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A Population-Based Nutrition Intervention in College Students

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A POPULATION-BASED NUTRITION INTERVENTION

IN COLLEGE STUDENTS

BY

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ABSTRACT

Coronary heart disease (CHD) is a leading cause of death in young adults and at least half of college students ages 18-24 have CHD risk factor. Unhealthy dietary choices made by college students contribute to the development of CHD risk factors. Eighty-percent of heart disease is preventable through diet and lifestyle and college students are ideal targets for prevention efforts since they are in the process of establishing lifestyle habits, which track forward into adulthood. The purpose of this dissertation is to provide evidence for the need to target this age group before disease progression occurs and to present the results of a population-based intervention to increase whole grains and improve CHD factors in college students.

Manuscript 1 "*Coronary Heart Disease Risk Factors in College Students*" is a narrative review paper highlighting the need for improved heart disease risk assessment and awareness in college students. This review provides pathological evidence along with current risk factor prevalence data to demonstrate the need for early detection. The impact of diet is addressed and population-based strategies are presented as cost-effective ways to produce wide-scale risk reduction.

Manuscript 2 "*A Population-Based Nutrition Intervention to Increase Whole Grain Intake in College Students*" is a primary research paper on the impact of a nutrition messaging intervention in campus dining halls. Results indicate that a 6-week messaging intervention in campus dining halls had a positive impact on whole grain consumption and on HDL-C in college students. Future research should focus on population-based approaches on college campuses to prompt students to make healthier selections.

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PREFACE

This dissertation was prepared in manuscript format.

Manuscript 1 "Coronary Heart Disease Risk Factors in College Students" is published in Advances in Nutrition (Arts J, Fernandez ML, Lofgren IE. Coronary Heart Disease Risk Factors in College Students. *Adv Nutr*. 2014; 5: 177-187).

Manuscript 2 "A Population-Based Nutrition Intervention to Increase Whole Grain Intake in College Students" will be submitted to the *American Journal of Health Promotion.*

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"Coronary Heart Disease Risk Factors in College Students" is published in
Advances in Nutrition.

Abstract:

More than one-half of young adults ages 18-24 years have at least one coronary heart disease (CHD) risk factor and nearly one-quarter have advanced atherosclerotic lesions. The extent of atherosclerosis is directly correlated with the number of risk factors. Unhealthy dietary choices made by this age group contribute to weight gain and dyslipidemia. Risk factor profiles in young adulthood strongly predict long-term CHD risk. Early detection is critical to identify individuals at risk and to promote lifestyle changes before disease progression occurs. Despite the presence of risk factors and pathological changes, risk assessment and disease prevention efforts are lacking in this age group. The majority of young adults are not screened and are unaware of their risk. This review provides pathological evidence along with current risk factor prevalence data to demonstrate the need for early detection. Eighty-percent of heart disease is preventable through diet and lifestyle and young adults are ideal targets for prevention efforts since they are in the process of establishing lifestyle habits, which track forward into adulthood. This review aims to establish the need for increased screening, risk assessment, education and management in young adults. These essential screening efforts should include assessment of all CHD risk factors and lifestyle habits (diet, exercise and smoking), blood pressure, glucose and body mass index in addition to the traditional lipid panel for effective long-term risk reduction.

Abbreviations: CHD, coronary heart disease; CVD, cardiovascular disease; AHA, American Heart Association; NHLBI, National Heart, Lung, and Blood Institute; CDAH, Childhood Determinants of Adult Health; TC, total cholesterol; BP, blood

pressure; LDL-C, LDL cholesterol; HDL-C, HDL cholesterol; SBP, systolic blood pressure; PDAY, Pathobiological Determinants of Atherosclerosis; cIMT, carotid artery intima media thickness; i3C, International Childhood Cardiovascular Risk Consortium; NGHS, National Heart, Lung, and Blood Institute Growth and Health Study; NHANES, National Health and Nutrition Examination Survey; WC, waist circumference; VLDL-C, VLDL cholesterol; DBP, diastolic blood pressure; American Academy of Pediatrics, AAP; US Preventive Services Task Force, USPSTF; National Cholesterol Education Program Adult Treatment Program III, NCEP ATP III; American College of Cardiology, ACC

Introduction:

Coronary heart disease (CHD) risk in young adults, ages 18-24, is underestimated despite the high prevalence of CHD risk factors (1-4) and early signs of atherosclerosis in this age group (5, 6). Obesity has more than doubled in children and more than tripled in adolescents over the past 30 years (7). This weight gain tracks forward and worsens in young adulthood (8). Heart disease risk increases by 2-4% for each year a young adult is obese (9). As many as 33% of young adults are overweight (1) and this excess weight leads to dyslipidemia (10) and increases in metabolic syndrome (11), diabetes (12) and CHD (3) risk. Coronary heart disease accounts for 50% of cardiovascular disease (CVD) deaths and is one of the leading causes of death in young adults (13). Coronary heart disease costs the US $108.9 billion each year in health care services, medications and lost productivity (14), which is more than any other disease. A death occurs from CVD every 40 seconds in the US, which would wipe out a college campus of 25,000 in less than 12 days (15).

More than half of young adults have at least one CHD risk factor and this greatly increases lifetime heart disease risk (16). Since many CHD risk factors surface in adolescence (13, 17-19) and track forward to adulthood (20), the American Heart Association's (AHA) 2020 Strategic Impact Goals along with the National Heart, Lung and Blood Institute's (NHLBI) 2012 Expert Panel on Integrated Guidelines for Cardiovascular Health and Risk Reduction in Children and Adolescents (21) emphasize primordial prevention beginning in childhood and adolescence (16). This concept of primordial prevention was introduced by Strasser in 1978 (22) and focuses on preventing the development of risk factors themselves (16). Dietary modifications are central to this approach (16).

Despite screening recommendations for all adults over age 20 (23, 24), < 50% of women and < 40% of men of this age are screened for CHD risk (25). In addition, the majority of young adults are unaware of their risk (26). Until primordial prevention strategies are implemented to avoid risk factor development in the first place, there is a need for improved screening, risk assessment, management and education in this age group. Early detection and intervention are critical since 80% of CVD events are preventable through diet and lifestyle (27). Diets low in saturated fat and high in fruits and vegetables reduce the risk of new cardiac events by 73% (28). Despite this evidence, young adults have high intakes of solid fats, added sugars (29) and sodium (1, 30), along with inadequate intakes of fruits and vegetables (31), whole grains (32, 33) and fiber (30). The AHA recently issued a scientific statement recommending reductions in added sugar intake in response to research linking sugar to excess energy intake, obesity, dyslipidemia and CHD risk (34). Sugar consumption

has increased by nearly 20% from 1970 to 2005, supplying almost 500 kcal/day (35). Adolescents consume more sugar than any other age group (549 kcals) (34) and this continues into young adulthood (29). Collectively, these poor dietary choices contribute to the high prevalence of CHD risk factors in this age group (36-39).

In 2011, Magnussen et al. (40) reviewed findings from two population-based studies in Finland that support the ability to avoid or delay premature atherosclerosis by prevention efforts early in life. In 2012, Rubin et al. (41) reviewed atherosclerotic versus non-atherosclerotic causes of CHD in young adults. Although these two recent reviews have examined the causes of CHD in young adults (40, 41), there is a need for a review of pathological evidence along with recent risk factor and screening data to highlight the need for increased screening, risk assessment, education and management in this age group.

The purpose of this review is to demonstrate the need for improved screening and risk awareness of CHD in young adults by revealing pathological changes that start in childhood and manifest themselves in young adult CHD risk factors. In addition, successful population-based prevention/treatment strategies used in other populations will be discussed with a focus on how these strategies can be applied to this age group.

Current Status of Knowledge:

Progression of Atherosclerosis

Childhood Risk Factors Correlated with Extent of Lesions

Research indicates that atherosclerosis has childhood roots. In the 1950s and 60s Holman et al., McGill et al. and Strong et al. (42-44) were the first to show that

fatty streaks were present in the aortas of children as young as 3 years of age, without a congenital heart condition, and progressed to fibrous plaques by the second decade of life. This evidence of atherosclerosis early in life led to large, observational studies in the 1970s and 1980s (6, 45-47) to examine childhood CVD risk factors, lifestyle patterns and the development of CVD later in life.

The Muscatine, Bogalusa Heart, Cardiovascular Risk in Young Finns, and Childhood Determinants of Adult Health (CDAH) studies are the largest cohorts that tracked childhood risk factors into adulthood, with an average follow up time of 30 years (48) (**Table 1**). The Muscatine Study (1970) indicated that risk factors predictive of CHD in adulthood, such as total cholesterol (TC), TG, blood pressure (BP) and obesity, are prevalent in school-aged children (47). The Bogalusa Heart Study (1973) linked these childhood risk factors with atherosclerosis in young adults. This autopsy study showed that the extent of atherosclerotic lesions was directly correlated to antemortem levels of TC, TG, LDL cholesterol (LDL-C), HDL cholesterol (HDL-C), BP, BMI and cigarette smoking in young adults (6, 49). The Cardiovascular Risk in Young Finns Study (1980) provided longitudinal data to show that CHD risk factors such as TC, HDL-C, LDL-C, TG, BMI, and systolic blood pressure (SBP) track forward to adulthood (8, 45). Associations between childhood risk factors and those measured 27 years later were strongest for TC and LDL-C. In addition, dietary intake and patterns showed significant tracking over time as individuals in the highest quintiles of either a traditional Finnish dietary pattern or a health-conscious dietary pattern remained in the same quintile twenty-one years later (50). The CDAH study (1985) supported the findings from the previous cohort studies

and further demonstrated that healthy lifestyle behaviors such as consuming a diet low in saturated fat and sodium and being physically active were associated with a better cardiovascular risk profile even in young adults (51). Each of these studies contributed to the understanding that early life factors influence the development of adult CVD (40).

Further evidence was provided by the Pathobiological Determinants of Atherosclerosis (PDAY) study (1987), which examined the onset and progression of atherosclerosis in over 3,000 subjects in the US ages 15-34 years (52). Although earlier autopsy studies (1970's and 80's) indicated that risk factors for CHD were associated with atherosclerosis in adults, PDAY and Bogalusa provided evidence for this in children and young adults (6, 52). PDAY found intimal lesions in all aortas and more than half of the right coronary arteries of adolescents ages 15-19 years (5). These lesions progress to more advanced, clinically significant lesions by young adulthood (52).

As many as 10-20% of young adults have advanced atherosclerotic lesions (53). This progression is correlated with the number of CHD risk factors; young adults with ≥ 3 childhood risk factors had a 9-fold increase in atherosclerotic plaque area compared to those with none (6). As shown in **Table 1**, risk factors in childhood were shown to be strong predictors of preclinical atherosclerosis even after adjustment for adult risk factors (54, 55). These findings are critical from a prevention standpoint as those at risk of developing atherosclerosis can be identified and treated decades before clinical manifestation of disease.

Childhood Risk Factors Associated with Preclinical Disease Markers

Hyperlipidemia early in life is directly related to pathologic changes and functional abnormalities and strongly predicts CHD in adulthood (56). The development of non-invasive techniques in the 1990s to measure preclinical markers such as carotid artery intima media thickness (cIMT), arterial endothelial function and coronary artery calcification allowed for the assessment of structural and functional changes indicative of preclinical atherosclerosis (57, 58). The Muscatine, Bogalusa Heart, Cardiovascular Disease Risk in Young Finns and CDAH studies provided evidence that these preclinical markers are associated with risk factors in childhood. Preclinical markers are strongly associated with risk of CVD events (57) but longer follow-up times are needed to directly link childhood risk factors with clinical events (40). In the absence of this data, these surrogate disease markers serve as intermediate end-points to assess the effects of risk factors and risk factor interventions before the clinical manifestation of disease and provide a better understanding of the evolution of CVD across the lifespan (40, 48).

