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Lynda B. Ransdell
Montana State University - Bozeman

Susan G. Mason
Boise State University

Thomas Wuerzer
Boise State University

Ka Man Leung
Hong Kong Baptist University

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Major Article

Predictors of Cycling in College Students

Lynda B. Ransdell[1]; Susan G. Mason[2]; Thomas Wuerzer[2]; Ka Man Leung[1]

[1] Department of Kinesiology, Boise State University, Boise, Idaho

[2]Department of Community and Regional Planning, Boise State University, Boise, Idaho

Abstract. Objectives: To: (1) assess cycling-related questions which have been added to the electronic version of the NCHA-ACHA II, (2) examine cycling prevalence; and (3) identify predictors of cycling in college students. **Participants:** Predominately female (69%), undergraduate (89%), and White (85%) students (N = 949) from a large, urban, northwestern, bicycle-friendly university completed the electronic version of the NCHA-ACHA II. **Methods:** Thirty cycling-related questions were added to the NCHA-ACHA II and a subsample of questions was analyzed. **Results:** Cycling questions added to the NCHA-ACHA II scale were reliable and valid, based on the psychometric data analysis. More than half (59%) of this sample cycled; of those, 58% cycled for transportation and 44% for recreation. Facilitators and barriers to cycling were different for cycling in general and cycling for transportation. **Conclusions:** Cycling questions added to the NCHA-ACHA II can be utilized to enhance knowledge relative to cycling on college campuses.

Keywords: active transportation, bicycling, community health, health education, recreation

INTRODUCTION

Less than half (47.4%) of the college student population is participating in health-enhancing levels of physical activity (PA)[1]. With this low level of PA, a concurrent increase in overweight and obesity has occurred, even in young adults. In the 2011 American College Health Association (ACHA) survey, 34.1% of the college student population was obese or overweight, which constitutes a 1% per year rise in obesity and overweight since the year 2008 [1]. Sedentary behavior also increases the risk of hypokinetic diseases such as cardiovascular disease, thromboembolic stroke, hypertension, type 2 diabetes mellitus, obesity, colon cancer, breast cancer, anxiety and depression [2, 3].

Traditional strategies for increasing PA in college students (e.g., sports, fitness classes, etc.) are not working as well as they should [4], thus, there is a need to encourage a multitude of options for increasing PA. One underutilized strategy for increasing PA in college students is encouraging them to ride bicycles for recreation or transportation. Cycling for transportation is a unique type of activity in that it not only improves health and fitness, but it also plays a role in improving air quality (e.g., reducing greenhouse gas emissions) and boosting the economy (e.g., creating construction jobs and increasing property values)[5]. Increasing the proportion of trips made via cycling is so important, that it is a major objective within *Healthy People 2020* [6], researchers have suggested that cycling should be used to tackle the crisis of obesity [7], and the CDC has designed a major initiative (Active Community Environments or ACES) to promote walking and cycling and provide recommendations for improving cycling infrastructure through community design.

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Despite the aforementioned initiatives and potential benefits of bicycling, the level of bicycling in the United States is still very low. Data on U.S. cycling behavior indicated that only 1.0% of total trips are made by bicycle [8], and that number has not changed much in the last decade. Additionally, less than 2% of Americans cycle daily, and less than 1% of those individuals cycle for at least 30 minutes. In comparison, European countries (e.g. Sweden, Germany, Denmark and Netherlands) make 9% -26% of their daily trips on a bicycle [9]. These large differences in the prevalence of cycling for transportation between countries may occur because European cities are very compact and urban with significant cycling infrastructure[10-12], however, more research is necessary to discern the specific cross-cultural factors explaining these differences.

In addition to needing more information about cycling in the U.S., it is important to discern whether differences exist based on age. For example, Boarnet and colleagues[13] and the National Center for Safe Routes to School[14] have studied children, and Edmond & Handy [15] have studied high school students. Moudon et al. [16] conducted a study in the U.S., but they focused broadly on adults, not specifically on college students. Titze and colleagues [17] conducted a study with Austrian students, and Bopp et al. [18] recently directed a study examining active commuting patterns in students and faculty in the U.S.; however, previous college students studied were from Europe or from a mostly residential campus with students of traditional college age (e.g., 18-22 yrs. old). In the U.S., previous ACHA-NCHA II data suggest that 45.2% of college students sampled did not ride their bicycle during the last 12 months. Of those who did cycle, the majority (44%) never wore a helmet, 24% wore a helmet rarely or sometimes, and 32% wore a helmet most of the time or always[3]. Clearly, there is a need to examine cycling behavior in more detail and to examine predictors of cycling on an urban college campus, and with students who are older and non-traditional.

