The Relationship between Physical Activity of Active Transport and Characteristics among Residents in Regional Thailand

Thitikorn Topothai†
Chompoonut Topothai†
Rapeepong Suphanchaimat†
Viroj Tangcharoensathien†
Weerasak Putthasri‡

Corresponding author: *Thitikorn Topothai*

Abstract

The health benefits of physical activity are linked to active transport. The Thai Walking and Cycling Institute has implemented a project to promote walking and bicycle use in daily life in many provinces since 2017. This study aimed to identify the association between local demographic characteristics (sex, age, body mass index (BMI), education, occupation, and income), and the effects of physical activity from active transport. This was done in three purposive selected sites namely, 1) King Taksin Community, Chachoengsao, 2) Suksabaijai Community, Kalasin, and 3) Ban Thatsobvan Community, Phayao. A cross-sectional study was carried out through a self-administered questionnaire survey. The questionnaire was randomly distributed via community leaders. Multivariate Poisson regression was performed. The average amount of active transport energy expenditure in three communities at 180 metabolic equivalent task-minutes/week contributed to 30% of the World Health Organization's recommended physical activity levels. Being female, overweight or obese, higher educational attainment, higher income, and office-based employee had a significantly reduced chance of having higher energy from active transport than their counterparts. While being older and living in optimal size community and near the city center had significantly raised chance of having higher energy from active transport. Interventions for active transport promotion should be more attractive and appropriate to all demographics and contexts. In addition, the policy should aim not only at individual lifestyle modification but also at re-shaping the physical environments that facilitate active transport.

Keywords: physical activity, walking, bicycling, community, Thailand

† *International Health Policy Program, Ministry of Public Health*
‡ *National Health Commission Office*

Received 19 August 2021; Revised 20 October 2021; Accepted 11 March 2022

Suggested citation: Topothai T, Topothai C, Suphanchaimat R, Tangcharoensathien V, Putthasri W. The relationship between physical activity of active transport and characteristics among residents in regional Thailand. Journal of Health Systems Research 2022;16(1):85-97.

ฐิติกร โตโพธิ์ไทย, ชมพูนุท โตโพธิ์ไทย, ระพีพงศ์ สุพรรณไชยมาตย์, วิโรจน์ ตั้งเจริญเสถียร, วีระศักดิ์ พุทธาศรี. ความสัมพันธ์ระหว่างกิจกรรมทางกายจากการเดินทางและลักษณะทางประชากรของประชาชนในภูมิภาคของประเทศไทย. วารสารวิจัยระบบสาธารณสุข 2565;16(1):85-97.

ความสัมพันธ์ระหว่างกิจกรรมทางกายจากการเดินทางและลักษณะทางประชากรของประชาชนในภูมิภาคของประเทศไทย

ฐิติกร โตโพธิ์ไทย†, ชมพูนุท โตโพธิ์ไทย†, ระพีพงศ์ สุพรรณไชยมาตย์†, วิโรจน์ ตั้งเจริญเสถียร†, วีระศักดิ์ พุทธาศรี‡

† *สำนักงานพัฒนานโยบายสุขภาพระหว่างประเทศ กระทรวงสาธารณสุข*
‡ *สำนักงานคณะกรรมการสุขภาพแห่งชาติ*
ผู้รับผิดชอบบทความ: *ฐิติกร โตโพธิ์ไทย*

