Published in final edited form as:
*J Acad Nutr Diet*. 2012 May ; 112(5): 649–656. doi:10.1016/j.jand.2012.02.002.

# US acculturation is associated with health behaviors and obesity, but not their change, with a hotel-based intervention among Asian-Pacific Islanders

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## Abstract

**Background—**Immigration to the United States has been associated with obesity, yet the relationship of acculturation with obesity and energy balance (i.e., physical activity/dietary intake) in adults is a complex issue. Limited longitudinal data is available on immigrant Asians and Pacific Islanders.

**Design—**Analyses were conducted on baseline data and change data from baseline to 24 months in the hotel-based cluster-randomized Work, Weight and Wellness (3W) trial involving 15 control and 15 intervention hotels on the island of Oahu, Hawaii.

**Sample—**Participants were adult employees of predominantly Asian and Pacific Islander ancestry who were assessed one or more times over the course of 24 months. The full sample consisted of 4236 hotel workers (about 40% of hotel workforce) at baseline, 3502 hotel workers at year one and 2963 hotel workers at the 24-month follow up. 1115 hotel workers had at least two measurements, and were included in the analysis.

**Intervention—**The 3W intervention was designed to promote weight loss via motivation and support for increases in physical activity and increased access to and consumption of healthy low fat/low calorie foods. The measure of acculturation consisted of a score that was a compilation of a participant’s age when he or she immigrated to the US/Hawaii, country of birth, language spoken at home, and years of education.

**Statistical Analyses—**We used mixed effect regression models for cross-sectional baseline models and longitudinal multilevel regression analysis of change in diet and physical activity behaviors and obesity over time using a fixed intercept. Estimates of the intervention effect are expressed as an annual rate of change for all study outcomes.

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No authors declare a conflict of interest

**Results—**At baseline acculturation was positively associated with body mass index, physical activity level; and fruit, meat, and sweetened drink intake level. In analyses of change over 24-months, acculturation did not significantly influence change in dietary intake or indices obesity (i.e. BMI or waist/height ratio). However physical activity increased significantly more in the intervention group, over the course of the intervention, compared to the control group, which decreased activity, controlling for socio-demographic factors (including acculturation) and food intake behavior

## Introduction

Immigrants (foreign-born) were 12% of the US population in 2003 (1) and the proportion is steadily increasing. Lifestyle factors that change with migration and acculturation to US lifestyle are associated with obesity, including a diet high in energy-dense foods and physical inactivity (2). A growing body of research shows that migration and acculturation to the American diet contributes to obesity among Mexican-Americans (3) and African Americans (4), but the relationships between migration, acculturation and obesity have not been studied among Asians and Pacific Islanders.

Hawaii is well suited to examination of acculturation and obesity. About 17% of the population is foreign-born and 24% speak a language other than English at home (5). Also, body size and lifestyle behaviors vary substantially across the broad range of ethnic groups in Hawaii including Filipinos, other Asian ethnic groups, Native Hawaiians, and other Pacific Islander ethnic groups. The average body mass index (BMI, $kg/m^2$) of Pacific Islanders and Filipinos is greater than that of Whites, while BMI of most Asians is lower than that of Whites (6). Health risks in ethnic minority groups may vary with acculturation; for example, a study of Chinese adults who were US born had increased risk of carotid plaque, compared to foreign-born Chinese (7).

Previous measures of acculturation have assessed a range of socio-demographic characteristics including preferred language (i.e, language spoken at home, used when conversing with friends, language used in TV/radio programs and newspapers, etc), age at time of immigration, years lived in the US, and country of birth for respondent as well as respondent's parents and grandparents. Previous studies have combined several of these characteristics into an index that measures multiple dimensions of acculturation (5). The index of acculturation used in this study incorporates educational level, country of birth, age at immigration and whether the birth country uses English as the national language (8).

In previous analyses, food intake was found to be related to place of birth, generation of migration to the US, and acculturation to the US (8). This paper expands on these results by examining associations between acculturation, physical activity and obesity (BMI and waist/height ratio) both in a cross-sectional analysis and in a 24-month longitudinal analysis.

