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## Skills and Hills: Factors that Influence Women's and Non-Binary College Students' Decisions to Commute Via Bicycle

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### ABSTRACT

*International Journal of Exercise Science 17(8): 1003-1015, 2024.* College students, who actively travel in the forms of walking and/or bicycling, have shown a wide range of physical and mental health benefits. Despite the known benefits of bicycling, participation is influenced by various demographics, including gender identity, sexual orientation, and race/ethnicity. Universities have the potential to promote active travel participation to all populations. The study aimed to understand the environmental and social factors influencing female students' decision to commute via bicycle in a university setting. A volunteer sample of female college students (n=153) were surveyed to identify common themes from the participants' responses regarding why female students do not ride a bicycle to/from campus. Participants self-reported their confidence with riding a bicycle and trips to/from campus per week by mode of transportation. The most common themes noted through open-ended responses were amount of traffic (91.1%, n=82), safety concerns (63.3%, n=57), knowledge and ownership of a bicycle (33.3%, n=30), participants' preferences (15.6%, n=14), and riding conditions (13.3%, n=12). Participants (37.9%, n=58) reported feeling "somewhat unconfident" with riding a bicycle in the State College area. Participants (31.4%, n=48) also reported feeling "somewhat unconfident" with riding a bicycle on campus. Participants reported an average of 6.06 (M=6.06; SD=6.25) weekly walking trips to/from campus as compared to 0.40 (M=0.40; SD=1.57) bicycling trips to/from campus. Female college students are less likely to commute via bicycle to/from campus compared to other groups of students. Infrastructure improvements and implementing resources, such as educational programs, bicycle shares and e-bicycles, have the potential to improve female college student active travel participation.

**KEY WORDS:** Sustainable mobility, transportation choices, travel behavior, healthy behavior promotion

### INTRODUCTION

College students use a variety of transportation modes, including walking, bicycling, bus, public transit, car, and others to commute to/from campus (39). Although there are various ways students can get to and from campus, active travel (AT) in the forms of walking and/or bicycling can help participants reach recommended physical activity levels, while additionally reducing the risks of all-cause mortality, type 2 diabetes, and other non-communicable diseases (15, 21, 27). In college students specifically, studies have shown that participation in AT during this important transition time may be associated with better cardiovascular fitness, flexibility, lower systolic blood pressure, increases in relaxation, reduction in psychological stress, and is a

behavior which has additionally been shown to stay with people post-graduation (2, 31, 40). Although the individual/community health benefits are well established, only 2.6% American adults reported walking and 0.5% reported riding a bicycle to work/school in the 2019 United States Census (36).

Universities have the unique opportunity to play a major role in promoting AT participation as their defined boundaries and unique environment make it an ideal place to incorporate safe/effective walking and bicycling (20). Students typically live close to or on campus, which increases the likelihood of interventional strategies to improve AT participation and overall health of students on campus (14). Although campuses provide a supportive environment for AT, students may participate less in AT due to self-efficacy, weather, destination proximity, walkability, street connectivity, and the availability, accessibility, and price to destination (3, 9, 18, 26, 27).

AT behavior has also shown to be influenced by various demographics, including, but not limited to gender identity, sexual orientation, or race/ethnicity. Trends for participation in AT among racial and ethnic minority groups are inconsistent and few studies have examined influences on behavior (29). For example, students of color may participate in AT at a lower rate than non-Hispanic white students due to perceptions that their visibility on the street makes them targets for unjust violence or police surveillance (22). Stereotypes in society, social norms, lower self-esteem, and continued discrimination in higher education settings may additionally impact members of the LGBTQ+ community and their participation in AT, though research in this area is significantly limited and the overlap of influences between gender and sexual orientation is unclear (4, 14).