บทคัดย่อ

ประโยชน์ทางสุขภาพจากกิจกรรมทางกายสัมพันธ์กับการเดิน การใช้จักรยาน และการใช้ขนส่งสาธารณะ สถาบันการเดินและการจักรยานไทยได้ส่งเสริมการเดินและการใช้จักรยานในชีวิตประจำวันในหลายจังหวัดตั้งแต่ ปี พ.ศ. 2560 การศึกษานี้ มีวัตถุประสงค์เพื่อค้นหาความสัมพันธ์ระหว่างลักษณะพื้นฐานทางประชากรและสังคมของประชาชน (เพศ อายุ ดัชนีมวลกาย ระดับการศึกษา อาชีพ และรายได้) กับกิจกรรมทางกายจากการเดินทางของประชาชนใน 3 ชุมชน คือ 1) ชุมชนสมเด็จพระเจ้าตากสิน อ.บางคล้า จ.ฉะเชิงเทรา 2) ชุมชนสุขสบายใจ อ.เมือง จ.กาฬสินธุ์ และ 3) ชุมชนบ้านธาตุสบแวน อ.เชียงคำ จ.พะเยา ระเบียบวิธีวิจัยเป็นการศึกษาภาคตัดขวาง ใช้แบบสอบถามในการสำรวจด้วยการสุ่มกระจายในชุมชนโดยผู้นำชุมชน วิเคราะห์ข้อมูลด้วยการวิเคราะห์ถดถอยปัวซอง (multivariate Poisson regression) ผลการศึกษาพบว่า พลังงานเฉลี่ยจากกิจกรรมทางกายในการเดินทางที่ 180 metabolic equivalent task-นาที/สัปดาห์ เป็นสัดส่วนร้อยละ 30 ของข้อแนะนำการมีกิจกรรมทางกายขององค์การอนามัยโลก เพศหญิง การมีน้ำหนักเกินหรืออ้วน การมีระดับการศึกษาและรายได้ที่สูง การทำงานในสำนักงาน ลดโอกาสการใช้พลังงานจากกิจกรรมทางกายในการเดินทาง ในขณะที่การมีอายุมากกว่า เพิ่มโอกาสการใช้พลังงานจากกิจกรรมทางกายในการเดินทาง มาตรการส่งเสริมการเดิน การใช้จักรยานและการใช้ขนส่งสาธารณะ ควรออกแบบให้น่าดึงดูดและเหมาะสมกับลักษณะพื้นฐานทางประชากรและสังคม รวมถึงบริบทพื้นที่ นอกจากนี้ นโยบายส่งเสริมไม่ควรเน้นเฉพาะระดับบุคคล แต่ควรปรับสภาพแวดล้อมทางกายภาพให้เหมาะกับการมีกิจกรรมทางกายในการเดินทางด้วย

คำสำคัญ: กิจกรรมทางกาย, การเดิน, การใช้จักรยาน, ชุมชน, ประเทศไทย

Background and Rationale

The benefits of physical activity have been well documented for preventing the incidence of heart diseases, stroke, breast and colon cancer, and diabetes, as well as improving mental health and quality of life.[1] The World Health Organization recommends weekly physical activity of at least 150 minutes for moderate physical activity or at least 75 minutes for vigorous physical activity.[2] As the resting state of the body equals 1 metabolic equivalent task (MET), and moderate- and vigorous-intensity of physical activity equal 4 and 8 MET, respectively,[3] the WHO recommended level of physical activity equals at least 600 MET-minute/week.

As physical activity is well connected to body movements throughout the day, it is worth paying attention to physical activities in the domain of transport (active transport) such as walking or cycling (alone or in combination with public transport).[4,5] In contrast to sports or exercise, active transport requires less time, motivation, and budget.[6] A growing number of studies have confirmed the health benefits of physical activity linked to active transport, especially for sedentary, obese, and older people. Active transport is easier to begin as a moderate form of regular physical activity than with sports or other types of vigorous physical activity.[6,7] In Thailand, based on the 2016 national health welfare survey of 108,416 adults, the energy expenditure of active transport contributed to 17% (286 MET-minute/week) of total daily energy expenditure from physical activity, equal to 48% of the WHO recommendation (600 MET-minute/week).[8] Moreover, Ronghanam's study[9] in 2013 identified the change of active transport behaviors of 399 adults in Bangkok after the operation of BTS (Bangkok Mass Transit System) sky train, a 18% shift from personal cars to BTS sky train. The walking distance also increased from 360 to 972 meters per day.

To promote active transport in Thailand, in 2017, the Thai Walking and Cycling Institute, funded by the Thai Health Promotion Foundation, initiated a project in ten communities in five regions. Through the project, the Institute worked closely with civil societies, academia, and communities to analyze active transport behaviors at community level and established interventions that suited local contexts to raise active transport and physical activity behaviors.[10] However, to date, the contribution of the active transport project on the locals in these communities has not been evaluated, as well as the associations between demographics of residents and active transport behaviors in Thailand. Though there are prior studies on the amount of active transport energy expenditure,[8,11] yet a specific exploration on associations between the demographic profiles of residents living in areas of active transport promotion has not been performed.

The objective of this study was to estimate the physical activity from active transport among the locals living in the communities participating in the active transport promotion project, and to identify the association between that physical activity from active transport and the individual characteristics.

