Psychosocial and environmental correlates of active and passive transport behaviors in college educated and non-college educated working young adults

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Abstract

Background

This study aimed to examine potential differences in walking, cycling, public transport and passive transport (car/moped/motorcycle) to work and to other destinations between college and non-college educated working young adults. Secondly, we aimed to investigate which psychosocial and environmental factors are associated with the four transport modes and whether these associations differ between college and non-college educated working young adults.

Methods

In this cross-sectional study, 224 working young adults completed an online questionnaire assessing socio-demographic variables (8 items), psychosocial variables (6 items), environmental variables (10 items) and transport mode (4 types) and duration to work/other destinations. Zero-inflated negative binomial regression models were performed in R.

Results

A trend (p<0.10) indicated that more college educated compared to non-college educated young adults participated in cycling and public transport. However, another trend indicated that cycle time and public transport trips were longer and passive transport trips were shorter in non-college compared to college educated working young adults. In all working young adults, high self-efficacy towards active transport, and high perceived benefits and low perceived barriers towards active and public transport were related to more active and public transport. High social support/norm/modeling towards active, public and passive
transport was related to more active, public and passive transport. High neighborhood walkability was related to more walking and less passive transport. Only in non-college educated working young adults, feeling safe from traffic and crime in their neighborhood was related to more active and public transport and less passive transport.

Conclusions

Educational levels should be taken into account when promoting healthy transport behaviors in working young adults. Among non-college educated working young adults, focus should be on increasing active and public transport participation and on increasing neighborhood safety to increase active and public transport use. Among college educated working young adults, more minutes of active transport should be encouraged.

Background

Insufficient physical activity is one of the leading risk factors for death worldwide, as one in four adults is not meeting the health related physical activity guidelines [1]. In Belgium, 11.4% of all-cause mortality is associated with physical inactivity [2]. Young or emerging adults (ranging from the late teens through the twenties) have shown to be particularly at risk for decreasing physical activity levels as they get older [3, 4]. Young adulthood is a critical period of decision making [5, 6] where major life events such as changes in employment, education, or place of residence can affect physical activity participation [7–10].

Active transport (AT) (i.e. walking, cycling) represents an opportunity to include physical activity into young adults' daily life [11]. AT, including walking or cycling to and from public transport, offers benefits such as higher levels of total moderate-to-vigorous physical activity [11–13], lower odds of being overweight or obese [14, 15], higher levels of cardiovascular fitness [14, 16, 17], an overall reduction in cardiovascular risk [16] and public health benefits due to improved air quality [18, 19]. Despite the many benefits of AT, only 12.2% and 13.6% of young adults (age 18–24) in Flanders (northern half of Belgium) respectively walk and cycle as their main mode of transport. For 34.5% of young adults, driving a car is the main transport mode in everyday life [20]. However, as travel habits are established in young adulthood, it is important to research their transport behavior and encourage sustainable travel choices (AT) that might persist into adulthood and provide long-term benefits [21].

Research on transport habits of young adults is scarce for young adults who are working (as compared to students), presumably because working young adults are not readily accessible through any institutional setting [5]. However, working young adults might be more car dependent because employment often implies the demand to have a driving license (as it is assumed to be associated with adulthood and responsibility) and because of greater financial means and the possibility to own/receive a car [22, 23]. One US study showed that the vast majority (90.4%) of working young adults commute by car [24]. Furthermore, working young adults’ transport behavior might differ according to educational attainment. Level of education reflects achievement of human capital via formal education, accreditation and lived experience [25]. This may influence a person’s health literacy and knowledge about the importance and benefits of AT [26], or the environmental implications of particular transport mode choices. Research found that having completed higher education (college or university), compared to lower education, is associated with more cycling to work in Flemish adults [27], more AT to
work in adults from Wales [28] and more AT to all destinations in Australian and UK adults [29, 30]. However, other studies found no or negative relations between educational levels and AT [31–34]. Nevertheless, promoting AT in working young adults, with increased attention for those who are lower educated, seems necessary. To date, the relation between educational level and transport behavior has not yet been studied in working young adults.

To design effective interventions promoting AT in both college and non-college educated working young adults, it is necessary to have a comprehensive understanding of the correlates of AT and of other modes of transport (e.g. public transport) in both target groups [35]. Ecological models state that transport choices are influenced by various factors at multiple levels, including psychosocial and environmental factors [36–38]. Previous studies investigating correlates of transport habits in young adults have focused on studying instead of working young adults [11, 39–41]. One qualitative study did include working young adults [42], but without taking educational level into account. Few AT studies (focusing on adults in general) have investigated moderators such as educational level and in those studies that did, mixed results were found (positive, negative and null associations) [27, 43–46].

Therefore, the aims of this study were (1) to examine differences in walking, cycling, public transport use and passive transport use to work and to other destinations between college and non-college educated working young adults, (2) to investigate which psychosocial and environmental factors are associated with the four transport modes and (3) to investigate whether these associations differ between college and non-college educated working young adults.

**Methods**

**Participants**

Working young adults (eligible age range: 18–26 years) were recruited from companies across Flanders (Belgium). A list of randomly selected companies that potentially employ many young people (both college and non-college educated or either one or the other) was made based on an internet search (n = 41). Contact was made via e-mail and phone with HR-managers of these companies. After agreement to participate, HR-managers were asked to forward an email with a link to an online questionnaire to the working young adults. Because of the low response rate of companies (n = 13, 30%) and employees, working young adults were also recruited face-to-face in other settings. Researchers went to random commercial and retail businesses to recruit young adult employees. In addition to these recruitment methods, social media (i.e. Facebook) was used in order to increase the sample size. An advertisement banner with an invitation to fill in the online questionnaire was placed on Facebook. Within young adults, social network sites are very popular and therefore an effective way to reach young people and send out online questionnaires [47]. Incentives (three folding bicycles) were raffled among participants who completed the questionnaire. The study protocol was approved by the ethics committee of the university hospital of the Vrije Universiteit Brussel (B.U.N. 143201112745).

**Research procedure and measures**

A cross-sectional design was used to collect self-reported data using an online survey (as also described previously in a study among older adolescents [48]). The survey assessed socio-demographic variables, general transport data, transport to work and to other destinations, psychosocial variables and environmental variables (see details below). The questions were based on validated questionnaires [27, 49, 50], but were adjusted to better fit the target group. These adjustments were made according to the results of a prior exploratory qualitative study using focus groups [42].
Socio-demographic variables. Self-reported socio-demographic variables included gender, age and nationality (Belgian, other). Educational level was dichotomized into non-college educated (elementary school or secondary school as highest degree) and college educated (college or university as highest degree). Furthermore, living situation was dichotomized into living with (grand)parents and not living with (grand)parents (with partner/alone/other). Living environment was dichotomized into rural area (countryside/village) and urban area (suburban area/city). Participants also reported their height and weight, which was used to calculate Body Mass Index (BMI).

General transport data. General transport data included possession of a driving license for a car (yes/no); ownership of moped, car/motorcycle and bicycle (yes/no); and pass ownership for public transport (yes/no) and for bicycle sharing schemes (yes/no).

Transport to work and to other destinations. Questions based on the International Physical Activity Questionnaire (IPAQ, long version), which has been validated in Flemish adults [51], were used to assess transport behavior to work and to destinations other than work. Frequency (days/week) and duration (minutes/day) of walking, cycling, public transport and passive transport (all questioned separately) within the last seven days were assessed. If participants combined transport modes (e.g. combining public transport and AT), they were asked to report each component separately. All information on transport modes was subdivided in four main groups: walking, cycling, public transport (train/bus/tram/subway) and passive transport (car/motorcycle/moped).

