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Moderating effect of gender on the associations of perceived attributes of the neighbourhood environment and social norms on transport cycling behaviours

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ABSTRACT

Introduction: Cycling for transport has various health benefits. However, in Australia, commuter cycling rates are low, especially among women. Despite this, little is known about the factors that may explain why women cycle for transport less than men. This study aimed to examine whether components of the neighbourhood built environment and social norms were associated with transport cycling differently in men and women.

Methods: This cross-sectional study recruited participants from organisations with bicycle user groups in Melbourne, Australia. An online questionnaire measured participant's (n = 228) perceptions about cycling infrastructure and cycling convenience in their neighbourhood, and descriptive and injunctive norms towards cycling. Logistic regression models were run to test the main effects of gender and participant's perceptions of each of these factors on transport cycling. The moderating effect of gender was tested by adding an interaction term between gender and each of the neighbourhood built environment and social norm variables into the main effects model.

Results: Results showed that women were significantly less likely to cycle for transport, while participants who reported positive perceptions of neighbourhood cycling convenience and descriptive norms were significantly more likely to cycle for transport in the previous week. Gender moderated the association between neighbourhood cycling convenience and cycling for transport whereby the association was only significantly positive in women.

Conclusion: Results from this study suggest that to increase rates of transport cycling in women it may be necessary to increase the convenience of cycling in neighbourhoods for multiple purposes, such as going to the shops, running errands, or escorting children. Additionally, improving social norms towards cycling may increase rates of commuter cycling in both men and women.

1. Introduction

There is overwhelming evidence showing that physical activity can prevent several chronic diseases in adults (Rhodes et al., 2017). To experience these beneficial effects, it is recommended that adults accumulate the equivalent of 150 min of moderate-to-vigorous physical activity each week (World Health Organization, 2018). However, in high income countries, available data suggests

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that 32.7% of adults do not achieve this level of physical activity (Rhodes et al., 2017). Recent results suggest that the prevalence of physical inactivity could be even greater in Australia where 44.5% of adults do not meet physical activity recommendations (Australian Bureau of Statistics, 2015).

Encouraging people to shift from motorised forms of transport to cycling for transport is one strategy that may increase levels of moderate-to-vigorous physical activity in the adult population (Foley et al., 2015; Sahlqvist et al., 2013). For example, it is estimated that if 20% of Australian adults who are considered insufficiently active added one, two or three 20 min bouts of cycling into their weekly routine, the percentage of the population who would achieve adequate levels of moderate-to-vigorous physical activity would increase by 4%, 10%, and 15% respectively (Garrard et al., 2012b). Cycling for transport, therefore, has health benefits including decreased risk of cardiovascular disease, diabetes, cancer, and all-cause mortality (Celis-Morales et al., 2017; Oja et al., 2011; Pucher et al., 2010). Additionally, an aggregate shift from motorised forms of transport to active transport at a population level may have further health benefits as a result of a reduction in the level of traffic incidents, and air and noise pollution created by motorised vehicles (Mueller et al., 2015).

Despite the benefits of cycling for transport, in Australia only 1.1% of trips to work are made by bicycle (Australian Bureau of Statistics, 2017). This rate is comparable to other developed nations including the United States, Canada and the United Kingdom. However, it is well below the rates of some European nations such as the Netherlands where one-quarter of trips are made by bicycle (Bassett et al., 2008). Research has demonstrated that there is a significant gender difference in transport cycling rates in Australia where men are significantly more likely to cycle for transport than women (Garrard et al., 2008; Heesch et al., 2012; Owen et al., 2010). In comparison, women are just as likely, if not more likely, as men to cycle for transport in Denmark, Germany and the Netherlands, where overall transport cycling rates are considerably greater (Engbers and Hendriksen, 2010; Pucher and Buehler, 2008). Similarly, local government areas in Melbourne, Australia, where there are a greater percentage of female cyclists have greater overall rates of commuter cycling (Pucher et al., 2011). Thus, increasing transport cycling participation among women is a priority to increase overall levels of transport cycling, and the associated public health benefits, in Australia. However, little is known about the factors that may explain the gender difference in transport cycling.