In an attempt to address the difficulties in obtaining sufficient follow-up CVD events data, the International Childhood Cardiovascular Risk Consortium (i3C) was developed in 2011 to pool data previously collected from childhood to adulthood in large, multi-country cohort studies for a meta-analysis to increase the power to link longitudinal risk data with CVD events. Data from the four largest cohort studies (Muscatine, Bogalusa, Cardiovascular Disease Risk in Young Finns, and CDAH) and from similar smaller studies (Minneapolis Childhood Cohort Studies, Princeton Lipid Research Clinics Study, National Heart, Lung, and Blood Institute Growth and Health

Study (NGHS)) were combined for a total number of 12,000 participants with major CVD risk factors measured at least once in childhood and adulthood. In an effort to determine the effects of child and adult elevated BP on cIMT, data was pooled from the Bogalusa, Muscatine, Young Finns and CDAH with a mean follow-up of 23 years. Participants were 6-18 years old at baseline and 27-45 years old at follow-up. Results indicated that elevated blood pressure that persisted from childhood into adulthood increased cIMT (59). In a similar analysis using the same four cohort studies (n=4,380 ages 3-18 years at baseline, mean follow-up=22 years), the influence of age on the associations between childhood risk factors and cIMT in adulthood was examined (60). Risk factors (TC, TG, BMI, SBP) measured in the oldest children (15-18 year olds) at baseline were the strongest predictors of increased cIMT more than 20 years later. These findings demonstrate that late adolescence is the optimal age for screening and these screenings can effectively identify those at risk of atherosclerosis in adulthood (60).

Another recent meta-analysis (2013) on young adults from the i3C consortium (Bogalusa, Young Finns, CDAH studies) and from the Minneapolis Childhood Cohort Studies and the Princeton Follow-Up Study assessed the association of ideal cardiovascular health with cIMT (61) in 5,785 participants ages 20-38 years (61). Ideal cardiovascular health is emphasized in the AHA's 2020 Strategic Impact Goals and is defined as blood pressure <120/80 mmHg, glucose <100 mg/dL, TC <200 mg/dL, BMI <25 kg/m^2, physical activity >150 min/wk moderate/vigorous or >75 min/wk vigorous, nonsmoking and 4-5 components of a healthy diet score (16). Ideal cardiovascular health was achieved by only 1% of young adults. The least commonly

met goal was diet-related; only 7% met the criteria for ideal diet. Compliance was particularly poor for sodium intake and saturated fat intake. The number of ideal cardiovascular health criteria was inversely associated with cIMT, demonstrating that these 7 health metrics are related to vascular health in young adults. The goal of future analyses from i3C data is to determine the independent effects of childhood and early adult levels of CVD risk factors on subsequent CVD occurrence (48). This will involve collecting CVD morbidity and mortality follow-up data, examining gene variants that increase disease risk and harmonizing non-invasive vascular measures to obtain a better understanding of causal pathways to CVD events (48).

Although diet was not the main outcome in any of the studies in the i3C consortium, it was measured in all studies. Future research should involve a pooled analysis to better understand the role that dietary intake in childhood and adolescence has on present and future CVD risk. Since diet is considered the first line of defense, this research would guide the development of both population-based and individual prevention efforts.

Poor Dietary Choices Negatively Impact CHD Risk Factors

Adolescents

Unhealthy diet choices are a major determinant of CHD risk (34, 62, 63). Recent NHANES data in 4673 adolescents ages 12-19 y show an alarmingly high prevalence of adolescents in poor and intermediate CHD risk factor categories (64). Adherence to the five components of the healthy diet score was assessed: >4.5 cups (0.001 m^3) of fruits and vegetables per day, > two 3.5 oz (99.2 g) servings of fish per

week, > three 1 oz (28.4 g) servings of fiber-rich whole grains (>1.1 g of fiber per 10 g of carbohydrate) per day, <1500 mg of sodium per day and <450 kcals (1884.1 kJ) from sugar-sweetened beverages per week. Healthy diet score was the least prevalent component of ideal cardiovascular health (64). Less than 1% met the criteria for an ideal healthy diet score and 90% had diets classified as poor. Adolescents consume as much as 34% of energy intake from solid fats and added sugars (65), exceeding recommendations by over 200%. Consumption of excess calories from solid fats and added sugars is a major contributor to weight gain, which increases CHD risk in a dose-response manner (66). Although not the focus of this paper, this data highlights the most prevalent dietary quality issues in this age group.

Dietary patterns established early in life carry into adulthood and are strongly associated with CHD risk (50). The transition from adolescence to young adulthood is considered a high risk period due to declines in diet quality and increases in body weight (67-69). This transition period is often marked by students entering college, living away from home for the first time and experiencing increased independence and responsibility for food choices (67, 70). If adolescents enter this transition period with poor diet quality, their chances of making positive dietary changes without intervention/education is slim.

College Students

College students consume excessive calories from high-fat snack foods (cookies, cake, chips, ice cream), frequently skip meals, avoid certain nutrient-dense foods (fruits, vegetables, low-fat dairy) and practice unhealthy weight-loss techniques (71-73). These unhealthy dietary choices and eating behaviors contribute to the

declines in diet quality observed during this period. College students' diets exceed recommendations of total fat (46% versus 35% of energy) and saturated fat (13% versus 10% of energy) (30). Total sugar (24% of energy) and added sugar (17% of energy) intake also surpass guidelines (<10% of energy) (29, 74). College students also fail to meet whole grain recommendations (32, 33), consuming just over 10% (10.5 g) of the recommended 3 oz (85.1 g) (33). Similarly, fiber intake is inadequate with only 43% of females and 51% of males meeting recommendations (30). Over 90% of college students exceed sodium recommendations (1). Dietary patterns high in solid fats, added sugars and sodium and low in whole grains and fiber are known to exacerbate CHD risk factors (37, 62).

The change in the college dining environment may play an important role in the worsening of eating behaviors and dietary intake during the transition from adolescence to young adulthood (75). Most dining halls are "all-you-can-eat" styles and allow unlimited meal frequency. The campus food environment is no longer restricted to dining halls; students now have access to a variety of on campus restaurants, cafes, snack bars, convenience stores and vending machines (76, 77). Although there are a greater variety of options both on and off-campus, there are few healthful options (76, 78).

In 2012, Horacek et al. (77) assessed the on-campus and off-campus dining environment at 15 universities. Unhealthy dining environments were widespread. Fast-food restaurants had significantly greater portion sizes and were more likely to have "combo meal" pricing compared to snack bars/cafes, dining halls and other sit down, fast casual and student union dining venues. Signs to encourage unhealthy or

overeating were most common at fast-food restaurants and at snack bars/cafes. Dining halls had significantly more healthy entrees, non-fried vegetables, no-sugar added fruit, vegetarian options, whole wheat bread and low-fat milk compared to all other dining settings. Dining halls, however, had one of biggest barriers to healthy eating: "all-you-can-eat" pricing. This "all-you-can-eat" environment and the wide variety of foods available in dining halls leads to larger portion sizes, increased energy intake and weight gain (79). In the first semester, college students gain weight up to 11 times faster compared to young adults not in college (71) and maintain this weight throughout college (80) and into adulthood. This additional weight, most of which is excess body fat, can lead to dyslipidemia and increased heart disease risk (10).

Prevalence of CHD Risk Factors in College Students

Coronary heart disease risk factors in young adulthood can be the result of pathological changes from childhood. Only 20% of CHD in young adults is related to non-atherosclerotic factors (41). Results from the few cross-sectional studies that have assessed CHD risk in college students, ages 18-24 years show an alarmingly high prevalence of young adults with abnormal risk factor profiles (**Table 2**). Huang et al. (81) reported that the most prevalent risk factors in a sample of 163 college students were elevated TC (12%) and low HDL-C (14%). Impaired glucose metabolism was also a concern as just over 6% had pre-diabetes. Overweight students had worse risk factor profiles (waist circumference (WC), BP, TC, LDL-C, VLDL cholesterol (VLDL-C), TG, leptin, insulin) compared to normal weight students and were nearly 3 times more likely to have at least one metabolic syndrome component.

Fernandes et al. (2) assessed the prevalence of metabolic syndrome criteria in 189 first year college students and found that 18% had elevated TG and 20% had low HDL-C for gender. Metabolic syndrome risk was also high; 28% met at least one of the criteria for metabolic syndrome and 4% had metabolic syndrome. Obese students were more likely to meet 3 or more metabolic syndrome criteria and had a higher prevalence of abnormal HDL-C, WC and BP compared to subjects with a BMI<30 kg/m^2. Gender differences were also noted, with males having a higher prevalence of risk factors (**Table 2**).

In a similar study by Huang et al. (4) that examined prevalence of metabolic risk and gender differences in a sample of 300 students, 24% had low HDL-C, 9% had elevated fasting glucose and 9% had elevated TG. Overall prevalence of metabolic syndrome was low (1%) but 1/3 of the sample had at least one component. As shown in **Table 2**, males had a worse metabolic profile than females.

In a larger study performed on 1,701 college students, Burke et al. (1) reported that more than half had at least one CHD risk factor. The sample had high rates of overweight/obesity (33%) and elevated LDL-C (53%), TC (27%) and BP (47%). Males also had a worse risk factor profile (BMI, glucose, TC, HDL-C, LDL-C, SBP and diastolic blood pressure (DBP)) than females in this study. In a subsequent analysis of the same data but with a larger sample size, (n=2,103) nearly 1/3 had low HDL-C, nearly 2/3 had high BP and approximately 1/4 had elevated TC or LDL-C (3). Metabolic syndrome was observed in up to 10% of the sample and those with a higher BMI had a significantly greater number of individual metabolic syndrome risk factors. In addition, males had higher risk prevalence (BMI, HDL-C, LDL-C, TG, BP).

The differences in prevalence rates across studies can be partially attributed to demographic differences between universities. Risk factor profiles can be expected to vary due to different ethnic breakdowns and lifestyle factors across geographically dispersed university samples (2). There were also gender differences; a higher prevalence of CHD risk factors was found in men. Risk factor profiles were worse in overweight and obese individuals, regardless of gender. Collectively, these studies demonstrate that dyslipidemia and metabolic dysfunction are a common and major concern in young adults. As previously discussed, poor dietary choices made by this age group contribute to the high prevalence of risk factors. These data underscore the need to identify those at risk, especially male and overweight/obese young adults, so that steps can be taken to prevent future CHD risk and manage existing risk factors. Data collected to-date demonstrates that college students are at risk for heart disease but additional research needs to be done on young adults not in college to get a more comprehensive profile of this age group.

CHD Risk Factor Screening in Young Adults

Historically Conflicting Guidelines

Data from the cross-sectional studies mentioned above demonstrate that CHD risk factor prevalence is high in this age bracket, yet universal risk assessment for primordial and primary prevention is lacking. Although the importance and need for screening for early detection and management of dyslipidemia is recognized from public health organizations, including the NHLBI, AHA, American Academy of Pediatrics (AAP), and US Preventive Services Task Force (USPSTF), the majority of

young adults are not screened (25). The absence of apparent disease in young adults

contributes to the underestimation of risk in this age group by both young adults

themselves and health professionals (26, 82, 83). This underestimation of risk and

historically differing risk assessment guidelines contribute to this problem (84).

