 THEN
P13=2
ELSE
P13=P13
END</td></tr>
</table></td></tr>
</table>

Producing tables

Once you have completed the GPAQ 1 recode and saved the results to your dataset, you will be able to produce all the results in the analysis section. Follow the instructions provided for each table to produce the results.

6 Cleaning GPAQ data with EpiInfo

Introduction

GPAQ collects information on three domains. These domains are:

- Activity at work
- Travel to and from places
- Recreational activities.

For analysis purposes these domains can be further broken down into six different "sub-domains". These "sub-domains" are:

- Work vigorous (codes P1-P3)
- Work moderate (codes P4-P6)
- Travel (codes P7-P9)
- Recreational vigorous (codes P10-P12)
- Recreational moderate (codes P13-P15)
- Sitting (code P16)

Grouping the GPAQ sections

The GPAQ data are cleaned as a whole. Thus is a participant gave an invalid answer to any domain, then their entire response is not included in any analyses. However, a participant needs only to give a valid response to a minimum of one domain, leaving the remaining domains blank, to be included in the analyses.

Cleaning Programs

A "CleanRecode" program exists for each subset of physical activity questions. These are: **CleanRecode P1-P3**, **CleanRecode P4-P6**, **CleanRecode P7-P9**, **CleanRecode P10-P12**, **CleanRecode P13-P15**, and **CleanRecode P16**. The first 5 of these programs are identical with the only exception being that the question codes are changed.
All programs can be downloaded from http://www.who.int/chp/steps/resources/database/en/index.html by clicking on "EpiInfo Analysis Programs".

CleanRecode P1-P3 is described in the following table. This same description applies to CleanRecode P4-P6, CleanRecode P7-P9, CleanRecode P10-P12, and CleanRecode P13-P15. Since the program CleanRecode P16 differs from the other 5 CleanRecode programs, its description is provided in the second table below.

Continued on next page

<table>
<tr><td colspan="6">CleanRecode P1-P3</td></tr>
<tr><td>Questions Used</td><td colspan="5">P1, P2, P3a, P3b</td></tr>
<tr><td>General Information</td><td colspan="5">Before checking for valid responses to P1 through P3a&b, P3a and P3b are checked for possible data entry errors (i.e. minutes entered where hours are expected). To have a "clean" response, respondents must have answered all 3 questions correctly and consistently (P1t3CLN=1).</td></tr>
<tr><td rowspan="9">Modified Variables</td><td colspan="5">Before any new variables are created, P3a and P3b are modified using the following logical tests. To summarize, these tests try to correct obvious data entry errors where minute values of 15, 30, 45, or 60 were entered as hour values in P3a. These changes are only saved to the temporary dataset used for analysis, the actual dataset is left unchanged.</td></tr>
<tr><td colspan="3">Condition</td><td>New P3a Value</td><td>New P3b Value</td></tr>
<tr><td colspan="3">P3a=15 AND (P3b=(.) OR P3b=0 OR P3b=15 OR P3b=77 OR P3b=88 OR P3b=99)</td><td>0</td><td>15</td></tr>
<tr><td colspan="3">P3a=30 AND (P3b=(.) OR P3b=0 OR P3b=30 OR P3b=77 OR P3b=88 OR P3b=99)</td><td>0</td><td>30</td></tr>
<tr><td colspan="3">P3a=45 AND (P3b=(.) OR P3b=0 OR P3b=45 OR P3b=77 OR P3b=88 OR P3b=99)</td><td>0</td><td>45</td></tr>
<tr><td colspan="3">P3a=60 AND (P3b=(.) OR P3b=0 OR P3b=60 OR P3b=77 OR P3b=88 OR P3b=99)</td><td>1</td><td>0</td></tr>
<tr><td colspan="3">(P3a=7 AND P3b=77) OR (P3a=8 AND P3b=88) OR (P3a=9 AND P3b=99)</td><td>0</td><td>0</td></tr>
<tr><td colspan="3">P3a=77 OR P3a=88 OR P3a=99</td><td>0</td><td>(leave as is)</td></tr>
<tr><td colspan="3">P3b=77 OR P3b=88 OR P3b=99</td><td>(leave as is)</td><td>0</td></tr>
<tr><td rowspan="12">Created Variables</td><td>Name</td><td>Purpose</td><td>Value</td><td colspan="2">Condition</td></tr>
<tr><td rowspan="2">P3amin</td><td rowspan="2">Computes min value for P3a.</td><td>0</td><td colspan="2">P3a=(.)</td></tr>
<tr><td>P3a*60</td><td colspan="2">ELSE</td></tr>
<tr><td rowspan="2">P3bmin</td><td rowspan="2">Set equal to P3b, with 0's replacing missing values.</td><td>0</td><td colspan="2">P3b=(.)</td></tr>
<tr><td>P3b</td><td colspan="2">ELSE</td></tr>
<tr><td>P3</td><td>Total time in mins.</td><td>P3amin+P3bmin</td><td colspan="2"></td></tr>
<tr><td rowspan="2">P2CLN</td><td rowspan="2">Checks for a valid response to P2</td><td>1</td><td colspan="2">P1=1 AND P2>0 AND P2<8
OR
P1=2 AND (P2=0 OR P2=(.) OR P2=99)</td></tr>
<tr><td>2</td><td colspan="2">ELSE</td></tr>
<tr><td rowspan="2">P3CLN</td><td rowspan="2">Checks for a valid response to P3: P2 must have a valid response with nr. of days = 1 through 7, and P3 must be at least 10 mins. and at most 960 mins. (max. of 16 hrs. per day)</td><td>1</td><td colspan="2">P2CLN=1 AND P2>0 AND P2<8 AND P3>9 AND P3<961
OR
P2CLN=1 AND (P2=0 OR P2=(.) OR P2=99) AND P3=0</td></tr>
<tr><td>2</td><td colspan="2">ELSE</td></tr>
<tr><td rowspan="2">P1t3CLN</td><td rowspan="2">Checks for valid response to P1 through P3a&b. Allows for respondents to skip entire section but a check in the physical activity programs that use these cleaning programs ensures that at least one section of all physical activity sections has a response.</td><td>1</td><td colspan="2">P3CLN=1 AND Valid=1
OR
P1=(.) AND (P2=0 OR P2=(.) OR P2=99) AND P3=0 AND Valid=1</td></tr>
<tr><td>2</td><td colspan="2">ELSE</td></tr>
</table>

Continued on next page

CleanRecode P16					
Questions Used	P16a, P16b				
General Information	Responses are first checked for possible data entry errors (i.e. minutes entered where hours are expected). To have a "clean" response, respondents must have given a valid response to P16 (P16CLN=1).				
Modified Variables	Before any new variables are created, P16a and P16b are modified using the following logical tests. To summarize, these tests try to correct obvious data entry errors where minute values of 15, 30, 45, or 60 were entered as hour values in P16a. These changes are only saved to the temporary dataset used for analysis, the actual dataset is left unchanged.				
	Condition			**New P16a Value**	**New P16b Value**
	P16a=15 AND (P16b=(.) OR P16b=0 OR P16b=15 OR P16b=77 OR P16b=88 OR P16b=99)			0	15
	P16a=30 AND (P16b=(.) OR P16b=0 OR P16b=30 OR P16b=77 OR P16b=88 OR P16b=99)			0	30
	P16a=45 AND (P16b=(.) OR P16b=0 OR P16b=45 OR P16b=77 OR P16b=88 OR P16b=99)			0	45
	P16a=60 AND (P16b=(.) OR P16b=0 OR P16b=60 OR P16b=77 OR P16b=88 OR P16b=99)			1	0
	(P16a=7 AND P16b=77) OR (P16a=8 AND P16b=88) OR (P16a=9 AND P16b=99)			0	0
	P16a=77 OR P16a=88 OR P16a=99			0	(leave as is)
	P16b=77 OR P16b=88 OR P16b=99			(leave as is)	0
Created Variables	**Name**	**Purpose**	**Value**	**Condition**	
	P16amin	Computes min value for P16a	0	P16a=(.)	
			P16a*60	ELSE	
	P16bmin	Set equal to P16b, with 0's replacing missing values	0	P16b=(.)	
			P16b	ELSE	
	P16	Total time in mins	P16amin+P16bmin		
	P16CLN	Checks for a valid response to P16 (can be from 0 mins. to 1440 mins. (24 hrs.))	1	P16<1441 AND Valid=1	
			2	ELSE	

7 Analysis Guidelines and Calculations

Introduction

A population's physical activity (or inactivity) can be described in different ways. The two most common ways are
(1) to estimate a population's mean or median physical activity using a continuous indicator such as MET-minutes per week or time spent in physical activity, and
(2) to classify a certain percentage of a population as 'inactive' by setting up a cut-point for a specific amount of physical activity.
The following guidelines describe both how to derive at continuous as well as categorical indicators when analysing GPAQ data.

Continuous indicator

As described in the overview (p. 2), MET values are applied to the time variables according to the intensity (moderate or vigorous) of the activity. Applying MET values to activity levels allows us to calculate total physical activity.
For the calculation of a person's overall energy expenditure using GPAQ data, the following MET values are used:

Domain	MET value
Work	• Moderate MET value = 4.0 • Vigorous MET value = 8.0
Transport	Cycling and walking MET value = 4.0
Recreation	• Moderate MET value = 4.0 • Vigorous MET value = 8.0

Categorical indicator

For the calculation of a categorical indicator, the total time spent in physical activity during a typical week, the number of days as well as the intensity of the physical activity are taken into account.
The three levels of physical activity suggested for classifying populations are low, moderate, and high. The criteria for these levels are shown below.

- **High**

A person reaching any of the following criteria is classified in this category:
- Vigorous-intensity activity on at least 3 days achieving a minimum of at least 1,500 MET-minutes/week OR
- 7 or more days of any combination of walking, moderate- or vigorous-intensity activities achieving a minimum of at least 3,000 MET-minutes per week.

- **Moderate**

A person not meeting the criteria for the "high" category, but meeting any of the following criteria is classified in this category:
- 3 or more days of vigorous-intensity activity of at least 20 minutes per day OR
- 5 or more days of moderate-intensity activity or walking of at least 30 minutes per day OR
- 5 or more days of any combination of walking, moderate- or vigorous-intensity activities achieving a minimum of at least 600 MET-minutes per week.

- **Low**

A person not meeting any of the above mentioned criteria falls in this category.

Levels of total physical activity

Description: Percentage of respondents classified into three categories of total physical activity.

