

BMJ Open Associations between cardiometabolic risks and physical activity in early adulthood: a cross-sectional study

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To cite: Yen H-Y, Li C. Associations between cardiometabolic risks and physical activity in early adulthood: a cross-sectional study. *BMJ Open* 2021;**11**:e042668. doi:10.1136/bmjopen-2020-042668

► Prepublication history for this paper is available online. To view these files, please visit the journal online (<http://dx.doi.org/10.1136/bmjopen-2020-042668>).

Received 10 July 2020
Revised 15 April 2021
Accepted 20 April 2021



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ABSTRACT

Objectives Young adults' physical activity (PA) is a foundation of creating future healthy lifestyles. The purpose of this study was to explore differences in PA, sedentary behaviour, walkability and health beliefs among young adults with different levels of cardiometabolic risks and the influence of moderate-to-vigorous PA.

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

Participants Totally, 1149 valid responses were received for a response rate of 86.32%. According to the self-reported worst health condition, participants were categorised into healthy adults, and adults at levels 1 (overweight), 2 (obese), 3 (hypertensive, hyperlipidaemic, and/or hyperglycaemic), and 4 (with a diagnosis of cardiometabolic diseases) of cardiometabolic risks.

Primary outcome measures PA, sedentary time, walkability and health beliefs.

Results Significant differences in PA ($F=3.78$, $p<0.01$) and sedentary time ($F=2.39$, $p<0.05$) among groups with various cardiometabolic risk levels were found. Healthy adults and adults at level 1 risk had significantly higher PA than adults at risk levels 2 and 3. Young adults at risk level 3 were less likely to participate in moderate-to-vigorous PA than were healthy adults (OR=0.64 (95% CI 0.41 to 0.99), $p<0.05$). Individuals who perceived that there were more recreational facilities (OR=1.27 (1.05 to 1.53), $p<0.05$), who had higher benefits of exercise (OR=1.73 (1.30 to 2.31), $p<0.001$), and who had lower barriers to exercise (OR=0.42 (0.32 to 0.55), $p<0.001$) were more likely to participate in moderate-to-vigorous PA.

Conclusions Being aware of body weight changes could be a danger sign of a lack of PA. Developing environmental and psychological strategies to promote engaging in PA is necessary to promote the cardiometabolic health of young adults.

INTRODUCTION

Physical inactivity is the fourth leading cause of death. Individuals who spend lots of time engaged in sedentary behaviours 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 behaviours in order

Strengths and limitations of this study

- Young adults were categorised into five levels of cardiometabolic risks from level 0 (healthy adults) to level 4 (with a diagnosis of cardiometabolic disease).
- In total, 1331 participants responded, for a valid response rate of 86.32%.
- The power of the final model was 16.0% for predicting moderate-to-vigorous physical activity.
- This cross-sectional study can present associations but cannot present cause-and-effect relationships.
- An internet survey has potential sampling and self-reported recall biases and possibly may lack representativeness.

to prevent NCDs, especially cardiometabolic diseases (ie, hypertension, hyperlipidaemia, diabetes and metabolic syndrome). Increasing moderate-to-vigorous PA (MVPA) and decreasing sedentary behaviours are key to preventing NCDs and promoting health. Consistently, integrating MVPA into one's daily life leads to lower prevalence rates and mortality due to cardiometabolic diseases.⁴⁻⁶ Engaging in MVPA and exercise training improves cardiopulmonary function, physical fitness, insulin sensitivity and muscle power, while decreasing the body mass index (BMI).^{7 8} However, even though PA are important in preventing NCDs, 21.4% of people worldwide still engage in an inactive daily lifestyle.⁹

If a decline in PA occurs, the first priority is to identify personal characteristics, the physical environment, and psychological factors.¹⁰ Two main strategies for promoting individuals' MVPA are environmental and psychological.¹¹ Characteristics of the living environment influence residents' behaviour, especially in terms of walkability.¹² Creating a walkable environment is beneficial for pedestrians to increase walking behaviours and recreational PA, with such benefits as friendly neighbours, short distances to recreational facilities, aesthetic views, accessible

infrastructure and a feeling of safety.^{13 14} Walkability is associated with people's PA and sedentary behaviours.¹⁵ People living in an environment with higher walkability might have higher frequencies and longer time of PA.¹⁶ Therefore, high walkability also brings about benefits of lower incidence rates of cardiometabolic diseases through the mediator of MVPA.¹⁷