When looking to gender disparities in bicycling, women choose to ride a bicycle to/from campus almost 30% less often than men (5). This lower participation of female cyclists may be explained by increased concerns of cycling safety, risk of public display, appearance in the workplace, poor fitness levels, long distance, weather, climate, or lack of confidence in bicycling skills and bicycle maintenance, when compared to male cyclists (16, 17). Additionally, women have been shown to experience stress and anxiety provoked by the fear of mugging, privacy threats, and lower security when utilizing bicycling as a form of AT (38). Female cyclists report AT infrastructure improvements, educational bicycling programming, reduction of traffic, and additional bicycle rental stations would potentially increase their participation in AT (18, 38). Universities/colleges across the U.S. have the potential to provide substantial environmental (e.g., infrastructure) and programming (e.g., classes, campaigns) for bicycling promotion. Additionally, universities have noted significant increases in diversity (within all demographics) in their enrollments and may require proper resources in the present/future to assist in equitable health promotive interventions/programs (8, 10, 30).

Previous studies have identified barriers preventing college students from bicycling to/from campus. Bicycling behavior differences exist between various demographics, which are important to identify to improve AT participation in university settings. Universities have the potential to increase AT participation by partnering with off-campus organizations, conducting

needs assessments, diversity, equity and inclusion training, and connecting community/university infrastructures (11, 12). The purpose of this mixed methods study was to identify environmental and social factors influencing female and non-binary students' decision to commute via bicycle on a large, Northeastern campus and to recommend strategies to increase bicycling in college women.

## **METHODS**

### *Participants*

**Design:** An invitation to a mixed-methods web-based survey (Qualtrics, Provo, UT) was distributed to all presidents/leaders (or similar) of clubs/organizations on the Pennsylvania State University campus. Emails were gathered from the University's organizations website (focusing on female-centric organizations, such as women's club sports) and presidents/leaders received an email with a description of the survey and a hyperlink to access the survey and were asked to distribute this to all of their members. Informed consent was presented to all participants upon opening the link. The survey had 269 responses. Five themes (amount of traffic, personal preferences, safety concerns, riding conditions, and knowledge and ownership of a bicycle) were identified from the participants' responses. Incomplete survey data was discarded resulting in a completion rate of 72.9% and a final sample of n=196. Only women (n=140) and non-binary (n=13) students were included in analyses; men (n=40, 20.4%) were removed from the sample. The Pennsylvania State University Institutional Review Board approved this study and the study is aligned with the ethical polices of this journal (25).

**Context:** The Pennsylvania State University has approximately 42,000 students enrolled at its main campus location (where recruitment took place), as of the 2023-2024 school year. The campus size is 7,958 acres. The student body is composed predominantly of Non-Hispanic White students (62.4%) and male students (54%). The university's campus was ranked a gold level Bicycle Friendly University in 2023 by the League of American Bicyclists. The community in which the campus resides is categorized as a silver level Bicycle Friendly Community as of February 2024. It has a population size of 92,096 people within a 150.2 square mile area composed of predominantly Non-Hispanic White residents (80.3%) and male residents (54.3%). The area has a humid continental climate with moderately cold winters and warm summers.

### *Protocol*

**Gender Identity:** Participants self-reported their gender identity (man, woman, agender, androgyne, demi gender, genderqueer or gender fluid, queer, questioning or unsure, trans man, trans woman, additional, or prefer not to disclose). Due to sample size, gender identity was combined into 3 categories: cis-gender male, cis-gender female, and non-binary [all other gender identities].

**Sexual Orientation:** Participants self-reported their sexual orientation (straight/heterosexual, asexual, bisexual, gay, lesbian, pansexual, queer, questioning or unsure, same-gender loving, an identity not listed, or prefer not to disclose). Due to sample size, sexual orientation was

combined into four categories: straight/heterosexual, lesbian/gay, bisexual, other non-heterosexual [all other sexual orientations].

**Race and Ethnicity Identity:** Participants self-reported their race/ethnicity. Due to sample size, race and ethnicity identity was combined into six categories: non-Hispanic white, black, Hispanic or Latino, Asian American, other [all other races or ethnicities], or multiracial [combination of two or more races/ethnicities].

**Bicycling Variables: Most Important Factors to Bicycling to/from Campus-** Participants were asked to state, from a list, which factor (time, weather, terrain, availability of sidewalks, maintenance of sidewalks in bad weather, availability of off-street bike paths, availability of on-street bike lanes, bike parking availability, and appearance) is the most important when choosing to bike to/from campus in an open-ended question within the survey.