A variety of approaches and attitudes toward screening in young adults has

existed among health professionals over the past two decades (84, 85). This can be

traced back to the 1990s, with the release of the National Cholesterol Education

Program Adult Treatment Panel III (NCEP ATP II) guidelines in 1993 that

recommended universal lipid screening, regardless of risk level, every 5 years for all

adults over age 20 years. The rationale for these recommendations was to detect

individuals at risk early on so that early intervention could reduce long-term CHD

risk.   Although these guidelines have been endorsed by representatives from over 40

different medical and health organizations, the American College of Physicians argued

against the need for screening in young adults due to the low short-term risk for CHD

is this age group (86). Despite the presence of detractors early on, however, the

strength of these screening recommendations was evidenced by their inclusion in 2004

NCEP ATP III Guidelines (17) and in more recent 2012 NHLBI Guidelines for

Cardiovascular Health and Risk Reduction in Children and Adolescents (21) and 2013

American College of Cardiology (ACC)/AHA Guidelines on Assessment of CVD

Risk (23).

Different recommendations over the past 20 years from other organizations has

also led to inconsistent screening practices (84). 2008 guidelines from the USPSTF

recommend screening in all men over age 35 and in men 20-35 years of age and

women over age 45 at increased risk (87). The USPSTF makes no recommendation, however, for or against routine screening in men and women over 20 years of age who are not at increased risk of CHD and states that the optimal screening interval is uncertain. Young adults in the 18-24 year age bracket span both children/adolescent and adult recommendations, which further complicate the issue. Screening guidelines for children and adolescents have also been conflicting since 1992 due to different recommendations by the NCEP (88), AHA (89), USPSTF (90), AAP (91) and National Lipid Association (92). This conflicting guidance over the past 20 years has made it difficult for a uniform screening protocol to be followed by doctors and other health professionals (84).

Much needed progress was made, however, with the release of the 2012 NHLBI Expert Panel on Integrated Guidelines for Cardiovascular Health and Risk Reduction in Children and Adolescents (21) and the ACC/AHA Guidelines on Assessment of CVD Risk in 2013 (23). The NHLBI's comprehensive, evidence-based guidelines represent a change in approach from targeted screening to universal screening with an emphasis on primordial and primary prevention. This change was supported by the inability of previous high-risk, targeted screening approaches to detect up to 60% of children and adolescents with hypercholesterolemia (93). The 2012 evidence-based recommendations for lipid assessment recommend universal lipid screening by a non-fasting non-HDL-C level between ages 9-11 and 17-21 years of age. Targeted screening is recommended between 2-8 and 12-16 years of age if risk factors are present. These new lipid screening guidelines are endorsed by the AAP but the new expanded screening guidelines have not been without their detractors (84, 94-

96). There are concerns that the new guidelines may result in over diagnosis, false-positives, and overuse of statins in children (94-96). Although some experts disagree with the conservative nature of the guidelines, they are a pivotal step in the shift toward primordial, population-based prevention strategies that are needed to reduce future risk (16, 23, 64, 97, 98).

More recent 2013 ACC/AHA CVD Assessment Guidelines also support the need for risk assessment early in life to motivate lifestyle changes in younger individuals who may be at low short-term risk but could benefit from long-term risk assessment. Long-term risk assessment of traditional CVD risk factors is recommended every 4-6 years beginning at age 20 for those who are free from atherosclerotic cardiovascular disease (23).

Inadequate Screening in Young Adults

National Health and Nutrition Examination Survey data from 1999-2006 on 2587 young adults ages 20-45 years, indicated that 2/3 have at least one CVD risk factor. This is alarming since less than 50% of females and less than 40% of males reported being screened prior to the assessment visit. The screening rate for young adults in the 18-24 year age bracket can be expected to be even lower as screening rates increase with age (99). Younger males, in particular, are more than 50% less likely than their female counterparts to obtain preventive services (100). Data from NHANES show that women are more likely to have health insurance and see a healthcare provider (25). These low screening rates are especially concerning among

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young adults with multiple risk factors as the extent of atherosclerosis is directly correlated with the number of risk factors.

The AHA supports population-based strategies such as screenings at universities to identify at risk individuals (16, 97, 101). Policy changes are needed to promote increased screening in primary care settings, clinics, schools, worksites and community sites. These screenings are particularly important in the young adult age group that may go otherwise undetected by the health care system (102) partly due to the underestimation of risk (26, 82, 83). As discussed in the AHA's 2013 Science Advisory, screenings should include assessment of all CHD risk factors including lifestyle habits (diet, exercise and smoking), BP, glucose and BMI in addition to the traditional lipid panel (97). Screening, however, must be accompanied by reliable interpretation of results, provision of appropriate educational material and referral to a physician for those who need it, in order for follow-up to be most effective. Young adults should be informed of the meaning of their results, the importance of dietary changes and the appropriate follow-up steps that need to be taken depending on their other risk factors (102) (**Figure 1**). As outlined in the 2013 AHA/ACC Guidelines on Lifestyle Management to Reduce Cardiovascular Risk and in the 2013 ACC/AHA Guidelines on Assessment of Cardiovascular Risk, heart healthy nutrition and physical activity behaviors are recommended for all adults over age 18 for both prevention and treatment (23, 103). These preventive efforts are essential for reducing CHD events later in life and reducing the burden of CHD on a population level (97). Future research is needed to better understand and eliminate barriers to screening. This needs

to be done at the policy, provider and patient level to improve suboptimal screening in young adults (104).

Population-Based Nutrition Interventions in College Students

Until primordial prevention strategies are successful in avoiding risk factor development all together, risk factor screening needs to work in tandem with education and management for effective disease prevention. Strategies that focus on high-risk individuals are effective in reducing CHD events but population-level strategies are needed to produce wide scale risk reductions (16, 97). Population-based interventions on college campuses are cost-effective strategies to manage existing risk factors by promoting lifestyle changes, which are the foundation for risk reduction efforts (103). The college setting is an ideal forum to reach large numbers of the young adult population as 12.5 million (nearly 50%) of those ages 18-24 years were enrolled in U.S. colleges and universities in 2010 (105). Interventions aimed at the college population represent an opportunity to promote healthy eating while lifestyle habits are still being formed and to target CHD risk factors before disease progression occurs.

Previous population-based strategies have proven to be successful in reducing CHD risk in other populations (16). In the late 1980's, a population-based approach was used to lower CHD risk in the island nation of Mauritius. The fatty acid composition of imported cooking oil was changed to contain higher levels of polyunsaturated fat instead of saturated fat. The mean TC concentration fell from 225 mg/dL in 1987 to 182 mg/dL in 1992, decreasing the prevalence of hypercholesterolemia from 25% to 6% in men and from 22% to 5% in women (106,

107). This intervention was a classic example of a population-based strategy that effectively shifted the entire distribution of risk. Estimates from the World Heart Federation show that a universal reduction in sodium intake by 1 gram/day would lead to a 50% reduction in the number of individuals needing treatment for hypertension, a 22% decrease in deaths from stroke and a 16% drop in deaths from CHD (28).

Similar population-based strategies can be applied to the college setting. Although cafeterias can contribute to an obesogenic environment on college campuses, they also represent an opportunity to influence students' diets for the better by providing nutrition information to guide healthy choices (108). To motivate students to choose healthier options, colleges need to identify healthy choices, provide nutrition information and utilize point-of-selection signage (77). This nutrition information may provide the stimulus for students to reevaluate and change their eating habits (109). Pyramids that displayed energy and nutrient content of menu offerings at a university cafeteria led 71% of patrons to change their lunch selections by choosing meals lower in energy and fat (110).

Peterson et al. (111) reported increased awareness of healthy foods as the primary reason for selecting healthier food choices in a dining hall intervention consisting of signs, table tents, flyers and benefit-based messages. Similar studies have also found that point-of-selection nutrition labels in dining halls resulted in better food choices and decreased energy intake at meals (112, 113). In another study, students with the highest nutrition knowledge were 12 times more likely to meet dietary recommendations compared to those with the lowest knowledge (114). Drawing attention to nutrition and health in a campus dining hall setting has a positive impact

on food choices (111). Relatively small changes in the physical environment can produce behavioral changes (115). For example, placing healthy foods in more prominent places and removing trays from dining halls are other inexpensive ways to prompt healthier dietary choices.

Recently, technology has been used to promote behavior change. Technology-based interventions are particularly appealing to the young adult population and are quick, cost-effective and convenient ways to transmit information to a large audience (116). For example, messages displayed on computer screens at "point of decision" spots in a college dining hall influenced students to increase their fruit intake (117). Poddar et al. (118) demonstrated that 8 weeks of email messages as part of a dairy intake intervention were effective in increasing dairy intake in college students relative to the comparison group. Greene et al. (31) found that a 10-lesson, web-based nutrition and physical activity intervention resulted in higher fruit and vegetable intake and greater physical activity in 1689 college students from eight universities.

Other studies have also reported success with mobile technology-based interventions. (119-123). Text messaging, in particular, has been used in a variety of behavioral intervention studies to provide reminders, cues, positive reinforcement and enhance self-monitoring (124-127). All of these features are recognized as keys to successful maintenance of dietary changes (123). Text messaging is an especially appealing intervention mode for college students as 99.8% of college students own a cell phone and 97% of college students rely on text messaging as their main form of communication (128).

Conclusions:

This review highlights the need for improved risk assessment and increased awareness in young adults. Cross-sectional studies provide evidence of the high prevalence of CHD risk factors in this age group. It is well established that these risk factors are associated with pathological changes and substantially increase lifetime CHD risk. Until successful primordial prevention strategies are part of the public health care infrastructure and prevent risk factors, the focus must be on improving screening, assessment, education and treatment of CHD risk factors. Targeting young adults at a time in their lives when lifelong habits are being developed is critical to prevent disease progression.

The low screening rates in this age group are concerning in light of the high prevalence of risk factors. Increased screening is the first step as young adults at risk must first be identified before treatment approaches can be initiated. College campuses provide an opportunity for population-based screening approaches. College students and health professionals on campus must first be made aware of the need for risk assessment and then risk reduction through lifestyle changes.

Future research needs to be done to identify the most effective and efficient ways of screening large numbers of young adults. Screenings embedded into course curricula in health courses, as part of university wellness programs or as a part of freshmen orientation are potential avenues to increase screening rates in this age group. Increased screening needs to work in conjunction with education to effectively identify and manage CHD risk.

