

Environmental and Psychological Differences in Moderate-to-Vigorous Physical Activity Among Young Adults at Cardiometabolic Risks: A Case-Control Study

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Research

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Abstract

Background: Young adults' physical activity is a foundation of creating future healthy lifestyles. The purpose of this study was to explore differences in physical activity, sedentary behavior, walkability, and health beliefs between young adults with and without cardiometabolic risk factors and the influence of moderate-to-vigorous physical activity.

Methods: A cross-sectional study was conducted using a structured questionnaire.

Results: Totally, 1149 valid responses were received for a response rate of 86.32%. A significant effect of cardiometabolic risk factors on the physical activity and sedentary time among groups was found. Young adults at high risk had a lower probability of moderate-to-vigorous physical activity than did healthy adults. Individuals who perceived that there were more recreational facilities, higher benefits of exercise, and lower barriers to exercise were more likely to participate in moderate-to-vigorous physical activity.

Conclusions: Engaging in physical activity from environment and psychological perspectives is necessary for young adults' cardiometabolic health promotion.

Background

Physical inactivity is the fourth leading cause of death. Individuals who spend lots of time engaged in sedentary behaviors have increased risks of non-communicable diseases (NCDs), such as obesity, cardiovascular diseases, type II diabetes, and certain cancers (1, 2). Every year 63% of deaths are estimated to result from NCDs worldwide (3).

Physical activity (PA) is one of the most effective modifiable behaviors in order to prevent NCDs, especially cardiometabolic diseases (i.e., hypertension, hyperlipidemia, diabetes, and metabolic syndrome). Increasing moderate-to-vigorous PAs (MVPAs) and decreasing sedentary behaviors are key to preventing NCDs and promoting health. Consistently integrating MVPAs into one's daily life leads to lower prevalence rates and mortality due to cardiometabolic diseases (Hill et al., 2015; Hunter et al., 2015; Rao et al., 2016). Engaging in MVPAs, exercise training, and rehabilitation improves cardiopulmonary functions, physical fitness, insulin sensitivity, and muscle power (7). Consistently participating in MVPAs can decrease the body-mass index (BMI), the history of chronic diseases, and the mortality rate from cardiometabolic diseases (8). However, even though PAs are important in preventing NCDs, 21.4% of the population still engages in an inactive daily lifestyle worldwide (9).

If a decline in PA occurs, the first priority is to identify changes in personal characteristics, the physical environment, and psychological factors (10). Two main strategies for promoting individuals' MVPAs are environmental and psychological (11). Characteristic of the living environment influence residents' behaviors and well-being (12). Creating a walkable environment is beneficial for pedestrians to increase walking behaviors and recreational PAs, with such benefits as friendly neighbors, short distances to recreational facilities, esthetic views, accessible infrastructure, and a feeling of safety (13, 14). Walkability is a determinant of people's PAs and sedentary behaviors (15). People living in an environment with higher walkability have higher frequencies and longer times of PAs (16). Therefore, high walkability also brings about benefits of lower incident rates of cardiometabolic diseases through the mediator of MVPAs (17).

On the other hand, PAs are also influenced by intra- and interpersonal factors in psychological domains, including socioeconomics, knowledge, attitudes, and social interactions (18, 19). The Health Beliefs Model is often used to explain the psychological domain of health behaviors, for example, health beliefs of PA (HBPA) (19). Once people are aware of the serious consequences of physical inactivity, they might begin to achieve minimal PA requirements. When perceived benefits are higher than the costs of PAs, people will choose an active lifestyle. In contrast, individuals with insufficient knowledge of future health threats of physical inactivity or who perceive many barriers to exercise might spend much time in sedentary behaviors (20). Social relationships with family, friends, and neighbors also impact PA self-choices (21).

The prevalence of engaging in PAs in healthy populations also differs from that of populations with no chronic diseases, such as obesity, hyperlipidemia, hypertension, and diabetes. The duration of individuals' chronic disease history is negatively associated with the prevalence of PAs (22). One meta-analysis that compared healthy children and adolescents to those with chronic diseases found that patients with cardiovascular diseases or diabetes had lower amounts of PA per day, fewer days when they achieved the MVPA standard, and longer sedentary times than the healthy control group (23). Healthy older adults have a higher level of leisure-time PAs and shorter sedentary times than older adults with two and more diagnoses of chronic diseases (24). However, few studies have focused on comparisons of young adults as the main target population.