Age as a predictor of cycling behavior should be examined in addition to other predictors of cycling behavior. Predictors are correlates, facilitators, or barriers, and they can be examined as personal (i.e., age or gender) and/or environmental (i.e., cycling infrastructure safety such as bike lanes, traffic calming devices, bike theft, etc., and factors related to convenience such as showers and weather) characteristics. Knowing predictors of cycling behaviors in college students will help physical activity promoters develop more successful interventions that target this population. The literature to date has identified several predictors of cycling. Table 1 presents a summary of predictors of cycling behavior currently found in the literature. In addition, the table contains information about the ways in which the survey items from this study align with previously identified predictors [19-21].

[INSERT TABLE 1 ABOUT HERE]

Given the lack of information about correlates to cycling in U.S. college students, the purposes of this study were to: (1) assess cycling-related questions that were added to the electronic version of the NCHA-ACHA II, (2) examine the prevalence of cycling for transportation and recreation; and (3) identify predictors of cycling in a sample of non-traditional-aged college students who attend a large bicycle-friendly, urban university in the Northwest.

METHODS

Participants. The Core User's Manual [22], endorsed by the American College Health Association, recommended using a random sample of 4,450 students (out of a student population of nearly 20,000 students) to complete the online survey for the National Collegiate Health Assessment (NCHA) in November of 2011. Students were randomly selected to receive an email request to complete the questionnaire. The inclusion criteria for the study were that students: were 18 years or older, enrolled in 4 or more credits at the university, and not dually enrolled in high school. The Institutional Review Board (IRB) at a large Northwestern university approved this study and participants who answered the survey were told that they granted informed consent when they completed the questionnaire.

Instrument. The National College Health Assessment II (NCHA-ACHA II), a 66 item instrument that assesses the health habits, behaviors, and perceptions among college students in the United States [1], was delivered online to the participants described in the previous section. This university has participated in the national data collection process for the NCHA-ACHA II during the past 6 years and the NCHA-ACHA II is conducted on participating campuses across the United States every two years. The health topics examined in this assessment include health education, safety, alcohol, tobacco, drugs, sexual behavior, weight, nutrition, physical activity, mental and physical health and barriers to academic performance. For this study, a subset of items (e.g., physical activity and demographic information) was used.

Three items in the NCHA-ACHA II assessed student physical activity (PA). These items asked respondents their frequency of moderate-intensity exercise, vigorous-intensity exercise and strength training exercise performed during the past 7 days. The physical activity related items used in this assessment were “On how many of the past 7 days did you do moderate intensity cardio or aerobic exercise for at least 30 minutes?” “On how many of the past 7 days did you do vigorous intensity cardio or aerobic exercise for at least 20 minutes?" and “On how many of the past 7 days did you do 8-10 strength training exercises for 8-12 repetitions each?”. Respondents’ answers ranged from 0 = “0 days” to 7 = “7 days”. Answers from these three questions were re-coded and used to assess whether students met the physical activity recommendation of moderate to vigorous PA 5 or more days of the week, on average. Moderate to strong reliability, and acceptable construct and measurement validity of the NCHA-ACHA II have been reported [23].

In addition to the 66 questions on the NCHA-ACHA II (including participation in PA), extra questions about cycling behavior and predictors of cycling, divided into barriers and facilitators, were asked. In regard to the cycling behaviors, questions about cycling for transportation and for recreation were asked. To assess the prevalence of cycling for transportation and cycling for recreation, the following questions were asked: “Within the last 30 days, what was your average biking distance (miles), duration (minutes) and frequency (days) for transportation per day?” and “Within the last 30 days, what was your average biking distance (miles), duration (minutes) and frequency (days) for recreation and/or fitness per day?"

Thirty (30) items were developed to assess barriers and facilitators for cycling. The survey questions on facilitators and barriers to cycling were developed by a group of specialists who are familiar with psychometric test theory and predictors or facilitators and barriers to cycling. This group surveyed the literature on facilitators and barriers to cycling for transportation and recreation and developed a series of questions (See Table 1). Twelve items asked about facilitators of cycling and 18 items asked about barriers of cycling. Sample questions related to cycling barriers included: “I think biking in our city (name deleted for review purposes) is difficult because it is too hilly to bike” or "I think biking in in our city (name deleted for review purposes) is difficult because there is too much car traffic." Sample questions related to cycling facilitators included: "I think biking in our city (name deleted for review purposes) is great because it allows me to save money" or "I think biking in our city (name deleted for review purposes) is great because I can access the greenbelt easily." Participants were asked to answer these questions using a five-response, forced-choice Likert format from 5 = “strongly agree” to 1 = “strongly disagree.”

In order to explore distance as a predictor of cycling and the relationship between distance to campus and frequency of bicycling, students were asked to provide their zip code and the closest intersection (street and cross street) in proximity to their current residence. This information was geocoded within a geographic information system (ArcGIS) and a network-distance estimate was calculated from the reported and then geocoded intersection to the center of campus. For this purpose, we designed a "bicycle friendly network" which integrated priorities for cycling into our GIS, giving multipurpose trails for pedestrians and bikes the highest priority. Streets with bike lanes and streets with bike routes were assigned the next highest probability of being chosen as a route to campus. This technique assumes that a bicyclist will choose the most bike-friendly street or trail-path, such as the greenbelt (a 26 mile bike trail along the local river), when available. In other words, it is likely that cyclists will choose a safe route over high-traffic main roads with potential safety issues. This assumed-preference-based network measure in GIS induces some potential bias, but only a labor-intensive detailed cycling-journal (in which the student notes every route and travel) would validate this technique. Keeping a journal, while accurate, is inherently difficult, especially in large samples. We feel that the assumed-preference-based network distance is an adequate measure for a larger sample size when detailed local knowledge on bike-paths is properly integrated into GIS.