Instrument questions:

- **P1-P6a&b:** activity at work
- **P7-Pa9&b:** travel to and from places
- **P10-P15a&b:** recreational activities

Level of total physical activity							
Age Group (years)	Gender						
	n	% Low	95% CI	% Moderate	95% CI	% High	95% CI

Questions Used	P1-P15a&b
Program	**Ptotallevels** (unweighted), **PtotallevelsWT** (weighted)
Equations	Total physical activity MET-minutes/week (= the sum of the total MET minutes of activity computed for each setting) Equation: Total Physical Activity = [(P2 * P3 * 8) + (P5 * P6 * 4) + (P8 * P9 * 4) + (P11 * P12 * 8) + (P14 * P15* 4)]
Program Information	Places each respondent into one of 3 categories of physical activity. Before any of the below variables are created ALL CleanRecode programs are called. To be included in the output, the respondent must have either left blank or given a valid response to each subset of the physical activity questions AND have given a valid response to at least one subset of the physical activity questions (CLN=1).

Level of total physical activity	Physical activity cutoff value
High	• IF:(P2 + P11) ≥ 3 days AND Total physical activity MET minutes per week is ≥ 1500 **OR** • IF: (P2 + P5 + P8 + P11 + P14) ≥ 7 days AND total physical activity MET minutes per week is ≥ 3000
Moderate	• IF: level of physical activity does not reach criteria for high levels of physical activity **AND at least one of the following:** • IF: (P2 + P11) ≥ 3 days AND ((P2 * P3) + (P11 * P12)) ≥ 3*20 minutes **OR** • IF: (P5 + P8 + P14) ≥ 5 days AND ((P5 * P6) + (P8 * P9) + (P14 * P15) ≥ 150 minutes **OR** • IF: (P2 + P5 + P8 + P11 + P14) ≥ 5 days AND Total physical activity MET minutes per week ≥ 600
Low	IF level of physical activity does not reach the criteria for either high or moderate levels of physical activity

Created Variables	Name	Purpose	Values	Condition
	P1t3	MET value of vigorous work activity per week	P2*P3*8	P1t3CLN=1
			(.)	ELSE
	P4t6	MET value of moderate work activity per week	P5*P6*4	P4t6CLN=1
			(.)	ELSE
	P7t9	MET value of transport activity per week	P8*P9*4	P7t9CLN=1
			(.)	ELSE
	P10t12	MET value of vigorous recreational activity per week	P11*P12*8	P10t12CLN=1
			(.)	ELSE
	P13t15	MET value of moderate recreational activity per week	P14*P15*4	P13t15CLN=1
			(.)	ELSE
	Ptotal	Sum of all activity per week	p1t3+p4t6+p7t9+p10t12+p13t15	
	CLN	Checks to see if all physical activity responses, as a combined set, are valid: all subsets of responses must be clean and at least one subset of responses must have a response (not missing)	1	Valid=1 AND P1t3CLN=1 AND P4t6CLN=1 AND P7t9CLN=1 AND P10t12CLN=1 AND P13t15CLN=1 **AND** P1≠(.) OR P4≠(.) OR P7≠(.) OR P10≠(.) OR P13≠(.)
			2	ELSE
	C	Output table values: places respondents into 1 of 3 physical activity categories; the checks proceed in the order presented here, thus, for example, if a person does not meet "High" requirements, C will still be missing and thus C=(.) will be true for the checks for the "Moderate" category	**"High"**	(P2+P5+P8+P11+P14)>6 AND Ptotal>2999 **OR** (P2+P11)>2 AND Ptotal>1499
			"Moderate"	C=(.) AND (P2+P5+P8+P11+P14)≥5 AND Ptotal≥600 **OR** C=(.) AND ((P2+P11)=3 OR (P2+P11)=4) AND P12≥20 AND P3≥20 **OR** C=(.) AND P2≥3 AND P11≥3 AND (P12≥20 OR P3≥20) **OR** C=(.) AND ((P2≥3 AND P11<3 AND P3≥20) OR (P11≥3 AND P2<3 AND P12≥20)) **OR** C=(.) AND (P5+P8+P14)≥5 AND ((p5*P6)+(p8*P9)+(P14*P15))≥150
			"Low"	C=(.)

Total physical activity

Description: Mean / median time of total physical activity on average per day.

Instrument questions

- **P1-P6a&b:** activity at work
- **P7-P9&b:** travel to and from places
- **P10-P15a&b:** recreational activities

Mean/Median minutes of total physical activity on average per day									
Age Group (years)	Men			Women			Both Sexes		
	n	# minutes	95% CI	n	# minutes	95% CI	n	# minutes	95% CI

Questions Used	P1-P15a&b			
Program	**Ptotal** (unweighted mean & median values), **PtotalWT** (weighted mean values), **PtotalmedianWT** (weighted median values)			
Program Information	Reports the mean or median amount of physical activity per day in minutes. Before any of the below variables are created ALL CleanRecode programs are called. To be included in the output, the respondent must have either left blank or given a valid response to each subset of the physical activity questions AND have given a valid response to at least one subset of the physical activity questions (CLN=1).			
Created Variables	**Name**	**Purpose**	**Values**	**Condition**
	P1t3	Vigorous work activity in minutes per week	P2*P3	P1t3CLN=1
			(.)	ELSE
	P4t6	Moderate work activity in minutes per week	P5*P6	P4t6CLN=1
			(.)	ELSE
	P7t9	Transport activity in minutes per week	P8*P9	P7t9CLN=1
			(.)	ELSE
	P10t12	Vigorous recreational activity in minutes per week	P11*P12	P10t12CLN=1
			(.)	ELSE
	P13t15	Moderate recreational activity in minutes per week	P14*P15	P13t15CLN=1
			(.)	ELSE
	Ptotalday	Sum of all activity per week divided by 7 to get avg. per day	(p1t3+p4t6+ p7t9+p10t12 +p13t15)/7	
	CLN	Checks to see if all physical activity responses, as a combined set, are valid: all subsets of responses must be clean and at least one subset of responses must have a response (not missing)	1	Valid=1 AND P1t3CLN=1 AND P4t6CLN=1 AND P7t9CLN=1 AND P10t12CLN=1 AND P13t15CLN=1 **AND** P1≠(.) OR P4≠(.) OR P7≠(.) OR P10≠(.) OR P13≠(.)
			2	ELSE

Setting-specific physical activity-mean / median

Description: Mean / median number of minutes spent on average per day, in work-, transport- and recreation-related physical activity.

Instrument questions

- **P1-P6a&b:** activity at work
- **P7-P9&b:** travel to and from places
- **P10-P15a&b:** recreational activities

Mean/Median minutes of [*insert domain*]-related physical activity on average per day									
Age Group (years)	**Men**			**Women**			**Both Sexes**		
	n	# minutes	95% CI	n	# minutes	95% CI	n	# minutes	95% CI

Questions Used	P1-P15a&b			
Program	**Psetspecific** (unweighted mean & median values), **PsetspecificWT** (weighted mean values), **PsetspecificmedianWT** (weighted median values)			
General Information	Reports the mean or median amount of physical activity in minutes. Before any of the below variables are created ALL CleanRecode programs are called. To be included in the output, the respondent must have either left blank or given a valid response to each subset of the physical activity questions AND have given a valid response to at least one subset of the physical activity questions (CLN=1).			
Created Variables	**Name**	**Purpose**	**Values**	**Condition**
	P1t3	Vigorous work activity in minutes per week	P2*P3	P1t3CLN=1
			(.)	ELSE
	P4t6	Moderate work activity in minutes per week	P5*P6	P4t6CLN=1
			(.)	ELSE
	P7t9	Transport activity in minutes per week	P8*P9	P7t9CLN=1
			(.)	ELSE
	P10t12	Vigorous recreational activity in minutes per week	P11*P12	P10t12CLN=1
			(.)	ELSE
	P13t15	Moderate recreational activity in minutes per week	P14*P15	P13t15CLN=1
			(.)	ELSE
	Pwork-day	Average work-related activity per day	(p1t3+p4t6)/7	
	Ptravel-day	Average transport-related activity per day	p7t9/7	
	Precday	Average recreation-related activity per day	(p10t12+p13t15) /7	
	CLN	Checks to see if all physical activity responses, as a combined set, are valid: all subsets of responses must be clean and at least one subset of responses must have a response (not missing)	1	Valid=1 AND P1t3CLN=1 AND P4t6CLN=1 AND P7t9CLN=1 AND P10t12CLN=1 AND P13t15CLN=1 **AND** P1≠(.) OR P4≠(.) OR P7≠(.) OR P10≠(.) OR P13≠(.)
			2	ELSE

No physical activity by setting

Description: Percentage of respondents classified as doing no work-, transport-, or recreation-related physical activity.

Instrument questions

- **P1-P6a&b:** activity at work
- **P7-P9&b:** travel to and from places
- **P10-P15a&b:** recreational activities

No [*insert domain*]-related physical activity									
Age Group (years)	Men			Women			Both Sexes		
	n	%	95% CI	n	%	95% CI	n	%	95% CI

Questions Used	P1-P15a&b			
Program	**Pnoactivitybyset** (unweighted), **PnoactivitybysetWT** (weighted)			
General	Reports the percentage of respondents who reported no work-, transport-, or recreation-related physical activity. Before any of the below variables are created ALL CleanRecode programs are called. To be included in the output, the respondent must have either left blank or given a valid response to each subset of the physical activity questions AND have given a valid response to at least one subset of the physical activity questions (CLN=1).			
Created	**Name**	**Purpose**	**Values**	**Condition**
	Work	Indicates whether or not respondent did any work-related activity	"did work activity"	P1=1 OR P4=1
			"did no work activity"	ELSE
	Trans	Indicates whether or not respondent did any transport-related activity	"did transport activity"	P7=1
			"did no transport activity"	ELSE
	Rec	Indicates whether or not respondent did any recreation-related activity	"did recreation activity"	P10=1 OR P13=1
			"did no recreation activity"	ELSE
	CLN	Checks to see if all physical activity responses, as a combined set, are valid: all subsets of responses must be clean and at least one subset of responses must have a response (not missing)	1	Valid=1 AND P1t3CLN=1 AND P4t6CLN=1 AND P7t9CLN=1 AND P10t12CLN=1 AND P13t15CLN=1 **AND** P1≠(.) OR P4≠(.) OR P7≠(.) OR P10≠(.) OR P13≠(.)
			2	ELSE

Composition of total physical activity

Description: Percentage of total physical activity on average per day that comes from each of the 3 types of activity: work-, transport-, or recreation-related.
Instrument questions

- **P1-P6a&b:** activity at work
- **P7-P9&b:** travel to and from places
- **P10-P15a&b:** recreational activities

Composition of total physical activity							
Age Group (years)	Gender						
	n	% Work	95% CI	% Transport	95% CI	% Recreation	95% CI