Psychosocial variables. The following psychosocial variables in relation to active and passive transport to all destinations were assessed: self-efficacy, social norm, modeling, social support, perceived benefits and perceived barriers. They were selected based on the Attitude-Social influence-self-Efficacy (ASE) model [52]. A summary of the measures of psychosocial variables and Cronbach’s alpha for internal consistency are shown in Table 1. Averages of item scores were used for the present data analyses. Self-efficacy was assessed by asking participants how confident they were to choose AT over other transport modes in 11 potentially difficult situations (i.e. bad weather, darkness, when tired). Social norm was measured by asking if participants believed that partner/parents/siblings/friends/colleagues (asked separately) expect them to (a) walk or cycle; (b) take a car/motorcycle/moped; (c) use public transport. Modeling was assessed by asking how frequently partner/parents/siblings/friends/colleagues (asked separately) (a) walk or cycle; (b) take a car/motorcycle/moped; (c) use public transport. Social support, participants were asked (1) how often partner/parents/siblings/friends/colleagues (asked separately) encourage them to (a) walk or cycle; (b) take a car/motorcycle/moped; (c) use public transport and (2) how often they do this together with them. To measure perceived benefits, participants were asked about potential benefits (i.e. health, cost, independence) of (a) walking or cycling; (b) taking the car/motorcycle/moped; (c) using public transport. Perceived barriers were assessed by asking participants about potential barriers (i.e. time, accidents, delays) of (a) walking or cycling; (b) taking the car/motorcycle/moped; (c) using public transport.

Perceived environmental variables. A summary of the measures of environmental variables are shown in Table 1. Perceived environmental variables were assessed using questions derived from validated questionnaires: the European environmental questionnaire (ALPHA questionnaire) [53] and the Neighborhood Environment Walkability Scale (NEWS, original version) [54, 55]. ‘Neighborhood’ was defined as ‘the environment within a walking or cycling distance of 10–15 minutes from home’. Data were cleaned and analyzed according to the ALPHA environmental questionnaire Manual [56] and the NEWS scoring procedures [57]. The following perceived environmental variables were assessed: residential density (ALPHA), land use mix diversity (ALPHA), land use mix access (NEWS), street connectivity (NEWS),
Table 1. Summary of psychosocial and environmental measures, Cronbach’s alpha (α) and mean scores (SD).

| Scale (composition)      | Response category                                                                 | α         | M (SD)    |
|--------------------------|-----------------------------------------------------------------------------------|-----------|-----------|
| **Psychosocial**         |                                                                                   |           |           |
| Self-efficacy            | active transport 11 items five-point scale from 1 (know I cannot do it) to 5 (know I can do it) | 0.89      | 3.45 (0.92) |
|                          | Social norm active transport 5 items five-point scale from 1 (strongly disagree) to 5 (strongly agree) | 0.90      | 2.78 (1.14) |
|                          | public transport 5 items five-point scale from 1 (strongly disagree) to 5 (strongly agree) | 0.93      | 2.35 (1.12) |
|                          | passive transport 5 items five-point scale from 1 (strongly disagree) to 5 (strongly agree) | 0.96      | 2.39 (1.18) |
| Social modeling          | active transport 5 items five-point scale: never or once per year, 1 time per month, several times per month, several times per week, almost every day | 0.74      | 2.98 (0.99) |
|                          | public transport 5 items five-point scale: never or once per year, 1 time per month, several times per month, several times per week, almost every day | 0.63      | 2.45 (0.92) |
|                          | passive transport 5 items five-point scale: never or once per year, 1 time per month, several times per month, several times per week, almost every day | 0.86      | 4.06 (1.02) |
| Social support           | active transport 5 items five-point scale from 1 (never) to 5 (always)             | 0.79      | 2.21 (0.69) |
|                          | public transport 5 items five-point scale from 1 (never) to 5 (always)             | 0.86      | 1.84 (0.70) |
|                          | passive transport 5 items five-point scale from 1 (never) to 5 (always)            | 0.89      | 2.48 (0.76) |
| Perceived benefits       | active transport 18 items five-point scale from 1 (strongly disagree) to 5 (strongly agree) | 0.88      | 3.68 (0.66) |
|                          | public transport 6 items five-point scale from 1 (strongly disagree) to 5 (strongly agree) | 0.76      | 2.61 (0.82) |
|                          | passive transport 7 items five-point scale from 1 (strongly disagree) to 5 (strongly agree) | 0.83      | 3.50 (0.81) |
| Perceived barriers       | active transport 22 items five-point scale from 1 (never) to 5 (always)            | 0.90      | 2.17 (0.61) |
|                          | public transport 8 items five-point scale from 1 (never) to 5 (always)             | 0.83      | 2.91 (0.80) |
|                          | passive transport 11 items five-point scale from 1 (never) to 5 (always)           | 0.85      | 2.30 (0.76) |
| **Environmental**        | Residential density 3 items five-point scale from 1 (no houses/ apartments) to 5 (all houses/apartments) | 2.33      | (0.86)    |
|                          | Land use mix diversity 8 items five-point scale: 1–5 min, 6–10 min, 11–20 min, 20–30 min, > 30 minutes | 3.49      | (0.93)    |
|                          | Land use mix access 6 items four-point scale: strongly disagree, somewhat disagree, somewhat agree, strongly agree | 3.04      | (0.58)    |
|                          | Street connectivity 5 items four-point scale: strongly disagree, somewhat disagree, somewhat agree, strongly agree | 2.73      | (0.43)    |
|                          | Walking and cycling facilities 12 items four-point scale: strongly disagree, somewhat disagree, somewhat agree, strongly agree | 2.47      | (0.40)    |
|                          | Aesthetics 4 items four-point scale: strongly disagree, somewhat disagree, somewhat agree, strongly agree | 2.70      | (0.55)    |

(Continued)
walking and cycling facilities (ALPHA and NEWS), aesthetics (ALPHA), safety from traffic (NEWS) (a high perceived safety from traffic = feeling safe from problems such as speed of traffic in neighborhood) and safety from crime (NEWS) (a high perceived safety from crime = feeling safe from problems such as crime prevalence in the neighborhood). Furthermore, facilities at work (e.g., showers, bicycle storage, car park) and self-reported distance to work (in kilometers) were assessed (ALPHA).

**Data analysis**

To examine differences in transport behavior between college and non-college educated working young adults, and to investigate the associations of psychosocial and environmental factors with walking, cycling, public transport and passive transport, zero-inflated negative binomial (ZINB) regression models were used. Analyses were done using R with the package ‘pscl’ [58]. ZINB models were used as the dependent variables were positively skewed and contained a large number of zero values. Vuong tests supported the need to use zero-inflated regression models [59] and Akaike’s Information Criterium (AIC) showed that a ZINB model was preferred over a zero-inflated poisson model. ZINB models evaluate the relationships of the independent variables (psychosocial and environmental factors) with the odds of non-participation in walking, cycling, public transport use and passive transport use to work and to other destinations. Simultaneously, ZINB models estimate the relationships of the independent variables with minutes per week participated in these transport modes for those who did make use of these transport modes. The zero-inflated model and the negative binomial model might differ in predictors. Hence, one ZINB model might yield two regression coefficients for the independent variables: an odds ratio (OR) (for the relationship between the independent variable and the odds of not participating in walking, cycling, using passive transport or using public transport) and a negative-binomial model regression coefficient (exponentiated beta coefficient representing the proportional change in minutes/week walking, cycling, using public transport or using passive transport with a one-unit increase in the independent variable for those who did participate in these transport modes).

All analyses were conducted separately for the four dependent variables (walking, cycling, public transport and passive transport) and separately for trips to work and to other destinations. Initially, a model was developed for each dependent variable with all demographic variables (gender, age, BMI, living situation, living environment, car ownership, bicycle sharing schemes pass ownership, public transport pass ownership). In all of the following models, demographic variables that were significantly related to the outcome in the initial step were included as covariates. To answer the first study aim (exploring differences in transport behavior between college and non-college educated working young adults), a model was estimated.
that included educational level and relevant covariates. To investigate the second and third aim (investigating psychosocial and environmental correlates and differences between college and non-college educated working young adults), two basic models, one including all psychosocial variables plus educational level and one including all environmental variables plus educational level, were developed for each dependent variable (16 models). Next, the interaction term between educational level and each of the independent variables were added separately to the two basic models. Following that, all significant interaction terms observed in the previous step were entered simultaneously into one of the two basic models. Finally, all significant independent variables and interaction terms of the two basic models were entered simultaneously into a final model. The results of these 8 final models (one for each dependent variable) were presented. Distance to work and facilities at work were only included in the models for transport to work. Level of significance was set at $p < 0.05$. A trend for significance was considered at $p < 0.10$.