Hotel workers were chosen for this study for several reasons. First, the industry is world-wide and the work, environment, and the labor practices are very similar regardless of location, at least in major chain hotels. Almost all hotels are composed of a mixture of workers in a wide range of job categories such as facility maintenances, direct operations (servers, housekeepers, porters, kitchen workers, bartenders, etc,), management, marketing, and human resources. Identification of the degree to which acculturation is associated with the risk factors for obesity within such a worksite setting would be helpful for the development and implementation of culturally sensitive interventions to prevent or curb the obesity epidemic. Importantly, hotels are key employers of immigrants to Hawaii, and those immigrants are predominantly Asian and Pacific Islander. Thus, our purpose was to examine the relationship of acculturation to health behaviors and obesity, and their change, among Asians and Pacific Islanders in Hawaii.

## Methods and Procedures

### Study design and population

Adults were enrolled in the Work, Weight and Wellness (3W) program - a community-based cluster-randomized trial involving 30 independent hotels on the island of Oahu in the state of Hawaii from 2005–2008. A detailed description of the study's methods has been published (6), and a brief summary of the methods is presented here.

Hotels were randomly assigned to the control condition (n = 15 hotels) or to the intervention condition (n = 15). The intervention used a social ecological theoretical model to promote diet and physical activity change (9). The 3W study is described in detail elsewhere; the intervention was designed to reduce weight among hotel workers via changes in dietary intake and physical activity over a 24-month period (6). The sample consisted of 4236 hotel workers (about 40% of hotel workforce in Hawaii) at baseline, 3502 hotel workers at one-year follow-up, and 2963 hotel workers at two year follow up. The acculturation questions were only asked on the year 2 assessment questionnaire.

The sample includes only overweight and obese subjects (BMI ≥ 25) with responses to the migration question, or 1612 subjects (Table 1). The acculturation analysis was limited to subjects with at least two longitudinal measurements (n=1115). There were a varying number of subjects available for each analysis due to missing data (Table 2).

**Employee assessment—**Hotel employees at intervention and control sites were invited to participate in three annual assessments (baseline, 12 months and 24 months). These assessments included physical measurement of height, weight, and waist and hip circumference by project staff, plus a set of self-administered questionnaires covering health behaviors and demographics. Participation at each assessment was voluntary and employees were not required to commit to future assessments or participation in the intervention program. Thus, there were two groups of employees that contributed to this paper's analyses: 1) a cohort of individuals who had multiple assessments (i.e., two or three measurements) over 24 months, and 2) a cross sectional sample used to describe health behaviors and who may have been assessed only once at 24 months.

**3W Intervention—**Although all employees were invited to participate in the study, regardless of their BMI, the intervention was tailored for employees with a BMI ≥25, and data are presented here only on those with BMI ≥ 25. A financial incentive ($10 gift card) was given to employees who participated in an assessment. Rather than being tailored to specific ethnic or gender subgroups, the intervention was designed around the broad patterns of culture found in Hawaii. That is, it incorporated dietary elements from a variety of ethnic foods commonly consumed by the general population in Hawaii, regardless of ethnicity, and physical activities appropriate for the local environment. Precise tailoring to individual ethnicity was not practical in this mixed ethnic sample. The intervention was a multi-component theoretically-derived social ecological intervention that included changes to the hotel environment (for example, healthy food choices in the employee cafeteria newsletters/flyers/table tents with brief tips on how to increase physical activity/health eating practices) and group-based classes both of which were designed to improve dietary habits, increase physical activity, and encourage weight control practices.

**Personal health advice for all participants—**After every assessment, participants in both intervention and control groups received brief personalized oral and written health recommendations, based on their health risks as determined from their completed questionnaires. No further intervention, beyond this feedback at each assessment, was provided at control hotels.

## Behavioral Measurements

**Food Intake—**Food intake was assessed using a screening questionnaire that included validated questions from Martinez-Gonzalez et al (10), Serdula et al (11) and Block et al (12, 14). The screener included both “energy dense” and “not-energy dense” foods that previous research had shown to be significant contributors to BMI (13). Food intake questions were queried in number of servings, with examples and descriptions of portion size (eg. How many servings of sweetened drinks or soda do you drink in a day? One serving is a 12 oz. can, a small size drink, or one regular glass. Examples of sweetened drinks include regular soda, sweetened fruit juices and teas, punch, Hawaiian Sun, and coffee drinks).