Qu. Used	P1-P15a&b			
Program	**Pcomposition** (unweighted), **PcompositionWT** (weighted)			
General Information	Reports the percentage of activity that comes from each of the three types of activity (work, transport, or recreation). Before any of the below variables are created ALL CleanRecode programs are called. To be included in the output, the respondent must have either left blank or given a valid response to each subset of the physical activity questions AND have given a valid response to at least one subset of the physical activity questions (CLN=1).			
Created Variables	**Name**	**Purpose**	**Values**	**Condition**
	P1t3	Vigorous work activity in minutes per week	P2*P3	P1t3CLN=1
			(.)	ELSE
	P4t6	Moderate work activity in minutes per week	P5*P6	P4t6CLN=1
			(.)	ELSE
	P7t9	Transport activity in minutes per week	P8*P9	P7t9CLN=1
			(.)	ELSE
	P10t12	Vigorous recreational activity in minutes per week	P11*P12	P10t12CLN=1
			(.)	ELSE
	P13t15	Moderate recreational activity in minutes per week	P14*P15	P13t15CLN=1
			(.)	ELSE
	Ptotal	Sum of all activity per week	p1t3+p4t6+p7t9+ p10t12+p13t15	
	Percent-Work	Percent of all activity from work-related activities	(p1t3+p4t6)/Ptotal*100	
	Percent-Trans	Percent of all activity from transportation-related activities	p7t9/Ptotal*100	
	Percent-Rec	Percent of all activity from recreational activities	(p10t12+p13t15)/ Ptotal*100	
	CLN	Checks to see if all physical activity responses, as a combined set, are valid: all subsets of responses must be clean and at least one subset of responses must have a response (not missing)	1	Valid=1 AND P1t3CLN=1 AND P4t6CLN=1 AND P7t9CLN=1 AND P10t12CLN=1 AND P13t15CLN=1 **AND** P1≠(.) OR P4≠(.) OR P7≠(.) OR P10≠(.) OR P13≠(.)
			2	ELSE

No vigorous physical activity

Description: Percentage of respondents not engaging in vigorous physical activity.

Instrument questions

- **P1-P6a&b:** activity at work
- **P7-P9&b:** travel to and from places
- **P10-P15a&b:** recreational activities

No vigorous physical activity									
Age Group (years)	Men			Women			Both Sexes		
	n	%	95% CI	n	%	95% CI	n	%	95% CI

Qu. Used	P1-P15a&b			
Program	**Pnovigorous** (unweighted), **PnovigorousWT** (weighted values)			
General	Reports percentage of respondents who did no vigorous physical activity. Before any of the below variables are created ALL CleanRecode programs are called. To be included in the output, the respondent must have either left blank or given a valid response to each subset of the physical activity questions AND have given a valid response to at least one subset of the physical activity questions (CLN=1).			
Created Variables	**Name**	**Purpose**	**Values**	**Condition**
	C	Output table values	"did vigorous physical activity"	P1=1 OR P10=1
			"did no vigorous physical activity"	ELSE
	CLN	Checks to see if all physical activity responses, as a combined set, are valid: all subsets of responses must be clean and at least one subset of responses must have a response (not missing)	1	Valid=1 AND P1t3CLN=1 AND P4t6CLN=1 AND P7t9CLN=1 AND P10t12CLN=1 AND P13t15CLN=1 AND P1≠(.) OR P4≠(.) OR P7≠(.) OR P10≠(.) OR P13≠(.)
			2	ELSE

Sedentary Description: Minutes spent in sedentary activities on average per day.

Instrument questions

- **P16:** sedentary behaviour

Mean/Median minutes spent in sedentary activities on average per day									
Age Group (years)	Men			Women			Both Sexes		
	n	# minutes	95% CI	n	# minutes	95% CI	n	# minutes	95% CI

Questions Used	P16a&b			
Program	**Psedentary** (unweighted mean & median values), **PsedentaryWT** (weighted mean values), **PsedentarymedianWT** (weighted median values)			
General	Reports the mean or median amount of sedentary activity in minutes. Before any of the below variables are created ALL CleanRecode programs are called. To be included in the output, the respondent must have either left blank or given a valid response to each subset of the physical activity questions AND have given a valid response to at least one subset of the physical activity questions (CLN=1). Note: P16 was created in CleanRecodeP16 from P16a and P16b. It contains the total sedentary time in mins.			
Created Variables	**Name**	**Purpose**	**Values**	**Condition**
	CLN	Checks to see if all physical activity responses, as a combined set, are valid: all subsets of responses must be clean and at least one subset of responses must have a response (not missing)	1	Valid=1 AND P16CLN=1
			2	ELSE

Medical History

Medical history will be assessed through a short list of questions about the presence of existing physician-diagnosed medical conditions, and this questionnaire will also be administered through the web-based interface managed by SRI. This assessment is brief, easy to administer, and completed in 5-10 minutes or less.

Medical History Form – EnHANCE 2011-2012

Are you in good health? Yes No Has your general health changed in the past year? Yes No
Please explain_____

Family Health History – *Check all conditions that any of your blood relatives has had (i.e. parents, grandparents, siblings).*

☐ Alcohol or other drug problem	☐ Autoimmune disorder	☐ Diabetes	☐ Hereditary disorder	☐ Migraines
☐ Asthma or hay fever	☐ Cancer	☐ Heart disease	☐ High blood pressure	☐ Other

Please provide a brief explanation for any items checked_____

_____

Personal Health History – Has a doctor diagnosed you with any of the following conditions? *Check all you have had in the past or have at this time.*

☐ Allergies to foods
If yes, please specify which foods and indicate if your reaction is ***mild/moderate/severe***

_____

_____

☐ Allergies, other than food* (specify below)
☐ Asthma, in the past
☐ Asthma, currently have
☐ Autoimmune disorder* (specify)
☐ Blood disorders, anemia
☐ Cancer

Cardiovascular disease
- ☐ Heart problem
- ☐ High blood pressure
- ☐ High cholesterol

☐ Eating disorder

Endocrine disorder
- ☐ Diabetes
- ☐ Thyroid
- ☐ Other* (specify)

☐ Gallbladder disease or gallstones
☐ Gastrointestinal condition* (specify)
☐ Hospitalizations* (specify)
☐ Kidney disease
☐ Menstrual disorders

Mental Health concern
- ☐ Anxiety-spectrum disorder
- ☐ Depression
- ☐ Other emotional concerns* (specify)

☐ Migraine headaches
☐ Mobility limitations* (specify)

Musculoskeletal problems
- ☐ Fractures* (specify)
- ☐ Other* (specify)

☐ Neurologic concerns
☐ Sleep disorder *(specify)
☐ Surgical operations or procedures* (specify)

Alcohol, tobacco, and other drugs. *Check all that apply.*
- ☐ Alcohol intoxication in past year
- ☐ Alcohol or other drug treatment
- ☐ Unsuccessful attempt to cut back on alcohol or other drug use
- ☐ Use of anabolic steroids

*Please provide a brief explanation regarding any checked items:

_____

Medications (frequent or regular)

☐ Acne medication	☐ Birth control	☐ Insulin
☐ ADD/ADHD medication	☐ Blood pressure medication	☐ Pain medication
☐ Allergy medication	☐ Bowel medication	☐ Psychological condition medication
☐ Allergy shots	☐ Headache medication	☐ Vitamin Supplements
☐ Antidepressant medication	☐ Heart-rhythm medication	☐ Multivitamins
☐ Asthma medication	☐ Herbal treatments	☐ Other* (specify below)

Please provide the name, dosage and frequency, and indication for the medications/remedies you marked above:_____

_____

_____

Eating Attitudes

Two questionnaires will be used to assess attitudes towards eating, and the widely used Satter Eating Competency Scale and the Three Factor Eating Questionnaire were chosen to assess this domain. This short questionnaire has 16 questions about eating, and takes about five to ten minutes to complete. To capture eating behaviors related to uncontrolled eating, cognitive restraint, and emotional eating, the three factor eating questionnaire will be administered. This questionnaire has been validated in adolescents and adults as well as obese and non-obese persons. This brief tool is comprised of 18 questions, and takes 10-15 minutes to complete.

ecSatter Inventory

Below are 16 statements about your eating. Think about each one, then check the box that shows how often you think, do or feel that way.

Name_____ Date_____

Age_____

A = Always O = Often S = Sometimes R = Rarely N = Never

	A	O	S	R	N
1. I am relaxed about eating.	☐	☐	☐	☐	☐
2. I am comfortable about eating enough.	☐	☐	☐	☐	☐
3. I enjoy food and eating.	☐	☐	☐	☐	☐
4. I am comfortable with my enjoyment of food and eating.	☐	☐	☐	☐	☐
5. I feel it is okay to eat food that I like.	☐	☐	☐	☐	☐
6. I experiment with new food and learn to like it.	☐	☐	☐	☐	☐
7. If the situation demands, I can "make do" by eating food I don't much care for.	☐	☐	☐	☐	☐
8. I eat a wide variety of foods.	☐	☐	☐	☐	☐
9. I assume I will get enough to eat.	☐	☐	☐	☐	☐
10. I eat as much as I am hungry for.	☐	☐	☐	☐	☐
11. I eat until I feel satisfied.	☐	☐	☐	☐	☐
12. I tune in to food and pay attention to myself when I eat.	☐	☐	☐	☐	☐
13. I make time to eat.	☐	☐	☐	☐	☐
14. I have regular meals.	☐	☐	☐	☐	☐
15. I think about nutrition when I choose what to eat.	☐	☐	☐	☐	☐
16. I generally plan for feeding myself. I don't just grab food when I get hungry.	☐	☐	☐	☐	☐

Lifestyle

A short questionnaire (29 questions) collects information about key aspects of lifestyle (smoking, sleep patterns, sunlight/UV exposure, weight control efforts, snacking habits) that may be associated both with eating behaviors, dietary intake and transition to college; the questionnaire is administered through the web-based interface managed by SRI, and takes about 15-20 minutes to complete.

July Questionnaire is shown: note that minor modifications to time frame asked about and to lifetime history are changed in versions of the questionnaire administered at later time points in the study.

Tobacco Use: These questions ask about your lifetime use of tobacco and your current habits.