In Erikson's stage of human psychological development, individuals with the age of 20–39 years old are in the Early adulthood (Erikson, 1959). Young adults experience many major life changes, such as graduation and marriage, especially when aged 18 ~ 45 years. Such life changes impact one's self-identity, self-determination, future lifestyle, and long-term health behaviors (26). However, few studies have discussed the relationship of young adults' health behaviors and cardiometabolic diseases. In this population, it is important to identify environmental and psychological risk factors that affect changes in health behaviors. Young adults are encouraged to engage in MVPAs and embrace the habit for their future lifestyle.

Purpose

Young adults' lifestyle and health behaviors form the foundation of creating the lifestyle when they are older. Differences in environmental and psychology factors impact whether young adults participate in MVPAs. Therefore, the purpose of this study was to explore differences in PAs, walkability and health

beliefs between healthy young adults and young adults with cardiometabolic risks, and determine the influence of cardiometabolic risk factors, walkability, and health beliefs on MVPAs. The research questions were as follows:

1. Are there any differences in PA, sedentary behaviors, perceived walkability, and health beliefs concerning PAs by early adults with and those without cardiometabolic risk factors?
2. Do cardiometabolic risks, perceived walkability, and health beliefs have an influence on MVPAs?

Methods

Research Design

A case-control study was conducted from December 2016 to June 2017. According to their self-identified current health condition, all participants were assigned to one of five groups: (1) healthy adults: young adults with no cardiometabolic risk factors as a control group; (2) overweight: young adults with a body-mass index (BMI) of $24 \sim 27 \text{ kg/m}^2$; (3) obesity: young adults with a BMI of $\geq 27 \text{ kg/m}^2$; (4) high (cardiometabolic) risks: young adults with self-reported hypertension, hyperlipidemia, and hyperglycemia; and (5) (cardiometabolic) diseased: young adults with at least one diagnosis of metabolic syndrome, hypertensive diseases, hyperlipidemia, or type II diabetes. If an individual had more than one health condition of interest, the individual was given a higher number. For example, a participant with simultaneous obesity, self-reported hypertension, and type II diabetes would be assigned to the fifth group of cardiometabolic diseases.

Participants and Sampling

The criteria of participants were (1) young adults aged $18 \sim 45$ years, (2) currently living in urban, and (3) with no physical or mental disability. The Walkability Index (WI) in each administrative region was calculated by the sum of Z-scores of street connectivity, land use mix, residential density, socioeconomic status, and crime rate from objective open government data (27, 28). According to the WI, 19 administrative regions were ranked into four levels. Quota sampling was used to recruit 300 participants in each level based on their current address. An internet survey through social media was conducted, including FaceBook, Intragram, Twitter, and various forums. In total, 1331 people responded, and the valid response rate was 86.32%. Participants satisfied the minimal sample size ($n > 384$) for a population exceeding 10,000 for internet survey research.

Data Collection

Participants were required to complete an anonymously structured questionnaire composed of four parts to collect data. The first part was their demographic background, including questions of gender, age, educational level, and income. The current health condition concerned participant's height, weight, and whether they had any cardiometabolic risk factors (i.e., hypertension, hyperlipidemia, and hyperglycemia) or previous diagnoses of cardiometabolic diseases (i.e., metabolic syndrome, hypertensive diseases, hyperlipidemia, or type II diabetes).

The Physical Activity Neighborhood Environment Survey (PANES) was developed by Sallis and Saelens (2000) to evaluate perceived walkability in neighborhood environments (walking times of $10 \sim 15$ min). The inventory includes 17 items with a 4-point Likert scale. According to the scoring guide, *How to Score PANES* (Sallis, 2016), the score was categorized into several constructs of walkability in a neighborhood, such as land use mix, safety, infrastructure, recreational facilities, esthetics, and so on. The construct validity and internal consistency of the inventory were tested in different languages (Sallis et al., 2009). Cronbach's alpha was 0.72 in this study.