On the other hand, PA is associated with intrapersonal and interpersonal factors in psychological domains, including socioeconomic, knowledge, attitudes and social interactions.^{18 19} The Health Beliefs Model is often used to explain the psychological domain of health behaviour, 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 PA, 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 behaviours.²⁰ Social relationships with family, friends and neighbours also impact PA self-choices.²¹

The prevalence of engaging in PA in healthy populations also differs from that of populations with chronic conditions.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 time than the healthy control group.²³ Healthy older adults have a higher level of leisure-time PA and shorter sedentary time 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 stages of human psychological development, individuals at the ages of 20–39 years are in early adulthood.²⁵ Young adults, especially those aged 18–45 years, experience many major life changes, such as graduation and marriage. Such life changes impact one's self-identity, self-determination, future lifestyle and long-term health behaviours.²⁶ However, few studies have discussed the relationship of young adults' health behaviours and cardiometabolic diseases. In this population, it is important to identify environmental and psychological risk factors that affect changes in health behaviours.

Young adults' lifestyle and health behaviours form the foundation of creating a lifestyle when they are older. Therefore, the purpose of this study was to explore differences in PA, walkability and health beliefs between healthy young adults and young adults with different levels of cardiometabolic risks, and determine the influence of cardiometabolic risks, walkability and health beliefs on MVPA. The research questions were as follows:

1. Are there any differences in PA, sedentary behaviour, perceived walkability and health beliefs in young adults with different levels of cardiometabolic risk?

2. Are cardiometabolic risks, perceived walkability and health beliefs associated with MVPA?

METHODS

Participants and sampling

A cross-sectional study was conducted from December 2016 to June 2017. The target population was urban residents in early adulthood in Taiwan. Therefore, an internet survey through social media was conducted using Facebook, Instagram, Twitter and various forums. The inclusion criteria of participants were (1) young adults aged 18–45 years, (2) currently living in an urban area and (3) with no physical or mental disability. Participants were required to complete an anonymous questionnaire and consent to participate in the survey.

In the sampling process, 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 in Taiwan were ranked into four levels. Quota sampling was used to recruit 300 participants from each level based on their current address. In total, 1331 people responded, and the valid response rate was 86.32% after excluding participants who did not meet the inclusion criteria. This number of participants satisfied the minimal sample size ($n > 384$) for a population exceeding 10 000 for internet survey research.

Patient and public involvement

Patients or the public were not involved in the design, or conduct, or reporting, or dissemination plans of our research.

Data collection

All outcomes were measured using self-reported data. Participants were required to complete a structured questionnaire composed of four parts to collect data. The first part was their demographic background, including questions of gender, age, educational level (college: associate and bachelor's degree; graduate school: master's and doctoral degree; others), and income. The self-reported current health condition concerned participant's height, weight and two items of cardiometabolic risks. The first item was 'Have you ever found that you have the following health conditions (hypertension, hyperlipidaemia, and/or hyperglycaemic)?' The second item was 'Have you been diagnosed by a doctor to have the following chronic diseases and need treatment or long-term follow-up? (metabolic syndrome, hypertensive diseases, hyperlipidaemia, or type II diabetes)?'

The Physical Activity Neighborhood Environment Survey (PANES)²⁹ was developed to evaluate perceived walkability in neighbourhood environments (walking time of 10–15 min). The inventory includes 17 items with a 4-point Likert scale. According to the scoring guide,³⁰ the score was categorised into several constructs of walkability in a neighbourhood, such as land use mix, safety,

infrastructure, recreational facilities, aesthetics, and so on. The higher the score, the higher the perceived walkability. Cronbach's alpha was 0.72 in this study.

The HBPA³¹ was developed to measure psychological properties of PA according to the Health Beliefs Model. 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. The higher the score, the higher the perceived health beliefs. Cronbach's alpha was 0.92 in this study.

The International Physical Activity Questionnaire (IPAQ) collected participants self-reported PA over the previous 7 days. Participants' PA level (metabolic equivalents of task (MET)-min/week) was calculated in accordance with the scoring protocol. The higher the score, the higher the PA and sedentary time. Participants were also categorised as to whether or not they participated in MVPA, depending on whether their PA met the minimal requirement of MVPA (600 MET-min/week).³²

Data analysis

According to their self-identified current health condition, participants were categorised into one of five levels of cardiometabolic risks. If an individual had more than one health condition of interest, the individual was given a higher level. For example, a participant with a simultaneous BMI of ≥ 27 kg/m², self-reported hypertension, and type II diabetes would be categorised in to level 4 of cardiometabolic risks.