Methodology

Study Design, Population, and Sample Size

A cross-sectional study was employed. Three communities were purposively selected and agreed to be enrolled in the study. These three communities were selected based on their characteristics representing all ten communities initiated by the Thai Walking and Cycling Institute. These three communities were; 1) King Taksin community in Bangkhla district, Chachoengsao province (henceforth called community A), 2) Suksabaijai community in Mueang Kalasin district, Kalasin province, (community B), and 3) Ban Thatsobvan community in Chiangkham district, Payao province (community C). The geography and built environments of these three communities are presented in Table 1. In general, three areas contained plain topography and were mainly used for residential purposes. Community B had the longest village diameter (a distance between two farthest borders through the center of the community) at 1,500 meters, followed by communities C and A at 1,000 and 500 meters, respectively. Community C had the highest population density (1,808 persons/square kilometer (sq.km.), followed by community A (900 persons/sq.km.) and community B (384 persons/sq.km.). Community B had a bypass road (with a speed limit of up to 70 kilometer (km.)/hour) passing through the community and had few public amenities in the city center.[12-16] The most common transport mode in three communities was motorcycle, followed by car and bicycle. The direct observation was used by the researchers to count the number of vehicles in the morning, noon, and evening, at least one time per period.

We used one-sample formula with dichoto-

Table 1 Geography and built environments of three communities

	Community A (King Taksin)	Community B (Suksabaijai)	Community C (Ban Thatsobvan)
Region	Central and East	North-East	North
Level of municipality	Subdistrict	Town	Subdistrict
Village diameter (meters)	500	1,500	1,000
Population density (persons/sq.km.)	900	384	1,808
Topography	Plain	Plain	Plain
Type of land use	Accommodation zone, close to market and city center (500 meters from village center)	Accommodation zone, far from market and city center (1,500 meters from (500 village center)	Accommodation zone, close to market and city center meters from village center)
Road and intersection	1-2 lane road, intersection every 50-100 meters	1-2 lane road, intersection every 50-100 meters, bypass across community	1-2 lane road, intersection every 50-100 meters
Average vehicle speed (km./hour)	20-40	40-70	20-40
Pathway	Functional sidewalk, bike lane found outside community	Functional sidewalk, bike lane found outside community	Narrow sidewalk, no bike lane, good road lights
Public transport	Small bus to Chachoengsao city every 15 minutes	No public transport in the community	No public transport in the community
Proportion of transport mode	Motorcycle (40%), car (20%), bicycle (20%), walking (10%), public transport use (10%)	Motorcycle (40%), car (30%), bicycle (15%), walking (15%)	Motorcycle (30%), car (30%), bicycle (20%), walking (20%)

mous variable to calculate the sample size.[17] The formula was described as follows.

$$N = \frac{(Z_{\frac{a}{2}} + Z_{\beta})^2 \pi (1-\pi)}{(\pi - \pi_0)^2} \quad (1)$$

- $Z_{\frac{a}{2}}$ = 1.96 at 95% confidence level
- Z_{β} = 0.84 at 80% of power
- π = expected prevalence of adequate physical activity level of the study
- π_0 = prevalence of adequate physical activity level at population level

In the formula, the prevalence of adequate physical activity at a population level of 62% was derived from the Annual National Physical Activity Survey by Mahidol University in 2016,[18] thus π_0 was 0.62. The expected prevalence of adequate physical activity of three communities was set as 3 times higher than the annual 1% increase in physical activity levels from the 2012-2016 national annual surveys,[18] hence the Thailand Physical Activity Plan 2018-2030 target of a 1% annual increase.[19] As the data collection of the study was in 2019, thus π = 0.71. By replacing those values in the equation, the sample size was 199. Details are as follows;

$$n = \frac{(1.96+0.84)^2 \times 0.71(1-0.71)}{(0.71-0.62)^2} \quad (2)$$

$$n = 199.29$$

Considering a non-response rate of 10%, therefore, we expected to have 220 samples. In practice, the community leaders could identify more participants, 343 samples were recruited. The participants were selected via the consultation between researchers and community leaders to distribute the questionnaires to the participants in the communities based on geography distribution. In practice, the questionnaires were allocated to 10-15 community committee members to further distribute to their nearby houses. Then all members in those selected nearby houses were asked to complete the questionnaires by themselves.