**Results**

In total 355 working young adults participated in the survey of which 224 (63%) completed the entire questionnaire. Table 2 presents socio-demographic characteristics, general transport data and data on transport to work and other destinations for the whole sample and separately for college and non-college educated working young adults. In total, 56% of the sample was female with a mean age of 25 years, 39% lived with their (grand)parents and 50% lived in a rural area.

**Differences in choice of transport mode between college and non-college educated working young adults (Table 3)**

The logit model showed a trend that, for cycling to work and for public transport to other destinations, being higher educated was associated with 47% lower odds of being a non-participant. In other words, college educated working young adults were more likely to cycle to work and more likely to use public transport to other destinations than non-college educated participants. Among those who did walk, cycle, use public transport or use passive transport, it was found that college educated working young adults cycled 44% less minutes/week to other destinations, used public transport 29% less minutes/week to work (trend) and commuted 38% more minutes/week passively than non-college educated working young adults.

**Correlates of walking**

**Main effects of psychosocial and environmental correlates on walking.** Table 4 shows that for walking to work, a one-unit increase in perceived safety from traffic was associated with 73% more minutes/week walking among those who did walk.

For walking to other destinations, working young adults with a higher self-efficacy towards AT, those perceiving higher land use mix diversity and those perceiving less walking and cycling facilities were more likely to walk. Among those who did walk, a one-unit increase in social support was associated with 41% more minutes/week walking. In addition, a one-unit increase in land use mix diversity and a one-unit increase in aesthetics was associated with respectively 23% and 31% less minutes/week walking.

**Interaction effects with educational level.** For walking to work, no interaction effects between correlates and educational level were found in the logit model. Among those who did walk to work, an interaction effect between educational level and perceived benefits regarding AT was found. In non-college educated working young adults, a one-unit increase in perceived benefits regarding AT was associated with 233% more minutes/week walking. There was no effect of perceived benefits in college educated working young adults (95% CI = 0.51, 1.17).
For walking to other destinations, no interaction effects between correlates and educational level were found in the logit model. Among those who did walk to other destinations, an interaction effect was found between educational level and perceived barriers regarding AT. In non-college educated working young adults, a one-unit increase in perceived barriers regarding AT was associated with 46% less minutes/week walking. There was no effect of perceived barriers in college educated participants (95% CI = 0.92, 1.84).

| Table 2. Descriptive characteristics of the sample (%, Mean (SD)). |
|---------------------------------------------------------------|
|                                                               |
| **Socio-demographic characteristics**                          |
|                                                               |
| Gender (% female)                                              |
| 55.8                                                          |
| 59.5                                                          |
| 47.9                                                          |
| Age (years)                                                   |
| 24.6 (1.4)                                                    |
| 24.8 (1.1)                                                    |
| 24.4 (1.9)                                                    |
| BMI (kg/m²)                                                   |
| 22.9 (3.3)                                                    |
| 22.6 (3.2)*                                                   |
| 23.5 (3.4)*                                                   |
| Nationality (% Belgian)                                       |
| 96.9                                                          |
| 95.4                                                          |
| 100.0                                                         |
| Living situation (% living with their (grand)parents)         |
| 39.3                                                          |
| 37.9                                                          |
| 42.3                                                          |
| Living environment (% living in rural area)                   |
| 49.6                                                          |
| 47.7                                                          |
| 53.5                                                          |
| **Transport in general**                                      |
|                                                               |
| Car/motorcycle                                                |
| Driving license (%)                                           |
| 84.8                                                          |
| 86.9                                                          |
| 80.3                                                          |
| Ownership (%)                                                 |
| 64.3                                                          |
| 64.1                                                          |
| 64.8                                                          |
| Moped                                                         |
| Driving license (%)                                           |
| 23.2                                                          |
| 20.3                                                          |
| 29.6                                                          |
| Ownership (%)                                                 |
| 3.6                                                           |
| 3.3                                                           |
| 4.2                                                           |
| Bicycle                                                       |
| Ownership (%)                                                 |
| 93.8                                                          |
| 96.1                                                          |
| 88.7                                                          |
| Ownership public transport pass (%)                           |
| 37.5                                                          |
| 36.6                                                          |
| 39.4                                                          |
| Ownership bicycle sharing schemes pass (%)                    |
| 8.5                                                           |
| 10.5                                                          |
| 4.2                                                           |
| Kilometres to work                                            |
| 21.1 (48.6)                                                   |
| 18.9 (17.8)                                                   |
| 25.8 (82.0)                                                   |
| **Transport to work (mode and duration)**                     |
|                                                               |
| Participants who walked (n)                                  |
| 39                                                            |
| 29                                                            |
| 10                                                            |
| Amount walking (minutes/week)                                 |
| 90.8 (90.1)                                                   |
| 82.6 (66.5)                                                   |
| 114.5 (140.2)                                                 |
| Participants who cycled (n)                                  |
| 78                                                            |
| 60*                                                           |
| 18*                                                           |
| Amount cycling (minutes/week)                                 |
| 135.3 (108.0)                                                 |
| 31.1 (102.5)                                                  |
| 149.2 (126.9)                                                 |
| Participants who made use of public transport (n)             |
| 67                                                            |
| 46                                                            |
| 21                                                            |
| Amount public transport use (minutes/week)                    |
| 332.1 (235.3)                                                 |
| 307.6 (247.0)                                                 |
| 385.7 (202.7)                                                 |
| Participants who made use of passive transport (n)            |
| 131                                                           |
| 87                                                            |
| 44                                                            |
| Amount passive transport use (minutes/week)                   |
| 232.6 (169.2)                                                 |
| 253.0 (174.1)*                                               |
| 192.9 (153.8)*                                               |
| **Transport to other destinations (mode and duration)**       |
|                                                               |
| Participants who walked (n)                                  |
| 117                                                           |
| 87                                                            |
| 40                                                            |
| Amount walking (minutes/week)                                 |
| 106.9 (168.8)                                                 |
| 96.0 (142.6)                                                  |
| 130.8 (215.4)                                                 |
| Participants who cycled (n)                                  |
| 92                                                            |
| 66                                                            |
| 26                                                            |
| Amount cycling (minutes/week)                                 |
| 117.9 (130.0)                                                 |
| 96.8 (91.6)*                                                 |
| 171.7 (188.4)*                                               |
| Participants who made use of public transport (n)             |
| 82                                                            |
| 60                                                            |
| 22                                                            |
| Amount public transport use (minutes/week)                    |
| 196.5 (221.4)                                                 |
| 171.8 (214.3)*                                               |
| 263.9 (231.4)*                                               |
| Participants who made use of passive transport (n)            |
| 187                                                           |
| 128                                                           |
| 60                                                            |
| Amount passive transport use (minutes/week)                   |
| 211.6 (267.9)                                                 |
| 222.7 (281.5)                                                 |
| 187.8 (236.4)                                                 |

*p<0.10
* p<0.05

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Correlates of cycling  

Main effects of psychosocial and environmental correlates on cycling. Table 5 shows that for cycling to work, working young adults with a higher self-efficacy towards AT, those perceiving more facilities at work in favor of walking and cycling and those living closer to work were more likely to cycle. Among those who did cycle to work, a one-unit increase in perceived benefits regarding AT and in walking and cycling facilities was associated with respectively 52% and 70% more minutes/week cycling.

For cycling to other destinations, those with a higher self-efficacy towards AT, those perceiving less barriers towards AT and those perceiving a lower land use mix diversity were more likely to cycle. Among those who did cycle to other destinations, a one-unit increase in perceived benefits regarding AT was associated with 49% more minutes/week cycling. Additionally, a one-unit increase in perceived barriers regarding AT and in safety from traffic was associated with respectively 28% and 36% less minutes/week cycling to other destinations.

Interaction effects with educational level. For cycling to work, no interaction effects were found with educational level. For cycling to other destinations, an interaction effect was found between educational level and perceived benefits and a trend towards an interaction effect was found between educational level and safety from traffic. In non-college educated working young adults, there was no effect of perceived benefits, but those perceiving a higher safety from traffic were more likely to cycle. In college educated working young adults, those perceiving more benefits regarding AT were more likely to cycle (56% lower odds, 95% CI = 0.19, 0.98), but no effect of safety from traffic was found (95% CI = 0.30, 2.74). Among those who did cycle to other destinations, a trend towards an interaction effect was found between educational level and social norm. In non-college educated working young adults, a one-unit increase in social norm regarding AT was associated with 50% more minutes/week cycling, but there was no effect of social norm in college educated participants (95% CI = 0.84, 1.19).