Aldred et al. (2016) suggest that gender inequities in cycling participation may be explained by three factors: differences in trip purpose, infrastructural preference, and cultural norms. It is suggested that women have more complex travel behaviours that may make cycling inconvenient, women prefer cycling infrastructure separated from traffic because it is safer, and cultural or social norms are inconsistent with women cycling for transport. However, few studies have empirically tested how factors influence transport cycling differently in women compared to men.

In support of the suggestion that trip purposes make cycling inconvenient for women, it was found that women who make one or more trips for escorting (i.e. traveling with other household members to a destination) or maintenance activities (e.g. to do grocery shopping or personal business, attend a healthcare appointment) were less likely to cycle for transport than those who did not make any escorting or maintenance trips, whereas the opposite was true for men (Singleton and Goddard, 2016). Additionally, women who believed that they needed a car to do personal activities where significantly less likely to cycle, whereas this was not the case in men (Emond et al., 2009). Emond et al. (2009), suggest this may be a result of women making trips for multiple purposes that may not be convenient by bicycle. Therefore, whether cycling is a convenient option for multiple purposes within local neighbourhoods might be an important factor determining women's participation in cycling. In countries where women cycle for transport at similar or higher rates than men, cycling within neighbourhoods is the most convenient form of transport (Pucher and Buehler, 2008). Additionally, a recent study found that women who perceived that they had a choice between different routes to cycle in their neighbourhood were significantly more likely to cycle for transport (Mertens et al., 2016). Similarly, in a study with Canadian adults, where transport cycling rates are similar to Australia, the majority of women who were considering commuting by bicycle, but did not currently cycle, reported a greater number of direct cycling routes may encourage them to commute by bicycle in the future (Twaddle et al., 2010). Convenient cycling routes have also been identified in a sample of Australian utility and non-utility cyclists as a motivator to increase their amount of utility cycling (Heesch and Sahlqvist, 2013). Thus, convenient cycling routes to destinations within neighbourhoods, not just places of work, may be an important factor in determining whether women cycle for transport.

With regards to differences in preference for cycling infrastructure between men and women, a recent systematic review found strong evidence that women, compared to men, had a stronger preference for cycling infrastructure separated from traffic (Aldred et al., 2017). For example, in Canada, women who did not commute by bicycle reported not knowing a safe route and feeling unsafe riding on roads as the main barriers preventing them from commuting by bicycle (Twaddle et al., 2010). Similarly, women cyclists are more likely to choose routes with a greater percentage of cycling infrastructure and lower levels of traffic (Misra and Watkins, 2018). A study of university students and staff also found that living close to bicycle trails was positively related with the choice to cycle to the campus in women but not men (Akar et al., 2013). Additionally, countries where transport cycling rates among women are equal to or greater than men have extensive cycling networks made up of cycling specific infrastructure separated from traffic (Buehler and Dill, 2016). However, a recent study in England and Wales found that the number of neighbourhood on-road cycling lanes was positively related to commuter cycling in women, but the number of neighbourhood off-road cycling paths was not (Grudgings et al., 2018). Similarly, other studies have found that the presence of bicycle lanes (Mertens et al., 2017), but not bicycle paths (Mertens et al., 2016), are positively associated with cycling for transport in women.

Cultural or social norms may also explain gender inequities in transport cycling. Descriptive norms, which is defined as what is typically done within a group of people (Cialdini, 2012), may be associated with transport cycling differently in men and women. For example, although it has been found that women were more likely to perceive cycling as a normal form of transport, perceiving cycling as “normal” is only positively associated with cycling in men (Emond et al., 2009). Similarly, descriptive norms for cycling were not associated with transport cycling in a sample of Australian women (Ball et al., 2010). Injunctive norms, which is whether a

behaviour is typically approved or encouraged by a group of people (Cialdini, 2012), may also be associated with transport cycling differently in men and women. For instance, women who cycle for transport were significantly more likely than men who cycle for transport to report receiving encouragement from their employer, but not family, friends or work colleagues, as a motivator for them to cycling (Heesch et al., 2012). Therefore, it might be that viewing cycling as normal may not be associated with cycling in women, whereas feeling like others approve of women cycling may be.