The proposed 30 questions were pilot tested with current university students in graduate (n = 42) and undergraduate (n = 63) courses, and upon recommendations, questions were re-formatted for clarity and ease of survey completion. The researchers were limited in the number of questions they could add to the NCHA-ACHA II in the interest of maintaining a reasonable subject burden and due to the cost of adding a significant number of questions to the local portion of the electronic survey.

Although other questionnaires exist that examine correlates of cycling (e.g., Neighborhood Environmental Walkability Scale (NEWS)[24], and instruments developed in South Carolina and St. Louis, as cited in Titze et al. [17]), other questionnaires include both walking and cycling and they focus mostly on cycling for transportation without incorporating questions for use on a college campus. The questionnaire developed by Titze et al. [17] was designed for use in Austria, not the United States, and facilitators and barriers to cycling may be distinctly different from those in the U.S. due to geographic, city planning, and cultural differences. Our goal in designing the 30 questions used in this study was to develop survey questions that could be added to the electronic version of the NCHA-ACHA II and utilized by college campuses in the U.S. that are interested in learning more about cycling behavior on their campus.

Statistical Analysis. Data analyses were conducted with the Statistical Package for Social Sciences (SPSS, Version 19.0), and significance value was set at 0.05. To examine the psychometric properties of the cycling questions added to the NCHA-ACHA II, to reduce the number of independent variables, and still take into account the complexity of the concepts of facilitators and barriers to cycling, the individual questionnaire items were included in a factor analysis to create indices with an Equamax (oblique) rotation. Cronbach's alpha was used to test the internal consistency (reliability) of the questions for the concepts of facilitator and barrier. Factor analysis, a purely statistical technique, is a method used to test the validity of the constructs measured. There are two uses of factor analysis: exploratory and confirmatory. In this study, exploratory factor analysis was pursued to determine if particular items are related to one another on the factors of barriers and facilitators of cycling. Factor analyses test the validity of the constructs, whereas Cronbach's Alpha helps determine the reliability of the measures. Typically a Cronbach's Alpha of 0.7 or higher demonstrates a very reliable measure of the concept. In addition to examining validity and reliability of the added questions on cycling, descriptive statistics were computed to examine the prevalence of cycling. Finally, to examine predictors (i.e., facilitators and barriers) of cycling, five binomial logistic regressions were estimated and analyzed to assess the effect of the previously noted factors on the likelihood of college students to (a) cycle in general, (b) specifically cycle for transportation, (c) specifically cycle for recreation, (d) cycle regularly (i.e. four or more times a week) for transportation, and (e) cycle regularly for recreation. In the end, the data for cycling for recreation were insufficient to model the effects, leaving only three models reported here. From the binomial logistic regressions, odds ratios were reported to indicate the likelihood of cycling for each statistically significant variable in the model. An odds ratio greater than 1 indicates an increased likelihood that a one-unit change in the independent variable increases the odds of cycling by 1 minus the odds ratio figure. An odds ratio of less than 1 indicates a decrease in the odds for each one-unit change in the independent variable by 1 minus the odds ratio number. A negative sign before the odds ratio indicates that for an increase in the independent variable by one unit, the dependent variable would decrease by the odds ratio.

RESULTS

The overall response rate for the NCHA-ACHA II at this site was 949 (21%) of the 4,450 students surveyed, resulting in a margin of error at +/- 3 percent at the 95 percent confidence interval. Most of the participants were female (69%), undergraduate (89%), White (86%), and from the United States (94%) (see Table 4). The mean age of participants was 26.5 years (SD = 8.95), ranging from 18 to 64 years. A large proportion of the sample (47%) was either overweight or obese, and 68% of students did not meet the moderate or vigorous physical activity recommendation. The sample for this study was representative of the university population on the characteristics of age (26.5 y in sample vs. 26.2 y actual) and level of education (89% undergraduate in the sample vs. 91% actual). We unintentionally oversampled females (16% higher proportion of females in sample versus actual) and international students (4% higher in sample versus actual). We unintentionally undersampled students who live off campus (6% lower in sample versus actual), and minorities (10% lower in sample versus actual).

Psychometric Properties of Facilitators of Cycling

A principal component analysis with an Equamax (oblique) rotation was conducted to identify the underlying structure of 12 items considered to be facilitators of cycling. Table 2 presents the structure of these facilitators. Using all 12 items from the survey that measured facilitators of cycling, three component factors were extracted, explaining nearly 62% of the variance. The sample is adequate for factor analysis as demonstrated by the Kaiser-Meyer Olkin score (KMO = 0.84). The Cronbach's Alpha exceeds the criteria needed to demonstrate that the index is a reliable measure of facilitators (α= 0.86).