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Correlates of public transport use

Main effects of psychosocial and environmental correlates on public transport use. Table 6 shows that for public transport use to work, working young adults perceiving a higher social norm were more likely to use public transport. Among those who did commute by public transport, a one-unit increase in residential density and a 1 km increase in distance to work was associated with respectively 23% and 2% more minutes/week public transport use. In addition, a one-unit increase in facilities at work in favor of walking and cycling was associated with 49% less minutes/week public transport use.

For public transport to other destinations, working young adults perceiving more social support and more modeling were more likely to use public transport. Among those who did use public transport to other destinations, a one-unit increase in social norm and in perceived barriers was associated with 42% more minutes/week public transport use. Furthermore, a one-unit increase in perceived benefits was associated with 46% less minutes/week public transport use.

Table 4. Associations of psychosocial and environmental variables and the interactions terms with walking.

| Psychosocial | Walking to work | | | Walking to other destinations | Logit model: OR of being non-participant in walking* (95% CI) | Negative binomial model: minutes/week walkingb (95% CI) | Logit model: OR of being non-participant in walking* (95% CI) | Negative binomial model: minutes/week walkingb (95% CI) |
|--------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Self-efficacy | 0.57 (0.39, 0.83)** | 0.79 (0.54, 1.16) | 0.65 (0.41, 1.03) | 0.79 (0.57, 1.11) | 3.33 (1.13, 9.79)*, c | 0.54 (0.32, 0.89)*, c |
| Social support | 1.41 (1.06, 1.88)* | 0.77 (0.62, 0.95)* |
| Social norm | 0.79 (0.54, 1.16) | 0.65 (0.41, 1.03) | 0.79 (0.57, 1.11) | 3.33 (1.13, 9.79)*, c | 0.54 (0.32, 0.89)*, c |
| Modeling | 0.65 (0.41, 1.03) | 0.79 (0.57, 1.11) | |
| Perceived benefits | 0.54 (0.32, 0.89)*, c |
| Perceived barriers | 0.54 (0.32, 0.89)*, c |

Environmental

| Land use mix diversity | 0.62 (0.43, 0.90)* | 0.77 (0.62, 0.95)* |
| Street connectivity | 0.45 (0.17, 1.17) | 0.75 (0.46, 1.20) | 3.09 (1.34, 7.13)** |
| Walking and cycling facilities | 0.75 (0.46, 1.20) | 3.09 (1.34, 7.13)** |
| Aesthetics | 0.69 (0.49, 0.96)* |
| Safety from traffic | 1.73 (1.21, 2.49)** |
| Facilities at work | 0.96 (0.37, 2.49) |
| Distance | 0.99 (0.98, 1.00) | 0.99 (0.99, 1.00) |

Interaction terms

| Perceived benefits*educational level | 0.23 (0.07, 0.80)* |
| Perceived barriers*educational level | 2.41 (1.30, 4.47)** |

OR = odds ratio
CI = confidence interval
* p<0.05
** p<0.01.

* Logit model: ZINB models evaluate the correlates of the odds of non-participation in walking to work or to other destinations.
** Negative binomial model: simultaneously, among participants who did walk to work or to other destinations, ZINB models evaluate the correlates of weekly minutes walking to work or to other destinations. Negative binomial model parameters represent the proportional increase in minutes/week walking to work or to other destinations with a one-unit increase in the predictor. The model for commuting was adjusted for distance to work.

Reference category is non-college educated

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Interaction effects with educational level. For public transport use to work, interaction effects of modeling and distance to work with educational level were found. No effects of modeling and distance were found in non-college educated participants, but college educated working young adults perceiving more modeling for public transport and living further away from work (respectively 64% (95% CI = 0.18, 0.72) and 4% (95% CI = 0.93, 0.98) lower odds) were more likely to use public transport. Although a trend towards an interaction effect was found between educational level and perceived benefits, no effect of perceived benefits was found in non-college or college (95% CI = 0.72, 2.66) educated participants. Among those who did commute by public transport, an interaction effect was found between educational level and safety from crime. In non-college educated working young adults, a one-unit increase in safety from crime was associated with 76% more minutes/week public transport use, but there was no effect of safety from crime in college educated participants (95% CI = 0.68, 1.29). Although a trend was found towards an interaction effect between educational level and land use mix diversity, no effect of land use mix diversity was found in either group (95% CI = 0.72, 1.69).
use mix diversity, there was no effect of land use mix diversity in non-college or college (95% CI = 0.64, 1.14) educated working young adults.

For public transport use to other destinations, interaction effects of land use mix diversity and safety from crime with educational level were found. Non-college educated working young adults perceiving a lower land use mix diversity and a higher safety from crime were more likely to use public transport. No effects of land use mix diversity (95% CI = 0.68, 2.45) and safety from crime (95% CI = 0.48, 2.49) were found in college educated participants.
Among those who did use public transport to other destinations, no interaction effects were found with educational level.

Correlates of passive transport

Main effects of psychosocial and environmental correlates on passive transport. Table 7 shows that for passive transport to work, working young adults perceiving more modeling for passive transport, living in a less densely built neighborhood, perceiving a lower land use mix access and a lower safety from crime were more likely to use passive transport. Among those who did commute passively, a one-unit increase in social norm regarding

Table 7. Associations of psychosocial and environmental variables and the interaction terms with passive transport.

|                          | Passive transport to work | Passive transport to other destinations |
|--------------------------|---------------------------|-----------------------------------------|
|                          | Logit model: OR of being  | Logit model: OR of being                |
|                          | non-participant in passive| non-participant in passive              |
|                          | transport<sup>a</sup> (95% CI) | transport<sup>a</sup> (95% CI)          |
|                          | Negative binomial model:  | Negative binomial model:                |
|                          | minutes/week passive      | minutes/week passive                   |
|                          | transport use<sup>b</sup> (95% CI) | transport use<sup>b</sup> (95% CI)      |
| **Psychosocial**         |                           |                                         |
| social norm              | 2.13 (1.08, 4.23)<sup>*</sup>, <sup>c</sup> | 1.18 (1.09, 1.28)<sup>***</sup> | 0.63 (0.42, 0.96)<sup>*</sup> | 1.21 (1.09, 1.34)<sup>***</sup> |
| Modeling                 | 0.66 (0.44, 0.99)<sup>*</sup> |                                         |                           |
| perceived benefits       | 0.60 (0.33, 1.08)         | 0.43 (0.23, 0.79)<sup>**</sup>         |                           |
| perceived barriers       |                           | 0.59 (0.31, 1.14)                      | 0.74 (0.56, 0.99)<sup>*</sup>, <sup>c</sup> |
| **Environmental**        |                           |                                         |                           |
| residential density      | 1.78 (1.02, 3.12)<sup>*</sup> |                                         |                           |
| land use mix diversity   |                           | 0.83 (0.74, 0.94)<sup>**</sup>         |                           |
| land use mix access      | 3.06 (1.29, 7.24)<sup>*</sup> |                                         | 0.92 (0.71, 1.19)         |
| safety from traffic      | 6.30 (1.19, 33.31)<sup>*</sup>, <sup>c</sup> | 5.26 (1.01, 27.54)<sup>*</sup>, <sup>c</sup> |                           |
| safety from crime        | 4.15 (1.82, 9.45)<sup>***</sup> | 1.35 (1.01, 1.80)<sup>*, <sup>c</sup> | 0.72 (0.58, 0.90)<sup>**</sup> |
| facilities at work       | 2.98 (0.62, 14.41)        | 0.64 (0.43, 0.95)<sup>*</sup>         |                           |
| Distance                 | 0.98 (0.95, 1.00)         | 1.00 (0.99, 1.00)<sup>c</sup>         |                           |
| **Interaction terms**    |                           |                                         |                           |
| social norm*educational  | 0.30 (0.13, 0.69)<sup>**</sup> |                                         |                           |
| level                    |                           |                                         |                           |
| perceived barriers*educational level | 1.66 (1.17, 2.35)<sup>**</sup> |                                         |                           |
| safety from traffic*educational level | 0.02 (0.00, 0.16)<sup>***</sup> |                                         | 0.08 (0.01, 0.60)<sup>*</sup> |
| safety from crime*educational level | 0.59 (0.42, 0.83)<sup>**</sup> |                                         |                           |
| distance*educational level | 1.02 (1.02, 1.03)<sup>***</sup> |                                         |                           |

**OR** = odds ratio

**CI** = confidence interval

<sup>*</sup> p<0.05

<sup>**</sup> p<0.01

<sup>***</sup> p<0.001.