**Confidence Riding a Bicycle:** Participants were asked to indicate how confident they were to ride a bicycle on campus or in the State College area (1 being completely unconfident, 7 being completely confident). Participants who answered with a response less than 4 (somewhat confident) were asked to explain why they were not confident to ride a bicycle in an open-ended question.

**Trips to/from Campus:** Participants were asked how many trips per week they typically use different forms of transportation (car, bike, walk, bike, electric scooter/skateboard, or other non-motorized transportation) to/from campus (range 0-15 trips/week per mode).

#### *Statistical Analysis*

Data was checked for normality and were analyzed using SPSS version 26.0 (IBM, Armonk, NY, USA). Basic frequencies and descriptive statistics were used to describe the sample. Qualitative coding and thematic analysis were completed using Atlas.ti Version 8.4.5 (Berlin, Germany) to identify major themes among the participants who responded to the open-ended questions (n=90).

## **RESULTS**

Participants (n=196) were predominately cis-gender female (n=140, 71.4%), Non-Hispanic White (n=148, 75.5%), and heterosexual (n=135, 68.9%). Complete descriptive statistics can be found in Table 1.

**Confidence Riding a Bicycle:** Participants (37.9%, n=58) reported feeling “somewhat unconfident” with riding a bicycle in the State College area. Participants (31.4%, n=48) also reported feeling “somewhat unconfident” with riding a bicycle on campus. These results indicate that most participants lack confidence with riding a bicycle in the [NAME OF CITY] or on campus. Complete frequencies can be found in Table 1.

**Most Important Factors to Bicycling to/from Campus:** Common themes were identified from the participants’ responses regarding why female students do not ride a bicycle to and from

campus. These themes are outlined below and reported frequencies are calculated from those who responded to the open-ended question (n=90). The most common themes were amount of traffic (91.1%, n=82), safety concerns (63.3%, n=57), knowledge and ownership of a bicycle (33.3%, n=30), participants' preferences (15.6%, n=14), and riding conditions (13.3%, n=12). Participants could be repeated if their response applied to more than one theme. A majority of the participants (92.2%, n=83) identified as a woman compared to man or non-binary. Illustrative quotes for participants whose responses applied to one or more of the common themes can be found in Tables 2 and 3.

**Table 1.** Demographics of study population (n=153)

|  | N (%)       | M    | SD   |
|--|-------------|------|------|
| <b>Gender Identity</b>                                       |             |      |      |
| Cis-gender female  | 140 (72.5%) |      |      |
| Non-binary   | 13 (6.7%)   |      |      |
| <b>Sexual Orientation</b>                                    |             |      |      |
| Straight/heterosexual  | 102 (66.7%) |      |      |
| Lesbian/Gay  | 9 (5.9%)    |      |      |
| Bisexual   | 26 (16.9%)  |      |      |
| Other non-heterosexual                                       | 16 (10.5%)  |      |      |
| <b>Race and Ethnicity</b>                                    |             |      |      |
| Non-Hispanic White   | 119 (77.8%) |      |      |
| Black  | 3 (1.9%)    |      |      |
| Hispanic or Latino   | 6 (3.9%)    |      |      |
| Asian American   | 10 (6.5%)   |      |      |
| Other  | 7 (4.6%)    |      |      |
| Multiracial  | 7 (4.6%)    |      |      |
| Missing  | 1 (0.7%)    |      |      |
| <b>Mode of Transportation (Average trips to/from campus)</b> |             |      |      |
| Car  |             | 2.29 | 2.85 |
| Bus  |             | 1.66 | 2.85 |
| Walk   |             | 6.06 | 6.25 |
| Bicycle  |             | 0.40 | 1.57 |
| Scooter  |             | 0.05 | 0.60 |
| Other  |             | 0.00 | 0.04 |
| <b>Confidence with biking in the State College area</b>      |             |      |      |
| Completely unconfident                                       | 45 (29.4%)  |      |      |
| Somewhat unconfident   | 58 (37.9%)  |      |      |
| Somewhat confident   | 36 (23.5%)  |      |      |
| Completely confident   | 14 (9.2%)   |      |      |
| <b>Confidence with biking on campus</b>                      |             |      |      |
| Completely unconfident                                       | 50 (32.7%)  |      |      |
| Somewhat unconfident   | 48 (31.4%)  |      |      |
| Somewhat confident   | 34 (22.2%)  |      |      |
| Completely confident   | 21 (13.7%)  |      |      |