"Personal Experiences," made up of five items (i.e., exercise opportunity, love to ride a bicycle, save money, access to greenbelt, (our city's bike trail system), and social experience), explained 23.66% of the variance in cycling behavior. "Convenience and Safety," made up of four items (i.e., access to trails/paths for commuting, access to trails/paths for recreation, separate bike lanes, and bicycles respected as traffic partners) explained 22.75% of the variance in cycling behavior. Finally, "Bike Access," consisting of three items (e.g., ability to combine bike and bus trips, don't own a car, and use of a bike share program), explained 14.95% of the variance in cycling behavior.

[INSERT TABLE 2 ABOUT HERE]

Psychometric Properties of Barriers to Cycling

A principal component analysis with an Equamax (oblique) rotation was conducted to examine the underlying structure of barriers to cycling. Table 3 presents the barriers identified in this sample. There were 18 items related to students' perceptions of barriers to cycling on this college campus. As a whole, the four-factor model accounted for 62.17% of total variance. The high Kaiser-Meyer Olkin value (KMO = .89) shows that the degree of common variance among the variables was high when factor analysis was done, indicating that the sample was adequate to conduct factor analysis. The Cronbach's alpha exceeds the criteria needed to demonstrate that the index is a reliable measure of barriers ($\alpha = 0.92$).

The first factor, labeled "Environmental Constraints" consisted of seven factors related to safety and convenience that inhibited cycling. These items explained 19.90% of the variance in cycling behavior. "Personal Constraints," the second factor, included four items (i.e., fear of bike theft, don't like to arrive sweaty, no place to shower, and bad weather,) and explained 14.38% of

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the variance in cycling behavior. "Other Factors," made up of three items (i.e., live too far away, don't have time to bike to school, and satisfied driving a car), explained 14.35 % of the variance in cycling behavior. Finally, “Lack of Bike and Path Access," made up of four items (i.e., don't know bike routes, need to borrow a bike to ride, do not own a bike, and no opportunities to use bike share program), explained 13.54% of the variance in cycling behavior.

[INSERT TABLE 3 ABOUT HERE]

Cycling for Transportation and Recreation

Table 4 provides coding information and descriptive statistics for the socio-demographic variables in the logistic regression model. The prevalence of cycling in this sample was high with 59 percent (556/943) of the respondents reporting that they cycle. Of those respondents, 58 percent (320/555) reported cycling for transportation and 44 percent (243/556) reported cycling for recreation. Within that subsample of cyclists, 47 percent (149/317) cycled regularly (4 or more times weekly) for transportation, and only 12 percent (27/227) cycled regularly for recreation. The average distance cycled (e.g., for transportation to campus and back), estimated using ArcGIS methodology, was 7.69 miles (SD = 8.88). A correlation matrix demonstrated there were no potential problems with multi-collinearity for the regression models. The largest correlation was 0.385 between the variables of the index for cycling and cycling in general.

[INSERT TABLE 4 ABOUT HERE]

Logistic Regression Model Findings

Table 5 presents statistically significant predictors of cycling, using logistic regression analyses. Non-significant facilitators and barriers were not included in Table 5, but data are available from the authors upon request. The first model, which examined predictors of all reported cycling, revealed that students who reported that they were at a "healthy weight" were 0.90 times more likely to cycle compared to students who reported that they were over or under weight. For each additional facilitator item of cycling reported in the index, the likelihood of cycling increased by 0.37 times. Barriers were not significant predictors in those who reported any type of cycling.

In the second model, which examined predictors of any reported cycling for transportation, the following items were significant: (a) for every one year of increasing age, the probability of cycling decreased by .05 times, (b) being female reduced the probability of cycling by 0.72 times, and (c) for every one mile increase in the distance a student lived from the university campus, the likelihood of cycling for transportation decreased by 0.06 times. For every additional facilitator item reported in the index, the likelihood of cycling increased by 0.35 times. For every additional barrier item reported in the index, the likelihood of cycling decreased by 0.10 times.

In the third model, which examined facilitators and barriers to cycling in those who cycled regularly for transportation (i.e., 4 or more times per week), being female reduced the likelihood of cycling regularly for transportation by 0.61 times, and living off campus decreased the likelihood of cycling regularly for transportation by 0.71 times. Additionally, U.S. citizens were 0.91 times less likely to cycle regularly for transportation. For each one mile increase in the distance from campus, biking regularly for transportation decreased by 0.26 times. For every additional facilitator reported, the likelihood of cycling for transportation regularly decreased by 0.27 times, and for every additional barrier reported, the likelihood of cycling regularly for transportation decreased by 0.28 times.