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Table 1: Cohort Studies

Authors (ref.)	Study, Country	Year Baseline	Subjects	Year Follow-Up	Key Outcomes
Lauer et al. (47)	**Muscatine**, USA	1970	n=11,337 5-18 yo	1970-1981 1982-1991 1992-ongoing	TC: 37% >200 mg/dL TG: 15% >140 mg/dL BP: 21% ≥140/90 mmHg Weight: 33% ≥110% relative weight Elevated TC, TG, BP and relative weight in youth predict CHD in adults
Berenson et al. (6)	**Bogalusa Heart**, USA	1973	n=12,164 4-17 yo	1977-1996 2001-2002 2003-2005 2007-ongoing	Pathological changes occur by 5-8 years of age Extent of lesions significantly related to levels of TC, LDL-C, TG, BMI, HDL-C and BP
Raitakari et al. (45)	**Cardiovascular Risk in Young Finns**, Finland	1980	n=3,596 3-18 yo	1983-ongoing	CVD risk factors (elevated TC, LDL-C, BP, smoking) early in life lead to structural and functional vascular changes related to atherosclerosis Increased LDL-C, BP, obesity and cigarette smoke in adolescence predict increased cIMT and decreased elasticity in adulthood
Gall et al. (46)	**Childhood Determinants of Adult Health Study**, USA	1985	n=8,498, 7-15 yo	2004-2006 2013-ongoing	Childhood physical activity, obesity and TC are important determinants of adult CVD risk factors (obesity, IR, dyslipidemia, cIMT)

BP, blood pressure; CHD, coronary heart disease; cIMT, carotid intima media thickness; CVD, cardiovascular disease; HDL-C, HDL cholesterol; IR, insulin resistance; LDL-C, LDL cholesterol; TC, total cholesterol

Table 2: CHD Risk Factor Prevalence in College Students

Authors (ref.)	TC (≥200 mg/dL)	LDL-C (≥100 mg/dL)	HDL-C (<40 M, <50 F mg/dL)	TG (≥150 mg/dL)	Glu (≥100 mg/dL)	BP (≥130/85 mmHg)	WC (>102 M, >88 F cm)
Fernandes et al. (2)							
M	--	--	3.2	3.7	2.1	2.1	1.1
F	--	--	16.9	13.8	5.3	0.0	6.3
Huang et al. (4)							
M	--	--	22.5	15.7	14.7	13.7	2.9
F	--	--	25.3	5.6	7.6	0.5	2.5
Burke et al. (1)							
M	27.0	63.0	29.0	--	8.0	--	4.0
F	27.0	47.0	23.0	--	5.0	--	4.0
Morrell et al. (3)							
M	24.7	61.9	30.6	12.2	13.7	62.1	5.2
F	25.8	45.5	23.7	18.3	6.4	21.2	4.2

BP, blood pressure; Glu, glucose; HDL-C, HDL cholesterol; LDL-C, LDL cholesterol; TC, total cholesterol; WC, waist circumference

35

Figure 1: Progression of Atherosclerosis and Prevention Targets
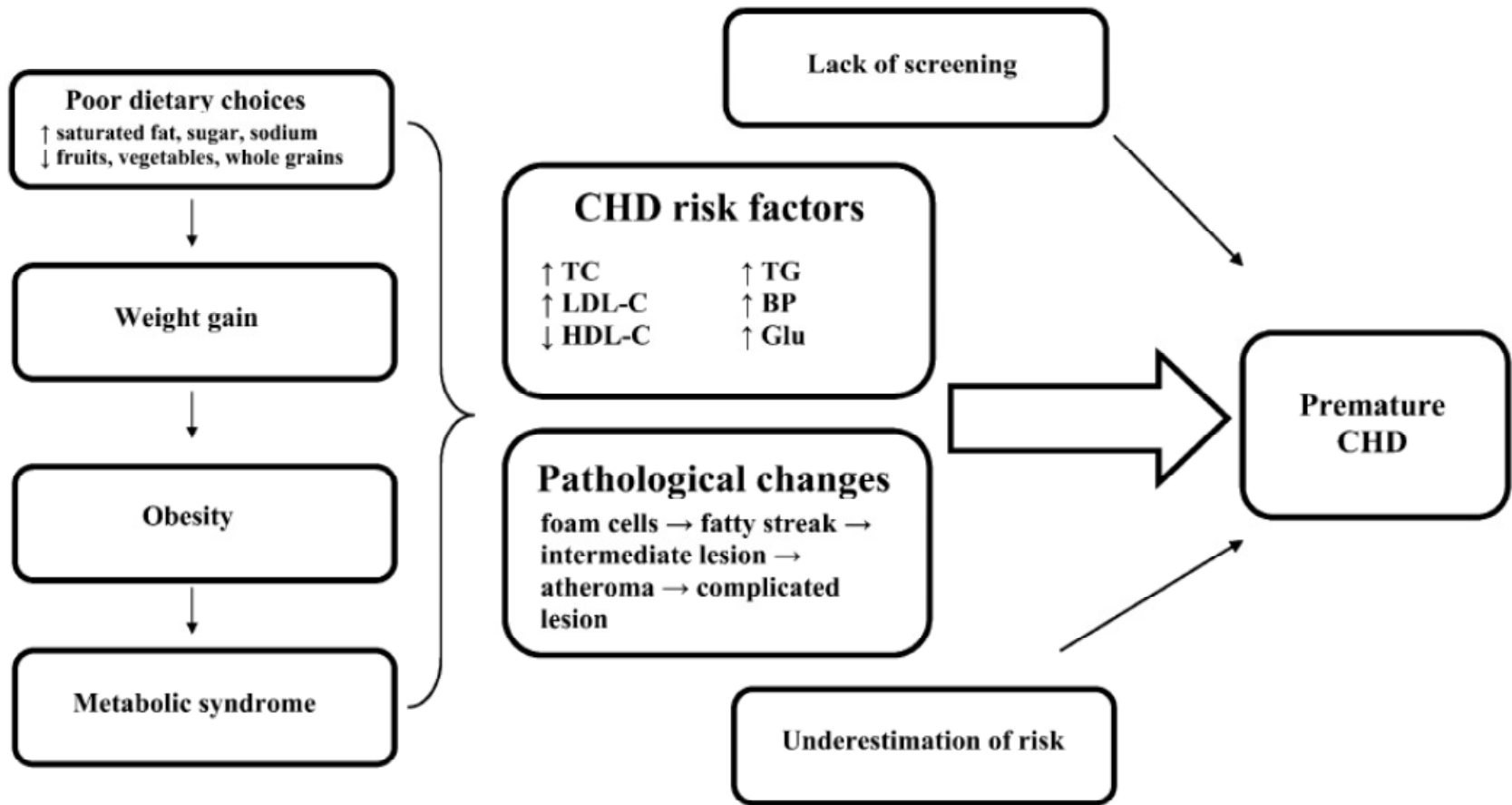
BP, blood pressure; CHD, coronary heart disease; Glu, glucose; HDL-C, HDL cholesterol; LDL-C, LDL cholesterol; TC, total cholesterol

<div align="center">**MANUSCRIPT 2**</div>

"A Population-Based Nutrition Intervention to Increase Whole Grain Intake in College Students" is prepared for submission to the *American Journal of Health Promotion*.

ABSTRACT:

Purpose: The purpose of this study was to increase whole grain intake in college students through a population-based intervention in campus dining halls. The secondary aim was to improve coronary heart disease (CHD) risk factors. The exploratory aims were to evaluate the impact of a text messaging intervention on whole grain and low-fat dairy intake and CHD risk factors in a subsample of participants. *Design:* Quasi-experimental with measurements at baseline, post-intervention, and follow-up (6 months). *Subjects:* College students (18-24 years old, n=98) from a northeastern U.S. university. *Intervention:* A 6-week population-based intervention consisting of benefit-based whole grain and low-fat dairy messages in campus dining halls. Daily text messages or emails were sent to the subsample (n=26). *Measures:* Dietary intake, anthropometrics, blood lipids, fasting glucose and blood pressure were assessed at each time point. *Analysis:* Repeated measures analysis of variance. *Results:* Whole grain intake increased over time (0.8±1.1 oz to 1.1±1.5 oz, p=0.008). High-density lipoprotein cholesterol (HDL-C), body weight and body mass index (BMI) significantly increased over time. Total dairy intake decreased over time. *Conclusion:* A 6-week population-based messaging intervention in campus dining halls had a positive impact on whole grain consumption and on HDL-C in college students. Future research should focus on population-based weight reduction interventions in this age group. Also, findings suggest that tailored interventions targeting dairy intake in this group are warranted.

INTRODUCTION:

Heart disease is a leading cause of death in young adults [1]. Many coronary heart disease (CHD) risk factors surface in adolescence [1-4] and track forward to adulthood [5]. Since 80% of cardiovascular events are preventable through diet and lifestyle [6], primordial and primary prevention approaches are emphasized in the American Heart Association's 2020 Strategic Impact Goals [7] and in the National Heart, Lung and Blood Institute's 2012 Expert Panel on Integrated Guidelines for Cardiovascular Health and Risk Reduction in Children and Adolescents [8]. Despite this emphasis on the importance of early prevention efforts, little has been done to address CHD risk in young adults who are unaware [9] and have not been screened for CHD risk [10].

The few cross-sectional studies that have assessed CHD risk in college students ages 18-24 demonstrate the need for increased screening, risk assessment and disease prevention in this age group [11-14]. More than 50% of college students have elevated low-density lipoprotein cholesterol (LDL-C) [15]. Additionally, as many as 27% have elevated total cholesterol (TC), 47% have hypertension [15], 18% have elevated triacylglycerides (TAG), 20% have low high-density lipoprotein cholesterol (HDL-C) [14] and 13% have elevated glucose [16]. These risk factors are strongly correlated with the extent of atherosclerotic lesions [17], which progress to advanced lesions in as many as 20% of young adults [18].

Typical diets consumed by college students, which are high in saturated fat [19] and low in whole grains [20] negatively affect these risk factors, especially LDL-C. More than 70% of college students exceed total and saturated fat recommendations [19]. They also fail to meet whole grain recommendations [20, 21], consuming only 12% (0.37

oz) of the recommended minimum of 3 oz [20]. Low-density lipoprotein cholesterol concentrations can be improved by decreasing saturated fat and increasing whole grain consumption [22, 23]. Saturated fat reduces LDL receptor-mediated clearance by decreasing the number of LDL receptors via reduced transcription of the LDL receptor gene [24]. Receptor activity is also reduced by saturated fat due to negative changes in membrane fluidity that interfere with LDL binding to the LDL receptor [23, 25, 26]. The LDL-C lowering effect observed with whole grain intake is associated with the soluble fiber component of the grain [27]. Soluble fiber binds bile acids in the small intestine and leads to their excretion, preventing their normal reabsorption and reutilization [28, 29]. This causes the liver to synthesize additional bile acids from cholesterol, which lowers the cholesterol content of hepatocytes, stimulating LDL receptor production and subsequent clearance of LDL-C from circulation [28, 29].

Because 42% of US young adults attend college or universities [30], these campuses provide an ideal opportunity to target young adults at a point in life when lifestyle choices are being made and before disease progression occurs [31]. Previous research has demonstrated that increased awareness of healthy options through point-of-selection (POS) signage and benefit-based messages has increased the selection of healthier options in university dining halls [32-34]. Recently, technology has been used to promote behavior change in college students [35-38] but no studies have utilized text messaging to produce dietary changes in this age group. To the best of our knowledge, this is the first study to utilize both point-of-selection and text messaging in a nutrition intervention on a college campus. The purpose of this study was to increase whole grain consumption through a population-based intervention in campus

dining halls. A secondary aim was to improve CHD risk factors. An exploratory aim was to analyze the impact of a text messaging intervention on whole grain and low-fat dairy intake and CHD risk factors in a subsample of participants.

METHODS:

Design

A quasi-experimental design was used to assess the impact of a population-based whole grain and low-fat dairy intervention on CHD risk factors. Baseline and post-intervention assessments were conducted immediately before and after the six-week intervention and the follow-up assessment occurred six months after the baseline assessment. A subsample (n=26) was recruited for Heart Start II, which involved additional measures. All measurements described were obtained at baseline, post-intervention and follow-up.

Sample

Participants were recruited via classroom announcements at a medium sized northeastern university. Eligible participants were 18-24 year old males and females with a campus meal plan and a BMI ≥ 18.5 kg/m^2. Exclusion criteria included being pregnant or lactating, or self-report of one of the following conditions: eating disorder, liver disease, bleeding disorder, diabetes, cancer, or CHD. All participants read and signed an informed consent approved by the University's Institutional Review Board.

Measures

Dietary Intake

The National Health and Nutrition Examination Survey (NHANES) 2009-2010
National Cancer Institute Dietary Screener Questionnaire (NCI Screener) was used to
assess intake of fruits and vegetables, dairy/calcium, whole grains/fiber, added sugars,
red meat, and processed meat in all participants [39].