Level 0: healthy young adults with no cardiometabolic risks;

Level 1: young adults with a BMI of 24–27 kg/m²;

Level 2: young adults with a BMI of ≥ 27 kg/m²;

Level 3: young adults who reported hypertension, hyperlipidemia, or hyperglycaemic;

Level 4: young adults who reported at least one diagnosis of metabolic syndrome, hypertensive diseases, hyperlipidemia, or type II diabetes.

Descriptive analyses of all variables were by the mean and SD. A χ^2 test was used to identify associations between demographic background variables and levels of cardiometabolic risks. A one-way analysis of covariance (ANCOVA) with a post-hoc test was used to analyse differences in PA, sedentary behaviour, walkability and health beliefs among adults with different levels of cardiometabolic risks while using covariables of the demographic background. The variance inflation factor of variables ranged 1.05–2.40 without multicollinearity. OR estimates and 95% CIs of demographic background variables, cardiometabolic risks, walkability and health beliefs were obtained from a logistic regression model for predicting whether subjects participated in MVPA. The model included dummy variables for each level of cardiometabolic risk in reference to healthy adults. Nagelkerke R^2

was used as the explanatory power in the logistic regression model.

RESULTS

Demographic background variables and cardiometabolic risks

Details of participants' demographic background are given in [table 1](#). Numbers in the five groups were 713 (62.10%) healthy adults, 113 (11.60%) with level 1 cardiometabolic risks, 68 (5.9%) with level 2 cardiometabolic risks, 150 (13.10%) with level 3 cardiometabolic risks, and 85 (7.40%) with level 4 cardiometabolic risks. Significant associations were found between the frequencies of adults with different levels of cardiometabolic risks and gender ($p < 0.01$), age ($p < 0.01$), educational level ($p < 0.01$), and income ($p < 0.01$). Young adults with level 4 cardiometabolic risks were more frequently male (67.06%), aged 26–45 years (44.70%), with a graduate degree (62.35%), and with an annual income of New Taiwan US\$260 000–500 000 (\approx US\$8700–17 000) (31.76%).

Differences in PA and sedentary behaviours among participants with various cardiometabolic risks

Results of the one-way ANCOVA and post-hoc tests are given in [table 2](#). There was a significant effect of cardiometabolic risks on PA ($F=3.78$, $p < 0.01$) and sedentary time ($F=2.39$, $p < 0.05$) after controlling for gender, age, educational level and income. Post-hoc tests showed that healthy adults and adults at level 1 had significantly higher PA than adults at levels 2 and 3. Post-hoc tests also showed that healthy adults and adults at level 4 had significantly longer sedentary time than the group at level 2.

Differences in walkability and health beliefs among those with cardiometabolic risks

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 ([table 2](#)). For environmental factors, only the residential density was found to significantly differ among young adults with different levels of cardiometabolic risks. Adults at level 4 resided in the lowest density residential areas. The effects of other indicators of walkability were not statistically significant among the different levels of cardiometabolic risks.

As to 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 healthy adults and adults at level 1 was significantly lower than that in adults at levels 2 and 4. Exercise barriers in healthy adults and the group at level 1 were significantly lower than those of groups at levels 2, 3, and 4. The results showed that effects of other indicators of health beliefs

Table 1 χ^2 tests between demographic variables and cardiometabolic risk groups

Level of cardiometabolic risks	Level 0		Level 1		Level 2		Level 3		Level 4		Total		χ^2	P value
	N	(%)	N	(%)	N	(%)	N	(%)	N	(%)	N	(%)		
Demographics														
Gender														
Male	301	(42.22)	77	(57.89)	41	(60.29)	89	(59.33)	57	(67.06)	565	(49.17)	38.3	<0.001
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	<0.001
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	<0.001
Graduate degree	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	<0.001
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)		

Level 0, healthy adults; Level 1, overweight; Level 2, obese; Level 3, self-reported hypertension, hyperlipidaemia, hyperglycaemic; Level 4, a diagnosis of cardiometabolic diseases. College: associate and bachelor's degree; graduate school: master's and doctoral degree. In 2017, the average exchange rate was US\$1.00=New Taiwan (NT) \$30.00.