[INSERT TABLE 5 ABOUT HERE]

COMMENT

The purposes of this study were to: (1) test the psychometric properties of cycling-related questions added to the electronic version of the NCHA-ACHA II, (2) examine the prevalence of cycling for transportation and recreation, and (3) identify the facilitators and barriers to cycling in college students who attend a large bicycle-friendly, urban university in the Northwest.

The most important findings were as follows. First, this sample was quite different from previous samples with college students in that the majority of participants were White, female, and older than traditional college age. In addition, the sample for this study reported a larger percentage of students perceiving themselves as over or under weight (47%) compared to the NCHA-ACHA II national database (34%). Second, the 30 questions added to the NCHA-ACHA II scale were deemed reliable and valid based on the psychometric data analysis. Third, the prevalence of cycling in this sample was quite high (59% or 556/943 students), even though the prevalence of PA was fairly low (34% overall, 39% for men and just 31% for women); and of those who cycled, more cycled for transportation (58% or 320/556 cycling students) than recreation (44% or 243/556 students). Finally, facilitators and barriers to cycling were different when all cyclists were grouped together compared to when only cycling for transportation was examined.

Our findings concur with previous research that suggests females typically cycle for transportation less than their male counterparts[25]. In addition, participants who perceived their weight as "normal," were more likely to cycle than those who perceived they were over or under weight. Those who perceive their weight as "normal" may be more likely to cycle because they are more comfortable with their weight and their ability to cycle. We cannot yet conclude that cycling helps participants maintain weight because it may be that people who are already their correct weight are more inclined to cycle, or they may participate in other types of physical activity that helps them maintain their weight. To increase cycling in this group, it may be helpful to suggest that cycling is an ideal choice of transportation, with potential benefits such as increasing general health/fitness, living a healthier lifestyle, and promoting weight loss.

The thirty questions about facilitators and barriers to cycling added to the electronic version of the NCHA-ACHA II demonstrated a high level of internal consistency (reliability) in that the Cronbach's Alphas for both facilitators and barriers were higher than the value ($\alpha = .70$) recommended by Nunally [26]. This indicates that our questions labeled facilitators probably effectively measured some facilitators and our questions labeled barriers probably effectively measured some barriers. In addition, when our instrument was compared to previous facilitators and barriers in the literature (see Table 1), it was consistent with the literature and demonstrated some measure of construct validity. In other words, the constructs previously noted in the literature were also present in our instrument and the subscales identified were consistent with the literature. The noteworthy difference between our survey instrument and those established previously, is that in terms of facilitators, our instrument further subdivided facilitators into categories such as experience, convenience and safety, and bicycle access. These facilitators, which have not been previously delineated in college students, can possibly be used in the future to identify important facilitators of cycling in a non-traditional college age sample similar to ours, and to develop an even more accurate predictor model. Similarly, the barriers to cycling are

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further subdivided and can be used in future studies to continue to develop a model or compare findings from our sample to findings on other college campuses.

Because the three factors related to facilitators (i.e., personal experience, convenience/safety, and bike access) and the four factors related to barriers (i.e., environmental constraints, personal constraints, other, and bike access) from our additional questions explained about 62% of the variance in factors that are facilitators and barriers to cycling, it is possible that if these questions are added to future versions of the NCHA-ACHA II, researchers may be able to further validate factors that predict cycling behavior on college campuses.

The prevalence of cycling in this sample was quite high in that 59% (n = 556) reported participating in some cycling; of those who cycled, 58% (n = 320) cycled for transportation and 44% (n = 243) for recreation. The prevalence of cycling in this sample (59%) was higher than that reported by Titze et al. [17] (41%), but it is possible that our sample reflects a "bicycle friendly" campus not surveyed previously, or it is possible that the questions we asked were more comprehensive and provided an opportunity to report cycling for transportation and/or cycling for recreation. Additionally, compared to Titze's sample of Austrian college students [17], our sample was almost twice as large, data were collected electronically, more women participated, and subjects were older and more likely to be overweight or obese. Differences in the samples studied point to the need to examine more specific reasons why students in this sample cycled, presumably more than adults in previous samples. It may be that college students, even those on a campus that serves older, non-traditional students, may participate in cycling because of the high prevalence of cyclists in our city, or because of the greenbelt, or other bicycle friendly amenities on campus or in the community [27,28].

Another interesting finding is that despite a low prevalence of participating in PA at recommended levels (i.e., 5 days/week), a relatively high number of students participated in cycling for both recreation and transportation. This may indicate that in populations of non-traditional students who are older, overweight, and less active, cycling may be a viable alternative for physical activity. Cycling is considered non-weight bearing, and many consider it less damaging to joints compared to running, or other types of exercise [29]. In addition, with the price of gasoline increasing drastically, along with the cost of attending college, cycling for transportation may be a viable option for most student demographics.

Using logistic regression models, we identified predictors of participating in any cycling at all, any cycling for transportation, and cycling regularly (e.g., 4 or more days per week) for transportation. As mentioned previously, self-perceived weight affected the likelihood of cycling at all, in that those who perceived themselves as being "healthy weight" were more likely to cycle than those who felt they were overweight or underweight. These findings are in agreement with others who have reported that correctly perceiving their body weight is positively related to participation in physical activity [30]or more specifically, cycling [31].