Purchasing records from dining services were used as a proxy for whole grain
and low-fat dairy consumption. Purchasing records were obtained for bread and dairy
products that offered a whole grain or low-fat dairy alternative (bread, rolls,
breadsticks, English muffins, milk and yogurt) to determine if students selected the
whole grain or low-fat dairy option. Purchasing records were obtained at baseline,
intervention, post-intervention and 6-month follow-up. Average values were
calculated for individual items at each time point and were used for the analyses.

Twenty-four hour dietary recalls were collected and analyzed for Heart Start II
participants (n=26) using the multiple pass method in conjunction with the Nutrition
Data System for Research (NDS-R) software (University of Minnesota, Minneapolis,
MN) version 2012. All participants completed three 24-hour dietary recalls: one in-
person and two over the phone on three non-consecutive days (including two
weekdays and one weekend day) [40, 41]. Nasco food models (eNasco, Fort Atkinson,
WI) and food amounts booklets were available during the initial in-person 24-hour
recall to more accurately estimate portion size [42]. Participants were given the booklets
after the initial recall for the phone recalls. The mean values of the three recalls

provided dietary data for analysis. Healthy Eating Index 2010 scores were calculated from the mean values from the three 24-hour recalls for Heart Start II participants to assess diet quality in Heart Start II participants (n=26).

Biochemical

Following a 12-hour fast, finger sticks were performed on all participants to obtain blood samples for determination of blood lipid and glucose concentrations. Values for LDL-C, TC, TAG, HDL-C and glucose were obtained using Cholestech LDX table-top analyzers (Cholestech, Hayward, CA).

Anthropometrics

Height was measured to the nearest 0.1 cm using a Seca 220 stadiometer (Seca Corporation, Hamburg, Germany). Weight was measured to the nearest 0.1 kg using a calibrated digital Seca 769 scale (Seca Corporation, Hamburg, Germany). Measurements were taken in duplicate and the average of the two values was used for the analysis. Body mass index was calculated using the following formula: weight in kilograms/height in meters^2. Waist circumference was measured in duplicate at the top of the iliac crest upon exhalation to the nearest 0.1 cm using a Gulick fiberglass, non-stretchable tape measure with an attached tensometer (Patterson Medical, Mount Joy, PA). The average of the two values was used for the analysis.

Blood Pressure

Blood pressure was measured after a 5 minute seated rest period using an automatic blood pressure monitor with arm cuff (Omron HEI-711, Omron Health Care

Products, Issaquah, WA). Measurements were re-taken two minutes apart until values were within 2 mmHg. The average of the two values in agreement was used for the analysis.

Intervention

Heart Start I and II participants were exposed to a 6-week intervention which consisted of benefit-based nutrition messages in the two main campus dining halls (Hope and Butterfield). Messages were displayed on television monitors and on point-of-selection signs at the deli and dairy stations in both dining halls. Prompts to choose whole grain bread were also verbally provided by the deli station staff in both dining halls. Additionally, nutrition education booths to promote whole grain and low-fat dairy consumption were positioned in a high traffic area outside of Hope. Message and booth content alternated between whole grains and low-fat dairy each week. Students with meal plans were able to eat at either dining hall and all students who ate at the dining halls were exposed to the intervention.

Intervention materials addressed specific motivators of healthy eating (increased energy, healthy body weight and staying full) from previously conducted focus groups [43]. Additionally, Heart Start II participants received the same nutrition message that was displayed on the television monitors in the dining halls each weekday via text message or email, depending on their preference. Google Voice (Google, Mountain View, CA), a web-based application, was used to deliver text messages.

Analysis

Descriptive statistics were performed and skewness and kurtosis were examined to determine data distribution. Non-normally distributed data were transformed. Body mass index, LDL-C, total grains, low-fat dairy and soluble fiber were log transformed. Triacylglycerides and sugar-sweetened beverages (SSB) were square root transformed. Whole grains, semi-whole grains, total fiber, reduced fat dairy, glucose and systolic blood pressure (SBP) were analyzed using non-parametric tests. Continuous variables were expressed as mean ± standard deviation and categorical variables were expressed as frequencies. Repeated measures analysis of variance with post hoc tests using the Bonferroni adjustment were used to determine if there were significant differences over time. The Friedman test with post hoc Wilcoxon signed rank tests using a Bonferroni adjusted alpha value were used to assess differences over time for whole grains, semi-whole grains, fiber and glucose. Mixed between-within analysis of variance assessed differences between groups over time. Chi-square tests were used to analyze categorical variables. Statistical significance was set at $p < 0.05$ for all tests.

RESULTS:

Participant characteristics at baseline are presented in Table 1. The majority of the sample was female (78%) and Caucasian (81%). The mean age was 18.2 ± 0.6 years. At baseline, more than 50% of females and 36% of males had low HDL-C for gender (<40 M, <50 F mg/dL), 19% had elevated LDL-C ($\geq$100 mg/dL), 14% had elevated TAG ($\geq$150 mg/dL) and 13% had elevated SBP ($\geq$130 mmHg). More than

80% of the sample had never or were unsure as to whether they ever had their cholesterol checked. Sixty-three Heart Start I participants completed all three assessment visits and 18 of these 63 completed additional measurements for Heart Start II.

Data from the NCI Screener indicated that whole grain intake increased over time (χ^2 (2, n=69) = 10.6, p=0.005). Whole grain intake increased from baseline to follow-up (0.8 ± 1.1 oz to 1.1 ± 1.5 oz, p=0.008) and from post-intervention to follow-up (0.8 ± 0.8 oz to 1.1 ± 1.5 oz, p=0.006). Purchasing record data (used as a proxy for consumption) indicated that percent whole grain consumption doubled (12.7% to 23.9%) in the dining hall with nutrition education booths, point-of-selection signs, promotion by deli counter staff and messaging on television monitors (Hope) during the 6 week intervention (data not shown). In Hope, baseline whole grain consumption was significantly lower than the intervention and follow-up period but not different from post-intervention. In Butterfield, whole grain consumption significantly increased across baseline, post-intervention and follow-up periods and was higher than consumption at Hope at all time points.

As displayed in Table 2, there were no changes in LDL-C over time (Wilks' Lambda = 0.94, $F_{2,56}$ = 1.83, p=0.17, η^2=0.06). However, positive changes were seen in HDL-C over time (Wilks' Lambda = 0.82, $F_{2,59}$ = 6.66, p=0.002, η^2=0.18). There was also a significant effect of time for glucose (χ^2 (2, n=61) = 11.92, p=0.003). Significant increases in body weight (Wilks' Lambda = 0.72, $F_{2,61}$ = 11.84, p<0.001, η^2=0.28) and BMI (Wilks' Lambda = 0.78, $F_{2,61}$ = 8.44, p=0.001, η^2=0.22) were observed over time.

There was no primary measure of low-fat dairy intake. However, purchasing records used as a proxy for dairy intake indicated that nonfat dairy increased by 3-4% during the intervention and were significantly higher at follow-up compared to other time points in Hope (data not shown). Data from the NCI screener showed that total dairy intake decreased over time (Wilks' Lambda = 0.85, $F_{2, 69}$ = 6.16, p=0.003, η^2=0.15). Sugar-sweetened beverages (SSB) also significantly decreased over time (Wilks' Lambda = 0.86, $F_{2, 70}$ = 5.72, p=0.005, η^2=0.14).

Exploratory analyses on Heart Start II participants (n=18) revealed no changes over time in whole grain intake as assessed by 24-hr dietary recalls (Wilks' Lambda = 0.95, $F_{2, 16}$ = 0.40, p=0.678, η^2=0.05). There were no changes in LDL-C over time (Wilks' Lambda = 0.95, $F_{2, 16}$ = 0.40, p=0.678, η^2=0.05). High-density lipoprotein cholesterol increased (Wilks' Lambda = 0.63, $F_{2, 16}$ = 4.63, p=0.026, η^2=0.37).

Heart Start II participants also had significant increases in weight (Wilks' Lambda = 0.58, $F_{2, 16}$ = 5.89, p=0.012, η^2=0.42), BMI (Wilks' Lambda = 0.67, $F_{2, 16}$ = 3.91, p=0.042, η^2=0.33) and WC (Wilks' Lambda = 0.60, $F_{2, 16}$ = 5.39, p=0.016, η^2=0.40) over time. Weight increased from baseline to post-intervention (69.1 ± 13.3 kg to 70.1 ± 13.7 kg, p=0.029) and from baseline to follow-up (69.1 ± 13.3 kg to 70.6 ± 13.8 kg, p=0.030). Body mass index increased from baseline to post-intervention (25.1 ± 4.9 kg/m^2 to 25.4 ± 5.0 kg/m^2, p=0.049) and from baseline to follow-up (25.1 ± 4.9 kg/m^2 to 25.6 ± 4.9 kg/m^2, p=0.022). Waist circumference increased from baseline to post-intervention in this subsample (82.5 ± 11.5 cm to 84.0 ± 12.5 cm, p=0.022).

Twenty-four hour recall data showed no changes in total grain, semi-whole grain, refined grain, fiber, total dairy, full fat dairy, reduced fat dairy, low-fat dairy or saturated fat intake in Heart Start II participants ($p > 0.05$). Energy intake significantly decreased over time (Wilks' Lambda = 0.58, $F_{2, 16} = 5.70$, p=0.014, η^2=0.42). Decreases in energy intake occurred from baseline to post-intervention (1896.4 ± 553.3 kcals to 1658.0 ± 491.1 kcals, p=0.009). There were no significant changes over time in overall diet quality as measured by the Healthy Eating Index-2010 (p=0.39).

Mixed between-within ANOVAs comparing Heart Start I and Heart Start II indicated that there was a significant effect of time for HDL-C (Wilks' Lambda = 0.83, $F_{2, 58} = 6.04$, p=0.004, η^2=0.17) and total dairy (Wilks' Lambda = 0.90, $F_{2, 68} = 3.93$, p=0.024, η^2=0.10) but no significant differences existed between groups. There was also a significant effect of time and group for weight (time: Wilks' Lambda = 0.72, $F_{2, 60} = 11.50$, p<0.001, η^2=0.28, group: $F_{1, 61} = 4.76$, p=0.033, η^2=0.07) and BMI (time: Wilks' Lambda = 0.81, $F_{2, 60} = 7.27$, p=0.001, η^2=0.20, group: $F_{1, 61} = 4.90$, p=0.031, η^2=0.02). The mean values for weight and BMI were significantly greater in Heart Start II participants compared to Heart Start I participants at each time point. Due to data distribution, a mixed between-within analysis could not be performed for whole grains.

A post-intervention survey revealed that nearly 80% of participants noticed the messages. Seventy percent reported that the messages prompted them to choose whole grains, while only 40% indicated that the messages prompted them to choose low-fat

dairy. Point-of-selection messaging was the most effective messaging delivery method for both whole grains and low-fat dairy (Figure 1).

DISCUSSION:

The results of this study demonstrate that population-based POS messaging in campus dining halls is an effective strategy to increase whole grain intake in college students. Improvements in HDL-C were seen. Declines in total dairy intake over time suggest that the focus of interventions should shift from low-fat dairy to total dairy.

Whole grain consumption (as measured by the NCI screener) increased by nearly 40% from baseline to follow-up. This is supported by the purchasing records, which indicated that percent whole grain consumption doubled during the 6-week intervention. It is also consistent with the findings from pilot testing in the spring of 2012 that showed a 12% increase in whole grains when messages were displayed in dining halls for one-week (S. Mello, personal communication). Results from this study suggest that sustained messaging is needed to produce lasting behavior change as whole grain consumption returned to baseline levels after the messages were removed. Although increases in whole grain consumption were observed, the mean intake at follow-up still fails to meet recommendations. This is consistent with findings by Ha et al. [20] that reported an increase in whole grain consumption in college students after a whole grain intervention embedded in a semester-long nutrition course significantly increased whole grain intake from 0.37 oz to 1.16 oz. Despite this increase, whole grain intake after the intervention was >50% less than the minimum recommendation of 3 oz. Exploratory analyses on Heart Start II participants who received the additional

text messages indicated that this subgroup had non-significant increases in their whole grain intake. This may be attributed to the small sample size in this subgroup analysis (n=18).