The aim of the present study was to examine whether gender moderated the association between perceptions of neighbourhood cycling convenience, neighbourhood cycling infrastructure, descriptive norms and injunctive norms and cycling for transport.

2. Methods

2.1. Study design and participants

This cross-sectional study was conducted in Metropolitan Melbourne, Australia. Data was collected between July and August, 2017 from an online questionnaire administered with Qualtrics software (Version 3.7.0, Provo, UT, USA). A convenience sample of organisations (including private organisations, NGOs, and government organisations) with bicycle user groups, which were identified from a publicly accessible database (Bicycle Network, 2018), were recruited by email. Organisations that chose to be involved in the study were prompted to distribute the questionnaire hyperlink to employees using internal communication channels. Therefore, although contact with each organisation was initially made via a bicycle user group representative, the questionnaire was distributed to all members of the organisation, regardless of whether they were a member of their workplace's bicycle user group, and it was emphasised that employees were eligible to complete the questionnaire regardless of whether they cycle or not. Though response rates could not be calculated, in an attempt to increase response rates the questionnaire length was kept short (i.e. less than 10 min to complete), and participants who completed the questionnaire were eligible to go into the draw to win one of five $50 department store gift cards, which was made clear in the recruitment email. A total of 228 adults (53% female) aged between 22 and 70 years (M = 38.92, SD = 10.85) completed the questionnaire. Ethics approval was obtained from the Victoria University Human Research Ethics Committee (HRE17-092).

2.2. Survey measures

Socio-demographic variables that were measured were gender, age, education level, the number of cars at the participant's household, whether the participant had regular access to a working bicycle, and the distance the participant lived from their workplace.

Cycling for transport was measured using an item from the International Physical Activity Questionnaire (Craig et al., 2003). This measure was selected as it has displayed good test-retest reliability (Craig et al., 2003), and has been used widely to measure levels of transport cycling in other studies (e.g. Christiansen et al., 2016; Mertens et al., 2017). Participants were asked to report the number of days they cycled for transport in the previous week and the number of minutes they usually spent on one of those days cycling for transport. Participants were instructed to only include times they cycled to get from place-to-place such as work, shops, and public transport. The minutes of cycling was significantly positively skewed, so the decision was made to dichotomise the variable. The dichotomised outcomes were “cycled for transport in the last week” and “did not cycle for transport in the last week”.

Perceived neighbourhood cycling infrastructure and perceived neighbourhood cycling convenience were measured using items from the Instrument for Assessing Levels of Physical Activity and Fitness Environmental Questionnaire (Spittaels et al., 2009). Similar to the process taken in other studies, the items in the questionnaire were selected on their applicability to cycling (Mertens et al., 2016; Simons et al., 2017). Additionally the wording of the questionnaire was adjusted slightly from “the area you can walk in under 15 min” to “the area you can cycle in under 15 min” to account for the increased mobility of cycling compared to walking (Hoehner

Table 1
Perceived neighbourhood built environment, workplace environment and social norm measures.

Variable	Questions
Perceived neighbourhood cycling infrastructure [a]	There are special lanes, routes or paths for cycling in my neighbourhood.
	There are cycling routes in my neighbourhood that are separated from traffic.
Perceived neighbourhood cycling convenience [a]	Cycling is quicker than driving in my neighbourhood during the day.
	There are many road junctions in my neighbourhood.
	There are many different routes for cycling from place to place in my neighbourhood so I don't have to go the same way every time.
Perceived descriptive norm [b]	My closest friends cycle.
	My family/partner cycle.
	My work colleagues cycle.
Perceived injunctive norm [b]	My closest friends accept me cycling.
	My family/partner accept me cycling.
	My work colleagues accept me cycling.