Distance from campus, as calculated using the GIS data, affected the likelihood of cycling for transportation at all and cycling regularly for transportation. These findings make intuitive sense and are in agreement with Panter, Jones, Van Sluijs, Griffin [32] who studied children and found that distance to a cycling destination is negatively related to the likelihood of cycling to that destination. In other words, as the distance to a destination increases, the likelihood of cycling to it decreases.

To increase cycling as a mode of physical activity in American society, there are several bicycling encouragement programs. Safe routes to school programs (http://www.saferoutesinfo.org/), which are designed for K-12 students, offer ways to minimize the potential negative effect of distance to school and arrange bike-pooling so riders can travel safely together. These programs emphasize the five E's of Education, Encouragement, Enforcement, Engineering and Evaluation to create programs that address barriers to walking and riding for youth. Bike Rodeos and skills camps that focus on getting children on their bikes to develop specific skills are organized by cycling groups, schools or other advocacy groups in a community. These programs also support "earn a bike" and "recycle a bike" programs that give lower income and underserved youth access to transportation options as they build vocational skills. Still other programs focus on teaching bicycle repair as way to earn a "free" bike [33]. Cities could work with university campuses to devise comparable programs to those available to K-12 schools such that safe routes to college campuses can be identified, cycling skills can be developed, and more bikes made available to the underserved.

The presence of cycling facilitators positively affected cycling at all for any reason, and cycling at all for transportation; however, cycling facilitators negatively affected cycling regularly for transportation. It is possible that facilitators are more important for those who do not systematically engage in cycling regularly for transportation (e.g., those at earlier stages of change such as pre-contemplation and contemplation), and that those who regularly cycle for transportation (e.g., those in later stages of change such as maintenance) are not highly influenced by cycling facilitators [34]. Cyclists who regularly bike for transportation have already assimilated healthy levels of physical activity such that they will find a way to cycle for transportation, regardless of circumstances. It is also possible that facilitators to cycling (for a group that already cycles regularly for transportation) were not well-measured by this questionnaire and that other questions need to be developed to capture facilitators of cycling unique to regular bicycle commuters.

Barriers negatively affected any cycling for transportation and regularly cycling for transportation, but not any general cycling. Those who cycle for various reasons (e.g., for recreation in addition to transportation) may have unique barriers that were not captured in this survey, or they may cycle randomly, out of need, and without planning, which is less influenced by the barriers mentioned in the survey (e.g., time of day, weather, crime, hilly terrain). Finally, a couple variables negatively influenced cycling regularly for transportation. Specifically, those who lived off-campus and those who were U.S. citizens were less likely to cycle regularly for transportation than their counterparts. It is possible that those who live off-campus were farther from campus, making it more difficult for them to cycle regularly for transportation --and these findings support the notion that a large proportion of students who come to campus commute from various distances. It is also possible that international students, as compared to their U.S. counterparts, rely more on bicycles for transportation due to financial and legal constraints, and due to the fact that they typically seek room & board on campus. It is also possible that bicycling habits outside the U.S. (e.g., as in The Netherlands, Belgium, Denmark, China) are different, due to higher population density and better bike infrastructure, thus international students may be more familiar with utilizing bicycles for transportation.

From these findings, several recommendations are presented to help college campuses-- especially those serving non-traditional age students-- increase the prevalence of cycling. First, it is likely that policies or bike-friendly promotion programs could decrease the likelihood of perceived barriers. Increased bike-signage and way-finding tools could promote a bike-oriented infrastructure. Providing locked/secure facilities for bike storage and parking such as bike barns and offering facilities for showering and changing could decrease the "sweat" and "clothing" barriers. Bike share systems that provide rental bikes (free of charge for short term), will help increase the acceptance of bicycling as a mode of transportation. In the future, due to high gasoline prices, it is possible that students' housing and transportation behavior/decisions will increasingly change to positively impact their health. Finally, universities could provide incentives for combining regional transit systems and bicycling, or call out for bike-weeks/months in which biking and bike-safety are promoted.