**Physical activity—**Physical activity was measured by a validated instrument, the Godin Leisure-Time Questionnaire (14), measured in metabolic equivalent (MET) adjusted minutes per week of light, moderate and hard levels of “leisure time” physical activity. Work-related physical activity was not measured, since the intervention was not designed to modify occupational physical activity.

**Anthropometry—**Weight was measured to the nearest 0.1 lb. on a Tanita WB-100 Series Digital Physician Scale (Arlington Heights, Illinois). Height was measured to the nearest 0.125 inch with a Seca stadiometer (214 Road Rod (Ontario, CA). Body Mass Index was calculated (BMI, $kg/m^2$). Waist circumference was measured the end of normal exhalation, at the midpoint between the participant’s lowest rib and iliac crest, with a tape measure to the nearest 16th of an inch, over light clothing. Measures were converted to kg and cm.

## Demographics

The study questionnaire was available in three languages: English, Chinese, and Korean (almost all of the Filipino hotel workers spoke English). Chinese and Korean versions of the questionnaires were validated by comparing a back-translated version produced from the original English version by a separate translator.

The questionnaires included:

**Race/Ethnicity—**Participants could select one or more race/ethnic group from a list of 18 race/ethnic categories. For this paper these categories were collapsed into: Other Asian, Filipino, Pacific Islander, White, and Other. Participants who self-identified as Samoan, Native Hawaiian, Guamanian, or from another Pacific Islander race were assigned to Pacific Islander race. Participants with Korean, Vietnamese, Japanese, Chinese, or other Asian races, were assigned to the “Asian” category. The remaining categories had too few participants to warrant a separate group and thus these individuals were assigned to the “Other” category (i.e., American Indian, Alaskan Native, Black/African American, Hispanic or Latino).

Filipino ethnicity was retained as a separate category from Asian because the proportion of Filipinos in Hawaii is very large relative to other Asian race/ethnic groups, and data have shown Filipinos in Hawaii are at higher risk for obesity and for obesity-related illnesses compared to other Asian groups (6). Further, immigration from the Philippines to Hawaii has historically occurred without restriction; thus, Filipinos represent a high proportion of the foreign-born population in Hawaii with varying degrees of acculturation. Race/ethnicity data for 126 subjects were missing and they were excluded from analyses. Hispanic was not treated as a separate race/ethnic category since those who reported it also selected another race. The 8% who reported Hispanic were collapsed into other groups as follows: Filipino (3%), Other Asian (1%), Pacific Islander (2%), and Other (2%).

**Acculturation—**An index of acculturation was previously developed (6), which includes: country of birth, age when immigrated to US, number years lived in the United States, language spoken at home, and highest level of formal education (defined as years of schooling: 8th grade or less; some high school, but did not graduate; high school graduate or GED; some college or 2-year degree; technical/business school graduate; college graduate; post-graduate degree (master's, doctorate, or equivalent); the index adapted a scale previously developed to investigate the association between acculturation and BMI among Mexican immigrants (15). The acculturation scale for this paper ranged from a low (score = 0) to high (score = 6) levels of acculturation. Low (0) was defined as immigration to the US at age 19 or older, plus country of birth was non-European or non-English-speaking country, English was not spoken at home, and highest education level was less than high school. High (6) was defined as born in US or came from European or English-speaking country, and English spoken at home.

### Analyses

In addition to reexamination of cross-sectional models of health behavior and obesity previously published (6), but with the addition of physical activity, we modeled change in six outcome variables: change in level of physical activity, change in dietary intake (3 food group variables – sweetened drinks, meat, fruit), change in BMI and waist circumference/height ratio. These changes reflected changes from baseline to year one, and year one to year two. Model covariates were obesity at baseline, intervention group assignment (control or intervention), study year, study year × intervention group interaction (effect of the intervention of outcome variable across time), acculturation level, study year × acculturation (effect of acculturation on outcome variable across time), ethnicity, place of birth, age, gender, height, job category, physical activity and dietary intake of each of five food groups (meat, dairy, sweetened drinks, fruit, vegetables). A two level covariance structure was used, where the first level included: obesity at baseline, intervention group, study year × intervention group interaction [or effect of the intervention on outcome variable across time], study year, acculturation level and study year × acculturation level [or effect of acculturation on outcome variable across time]. The second level of covariance included gender, height, race/ethnicity, job category, education, birthplace, physical activity level (except where it was an outcome), servings of dairy intake, servings of fruit intake (except where it was an outcome), servings of meat intake (except where it was an outcome), servings of sweetened drink intake (except where it was an outcome).