[a] Measured on 4 point scale (1 = strongly disagree, 4 = strongly agree).
[b] Measured on a 5 point scale (1 = strongly disagree, 5 = strongly agree).

et al., 2005; Van Dyck et al., 2009). Individual items used in this study have moderate-to-good test-retest reliability (Spittaels et al., 2010). Each of the individual items are presented in Table 1.

Perceived social norms were measured using items developed previously to specifically measure people's social norms towards cycling (Forward, 2014). To measure descriptive norms participants were asked about whether people that they know cycle. To measure injunctive norms participants were asked about whether people that they know accepted them cycling. Each of the individual items are presented in Table 1.

2.3. Statistical analysis

All statistical analysis was conducted with SPSS version 25. In total, 3% of cases had missing data, ranging from 3 to 7% for individual cases. To impute missing data the expectation maximization method was used (Dempster et al., 1977). Descriptive statistics were computed for all independent variables, stratified by gender and whether or not participants cycled for transport in the last week. Bivariate associations between cycling for transport and socio-demographic variables for men and women were examined using chi-square test of independence for categorical variables and independent sample t-tests for continuous variables. Associations between gender and socio-demographic and independent variables (i.e. neighbourhood cycling environment and social norms) were also examined using chi-square test of independence for categorical variables and independent sample t-tests for continuous variables.

Multivariate logistic regression models were run to examine main effects between independent variables and cycling for transport, and interactions between independent variables and gender. As factors associated with bicycle ownership and bicycle use may be unique (Handy et al., 2010; Sallis et al., 2013), participants who reported not having access to a bicycle (n = 32) were excluded from the analysis leaving a total of 197 cases (51% female). First, all independent variables were entered into the model to test their main effects on transport cycling. Next, to test whether gender moderated the association between the independent variables and cycling for transport, interaction terms between gender and each of the independent variables were individually added to the main effects model. Each model controlled for distance that participants lived from their workplace.

Before being entered into the model, each of the independent variables, except gender which was dummy coded (0 = male, 1 = female), were standardised to have a mean of zero and a standard deviation of one. By standardising the independent variables, the regression coefficients can be interpreted as the odds of cycling for transport associated with a one standard deviation increase in the independent variable (Menard, 2004). Statistical significance was set at $p < 0.05$ for main effect and $p < 0.10$ interaction effects to account for lower power of interactions (Twisk, 2006). All significant interactions were analysed post-hoc by running logistic regression models to test the association in men and women separately, controlling for all other independent variables. Significant interactions were also plotted using the spreadsheet formulas created by Dawson (n.d.).

3. Results

3.1. Descriptive statistics

There were slightly more females (53%) than males involved in this study. Additionally, females were significantly younger (7.15 years, 95%CI = 4.66, 9.84) than the males in this study. There were no significant differences between the males and females in any other of the socio-demographic variables (Table 2). Female cyclists were significantly more likely to have access to a working bicycle ($\chi^2 = 16.75$, $p < 0.001$), and live closer to where they work ($\chi^2 = 9.60$, $p = 0.022$) than female non-cyclists. Like female cyclists, male cyclists were also significantly more likely to have access to a working bicycle ($\chi^2 = 22.06$, $p < 0.001$), and live closer to where they work ($\chi^2 = 8.14$, $p = 0.043$) than male non-cyclists (Table 2). There were no significant difference in perceived neighbourhood cycling infrastructure, perceived neighbourhood cycling convenience, and perceived descriptive and injunctive norms between males and females (Table 3).

3.2. Main associations of gender, the neighbourhood built environment and social norms on the odds of cycling for transport

Women were significant less likely than men to cycle in the previous week ($B = 0.50$ [0.27, 0.90], p = 0.02). There was a significant positive association between perceived neighbourhood cycling convenience and cycling for transport whereby participants one standard deviation above the average for perceived neighbourhood cycling convenience were 1.72 times (p = 0.002, 95%CI = 1.22, 2.41) more likely to cycle for transport in the previous week. There was also a significant positive association between descriptive norms and transport cycling, whereby a one standard deviation increase in perceived descriptive norms increased the odds of participants cycling for transport by 1.83 times (p < 0.001, 95%CI = 1.31, 2.57). No main effect was found for perceived neighbourhood infrastructure or injunctive norms on cycling for transport (Table 4).

