Health, time, and financial co-benefits of active travelling: a case report of one cyclist in the Tokyo metropolitan area

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ABSTRACT

Background: Limited data exist on bicycle travel in the Tokyo Metropolitan area. This study aimed to quantify the health, time, and financial co-benefits of active travel in this region.
Methods: This case report focuses on a Tokyo resident who switched from public transportation to active travel. Geographic and time data from 11 months of travel, recorded using the Runkeeper application, were analyzed retrospectively. Bicycle trips were identified and compared to public transportation on the same routes regarding cost and duration. The subject also performed maximal oxygen consumption tests before and after the observation period.
Results: Over the 11-month observation period, the subject traveled a total of 3,959 km, which took 16,513 minutes to complete. The estimated public transportation duration for the same routes was 23,576 minutes, resulting in a time savings of 4 days, 21 hours, and 43 minutes due to active travel. The financial savings were estimated to be between ¥125,620 and ¥177,120. Additionally, an increase of 6.8 ml/kg/min in maximal oxygen consumption was observed.
Conclusion: In addition to improving physical fitness, adopting active travel habits appears to provide significant time and financial benefits. Larger-scale intervention studies are needed. Communicating the co-benefits of active travel may be a promising tool for promoting physical activity.

Keywords: active commuting, active transportation, active travel, bicycle, physical activity promotion

INTRODUCTION

Active travelling, sometimes referred to as active transportation or active mobility, describes the activity of moving by using transportation means that require the traveler to be physically active, e.g., walking, cycling, roller skating, etc. Despite contrasting findings in the literature [1-3], one may believe that active traveling can play an important role in the prevention of non-communicable diseases by replacing sedentary transportation habits with more physically active ones. In urban areas, active travelling is also considered a promising option to address important issues such as traffic congestion, inhabitants' exposure to pollutants, and noise pollution.
Bicycles are commonly viewed as one of the most suitable forms of active transportation, especially in flat or less hilly areas. Therefore, an increasing number of cities are integrating bicycle lanes and bicycle-sharing services into their transportation networks [4-5]. Policies that

implement negative or positive financial incentives have also been tested in various locations and could be considered an option to promote active travelling on a larger scale [6]. At the individual level, such short-term rewards may indeed be more effective than the more distant health-related benefits, facilitating easier behavioral changes.

Several studies have explored active commuting habits in Japan [7]. Some have investigated the interaction with the built environment, while others have demonstrated a reduced risk of non-communicable diseases among active commuters [8]. However, possibly due to the complexity of conducting an intervention study on this topic, no report has yet described the potential time and financial benefits of active travelling, particularly in the Tokyo Metropolitan area. The present report explores the health, time, and financial co-benefits of active travelling for one inhabitant of the Tokyo metropolitan area, who shifted from sedentary public transportation to consistent bicycle use over an 11-month observation period.

METHOD

Case description

The subject was a healthy 32-year-old Caucasian man living in the Tokyo metropolitan area, Japan. The Tokyo Metropolitan Employment Area comprises a continuous urban patch with approximately 27 million inhabitants. Like around 9 million other Tokyoites, the subject resided in one of the 23 special wards of Tokyo, which form the core of the metropolitan area. He worked in another of these 23 special wards. The subject reported a gradual transition from an active to a sedentary lifestyle during his twenties and declared no regular physical activity in the six years preceding the observation period. He had never been diagnosed with any chronic conditions. His body mass index (BMI) was 24.6 kg/m², measured in December 2012.

In April 2013, the subject purchased a single-speed, 27-inch utility bicycle (commonly known as a “mamachari”), which featured a lower top tube, a front shopping basket, and a rear luggage rack. He decided to use it consistently for his travels within the Tokyo metropolitan area, as long as the distance, transported goods, and accompanying persons permitted. From May 12, 2013, to March 31, 2014, he logged all bicycle trips that would otherwise have been completed using public transportation via the GPS-based smartphone application Runkeeper. He consented to share this 11-month travel record. The Ethical Committee of Ochanomizu University for Biomedical Research approved the study protocol (ref: 2018-3), and the subject provided written informed consent to participate. The subject ceased registering his travel activities after losing his smartphone, leading to a discontinuation in data collection.