A mixed effect regression model was used for cross-sectional models and longitudinal multilevel (GEE) regression analysis (16), with random intercept, for the models of behavior and obesity change over time. These analyses explicitly model the intra-class correlation of repeated outcome measurements within employees and employees' trajectories within hotel clusters. A generalized model can be written as: $Y_i = X_i\beta + Z_i + \gamma_i + \varepsilon_i$ where $X_i$ and $Z_i$ are the fixed and random design matrices respectively, $\beta$ is a vector of fixed effects, $\gamma_i$ is a vector unknown random effects, and $\varepsilon_i$ is the unknown random error. Time was the random effect in the models, while the intervention and covariates were the fixed effects. A full maximum likelihood was used to estimate model parameters and imposed the least restrictive structure on within-cluster covariance. The estimates of the intervention effect are expressed as an *annual rate of change* and used all available data. SAS v9.1 software package was used to conduct the analyses (Carey, North Carolina, 2007).

### Human Subjects

The study was conducted by the Kaiser Permanente Center for Health Research Hawaii. The Kaiser Permanente Institutional Review Board approved the study. Informed consent was obtained from all participants.

## Results

The study population's (n=1612) mean age was 46.0 ± 10.2 y and 48% male. Race/ethnicity of participants was 42% Filipino, 32% other Asian, 13% Pacific Islander, 9% White, 1% African American, and 3% other. Place of birth was: 39% Hawaii; 39% Philippines; 8% US mainland,; 5% in China, Taiwan or Singapore; 2% on another Pacific Island; 2% in Japan; 2% in Europe, Canada, Australia or New Zealand; 2% in Southeast Asia; 1% in Korea; and 0.4% in other places.

Education level in the entire sample was: 8% (n=285) had a technical or business degree; 21% (n=768) had a college degree or more 30% (n=1075) had a two-year college degree or some college; 30% (n=1064) had a high school degree or diploma; 6% (n=207) had some high school education; and 5% (n=193) had 8 years or less education.

Health behavior and obesity characteristics at baseline are shown in Table 1. The mean BMI was 29.3 ± 4.2 kg/m$^2$, a mean value that would be classified as overweight (25–25.9 kg/m$^2$, but close to the cut-point of obese at 30 kg/m$^2$) (17, 19). Approximately half of all participants were obese (BMI ≥ 30) at baseline (1138 obese, 2482 not obese); and obesity level did not differ by intervention group assignment at baseline (intervention: 29.5 ± 26.6 kg/m$^2$ vs. control: 29.8 ± 27.2 kg/m$^2$). In the sample used for the present analysis (with 2 measurements), the majority were overweight (67%), with only 3% obese. Using the waist/height ratio to classify obesity of the sample, the mean and SD of 0.56 ± 0.06 would be classified as obese (>0.5) (18). The physical activity level appears high, though the reference data in the Table are not strictly comparable as the reference refers only to moderate and physical activity (Table 1), while this study measured all leisure time physical activity.

Data were compared to the 1992 Food Guide Pyramid which used servings/day as the units of reference, as did this study (19). According to that reference, combined fruit and vegetable intake is adequate at 3 servings/day, though others have recommended up to 9 servings per day for optimal health (20). Compared to the reference values (Table 1) reported meat intake was low at 1.6 servings/day. Sweetened beverage intake was higher than recommended at one serving/day (none is recommended).