Have you ever smoked cigarettes regularly (at least 1 cigarette a day) for at least one year?
o No
o Yes (please answer a-d below)

a. How old were you when you first started smoking cigarettes regularly?
o 11 or younger
o 12-14
o 15-17
o 18 or over, or in the last year

b. During the years you smoked, how many cigarettes did you usually smoke each day?
o 1-4
o 5-14
o 15-24
o 15-34
o 35-44
o 45-54
o 55 or more

c. How many years have you been (were you) a regular smoker? Do not count years you did not smoke.
o 1-4
o 5-9
o 10 or more

d. Do you smoke cigarettes now?
o No
o Yes

The next series of questions asks about the past three months.
Sleep Habits

On a typical night when you have school or work the next day, how many hours of sleep do you usually get?
o Less than 5 hours
o 5-6 hours
o 7-8 hours
o 9 or more hours

Are you usually sleepy during the daytime? *Do not count taking a daily nap as feeling sleepy.*
o Yes
o No
o Don't know

During the past month, how would you rate the overall quality of your sleep?
o Very bad
o Somewhat bad
o Somewhat good
o Good
o Very good

Sunlight/UV Exposure

After you have been out in the sun for 45-60 minutes for the first time during the summer, which describes the reaction of your unprotected, exposed skin?
o Always burns easily, never tans (very fair skin tone)
o Usually burns easily, rarely tans (fair skin tone)
o Burns moderately, tans gradually (fair to medium skin tone)
o Rarely burns, always tans well (medium skin tone)
o Very rarely burns, tans very easily (olive or moderately dark skin tone)
o Never burns, deeply pigmented skin (very dark skin tone)

During the last three months how much time per day, on average, did you spend outside during the daytime during the **weekdays**?
o Less than 15 minutes
o 15-30 minutes
o 30 minutes to 1 hour

o 1-2 hours
o More than 2 hours

During the last three months how much time per day, on average, did you spend outside during the daytime during the **weekends**?
o Less than 15 minutes
o 15-30 minutes
o 30 minutes to 1 hour
o 1-2 hours
o More than 2 hours

How many times have you used a tanning bed in the last three months?
o None
o 1-2 times
o 3-6 times
o 7-10 times
o 11 times or more

Weight Control

In the past three months, how often have you…
- thought about wanting to have toned or defined muscles?
- worried about having fat on your body?
- thought about wanting to be thinner?
- felt fat?

o Never
o A little
o Sometimes
o Often
o Always

In the past three months, did you try to lose weight or keep from gaining weight?
o Yes
o No

If yes, how often did you go on a diet to lose or keep from gaining weight?
o Never
o A couple of times

o Several times
o Always on a diet

In the past three months, did you do any of the following to lose weight or keep from gaining weight?

- Fast (not eat for at least a day)
- Make yourself throw up
- Take laxatives

o Never
o Less than monthly
o 1-3 times per month
o Weekly
o 2 or more times per week

In the past three months, how often have you eaten so much food in a short period of time you would be embarrassed if someone saw you?
o Never
o 1-3 times per month
o Once per week
o More than once per week

What influences your personal satisfaction with your body? (check all that apply)
o Friends
o Family
o Peers
o Advertisements
o TV/Internet programs
o Print media
o *(i.e. magazines)*
o None on this list

Meal and Snack Habits

How many meals do you typically eat per day?
o 1
o 2
o 3

o 4
o 5
o 6 or more

How many snacks (excluding meals) do you typically eat before your evening meal?
o 0
o 1
o 2
o 3
o 4
o 5
o 6 or more

How many snacks do you typically eat after your evening meal?
o 0
o 1
o 2
o 3
o 4 or more

In the last 3 months, how often have you eaten a meal or snack during nighttime when you would normally be sleeping? *(for example, between 12 a.m.-4 a.m.)*
o Less than monthly
o 1-3 times per month
o 1 time per week
o More than 1 time per week

Do you keep track of your intake of calories from food throughout the day?
o Never
o Occasionally
o Usually
o I always count the calories I eat or drink

What foods do you typically choose to snack on during the day?
o I do not snack during the day
o Salty snacks
o Trail mix or nuts and seeds
o Candy
o Pastries
o Cookies or other sweet baked goods

o Fried food
o Homemade dishes
o Raw fruit
o Raw vegetables
o Bread, cereal, grains
o Dairy products (i.e. cheese, milk, yogurt)
o Other: _____

What foods do you typically snack on at night?
o I do not snack at night
o Salty snacks
o Trail mix, nuts and/or seeds
o Candy
o Pastries
o Cookies or bars
o Fried food
o Homemade dishes
o Raw fruit
o Raw vegetables
o Bread, cereal, grains
o Dairy products (i.e. cheese, milk, yogurt)
o Other: _____

Compared to your overall eating habits 3 months ago, would you say you are eating …
o About as much as you ate then
o More than you ate then
o Less than you ate then

Does your personal stress influence your eating habits?
o No, not at all
o Occasionally
o Often
o Always. Whenever I am stressed, it influences my eating habits.

Healthy Days — Health-Related Quality of Life During the Last Three Months

Now thinking about your physical health, which includes physical illness and injury, for how many days during the past 90 days (three months) was your physical health

not good?
(Blank field to enter number of days)

Now thinking about your mental health, which includes stress, depression, and problems with emotions, for how many days during the past 90 days was your mental health not good?
(Blank field to enter number of days)

During the past 90 days, for about how many days did poor physical or mental health keep you from doing your usual activities, such as self-care, school, or recreation?
(Blank field to enter number of days)

Sedentary Activity

During the last three months, how much time per week, Monday through Friday, do you spend doing the following:

Indicate one answer for each activity
<first circle> <30min
<second circle> 30 min-2 hours
<third circle> 2.5-5 hours
<fourth circle> 5.5-10 hours
<fifth circle> 10.5-15 hours
<sixth circle> 15.5 hours or more
Watching TV o o o o o o
Watching DVDs/Videos/Movies o o o o o o
Reading or doing homework o o o o o o
Video Games (Computer, Console, Handheld) o o o o o o
Computer/Internet (not including above, schoolwork, or other work) o o o o o o

During the last three months, how much time on per weekend, Saturday and Sunday, do you spend doing the following:

Indicate one answer for each activity
<first circle> <30min
<second circle> 30 min-2 hours
<third circle> 2.5-5 hours
<fourth circle> 5.5-10 hours
<fifth circle> 10.5-15 hours

<sixth circle> 15.5 hours or more
Watching TV o o o o o o
Watching DVDs/Videos/Movies o o o o o o
Reading or doing homework o o o o o o
Video Games (Computer, Console, Handheld) o o o o o o
Computer/Internet (not including above, schoolwork, or other work) o o o o o o

December Questionnaire:
The following questions ask about your lifestyle during the last three months.

Tobacco Use
In the last three months, have you smoked any cigarettes?
o No
o Yes (please answer a-b)

a. On average, how many cigarettes per day have you smoked?
o 1-4
o 5-14
o 15-24
o 25-34
o 35-44
o 45 or more

b. In the last three months have you quit smoking?
o No
o Yes

Sleep Habits

On a typical night when you have school or work the next day, how many hours of sleep do you
usually get?
o Less than 5 hours
o 5-6 hours
o 7-8 hours
o 9 or more hours

Are you usually sleepy during the daytime? *Do not count taking a daily nap as feeling sleepy.*
o Yes
o No

During the past three months, how would you rate the overall quality of your sleep?
o Very bad
o Somewhat bad
o Somewhat good
o Good
o Very good

Sunlight/UV Exposure

How many times did you sunburn last summer (that is, how many times did exposed parts of your skin stay red for several hours after you had been out in the sun)?
o Never
o 1-2 times
o 3-4 times
o 5 times or more

During the last three months how much time per day, on average, did you spend outside during the daytime during the **weekdays**?
o Less than 15 minutes
o 15-30 minutes
o 30 minutes to 1 hour
o 1-2 hours
o More than 2 hours

During the last three months how much time per day, on average, did you spend outside during the daytime during the **weekends**?
o Less than 15 minutes
o 15-30 minutes
o 30 minutes to 1 hour
o 1-2 hours
o More than 2 hours

How many times have you used a tanning bed in the last three months?

o None
o 1-3 times
o 4-7 times
o 8-11 times
o 12-16 times
o 17 times or more

Weight Control

In the three months, how often have you…
- Thought about wanting to have toned or defined muscles?
- Worried about having fat on your body?
- Thought about wanting to be thinner?
- Felt fat?

o Never
o A little
o Sometimes
o Often
o Always

In the past three months, did you try to lose weight or keep from gaining weight?
o Yes
o No

If yes, how often did you go on a diet to lose or keep from gaining weight?
o Never
o A couple of times
o Several times
o Always on a diet

In the past three months, did you do any of the following to lose weight or keep from gaining weight?

- Fast (not eat for at least a day)
- Make yourself throw up
- Take laxatives

o Never
o Less than monthly
o 1-3 times per month

o Weekly
o 2 or more times per week

In the past three months, how often have you eaten so much food in a short period of time you would be embarrassed if someone saw you?
o Never
o 1-3 times per month
o Once per week
o More than once per week

What influences your personal satisfaction with your body? (check all that apply)
o Friends
o Family
o Peers
o Advertisements
o TV/Internet programs
o Print media *(i.e. magazines)*
o None on this list

Meal and Snack Habits

How many meals do you typically eat per day?
o 1
o 2
o 3
o 4
o 5
o 6 or more

How many snacks (excluding meals) do you typically eat before your evening meal?
o 0
o 1
o 2
o 3
o 4
o 5
o 6 or more

How many snacks do you typically eat after your evening meal?

o 0
o 1
o 2
o 3
o 4 or more

In the last three months, how often have you eaten a meal or snack during nighttime when you would normally be sleeping? *(for example, between 12 a.m.-4 a.m.)*
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o I always count the calories I eat or drink

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o Trail mix or nuts and seeds
o Candy
o Pastries
o Cookies or other sweet baked goods
o Fried food
o Homemade dishes
o Raw fruit
o Raw vegetables
o Bread, cereal, grains
o Dairy products (i.e. cheese, milk, yogurt)
o Other: _____

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o I do not snack at night
o Salty snacks
o Trail mix, nuts and/or seeds
o Candy
o Pastries

o Cookies or bars
o Fried food
o Homemade dishes
o Raw fruit
o Raw vegetables
o Bread, cereal, grains
o Dairy products (i.e. cheese, milk, yogurt)
o Other: _____

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o More than you ate then
o Less than you ate then

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(Blank field to enter number of days)

Now thinking about your mental health, which includes stress, depression, and problems with emotions, for how many days during the past 90 days was your mental health not good?
(Blank field to enter number of days)

During the past 90 days, for about how many days did poor physical or mental health keep you from doing your usual activities, such as self-care, work, or recreation?
(Blank field to enter number of days)

Sedentary Activity

During the last three months, how much time per week, Monday through Friday, do you spend doing the following:

Indicate one answer for each activity
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<second circle> 30 min-2 hours
<third circle> 2.5-5 hours
<fourth circle> 5.5-10 hours
<fifth circle> 10.5-15 hours
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Watching TV o o o o o o
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Reading or doing homework o o o o o o
Video Games (Computer, Console, Handheld) o o o o o o
Computer/Internet (not including above, schoolwork, or other work) o o o o o o

During the last three months, how much time on per weekend, Saturday and Sunday, do you spend doing the following:

Indicate one answer for each activity
<first circle> <30min
<second circle> 30 min-2 hours
<third circle> 2.5-5 hours
<fourth circle> 5.5-10 hours
<fifth circle> 10.5-15 hours
<sixth circle> 15.5 hours or more
Watching TV o o o o o o
Watching DVDs/Videos/Movies o o o o o o
Reading or doing homework o o o o o o
Video Games (Computer, Console, Handheld) o o o o o o
Computer/Internet (not including above, schoolwork, or other work) o o o o o o

Stress

The perceived stress of the participant will be assessed with a 10-item scale developed and tested by Cohen, Kamarck, and Mermelstein that indicates the degree to which situations in the respondent's life are appraised as stressful. During its development, this tool was validated in freshmen college students and is a global measurement of perceived stress. This tool is brief, simple and takes less than 10 minutes of the participant's time.