Data extraction and treatment

Each Runkeeper entry was systematically screened, and only bicycle (or "ride") activities were included in the analysis. For each trip, the departure and arrival dates, times, and locations were collected, and the estimated distance and average speed were calculated. In addition to the subject's regular commuting route, several recurring itineraries were identified, such as travel from home to a commercial district, children's school, or a community center.

If the Runkeeper application was unintentionally interrupted before the end of a trip (e.g., the recorded activity ended at an unidentified location) or if the subject forgot to stop the application upon arrival (e.g., the timer continued running), the entry was used solely to identify the trip type (e.g., commute or other). However, the GPS segment and time metrics were deemed unreliable and excluded from further analysis. Entries where the GPS data could not confirm the trip type—such as routes ending near the departure location—were excluded. Missing trips were identified when the departure location of one trip did not match the arrival location of the previous registered trip. In an effort to remain conservative, missing trips and corrupted time data were replaced with the average duration of all similar trips completed in the same direction, plus one standard deviation. This data extrapolation method was not applied when no recurrent travel route could be identified.

Estimation of pecuniary and time benefits

For each trip, the estimated cost of the same route using public transportation was calculated. First, a "low price" estimate was derived by selecting the cheapest route suggested by Google Maps. If the suggested route included walking segments of more than 20 minutes, a second estimate was generated to reflect a more "natural use" of public transportation. For trips occurring on the subject's regular home-to-workplace route, a cost adjustment was applied to account for the use of a commuter pass.

These cost estimates were performed for all identified bicycle trips. The sum of all "low price" estimates represents the minimum savings potentially achieved by choosing active travel over an 11-month period in the Tokyo metropolitan area. To reflect a more realistic estimate of pecuniary benefits, the total savings were adjusted to account for the difference between the “natural use” and “low price” estimates where applicable. Additionally, the duration of each bicycle trip was compared to the estimated duration of the fastest corresponding public transportation route (as suggested by Google Maps). The sum of these differences represents a conservative estimate of the time savings that could potentially be achieved over an 11-month period of active traveling in the Tokyo metropolitan area.

Each instance of missing or extrapolated data was verified with the subject, cross-referenced with his personal calendar. Extrapolated data were removed if there was any doubt about their validity or accuracy.

Physical fitness

The subject provided the results of two ramp tests performed on an ergocycle in December 2012 and April 2014 at the same facility. Thus, data on body weight and maximal oxygen consumption before and after the observation period were available.

RESULTS

Data quality

During the 11-month observation period, 659 entries were recorded using the Runkeeper application. Of these, 133 were duplicates, reducing the dataset to 526 unique activities. An additional 30 running activities and 4 miscellaneous entries were excluded from the analysis, resulting in a total of 492 bicycle activities eligible for further screening. Seventy-five entries contained corrupted data, where the trip was identifiable, but the time and distance values were deemed unreliable. Moreover, 82 missing trips were identified, bringing the total number of trips considered for analysis to 574. These 574 trips were included in the estimation of public transportation costs. However, for 18 of the 157 corrupted or missing entries, the duration could not be extrapolated, and therefore, these entries were excluded from the comparison of bicycle and public transportation travel times.

Travel habits

During the 11-month observation period, the subject completed 574 active trips. Of the 556 trips with available distance data, a total of 3,959 km was covered, with an average reported speed of 14.9 km/h. Ninety-nine percent of the trips occurred within the Tokyo 23 special wards area. Trips under 5 km, between 5 and 10 km, and over 10 km accounted for 18%, 78%, and 4% of the total active travel time, respectively. The longest recorded trip was 20.0 km, and the greatest distance covered in a single day was 40.1 km. The subject's commute typically spanned 8 to 9 km, making up 66% of the total active travel time. This commuting route comprised: 1) small roads with low traffic in high-density residential areas (62%, Fig. 1A), 2) multilane boulevards with higher traffic (22%, Fig. 1B), and 3) sidewalks with bicycle lanes (16%, Fig. 1C). The average elevation along the route was 93 meters. As a result, a typical workday involved about 17 km of active travel. The Runkeeper app recorded an average speed of 15.3 km/h for all commuting trips, amounting to 1 hour and 7 minutes of moderate to vigorous physical activity per working day. Other common routes included trips to the nearest commercial district, community center, and children's school. Over the 11-month observation period, the subject spent a total of 16,513 minutes (or 11 days 11 h 13 min) in active travelling. The corresponding public transportation duration was estimated at 23,576 min (16 days 8 h 56 min) resulting in a time benefit of 7,063 min (4 days 21 h 43 min). More details on the active travelling-related time benefits have been presented in Table 1.

