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Promoting transportation cycling for women: The role of bicycle infrastructure

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Abstract

Objective. Females are substantially less likely than males to cycle for transport in countries with low bicycle transport mode share. We investigated whether female commuter cyclists were more likely to use bicycle routes that provide separation from motor vehicle traffic.

Methods. Census of cyclists observed at 15 locations (including off-road bicycle paths, on-road lanes and roads with no bicycle facilities) within a 7.4 km radius of the central business district (CBD) of Melbourne, Australia, during peak commuting times in February 2004.

Results. 6589 cyclists were observed, comprising 5229 males (79.4%) and 1360 females (20.6%). After adjustment for distance of the bicycle facility from the CBD, females showed a preference for using off-road paths rather than roads with no bicycle facilities (odds ratio [OR] = 1.43, 95% confidence interval [CI]: 1.12, 1.83), or roads with on-road bicycle lanes (OR = 1.34, 95% CI: 1.03, 1.75).

Conclusions. Consistent with gender differences in risk aversion, female commuter cyclists preferred to use routes with maximum separation from motorized traffic. Improved cycling infrastructure in the form of bicycle paths and lanes that provide a high degree of separation from motor traffic is likely to be important for increasing transportation cycling amongst under-represented population groups such as women.

Keywords: Transport; Bicycling; Gender; Physical activity; Public health

Introduction

Cycling for transportation has a range of health, environmental, social and community benefits (Hendriksen et al., 2000; Carlos and Phillips, 2000; Wagner et al., 2001; Kjellstrom et al., 2003).

Use of active transport modes is low in most English speaking countries (Pucher and Dijkstra, 2003). Countries with low rates of utilitarian cycling also have substantial gender differences in cycling. In Australia, the female rate of commuter cycling is less than one third that of the male rate (Bell et al., 2006). Substantial gender differences in cycling participation in Australia and other English speaking countries have led some researchers to suggest that women are not interested in cycling (Merom et al., 2003). This is not the case in several western European countries, where utilitarian cycling rates are high, and women cycle more frequently than men (Garrard, 2003).

Traffic safety concerns have been identified as a major constraint on cycling in countries with low rates of cycling, high rates of car use, and large gender differences in cycling (Garrard et al., 2006; Goldsmith, 1992). These concerns appear to have a differential impact on women, perhaps because they are more risk averse than men (Byrnes et al., 1999).

Female respondents in an on-line survey of 2403 cyclists in Melbourne, Australia, in 2005 were more likely than males to report that 'concerns about cycling in traffic' and 'aggression from motorists' were constraints on cycling (Garrard et al., 2006). In a telephone survey of 1880 adult Australians conducted by the Australian Associated Motor Insurers (AAMI) in 2004, women (46%) were significantly more likely than men (38%) to agree with the statement "aggressive drivers put me off walking or cycling" (unpublished data, Australian Associated Motor Insurers, 2004).

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Many countries provide on-road and off-road bicycle facilities to address this constraint on utilitarian cycling, but the impact of these facilities on population or gender-specific cycling rates or route choice is difficult to measure rigorously (Nelson and Allen, 1997; Ogilvie et al., 2004). Stated preference surveys, where respondents are asked to choose between alternatives with different attributes, have found gender differences in safety concerns associated with commuter cycling route choice (Krizek et al., 2005; Tilahun et al., nd). A small-scale stated preference study in Melbourne reported that female commuter cyclists perceived on-road facility type (on-road lane compared with no bicycle facility) to be more important in route choice than males (DeGruyter, 2003).

We are not aware of any published studies of gender differences in commuter cyclist route choice based on observed behaviour, rather than self-reported behaviours or stated preferences. Gender-specific cyclist counts at several inner-Melbourne locations provided an opportunity to explore the impact of cycling facilities on a population group (women) with greater sensitivity to adverse traffic conditions. We investigated if females are more likely than males to use bicycle facilities with greater separation from motor vehicle traffic for personal travel by bicycle (principally to and from work).

Methods

Setting

The study was conducted in Melbourne, Australia. Melbourne has a population of about 3.6 million people, with a relatively low population density of 412 persons per square kilometre (Baker et al., 2001). It has a temperate climate with a relatively flat terrain in most areas. Personal travel is principally by car, with bicycle trips comprising 1.2% of all trips (McGinley, 2003).