Questionnaire Design and Data Collection

A self-administered questionnaire was used. The main focus of the questionnaire was adequate physical activity level adapted from the WHO Global Physical Activity Questionnaire (GPAQ).[3] The questionnaire comprised two main parts: (i) demographic profiles of the respondents, and (ii) physical activity level. In the first part, the questionnaire included certain variables, namely, sex, age, body mass index (BMI), education level, occupation, monthly income, and residential area. The second part of the questionnaire included five sections about physical activity: (i) vigorous intensity at work, (ii) moderate intensity at work, (iii) moderate intensity in transport, (iv) vigorous intensity at recreational activities, and (v) moderate intensity at recreational activities. Each section was composed of three questions: (i) did you do physical activity in this section last week?, (ii) if yes, how many days of physical activity did you have last week?, and (iii) how many minutes of physical activity did you have per day? The study focused on the moderate intensity in transport or active transport in section iii.

The questionnaire was piloted among 30 participants to test validity and to finetune for understanding of the questions. The time used to fill in the self-administered questionnaire was about fifteen minutes per person. No incentives were offered to respondents. All individual identity data were automatically encrypted to protect confidentiality. The data collection was performed during December 2019 – March 2020.

Variable Management and Data Analysis

The primary outcome was the energy expenditure of active transport based on the WHO GPAQ[3] The energy expenditure of active transport was calculated from responses to the third section of physical activity in the second part of the questionnaire as illustrated below. The fourth term of the formula stands for the intensity of moderate physical activity (4 MET).

Energy expenditure of active transport (MET-minutes/week) = (having physical activity or not) x (number of days) × (number of minutes) × (4 MET) (3)

The key independent variables were sex, age, BMI group, education level, occupation, monthly income range, and residential areas. As the median age of all participants was 53 years, age was categorized into two groups: (i) 8-52 years old (below median), and (ii) 53-85 years old (equal to or above median). BMI was classified into (i) underweight (BMI <18.5 kg /m^2) or normal (BMI > =18.5 and < 23 kg /m^2), and (ii) overweight (BMI > =23 and < 30 kg /m^2) or obesity (BMI > =30 kg /m^2)[20] Education level was categorized as (i) primary education or less, and (ii) secondary education or above. Occupation was described as (i) agricultural workers, (ii) office-based employees or business owners, and (iii) retired or unemployed. Income range was grouped into (i) 0-12,000 baht, and (ii) 12,001-85,000 baht since the median income of the participants was 12,000 baht (1 US$ = 33.39 baht as of 19 August 2021).

The analysis plan consisted of two steps. First, the demographic data and the energy expenditure of active transport were analyzed by univariate Poisson regression. Second, the effect of the energy expenditure of active transport accounting for the influence of all covariates (p-value < 0.05 for univariate Poisson regression) were analyzed by multivariate Poisson regression, and the results were presented in terms of the adjusted incidence rate ratio (IRR) and 95% confidence interval (CI). All calculations were performed by STATA software version 17, StataCorp, College Station, TX, USA (serial number: 401709350741).

Ethical Consideration

The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Institutional Review Board of Institute for Development of Human Research Protection in Thailand (protocol code IHRP2019115, No.110-2562, December 23, 2019). All participants were well informed about this study. A participant information sheet was given to all participants. Written informed consent was required before participating in the survey. Informed consent was obtained from all subjects involved in the study.

Results

Baseline Characteristics

Respondents from community B accounted for 43% of total samples, followed by those from community C (36%) and community A (21%), as shown in Table 2. About two-thirds of the participants were female (63%). The median age was 53 years. Underweight or normal-weight respondents accounted for 59% of all participants. Most participants were educated to primary level. Approximately 12% of the participants were agricultural farmers, 58% were office-based employees or business owners, and 30% were retired or unemployed. The median income was 12,000 baht.

Table 2 Personal attributes and active transport energy expenditure, a univariate analysis

Characteristics	Number of participants (%)	Mean of active transport energy expenditure (SD)	Median of active transport energy expenditure (Q1, Q3)
Total	343 (100)	406 (690)	180 (0, 600)
Sex*			
Male	125 (37)	439 (936)	120 (0, 560)
Female	214 (63)	390 (502)	240 (0, 600)
Age group*			
8-52 years	163 (48)	273 (423)	0 (0, 400)
53-85 years	177 (52)	532 (852)	360 (0, 840)
Body mass index (BMI)*			
Underweight or normal	199 (59)	419 (574)	240 (0, 600)
Overweight or obese	139 (41)	381 (836)	140 (0, 560)
Education level*			
Primary school or below	70 (22)	683 (1,243)	240 (0, 840)
Secondary school or above	249 (78)	316 (422)	120 (0, 560)
Occupation*			
Agricultural workers	36 (12)	453 (748)	0 (0, 600)
Office-based employees or business owners	184 (58)	347 (738)	100 (0, 520)
Retired or unemployed	95 (30)	568 (612)	560 (80, 840)
Income range*			
0-12,000 baht	170 (55)	450 (609)	220 (0, 840)
12,001-85,000 baht	140 (45)	346 (792)	120 (0, 480)
Address*			
Community A	71 (21)	341 (325)	280 (0, 600)
Community B	149 (43)	252 (585)	0 (0, 240)
Community C	123 (36)	631 (880)	480 (120, 840)