The Health Beliefs in Physical Activity (HBPA) was first developed by Hayslip, Weigand, Weinberg, Richardson, and Jackson (1996) to measure the psychological properties of PAs by the Health Belief Model. The inventory was translated into Chinese with good validity and reliability (33). The HBPA inventory includes 41 items with a 5-point Likert scale. An exploratory factor analysis divided the inventory into five factors (Kaiser-Meyer-Olkin = 0.92), including susceptibility to health problems, benefits of exercise, barriers to exercise, significant others' support, and cues to action. These factors were the same as those of the original HBPA inventory. Cronbach's alpha was 0.92 in this study.

The International Physical Activity Questionnaire (IPAQ) collected participants self-reported PAs over the previous 7 days. Participants' PA level (MET-min/week) was calculated in accordance with the scoring protocol. The IPAQ Taiwanese version was shown to have good content validity and test-retest reliability (34). Participants were also categorized as to whether or not they participated in MVPAs, depending on whether their PAs met the minimal requirement of MVPAs (600 MET-min/week) (International Physical Activity Questionnaire, 2016).

Data Analysis

All variables were descriptively analyzed. The Chi-squared test was used to identify interactions between demographic background data and groups of cardiometabolic risk factors. A one-way analysis of covariance (ANCOVA) with a post-hoc test was used to analyze differences in PAs, sedentary behaviors, walkability, and health beliefs using covariables of the demographic background. The variance inflation factor of variables ranged $1.05 \sim 2.40$ without multicollinearity. Odds ratio (OR) estimates of demographic background, cardiometabolic risk factors, walkability, and health beliefs were obtained from a logistic regression model for predicting whether subjects participated in MVPAs.

Results

Demographic background and cardiometabolic risks

Details of participants' demographic background are given in Table 1. Numbers in the five group were 713 (62.10%) in healthy adults, 113 (11.60%) in overweight, 68 (5.9%) in obesity, 150 (13.10%) in high risks, and 85 (7.40%) in diseased. Chi-square tests were performed, and significant interactions between the frequencies of adults with and those without cardiometabolic risk factors included gender ($\chi^2 = 38.30, p < 0.01$), age ($\chi^2 = 63.21, p < 0.01$), educational level ($\chi^2 = 23.82, p < 0.01$), and income ($\chi^2 = 64.97, p < 0.01$).

Table 1
Chi-square Tests between Demographic Variables and Cardiometabolic Risk Groups

Demographic	(1) <i>Healthy adults</i>		(2) <i>Overweight</i>		(3) <i>Obese</i>		(4) <i>High risk</i>		(5) <i>Diseased</i>		Total		χ^2	<i>p</i>
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%		
Gender														
Male	301	42.22	77	57.89	41	60.29	89	59.33	57	67.06	565	49.17	38.30	< .001
Female	412	57.78	56	42.11	27	39.71	61	40.67	28	32.94	584	50.83		
Age (years)														
18 ~ 25	301	42.30	39	29.50	28	41.20	30	20.00	18	21.20	416	36.30	63.21	< .001
26 ~ 35	331	46.50	69	52.30	33	48.50	88	58.70	38	44.70	559	48.70		
36 ~ 45	80	11.20	24	18.20	7	10.30	32	21.30	29	34.10	172	15.00		
Educational Level														
College	109	15.29	21	15.79	7	10.29	9	6.00	6	7.06	152	13.23	23.82	< .001
Graduate School	429	60.17	81	60.90	50	73.53	87	58.00	53	62.35	700	60.92		
Others	175	24.54	31	23.31	11	16.18	54	36.00	26	30.59	297	25.85		
Income (NT\$/year)														
< 250,000	356	49.93	51	38.35	35	51.47	43	28.67	24	28.24	509	44.30	64.97	< .001
260,000 ~ 500,000	161	22.58	27	20.30	14	20.59	35	23.33	27	31.76	264	22.98		
501,000 ~ 750,000	126	17.67	33	24.81	9	13.24	30	20.00	13	15.29	211	18.36		
> 751,000	70	9.82	22	16.54	10	14.71	42	28.00	21	24.71	165	14.36		
Total	713	62.10	133	11.60	68	5.90	150	13.10	85	7.40	1149	100.00		
In 2017, the average exchange rate was US\$1.00 ≈ New Taiwan (NT)\$30.00.														