**Theme 1: Amount of Traffic**

Most (91.1%, n=82) of the participants mentioned traffic being a main factor in their choice to ride a bicycle to or on campus. One participant responded: "There is a lot of traffic in [NAME



OF CITY], and I have other forms of transportation that make me feel safer” (Woman, Heterosexual White). Another participant responded: “Undergraduates darting out in front of me like chipmunks when the light is green, and I have the right of way. They usually are not looking before they cross the street and have AirPods in their ears” (Woman, Heterosexual, White). Another participant responded: “Watching other people using bikes and how many times they have to swerve around people to not hit them or wreck. The buses do not care whether they almost hit or not, they just go” (Woman, Straight, White). The responses from the participants made it evident that the amount of traffic on or near campus discourages students to ride a bicycle to or on campus.

**Table 2.** Illustrative quotes from participants who reported amount of traffic and personal preferences as barriers to bicycling to/from campus

| Theme                | Illustrative Quote  |
|----------------------|---|
| Amount of Traffic    | <p>“Traffic, reckless driving, foot traffic on campus” (Woman, Other Non-heterosexual, Multi-racial)</p> <p>“There is too much foot traffic and too many obstacles to try and avoid” (Woman, Heterosexual, White)</p> <p>“There is absolutely not enough sidewalk or road space to bike on campus. Pedestrians are not educated on etiquette of sharing space with bikes, and I am afraid of hitting them. There are a lot of stairs in central campus that make it necessary to go around or carry my bike down the steps.” (Woman, Heterosexual, White)</p>                                 |
| Personal Preferences | <p>“It seems easier to walk rather than having to navigate a bike when many other people are walking.” (Woman, Bisexual, White)</p> <p>“In general, I am not the biggest fan of biking. I would feel especially uncomfortable trying to bike in an area with so much traffic (both vehicle and foot).” (Woman, Heterosexual, White)</p> <p>“I don’t enjoy biking, consistently stopping for pedestrians” (Woman, Heterosexual, White)</p> <p>“Hard with a backpack...” (Woman, Heterosexual, White)</p> <p>“I do not own a bike, I’d rather drive” (Woman, Heterosexual, Hispanic/Latino)</p> |

**Theme 2: Personal Preferences**

Participants (15.6%, n=14) mentioned personal preferences impacting their choice to ride a bicycle to/from campus. One participant responded: “It is not that I’m not confident, I just preferred to walk places as it is less of a hassle” (Woman, Heterosexual, Hispanic/Latino). Another participant mentioned the number of belongings they must carry and said, “... On Campus, I cannot travel with my work supplies on a bike safely, so there is no need for me to bike.” (Woman, Heterosexual, White). A different participant mentioned their arrival to their destination and responded: “I sweat a lot and don’t want to smell in class” (Woman, Heterosexual, White). Another participant commented: “... Sometimes I think with all the congestion it’s just easier to walk around campus” (Woman, Heterosexual, White). The responses made it evident that participants prefer a different form of transportation, including walking, instead of riding a bicycle.

**Theme 3: Safety Concerns**

Approximately half of the participants (63.3%, n=57) stated safety as one of the main factors they do not ride a bicycle to and on campus. One participant responded: "There are not many bike lanes. Many of the roads between my home and campus are 40 mph (and people typically go faster) and the side of the road to ride my bike is not very big." (Woman, Heterosexual, White). Another participant stated: "The cars around me make me uncomfortable to bike on campus. In the past, they have gotten close to me as well as cut me off. Many of the roads on campus do not have a designated bike lane" (Woman, Heterosexual, White). A different participant responded: "Lack of proper bike lanes and signs on the road. Most roads are either dangerous and/or confusing for bikers. Even for someone who is used to ride a bike, the roads in State College are just not built for safe biking." (Non-binary, Gay/Lesbian, Asian American). The responses make it evident that safety is a concern for participants, in particular traffic and how dangerous it is to ride on the road with other motorized vehicles.