Participants

A census of cyclists was conducted by VicRoads (the Victorian statutory authority responsible for Victoria's network of arterial roads and freeways) at 15 locations (mainly intersections) surrounding the Central Business District (CBD) of Melbourne in February 2004 during morning and afternoon peak commuting times. At each location, counting was conducted for a total of four daylight hours (07:00 to 09:00 h, and 16:30 to 18:30 h). Data were collected on 11 midweek days (5th to 27th of February) when the weather conditions were fine. The average maximum temperature in Melbourne in February is 26 °C.

The 15 locations included many of the most frequently used bicycle and motor vehicle routes (excluding freeways) into the Melbourne CBD, distributed across an approximately 270° arc surrounding the CBD (excluding the Port Phillip Bay area to the southwest of the CBD). The 15 locations did not comprise a representative sample of the Melbourne bicycle route network. The Melbourne Principal Bicycle Network consists of approximately 1200 km of various bicycle facilities (on-road lanes, off-road paths and lanes, wide kerbside lanes, shared bus/bicycle lanes, etc.) spread across the greater Melbourne metropolitan area. Many of these facilities are not well-linked and are used infrequently for commuting by bicycle to the Melbourne CBD. For this reason, the 15 locations were selected strategically, rather than randomly.

The 15 count locations comprised 56 legs, where a leg refers to each branch of the intersection. A cross-road (+) intersection (the majority of the 15 locations) comprises four legs. Cyclists at the intersection were coded according to the leg on which they exited the intersection, including turning cyclists. Because each of the four legs of an intersection can have a different type of bicycle facility, the type of bicycle facility and the number of cyclists were coded separately for each leg. Morning and afternoon counts were coded separately, and the gender of each cyclist was recorded.

Bicycle facilities

Bicycle facilities were categorised according to the degree of separation between cyclist and motor vehicle traffic: (i) 'off-road paths' (bicycle-only or shared pedestrian/bicycle paths); (ii) 'on-road lanes' (marked and signed bicycle lanes adjacent to motor vehicle traffic); and (iii) 'no bicycle facility' (no bicycle facility or unmarked wide curb side lanes). The latter two categories were mainly high traffic volume arterial roads used for commuting to and from the city. Twenty-one of the fifty-six legs had no bicycle facility, twenty-six legs had on-road lanes, and nine were off-road paths (Table 1).

The distance of the count location from the CBD was estimated as the straight-line distance between the count location and the Melbourne General Post Office (GPO), located near the centre of the CBD. In all cases distances are estimates only of cyclists' trip distance because cyclists' actual trip origins and destinations are unknown. However, it is likely that the majority of the observed cyclists lived outside the CBD and cycled to work in the CBD (VicRoads, 2004). Distances of the count locations to the GPO ranged from 1.2 km to 7.4 km.

Table 1
Number of cyclists by gender and location, Melbourne, Australia, 2004

Intersection location	Number and type of intersection legs			Distance from GPO (km)	Female cyclists (%)	Male cyclists (%)	Total
	Off-road	On-road	No bicycle facility				
(1) Main Yarra Trail/Gardiner's Creek Trail	3	0	0	6.0	210 (12.2)	1514 (87.8)	1724
(2) St Kilda/Southbank	0	2	2	1.2	167 (20.6)	642 (79.4)	809
(3) Brunswick/Johnston	0	2	2	2.2	173 (27.1)	465 (72.9)	638
(4) Royal/Gatehouse	1	2	1	2.5	176 (31.2)	389 (68.8)	565
(5) St Georges/Charles	2	0	2	4.8	141 (31.7)	304 (68.3)	445
(6) Chapel/Toorak	0	2	2	4.0	88 (20.4)	344 (79.6)	432
(7) Church/Bridge	0	2	2	3.2	74 (19.6)	303 (80.4)	377
(8) Flemington/Gatehouse	1	3	0	2.2	90 (27.3)	240 (72.7)	330
(9) Chapel/Malvern	0	0	4	4.5	54 (16.6)	272 (83.4)	326
(10) Church/Swan	0	2	2	3.4	63 (22.4)	218 (77.6)	281
(11) Mt Alexander/Citylink	0	2	0	3.6	35 (16.2)	181 (83.8)	216
(12) Church/Victoria	0	3	1	3.4	41 (23.3)	135 (76.7)	176
(13) Moonee Ponds Creek Trail	2	0	0	4.0	34 (20.9)	129 (79.1)	163
(14) Racecourse/Smithfield	0	4	0	4.4	7 (12.3)	50 (87.7)	57
(15) Mt Alexander/Napier	0	2	3	7.4	7 (14.0)	43 (86.0)	50
Total	9	26	21	–	1360 (20.6)	5229 (79.4)	6589

Data analysis

Data were analysed using SPSS v14.0. Independent *t*-test and analysis of variance followed by Duncan's multiple comparison were used to test the differences in distance from the GPO between males and females, and between different types of facilities, respectively. Multinomial logistic regression was used to examine the impact of gender on the use of bicycle facilities with differing degrees of separation from motor vehicle traffic. The interaction between gender and distance was also examined.