* *p*-value < 0.001 (non-parametric test), Q = quartile

Participants' Profile and Active Transport Energy Expenditure: A Univariate Poisson Regression

Overall, the median of active transport energy expenditure of all respondents was 180 MET-minutes/week, as shown in Table 2. Female spent higher energy for active transport than male at 240 and 120 MET-minutes/week respectively (*p*-value < 0.001). The older participants (53-85 years) and underweight or normal BMI used more energy for active transport than their counterparts at 360 and 240 MET-minutes/week respectively (*p*-value < 0.001). Those with lower educational attainment, retired or unemployed, and had lower income showed a greater amount of energy from active transport than their counterparts at 240, 560, and 220 MET-minutes/week respectively (*p*-value < 0.001). In addition, participants living in community C spent the highest energy from active transport at 480 MET-minutes/week (*p*-value < 0.001).

Participants' Profile and Active Transport Energy Expenditure: A Multivariate Poisson Regression

Based on the multivariate Poisson regression, findings revealed that female, those who were overweight or obese, had higher educational attainment, and had higher income, had significantly reduced chance to spend higher energy for active transport than their counterparts (adjusted IRR = 0.75, 95% CI: 0.74-0.76, adjusted IRR = 0.48, 95% CI: 0.48-0.49, and adjusted IRR = 0.90, 95% CI: 0.89-0.92, respectively) - as shown in Table 3. In addition, those who were office-based employees or business owners, or retired or unemployed, had significantly reduced chance of spending higher energy for active transport than those who were agricultural workers (adjusted IRR = 0.78, 95% CI: 0.76-0.79, and adjusted IRR = 0.82, 95% CI: 0.81-0.84, respectively). On the other hand, being older had significantly higher chance of spending higher energy for active transport (adjusted IRR = 1.45, 95% CI: 1.43-1.47). Moreover, those living in the community C had significantly higher chance of spending higher energy for active transport (adjusted IRR = 1.71, 95% CI: 1.68-1.74), while those living in the community B had significantly lower chance of spending higher energy for active transport (adjusted IRR = 0.69, 95% CI: 0.68-0.70) compared to community A.

Table 3 Multivariable Poisson regression of achieving the adequate physical activity level

Variables	Multivariable Poisson regression	
	Adjusted incidence rate ratio	95% confidence interval
Sex		
Female	0.75*	0.74-0.76
(ref = male)		
Age group		
53-85 years	1.45*	1.43-1.47
(ref = 8-52 years)		

Table 3 Multivariable Poisson regression of achieving the adequate physical activity level (cont.)

Variables	Multivariable Poisson regression	
	Adjusted incidence rate ratio	95% confidence interval
Body mass index (BMI)		
Overweight or obese	0.89*	0.88-0.90
(ref = underweight or normal)		
Education level		
Secondary school or above	0.48	0.48-0.49
(ref = primary school or below)		
Occupation		
Office-based employees or business owners	0.78*	0.76-0.79
Retired or unemployed	0.82*	0.81-0.84
(ref = agricultural workers)		
Income range		
12,001-85,000 baht	0.90*	0.89-0.92
(ref = 0-12,000 baht)		
Address		
Community B	0.69*	0.68-0.70
Community C	1.71*	1.68-1.74
(ref = community A)		