Perceived Stress Scale- 10 Item

The questions in this scale ask you about your feelings and thoughts during the last month. In each case, please indicate with a check how often you felt or thought a certain way.

1. In the last month, how often have you been upset because of something that happened unexpectedly?

___0=never ___1=almost never ___2=sometimes ___3=fairly often ___4=very often

2. In the last month, how often have you felt that you were unable to control the important things in your life?

___0=never ___1=almost never ___2=sometimes ___3=fairly often ___4=very often

3. In the last month, how often have you felt nervous and "stressed"?

___0=never ___1=almost never ___2=sometimes ___3=fairly often ___4=very often

4. In the last month, how often have you felt confident about your ability to handle your personal problems?

___0=never ___1=almost never ___2=sometimes ___3=fairly often ___4=very often

5. In the last month, how often have you felt that things were going your way?

___0=never ___1=almost never ___2=sometimes ___3=fairly often ___4=very often

6. In the last month, how often have you found that you could not cope with all the things that you had to do?

___0=never ___1=almost never ___2=sometimes ___3=fairly often ___4=very often

7. In the last month, how often have you been able to control irritations in your life?

___0=never ___1=almost never ___2=sometimes ___3=fairly often ___4=very often

8. In the last month, how often have you felt that you were on top of things?

___0=never ___1=almost never ___2=sometimes ___3=fairly often ___4=very often

9. In the last month, how often have you been angered because of things that were outside of your control?

___0=never ___1=almost never ___2=sometimes ___3=fairly often ___4=very often

10. In the last month, how often have you felt difficulties were piling up so high that you could not overcome them?

___0=never ___1=almost never ___2=sometimes ___3=fairly often ___4=very often

This scale can be found in:

Cohen, S., Kamarck, T., Mermelstein, R. (1983). A global measure of perceived stress. Journal of Health and Social Behavior, 24, 385-396. Link to full-text (pdf)

Cohen, S., & Williamson, G. (1988). Perceived stress in a probability sample of the United States. In S. Spacapam & S. Oskamp (Eds.), The social psychology of health: Claremont Symposium on applied social

psychology. Newbury Park, CA: Sage. Link to full-text (pdf)

updated July 8, 2008

Anthropometry and Adiposity Data Collection

Data on body measurements, or anthropometrics, will be gathered in the study at the four in-person brief visits that students make to the College of Human Ecology Human Metabolic Research Unit (HMRU). Using a team of trained graduate student volunteers from the Division of Nutritional Science, direct measurements of the following will be completed: weight, height, waist and hip circumference will be completed at the first in-person visit that takes place during the first 2 days on campus. Body composition via dual energy x-ray absorptiometry (DXA) will be conducted by a radiology technician and will be scheduled for a visit soon thereafter, to spread visits out more and to reduce pressure on limited time available during freshmen orientation. It is not expected that body compartments will change quickly (whereas metabolic biological markers may), thus completing the DXA within the first two weeks at college is reasonable. Individual students will be scheduled for DXA as their academic schedules allow. Time points for the measurements are shown on the data collection plan in Section 3 of the Appendix.

Student Record Data

Some data will be gathered from existing student records, for example information on college, major, type of residence, number of roommates, location of residence, number of credits will be obtained through University records [we are investigating whether a release of information from educational records will be necessary, or if the consent we obtain from students will be adequate to obtain these data from existing University records]. Data on food purchases on-campus using dining services (tracked centrally by student's meal plan card) will also be obtained via existing databases.

Data Collection Participant Time Commitment

In total, over the full study, the time to complete online questionnaires and in-person visits will be approximately 12 hours, thus approximately 6 hours per semester.

SECTION 4: Biospecimen Collection and Storage

- Biospecimen Collection Overview
- Blood Specimen Collection Operating Procedures
- Saliva Specimen Collection Operating Procedures
- HMRU Freezer Operating Procedure

Introduction

The design of the EnHANCE Pilot Study requires blood and saliva specimens to be collected on all study participants. Blood specimens are being collected to quantitatively measure biological markers that assess general health and nutritional status, including markers of diabetes, cardiovascular disease and obesity. Saliva specimens are being collected for isolation of DNA to examine the effects of nutritional status on molecular markers of diabetes, cardiovascular disease and obesity.

Biological specimens will be collected, with the help of Cayuga Medical Center, at the Human Metabolic Research Unit within the Division of Nutritional Sciences. Specimens will also be processed and stored at the facilities of the Human Metabolic Research Unit. Study participants are required to sign a written consent form in order to submit both blood and saliva specimens. Participants may request at anytime to destroy any collected specimen and withdraw from the study.

EnHANCE Study Blood Specimens

Blood specimens will be collected from all consenting participants including those that may potentially have blood-borne infectious disease. Specimens will be collected both by venipuncture and fingerstick.

Confidentiality and Safety

This section discusses concerns that participants may have about confidentiality and safety, as well as concerns regarding collecting samples in participants with blood-borne pathogens.

Confidentiality

During collection, all specimens will be labeled with a barcode and a unique ID number that is assigned during the initial registration of the participants. This unique identification number will be used during processing, testing, and storing of participants specimens. All information that pertains to the participant will be stored in a separate controlled database that can only be accessed by approved study personnel.

Safety

The Human Metabolic Research Unit has been designated as a blood collection facility and follows all the Universal Precautions in the collection, handling, and disposal of blood and collection materials. *See following HMRU Standard Operating Procedures on Venipuncture.* Phlebotomist will be contracted out with Cayuga Medical Center and they have their own blood collection and safety protocols.

Materials

Blood Tube Labels

Blood Collection Supplies

Requirements per subject

- One Serum Separator Tube (SST)- red/gray top- 10ml
- One BD™ P800 Blood Collection Tubes - BD™ Hemogard/Clear top, 2.0 ml
- One Cell Preparation Tube (CPT)- blue/black top -8 ml
- BD™ Microtainers – Lithium/Heparin
- Dried Blood Spot (DBS) Cards

Blood Specimen Collection

This section describes the preparation necessary at the HMRU before collecting specimens, procedures for collecting the blood specimens, and procedures for storing specimens.

Preparation for Blood Specimen Collection

- Approximately thirty minutes before collection, the P800 tubes, which are stored refrigerated, should be taken out of refrigeration and brought to room temperature. All other vacutainers are stored at room temperature.
- Labels will be placed on the three vacutainers (SST, P800, and CPT tubes) and on the microtainer during the check-in process.

- Determine when the subject ate last

- Vacutainers and microtainer are placed in a biohazard labeled Ziploc bag and handed to the subject

- The subject will then take the vacutainers and microtainer to one of the Cayuga Medical phlebotomist.

Blood Specimen Collection

- Confirm that each of the vacutainers and the microtainers have labels

- Collect blood into each of the vacutainers and fingerstick blood into the microtainer *See following CDC protocol for collecting fingerstick blood in a microtainer for preparing dried blood spots*

- Collection order:
    1) Serum Separator Tube (SST) 10 ml
    2) BD ™ P800 Tube 2 ml
    3) Cell Preparation Tube (CPT) 8 ml
    4) Microtainer

- Vacutainers should be inverted eight times to mix, Microtainer ten times

- Store specimens in the refrigerator at 4°C until ready to transfer to the clinical laboratory for processing.

HMRU Standard Operating Procedure on Venipuncture

Definition:

Venipuncture is the collection of blood from a vein, usually for laboratory testing.

Need for Procedure:

The collection of blood from individuals participating in human metabolic studies is necessary to perform various clinical chemistry tests to gather data.

Standard Operating Procedure:

This SOP must be used for any research conducted in the HMRU that includes venipuncture. If any changes in the protocol are necessary, the changes in protocol must be addressed in the IRB proposal, and approved by the MD responsible for Medical Oversight of this procedure.

Any individual performing venipuncture must:

1. be approved to conduct venipuncture in the HMRU;

2. be current in Bloodborne Pathogen Training provided by Environmental Health and Safety;

3. be current in CPR/AED Training;

4. have another individual present in the HMRU should they need assistance; and

5. have completed Cornell University's Human Subjects training.

Equipment and Supplies:

Non-latex exam gloves, alcohol swab/pad, vacutainer(s), sterile double-ended safety needles or butterfly needles, non-latex tourniquet, gauze and tape or bandage, and sharps container.

Procedures:

1. Assemble all equipment and supplies (see Equipment and Supplies above) including vacutainer tubes labeled with human participant identifier number and a list of human participants with their associated identifier number; the tubes and the list should be provided by research study's Principal Investigator (PI).

2. Wash hands thoroughly and put on exam gloves. When multiple human participants are having venipuncture, exam gloves should be changed between participants, and hand sanitizer should be used each time gloves are changed.

3. Confirm the identity of the human participant by asking their name and/or their study ID number.

4. Explain the procedure and that the participant can end the procedure at any time for any reason.

5. Position human participant so that they are seated or reclined comfortably with their arm extended to form a straight line from the shoulder to the wrist. In either situation the human participant's arm and elbow should be firmly supported and not bent.

6. Check both arms to identify a vein, preferably one which runs along to inner part of the forearm close to the surface of the skin. Use of the median cephalic vein or median basilic vein are preferable. To avoid a hematoma major superficial veins should always be used. Select the larger and fuller vein. To prevent a hematoma from forming only the uppermost wall of the vein should be punctured. It's important to be sure that the needle completely penetrates the upper most wall of the vein. Failure to do this may allow blood to leak into the soft tissue surrounding the vein by way of the needle bevel.

7. Palpate and trace the path of the vein several times with your index finger.

8. Open packaged equipment and supplies in the presence of the human participant so that they can see that these items come from original packaging.

9. Tap the vein at the site of the draw with your index finger and third finger; this

will cause the vein to dilate.

10. Apply tourniquet above the desired site of puncture.

11. Ask human participant to form a fist holding it tightly. They should avoid opening and closing the fist as studies show that this can increase blood potassium.

12. Clean the draw site with an alcohol swab (70% isopropyl alcohol) in a circular motion from the center of the area and allow the alcohol to dry. DO NOT touch the venipuncture site again.