Results

Locations and cyclist counts

6589 cyclists were observed at the 15 locations. The cyclists comprised 5229 males (79.4%) and 1360 females (20.6%). Cyclist counts at each location are summarised in Table 1.

During the morning count period most cyclists (78.0%) were travelling towards the CBD, whilst in the afternoon most cyclists (69.7%) were travelling away from the CBD. These data indicate that the CBD was the most likely trip destination/origin for cyclists. There were no significant differences in gender by direction.

Male cyclists outnumbered female cyclists at all locations, with the proportion of female cyclists ranging from 12.2% at the Main Yarra Trail/Gardiner's Creek Trail intersection to 31.7% at the St Georges Road/Charles Street intersection.

Use of bicycle facilities

The majority of cyclists (2869, 43.5%) were observed using on-road lanes, consistent with the over-representation of these facilities at the 15 locations. The proportion of female cyclists varied according to the type of bicycle facility (Table 2), suggesting that females preferred to use on-road lanes and roads with no bicycle facilities compared with off-road paths. Because this finding is inconsistent with several studies in which females self-report a preference for using bicycle facilities that provide separation from motorised traffic (Garrard et al., 2006; Krizek et al., 2005; Tilahun et al., nd; DeGruyter, 2003), the possibility of confounding due to the three different types of cycling facilities being located at differing distances from the CBD was investigated. Several studies have reported that females undertake shorter bicycle commute trip distances than males (Krizek et al., 2005), including two studies in Melbourne (McGinley, 2003; Bicycle Victoria, 2006).

Table 2
Cyclists by gender and bicycle facility, Melbourne, Australia, 2004

Bicycle facility	Cyclists			
	Male (%)	Female (%)	Total (%)	% Female[a]
No bicycle facility	1104 (21.1)	288 (21.2)	1392 (21.1)	20.7
On-road lane	2179 (41.7)	690 (50.7)	2869 (43.5)	24.1
Off-road path	1946 (37.2)	382 (28.1)	2328 (35.3)	16.4
Total	5229 (100.0)	1360 (100.0)	6589 (100.0)	20.6

[a] Percentage of cyclists observed using each type of bicycle facility who were female.

Overall, the mean distance of cyclists from the GPO was 3.81 (SD = 1.62) km. Significant differences in distance from the GPO were found for the three types of bicycle facility; post hoc analysis revealed that all of them were different from each other (off-road paths: 5.5(0.82) km; no facility: 3.6(0.88) km; on-road lanes: 2.4 (1.1) km; $p < 0.001$). Males were observed cycling at a greater average distance from the GPO than females: 3.91(1.64) km vs 3.43(1.50) km; $p < 0.001$, consistent with previous study findings (Krizek et al., 2005; McGinley, 2003; Bicycle Victoria, 2006). Accordingly, regression analysis was undertaken to adjust for distance from the GPO.

Multinomial logistic regression was used to examine the impact of gender on use of bicycle facilities with differing degrees of separation from traffic. After adjustment for distance from the GPO, female cyclists showed a preference for off-road paths over roads with no bicycle facilities (odds ratio [OR] = 1.43, 95% confidence interval [CI]: 1.12, 1.83, $p = 0.004$). Similarly, female cyclists preferred off-road paths over on-road lanes (OR = 1.34, 95% CI: 1.03, 1.75, $p = 0.023$). On the other hand, the proportions of female and male cyclists using on-road lanes and roads with no bicycle facilities were almost identical after adjustment for distance (OR = 1.07, 95% CI: 0.90, 1.27; $p = 0.46$).

Discussion

Overall, male cyclists (5229) outnumbered females (1360) by a ratio of nearly four to one, consistent with previous studies (Bell et al., 2006; McGinley, 2003). A consistent pattern of gender differences in cycling in countries such as Australia and North America has been attributed in part to the risks (actual and perceived) associated with cycling in countries with relatively poor cycling infrastructure, policies and regulations, and low cycling prevalence (Garrard et al., 2006; Pucher and Dijkstra, 2003).