<sup>a</sup> Logit model: ZINB models evaluate the correlates of the odds of non-participation in passive transport to work or to other destinations.

<sup>b</sup> Negative binomial model: simultaneously, among participants who did use passive transport to work or to other destinations, ZINB models evaluate the correlates of weekly minutes passive transport use to work or to other destinations. Negative binomial model parameters represent the proportional increase in minutes/week passive transport use to work or to other destinations with a one-unit increase in the predictor. The model for commuting was adjusted for distance to work.

<sup>c</sup> Reference category is non-college educated

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passive transport was associated with 18% more minutes/week using passive transport. In addition, a one-unit increase in land use mix diversity and in facilities at work in favor of walking and cycling was associated with respectively 17% and 36% less minutes/week using passive transport.

For passive transport to other destinations, working young adults perceiving a higher social norm and more benefits regarding passive transport were more likely to travel passively. Among those who did use passive transport to other destinations, a one-unit increase in social norm and safety from crime was associated with respectively 21% more minutes/week and 28% less minutes/week using passive transport.

**Interaction effects with educational level.** For passive transport to work, interaction effects of social norm and safety from traffic with educational level were found. Non-college educated working young adults perceiving a lower social norm towards passive transport were more likely to commute passively. There was no effect of social norm in college educated participants (95% CI = 0.39, 1.05). In non-college educated working young adults, those perceiving a lower safety from traffic were more likely to use passive transport, but in college educated participants, the opposite effect was found (95% CI = 0.03, 0.44). Among those who did use passive transport to work, interaction effects of safety from crime and distance to work with educational level were found. In non-college educated working young adults, a one-unit increase in safety from crime was associated with 35% more minutes/week using passive transport, whereas in college educated participants, this was associated with 20% less minutes/week using passive transport (95% CI = 0.65, 0.97). No effect of distance was found in non-college educated working young adults, but in college educated participants, a one kilometer increase in distance to work was associated with 2% more minutes/week using passive transport to work.

For passive transport to other destinations, an interaction effect was found between educational level and safety from traffic. Non-college educated working young adults perceiving a lower safety from traffic were more likely to use passive transport, but there was no effect of safety from traffic in college educated participants (95% CI = 0.13, 1.35). Among those who did use passive transport to other destinations, an interaction effect was found between educational level and perceived barriers. In non-college educated working young adults, a one-unit increase in perceived barriers was associated with 26% less minutes/week using passive transport. No effect of perceived barriers was found in college educated participants (95% CI = 0.99, 1.54).

**Discussion**

First, we examined differences in walking, cycling, public transport and passive transport to work and to other destinations between college and non-college educated working young adults. A trend (p < 0.10) showed that college educated compared to non-college educated participants were more likely to cycle to work (39.2% vs. 25.4%) and to use public transport to other destinations (39.2% vs. 31.0%). Public transport use can, in combination with AT, contribute to a sustainable and healthy transport behavior. The additional minutes of walking or cycling before and after public transport trips may help to increase physical activity levels and reduce health risks [60–62]. Our results also showed that, among those who did use the corresponding transport mode, non-college educated participants cycled longer to other destinations and made longer public transport trips (trend) and shorter passive transport trips to work than their college educated counterparts. Making longer AT trips (and shorter passive transport trips) may result in greater health effects [17], but it only applies to those actually participating in AT. Thus, although it is good that non-college educated participants make
longer AT trips, it is disadvantageous that fewer of them do it. Therefore, future interventions targeting a healthy transport behavior should firstly focus on the adoption of a habit of overall participation in AT and in public transport among non-college educated working young adults. To do that, it might be necessary to increase their knowledge on the importance and benefits of these sustainable transport mode [26]. In higher educated working young adults, longer AT trips, although still within a feasible walking or cycling distance [63], could be encouraged when possible (also to destinations other than work).

Overall, both psychosocial and environmental variables were related to the four transport modes in college and non-college educated working young adults. However, results suggest that psychosocial variables are more important than environmental variables for transport to destinations other than work. For transport to work, environmental variables, especially those related to the workplace (distance to work, facilities at work) seemed more important than psychosocial variables. Travelling to other destinations might be less of a necessity compared to travelling to work, which allows people to be more influenced by factors such as perceived benefits and barriers.

A higher self-efficacy towards AT was related to being more likely to walk and cycle in all working young adults. This reinforces existing evidence on the importance of self-efficacy as a determinant of AT [27, 38, 48, 64] and physical activity [65] among adults in general. Also in all working young adults, perceived benefits and barriers towards AT were respectively positively and negatively related to the amount and the likelihood of cycling, which is in line with previous research in adults [27, 66]. In non-college educated participants only, perceiving more barriers towards passive transport was related to less minutes passive transport. Also in non-college educated participants, perceiving more benefits and less barriers towards AT was related to more minutes walking. However, in a study among lower and higher educated women, psychosocial factors (e.g. perceived barriers) did not influence the association between educational level and walking for transport [64]. Further research is required to investigate the link between attitude and walking/passive transport in non-college educated young adults in more detail. In all working young adults, social support, social norm and modeling towards AT and public transport were positively related to active and public transport. Previous studies also showed positive associations of social aspects with AT in (young) adults [27, 42, 48] and with public transport in older adolescents and adults [48, 67]. Modeling and social norm towards passive transport were also positively associated with passive transport. Especially among employed people, image and social status (e.g. presented to co-workers) have shown to be an important motive for driving a car [68, 69]. It is important to improve the image of AT and public transport and to create a positive social climate towards these transport modes in order to increase AT and decrease passive transport among working young adults.

Regarding environmental correlates, we found that for trips to other destinations, a higher land use mix diversity was associated with being more likely to walk, but less likely to cycle. A review on correlates of walking showed indeed a positive relation with land use mix diversity [70], but it has also been found that high walkable environments (with a high land use mix diversity) do not support cycling [71–73]. It might be that in areas with various destinations, distances are very short and pedestrians are omnipresent, hindering young people’s preferred cycling behaviors and speeds [42, 71]. Thus, appropriate cycling facilities are necessary. Next, living closer to work was positively related to cycling (in all participants) and negatively related to public and passive transport (only in college educated participants). Indeed, distance is one of the most consistent predictors of AT in all age groups [74–77]. All working young adults were more likely to commute passively when perceiving a lower density and a lower land use mix access, implying that areas with a high walkability (dense, good access to services) supported less car-dependent living [73]. Overall, these results are in line with previous reviews on
environmental correlates in adults and youth [38, 76, 77], indicating that walkability of neighborhoods is important for AT (for walking and for less passive transport). However, appropriate cycling facilities are needed, especially in high walkable neighborhoods (e.g. separate cycling lanes and routes [77]) and at work (e.g. bicycle storage, showers).

In non-college educated working young adults, feeling safe from traffic and from crime was particularly important for their active and public transport use. They were more likely to cycle and less likely to use passive transport to all destinations when feeling safe from traffic. A previous review showed inconsistent associations between neighborhood traffic safety (both perceived and objective) and AT in adults in general [38]. However, traffic safety might be especially important for lower educated people as previous studies found social inequalities in traffic accidents [78–80]. Population groups who are disadvantaged in terms of income, education or quality of their residential areas are disadvantaged as users of the road transport system by sustaining injury more often than more advantaged population groups [79]. Furthermore, traffic accidents occur significantly more in neighborhoods that are poorer or more deprived [80]. Increasing traffic safety could help in promoting AT in non-college educated working young adults. Furthermore, non-college educated participants feeling safe from crime reported longer public transport trips to work and were more likely to use it to other destinations. Previous studies in adults found that perceptions of high crime [81] and an unsafe built environment related to personal safety (e.g. low visibility, low aesthetic quality) [82] were negatively associated to public transport use. Moreover, an inverse relationship between educational attainment and fear from crime has been found in existing research [83]. Decreasing neighborhood crime might increase public transport, but also decrease passive transport, as results showed that feeling safe from crime was related to being less likely to commute passively among all participants.