**Physical Activity Outcome—**For models examining influences on physical activity, there were 2542 observations representing 1113 participants. At baseline, the obese participants had a lower level of physical activity than non-obese (estimate 150.4 ± SE 64.9 MET minutes/week, F=5.37, p=0.02). Controlling for other factors, physical activity increased in the intervention group and decreased in the control group (control −53.7 ± 89.0 MET minutes/week, intervention 1000.1 ± 94.5 minutes/week, F=12.2, p<0.0005). Acculturation level was significantly associated with level of physical activity at baseline (Table 2, F=3.32, p=0.003), but did not significantly modify the change in physical activity with across time. Physical activity increased more in females compared to males (117.7 ± 43.9 MET minutes/week, F=7.19, p=0.007), though females had lower levels of activity at baseline than males (−748 ± 86.6 MET minutes/week lower than males, p<0.0001). Higher education level was associated with higher level of physical activity at baseline (F=2.58, p=0.03). There were ethnic differences in physical activity level, both at baseline (F=7.88, p<0.0001) and across time (F=5.14, p=0.0005). Asians and Filipinos had lower levels of activity than Whites at baseline; while Filipinos increased more with the intervention than did Whites. Place of birth was associated with level of physical activity (F=4.48, p=0.0006); those from Hawaii had lower levels of physical activity than those from the US mainland (−253.3 ± 91.3 fewer MET minutes/week, t= 2.78, p=006).

**Servings of Meat Outcome—**For the meat intake analysis, 3422 observations were available, representing 1585 subjects. Obesity at baseline was positively associated with consumption of more daily servings of meat (0.11 ± SE 0.04 servings/day among the obese; F= 8.53, p=0.004). There were ethnic differences in servings of meat per day using whites as the comparison group: Asians 0.34 ± SE 0.08 more (t=5.11, p<0.0001), Filipinos 0.29 ± SE 0.08 more (t=3.63, p=0.0003) and Pacific Islanders 0.22 ± SE 0.07 more (t=2.91, p=0.004). Males consumed 0.16 ± 0.05 more meat servings/day compared to females (t=3.22 ± 0.001, p=0.001). Taller individuals consumed 0.88 ± 0.27 servings/day more meat for each meter taller (t=3.23, p=0.001). Those who consumed one or more servings of sweetened drinks per day also consumed 0.12 ± 0.02 more servings/day meat (t=7.84, p<0.0001). Those who consumed one more serving of fruit consumed 0.06 ± 0.02 servings/day of meat (3.79, p=0.0002); and those who consumed one more serving/day of dairy consumed 0.13 ± 0.02 more servings/day of meat (t=6.79 <0.0001). Age, education, birthplace, job and physical activity were not significantly related to daily servings of meat consumed, and meat consumption did not change significantly over the course of the two-year intervention. Acculturation was associated with consuming more servings of meat at baseline (F=4.45, p<0.0002, Table 2).

**Servings of Sweetened Drinks Outcome—**For the analysis of influences on sweetened drink consumption, there were 3418 observations, representing 1582 subjects. Obesity at baseline was not associated with greater consumption of sweetened drinks (F=6.15, p=0.04). Men consumed fewer daily sweetened drinks than women at baseline (−0.15 ± SE 0.04 servings/day, F=13.2, p=0.0003). Job type was associated with sweetened drink intake (F=4.41, p=0.01), where food service workers and housekeeping workers consumed more servings of sweetened drinks at baseline as compared to landscaping/maintenance workers (0.17 ± 0.11 and 0.008 ± 0.02 servings/day, respectively). Also those who consumed an additional serving of meat and of dairy consumed more meat also consumed more servings/day of sweetened drinks (0.15 ± 0.02, F=57.9 +<0.0001 and 0.13 ± 0.02, F=37.1, p<0001, respectively). Those who increased their physical activity by one hundred MET minutes/week decreased their sweetened drink intake by −0.003 + 0.001 servings/week (F = 7.23, p=0.008). Acculturation was positively associated with consuming sweetened drinks at baseline (F=2.58, p=0.02, Table 2), but was not associated with a change in sweetened drink consumption across the intervention period.

**Daily Servings of Fruit Outcome—**For analysis of fruit consumption, there were 2498 observations, representing 1109 participants. Fruit intake increased with each year of study intervention (F=9.98, p=0.002). Job type influenced servings of fruits consumed at baseline (F=5.08, p=0.007), where housekeeping workers (0.18 + 0.06, t=−2.93, p=0.004) ate fewer servings of fruit than food service workers. At baseline, males consumed fewer servings of fruit than females (estimate −0.15 ± 0.04; F=12.3, p=0.0005). For each additional daily serving of fruit, participants also ate more servings of meat (0.07 ± 0.02, t=3.33, p=0.001) and dairy (0.21 ± 0.02, t=9.85, p<0.0001). For every serving of fruit consumed by Whites, Asians ate (−0.35 ± 0.09; t=3.33, =0.001) fewer daily servings and Filipinos ate (−0.22 ± 0.09, t=−2.54, p=0.01) fewer daily servings. For every additional daily serving of fruit, daily physical activity level was 0.0001 ± 9.00002, t=6.91 p<0.0001) MET adjusted minutes/week greater. Acculturation was positively associated with fruit consumption at baseline (F=5.58, p<0.0001, Table 2). Acculturation was not associated with change in fruit intake across the intervention period.