Differences in PAs and sedentary behaviors among participants with various cardiometabolic risk factors

Results of the one-way ANCOVA and post-hoc tests are given in Table 2. There was a significant effect of cardiometabolic risk factors on PAs ($F = 3.78, p < 0.01$) and sedentary time ($F = 2.39, p < 0.05$) after controlling for gender, age, educational level, and income. Post-hoc tests showed the healthy adult and overweight groups had significantly higher PAs than the high-risk and diseased groups. Post-hoc tests also showed that the healthy-adult and diseased groups had significantly longer sedentary times than the obesity group.

Table 2

One-way ANCOVA Results of Physical Activity (PA), Sedentary Behavior (SB), Walkability, and Health Beliefs among Cardiometabolic Risk Groups

Cardiometabolic risks groups	(1) <i>Healthy adults</i>		(2) <i>Overweight</i>		(3) <i>Obese</i>		(4) <i>High risk</i>		(5) <i>Diseased</i>		F	<i>p</i>	post-hoc
Adjusted	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD			
Physical activity (MET-min)	1887.71	67.12	1901.04	154.18	1172.05	214.28	1515.73	146.57	1600.49	195.51	3.78	0.01	1,2 > 3,4
Sedentary time (min)	2624.34	62.24	2467.12	143.13	2057.81	198.17	2391.89	135.14	2649.22	180.73	2.39	0.05	1,5 > 3
Walkability													
Residential Density	0.83	0.01	0.79	0.03	0.83	0.05	0.80	0.03	0.69	0.04	2.47	0.04	1,3,4 > 5
Land Use Mix	6.45	0.06	6.41	0.13	6.58	0.18	6.42	0.12	6.11	0.16	1.19	0.31	
Transit Access	3.03	0.04	3.18	0.10	2.94	0.14	2.98	0.09	2.89	0.12	1.09	0.36	
Pedestrian Infrastructure	5.06	0.06	5.17	0.15	4.79	0.21	5.08	0.14	5.23	0.19	0.74	0.56	
Bicycling Infrastructure	4.54	0.06	4.67	0.15	4.24	0.20	4.68	0.14	4.44	0.19	1.08	0.37	
Recreational Facilities	2.77	0.04	2.74	0.09	2.69	0.12	2.89	0.08	2.74	0.11	0.71	0.59	
Street Connectivity	3.20	0.03	3.17	0.07	3.35	0.10	3.18	0.07	3.10	0.09	0.96	0.43	
Crime Safety	6.19	0.06	6.09	0.13	6.05	0.18	6.11	0.12	6.20	0.16	0.31	0.87	
Traffic Safety	5.36	0.06	5.61	0.14	5.33	0.19	5.37	0.13	5.47	0.18	0.76	0.55	
Pedestrian Safety	3.01	0.03	3.20	0.07	3.06	0.10	3.05	0.07	3.06	0.09	1.52	0.19	
Aesthetics	2.77	0.03	2.76	0.07	2.78	0.10	2.72	0.07	2.81	0.09	0.22	0.93	
Health Beliefs in PAs													
Susceptibility ¹	31.18	0.34	31.58	0.78	35.40	1.09	32.20	0.74	34.04	0.99	4.87	<.001	1,2 < 3,5
Benefits of Exercise	32.25	0.20	33.01	0.45	31.63	0.63	32.21	0.43	32.24	0.58	0.93	0.44	
Barriers to Exercise	23.15	0.26	22.50	0.59	25.40	0.82	24.62	0.56	25.27	0.74	4.90	<.001	1,2 < 3,4,5
Cues to Action	26.03	0.25	25.88	0.57	26.77	0.79	26.68	0.54	27.09	0.72	0.89	0.47	
Significant Others' Support	16.38	0.17	15.89	0.38	16.54	0.53	16.29	0.36	17.02	0.48	0.92	0.45	
* Adjusted for gender, age, educational level, income; ¹ Susceptibility to health problems.													