Baseline CHD risk factor prevalence data was similar to previous cross-sectional estimates of CHD risk factors in this age group [12-14, 44]. Despite this documented presence of risk factors in college students, there is a lack of research assessing the impact of nutrition interventions on CHD risk factors in college students. Spinler et al. [19] reported no changes in total fat, saturated fat or plasma cholesterol concentrations over a 3-month period following a nutrition and cardiovascular disease education in pharmacy students. Although there were no changes in LDL-C in the present study, there were improvements in HDL-C and low HDL-C was the most prevalent risk factor in this sample of college students. The significant increase in HDL-C over time may be explained by the dietary changes, as increases in whole grains have been associated with improvements in HDL-C [45].

Weight gain during the first year of college is well documented [46-51]. Our sample gained less weight than has been previously reported in this age group [49, 50]. Although weight status was not a primary aim of the intervention, the weight gain observed in this population highlights the need for weight gain prevention efforts in this age group. However, interventions focusing on weight must be sensitive to the higher prevalence of disordered eating in this age group [52, 53].

Purchasing records showed a slight increase in non-fat dairy over time but the NCI Screener indicated that total dairy intake decreased over time. Since this screener

did not allow for the analysis of components of total dairy (reduced fat, low-fat, nonfat) it cannot be determined whether there was a shift to low-fat dairy over time. A decrease in total dairy, however, is consistent with previous findings [54, 55] and provides evidence for the need for additional efforts in this age group to prevent further declines in dairy intake. A reduction in dairy intake typically coincides with an increase in SSB as a result of displacement [56]. In this sample, however, SSB consumption significantly decreased along with dairy consumption over time. Decreased consumption of dairy at follow-up may be a function of weight conscious eating behaviors that occur pre-spring break in anticipation of beaches, as dairy is perceived to be "fattening" [32, 57]. Similarly, purchasing records at follow-up showed an increase in whole grain consumption, which may be a function of pre-spring break healthier eating.

Feedback on the individual intervention components revealed that POS messaging was the preferred method of messaging. Point-of-selection messaging has previously been shown to be an effective population-based strategy to promote healthy choices in college dining halls [58]. In a dining hall intervention that utilized signs, table tents, flyers and benefit-based messages, college students reported increased awareness of healthy options as the primary reason for selecting healthier choices [32].

A major strength of this study was the use of multiple measures to assess dietary intake. To the best of our knowledge, this was the first study to use purchasing records to quantify intake in campus dining halls. An additional strength was the use of multiple methods of message delivery. Although previous studies have used text messaging as an intervention delivery method in this age group [35-38, 59], this was the

first to use text messages to target dietary choices known to have a positive impact on CHD risk.

Despite these strengths, there were some limitations. The majority of the sample was female and Caucasian, limiting the extent to which results can be generalized to other populations. The use of purchasing records as a proxy for consumption also has limitations. Items were chosen that dining services reported as having minimal waste but plate waste could not be accounted for. Another limitation was the lack of a primary measure for low-fat dairy.

Overall, findings from this study indicate that a population-based nutrition intervention was effective in increasing whole grain intake in college students. Future research should focus on implementing population-based approaches to promote healthy eating on college campuses as cost-effective ways to guide students in making better dietary choices.

SO WHAT? Implications for Health Promotion Practitioners and Researchers

What is already known on this topic?

Typical diets consumed by college students fail to meet recommendations for whole grains and exceed saturated and total fat recommendations. These dietary choices negatively impact CHD risk factors. Population-based intervention strategies are needed to address the high prevalence of CHD risk factors in this overlooked age group.

What does this article add?

Findings from this study demonstrate that relatively small environmental changes such as POS messaging in campus dining halls can positively impact dietary intake and improve CHD risk factors in college students.

What are the implications for health promotion practice or research?

College campuses provide an ideal setting to implement population-based approaches to promote healthier dietary choices. Targeting young adults at a point in their lives when lifestyle choices are being made presents an opportunity to influence lifelong eating habits and improve CHD risk factors in this population. A concerted effort from health professionals, policy makers, dining hall managers and on-campus restaurant owners is needed to create an environment that promotes the adoption of lifelong healthy behaviors.

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Table 1: Participant Characteristics

Baseline Characteristics	
	Mean ± S.D.
Age (yrs)	18.2 ± 0.6
	%
Gender	
Male	22.4
Female	77.6
BMI	
Normal weight (18.5-24.9 kg/m^2)	76.5
Overweight (25.0-29.9 kg/m^2)	18.4
Obese (>30.0 kg/m^2)	5.1
Race	
Caucasian	81.4
Black or African American	2.1
Hispanic/Latino	8.2
Asian	3.1
Mixed	4.1
Other	1.0
Major	
Nutrition/kinesiology	21.3
Allied health (nursing, pharmacy)	15.3
Other	63.4

BMI, body mass index

Table 2: Heart Start I Anthropometric, Biochemical, Clinical Results

Characteristics	Baseline (n=63)	Post-Intervention (n=63)	Follow-Up (n=63)
Weight (kg)	64.6 ± 10.4^a	65.7 ± 11.0^b	65.8 ± 11.3^b
Body mass index (kg/m²)	23.3 ± 3.2^a	23.6 ± 3.4^b	23.9 ± 3.7^b
Waist circumference (cm)	77.7 ± 8.0	78.4 ± 9.0	78.3 ± 9.1
Total cholesterol (mg/dL)	152.4 ± 27.7	158.1 ± 29.3	159.7 ± 28.0
LDL cholesterol (mg/dL)	82.9 ± 21.2	85.0 ± 22.7	84.3 ± 22.0
HDL cholesterol (mg/dL)	50.3 ± 14.5^a	$50.8 \pm 12.5^{a,b}$	54.7 ± 13.5^b
Triacylglycerides (mg/dL)	97.8 ± 44.4	107.3 ± 40.7	107.1 ± 48.2
Glucose (mg/dL)	87.0 ± 8.8^a	89.0 ± 7.3^b	86.0 ± 6.9^a
SBP (mmHg)	115.4 ± 12.4	115.2 ± 11.5	113.0 ± 8.8
DBP(mmHg)	70.9 ± 8.4	72.9 ± 7.6	71.5 ± 7.0

LDL, low-density lipoprotein; HDL, high-density lipoprotein; SBP, systolic blood pressure; DBP, diastolic blood pressure

Different superscripts denote significance (p<0.05)

Figure 1: Preferred Intervention Delivery Method
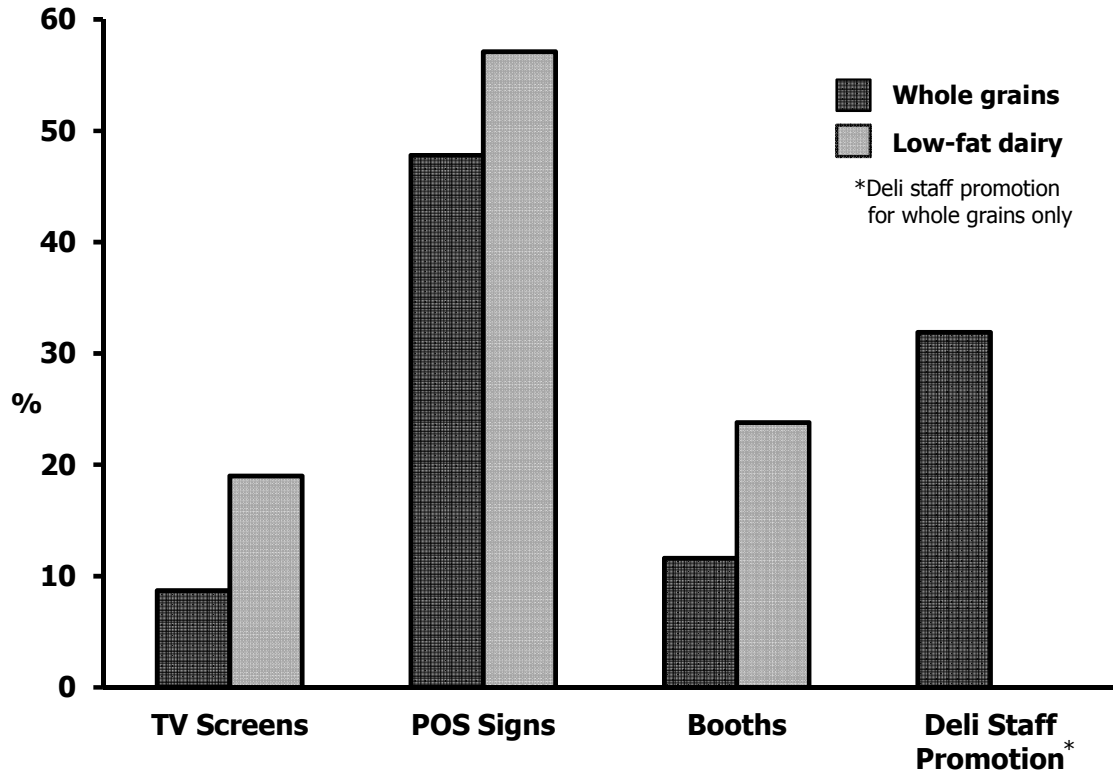
POS, point-of-selection

APPENDIX 1: EXTENDED METHODS

Design:

     A quasi-experimental design was used to assess the impact of a population-based low-fat dairy and whole grain messaging intervention on CHD risk factors. Baseline and post-intervention assessments were conducted immediately before and after the six-week intervention and the follow-up assessment occurred six months after the baseline assessment.

Study Timeline:
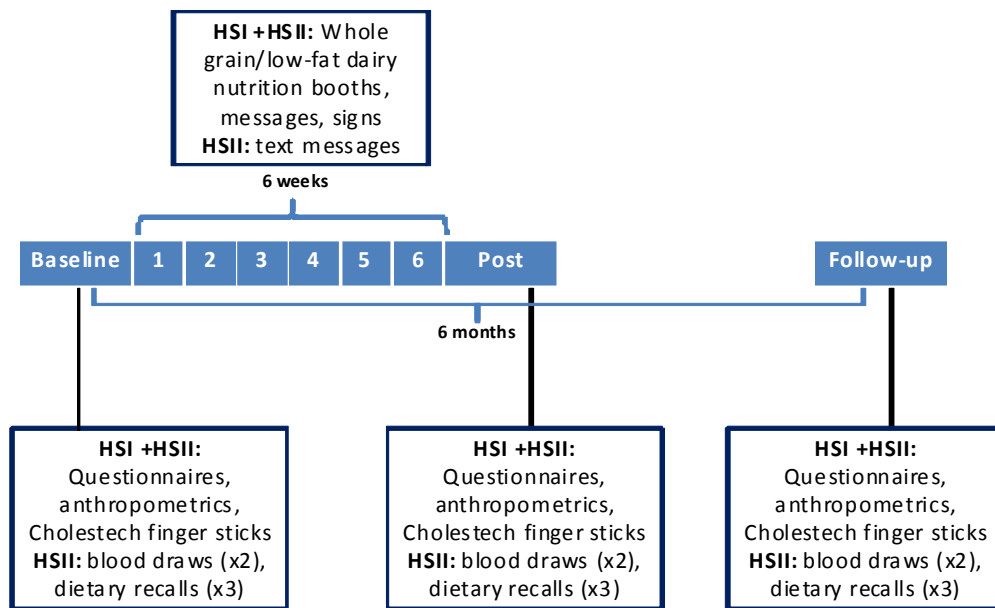
Recruitment:

     URI 101 courses were used to recruit URI students ages 18-24 years with campus meal plans. URI 101 professors were contacted via email to obtain permission for a study staff member to make a class announcement. Nutrition and kinesiology courses were excluded initially but were subsequently included to recruit additional

participants. Recruiting was also extended to a large introductory general education course (AVS 101).