3.3. Gender moderated associations of the neighbourhood cycling environment and social norms on the odds of cycling for transport

Only the interaction between gender and neighbourhood cycling convenience was significant at p < 0.10 (Table 4). The significant interaction between gender and neighbourhood cycling convenience on cycling for transport ($B = 2.05$ [1.01, 6.25], $p = 0.032$) indicated that the association between perceived neighbourhood cycling convenience and transport cycling was stronger for women than men. Post-hoc analysis showed that, controlling for all other independent variables, a one standard deviation

Table 2
Descriptive statistics and bivariate association between socio-demographic variables and cycling for transport for men and women.

	Female			Male			
	Did not cycle for transport in the last week n = 64	Cycled for transport in the last week n = 56	p-value [a]	Did not cycle for transport in the last week n = 41	Cycled for transport in the last week n = 67	p-value [a]	Gender difference p-value [a]
Age M(SD)	35.1(9.4)	36.0(8.8)	0.406	42.5(11.9)	42.8(11.1)	0.913	< 0.001
Education %							
Did not complete secondary school	0.0	1.8	0.303	0.0	0.0	0.963	0.063
Secondary	0.0	1.8		7.3	6.0		
Certificate or Diploma	14.1	7.1		14.6	14.9		
Bachelor degree or higher	85.9	89.3		78.0	79.1		
Number of cars in household M(SD)	1.53(0.7)	1.16(0.8)	0.100	1.4(0.9)	1.3(0.9)	0.648	0.700
Access to working bicycle							
Yes	70.3	98.2	< 0.001	70.7	100.0	< 0.001	0.228
No	29.7	1.8		29.3	0.0		
Distance lived from work							
Less than 1 km	3.1	0.0	0.022	7.3	0	0.043	0.163
1–5 kms	20.3	30.4		14.6	14.9		
6–10 kms	28.1	44.6		22.0	40.3		
More than 10 kms	48.4	25.0		56.1	44.8		

[a] p-values for age and number of cars in the household derived from independent sample t-tests; p-values for education, access to working bicycle and distance lived from workplace derived from chi-square test of independence.

Table 3
Gender differences in perceptions of the neighbourhood cycling environment and social norms.

	Women (n = 118)	Men (n = 108)	p-value
Neighbourhood cycling infrastructure [a]	3.20(0.80)	3.19(0.64)	0.989
Neighbourhood cycling convenience [a]	2.86(0.59)	2.96(0.54)	0.186
Descriptive norm [b]	3.69(0.78)	3.61(0.80)	0.444
Injunctive norm [b]	4.48(0.58)	4.45(0.73)	0.706

[a] Measured on a 4 point scale.
[b] Measured on a 5 point scale.

Table 4
Main and gender moderated effects of neighbourhood cycling environment and social norms on odds of cycling for transport (n = 197).

	B	95%CI	p-value
Main Effects			
Gender (Male referent)	0.50	0.27, 0.90	0.020
Infrastructure	1.00	0.75, 1.34	0.991
Cycling convenience	1.72	1.22, 2.41	0.002
Descriptive norms	1.83	1.31, 2.57	< 0.001
Injunctive norms	1.16	0.85, 1.58	0.348
Moderating Effects [a]			
Gender*Infrastructure	1.39	0.76, 2.57	0.287
Gender*Cycling convenience	2.05	1.06, 3.96	0.032
Association in women	2.20	1.29, 3.75	0.004
Association in men	1.19	0.71, 1.66	0.539
Gender*Descriptive norms	0.78	0.27, 1.51	0.467
Gender*Injunctive norms	1.55	0.83, 2.91	0.172

Model controls distance lived from workplace.
[a] Interaction terms entered individually into the main effects model.

increase in perceived neighbourhood cycling convenience increased the likelihood of women cycling by 2.20 times ($p = 0.004$, 95%CI = 1.29, 3.75). In comparison, perceived neighbourhood cycling convenience was not significantly associated with transport cycling in men ($p = 0.539$) (Table 4). A line graph plotting the interaction between perceived neighbourhood cycling convenience and gender illustrates this interaction (Fig. 1).