Differences in walkability and health beliefs among those with cardiometabolic risk factors

Tests of walkability and health beliefs were conducted using a one-way ANCOVA to compare the five groups with and those without cardiometabolic risk while controlling for gender, age, educational level, and income. For environmental factors, only the residential density was found to significantly differ among the healthy-adult, obesity, high-risk, and diseased groups. The diseased group had the lowest residential density. The effects of other indicators of walkability were insignificant among groups with and those without cardiometabolic risk factors. For psychological factors, there were significant differences in susceptibility to health problems ($F = 4.87, p < 0.01$) and exercise barriers ($F = 4.90, p < 0.01$). Post-hoc tests revealed that the susceptibility to health problems in the healthy-adult and overweight groups was significantly lower than that in the obesity and diseased groups. Exercise barriers in the healthy adult and overweight groups were significantly lower than those of the obesity, high-risk, and diseased groups. The results showed that effects of other indicators of health beliefs were insignificant, including exercise benefits, cues to action, and significant others' support.

Logistic Regression Model of MVPAs

A logistic regression was carried out to determine effects of cardiometabolic risk factors, environmental factors, and psychological factors on the probability of engaging in MVPAs. The model included dummy variables for each group of cardiometabolic risk factors against healthy adults. The logistic

regression results are given in Table 3. In model 1, there were significant associations of gender, age, education, and cardiometabolic risk factors with participation in MVPAs. Females, older individuals, and those with a lower educational level were less likely to participate in MVPAs than were younger individuals and those with a higher educational level. There was no significant interaction with income. Young adults in the high-risk group had a lower probability of engaging in MVPAs than those in the healthy adult group (OR: 0.64, confidence interval (CI): 0.41 ~ 0.99, $p < 0.05$). Demographic background and cardiometabolic risk factors in the logistic model together accounted for 4.6% of the explanation for the probability of engaging in MVPAs.

Table 3
Logistic Regression of Three Models in odds ratio for Moderate-to-Vigorous Physical Activity (MVPA)

Variables	Model 1			Model 2			Model 3			
	OR	95% CI		OR	95% CI		OR	95% CI		
Demographic										
Gender	0.59	***	0.44 - 0.80	0.61	**	0.45 - 0.83	0.67	*	0.48 - 0.92	
Age	0.97	*	0.95 - 0.99	0.97	*	0.95 - 1.00	0.97	**	0.94 - 0.99	
Educational Level	1.44	**	1.10 - 1.90	1.44	*	1.09 - 1.90	1.38	*	1.03 - 1.85	
Income	0.95		0.80 - 1.12	0.93		0.78 - 1.09	0.90		0.76 - 1.07	
Cardiometabolic Risks (Ref: Healthy Adults)										
<i>Overweight</i>	1.63		0.96 - 2.78	1.58		0.92 - 2.71	1.55		0.89 - 2.71	
<i>Obese</i>	0.90		0.46 - 1.78	0.94		0.48 - 1.87	1.15		0.57 - 2.35	
<i>High risk</i>	0.64	*	0.41 - 0.99	0.62	*	0.39 - 0.97	0.69		0.43 - 1.11	
<i>Diseased</i>	0.99		0.61 - 1.59	0.92		0.57 - 1.50	1.14		0.68 - 1.90	
Walkability										
Residential Density				0.72		0.47 - 1.10	0.78		0.51 - 1.21	
Land Use Mix				1.01		0.88 - 1.15	0.96		0.83 - 1.11	
Transit Access				1.08		0.92 - 1.26	1.07		0.91 - 1.25	
Pedestrian Infrastructure				0.96		0.85 - 1.08	0.98		0.87 - 1.11	
Biking Infrastructure				1.04		0.93 - 1.17	1.07		0.95 - 1.21	
Recreational Facilities				1.27	*	1.05 - 1.53	1.26	*	1.03 - 1.53	
Street Connectivity				0.92		0.74 - 1.15	0.84		0.67 - 1.06	
Crime Safety				0.97		0.86 - 1.09	0.87		0.77 - 0.99	
Traffic Safety				1.05		0.93 - 1.17	1.00		0.89 - 1.12	
Pedestrian Safety				0.97		0.77 - 1.21	0.92		0.72 - 1.17	
Esthetics				1.00		0.80 - 1.24	0.99		0.79 - 1.26	
Health Beliefs in PA										
Susceptibility to Health Problems							1.03		0.83 - 1.29	
Benefits of Exercise							1.73	***	1.30 - 2.31	
Barriers to Exercise							0.42	***	0.32 - 0.55	
Cues to Action							0.75		0.55 - 1.04	
Significant Others' Support							1.08		0.82 - 1.43	
Model 1: Demographic, Cardiometabolic Risk Factors.										
Model 2: Demographic, Cardiometabolic Risk Factors, Walkability.										
Model 3: Demographic, Cardiometabolic Risk Factors, Walkability, Health Beliefs.										
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.										