The mean distance of female cyclists from the city centre was less than that of male cyclists, consistent with gender differences in trip distance in most countries (Krizek et al., 2005). This may reflect females' preference for less strenuous forms of physical activity (Australian Bureau of Statistics, 2006), or that females are more likely to work closer to home and make more short, linked journeys (e.g. work, shops, school, home) (Lehner-Lierz, 1997). Women also have less discretionary time than men, particularly when they combine work and family responsibilities (Australian Bureau of Statistics, 1997).

The proportion of female cyclists observed using roads with no bicycle facilities, on-road lanes and off-road paths did not show a consistent pattern of female preference for greater separation from motor vehicle traffic. However, we found that after adjustment for distance from the city centre females preferred off-road paths over on-road lanes or roads with no bicycle facilities. Female cyclists showed no preference for on-road lanes over roads with no bicycle facilities. We were unable to locate any published studies of gender differences in commuter cyclists' route choice based on observational data. However, data from adaptive stated preference surveys in the US and Melbourne are generally consistent with the study findings. Two small-scale surveys conducted in Minnesota found that, on a range of measures, female commuter cyclists

tended to be more concerned about safety factors than males (Krizek et al., 2005; Tilahun et al., nd). The Melbourne study of 42 commuter cyclists (27 males and 15 females) reported that females perceived on-road facility type (on-road lane compared with no bicycle facility) to be more important in route choice than males (DeGruyter, 2003). No directly comparable gender difference in observed preference for on-road lanes rather than no bicycle facility was found in this study, but the finding that females prefer off-road facilities is consistent with a general trend towards females preferring a higher degree of separation from motor vehicle traffic.

Study limitations and strengths

Direct observation of cyclists avoids many of the biases (such as behavioural recall and social desirability response bias) associated with self-reported behaviours or stated preferences, but this observational survey had some limitations. The study is an opportunistic analysis of data collected by VicRoads for internal planning purposes, and locations were not selected to examine gender differences in the use of on and off-road bicycle facilities. No measures of reliability were undertaken for either cyclist numbers or gender, however, observers reported no difficulties in assessing gender in the daylight, summer-time and fine weather conditions. Observational studies of utilitarian physical activity (e.g. stair-use) report high levels of reliability for observational counts and gender assignment (Coleman and Gonzalez, 2001).

The estimated trip distance of cyclists is a key variable in the data analysis. We were not able to measure this directly in this observational study, so straight-line distance between the count location and the CBD was used to estimate distance. The assumption that the CBD was in fact the trip destination for most cyclists is supported by Australian census 'journey to work' data for Melbourne (VicRoads, 2004) and recent automated bicycle count data (VicRoads, 2007). Data also indicate that most cyclists observed at these times and locations are likely to be commuting rather than recreational cyclists (VicRoads, 2007). Nevertheless, in the absence of large-scale intercept studies, the study findings should be interpreted cautiously.

Conclusions

The present analysis provides some, but not definitive support for the study hypothesis. Insofar as females demonstrated a preference, it was for off-road paths. In Melbourne, off-road bicycle paths are limited and are mainly located alongside the rivers and creeks that flow from the middle and outer suburbs towards the Melbourne city centre and inner suburbs. Large, car-oriented cities such as Melbourne are difficult to retrofit with an integrated network of off-road cycling facilities. On-road lanes are often a more practical and less costly alternative. Findings from this study suggest that the provision of on-road lanes on busy arterial roads may not offer the level of separation from motor vehicle traffic needed to attract increased numbers of female commuter cyclists. While it is not possible to generalise the study findings to other large, car-oriented cities, these findings are consistent with international comparative data indicating that high bicycle transport mode share for both males and females occurs mainly in countries and cities with extensive networks of separate bicycle paths and lanes (Pucher and Dijkstra, 2003).

As this is the first reported study of its kind, further research is required to identify and quantify the characteristics of female-friendly cycling infrastructure in a range of urban environments. Studies should include observational studies of cycling behaviour, as well as stated preference surveys which allow a larger number of variables to be examined.

High variability in rates of cycling for transportation and in gender differences in cycling for transportation internationally suggests that non-route factors are also important determinants of female (and male) cycling (Pucher and Dijkstra, 2003; Garrard, 2003). Future research is needed to identify and quantify additional personal, environmental, cultural and economic determinants of transportation cycling for women and men in countries with low bicycle transport mode share.

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