* *p*-value < 0.001

Discussion

This paper is among the first studies[21,22] attempting to determine the associations between physical activity from active transport and the characteristics of local people in communities with active transport initiatives. The study showed that the amount of active transport energy expenditure, 180 MET-minutes/week, contributed to 30% of 600 MET-minutes/week of the WHO's recommended level.[2] While residents in the communities C and A spent energy for active transport around 480 and 280 MET-minutes/week or 80% and 47% of the WHO's recommendation. This might be because the environments in communities C and A were conducive for walking and cycling. For example, the diameter of the village is about 500-1,000 meters and the distance from village center to city center is only 500 meters, the optimal range for walking and cycling.[23-25] In the contrary, the community B had a wider range of village diameter (1,500 meters) and farer distance from village center to city center (1,500 meters). Moreover, community B located very close to the highway with high-speed vehicles, causing difficulty for safe walking and cycling. Besides, the city center of community B had very few public amenities, therefore, many inhabitants may need to own a private car to travel to destinations outside the city center.[21,26] Other possible explanations are a good proportion of bicycle use, a variety of type and high frequency of public transport, and short distance between bus stops in communities A and C recommended for creating active city.[27-30]

The findings from multivariate Poisson regression revealed that female, those who were overweight or obese, with higher education, higher income, and the white-collar worker or the unemployed, were living less active transport than their counterparts. These findings were in line with the epidemiologic patterns from the national surveys of physical activity in Thai people in the decade that these characteristics lived less active in a domain of physical activity in transport.[8,11,31-33] This maybe implied that these people used more personal motor vehicles rather than active transport when going outside due to gender preference, difficulties with physical co-morbidities from obesity and non-communicable diseases such as hemiplegia or diabetic feet in overweight or obese people, or having economic advantage to access to personal motor vehicles in higher income and education groups.[8,11,26,32,34]

On the other hand, older adults reported spending higher energy for active transport. This may be due to interventions to promote active transport in the communities were more suitable for older adults. For example, the installation of sculptural lighting along the village road in community C attracted older adults coming out walking and jogging in the early morning while children, adolescents or adults might not have enough time to do so.[14] Moreover, positive norms towards active transport in elderly could be a supporting factor, while adolescents and adults may perceive active transport as a symbol of obsolescence, slowness, and low social class.[26]

A few policy implications emerge. First, the campaign for active transport promotion should make it more attractive and appealing to all demographics. Second, the translation of policy into action may greatly vary across local contexts. Our findings found that the population in different areas responded to the campaign differently. Moreover, the policy should aim not only at individual lifestyle modification but also at re-shaping the physical environments that facilitate active transport. Or, more comprehensively, including the concept of healthy urban planning in local government policies in the context of rapid urbanization.

This study has both strengths and limitations. For strengths, the use of multivariable logistic analysis helped reduce the effect of confounding bias. However, there remain some limitations. First, the use of only three purposive selected communities meant that the study was not free from selection bias; hence, the representative power of the findings is undermined. Future studies using probabilistic sampling and nationally representative groups are recommended. Second, there was no baseline data on the active transport of participants. The active transport promoting project should collect baseline data on active transport in existing implementing areas as many as possible, or before new areas of the project starts, as this will allow a pre-post comparison. Lastly, it is likely that there were other key variables that had not been collected and analyzed. These included culture or lifestyle of the inhabitants, and the infrastructure in other aspects of communities.

Conclusions

The average amount of active transport energy expenditure in three communities constituted only 30% of the WHO's recommended physical activity level. Different demographics affected a chance to spending higher energy for active transport. Interventions for active transport promotion should be more attractive and appropriate to all demographics and contexts. Moreover, the policy should aim not only at individual lifestyle modification but also at re-shaping the physical environment that facilitates active transport.

Acknowledgement

We would like to thank all stakeholders in three communities for their leadership and unstinting support. We acknowledge our colleagues in the International Health Policy Program and Department of Health for their advice and continuous assistance, especially Dr. Walaiporn Patcharanarumol, Dr. Kanitta Bundhamchareon, Dr. Nareerut Pudpong, Dr. Warisa Panichkriangkrai, Ms. Woranan Witthayapipopsakul, Ms. Jarinporn Kongsrijan, Ms. Hathaichanok Sumalee, Ms. Waraporn Pongkantha, Ms. Boonyarak Chanprasobpol, Ms. Sirapat Timdee, and Dr.Udom Asawutmangkul. We reserve special thanks to Ms. Atjima Meepring from the Thailand Walking and Cycling Institute for her excellent supports throughout the study. Also, the first and second authors are fellows of the Capacity Building on Health Policy and Systems Research program (HPSR Fellowship) under cooperation between Bank for Agriculture and Agricultural Co-operatives (BAAC), National Health Security Office (NHSO) and International Health Policy Program Foundation (IHPF). So, we would like to thank all funders and organizations that contributed to the HPSR fellowship program.