Study Flow Chart:

```
┌─────────────────────┐              ┌─────────────────────┐
│   21 classroom      │              │                     │
│   announcements     │  ──────────▶ │     Completed       │
│  (n=1434 potential  │              │   survey (n=170)    │
│     subjects)       │              │                     │
└─────────────────────┘              └─────────────────────┘

┌─────────────────────┐              ┌─────────────────────┐
│  Eligible for HS I  │  ──────────▶ │ Eligible for HS II  │
│      (n=157)        │              │      (n=56)         │
└─────────────────────┘              └─────────────────────┘

┌─────────────────────┐              ┌─────────────────────┐
│ Completed baseline  │              │ Completed baseline  │
│      (n=98)         │              │      (n=26)         │
└─────────────────────┘              └─────────────────────┘

┌─────────────────────┐              ┌─────────────────────┐
│  Completed post-    │              │  Completed post-    │
│ intervention (n=84) │              │ intervention (n=25) │
└─────────────────────┘              └─────────────────────┘

┌─────────────────────┐              ┌─────────────────────┐
│ Completed follow-   │              │ Completed follow-   │
│    up  (n=65)       │              │    up  (n=18)       │
└─────────────────────┘              └─────────────────────┘
```
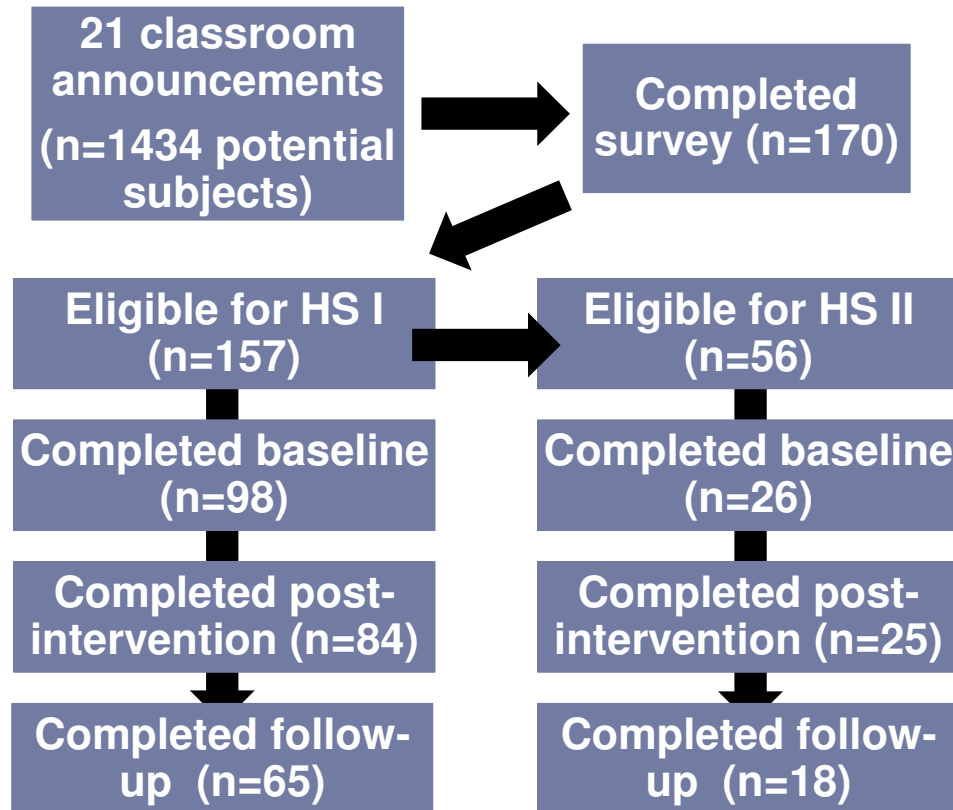
Data Collection:

Online Surveys

Students who were interested in participating emailed the study email address and were then sent a link to complete the online surveys before the initial assessment visit. The following surveys were included: Eligibility Screener, Brief Online Consent, Demographics and Health History Questionnaire, NHANES 2009-2010 National Cancer Institute Dietary Screener Questionnaire, International Physical Activity Questionnaire Short Form (1) , Weight Related Eating Questionnaire (2), Green Eating

Survey College Edition and College Environment Perception Survey. Survey data was collected using Survey Monkey (Survey Monkey, Palo Alto, CA) and eligibility was determined.   Eligible participants were 18-24 year old males and females with a campus meal plan and a body mass index ≥ 18.5 kg/m^2. Exclusion criteria included being pregnant or lactating, or self-report of one of the following conditions: eating disorder, liver disease, bleeding disorder, diabetes, cancer, or CHD.

Assessment Visits

Eligible participants were contacted to schedule the 1st assessment visit, which was conducted in Ranger Hall Room 305. At this visit, body mass index was confirmed by measuring height and weight to determine eligibility before the consent forms were signed (see protocol below). A subsample (n=26) was recruited for Heart Start II, which involved additional measures, based on responses to the green eating stage of change question from the Green Eating Questionnaire (see below). Eligible participants were in the precontemplation, action or maintenance stages of change.

Green eating includes participating in most of the following behaviors:

- Eating locally grown foods, produce that is in season and a limited amount of processed food

- Consuming foods and beverages that are labeled fair trade certified or certified organic

- Consuming meatless meals weekly and (if consuming animal products) selecting meats, poultry and dairy that do not contain hormones or antibiotics.

Based on the definition of green eating, which of the following best describes you now:

- I do not regularly practice green eating and do not intend to start within the next 6 months *(precontemplation)*

- I am thinking about practicing green eating within the next 6 months

- I am planning on practicing green eating within the next 30 days

- I regularly practice green eating and have been doing so for less than 6 months *(action)*

- I regularly practice green eating and have been doing so for 6 months or more *(maintenance)*

All participants read and signed an informed consent approved by URI's Institutional Review Board. All measurements were obtained at baseline, post-intervention and follow-up:

Anthropometrics

Height was measured to the nearest 0.1 cm using a Seca 220 stadiometer (Seca Corporation, Hamburg, Germany). Weight was measured to the nearest 0.1 kg using a calibrated digital Seca 769 scale (Seca Corporation, Hamburg, Germany). Measurements were taken in duplicate and the average of the two was used for the analysis. Body mass index (BMI) was calculated using the following formula: weight in kilograms/height in meters^2. Waist circumference was measured in duplicate at the top of the iliac crest upon exhalation to the nearest 0.1 cm using a Gulick fiberglass,

non-stretchable tape measure with an attached tensometer (Patterson Medical, Mount Joy, PA). The average of the two values was used for the analysis.

Biochemical

Following a 12-hour fast, finger sticks were performed on all participants to obtain blood samples for determination of blood lipid and glucose concentrations. Values for LDL-C, TC, TAG, HDL-C and glucose were obtained using Cholestech LDX table-top analyzers (Cholestech, Hayward, CA).

Heart Start II participants also provided two 12-hour fasting venous blood samples on two non-consecutive morning visits in the same week. Blood draws were performed by a trained phlebotomist. Plasma was obtained via centrifugation (Eppendorf Centrifuge 5810, Germany) of whole blood for 20 minutes at 2200 RPM's at $4^{o}C$. The following preservation cocktail was added to the plasma: 0.1 ml of phenylmethylsulfonyl fluoride/100 ml plasma (Roche, Indianapolis, IN), 0.1 ml of sodium azide/100 ml plasma (Fisher, Fairlawn, NJ) and 0.5 ml of aprotinin/100 ml plasma (Fisher, Fairlawn, NJ). Samples were stored in a -80 $^{°}$C freezer until analysis.

Total cholesterol concentrations were determined via a Roche Diagnostics Chol kit (Roche, Indianapolis IN) (3). Triacylglycerol concentrations were determined using a Roche/Hitachi Trig/GB kit (Roche, Indianapolis, IN) (4). A Roche/Hitachi Chol kit (Roche, Indianapolis, IN) was used for HDL-C analysis after dextran sulfate and magnesium chloride (Acros Organics, Morris Plains, NJ) were used to precipitate out the apolipoprotein B containing lipoproteins (5). Low-density lipoprotein cholesterol concentrations were calculated using the Friedewald equation (6).

Plasma glucose concentrations were obtained using an Autokit Glucose (Wako Diagnostics, Richmond, VA). All plates were read in a Biotek ELX 808 plate reader (Biotek, Winooski, VT).

Blood Pressure

Blood pressure was measured after a 5 minute seated rest period using an automatic blood pressure monitor with arm cuff (Omron HEI-711, Omron Health Care Products, Issaquah, WA). Measurements were re-taken two minutes apart until values were within 2 mmHg. The average of the two values in agreement was used for the analysis.

Dietary Intake

The NHANES 2009-2010 National Cancer Institute Dietary Screener Questionnaire (DSQ) was used to assess intake of fruits and vegetables, dairy/calcium, whole grains/fiber, added sugars, red meat, and processed meat in Heart Start I participants (7). Variables from the survey monkey download were re-named according to the DSQ codebook for the self-administered paper version. Eight-digit food codes were assigned to cereal responses. The SAS program and associated data files were used to analyze the dietary screener questionnaire data file (8). The following variables were calculated from the syntax: predicted fiber (gm) per day, predicted calcium (mg) per day, predicted added sugars (tsp) per day, predicted ounce equivalents of whole grains per day, predicted cup equivalents of dairy per day, predicted cup equivalents of fruits and vegetables (including legumes) per day,

predicted cup equivalents of fruits and vegetables (including legumes) except French fries per day and predicted added sugars (tsp) from sugar-sweetened beverages.

Purchasing records from dining services were used as a proxy for whole grain and low-fat dairy consumption. Purchasing records were obtained for bread and dairy products that offered a whole grain or low-fat dairy alternative (bread, rolls, breadsticks, English muffins, milk and yogurt) to determine if students selected the whole grain or low-fat dairy option. Purchasing records were obtained at baseline, intervention, post-intervention and 6-month follow-up. According to the whole grain definition used by dining services, items were categorized "whole grain" if the first ingredient was a whole grain. Dairy products were categorized as follows: whole (full fat), low-fat (1% or 2%) and nonfat (skim). Average values were calculated for individual items at each time point and were used for the analyses.

Twenty-four hour dietary recalls were collected and analyzed for Heart Start II participants (n=26) using the multiple pass method in conjunction with the Nutrition Data System for Research (NDS-R) software (University of Minnesota, Minneapolis, MN) version 2012. All participants completed three 24-hour dietary recalls: one in-person and two over the phone on three non-consecutive days (including two weekdays and one weekend day) (9, 10). Nasco food models (eNasco, Fort Atkinson, WI) and food amounts booklets were available during the initial in-person 24-hour recall to more accurately estimate portion size (11). Participants were given the booklets after the initial recall for the phone recalls. The mean values of the three recalls provided dietary data for analysis.

Healthy Eating Index 2010 scores were calculated from the mean values from the three 24-hour recalls for Heart Start II participants to assess diet quality in Heart Start II participants (n=26). The Healthy Eating Index 2010 reflects the 2010 Dietary Guidelines for Americans (12) and includes twelve dietary components (nine adequacy and three moderation) (13) **(Table 1)**. The University of Minnesota's NDSR "Guide to Creating Variables Needed to Calculate Scores for Each Component of the Healthy Eating Index-2010" was used to calculate scores using NDSR output files (14).