**Table 3.** Illustrative quotes from participants who reported safety concerns, riding conditions, and knowledge and ownership of bicycles as barriers to bicycling to/from campus

| Theme                               | Illustrative Quote   |
|-------------------------------------|--|
| Safety Concerns                     | <p>"There is no bike lane and some of the drivers are very reckless." (Woman, Heterosexual, White)</p> <p>"Afraid of getting hit by a car" (Woman, Heterosexual, White)</p> <p>"There are no bike paths, that I'm aware of. Currently, the streets are only wide enough for two lane traffic. Therefore, adding a bike lane will decrease the spacing between the bike lane and two-way traffic. The alternative would be to ride the bike on a sidewalk, but I'm almost worried about accidentally injuring someone or myself..." (Non-binary, Gay/Lesbian, White)</p> <p>"There have been a lot of traffic accidents including injuries of bicyclists and I am not very used to biking on roadways, so I do not feel safe." (Woman, Heterosexual, White)</p> |
| Riding Conditions                   | <p>"They bother me so much on campus because everyone on a bike almost runs me over when walking and there are so many hills, I would definitely lose control of the bike" (Woman, Heterosexual, White)</p> <p>"It gets you to the location faster, but it's colder" (Woman, Heterosexual, White)</p> <p>"Hills..." (Woman, Other Non-heterosexual, Asian American)</p> <p>"... Constant pedestrians, the many hills..." (Woman, Undisclosed, White)</p>   |
| Knowledge and Ownership of Bicycles | <p>"... I would definitely lose control of the bike" (Woman, Heterosexual, White)</p> <p>"... Also, I'm not the best at riding a bike." (Woman, Heterosexual, White)</p> <p>"I'm not accustomed to biking in crowded areas or navigating sidewalks." (Woman, Other Non-heterosexual, White)</p> <p>"I have never biked in a city and have little road bike experience" (Woman, Bisexual, Multi-racial)</p> <p>"Don't understand bike rules" (Woman, Heterosexual, White)</p> <p>"Don't want it to get stolen" (Woman, Heterosexual, White)</p>   |

**Theme 4: Riding Conditions**

Participants (13.3%, n=12) mentioned riding conditions as a factor for choosing to not ride a bicycle to/from campus. One participant stated: "... Hilly. And weather (too hot, cold, or rainy) most of the time" (Woman, Bisexual, White). Another participant stated: "There are too many

uphills" (Woman, Heterosexual, Other). A different participant stated "The hills and weather can make it a challenge, especially when I have a lot to carry on campus" (Woman, Heterosexual, White). Another participant stated "Campus is a very hilly area that I am not confident biking up" (Woman, Heterosexual, White). The responses highlight details of the climate and physical environment that are specific to the targeted area. It is evident that the conditions impact students' choice to ride a bicycle to/from campus.

#### Theme 5: Knowledge and Ownership of a Bicycle

Participants (33.3%, n=30) mentioned their knowledge of bicycles as well as whether they owned a bicycle or not as a factor to choosing to ride a bicycle to/from campus. One participant responded: "I don't have a bike and there are so many people here, I'm not sure I'd be able to" (Woman, Gay/Lesbian, White). Another participant responded: "There's too much automobile and foot traffic for my bike riding skill set." (Woman, Heterosexual, White). These responses make it evident that choosing to ride a bicycle can be determined by whether students know how to ride a bicycle and/or if they own a bicycle.

## DISCUSSION

Universities are important for promoting healthy behaviors, especially transportation-related physical activity, throughout student populations across the U.S. Many benefits for individual health, community health, and economics have been seen with promoting and utilizing biking for transportation within various communities (6, 28). Behaviors that are set during college years have the potential to continue into adulthood, so it is important to promote biking and active lifestyles to students, while understanding the barriers for all populations (1). This current study has identified environmental and social factors and suggested common themes as to why female college students are not actively traveling to/from campus, to propose recommendations to improve biking participation.