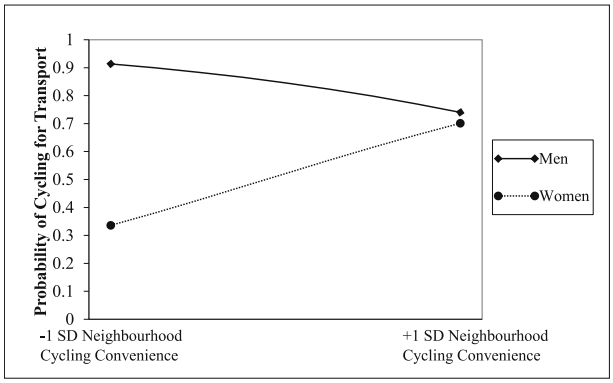

Fig. 1. Moderating effect of gender on the association between perceived neighbourhood cycling convenience and the odds of cycling for transport.

4. Discussion

The results from this study provide new understanding of the factors that may explain gender differences in transport cycling participation. Gender moderated the association between perceived neighbourhood cycling convenience and transport cycling whereby neighbourhood cycling convenience was only positively associated with transport cycling in women. This research adds to previous research that has shown that cycling convenience is a prominent motivating and constraining factor for transport cycling in women (Heesch et al., 2012; Twaddle et al., 2010). Neighbourhood cycling convenience may be an important factor for women because women are more likely to make trips for non-work related purposes in their neighbourhood, such as going to the shops, running errands, or escorting children (Damant-Sirois and El-Geneidy, 2015; Grossen and Purvis, 2004; Krizek et al., 2005). Women also generally work closer to home than men (Australian Bureau of Statistics, 2018; Crane, 2007), and cycle shorter distances (Larsen et al., 2010) which may explain why convenient cycling in their neighbourhood is more important to women than men. In addition to making more trips in their local neighbourhoods, women may be more sensitive to cycling distance when deciding to cycle for transport (Heinen et al., 2013). Therefore, providing convenient routes that minimise the distance that must be travelled to local amenities may be an important factor in determining women's decision to cycle for transport.

Traditionally, efforts to increase transport cycling have focused on commuter cycling rather than cycling to complete short trips within neighbourhoods for multiple utilitarian purposes (Garrard et al., 2012a). The results from this study suggest that there is also a need for policies and interventions to focus on making cycling more convenient within local neighbourhoods for multiple purposes. It is possible that efforts to increase transport cycling that focus solely on commuter cycling may, in fact, be contributing to the gender inequities in cycling for transport. To increase transport cycling rates in women, there may be a greater need to invest in infrastructure to develop local cycling networks that connect to key residential shopping centres, service precincts, and schools that make cycling more appealing and convenient choice for multiple purposes.

The results from this study also showed that descriptive norms are positively associated with transport cycling and that gender did not moderate this relationship. Unlike Emond et al. (2009), who found that descriptive norms were only positively associated with overall cycling in men, and Ball et al. (2010) who found that descriptive norms were not significantly associated with transport cycling in a sample of women, the results from this study suggest descriptive norms were positively related to transport cycling in men and women. A possible explanation for differences in findings is that this study assessed proximal social norms based on friends, family and work colleagues, whereas previous studies assessed general norms. These differences in results support the notion that proximal norms are likely to have a stronger influence on behaviours than distal norms (Randazzo and Solmon, 2018). The current results suggest that modifying social norms, especially social norms based on salient referent groups, as part of an intervention or program may have the potential to have positive effects on cycling participation in both men and women. Given the effectiveness of programs that normalise cycling, such as community-based social marketing campaigns (Rissel et al., 2010), and major cycling events (Rose and Marfurt, 2007), it appears prudent to continue to implement programs that aim to positively modify social norms towards cycling. However, as suggested by Garrard et al. (2012a), the overall aim should be to normalise cycling for women by promoting practical, utility cycling for multiple purposes consistent with their travel behaviours and lifestyles.