Some differences in transport to work between college and non-college educated participants might be more attributable to different occupational types, rather than to educational attainment. For example, college educated working young adults might be more likely to cycle to work because their occupations might be more centrally located within a city or business district, with reduced availability of low-cost car parking [84, 85] and no requirements of transporting heavy tools or specialized equipment. In addition, the importance of perceived safety (traffic and crime) for active and public transport use among non-college educated participants might be partly due to shift or night work with early mornings and late evenings during which darkness decreases perceived safety [86]. However, Bopp et al [87] found that occupation type did not influence transport mode choice to work.

Study limitations include the cross-sectional study design, so no causal relationships could be drawn from this study. Next, a self-reported questionnaire was used which could lead to participants’ over- or underestimating the use of questioned transport modes and distance to work. Since Belgium, and specifically Flanders, has good geographical and climatological conditions for cycling and a real ‘cycling culture’, caution should be taken when extrapolating the results outside Flanders [88]. Finally, results of the negative binomial model for walking, cycling and public transport to work in non-college educated working young adults need to be interpreted with caution, as post-hoc power analyses showed that statistical power was lower than 0.80. In future studies, a larger study sample would be needed to overcome this problem and to draw firm conclusions.

Strengths of this study include the chosen target group since evidence on transport behavior and its correlates is very limited in working young adults, especially among those with lower educational attainment. Next, walking, cycling, public transport use and passive transport use were questioned and analyzed separately but are all part of the same study, which allows to see broader patterns. Most previous studies solely focused on only one of these transport modes.
modes or combined them as active and passive transport. Following that, correlates of the different transport modes were investigated for both transport to work and transport to other destinations. Finally, psychosocial as well as environmental variables were investigated simultaneously.

Conclusions
To encourage healthy transport behaviors among the important risk group of working young adults (both college and non-college educated), future interventions should focus on high self-efficacy, high perceived benefits and low perceived barriers towards AT (especially to destinations other than work), and on creating a positive social climate towards AT and public transport. Additionally, high walkable neighborhoods and good cycling facilities are important environmental factors for all working young adults. Improving walkability and cycling facilities might increase healthy transport behaviors among the whole population, as these factors have shown to be also important in youth and adults. Furthermore, the focus should be on increasing active and public transport participation among non-college educated working young adults and on encouraging more minutes of AT in college educated working young adults. Among non-college educated working young adults, perceived safety (traffic and crime) was important for active and public transport use. Increasing safety in their neighborhoods could help to increase healthy transport behaviors in this group. In college and non-college educated working young adults, both psychosocial and environmental variables were related to the four transport modes, but psychosocial variables were more important for transport to other destinations than to work. For transport to work, environmental variables, especially those related to the workplace, were more important.

Supporting information
S1 Dataset. Data obtained from the online questionnaire.
(XLSX)

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References

1. World Health Organization. Fact Sheets: Physical activity: World Health Organization; 2015 [15/05/2016]. Available from: http://www.who.int/mediacentre/factsheets/fs385/en/.

2. Lee IM, Shiroma EJ, Lobelo F, Puska P, Blair SN, Katzmarzyk PT, et al. Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy. Lancet. 2012; 380(9838):219–29. https://doi.org/10.1016/S0140-6736(12)61031-9 PMID: 22818936

3. Poobalan AS, Aucott LS, Clarke A, Smith WC. Physical activity attitudes, intentions and behaviour among 18–25 year olds: A mixed method study. BMC Public Health. 2012; 12:640. Epub 2012/08/16. PubMed Central PMCID: PMC3490897. https://doi.org/10.1186/1471-2458-12-640 PMID: 22892291

4. Gordon-Larsen P, Nelson MC, Popkin BM. Longitudinal physical activity and sedentary behavior trends—Adolescence to adulthood. Am J Prev Med. 2004; 27(4):277–83. https://doi.org/10.1016/j.amepre.2004.07.006 PMID: 15488356

5. Arnett JJ. Emerging adulthood—A theory of development from the late teens through the twenties. Am Psychol. 2000; 55(5):469–80. PMID: 10842426

6. Bell S, Lee C. Emerging adulthood and patterns of physical activity among young Australian women. Int J Behav Med. 2005; 12(4):227–35. https://doi.org/10.1207/s15327558ijbm1204_3 PMID: 16262541

7. Allender S, Hutchinson L, Foster C. Life-change events and participation in physical activity: a systematic review. Health Promot Int. 2008; 23(2):160–72. https://doi.org/10.1093/heapro/dan012 PMID: 18364364

8. Dowda M, Ainsworth BE, Addy CL, Saunders R, Riner W. Correlates of physical activity among US young adults, 18 to 30 years of age, from NHANES III. Annals of Behavioral Medicine. 2003; 26(1):15–23. PMID: 12867350

9. Kwan MY, Cairney J, Faulkner GE, Pullenayegum EE. Physical Activity and Other Health-Risk Behaviors During the Transition Into Early Adulthood A Longitudinal Cohort Study. Am J Prev Med. 2012; 42(1):14–20. https://doi.org/10.1016/j.amepre.2011.08.026 PMID: 22176841

10. Simons D, Rosenberg M, Salmon J, Knuiman M, Granich J, Deforche B, et al. Psychosocial moderators of associations between life events and changes in physical activity after leaving high school. Prev Med. 2015; 72:30–3. https://doi.org/10.1016/j.ypmed.2014.12.039 PMID: 25575797

11. Sisson SB, Tudor-Locke C. Comparison of cyclists’ and motorists’ utilitarian physical activity at an urban university. Prev Med. 2008; 46(1):77–9. Epub 2007/08/21. https://doi.org/10.1016/j.ypmed.2007.07.004 PMID: 17707076

12. Fishman E, Boecker L, Helbich M. Adult Active Transport in the Netherlands: An Analysis of Its Contribution to Physical Activity Requirements. Plos One. 2015; 10(4).

13. Waygood EOD, Sun YL, Letarte L. Active Travel by Built Environment and Lifecycle Stage: Case Study of Osaka Metropolitan Area. Int J Environ Res Public Health. 2015; 12(12):15900–24. https://doi.org/10.3390/ijerph121215027 PMID: 26694429

14. Gordon-Larsen P, Boone-Heinonen J, Sidney S, Sternfeld B, Jacobs DR, Lewis CE. Active Commuting and Cardiovascular Disease Risk The CARDIA Study. Archives of Internal Medicine. 2009; 169(13):1216–23. https://doi.org/10.1001/archinternmed.2009.163 PMID: 19597071

15. Bere E, Seiler S, Eikemo TA, Oenema A, Brug J. The association between cycling to school and being overweight in Rotterdam (The Netherlands) and Kristiansand (Norway). Scand J Med Sci Spor. 2011; 21(1):48–53.

16. Hamer M, Chida Y. Active commuting and cardiovascular risk: A meta-analytic review. Prev Med. 2008; 46(1):9–13. https://doi.org/10.1016/j.ypmed.2007.03.006 PMID: 17475317

17. Oja P, Titze S, Bauman A, de Geus B, Krenn P, Reger-Nash B, et al. Health benefits of cycling: a systematic review. Scand J Med Sci Spor. 2011; 21(4):496–509.

18. Litman T. Integrating public health objectives in transportation decision-making. Am J Health Promot. 2003; 18(1):103–8. Epub 2003/09/19. PMID: 13677968

19. Int Panis L, de Geus B, Vandenburgulcke G, Willems H, Degraeuw B, Bleux N, et al. Exposure to particulate matter in traffic: A comparison of cyclists and car passengers. Atmos Environ. 2010; 44(19):2263–70.
20. Departement Mobiliteit en Openbare Werken. OVG Vlaanderen 4.2: Vlaamse Overheid; 2011 [cited 2013 07/01/2013]. Available from: http://www.mobielvlaanderen.be/pdf/ovg42/ovg42-b2b.pdf.