The results of the current study show that many female students lack confidence with riding a bicycle and were more likely to travel to/from campus by walking instead of riding a bicycle. Their lack of confidence with riding a bicycle may be attributed to their limited understanding of bicycle maintenance and related skills as well as concerns of verbal abuse/bullying and interactions with drivers on the roads (17, 19). The current study noted the perception of traffic as a significant factor; previous studies have noted this connection between driver behavior/traffic and confidence is a more significant influence of behavior for women compared with men (19). Lower confidence may also lead to an increase in the perception that traffic is a concern or barrier to cycling, which connects these two factors (23). Though traffic is a factor that will impact everyone, regardless of gender, women may experience a greater impact of traffic on their bicycling behavior because of the lower confidence. Participants noted other various environmental and social factors as a factor influencing their commute including personal preferences, safety concerns, riding conditions, and knowledge and ownership of a bicycle. Considering these themes, universities should aim to create a more suitable infrastructure for bicycling on their campuses, reduce the number of cars on the streets, and set up bicycle shares throughout campus, which would benefit the general campus population, but



women in particular (37). E-bicycles have also been seen to help increase participation since they allow cyclists to exert less energy and experience more enjoyment during their ride, possibly helping female students in particular who noted hilly terrain as a significant influence (192). Free or low-cost campus e-bike shares could be a potential strategy to overcome this barrier, in combination with skills-based training, which is noted to increase confidence in cycling in general, but particularly in urban settings with more traffic (24). Educational programs that partner with organizations that have pre-existing relationships with the targeted population, women in this case, could provide the best results (28).

Furthermore, community-wide campaigns, increasing access to places that promote physical activity, and behavioral and social support interventions (32, 33, 34), have been seen to successfully increase bicycling in communities and overall individual physical activity levels. Universities can organize student representatives with staff representatives from relevant departments, such as housing, transport, or police, to resolve issues related to biking on campus (37, 41). Some of the findings from the current study also point to some issues of intersectionality, where various demographic factors (e.g. race, gender identity) may indicate the importance of considering the experiences of different groups. Additionally, universities can provide diversity, equity and inclusion training to help programs that reach underserved populations through effective communication and intervention techniques (14). Lastly, institutions who form partnerships with local authorities, agencies, workplaces, and both on and off-campus organizations can increase effective programming as connections are expanded and the needs of all populations within their community are addressed (7, 14).

Despite the unique findings from the study, there are numerous limitations that reduce the study's internal and external validity. Questions from the survey were all self-reported, which could present biases or misrepresentation. Participation in the study was voluntary, which could lead to response bias. The study comes from a single university, which may not be generalizable to the entire U.S. college student population. Additionally, some responses for gender identity, sexual orientation, and race/ethnicity identity were omitted due to the small sample size, which could also present biases or misrepresentation. The lack of emphasis on the race/ethnicity identification of the participants in the study limits the ability to gauge complete demographic differences. Therefore, future studies should attempt to compare other demographics, use other objective measures, and evaluate intervention programs to understand the best practices for improving transportation-related physical activity participation among all college students at various institutions. Lastly, given that this sample focused exclusively on women, it is unclear how or if these same issues impact men's cycling on or to campus and comparisons were not possible with the initial small sample size of men. We hope to inform universities about these common themes to consider adapting interventions and strategies to improve AT participation for all populations on college campuses across the U.S.

Universities have the potential to play an important role in promoting active travel to all populations across their campuses and have an obligation to address the needs of all students equally. Although many AT benefits are already known, female college students report environmental and social factors impacting their choice to participate. Results from this study

suggest that female students are less likely to commute via bicycle to/from campus compared to other groups of students. Common themes identified among the female students who participated in the study were the amount of traffic, personal preferences, safety concerns, riding conditions, and knowledge and ownership of bicycles. These results suggest that universities should consider making infrastructure improvements and implementing different resources, such as educational programs, bicycle shares and e-bicycles, to improve female college student AT participation. By identifying the common themes among female college students and providing potential strategies, we hope AT participation improves in university settings across all populations with the goal of eliminating disparities.

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