Author Contributions: Conceptualization, T.T., R.S., and C.T.; formal analysis, T.T., R.S., C.T., and V.T.; resources, T.T.; writing—original draft preparation, T.T., R.S and C.T.; writing—review and editing, T.T., R.S., C.T., V.T., and W.P.; visualization, T.T. and R.S.; project administration, T.T., and C.T..; funding acquisition, T.T., C.T., R.S., and V.T.. All authors have read and agreed to the published version of the manuscript.

Source of Funding: The author gratefully acknowledges the joint funding support by (1) the Thai Health Promotion Foundation through the Thai Walking and Cycling Institute Foundation, (2) Thailand Science Research and Innovation (TSRI) for the Senior Research Scholar on Health Policy and System Research (Contract No. RTA6280007), and (3) the Capacity Building on Health Policy and Systems Research program (HPSR Fellowship) under cooperation between Bank for Agriculture and Agricultural Co-operatives (BAAC), National Health Security Office (NHSO) and International Health Policy Program Foundation (IHPF).

Conflicts of Interest: The authors declare no conflict of interest and the funders had no role in the design of the study; the collection, analyses, or interpretation of data; the writing of the manuscript, and the decision to publish the results.

References

1. Ding D, Lawson KD, Kolbe-Alexander TL, Finkelstein EA, Katzmarzyk PT, van Mechelen W, et al. The economic burden of physical inactivity: a global analysis of major non-communicable diseases. Lancet. 2016;388(10051):1311-24.
2. World Health Organization. WHO Guidelines on physical activity and sedentary behaviour for children and adolescents, adults and older adults. Geneva: World Health Organization; 2020.
3. World Health Organization. Global Physical Activity Questionnaire (GPAQ) Geneva: World Health Organization.
4. Mueller N, Rojas-Rueda D, Cole-Hunter T, de Nazelle A, Dons E, Gerike R, et al. Health impact assessment of active transportation: a systematic review. Preventive Medicine. 2015;76:103-14.
5. Sener IN, Lee RJ, Elgart Z. Potential health implications and health cost reductions of transit-induced physical activity. J Transp Health. 2016;3(2):133-40.
6. Gerike R, de Nazelle A, Nieuwenhuijsen M, Panis LI, Anaya E, Avila-Palencia I, et al. Physical activity through sustainable transport approaches (PASTA): a study protocol for a multicentre project. BMJ Open. 2016;6(1):e009924.
7. Koszowski C, Gerike R, Hubrich S, Götschi T, Pohle M, Wittwer R. Active mobility: bringing together transport planning, urban planning, and public health: challenges, solutions and collaborations. In: Beate Müller, Gereon Meyer, editors. Towards user-centric transport in Europe: challenges, solutions and collaborations. Cham: Springer International Publishing; 2019. p. 149-71.
8. Topothai T, Liangruenrom N, Topothai C, Suriyawongpaisan W, Limwattananon S, Limwattananon C, et al. How much of energy expenditure from physical activity and sedentary behavior of Thai adults: the 2015 national health and welfare survey. Journal of Health Systems Research. 2017;11(3):327-44. (in Thai)
9. Ronghanam P. Walking behaviors of commuter who have switched to use the Bangkok Mass Transit System (BTS). Bangkok: Chulalongkorn University; 2013. (in Thai)
10. Thailand Walking and Cycling Institute Foundation. The 7th Thailand Bike and Walk Forum 2019: Think Globally, Bike-Walk Locally. Bangkok: Thailand Walking and Cycling Institute Foundation; 2019. (in Thai)
11. Topothai T, Topothai C, Pongutta S, Suriyawongpaisal W, Chandrasiri O, Thamarangsi T. The daily energy expenditure of 4 domains of physical activity of Thai adults. Journal of Health Systems Research. 2015;9(2):168-80. (in Thai)
12. Bangkhla Subdistrict Municipality. Community development plan (2018-2022). Bangkhla: Bangkhla Subdistrict Municipality; 2018. (in Thai)
13. Bangkhla Subdistrict Municipality. Community development plan (2018-2022), revised 1/2019. Bangkhla: Bangkhla Subdistrict Municipality; 2019. (in Thai)
14. Chiangkam Subdistrict Municipality. Community action plan 2020. Chiangkam: Chiangkam Subdistrict Municipality; 2019. (in Thai)
15. Kalasin City Municipality. Community development plan (2018-2022), revised 1/2019. Kalasin: Kalasin City Municipality; 2019. (in Thai)
16. Kalasin Town Municipality. Community development plan (2018-2022). Kalasin: Kalasin Town Municipality; 2018. (in Thai)
17. Kaewkungwal J, Singhasivanon P. Sample size calculation in clinical research. In: Pannee Pitisuthitham, Chayan Pichiensunthorn, editors. Textbook of clinical research. Bangkok: Tropical Medicine Faculty, Mahidol University; 2011. p. 107-43. (in Thai)
18. Katewongsa P. National Physical Activity Survey 2011-2016. Nakornpathom: Institute for Population and Social Research, Mahidol University; 2016. (in Thai)
19. Division of Physical Activity and Health, Department of Health, Ministry of Public Health. Thailand Physical Activity Strategy 2018-2030. Bangkok: NC Concept; 2018. (in Thai)
20. World Health Organization. The Asia-Pacific perspective: redefining obesity and its treatment. Geneva: World Health Organization; 2000.
21. Topothai T, Topothai C, Suphanchaimat R, Chandrasiri O, Sukaew T, Tangcharoensatien V, et al. Physical activity, carbon dioxide emission and cost of transport: a case study of three communities in Thailand. Journal of Health Systems Research. 2020;14(4):458-77. (in Thai)
22. Topothai T, Topothai C, Suphanchaimat R, Chandrasiri O, Sukaew T, Putthasri W, et al. The promotion of walking and biking for transportation, and public transport using: A case study in four communities in Thailand. Nonthaburi: International Health Policy Program; 2020. (in Thai)