**BMI Outcome—**For the BMI outcome analyses, there were 3448 observations, representing 1584 participants. The statistical model differs from our previous published results (9, 11) by incorporating physical activity level, and considering both a baseline and a longitudinal effect (change in BMI). BMI at baseline was associated with race/ethnicity (F=12.02, p<0.0001), with Pacific Islanders having a higher BMI (0.51 ± SE 0.20 kg/$m^2$, t=2.58, p<0.01) and Asians (−0.43 ± SE 0.20 kg/$m^2$, t=−2.15, p=0.03) a lower BMI compared to Whites. BMI for Filipinos and "Others" were not significantly different from Whites at baseline.

An extra unit of BMI (kg/$m^2$) was associated with 0.08 ± 0.03 more daily servings of sweetened drinks (t= 3.00, p=0.003). Those with one unit higher BMI had −0.0001 ± 0.00002 fewer MET adjusted minutes/week of physical activity (t=4.94, p<0.0001). Baseline acculturation was also significantly related to BMI, where the more acculturated had higher BMI (F=2.66, p=0.02, Table 2). Gender, height, education level, birthplace and job category were not significantly associated with BMI at baseline. There were no significant changes in BMI across the intervention, and no measured variable had an effect on change in BMI.

**Waist Circumference/Height Outcome—**For the waist/height ration (WHR) outcome analysis, there were 3425 observations, representing 1583 participants. As expected, at baseline, obese subjects had larger WHR (8.24 ± SE 0.23, F=1232.9, p<0.0001). There was a study year main effect across time, where WHR decreased across time (estimate −0.38 ± SE 0.09, F=17.65, p<0.0001). Race/ethnicity was associated with WHR (F=5.18, p=0.0005) where Asians (−0.86 ± SE 0.37; t=−2.32, p=0.02) had lower values than Whites; Pacific Islanders, Filipinos and "Others" were not different from Whites. Servings of sweetened drinks were significantly associated with higher WHR; one serving was associated with a 0.40 ± SE 0.07 higher WHR (F=11.8, p=0.0007), as were servings of dairy (0.14 ± 0.37, t=2.12, p=0.04). Males had 3.15 ± 0.30 units higher WHR than females (t=10.6, p<0.0001). For every meter increase in height, participants had a −15.6 ± 1.63 smaller WHR (t=9.56, p<0.0001). Physical activity was protective for WHR; 100 minutes of physical activity a week was associated with 0.0003 ± SE 0.00005 lower WHR (F=44.35, p<0.0001). Acculturation, however, was not significantly associated with WHR.

## Discussion

In previous analyses of baseline data of the 3W study we found that acculturation to the US was positively associated with obesity and negatively associated with healthful dietary patterns (8). In this analysis we added physical activity to the models and examined change over a two-year follow-up period. Acculturation was positively related to both increased physical activity and obesity (BMI) at baseline. Physical activity and fruit intake ("healthful behaviors"), as well as consumption of meat and sweetened beverages (less healthful behaviors) were all positively associated with acculturation at baseline. Thus, both positive and negative behaviors have been adopted with acculturation to the United States. This was found in two other studies of acculturation of Asian Americans (20) and of Hispanics (22), where being foreign-born (22) and bi-culturalism (retaining ancestral culture and adopting US culture, 21) were protective for obesity. Indeed the studies suggested that being foreign-born is associated with a resiliency to obesity (22), while bi-culturalism allows a "selective acculturation" (21) to retain healthy ancestral behaviors (healthy foods), while adopting healthful behaviors associated with US lifestyle (such as increased recreational physical activity). However, in the present study acculturation did not significantly influence change in behavior over this two year intervention.