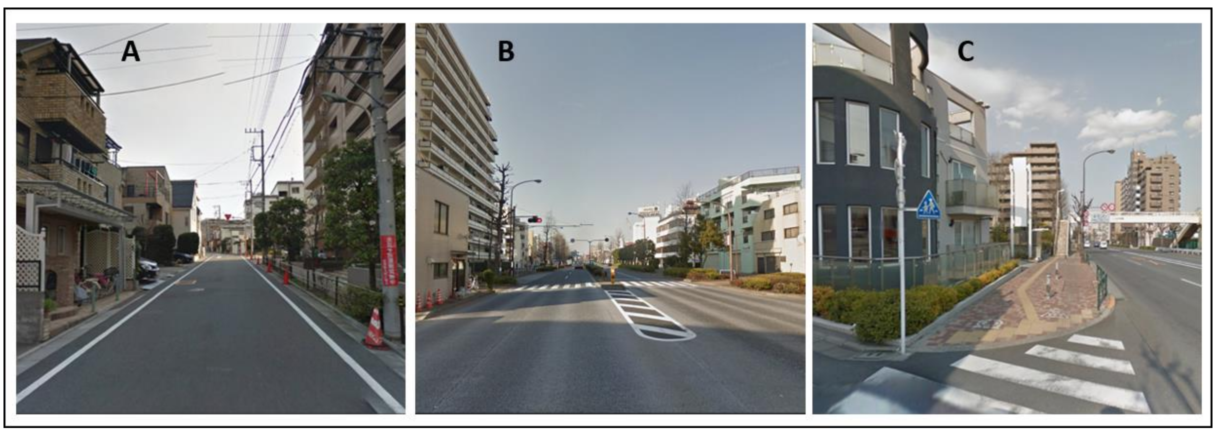

Figure 1. Examples of roads and bicycle lanes found in Tokyo. A: a small road in a high-density residential area. B: a multilane boulevard near the area of the photo showed in A. C: a sidewalk integrating both walking (left) and bicycle (right) lanes. Taken from Google Street View (under the fair use agreement).

Time benefits

Over the 11-month observation period, the subject spent a total of 16,513 minutes (or 11 days 11 h 13 min) in active travelling. The corresponding public transportation duration was estimated at 23,576 min (16 days 8 h 56 min) resulting in a time benefit of 7,063 min (4 days 21 h 43 min). More details on the active travelling-related time benefits have been presented in Table 1.

Table 1. Estimated time and pecuniary benefits of active travelling in Tokyo

	Total time (minute)			Cost (¥)		
	N	fastest public transportation	bicycle	N	route 1	route 2
All travels	556	23,576	16,513	574	176,730	125,620
Commuting	343	15,744	10,935	343	111,520	65,210
Non-commuting	214	7,832	5,578	231	65,210	60,020
< 5 km	131	3,771	2,461	131	27,560	23,890
5 - 9.9 km	402	18,399	12,900	402	132,550	86,410
≥ 10 km	24	1,406	1,153	24	12,000	11,230

In total, 574 travels were identified and used for the public transportation cost estimation. Only 556 of them with properly recorded or recovered time and distance data were used for the time estimation shown in this table. Route 1: cheapest route suggested by Google Map, which may include travels with over 20 min walking segments (referred in the text as “low price” estimation); Route 2: cheapest route suggested by Google Map that excludes travels with over 20 min walking segments (referred in the text as “natural use” estimation).

Pecuniary benefits

According to the "low price" estimation, the completion of the 574 travels using public transportations corresponding to the 574 active travels would have cost 125,620 ¥. The "natural use" estimation indicated a cost of 177,120 ¥. Thus, the pecuniary benefits that can be expected from an 11-month period of active travelling in the Tokyo Metropolitan area would be somewhere between 120,000 and 180,000 ¥. More details on the active travelling-related pecuniary benefits have been shown in Table 1.

Effect on physical fitness

The maximal oxygen consumption capacity of the subject increased by 6.8 points (43.7 to 50.5 ml/kg/min) between December 2012 and April 2014. During the same period, the subject lost 3.0 kg (82.3 to 79.3).