23. Sallis JF, Bull F, Burdett R, Frank LD, Griffiths P, Giles-Corti B, et al. Use of science to guide city planning policy and practice: how to achieve healthy and sustainable future cities. Lancet. 2016;388(10062):2936-47.
24. Sallis JF, Cerin E, Conway TL, Adams MA, Frank LD, Pratt M, et al. Physical activity in relation to urban environments in 14 cities worldwide: a cross-sectional study. The Lancet. 2016;387(10034):2207-17.
25. Sallis JF, Cerin E, Kerr J, Adams MA, Sugiyama T, Christiansen LB, et al. Built environment, physical activity, and obesity: findings from the International Physical Activity and Environment Network (IPEN) adult study. Annu Rev Public Health. 2020;41:119-39.
26. Topothai T, Topothai C, Meepring A. Promoting walking and cycling in daily life: a case study of four communities in Thailand. Journal of Health Systems Research. 2021;15(3):294-309. (in Thai)
27. Cole R, Dunn P, Hunter I, Owen N, Sugiyama T. Walk score and Australian adults' home-based walking for transport. Health Place. 2015;35:60-5.
28. Duncan DT, Meline J, Kestens Y, Day K, Elbel B, Trasande L, et al. Walk score, transportation mode choice, and walking among French adults: a GPS, accelerometer, and mobility survey study. Int J Environ Res Public Health. 2016;13(6).611.
29. Duncan DT, Sharifi M, Melly SJ, Marshall R, Sequist TD, Rifas-Shiman SL, et al. Characteristics of walkable built environments and BMI z-scores in children: evidence from a large electronic health record database. Environ Health Perspect. 2014;122(12):1359-65.
30. Meline J, Chaix B, Pannier B, Ogedegbe G, Trasande L, Athens J, et al. Neighborhood walk score and selected cardiometabolic factors in the French RECORD cohort study. BMC Public Health. 2017;17(1):960.
31. Liangruenrom N, Dumuid D, Craike M, Biddle SJH, Pedisic Z. Trends and correlates of meeting 24-hour movement guidelines: a 15-year study among 167,577 Thai adults. Int J Behav Nutr Phys Act. 2020;17(1):106.
32. Liangruenrom N, Topothai T, Topothai C, Suriyawongpaisal W, Limwattananon S, Limwattananon C, et al. Do Thai people meet recommended physical activity level?: The 2015 national health and welfare survey. Journal of Health Systems Research. 2017;11(2):205-20. (in Thai)
33. Thailand Physical Activity Knowledge Development Center. Regenerating physical activity in Thailand after COVID-19 pandemic. Nakornpathom: Thailand Physical Activity Knowledge Development Center; 2020. (in Thai)
34. Tuangratananon T, Liangruenrom N, Topothai T, Topothai C, Limwattananon S, Limwattananon C, et al. Differences in physical activity levels between urban and rural adults in Thailand: findings from the 2015 national health and welfare survey. Journal of Health Systems Research. 2018;12(1):27-41.