13. Using a sterile needle gently insert the needle into the vein at an angle roughly 15 degrees parallel to the vein making sure that the bevel of the needle is pointing up. Push the vacutainer tube into the holder and repeat as necessary. Vacutainers should be used in the following sequence, based on Clinical and Laboratory Standards Institute guidelines, to limit contamination of tube additives from tube to tube, which may cause erroneous result with some tests: Blood Culture, Royal Blue, Red (No additive), Light Blue (Sodium Citrate), Serum Separation, Green (Sodium Heparin), Yellow (ACD Solution), Pink (TMS), Pearl, and then Lavender (EDTA). **Engage the person in conversation as the needle is inserted and throughout the procedure to create a diversion. Verify that they are feeling well. If they indicate they are not feeling well immediately end the procedure.**

14. If the venipuncture is not successful, a second attempt can be made on the other arm. If the second attempt is not successful, the procedure should be terminated.

15. Once the last vacutainer tube has been filled remove the collection tube from the holder and remove the tourniquet. The tourniquet should always be removed before the needle is removed.

16. Remove the needle at the same angle it was inserted.

17. Dispose of the needle in the designated sharps container.

18. Using gauze apply pressure to the site of the venipuncture for 2 minutes or until

bleeding stops. **Ask participant to hold their arm above the level of their heart.**

19. Apply tape and gauze or a Band-Aid to the venipuncture site and discard used gauze in the sharps biohazard container.

20. Advise human participant to consult with primary care provider if any complications develop at the site of venipuncture. Ask them to also inform the investigators of any complications that may arise and provide them with a Venipuncture Information Sheet.

21. Remove gloves.

22. Wash hands.

P**ossible Risks to Human Participants:**

Drawing blood from a vein may cause discomfort, bruising, excessive bleeding or infection at the site of puncture. Fainting may occur.

Standard Operating Procedure for Dealing with Fainting:

Individuals having venipuncture may experience fainting (technically syncope). This is defined as the "sudden transient loss of consciousness with concurrent loss of postural tone". This usually results from any mechanism that decreases cerebral blood flow. The common faint is often precipitated by fear or anxiety or low blood sugar levels due to prolonged fasting and accompanied by dimming vision, sweating, nausea and loss of balance.

If the participant feels faint:

- Remain with the participant and summon help from a colleague.

- Help the participant lie down on the floor and raise legs above the level of the heart.

Do not attempt to move individual to the bed.

- When the participant no longer feels faint, allow the participant to sit up in place.
- Offer sips of juice
- Retain the participant for 15-20min to verify recovery.
- Complete an Incident Report as described below. If the participant loses consciousness:
- Remain with the participant and summon help from a colleague.
- Attempt to wake the participant by loudly calling his/her name and briskly tapping shoulder. If there is no response, call 911.
- Begin CPR.
- Continue CPR until emergency responders arrive.
- Notify MD and Research Advocate.
- Complete incident Report as described below.

Filing an Incident Report:

a. The completed form should be provided to the HMRU Operations Manager who will immediately share the report with the R.N/Participant Advocate, the M.D. responsible for medical oversight and/or with the Office of Risk Management. That physician and/or the Office of Risk Management will assess the incident and provide written advice for follow-up or recommendations for corrective actions if warranted. This documentation will be shared with the DNS Director, the DNS Executive Director for Finance and Administration, and the OVPR and will be retained in the HMRU Operations Manager's office.

b. If the event/incident is covered under Cornell University's IRB SOP 4 then the event/incident must be reported as required through the IRB.

Standard Operating Procedure for Dealing with Excessive Bleeding:

Excessive bleeding at the site of venipuncture may occur. Causes include: laceration of the vein, excessive tourniquet pressure, or failure to apply enough pressure after withdrawal of the needle.

1. If excessive bleeding occurs apply firm pressure at the site with the arm elevated above the level of the heart for several minutes.

2. If the bleeding is not controlled or if bleeding occurs in spurts (suggestive of arterial bleeding) the person performing venipuncture should:

a. Call 911 or ask a colleague to call 911 (the individual placing the call should follow the directions for calling emergency responders posted in the room they are calling from. The colleague should then go to the front of MVR to help guide emergency personnel to the HMRU).

b. File an Incident Report

CDC Protocol for Collecting Finger Stick Blood in a Microtainer® Tube for Preparing Dried Blood Spots

EnHance Saliva Specimen

Saliva specimens will be collected from all consenting participants including those that may potentially have blood-borne infectious disease.

Confidentiality and Safety

This section discusses concerns that participants may have about confidentiality and safety, as well as concerns regarding collecting samples in participants with blood-borne pathogens.

Confidentiality

During collection, all specimens will be labeled with a barcode and a unique ID number that is assigned during the initial registration of the participants. This unique identification number will be used during processing, testing, and storing of participants specimens. All information that pertains to the participant will be stored in a separate controlled database that can only be accessed by approved study personnel.

Safety

The Human Metabolic Research Unit has been designated as a blood collection facility and follows all the Universal Precautions in the collection, handling, and

disposal of blood, bodily fluids, and collection materials. Saliva collection will be assisted by

Materials

Saliva Tube Labels

Saliva Collection Supplies

Requirements per subject

- Oragene-DNA Collection Kit

Preparation for Saliva Specimen Collection

- A label will be placed on the Oragene-DNA Collection tube during the check- in process.
- Determine if the subject has chewed gum, ate, drank or smoked within the last 30 minutes.
- The collection tube will be are placed in a biohazard labeled Ziploc bag along with the blood collection supplies and handed to the subject.
- After blood draw, subjects will move on to saliva collection station and either a Cornell volunteer or a representative from DNA Genetek will assist in collection.

Saliva Specimen Collection

- If subject has ate, drank, smoke or chewed gum within 30 minutes prior to collection, have the subject proceed first with the blood draw and then have them wait until at least 20 minutes have passed.

- Verify that a label has been attached to the saliva collection tube.

- Tell the subject to relax and rub the cheeks for 30 seconds. If the subject has difficulty in creating saliva, place a ¼ tsp of table sugar on the tongue.

- The subject is to spit into the tube until the volume of fluid reaches the fill line.

- Close the lid and firmly push the lid down until there is a loud click.

- Remove the top portion of the tube or funnel, cap the tube tightly, and shake the tube for 5 seconds.

- Sample can then be stored at room temperature until processed.

Saliva Collection Standard Operating Procedure

1. At check-in, the participant selected for saliva donation will be instructed to not eat, drink, smoke or chew gum 30 minutes before giving a saliva sample.

2. Saliva collection will occur in the anthropometry data collection station by the anthropometrist. It takes about 2-5 minutes for an individual to deliver a saliva sample.

3. When the participant arrives to anthropometry with a checklist indicating they are to donate saliva, the anthropometrist will verify that the participant has not consumed food or beverage other than water, smoked or chewed anything within 30 minutes prior to sample collection. If the participant does not meet this specification or refuses to donate saliva, the anthropometrist will complete the anthropometry without collecting saliva, mark on the participant's checklist that saliva collection was not completed, and specify the reason.

4. Before spitting, tell the subject to relax and gently rub the cheeks for 30 seconds to stimulate saliva glands.
5. While the participant does this, the anthropometrist should don gloves, label the plastic box housing the saliva collection tube with the participant ID, and remove and open the tube.

6. If it is difficult to produce saliva, place a small amount of sugar on the tongue. Sugar packets will be available for this purpose in each anthropometry station; only a fraction of the packet is needed to induce salivation.

7. The anthropometrist should hand the tube to the participant and ask him/her to spit into the Oragene-DNA vessel until the saliva reaches the fill line (do not include bubbles in the volume).

8. Once the participant has completed filling the vessel, the Oragene vessel should be taken from the subject and closed by the gloved anthropometrist.

9. The anthropometrist will hold the tube upright with one hand and then close the lid with the other hand. Push firmly until a loud click is heard.

10. The liquid preservative from the cap will be released; be sure that the cap is tightly closed.

11. While holding the tube upright, unscrew the funnel cap from the lower tube. Recap with the small cap included in the kit. Make sure it is recapped tightly.

12. Shake the capped tube for 5 seconds and place the tube back into the original plastic package, which is labeled with the participant ID. Set the completed saliva tubes in a separate place to drop off at the lab.

13. Samples will be stored at room temperature until processed and delivered to lab periodically throughout the day.

14. When tubes arrive in the laboratory, archival bar code labels with the sample ID number (not the participant id number) will be placed directly on the tube containing saliva, after verifying that the sample ID number is correct (check the participant id number on outer tube against label sheet).

15. Tubes will be placed in freezer boxes, and stored at -80.

Human metabolic Research Unit (HMRU)
-80°C Freezer Storage Protocol and Standard Operating Procedure

The HMRU provides rental freezer storage space for a fee, in its -80°C freezers, for researchers in the Division of Nutritional Sciences. Though samples can be stored in the HMRU freezers for an indefinite time period researchers are asked to store only samples that will be useful for future studies. If a study is completed and samples are no longer useful, investigators should make a request to have the samples destroyed.

Samples to be stored in the HMRU -80 freezers:

- Must be clearly labeled but include ***no identifiers*** that would indicate a human participant's identity;
- Must have water resistant cryogenic labels affixed;
- Must be labeled (if handwritten) with permanent marker (preferably black) that are easily read;
- Must be contained in appropriate 1.5-2.0 ml vials that can withstand -80°C temperatures and have screw caps. Eppendorf tubes with snap caps are highly discouraged and researchers wishing to use inappropriate tubes accept responsibility for any samples damaged due to the container;
- Must not be filled to the rim - but should have some space for expansion during freezing; and
- Must be in freezer boxes – which the HMRU can provide. If an investigator prefers to provide their own box, it must be a 2" cardboard freezer box with 81 place dividers;

Sample management, oversight, security and safety:

- All samples stored in HMRU freezers are inventoried with *Freezerworks* software.
- The *Freezerworks* inventory can only be accessed by the individual identified as the "administrator", which at present, is the Manager of the HMRU's Clinical Chemistry Laboratory, Victoria Simon.
- The *Freezerworks* inventory is password protected and back-up on an external drive.
- The computer used for the *Freezerworks* inventory is a stand-alone unit (not networked in any way).
- The administrator is able to grant limited *Freezerworks* access to researchers who are customers.