Limitations. While this study reported several novel findings in a sample that is larger than previous studies, it is not without limitations. First, the study was based on individual survey data, and behaviors were self-reported. This assumes that participants answered the questions accurately and without bias. Second, although our sample was representative of certain Northwest urban university characteristics (e.g., age and education level), there were a greater number of female, white, on-campus, and international student respondents than were found in the university population. Given that this sample does not completely mirror the true university population, it behooves the reader to be very cautious when trying to generalize beyond the scope of this study. That said, this study does provide preliminary evidence for understanding the myriad of factors that influence college students' cycling behavior. With additional verification and adjustment for population characteristics, this study provides a useful starting point for understanding more about predictors of cycling among college students, particularly non-traditional students who attend a university in an urban setting. A third limitation is that because our regression models utilized a sample representing more Caucasians than other races (by 10%), it is possible that race was not found to be a significant predictor of cycling behavior simply due other races being under-represented in the sample. Fourth, while a reasonably large percentage of the variance was explained, some of the variance was left unexplained, indicating that other factors affect cycling behaviors. Additional research with this population should be conducted in an effort to discern additional predictors of cycling behavior on college campuses that serve a variety of constituents. Fifth, while we did create indexes to capture facilitators and barriers to cycling for recreation and transportation, there are still several unanswered questions. For example, we did not separate types of facilitators but rather made use of scales that took into account the complexity of the concepts of cycling facilitators and barriers. Although this created a more parsimonious model, it leaves questions about the way specific facilitators or barriers influence cycling. We asked some questions that were generalized to cycling for transportation and recreation, and these questions did not specifically separate the two types of cycling. In the future, it would be advisable to separate questions such that each facilitator or barrier is related to cycling for recreation or cycling for transportation. It is our belief that these factors are interrelated, but differ in this population (e.g., college-aged) compared to other studies [35].In summary, this study should be considered a pilot study that presents a plethora of information about strategies for learning more about cycling for transportation and recreation in college students, and a framework for future study.

Future Research Directions. Recommended future research directions include examining determinants of cycling behavior through the lens of an ecological model to see if changes in environmental infrastructure (e.g., bike share programs, bike lanes added, etc.) or specific individual perceptions of the environment, policies, culture, inter and intra-personal characteristics have a positive impact on cycling behavior. Further, it would be helpful to conduct a cross-sectional study comparing geographically diverse college campuses for differences based on these predictors and facilitators of cycling. Finally, it would be interesting to examine whether cities or campuses that are designated "bicycle friendly" have different facilitators and barriers to cycling compared to those that are not designated as such.

Conclusions. The questions added to the NCHA-ACHA II on cycling were reliable and valid, such that other universities interested in studying cycling on campus could use these to effectively establish information about their campus community. From this research, the prevalence of cycling was relatively high, although some cycled for transportation and some for recreation. Predictors, also known as facilitators and barriers, were different for those who participated in any cycling, compared to those who cycled irregularly or regularly for transportation. Public health, planning and public policy professionals should use this information to facilitate cycling on college campuses, and possibly to study cycling behaviors in other communities.

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Note

For comments and further information, address correspondence to Lynda B. Ransdell, Department of Kinesiology, Boise State University, 1910 University Dr., Boise, ID 83725-1710, USA (e-mail: lynda.ransdell@montana.edu).

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Table 1: Predictors (Facilitators and Barriers) of Cycling Behavior from Previous Literature

Facilitators from Previous Literature (Positively correlated with cycling)	**Question from this Study**	**Barriers from Previous Literature (Negatively correlated with cycling)**	**Question from this Study**
PERSONAL: Self-Actualization			
Desire to Improve Fitness	Q1		
Pleasure in Cycling	Q2		
PERSONAL: Social			
Friends Ride Bikes	Q5		
ENVIRONMENTAL: Convenience & Safety			
Easy Access to Trails	Q4, 6	Difficult to Access Trails	Q15, 24, 25
Near Public Transportation	Q10		
Existence of Traffic Calming Devices	Q8	Disconnected Streets	Q15
		Lack of Time	Q26
		Unsafe Places to Ride (e.g., high traffic, crime, fear of theft)	Q13, 16, 17, 18, 20
ENVIRONMENTAL: Other			

Pleasant Neighborhood Aesthetics	Q4	Hilly Terrain	Q19
Multiple Routes to Destination	Q4, 10	Inadequate Signage	Q14, 24
		Bad Weather (e.g., extreme heat, cold, rain, snow, pollution)	Q23
		Shortage of Cycling Amenities (e.g., showers, bike parking)	Q21, 22
ENVIRONMENTAL: Bike Access			
Bike Access	Q10,11,12	Limited Bicycle Access	Q28, 29, 30

Table 2: Rotated Component Matrix for Facilitators of Cycling

Item	Factor Loading		
I think biking in in our city (name deleted for review purposes) is great because:	Personal experiences	Convenience and safety	Bike Access
1) bike riding allows me to get some exercise during my busy schedule.	.85		
2) I love to ride my bicycle.	.82		

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3) bike riding allows me to save money.	.75		
4) I can use the greenbelt for commuting and recreation.	.57		
5) I have friends who bike with me for recreation.	.41		
6) I have easy access to trails/paths for my commute on a bike.		.77	
7) I have easy access to trail/paths for recreational biking.		.76	
8) there are separate bike lanes along most of the streets I ride on.		.72	
9) bikers are respected as traffic partners by car drivers.		.71	
10) I can combine riding my bike and using the bus.			.78
11) I do not own a car.			.75
12) I plan to use the new bike share program.			.67
Cronbach's Alpha	.83		
Eigenvalues	2.84	2.73	1.79
Percent of Total Variance	23.66	22.75	14.95
Total Explained Variance	61.36		