Table 2 Physical activity (PA), sedentary behaviour (SB), walkability, and health beliefs among cardiometabolic risk levels

Level of cardiometabolic risks	Level 0		Level 1		Level 2		Level 3		Level 4		F	P value	Post-hoc
	Mean	(SD)	Mean	(SD)	Mean	(SD)	Mean	(SD)	Mean	(SD)			
Physical activity (MET-min/week)	1887.71	(67.12)	1901.04	(154.18)	1172.05	(214.28)	1515.73	(146.57)	1600.49	(195.51)	3.78	0.01	0,1>2,3
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	0,4>2
Walkability													
Residential density	0.83	(0.01)	0.79	(0.03)	0.83	(0.05)	0.8	(0.03)	0.69	(0.04)	2.47	0.04	0,2,3>4
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	3.2	(0.03)	3.17	(0.07)	3.35	(0.10)	3.18	(0.07)	3.1	(0.09)	0.96	0.43	
Crime safety	6.19	(0.06)	6.09	(0.13)	6.05	(0.18)	6.11	(0.12)	6.2	(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)	3.2	(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 PA													
Susceptibility to health problems	31.18	(0.34)	31.58	(0.78)	35.4	(1.09)	32.2	(0.74)	34.04	(0.99)	4.87	<0.001	0,1<2,4
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)	22.5	(0.59)	25.4	(0.82)	24.62	(0.56)	25.27	(0.74)	4.9	<0.001	0,1<2,3,4
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	

Level 0, healthy adults; level 1, overweight; level 2, obese; level 3, with self-reported hypertension, hyperlipidaemia, hyperglycaemic; level 4, with a diagnosis of cardiometabolic diseases. Adjusted for gender, age, educational level and income. MET, metabolic equivalent of task.

were no statistically significant, including exercise benefits, cues to action and significant others' support.

Factors of MVPA

The logistic regression results are given in table 3. In model 1, there were significant associations of gender, age, education and cardiometabolic risks with participation in MVPA. Females, older individuals, and those with a lower educational level were less likely to participate in MVPA. There was no significant association with income. Young adults at level 3 had a lower probability of engaging in MVPA than those in the healthy adult group (OR: 0.64 (95% CI 0.41 to 0.99), $p < 0.05$). Demographic background and levels of cardiometabolic risks in the logistic model together accounted for 4.56% of the explanation for the probability of engaging in MVPA.

Model 2 added environmental factors, and this increased the explanatory power of the logistic model to 6.54%. Only one factor of recreational facilities (OR: 1.27 (1.05 to 1.53), $p < 0.05$) had a significant association with MVPA. Individuals who perceived more recreation facilities in a walkable neighbourhood were more likely to participate in MVPA. There were no significant associations with other environmental factors.

Model 3 added psychological factors, and this increased the explanatory power to 15.96% as the final model. Two factor scores had significant associations with MVPA: benefits of exercise (OR: 1.73 (1.30 to 2.31), $p < 0.001$) and barriers to exercise (OR: 0.42 (0.32 to 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 MVPA. No significant associations of susceptibility to health problems, cues to action, or significant others' support were observed in this model.

DISCUSSION

This study focused on adults in early adulthood. The present study found differences in demographic variables, PA and sedentary time among young adults at different levels of cardiometabolic risks. Differences in environmental and psychological factors of perceived residential density, susceptibility to health problems and barriers to exercise were also found among young adults with different levels of cardiometabolic risks. Finally, young adults with level 3 cardiometabolic risks were less likely to engage in MVPA. Recreational facilities, benefits of exercise and barriers to exercise were factors affecting MVPA engagement.

This study found that healthy young adults and young adults at level 1 had higher PA than those with higher levels of cardiometabolic risks. A difference in PA was found between levels 0–1 and 2–3. Most previous studies also showed that healthy control groups had a longer duration and a higher level of PA and more days that they achieved MVPA recommendations than groups with cardiometabolic diseases.²³ The PA level was negatively associated with an individual's number of diagnoses of

chronic diseases.³³ Therefore, it is important to be aware of changes in body weight which could be a danger sign of a lack of PA. However, the present study did not find a difference in PA between healthy adults and those at level 4. Chronic diseases can also be a trigger of changes in PA.³⁴

The study also found that healthy young adults and those at level 4 had longer sedentary time than other risk groups. Previous studies presented no marked differences and did not reach a conclusion about sedentary time between healthy groups and groups with chronic diseases.^{23 34} Healthy young adults have lifestyles with simultaneous high PA and long sedentary time. At this age, there is a balance between PA and sedentary behaviour. But it is possible to develop cardiometabolic risks when lifestyle changes cause an imbalance.⁴ Having cardiometabolic diseases and an inactive lifestyle could threaten the health and future life of young adults. Decreasing sedentary behaviours and increasing PA are both important in delaying pathological processes of current diseases.