- The -80 freezers are kept locked. Only two keys are available; one is held by the Manager of the Clinical Chemistry Laboratory/*Freezerworks* administrator and the other is in an undisclosed location away from the room containing the HMRU freezers. The location of this key is known only to Facilities staff, the Manager of the Clinical Chemistry Lab, the HMRU Operations Manager, and selected individuals approved by the Manager of the Clinical Chemistry Laboratory Manager.
- The HMRU freezers are presently located in 266-W MVR in the HMRU. They will be relocated to HEB 248 in July/August of 2011. These rooms are locked and access is controlled by the HMRU Operations Manager.
- The HMRU's -80 freezers are automatically switched to the College of human Ecology's Emergency Power System in case of whole building electrical outage.
- The HMRU's -80 freezers are connected to the University's Energy Management and Control System (EMCS) which is manned 24 hours a day, 7 days a week. If a freezer's temperature rises above a certain threshold, and alarms, the HMRU Operations Manager is contacted immediately by EMCS staff to rectify the situation.
- Should a HMRU -80 freezer fail, samples, which are organized by labeled rack, will be moved to another freezer in the HMRU.

Updated May 12, 2011

SECTION 5: **Physical Assessment**

- Anthropometry Overview
- Anthropometry Equipment and Supplies
- Anthropometry Data Collection Operation Procedures
- Dual Energy X-Ray Absorptiometry Overview
- Dual Energy X-Ray Absorptiometry Equipment and Supplies
- Dual Energy X-Ray Absorptiometry Scan Operating Procedures

Background of Anthropometric Measurements

Anthropometry is the study of the measurement of the human body in terms of the dimensions of bone, muscle, and adipose (fat) tissue. The word "anthropometry" is derived from the Greek word "anthropo" meaning "human" and the Greek word "metron" meaning "measure" (Ulajaszek, 1994). The field of anthropometry encompasses a variety of human body measurements. Weight, stature (standing height), recumbent length, skinfold thicknesses, circumferences (head, waist, limb, etc.), limb lengths, and breadths (shoulder, wrist, etc.) are examples of anthropometric measures.

Several indexes and ratios can be derived from anthropometric measurements. Perhaps the most well-known indicator of body fatness is the body mass index or "BMI." BMI values are calculated for EnHANCE participants using measured height and weight values as follows: weight (kilograms)/height (meters)^2. BMI criteria are used to screen for weight categories: underweight (BMI values < 18.5), normal or desirable weight (BMI values 18.5-24.9), overweight (BMI values 25.0-29.9), obese-Class I (BMI values 30.0-34.9), obese-Class II (BMI values 35.0-39.9), and extremely obese (BMI values > 40.0) (National Institutes of Health, 1998). EnHANCE BMI results will be used to track weight trends in Cornell students.

Purpose of Anthropometrics

The purpose of the EnHANCE anthropometry component is to collect high quality body measurement data using standardized examination procedures and calibrated equipment. Accurate data are fundamental to the evaluation of anthropometric trends over time. It is crucial for researchers to know that the differences evident between EnHANCE anthropometric data collected at different time points reflect true differences in the NHANES body measurement values rather than technician and protocol variability and/or measurement error. In order to ensure the collection of high quality data, EnHANCE staff are trained to follow standardized examination protocols, to calibrate equipment according to a prescribed schedule and method, and to measure and record the survey data with precision. Additionally, retraining sessions, gold standard examinations performed by expert examiners, and field observations, are conducted on a regular basis to reinforce the importance of measurement precision and standardized data collection methodology.

Importance of Anthropometric Data

Anthropometry is a key component of nutrition status assessment in children and adults (Simko, 1995). Anthropometry data from population based studies such as the National Health and Nutrition Examination Survey (NHANES) have been

used to track growth and weight trends in the U.S. population for more than 30 years (Flegal, 2002; Hedley, 2004). The anthropometric data for infants and children reflect general health status and dietary adequacy and are used to track trends in growth and development over time. The CDC has used NHANES data to produce national reference standards or "growth charts." These CDC growth charts are used extensively by pediatricians and researchers in the U.S. and abroad (Kuczmarski, 2002). A description of the history and statistical methodology that was used to develop the latest growth charts can be found at the CDC web site: http://www.cdc.gov/growthcharts/. There has been highly publicized NHANES data trends showing increases in overweight and obesity among U.S. children and adolescents (Ogden, 2002) which underscores the importance of identifying and tracking anthropometric trends among college students at Cornell University.

The EnHANCE anthropometric data are used to evaluate health and dietary status, disease risk, and body composition changes that occur over the college experience. Researchers in diverse health disciplines including cardiovascular health, microbiology, nutrition, and occupational health use anthropometric data to examine health status and health risk factors in this population. Functional status and general well-being are inevitably linked to weight status. A recent analysis of the NHANES 1999-2002 data using BMI criteria determined that overweight and obese individuals were more likely to report fair or poor health (rather than good or

excellent health), activity limitations, and more health provider visits per year compared to normal weight adults (McDowell, 2006).

Waist circumference measurements are widely used in epidemiologic research to assess cardiovascular disease risk. Specifically, individuals who have large deposits of abdominal fat tissue are at increased risk for hypertension, adult-onset diabetes mellitus, cardiovascular disease, gallstones, arthritis, and some forms of cancer. Hip circumference measurements also indicate a specific pattern of fat deposition that helps to describe disease risk.

Although much of the attention in today's popular media is on overweight and obesity, EnHANCE data can also be used to track trends in underweight. Underweight may occur due to a variety of factors, such as: poor nutrition and eating habits, substance abuse, chronic illness – physical or mental, medication therapy, surgical procedures, and other health problems.

Overview of EnHANCE Anthropometry Examination

The EnHANCE anthropometry or body measures examination is conducted in the Human Metabolic Research Unit (HMRU) in Martha Van Rensselaer Hall located on the Central Campus of Cornell University. All EnHANCE study participants (SPs) are eligible for the anthropometry examination component. The complete set of measurements includes weight, height, waist circumference and hip

circumference. The anthropometry examination protocol and procedures are described later under the section titled, Examination Protocol. An EnHANCE staff person trained in anthropometric assessment and technique, henceforth referred to as the anthropometrist, and data recorder work as a team to collect the anthropometry data. Examination results are saved to the study database using software developed with the Survey Research Institute at Cornell University.

Role of Anthropometrist and Data Recorder

The anthropometry component is staffed by anthropometrists and data recorders. The EnHANCE anthropometrists may serve as examiners or recorders for this component. In addition, other HMRU staff is trained to record anthropometry examination results. In the event that two anthropometrists are assigned to work as a team, each anthropometrist should complete the entire examination by measuring and recording data.

The examiner will position the participant, take all measurements, and tell the recorder the measurement values to record as described in the section titled, Examination Protocol. The recorder will enter the examination results on to an anthropometric data form for later date entry or directly into an electronic database setup and managed by SRI. The data recorder should always ask the examiner to verify the measurement value before proceeding to the next measurement. If a

measurement or recording error was made, the recorder will enter the correct value; if the original value is correct, the value is retained. Since EnHANCE includes participants of all shapes, sizes, and body builds, some unusual values are legitimate; however, measurement and recording errors do occasionally occur. Therefore, teamwork between the examiner and recorder is essential in order to measure and record accurate data.

Another important duty of the data recorder is to help the examiner position the participants during their examination. In this role the recorder also alerts the examiner if the respondent needs to be repositioned. For example, when the waist circumference is determined, the recorder checks that the tape measure lies parallel to the floor and snug but without compressing the skin. Assistance is needed because several body sites must be aligned to obtain an accurate measurement. Lastly, the recorder marks body sites that are measured by the examiner and hands equipment and supplies to the examiner when needed.

Overview of Equipment

A brief description of the anthropometry component equipment is provided below. At the beginning and end of each stand, the anthropometrist will take an inventory of all component-specific equipment and supplies. Any needed items should be noted on the inventory sheet; reported to the EnHANCE supervisory

personnel.

Equipment

1. Calibration Weights: The HMRU has 10-kilogram weights. The weights are used to calibrate the digital weight scale at the beginning of a stand; and the digital weight scale daily and at the beginning, middle, and end of a stand.

2. Digital Scale: The digital weight scale used to weigh SPs is in the hallway across from the room with the DXA equipment. The scale should not be moved and left stationary. Record the weight to the nearest 0.1 (tenth) of a kilogram.

3. Stadiometer: The stadiometer is used to measure standing height of persons older than 2 years. Record the height to the nearest 0.1 (tenth) of a centimeter.

4. Measuring tape: Measuring tape is used for assessing body circumferences (i.e. hip and waist). Record the circumference to the nearest 0.1 (tenth) of a centimeter.

Examination Protocol

General Guidelines for Measuring and Recording

Follow the guidelines below when taking anthropometric measurements and

subsequently recording the data:

1. Always tell the SP what you are going to do before you do it. Explain what you are doing and why, such as before adjusting the pants down to measure the waist circumference. Do not comment about the SP's body in any way. Maintain professionalism at all times.

2. Measure the right side of the body. If the SP has a physical disability or abnormality on the right side, the examiner should still attempt to measure the right side. Only

take measurements on the left side when the SP has a cast, prosthesis, or amputation on the appropriate right limb; or for some other reason the measurement cannot be taken accurately on the right side.

3. Turn the SP in the direction needed for a given measure. This promotes efficiency during the examination by saving time and avoiding unnecessary movement on the part of the examiner. In other words, do not move yourself around the SP.

4. Position the zero end of the measuring tape below the measurement value. With respect to circumference measures, do not take any measurement readings with the zero end of the tape placed above the section of the tape with the result.

5. Avoid parallax when taking measurement readings. Parallax describes the phenomenon where an observer reads a different value on a measuring device depending on the angle from which it is viewed. Parallax is a common cause of data error especially for measurements obtained using the skinfold calipers and measurement tape. The examiner should read the measurement with his or her line of sight directly in front of the value rather than at an angle or from even slightly off to the side.

6. Record all measurements to the nearest tenth of a centimeter (0.1 cm). Always verify the result before advancing to the next measure.

Examination Procedures

Body Weight

- The digital scale is stationary and should not be moved.

- Calibrate scale using the calibration weights. Place one 10 kg weight on the scale and adjust the display to read 10.00 kg. To maintain good quality control, calibration should be done at the beginning and periodically throughout each day that weight data is being collected.

- Make sure the scale is standing evenly on the floor.

- Ask the SP to remove all items from pants and shirt pockets and set their items aside within in sight. Ask the SP to remove bulky jewelry and extra layers of clothing so that they are in the lightest clothing comfortable, such as a t-shirt and pants.

- Ask the SP to step onto the scale facing the digital display. Assure that the SP is not holding on to anything to support their body weight.

- After the readout on the digital display stabilizes, record the weight in kg to the nearest 0.1 kg.

- Instruct the SP to step off the scale.

Standing Height

- Position the SP standing in a location where the portable stadiometer can be used. Ask him or her to remove any hair ornaments, jewelry, buns, or braids from the top of the head.

- First, have the SP stand up straight against the backboard with the body weight evenly distributed and both feet flat on the platform. Instruct the SP to stand with the heels together and toes apart. The toes should point slightly outward at approximately a 60° angle.