Table 3: Rotated Component Matrix for Barriers to Cycling

Item Biking in in our city (name deleted for review purposes) is difficult because:	Factor Loading			
	Environmental constraints	Personal constraints	Other Factors	Lack of Bike and Path access
1) there are not enough bike paths for commuting safely.	.82			
2) there are not enough well designed signs showing existing bike trails.	.74			
3) where I live, it is not easy to access trails/paths for recreational	.67			

biking.				
4) there is too much car traffic when I bike.	.65			
5) there are too many pedestrians on the greenbelt.	.63			
6) cars parked along the street prohibit safe biking.	.62			
7) it is too hilly to bike.	.53			
8) I'm afraid my bike will get stolen.		.71		
9) I don't like to arrive at school sweaty.		.71		
10) there is no place for me to shower when I arrive.		.64		
11) the weather is not good for regular biking.		.57		
12) I live too far away.			.82	
13) I don't have enough time to bike to school.			.78	
14) I am satisfied driving my car.			.66	
15) I am new to the area and do not know the bike routes.				.53
16) I have to borrow a bike every time I want to go on a ride.				.87
17) I do not own a bike.				.83
18) there are no opportunities to use a bike-share program.				.60
Cronbach's Alpha	.92			
Eigenvalues	3.58	2.59	2.58	2.44
Percent of Total Variance	19.90	14.38	14.35	13.54
Total Explained Variance =	62.167			

Table 4: Descriptive Statistics and Variable Coding

Variable	*Variable Type*	*μ*	*S*	*Survey Sample**	*Survey Sample Total***
Cycle	Nominal	.59	.5		943
Yes				556	
No				387	
Cycle for Transportation	Nominal	.58	.5		555
Yes				320	
No				235	

Cycle for Recreation	Nominal	.44	.5		556
Yes				243	
No				313	
Cycle for 4 or more Times a week for Transportation	Nominal	.46	.5		317
Yes				149	
No				171	
Cycle for 4 or more Times a week for Recreation	Nominal	.12	.32		227
Yes				27	
No				200	
Age	Interval	26.52 (26.2)	8.95		941 (17694)
Sex	Nominal				942 (17630)
Male		.31	.46	295 (8263)	
Female		.69	.46	647 (9367)	
Level of Education	Nominal				937 (17694)
Undergraduate		.89	.31	833 (16110)	
Graduate		.11	.31	104 (1584)	
Race	Nominal				949 (17694)
White		.89	.32	840 (13940)	
Other		.11	.32	109 (3754)	
Housing	Nominal				830 (17694)
Off-campus		.83	.37	691 (15647)	
On-campus		.17	.37	139 (2047)	
Body Mass Index	Nominal				925
+Normal Weight		.53	.5	492	
++Under Weight/Overweight/ Obesity		.47	.5	433	
Academic Performance	Nominal				939 (17694) ***
Cumulative GPA: A or B		.83	.38	779 (7139)	

Cumulative GPA: C or Below		.17	.38	160 (6709)
Type of student	Nominal			935 (17694)
International Student		.94	.23	54 (389)
U.S. Student		.06	.23	881 (17305)
Miles Living from Campus	Interval	7.69	8.88	843
Barrier Index****	Interval	3.48	3.1	406
Facilitator Index*****	Interval	4.42	2.87	448

* The numbers in parenthesis represent the sampled university population for the item

** The numbers in the parenthesis represent the total reported university population

*** At the time of the survey 3,846 student did not yet have a gpa

********The Barrier Index does not include question 3 from the factor analysis; that question specifically references recreational biking.

*****The Facilitator Index does not include questions 5 and 7 from the factor analysis; those questions specifically reference recreational biking.

+ Normal weight = BMI 18.5 to 24.9 $kg \cdot m^{-2}$

++ Underweight = BMI < 18.5 $kg \cdot m^{-2}$ or Overweight/Obese = BMI $\geq$ 25 $kg \cdot m^{-2}$

TABLE 5: Statistically Significant Binomial Logistic Regression Estimates of Demographics, Barrier and Facilitator Indexes on Cycling, Cycling for Transportation, and Cycling Regularly for Transportation with Odds Ratios (Standard Errors in Parentheses)

Independent Variables	Cycling	Cycling for Transportation	Cycling Regularly for Transportation
Age		.95+ (.03)	

Sex: Female		.28** (.12)	.39+ (.2)
Housing: Off Campus			-.29+ (.19)
Healthy Weight: not over or under weight	1.97* (.64)		
U.S. Citizen			-.09* (.12)
Miles Biked		-.94* (.03)	-.78** (.09)
Barrier Index		-.90+ (.06)	-.72** (.08)
Facilitator Index	1.37** (.08)	1.35** (.12)	.73* (.1)
Pseudo R^2	.18	.22	.25
LR Chi^2	53.37**	51.50**	41.58**
n	250	175	107

$^+$ $p \leq .05$ (one-tailed); * $p \leq .05$; ** $p \leq .01$ (two-tailed)