Regarding environmental differences among young adult groups, only one indicator of walkability exhibited a significant difference. Young adults at level 4 had the lowest score of perceived residential density. Individuals with cardiometabolic diseases had different insights as to their neighbourhood environment.³⁵ Walkability is a modifiable neighbourhood feature which can promote PA. Overall, PA is an important mediator between the environment and chronic illnesses.¹⁴ Regarding psychological differences among young adults, there were two domains in the HBPA with significant differences. Young adults at levels 2, 3 and 4 were more susceptible to health problems and barriers to exercise than were healthy young adults and those at level 1. A person's health and illness status impacted their health beliefs, especially those with chronic diseases. Patients with chronic diseases are more susceptible to health problem than are healthy adults.^{11 36} Interestingly, a difference in the HBPA was also found between levels 0–1 and 2–4.

The second main purpose of the present study was to determine the influence of cardiometabolic risks, walkability and health beliefs on MVPA. Young adults at level 3 were less likely to participate in MVPA. This study found that gender, age and educational level were associated with MVPA. Previous studies also showed that personal demographic variables, such as age, gender, race and years of education, were associated with chronic risk factors and disease in population-based studies.³³ 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 MVPA. Walkability was associated with residents' leisure-time PA, transportation choices and active lifestyles.³⁷ In model 2, only recreational facilities were a significant predictor of MVPA. The accessibility, distance, density and use of recreation facilities had positive associations with the level of PA in residents.³⁸ A previous study also found that not every indicator of walkability had a direct association

Table 3 Logistic regression of three models in OR for moderate-to-vigorous physical activity (MVPA)

Variable	Model 1			Model 2			Model 3					
	B	SE	OR	95%CI	B	SE	OR	95%CI	B	SE	OR	95%CI
Demographic variable												
Gender	-0.52	0.16	0.59	0.44 to 0.80	-0.50	0.16	0.61	0.45 to 0.83	-0.41	0.17	0.67	0.48 to 0.92
Age	-0.03	0.01	0.97*	0.95 to 0.99	-0.03	0.01	0.97*	0.95 to 1.00	-0.03	0.01	0.97†	0.94 to 0.99
Education	0.37	0.14	1.44†	1.10 to 1.90	0.36	0.14	1.44*	1.09 to 1.90	0.32	0.15	1.38*	1.03 to 1.85
Income	-0.06	0.08	0.95	0.80 to 1.12	-0.08	0.09	0.93	0.78 to 1.09	-0.10	0.09	0.90	0.76 to 1.07
Cardiometabolic risk (reference: Level 0: healthy adults)												
Level 1	0.49	0.27	1.63	0.96 to 2.78	0.46	0.28	1.58	0.92 to 2.71	0.44	0.29	1.55	0.89 to 2.71
Level 2	-0.10	0.35	0.90	0.46 to 1.78	-0.06	0.35	0.94	0.48 to 1.87	0.14	0.36	1.15	0.57 to 2.35
Level 3	-0.45	0.23	0.64*	0.41 to 0.99	-0.48	0.23	0.62*	0.39 to 0.97	-0.37	0.24	0.69*	0.43 to 1.11
Level 4	-0.01	0.24	0.99	0.61 to 1.59	-0.08	0.25	0.92	0.57 to 1.50	0.13	0.26	1.14	0.68 to 1.90
Walkability												
Residential density					-0.33	0.21	0.72	0.47 to 1.10	-0.24	0.22	0.78	0.51 to 1.21
Land use mix					0.01	0.07	1.01	0.88 to 1.15	-0.04	0.07	0.96	0.83 to 1.11
Transit access					0.07	0.08	1.08	0.92 to 1.26	0.06	0.08	1.07	0.91 to 1.25
Pedestrian infrastructure												
Bicycling infrastructure					-0.04	0.06	0.96	0.85 to 1.08	-0.02	0.06	0.98	0.87 to 1.11
Recreational facilities					0.04	0.06	1.04	0.93 to 1.17	0.07	0.06	1.07	0.95 to 1.21
Street connectivity					0.24	0.10	1.27*	1.05 to 1.53	0.23	0.10	1.26*	1.03 to 1.53
Crime safety					-0.08	0.11	0.92	0.74 to 1.15	-0.17	0.12	0.84	0.67 to 1.06
Traffic safety					-0.03	0.06	0.97	0.86 to 1.09	-0.14	0.06	0.87	0.77 to 0.99
Pedestrian safety					0.04	0.06	1.05	0.93 to 1.17	0.00	0.06	1.00	0.89 to 1.12
Aesthetics					-0.04	0.12	0.97	0.77 to 1.21	-0.09	0.12	0.92	0.72 to 1.17
Health beliefs of PA												
Susceptibility to health problems					0.00	0.11	1.00	0.80 to 1.24	-0.01	0.12	0.99	0.79 to 1.26
Benefits of exercise												
Barriers to exercise									0.03	0.11	1.03	0.83 to 1.29
Cues to action									0.55	0.15	1.73‡	1.30 to 2.31
Significant others' support									-0.86	0.14	0.42‡	0.32 to 0.55
Nagelkerke R ²	4.56%				6.54%				15.96%			