- Check that the back of the head, shoulder blades, buttocks, and heels make contact with the backboard.

- NOTE: Depending on the overall body conformation of the individual, all four contact points
    - head, shoulders, buttocks, and heels – may not touch the stadiometer backboard. For example, some overweight SPs cannot stand straight while

touching all four contact points to the backboard. In such instances it is important to obtain the best measurement possible according to the protocol.

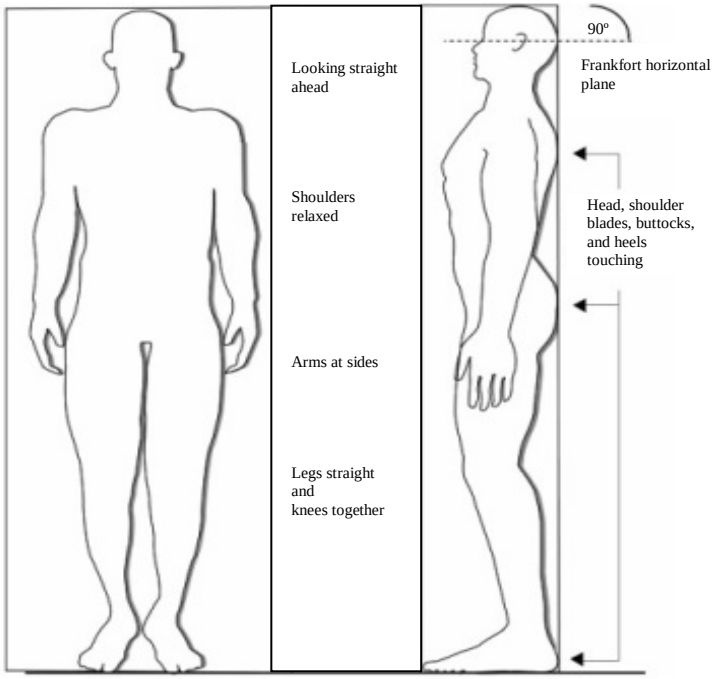
- Second, align the head in the Frankfort horizontal plane. The head is in the Frankfort plane when the horizontal line from the ear canal to the lower border of the orbit of the eye is parallel to the floor and perpendicular to the vertical backboard. See the figure below for help correctly positioning the SP for standing height measurement.

- Many people will assume this position naturally, but for some SPs the examiner may need to gently tilt the head up or down to achieve the proper alignment.

- Instruct the SP to look straight ahead.

- Next, lower the stadiometer head piece so that it rests firmly on top of the participant's head, with sufficient pressure to compress the hair.

- Instruct the SP to stand as tall as possible, take a deep breath, and hold this position. The act of taking a deep breath helps straighten the spine to yield a more consistent and reproducible stature measurement. Notice that the inhalation will cause the headpiece to rise slightly.



Abdominal (Waist) Circumference

- Position the SP. Instruct the participant to gather his or her shirt above the waist, cross the arms, and place the hands on opposite shoulders. Demonstrate the desired position of the arms. It may help to tell SPs to think of giving themselves a hug. If necessary, lower the pants and underclothing to slightly below the waist. Again, always tell the SP what you are going to do before you do it.

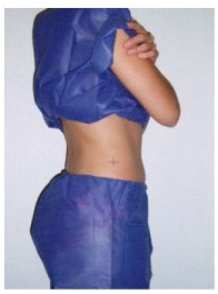
- Mark the Measurement Site. Visually identify the waist as the narrowest part of the SP's abdomen that is below the ribcage and above the hip bones. See the pictures below for help identifying and measuring the waist.

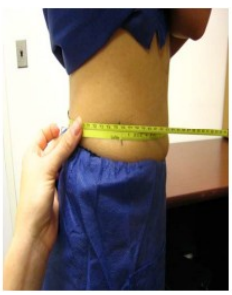
- NOTE: If it is difficult to identify the narrowest circumference of the abdomen, such as on SPs with larger waists, then stand on the participant's right side, begin inferior to the midaxillary line (toward the SPs front) and palpate the hip area to locate the right ilium of the pelvis. With the cosmetic pencil draw a horizontal line just above the uppermost lateral border of the right ilium. Cross this mark at the midaxillary line which extends from the armpit down the side of the torso.

- Take the Measurement. Extend the measuring tape around the waist. Position the tape in a horizontal plane at the level of the measurement mark. Use the wall mirror to ensure the horizontal alignment of the tape. While the examiner remains on the SPs right side, the recorder will come around to the SPs left side to check the placement of the tape.

- Check that the tape sits parallel to the floor and lies snug but does not compress the skin. Always position the zero end of the tape below the section containing the measurement value.

- Record the result to the nearest 0.1 cm from taking the measurement at the end of the SPs normal expiration.





Hip Circumference

- Position the SP so that you are standing on the right side of the SP. Instruct the participant to gather his or her shirt above the navel so the hips can be visually identified easily. Again, always tell the SP what you are going to do before you do it.

- Mark the Measurement Site. Visually identify the hips as the widest part of the SP's midsection that is below the waist and above the middle of the thighs. See the picture below for help identifying the appropriate location for hip girth measurement.

- Take the Measurement. Extend the measuring tape around the widest part of the hips. Position the tape in a horizontal plane at the level of the measurement mark. Use the wall mirror to ensure the horizontal alignment of the tape. While the examiner remains on the SPs right side, the recorder will come around to the SPs left side to check the placement of the tape.

- Check that the tape sits parallel to the floor and lies snug but does not compress the skin. Always position the zero end of the tape below the section containing the measurement value.

- Record the result to the nearest 0.1 cm from taking the measurement.

Post-Examination Procedures

- Courteously thank the SP for their cooperation and return all personal items set aside during the anthropometry.

Dual Energy X-Ray Absorptiometry (DXA)

Overview

Dual energy x-ray absorptiometry (DXA) is used to assess the density of the body, and precisely map body composition electronically. The exposure to radiation is very low, lower than a dental x-ray, and there are no known risks of this low level of radiation exposure. The DXA equipment used in EnHANCE is exclusively operated by a New York State licensed radiological technician specifically trained to operate the DXA in the HMRU.

DXA Information Sheet and Medical Oversight Questionnaire

- In advance of the DXA scan the Principal Investigator (PI) will provide the human participant with the attached DXA Information Sheet, Questionnaire, and the Consent Form approved by the IRB explaining that these documents should be reviewed and completed the day of the scan.

- The PI or his or her designee will review these documents with the human participant, ask the human participant if they have any questions, and obtain written consent.

- On the day of the DXA scan the LRT will confirm the identity of the human participant by asking their name. The LRT will obtain their height and weight and record this information on their questionnaire.

- The LRT will provide any female human participant between the ages of 11 and 55 with a urine pregnancy test kit. If the test is positive the LRT will inform the participant and refer them to their personal physician. If the test is negative the

LRT will confirm the negative result by signing the Questionnaire. A DXA scan will not be performed on any female who tests positive for pregnancy.

- The LRT will review and update the quality compliance log documenting operation and stability of DXA based on the daily/weekly DXA phantom scans. Division of Nutritional Sciences (DNS) Human Metabolic Research Unit (HMRU) Standard Operating Procedure.

- The LRT will ask the subject to remove jewelry, body piercings, clothing with zippers or metal buttons, etc. and to put on a gown or other unrestrictive clothing for the scan.

- LRT will position the patient on the DXA table and explain the procedure requesting that the patient remain still during the entire scan.

Equipment and Supplies

- DXA machine
- urine pregnancy test for female subjects
- exam gown (optional)
- all calibration and positioning aids needed for site specific DXA scans

Service Providers

All DXA scans in humans will be undertaken by a Radiologic Technologist licensed by the New York State Department of Health who has fulfilled all training requirements as mandated by Cornell University's Environmental Health and Safety.

Human Metabolic Research Unit Division of Nutritional Sciences Medical Oversight Plan Dual Energy X-Ray Absorptiometry (DXA)

Definition:

Dual energy X-ray absorptiometry (DXA) is a highly sophisticated and accurate imaging technology that utilizes two x-ray beams with differing energy levels to measure body compartments. The radiation dose is much less than a standard chest X-ray. DXA is most widely used to measure bone density. It can also be used to measure total body composition including fat content and muscle mass.

Need for Procedure:

In human metabolic research, measuring bone density, total body composition, and fat content, with a high degree of accuracy, is necessary. Ascertaining body composition is important as visceral fat is thought to be important in the metabolic regulation of glucose homeostasis and reproduction.

DXA Standard Operating Procedure:

This SOP must be used for any research conducted in the HMRU that includes a DXA scan. If any changes in the protocol are necessary, the changes in protocol must be addressed in the IRB proposal, and approved by the MD responsible for medical oversight of this procedure.

Any individual performing a DXA scan must:

1. be a licensed radiological technician (LRT) in the State of New York;
2. be listed on the Permit issued by Environmental Health and Safety (EH&S);
3. be certified by the manufacturer (Hologic, Inc.) to operate the HMRU's Discovery-A DXA;
4. be approved by the individual responsible for medical oversight for the procedure;
5. have another individual present on the HMRU should they need assistance;
6. have completed Cornell University's Human Subjects training.

Instrumentation:

The instrument used in the HMRU to perform DXA scans is a Hologic, Discovery-A, DXA scanner. The unit requires a series of quality assurance phantom scans before each use. This unit is also subject to annual certification by the manufacturer and other inspections by Cornell's Environmental Health and Safety and the New York State Department of Health.

Procedures for conducting a DXA scan:

1. In advance of the DXA scan the Principal Investigator (PI) will provide the human participant with the attached DXA Information Sheet, Questionnaire, and the Consent Form approved by the IRB explaining that these documents should be reviewed and completed the day of the scan.

2. The PI or his or her designee will review these documents with the human participant, ask the human participant if they have any questions, and obtain written consent.

3. On the day of the DXA scan the LRT will confirm the identity of the human participant by asking their name. The LRT will obtain their height and weight and record this information on their questionnaire.

4. The LRT will provide any female human participant between the ages of 11 and 55 with a urine pregnancy test kit. If the test is positive the LRT will inform the participant and refer them to their personal physician. If the test is negative the LRT will confirm the negative result by signing the Questionnaire. A DXA scan will not be performed on any female who tests positive for pregnancy.

5. The LRT will review and update the quality compliance log documenting operation and stability of DXA based on phantom scans.

6. The LRT will ask the subject to remove jewelry, body piercings, clothing with zippers or metal buttons, etc. and to put on a gown or other unrestrictive clothing for the scan.

7. LRT will position the patient on the DXA table and explain the procedure requesting that the patient remain still during the entire scan.

8. After the scan is complete the LRT will wipe the bed of the table with disinfectant.

SECTION 7: Literature Cited in the Appendix

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