Model 2 added environmental factors, and this increased the explanatory power of the logistic model to 6.5%. One factor had a significant association with MVPAs, recreational facilities (OR: 1.27, CI: 1.05 ~ 1.53, $p < 0.05$). Individuals who perceived a high level of recreation facilities in a walkable neighborhood were more likely to participate in MVPAs. There were no significant interactions with other environmental factors. Model 3 added psychological factors,

and this increased the explanatory power to 9.5%. Two factor scores had significant associations with MVPAs: benefits of exercise (OR: 1.73, CI: 1.30 ~ 2.31, $p < 0.001$) and barriers to exercise (OR: 0.42, CI: 0.32 ~ 0.55, $p < 0.001$). Individuals who understood the benefits of exercise and who perceived low barriers to exercise were more likely to participate in MVPAs. No significant interactions were observed among susceptibility to health problems, cues to action, and significant others' support in this model. Overall, the explanatory power of the final model accounted for 16.0%.

Discussion

The main purpose of the present study was to compare differences in PAs and sedentary time between individuals with and those without cardiometabolic risk factors, and we focused on a population of young adults. The study found that healthy young adults and young adults who were overweight had higher PAs than those with cardiometabolic risk factors. The severity of cardiometabolic risk factors impacted the level of PAs. Most previous studies showed that healthy control groups had a longer duration and a higher level of PAs and more days that they achieved MVPAs than groups with cardiometabolic diseases (23). The PA level was negatively associated with an individual's number of diagnoses of chronic diseases (36). When the history of chronic diseases, including diabetes and cardiovascular diseases, was longer, individuals' PAs were lower (5, 37). Chronic diseases are a trigger of changes in PAs (38). In the present study, the cutoff point reflecting a difference in PAs was between being overweight and obese. Therefore, it is important to be aware of changes in body weight which could be a danger sign of a lack of PAs.

The study also found that healthy young adults and young adults with cardiometabolic diseases had longer sedentary times than other risk groups. Previous studies presented no marked differences and did not reach a conclusion about sedentary times between healthy groups and groups with chronic diseases. The difference between strengthening and lightening PAs is more common than between being sedentary and initiating PAs (23, 38). Healthy young adults share a lifestyle with simultaneous high PAs and long sedentary times. There is a balance between PAs and sedentary behaviors for now. But it is possible to develop cardiometabolic risk factors when lifestyle changes cause an imbalance (4). Young adults with cardiometabolic diseases have an inactive lifestyle which threatens their own health and future life. Decreasing sedentary behaviors and increasing PAs are both important in delaying pathological processes of current diseases.

Regarding environmental differences among young adults, only one indicator of walkability exhibited a significant difference. Young adults with cardiometabolic diseases had the lowest score of perceived residential density. Individuals with cardiometabolic diseases had different insights as to their neighborhood environment (39). However, there was no difference between healthy young adults and other cardiometabolic risk groups. Overall, PAs are an important mediator between the environment and chronic illnesses (14). Walkability is a modifiable neighborhood feature which can promote PAs.

Regarding psychological differences among young adults, there were two domains in the HBPA with significant differences. Young adults in the obese, high-risk, and diseased groups were more susceptible to health problems and barriers to exercise than were healthy young adults and overweight young adults. A person's health and illness status impacted their health beliefs, especially with chronic diseases. Patients with chronic diseases are more susceptible to health problem than are healthy adults (11, 40). Interestingly, the cutoff point of reflecting on the difference in the HBPA was also between being overweight and obese.

The second main purpose of the present study was to determine the influence of cardiometabolic risk factors, walkability, and health beliefs on MVPAs. This study found that gender, age, and educational level had interactions with MVPAs. Previous studies also showed that personal demographic variables, such as age, gender, race, and years of education, have interactions with chronic risk factors and disease in population-based studies (36). Young adults with hypertension, hyperlipidemia, or hyperglycemia were less likely to participate in MVPAs in model 1. However, the predictive power of model 1 was low, so that environmental and psychological factors should be considered in the logistic regression model for predicting MVPAs.