Dependent variable: MVPA; level 0, healthy adults; level 1, overweight; level 2, obese; level 3, with self-reported hypertension, hyperlipidaemia, or hyperglycaemic; level 4, with a diagnosis of cardiometabolic diseases.

*P<0.05.

†P<0.01.

‡P<0.001.

PA, physical activity.

with PA or the risk of cardiometabolic diseases.³⁹ In model 3, the benefits of exercise and barriers to exercise were important factors in MVPA engagement. Benefits of exercise were positively associated with MVPA. In contrast, barriers to exercise were negatively associated with MVPA.³⁶ HBPA is a motivation to increase PA participation. Previous studies also showed that indicators of health beliefs significantly predicted the odds of MVPA or achievement of minimal PA requirements.^{11 40} Once individuals perceive more benefits of than barriers to exercise, they are more likely to engage in MVPA.⁴¹

When indicators of HBPA were added to the model of demographic variables and walkability, the explanatory power increased 9.5% to reach 16%. Young adults' thoughts were associated with their PA. Therefore, it is important to increase MVPA 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 PA and overcome barriers to exercise. MVPA can become a part of one's lifestyle that is beneficial for preventing cardiometabolic diseases and promoting health in their future lives.

There are some limitations in this study. First, this was a cross-sectional study which only focused on PA and cardiometabolic groups. The associations could not represent cause-and-effect relationships between variables. Second, the internet survey using structured questionnaires we conducted has potential for sampling and self-reported recall biases. All citizens were welcomed to complete the internet survey. The sample might have lacked representativeness of the population. Third, only 37.9% of participants had cardiometabolic risks, so small sample sizes of groups were used to compare differences. Also, participants were categorised into levels 2 and 3 because the BMI can be monitored simply at home by participants themselves, but hypertension, hyperlipidaemia and hyperglycaemia can only be measured by specific instruments. However, levels 2 and 3 were both cardiometabolic risk factors in previous studies. Finally, the explanatory power of the final model was still not high (16.0%). There are still other factors that influence PA, such as other diseases, an unhealthy lifestyle, immigration, healthcare costs, community settings, air pollution and public policies,⁴² which should be taken into consideration in future studies.

CONCLUSIONS

This was a cross-sectional study that focused on associations of adults' PA with cardiometabolic risks in early adulthood. Results found higher PA and lower sedentary time in healthy adults than those with cardiometabolic risks. A difference in PA was found between levels 0–1 and 2–3, and between participants who were overweight and those who were obese. Level 3 cardiometabolic risks, perceived recreational facilities, benefits of exercise, and barriers to exercise were associated with participation in

MVPA. The present study provides information on young adults' PA to which public health practitioners, health educators and the government should pay greater attention. By overcoming barriers against PA and decreasing environmental disparities, young adults will have more opportunities to engage in PA. Shaping an active lifestyle is important for young adults' future well-being.

Contributors HYY: data curation; methodology; software; validation; formal analysis; visualisation; and writing. CL: conceptualisation; writing; project administration; and funding.

Funding This work was supported by the Ministry of Science and Technology, Taiwan under grant no. [NSC-105-2410-H-003-049].

Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not required.

Ethics approval Ethical approval was granted by the Research Ethics Committee of National Taiwan Normal University (NTNU-REC 201605HM025).

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available upon reasonable request.

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