Leisure time physical activity was increased by the multiple component lifestyle intervention conducted at the hotel worksites, whereas none of the dietary behaviors were significantly changed by the intervention (controlling for acculturation, other socio-demographic factors, and the other behaviors). Though the effect was modest, the public health impact of modest shift in physical activity of a large population of workers may be important in reducing health risk. Contextual barriers (such as child rearing practices, or neighborhood characteristics) have been found to limit the increase in physical activity with acculturation (23). For culturally and linguistically diverse groups, challenges and barriers that limit physical activity participation have been found to include: cultural and religious beliefs, issues with social relationships, socioeconomic challenges, environmental barriers, and perceptions of health and injury (24). Still, in a highly diverse population, this study showed measurable improvement in physical activity with a multicomponent lifestyle intervention. Other studies have shown physical activity to be associated with better maintenance of weight loss (25), though few environmental interventions have been found to demonstrate improvement in physical activity, unless enhanced with a behavioral intervention (26).

Given the high risk of weight gain and associated chronic diseases for immigrant populations, these findings present some good news that should be further explored. Further study of positive effects of acculturation on health behaviors such as those found here (higher physical activity, fruit intake), among ethnically diverse populations in Hawaii and in other settings with other cultural groups, will further obesity prevention efforts. Also of note, this study used a more comprehensive construct for acculturation than many previous studies by incorporating age at immigration, education level, language, country immigrated from and country of birth. Hawaii has a unique multicultural environment with "western" lifestyle elements as well as Asian/Pacific Island cultural influences (eg. rice, sushi, etc…), with no dominant culture. Persons of the host culture, Native Hawaiians, comprise approximately 20% of the population, and another 20% of the population self-identifies as mixed race/ethnicity (6). Asian ethnic groups comprise the largest proportion, about 40%, and White race/ethnic ancestry comprises about 20% (6). Increasingly, as in Hawaii, immigrants join such cultures where the acculturation process is multidirectional and multicultural (27), necessitating increased specificity in describing cultural changes.

This study was not able to distinguish between acculturation to Hawaii versus to other US states, as the questions asked included where migrated from, but where migrated to, in the United States. Also, the questions that were used to describe acculturation in this analysis were only collected at the end of a 24 month study, weakening the temporality of the relationship between acculturation and behavior change in the study. Also, by including only those who had two measurements in order to assess change, the sample may represent the more motivated individuals who stayed with the program.

## Conclusions

Acculturation to the US was positively associated with higher levels of physical activity and increased consumption of fruit, meat and sweetened drink. Acculturation to the US was also associated with greater obesity (BMI), controlling for socio-demographic, physical activity and diet patterns. Acculturation did not significantly affect change in diet, physical activity or obesity in a two year work site based intervention. However, the intervention was successful in increasing physical activity, even after adjusting for socio-demographic factors (including acculturation) and dietary behaviors. The relationship between obesity, health behavior and acculturation warrants further attention and specificity, recognizing multidimensional impacts of acculturation.

## Acknowledgments

**Funding:** NIH/NHLBI 5-R01 HL079505

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**Table 1**

Health behaviors and obesity of the study population (n=1612)

| Variable | Mean | SD | Reference Values |
|---|---|---|---|
| Body Mass Index, kg/m$^2$ (n=1608) | 29.3 | 4.2 | >25 = overweight; >30 = obese[1] |
| 18–25 (n=33) | 25.0 | 0 | |
| 26–30, overweight (n=1081) | 27.2 | 1.39 | |
| >31, obese (n=44) | 34.1 | 4.16 | |
| Waist to Height Ratio, cm/cm (n=1603) | 0.56 | 0.06 | >0.5 = obese[2] |
| Leisure Physical Activity, total MET minutes/week (n=1593) | 1215.8 | 1274.3 | 150 moderate physical activity[3] |
| Sweetened drinks, servings/day (n=1599) | 1.02 | 1.01 | Few or none[4] |
| Fruits & vegetables, servings/day (n=1596) | 2.92 | 1.58 | 2–5[5] |
| Meat, servings/day (n=1601) | 1.64 | 0.88 | 2–3[5] |

[1]World Health Organization. *Obesity and Overweight*. 2009 [cited 2011 April 9, 2011]; Available at: http://www.who.int/mediacentre/factsheets/fs311/en/index.html (BMI ≥ 25 sample selection criteria)