Walkability impacts residents' leisure-time PAs, transportation choices, and an active lifestyle (41). Poor walkability causes long-term consequences of cardiometabolic diseases (42). In predictive models 2 and 3, only recreational facilities was a significant predictor of MVPAs. The accessibility, distance, density, and utility of recreation facilities had positive associations with the level of PAs in residents (43). However, previous studies also found that not every indicator of walkability has a direct association with PAs or the risk of cardiometabolic diseases (44). Creating an activity-friendly environment to change physical and social characteristics is effective in promoting PAs (45). NCDs are related to health inequalities (46). Governments should pay attention to designing healthy places to encourage residents' PAs to maintain a positive health status and low diseases status (47).

The psychological domain is important for the self-determination of MVPAs. In predictive model 3, the benefits of exercise and barriers to exercise significantly predicted the OR of MVPAs. Benefits of exercise were positively associated with MVPAs. In contrast, barriers to exercise were negatively associated with MVPAs (40). HBPA is a motivation to increase PA participation. Previous studies also showed that indicators of health beliefs significantly predicted the odds of MVPAs or achievement of minimal requirements of PAs (11, 48). An individual's susceptibility to chronic disease influences their health behavior decisions. Once an individual has enough cues to action and perceives more benefits of than barriers to exercise, they are more likely to engage in MVPAs (49).

Overall, more indicators of HBPA had significant impacts on MVPAs than walkability in this study. Between models 2 and 3, the R^2 value increased by about 9.5%. Young adults' thoughts impacted their PAs. Therefore, it is important to increase MVPAs beginning with health education for young adults. Young adults' lifestyles are not settled and can easily be modified. Increasing knowledge and awareness of diseases can help young adults understand the benefits of PAs and overcome barriers to exercise. MVPAs can become a part of one's lifestyle that is beneficial for preventing chronic diseases and promoting health in their future lives.

There are some limitations in this study, a case-control study which focused on PAs and associated factors and compared differences between a healthy control group and cardiometabolic groups. However, there are other cardiometabolic risk factors, such as eating behaviors, an unbalanced diet, smoking, and alcohol consumption, which should be taken into consideration. An internet survey using structural questionnaires has potential sampling and self-reported recall biases. All citizens were welcome to complete the questionnaires, and only one open question of “Do you have any other diseases, besides chronic diseases” was used to screen participants. Young adults with other diseases or mental problems might have been recruited in this study. Only 37.90% of participants had cardiometabolic risk factors, so that small sizes of samples in groups were used to compare PAs, sedentary behaviors, and environmental and psychological differences. Finally, the explanatory power of the final model was not high (16.0%). Future studies should consider other environmental or psychological models as predictors of participation in MVPAs.

Conclusion

This was a case-control study that focused on a population of young adults. Young adults are a target group which is more likely to modify their health behaviors. The results showed higher PAs in healthy adults and lower PAs in those with cardiometabolic risk factors. Environmental and psychological indicators also differed between the healthy control group and case groups. Health beliefs, walkability, and cardiometabolic risk factors influenced individual participation in MVPAs. The results provide information for public health practitioners, health educators, and the government to pay greater attention to young adults' PAs. By overcoming barriers against PAs and decreasing environmental disparities, young adults will have more opportunities to engage in MVPAs. This is important for shaping healthy lifestyles and making MVPAs a necessary part of their daily lives, in order to prevent NCDs and promote well-being in the future.

Declarations

Ethics approval and consent to participate:

All participants signed an informed consent form. Ethical approval was granted by the Research Ethics Committee of National Taiwan University (NTNU-REC 201605HM025).

Consent for publication:

Not applicable

Availability of data and materials:

All data generated or analysed during this study are included in this published article.

Competing interests:

The authors declare that they have no competing interests.

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Authors' contributions:

LC devised the project, the main conceptual ideas and proof outline, and carried out the experiment. HY performed the analytic calculations and contributed to the interpretation of the results. Both LC and HY authors contributed to the final version of the manuscript with discussion.

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