Table 1: Healthy Eating Index 2010 Components and Scoring

Component	Optimum Score	Standard for maximum score	Standard for minimum score of zero
Total Fruit[a]	5	≥0.8 cup eq/1,000 kcal	No fruit
Whole Fruit[b]	5	≥0.4 cup eq/1,000 kcal	No whole fruit
Total Vegetables[c]	5	≥1.1 cup eq/1,000 kcal	No vegetables
Greens and Beans[c]	5	≥0.2 cup eq/1,000 kcal	No dark-green vegetables or beans or peas
Whole Grains	10	≥1.5 oz eq/1,000 kcal	No whole grains
Dairy[d]	10	≥1.3 cup eq/1,000 kcal	No dairy
Total Protein Foods[e]	5	≥2.5 oz eq/1,000 kcal	No protein foods
Seafood and Plant Proteins[ef]	5	≥0.8 oz eq/1,000 kcal	No seafood or plant proteins
Fatty Acids[g]	10	(PUFAs+MUFAs)/SFAs >2.5	(PUFAs+MUFAs)/SFAs ≤1.2
Refined Grains	10	≤1.8 oz eq/1,000 kcal	≥4.3 oz eq/1,000 kcal
Sodium	10	≤1.1 gram/1,000 kcal	≥2.0 grams/1,000 kcal
Empty Calories[h]	20	≤19% of energy	≥50% of energy

[a] Includes 100% fruit juice.

[b] Includes all forms except fruit juice.

[c] Includes any beans and peas not counted as Total Protein Foods.

[d] Includes all milk products, such as fluid milk, yogurt, cheese, and fortified soy beverages.

[e] Beans and peas are included here (and not with vegetables) when the Total Protein Foods standard is otherwise not met.

[f] Includes seafood, nuts, seeds, soy products (other than beverages) as well as beans and peas counted as Total Protein Foods.

[g] Includes seafood, nuts, seeds, soy products (other than beverages) as well as beans and peas counted as Total Protein Foods.

[h] Calories from solid fats, alcohol, and added sugars; threshold for counting alcohol is >13 g/1000 kcal.

Intervention

Heart Start I and II participants were exposed to a 6-week intervention, which consisted of benefit-based nutrition messages in campus dining halls. Messages were

displayed on television monitors and on point-of-selection signs at the deli and dairy stations in both dining halls. Prompts to choose whole grain bread were also verbally provided by the deli station staff in both dining halls. Additionally, nutrition education booths to promote whole grain and low-fat dairy consumption were positioned in a high traffic area outside of Hope. Message and booth content alternated between whole grains and low-fat dairy each week. All URI students who ate at the dining halls were exposed to the intervention.

Intervention materials addressed specific motivators of healthy eating in for students (increased energy, healthy body weight and staying full) from previously conducted focus groups (15). Additionally, Heart Start II participants received the same nutrition message that was displayed on the television monitors in the dining halls each weekday via text message or email, depending on their preference. Google Voice (Google, Mountain View, CA), a web-based application, was used to deliver text messages.

Analysis

Sample Size

G*Power version 3.1.2 was used to calculate sample size. Sample size calculations were performed based on expected changes in LDL-C from a similar study with an effect size of 0.61 (16). Required sample size was determined to be 23, with alpha set at 0.05 to achieve statistical power at the 0.80 level.

Descriptive statistics were performed and skewness and kurtosis were examined to determine data distribution. Continuous variables were expressed as

mean ± standard deviation and categorical variables were expressed as frequencies. Predicted fiber (gm) per day, predicted added sugars (tsp) per day, total servings of low-fat dairy, LDL-C and BMI were log transformed. Predicted calcium (mg) per day, predicted cup equivalents of fruits and vegetables (including legumes) except French fries per day and TAG were square root transformed. Predicted ounce equivalents of whole grains per day, total servings of semi-whole grains, total servings of fiber, total servings of insoluble fiber, total servings of reduced fat dairy, % kcals from alcohol, predicted added sugars (tsp) from sugar-sweetened beverages and glucose were analyzed using non-parametric tests.

Repeated measures analysis of variance was used to determine if there were significant differences over time. Mixed between-within analysis of variance assessed differences between groups over time. Physical activity was included as a covariate as appropriate. Statistical significance was set at $p < 0.05$ for all tests.

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HOW 🫀 HEALTHY ARE YOU?

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874-2785

Questions? Dr Lofgren 874-5706
Department of Nutrition and Food Sciences, URI

THE
UNIVERSITY
OF RHODE ISLAND

The University of Rhode Island
Department of Nutrition and Food Sciences
301 Ranger Hall
HeartStart I

CONSENT FORM FOR RESEARCH

You have been invited to take part in a research project described below. The researcher will explain the project to you in detail. You should feel free to ask questions. If you have more questions later, Dr. Ingrid Lofgren (401-874-5706 or ingridlofgren@uri.edu) or Jennifer Arts (401-874-2785 or jarts@my.uri.edu), will discuss them with you. You must be 18-24 years old, have a URI meal plan, and have a body mass index ≥ 18.5 kg/m^2 to be in this research project. You are not eligible for this study if you have diabetes (Type 1 or Type II), cancer, coronary heart disease, liver disease, a bleeding disorder, are pregnant or lactating, have disordered eating or any health conditions that may influence energy balance, or if you are on lipid-lowering medication. If your body mass index is <18.5 kg/m^2 you will be referred to health services.

Description of the project:
The purpose of the study is to determine if a campus-wide dietary intervention will improve health status by decreasing coronary heart disease risk factors in college students. The intervention will consist of nutrition messages and education materials displayed around campus.

What will be done:
All students with meal plans will be exposed to the intervention in the dining halls. The study will involve the completion of questionnaires, two brief assessment visits, and a follow-up visit in Ranger Hall. If you decide to take part in this study here is what will happen:

Baseline Assessment:
Day prior to your first assessment visit (overnight)
- For the twelve hours prior to the first assessment visit, you will be asked to refrain from eating or drinking anything except for water. For example, if your screening visit is scheduled for 8 am on a Tuesday, you will be asked to not eat or drink anything (except for water) after 8 pm on Monday evening. We encourage you to drink as much water as you would like.

First assessment visit (approximately 30 minutes)
- Your height, weight, waist circumference and blood pressure will be measured.
- A finger prick will be performed to collect a few drops of blood for analysis of blood lipids and glucose.

3 Month Post-Intervention Assessment:
Prior to your second assessment visit (approximately 30 minutes)
- You will complete online questionnaires to assess dietary intake, eating behaviors, your college environment and physical activity.

Day prior to your second assessment visit (overnight)
- As with the day prior to the first assessment visit, you will be asked to refrain from eating or drinking anything except for water twelve hours prior to the second assessment visit.

Second assessment visit (approximately 30 minutes)
- Your height, weight, waist circumference and blood pressure will be measured.
- A finger prick will be performed to collect a few drops of blood for analysis of blood lipids and glucose.
- You will receive $20 upon completion of this visit.

6 Month Follow-Up Assessment:
Prior to your follow-up visit (approximately 30 minutes)
- You will complete online questionnaires to assess dietary intake, eating behaviors, your college environment and physical activity.

Follow-up visit (approximately 30 minutes)
- Your height, weight, waist circumference and blood pressure will be measured.
- A finger prick will be performed to collect a few drops of blood for analysis of blood lipids and glucose.
- You will receive $10 upon completion of this visit.

Risks or discomfort:
There are no known risks for the completion of questionnaires and the measurement of height, weight, waist circumference and blood pressure. Even though experienced personnel will obtain the blood samples there is a chance of discomfort from the finger stick.

Benefits of this study:
This study will improve understanding of behavioral and environmental factors that influence coronary heart disease risk and obesity. The direct benefits to you include

increasing your dietary knowledge and learning about your health status. You will receive the results from your assessment visits (height, weight, body mass index, waist circumference, blood lipids and glucose).

Confidentiality:
Your participation in this study is confidential. None of the information will identify you by name. All records will be stored in a locked office that is only accessible to study personnel.

In case there is any injury to the subject:
If this study causes you any injury, you should notify Dr. Ingrid Lofgren at 401-874-5706 or ingridlofgren@uri.edu. You may also contact the office of the Vice President for Research, 70 Lower College Road, University of Rhode Island, Kingston, Rhode Island, telephone: 401-874-4328.

Decision to quit at any time:
The decision to take part in this study is up to you. You do not have to participate. If you decide to take part in the study, you may quit at any time. If you wish to quit, simply inform Jennifer Arts at 401-874-2785 or jarts@my.uri.edu or Dr. Ingrid Lofgren at 401-874-5706 or ingridlofgren@uri.edu of your decision.
Rights and Complaints:
If you are not satisfied with the way this study is performed, you may discuss your complaints with Dr. Ingrid Lofgren, anonymously, if you choose. In addition, if you have questions about your rights as a research participant, you may contact the office of the Vice President for Research, 70 Lower College Road, Suite 2, University of Rhode Island, Kingston, Rhode Island, telephone: (401) 874-4328.

You have read the consent form. Your questions have been answered. Your signature on this form means that you understand the information and you agree to participate in this study.

_____   _____
Signature of Participant   Signature of Researcher

_____   _____
Typed/printed Name   Typed/printed name

_____   _____
Date   Date

I consent to be contacted for future research related to this project or other projects.

_____ _____

Signature of Participant   Signature of Researcher

_____ _____

Typed/printed Name   Typed/printed name

_____ _____

Date   Date

Please sign both consent forms, keeping one for yourself

APPENDIX 4: ASSESSMENT CHECKLIST

Subject ID# _____

Date: _____   **Time**: _____

Visit: Baseline   Post-Intervention   Follow-up

Researcher: _____

<u>Questions to ask participant</u>

1. At what time did you last have something to eat? _____ a.m. or p.m.

2. At what time did you last have something to drink? _____ a.m. or p.m.

3. Have you had any caffeine, tobacco, or tobacco products today?

    Yes   No

    If yes, please have participant explain:

      What: _____

      When: _____ a.m. or p.m.

    Have you participated in any structured exercise either yesterday or today?

    Yes   No

    If yes, please have participant explain:
    _____

4. Are you currently ill?   Yes   No

5. Is there any reason you feel you are unable to participate in testing today?   Yes
    No
        If yes, have participant explain:
      _____

6. Please ask participant if there is any additional information they would like to provide
    to the assessment staff member:

Reasons to Reschedule

1. If participant has eaten in the last 12 hours.
2. If participant drank something in the last 12 hours (exception water).
3. If participant had any caffeine in the last 12 hours.
4. If the participant is ill.
5. If participant states they are unable to participate today.

❑ Participant is cleared for the assessment today.
❑ Participant will need to be rescheduled because

_____

APPENDIX 5: WHOLE GRAIN AND LOW-FAT DAIRY MESSAGES

Whole Grain:

Fill up with fiber! Choose **whole grain** bread on your sandwich.

Make the switch to **whole grain** breads and wraps to **stay full** longer.

Maintain a **healthy weight**…choose **whole grain** breads, wraps and pitas.

Need energy? Eat **whole grain** bread and wraps.

Fiber up! Eat **whole grains**.

Low-Fat Dairy:

Maintain a **healthy weight**...choose **low-fat dairy**.

Be **heart smart**...drink **low-fat milk**.

Trim excess fat without sacrificing taste. Switch to **low-fat dairy**.

Choose **low-fat dairy**...your heart will love you.

Make the switch to **low-fat dairy** to cut unwanted fat.