DISCUSSION

The present case allowed a quantitative estimation of some co-benefits of active travelling in the Tokyo metropolitan area, Japan. Over the 11-month observation period, the subject was able to 1) reduce his transportation time by 4 days 21 h 43 min, 2) save a minimum of 125,620 ¥ on transportation fees, and 3) improve his overall physical fitness with a 6.8-point gain in VO2 max and a 3.0 kg weight loss.

The time benefit observed in the present study may be considered a minimal estimation. First, the durations of corrupted entries were replaced by the average duration of similar travels completed in the same direction plus one standard deviation (see supplementary file), resulting in conservative figures for 140 of the 556 bicycle travels. Second, 18 missing travels could not be retrieved and were consequently not included in the estimation. It is therefore likely that the actual time benefit significantly exceed 5 days, which represents a considerable amount of time in one of the most holiday-deprived nations among the developed countries.

The pecuniary benefits have been estimated between 125,620 and 176,730 ¥, which, in the Tokyo Metropolitan area, would be equivalent to a 1 to 1.5 months' rent for a 3–4-member family. While these figures may be lowered relative to the cost of a brand new mamachari-type bicycle (which costs 12,000–24,000 ¥), maintenance fees (7,000 ¥), and parking fees (6,300 ¥), the overall picture suggests that adopting active travelling habits could contribute to a better

work-life balance, not only by making more time available for leisure or family activities, but also by providing the necessary funding for these activities.
Finally, the 3.0 kg weight loss and 6.8-point increase in VO2 max observed in the present case certainly represent promising outcomes for the active travelling enthusiasts who are willing to maintain a healthy lifestyle. According to Laukkanen et al. [9], such an improvement in physical fitness would reduce the risk of mortality by 50% for all the causes of mortality. In addition, bicycling is usually categorized as a moderate-to-vigorous physical activity [10], and bicycling for a distance similar to the commuting route of the present case would help fulfill most of the World Health Organization (WHO) recommendations for daily physical activity (WHO).

Limitations

First, the case study design does not allow us to make overall conclusions on the co-benefits of active travelling, not even in the Tokyo Metropolitan area. The subject's VO2 max at the beginning of the observation period (43.7 ml/kg/min) may reflect a good aerobic capacity, and individuals with lower physical fitness may not be able to maintain a similar pace. In addition, active commute was the most important contributor to the time gain (-4,805 min, cf. Table 1) and the present observations cannot prevail for cases where the commuting routes may present a different profile (shorter or longer distance, higher elevation, higher proportion of small roads in high density residential areas, etc.). Second, while the safety issue is a recurrent focus in studies on active travelling, the present report did not address this dimension [11]. Para-data from interviews with the subject indicated his willingness to maintain a high pace during travels without compromising with the traffic code. However, this subject has been a victim of one collision with another bicycle while he was walking with his own bicycle in a parking lot area. He reported no physical damage. Finally, the subject also admitted to feeling at risk when riding on multilane boulevards. Third, one may believe that the improvement in physical fitness could have been induced by some structured exercise activities performed during the observation period. Apart from active travelling activities, the subject declared that he did not engage in regular exercise habits. Only, 30 leisure running activities were registered in the application. They consisted of sessions comprising 2.1 to 14.6 km runs (average distance: 7.4 km), a significant part of which were completed during holiday periods (summer and winter). While the contribution of these 30 running activities to the increase in maximal oxygen consumption capacity cannot be overlooked, the overall picture of the present case would suggest that the 574 active travels performed by bicycle also had significant impact.

Conclusion

To summarize, the present case study aimed at offering insight on possible individual-level co-benefits of active travelling in the Tokyo Metropolitan area. Over a nearly 1-year period of active traveling, the subject saved approximately 5 days in transportation time by opting for a bicycle instead of public transportation. He also saved over 120,000 ¥ in transportation fees and significantly improved his physical fitness. Communicating on time and financial co-benefits could be a powerful individual-level promotion tool. The present results should encourage researchers to design large scale studies investigating individual-level factors that would favor active travelling behaviors in the Japanese population for a better work-life balance.

Contributions

Contributed to conception and design: JT
Contributed to acquisition of data: JT
Contributed to analysis and interpretation of data: JT, YO
Drafted and/or revised the article: JT, YO
Approved the submitted version for publication: JT, YO

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Data and Supplementary Material Accessibility

N/A.

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