21. Beige S, Axhausen KW. Interdependencies between turning points in life and long-term mobility decisions. Transportation. 2012; 39(4):857–72.

22. Hopkins D. Can environmental awareness explain declining preference for car-based mobility amongst generation Y? A qualitative examination of learn to drive behaviours. Transportation Research Part A: Policy and Practice. 2016; 94:149–63.

23. Hopkins D, Stephenson J. The replication and reduction of automobility: Findings from Aotearoa New Zealand. Journal of Transport Geography. 2016; 56:92–101.

24. Gordon-Larsen P, Nelson MC, Beaman K. Associations among active transportation, physical activity, and weight status in young adults. Obes Res. 2005; 13(5):868–75. https://doi.org/10.1038/oby.2005.100 PMID: 15919840

25. Hatch SL, Feinstein L, Link BG, Wadsworth MEJ, Richard S M. The continuing benefits of education: Adult education and midlife cognitive ability in the British 1946 birth cohort. J Gerontol B-Psychol. 2007; 62(6):S404–S14.

26. Rabin A, de Nazelle A. Benefits of shift from car to active transport. Transport Policy. 2012; 19(1):121–31.

27. de Geus B, de Bourdeaudhuij I, Jannes C, Meeusen R. Psychosocial and environmental factors associated with cycling for transport among a working population. Health Educ Res. 2008; 23(4):697–708. https://doi.org/10.1093/her/cym055 PMID: 17947248

28. Rissel C, Greenaway M, Bauman A, Wen LM. Active travel to work in New South Wales 2005–2010, individual characteristics and association with body mass index. Aust Nz J Publ Heal. 2014; 38(1):25–9.

29. Adams J. Prevalence and socio-demographic correlates of "active transport" in the UK: Analysis of the UK time use survey 2005. Prev Med. 2010; 50(4):199–203. https://doi.org/10.1016/j.ypmed.2010.01.006 PMID: 20093137

30. Cerin E, Leslie E, Owen N. Explaining socio-economic status differences in walking for transport: An ecological analysis of individual, social and environmental factors. Soc Sci Med. 2009; 68(6):1013–20. https://doi.org/10.1016/j.socscimed.2009.01.008 PMID: 19193480

31. Makinen T, Borodulin K, Laatikainen T, Fogelholm M, Prattala R. Twenty-five year socioeconomic trends in leisure-time and commuting physical activity among employed Finns. Scand J Med Sci Spor. 2009; 19(2):188–97.

32. Andersen LB, Schnohr P, Schroll M, Hein HO. All-cause mortality associated with physical activity during leisure time, work, sports, and cycling to work. Archives of Internal Medicine. 2000; 160(11):1821–8. PMID: 10847255

33. Rachele JN, Kavanagh AM, Badland H, Giles-Corti B, Washington S, Turrell G. Associations between individual socioeconomic position, neighbourhood disadvantage and transport mode: baseline results from the HABITAT multilevel study. J Epidemiol Community Health. 2015; 69(12):1217–23. https://doi.org/10.1136/jech-2015-205620 PMID: 26243197

34. De Witte A, Hollevoet J, Dobruszkes F, Hubert M, Macharis C. Linking modal choice to motility: A comprehensive review. Transport Res a-Pol. 2013; 49:329–41.

35. Sallis JF, Owen N, Fisher EB, editors. Ecological models of health behavior. San Francisco: Jossey-Bass 2008.

36. Sigurdardottir SB, Kaplan S, Moller M, Teasdale TW. Understanding adolescents’ intentions to commute by car or bicycle as adults. Transport Res D-Tri E. 2013; 24:1–9.

37. Panter JR, Jones A. Attitudes and the Environment as Determinants of Active Travel in Adults: What Do and Don’t We Know? J Phys Act Health. 2010; 7(4):551–61. PMID: 20683098

38. Molina-Garcia J, Castillo I, Sallis JF. Psychosocial and environmental correlates of active commuting for university students. Prev Med. 2010; 51(2):136–8. https://doi.org/10.1016/j.ypmed.2010.05.009 PMID: 20510271

39. Shannon T, Giles-Corti B, Pikora T, Bursara M, Shilton T, Bull F. Active commuting in a university setting: Assessing commuting habits and potential for modal change. Transport Policy. 2006; 13(3):240–53.

40. Titze S, Stronegger WJ, Janschitz S, Oja P. Environmental, social, and personal correlates of cycling for transportation in a student population. J Phys Act Health. 2007; 4(1):66–79. Epub 2007/05/10. PMID: 17489008
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42. Simons D, Clarys P, De Bourdeaudhuij I, de Geus B, Vandelanotte C, Deforche B. Why do young adults choose different transport modes? A focus group study. Transport Policy. 2014; 36:151–9.

43. Van Dyck D, Cardon G, Deforche B, Giles-Corti B, Sallis JF, Owen N, et al. Environmental and Psychosocial Correlates of Accelerometer-Assessed and Self-Reported Physical Activity in Belgian Adults. Int J Behav Med. 2011; 18(3):235–45. https://doi.org/10.1007/s12229-010-9127-4 PMID: 21038103

44. Santos MSR, Vale MSS, Miranda L, Mota J. Socio-demographic and perceived environmental correlates of walking in Portuguese adults-A multilevel analysis. Health Place. 2009; 15(4):1094–9. https://doi.org/10.1016/j.healthplace.2009.05.009 PMID: 19540147

45. Beenackers MA, Kamphuis CBM, Giske S, Brug J, Kunst AE, Burdorf A, et al. Socioeconomic inequalities in occupational, leisure-time, and transport related physical activity among European adults: A systematic review. International Journal of Behavioral Nutrition and Physical Activity. 2012; 9.

46. Mertens L, Compernolle S, Gheysen F, Deforche B, Brug J, Mackenbach JD, et al. Perceived environmental correlates of cycling for transport among adults in five regions of Europe. Obesity Reviews. 2016; 17:53-61. https://doi.org/10.1111/obr.12379 PMID: 26879113

47. Jones L, Saksvig BI, Grieser M, Young DR. Recruiting adolescent girls into a follow-up study: Benefits of using a social networking website. Contemp Clin Trials. 2012; 33(2):268–72. https://doi.org/10.1016/j.cct.2011.10.011 PMID: 22101207

48. Verhoeven H, Simons D, Van Dyck D, Van Cauwenberg J, Clarys P, De Bourdeaudhuij I, et al. Psychosocial and Environmental Correlates of Walking, Cycling, Public Transport and Passive Transport to Various Destinations in Flemish Older Adolescents. Plos One. 2016; 11(1):e0147128. PubMed Central PMCID: PMCPMC4718705. https://doi.org/10.1371/journal.pone.0147128 PMID: 26784933

49. Craig CL, Marshall AL, Sjostrom M, Bauman AE, Booth ML, Ainsworth BE, et al. International physical activity questionnaire: 12-country reliability and validity. Med Sci Sport Exer. 2003; 35(8):1381–95.

50. Duchene F, De Bourdeaudhuij I, Lenoir M, Cardon G. Test-Retest Reliability and Validity of a Child and Parental Questionnaire on Specific Determinants of Cycling to School. Pediatr Exerc Sci. 2012; 24(2):289–311. PMID: 22728419

51. Vandelanotte C, De Bourdeaudhuij I., Sallis JF., Philippaerts R., Sjöström M. Reliability and validity of a computerised and Dutch version of the International Physical Activity Questionnaire (IPAQ). Journal of Physical Activity and Health. 2005; 2:63–75.

52. De Vries H, Backbier E, Kok G, Dijkstra M. The Impact of Social Influences in the Context of Attitude, Self-Efficacy, Intention, and Previous Behavior as Predictors of Smoking Onset. J Appl Soc Psychol. 1995; 25(3):237–57.