Unlike descriptive norms, the results showed that there was no main effect of injunctive norms on transport cycling. These results are consistent with previous research that showed injunctive norms were not associated with intention to cycle for transport (Eriksson and Forward, 2011). This may be because perceptions of injunctive norms can be very similar between those in different stages of behaviour change for cycling (Forward, 2014). Therefore, whether people feel as if others accept them cycling for transport appears to have little influence on their decision to cycle.

Finally, results from this study showed that perceived neighbourhood cycling infrastructure was not significantly associated with cycling for transport in either men or women. These findings are surprising considering that women are more likely than men to have a preference for bicycle infrastructure which is segregated from traffic (Aldred et al., 2017). However, these findings are similar to other studies which found that the presence of bicycle paths was not associated with cycling for transport in women (Grudgings et al., 2018; Mertens et al., 2016). Cycling infrastructure may not be related to cycling for transport because transport cyclists are generally

more experienced at cycling than recreational cyclists (Park et al., 2011). Therefore, women who cycle for transportation are less likely to report concerns about riding in traffic or aggression from motorists as a barrier to them cycling compared to females that only cycle for recreation (Heesch et al., 2012). Additionally, perceived safety from cycling infrastructure has been found to be less important for utilitarian trips than commuting trips among dedicated cyclists (Damant-Sirois and El-Geneidy, 2015). Therefore, although cycling infrastructure was not found to be an important factor in this sample, which had an overrepresentation of women who cycle for transport, it may still be an important factor for less experienced cyclists. Another possible explanation is that distance to destinations is an important factor in people's decision to cycle for transport (Heesch et al., 2015). For example, one study found that a 1% increase in distance reduces the probability of a cyclist choosing a route for transport cycling by 5–9% (Broach et al., 2012). Considering that in Melbourne most off-road cycling infrastructure is located in parks, or along rivers or creeks (Garrard et al., 2008; Pistoll and Goodman, 2014), cycling to a destination on off-road paths may be considerably longer than cycling on roads. Thus, the cost of the extra distance to destinations may be greater than the benefit of safety provided by the off-road cycling paths.

4.1. Strengths and limitations

This study contributes to the understanding of gender-specific associations between the neighbourhood built environment, social norms and transport cycling, and can aid the development of interventions and policy to increase women's participation in transport cycling. Notwithstanding, the current study has some limitations that should be considered when interpreting the results. First, this study employed a cross-sectional study design meaning the conclusions from this study can only infer association rather than causation. Secondly, transport cycling rates observed in this study were higher than the national average. Although this could be somewhat attributable to measuring transport cycling for multiple purposes rather than just commuter cycling, it is possible that recruiting from a convenience sample of organisations with bicycle user groups led to a selection bias that overrepresented cyclists. Additionally, using self-reported measures of cycling, which may be influenced by recall bias and social desirability, may have led to overestimations of transport cycling rates. Finally, although appropriate for the data analysis techniques employed, the sample size was relatively small and could have increased the likelihood of type II errors.

5. Conclusion

This study examined whether gender moderated the association between perceptions of neighbourhood cycling convenience, neighbourhood cycling infrastructure, and descriptive and injunctive norms and cycling for transport. Findings suggest that perceptions of neighbourhood cycling convenience is positively associated with transport cycling in women but not men. Therefore, to increase rates of transport cycling in women it may be effective to develop or improve cycling networks that connect to shops, services, and schools within local neighbourhoods. Findings also showed that there was an association between perceived descriptive norms and transport cycling which was not moderated by gender. Therefore, programs that aim to improve social norms, such as social marketing campaigns, may have a positive impact on transport cycling rates in men and women. Future confirmatory studies with large random representative samples are warranted to ratify the present findings.

Authors' contribution

MB designed the study and collected the data. An analysis plan was developed by MB, MC and TH, and statistical analysis was conducted by MB. The initial draft of this manuscript was prepared by MB and was critically proofed and revised by MC and TH. All authors have read and approved the final manuscript.

Conflicts of interest

There are no conflicts of interest to declare.

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