[2]Browning LM, Hsieh SD, Ashwell M. A systematic review of waist-to-height ratio as a screening tool for the prediction of cardiovascular disease and diabetes: 0·5 could be a suitable global boundary value. Nutr Res Rev. 2010 Dec;23(2):247–69. Epub 2010 Sept.nsity

[3]World Health Organization 2011 Physical Activity and Adults, [cited April 9, 2011]; Available at: http://www.who.int/dietphysicalactivity/physical-activity-recommendations-18-64years.pdf

[4]Cut back on foods and drinks with added sugars or caloric sweeteners (sugar- sweetened beverages). Drink few or no regular sodas, sports drinks, energy drinks, and fruit drinks… Choose water, fat-free milk, 100% fruit juice, or unsweetened tea or coffee as drinks rather than sugar-sweetened drinks.” (page 67, US Dietary Guidelines for Americans 2010) [cited April 9, 2011}; Available at: http://www.dietaryguidelines.gov

[5]U.S. Department of Health and Human Services and U.S. Department of Agriculture. The Food Guide Pyramid 1992. Available at: http://fnic.nal.usda.gov/nal_display/index.php?info_center=4&tax_level=3&tax_subject=256&topic_id=1348&level3_id=5729

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**Table 2**

Association between baseline acculturation level[1] and obesity (body mass index, kg/m$^2$) and lifestyle behaviors (dietary intake, and physical activity), controlling for socio-demographic and lifestyle behaviors (baseline obesity, intervention, study year, sex, height, baseline education, ethnicity, job)[2], Mixed Model (n=1612)

| Dependent Variable (n, obs) | Acculturation (Direction of association, p) | Level 0 (Estimate ± SE) | Level 1 (Estimate ± SE) | Level 2 (Estimate ± SE) | Level 3 (Estimate ± SE) | Level 4 (Estimate ± SE) | Level 5 (Estimate ± SE) |
|---|---|---|---|---|---|---|---|
| Meat intake, servings/d (1585, 3422) | (+, 0.0002) | −0.21 ± 0.08 | −0.17 ± 0.11 | −0.23 ± 0.08 | −0.11 ± 0.08 | 0.03 ± 0.10 | 0.21 ± 0.08 |
| Sweetened drink intake, servings/d (1582, 3418) | (+, 0.02) | −0.003 ± 0.09 | −0.03 ± 0.12 | 0.27 ± 0.09 | −0.05 ± 0.09 | 0.09 ± 0.11 | −0.16 ± 0.09 |
| Fruit intake, servings/d (1109, 2498) | (+, 0.0001) | 0.14 ± 0.09 | 0.33 ± 0.11 | 0.35 ± 0.009 | 0.40 ± 0.09 | 0.42 ± 0.12 | 0.13 ± 0.11 |
| Physical Activity, MET min/wk (1113, 2543) | (+, 0.0003) | −449.2 ± 132.2 | −455.5 ± 154.2 | −391.4 ± 119.1 | −224.4 ± 119.1 | −292.3 ± 161.1 | −30.6 ± 139.5 |
| Body Mass Index, kg/m$^2$ | (+, <0.0001) | −0.15 ± 0.09 | −0.17 ± 0.11 | −0.06 ± 0.09 | 0.006 ± 0.08 | −0.03 ± 0.11 | −0.04 ± 0.08 |

[1] Acculturation Level:

0 = came to US age 19 or older + came from non-European or non-English-speaking country, English not spoken at home, education < HS
1 = came to US at age 19 or older, came from non-European or non-English-speaking country, English not spoken at home, education >= HS
2 = came to US at age 19 or older, came from non-European or non-English-speaking country, English spoken at home, education < HS
3 = came to US at age 19 or older, came from non-European or non-English-speaking country, English spoken at home, education >= HS
4 = came to US before age 19 or English spoken at home, came from non-European or non-English speaking country, education <= HS
5 = came to US before age 19 or English spoken at home, came from non-European or non-English-speaking country, education >= HS
6 = born in US, came from European or English-speaking country, English spoken at home- Reference Group

[2] Lifestyle factors - sweetened drink, meat, fruit and vegetable, physical activity – when not the dependent variable