53. Spittaels H, Verloigne M, Gidlow C, Gioanec J, Titze S, Foster C, et al. Measuring physical activity-related environmental factors: reliability and predictive validity of the European environmental questionnaire ALPHA. Int J Behav Nutr Phys Act. 2010; 7(1):48. Epub 2010/05/28. PubMed Central PMCID: PMCPMC2892430. https://doi.org/10.1186/1479-5868-7-48 PMID: 20504339

54. Saelens BE, Sallis JF, Black JB, Chen D. Neighborhood-based differences in physical activity: an environment scale evaluation. Am J Public Health. 2003; 93(9):1552–8. Epub 2003/09/02. PubMed Central PMCID: PMCPMC1488009. PMID: 12948979

55. Cerin E, Saelens BE, Sallis JF, Frank LD. Neighborhood Environment Walkability Scale: validity and development of a short form. Med Sci Sports Exer. 2006; 38(9):1682–91. Epub 2006/09/09. https://doi.org/10.1249/01.mss.0000227689.83607.4d PMID: 16960531

56. Spittaels H. MANUAL: ALPHA environmental questionnaire [11/03/2014]. Available from: https://sites. google.com/site/alphaprojectphysicalactivity/alpaha-public-documents/environmental-questionnaire.

57. Sallis JF. Scoring procedures and preliminary psychometrics for the Neighborhood Environment Walkability Scale (NEWS) 2002 [11/03/2014]. Available from: http://sallis.ucsd.edu/measure_news.html.

58. Jackman S. pscl: Political Science Computational Laboratory, Stanford University: The Comprehensive R Archive Network; 2012 [cited 2014]. Available from: http://cran.r-project.org/web/packages/pscl/index.html.

59. Cheung YB. Zero-inflated models for regression analysis of count data: a study of growth and development. Stat Med. 2002; 21(10):1461–9. Epub 2002/08/21. https://doi.org/10.1002/sim.1088 PMID: 12185896

60. Zheng Y. The benefit of public transportation: Physical activity to reduce obesity and ecological footprint. Prev Med. 2008; 46(1):4–5. https://doi.org/10.1016/j.ypmed.2007.11.019 PMID: 18201578

61. Rissel C, Curac N, Greenaway M, Bauman A. Physical Activity Associated with Public Transport Use-A Review and Modelling of Potential Benefits. Int J Environ Res Public Health. 2012; 9(7):2454–78. https://doi.org/10.3390/ijerph9072454 PMID: 22851954
62. Villanueva K, Giles-Corti B, McCormack G. Achieving 10,000 steps: A comparison of public transport users and drivers in a University setting. Prev Med. 2008; 47(3):338–41. https://doi.org/10.1016/j.ypmed.2008.03.005 PMID: 18436296

63. Van Dyck D, De Bourdeaudhuij I, Cardon G, Deforce B. Criterion distances and correlates of active transportation to school in Belgian older adolescents. Int J Behav Nutr Phys Act. 2010; 7:87. Epub 2010/12/15. PubMed Central PMCID: PMC3004815. https://doi.org/10.1186/1479-5868-7-87 PMID: 21143868

64. Ball K, Timperio A, Salmon J, Giles-Corti B, Roberts R, Crawford D. Personal, social and environmental determinants of educational inequalities in walking: a multilevel study. J Epidemiol Community Health. 2007; 61(2):108–14. PubMed Central PMCID: PMC2465645. https://doi.org/10.1136/jech.2006.048520 PMID: 17234868

65. Trost SG, Owen N, Bauman AE, Sallis JF, Brown W. Correlates of adults’ participation in physical activity: review and update. Med Sci Sport Exer. 2002; 34(12):1996–2001.

66. Titze S, Stroengger WJ, Janschitz S, Oja P. Association of built-environment, social-environment and personal factors with bicycling as a mode of transportation among Austrian city dwellers. Prev Med. 2008; 47(3):252–9. https://doi.org/10.1016/j.ypmed.2008.02.019 PMID: 18417199

67. Bamberg S, Hunecke M, Blobbaum A. Social context, personal norms and the use of public transportation: Two field studies. J Environ Psychol. 2007; 27(3):190–203.

68. Steg L. Car use: lust and must. Instrumental, symbolic and affective motives for car use. Transport Res a-Pol. 2005; 39(2–3):147–62.

69. Mayes M, Halliday M, Hatch O. A qualitative assessment of attitudes to cycling in the UK. PTRC European Transport Forum. 1996.

70. Saelens BE, Handy SL. Built environment correlates of walking: A review. Med Sci Sport Exer. 2008; 40(7):S550–S66.

71. Kerr J, Emond JA, Badiand H, Reis R, Sarmiento O, Carlson J, et al. Perceived Neighborhood Environmental Attributes Associated with Walking and Cycling for Transport among Adult Residents of 17 Cities in 12 Countries: The IPEN Study. Environ Health Perspect. 2016; 124(3):290–8. https://doi.org/10.1289/ehp.1409466 PMID: 26186801

72. Sallis JF, Conway TL, Dillon LI, Frank LD, Adams MA, Cain KL, et al. Environmental and demographic correlates of bicycling. Prev Med. 2013; 57(5):456–60. https://doi.org/10.1016/j.ypmed.2013.06.014 PMID: 23791865

73. Eriksson U, Arvidsson D, Gebel K, Ohlsson H, Sundquist K. Walkability parameters, active transportation and objective physical activity: moderating and mediating effects of motor vehicle ownership in a cross-sectional study. International Journal of Behavioral Nutrition and Physical Activity. 2012; 9.

74. Nelson NM, Foley E, O’Gorman DJ, Moyna NM, Woods CB. Active commuting to school: How far is too far? Int J Behav Nutr Phys Act. 2008; 5.

75. Babey SH, Hastert TA, Huang W, Brown ER. Sociodemographic, Family, and Environmental Factors Associated with Active Commuting to School among US Adolescents. J Public Health Pol. 2009; 30: S203–S20.

76. Panter JR, Jones AP, van Stuijs EMF. Environmental determinants of active travel in youth: A review and framework for future research. Int J Behav Nutr Phys Act. 2008; 5.

77. Fraser SDS, Lock K. Cycling for transport and public health: a systematic review of the effect of the environment on cycling. Eur J Public Health. 2011; 21(6):738–43. https://doi.org/10.1093/eurpub/ckq145 PMID: 20929903

78. NICE. Preventing unintentional road injuries among under-15s 2010 [April 12, 2016]. Available from: https://www.nice.org.uk/guidance/ph31/resources/unintentional-injuries-on-the-road-interventions-for-under-15s-1996292434885.

79. European Transport Safety Council. Social and Economic Consequences of Road Traffic Injury in Europe. Brussels: 2007.

80. Morency P, Gauvin L, Plante C, Fournier M, Morency C. Neighborhood Social Inequalities in Road Traffic Injuries: The Influence of Traffic Volume and Road Design. Am J Public Health. 2012; 102(6):1112–9. https://doi.org/10.2105/AJPH.2011.300528 PMID: 22515869

81. Zwald ML, Hipp JA, Corseuil MW, Dodson EA. Correlates of Walking for Transportation and Use of Public Transportation Among Adults in St Louis, Missouri, 2012. Prev Chronic Dis. 2014; 11.

82. Chowdhury S, Zhai K, Khan A. The Effects of Access and Accessibility on Public Transport Users’ Attitudes. J Public Transport. 2016; 19(1):97–113.

83. Keane C. Victimization and fear: Assessing the role of offender and offence. Canadian J Criminology. 1995; 37(431).
84. Murray AT. Strategic analysis of public transport coverage. Socio-Economic Planning Sciences. 2001; 35(3):175–88.

85. Badland HM, Garrett N, Schofield GM. How Does Car Parking Availability and Public Transport Accessibility Influence Work-Related Travel Behaviors? Sustainability. 2010; 2(2):576.

86. van Bekkum JE, Williams JM, Graham Morris P. Cycle commuting and perceptions of barriers: Stages of change, gender and occupation. Health Education. 2011; 111(6):476–97.

87. Bopp M, Kaczynski AT, Besenyi G. Active commuting influences among adults. Prev Med. 2012; 54(3–4):237–41. https://doi.org/10.1016/j.ypmed.2012.01.016 PMID: 22327047

88. Vandenbulcke G, Thomas I, de Geus B, Degraeuwe B, Torfs R, Meeusen R, et al. Mapping bicycle use and the risk of accidents for commuters who cycle to work in Belgium. Transport Policy. 2009; 16 (2):77–87.