A Causal Model of Physical Activity Among People with Acute Coronary Syndrome After Percutaneous Coronary Intervention: A Cross-sectional Study

Thayuta Inkaew, Tipaporn Wonghongkul, Chiraporn Tachaudomdach, Chomphoonut Srirat*

Abstract: Physical activity is considered a fundamental component of cardiac rehabilitation programs and is recommended to improve the secondary prevention outcomes of people with acute coronary syndrome after percutaneous coronary interventions. However, the physical activity levels of this population are often low. Most research studies have primarily focused on older populations and chronic diseases. This descriptive cross-sectional study aimed to test a causal model of physical activities among adults based on the Health Action Process Approach. Four hundred twenty-four people were recruited using multi-stage sampling from the outpatient departments of seven tertiary hospitals in Thailand. Data were collected using a demographic data form, the International Physical Activity Questionnaire-Long form, the Self-Efficacy Questionnaire, the Outcome Expectation Questionnaire, the Risk Perception Questionnaire, the Behavioral Intention Questionnaire, the Planning Questionnaire, and the Action Control Questionnaire. Data were analyzed using descriptive statistics and structural equation modeling with Mplus software.

The findings of our study hold significant promise for patient care. The model we tested, which accounted for 46% of the physical activity variance, underscores the crucial role of self-efficacy, planning, and action control in directly influencing physical activity. Notably, self-efficacy was found to exert the most profound effect. Outcome expectation was shown to influence physical activity indirectly through intention and planning. This highlights the potential for nurses to design interventions that foster self-efficacy, planning, and self-regulatory strategies. These strategies can empower patients to overcome challenges in cardiac rehabilitation and maintain physical activities, thereby improving their health outcomes. However, it is important to stress that our proposed intervention should be rigorously tested for effectiveness before implementation.

Keywords: Acute coronary syndrome, Causal model, Health Action Process Approach, Percutaneous coronary intervention, Physical activity, Self-efficacy, Self-regulation

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Introduction

Acute coronary syndrome (ACS), which encompasses heart attacks with and without ST-segment changes (ST-elevated myocardial infarction:

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STEMI and non-ST elevated myocardial infarction: NSTEMI) and unstable angina, is a significant global health threat due to its high risk of death and disability. According to an American Heart Association report, the number of inpatient hospital discharges with ACS rose from 1,266,000 in 2019 to 1,278,385 in 2020.[1,2] Of these, 1,262,265 were people with myocardial infarction (MI), and 16,120 were people with unstable angina.[2] In Thailand, the number of people with ACS (PW-ACS) in 2022 was 15,740, and the mortality rate of ACS with STEMI in hospitals was 9.05%.[3] Revascularization, especially percutaneous coronary intervention (PCI), is recommended for treating ACS because this procedure can improve blood flow within a coronary artery for symptom relief in patients with angina and prognosis improvement and prevent myocardial infarction, cardiac death, and death.[4,5] However, to prevent the recurrence of cardiac issues after PCI, all patients must undergo cardiac rehabilitation.[4]

Physical activity encompasses any bodily movement triggered by skeletal muscles that increases energy consumption[1]; it was recommended to be performed as a standard of activity in phases II and III of cardiac rehabilitation among PW-ACS who have undergone PCI after discharge from the hospital within one year.[4,6] PW-ACS in phase II must perform physical activity more than or equal to five metabolic equivalents (METs). In contrast, without abnormal symptoms, PW-ACS in phase III can perform physical activity for at least eight METs.[6] However, several studies indicated that PW-ACS receiving PCI had low physical activity levels.[6-8] Low physical activity in PW-ACS after PCI could lead to negative consequences, including increased MI,[9] increased readmission within one year,[10] worse long-term outcomes,[11] increased mortality rate,[9,11] and low survival rate.[11] Therefore, promoting physical activity is essential for PW-ACS after PCI. This requires an understanding of the factors affecting their physical activity levels. Understanding the multiple factors and their causal mechanism of physical activity is crucial to developing specific strategies for promoting physical activity in this population.

Conceptual Framework and Review of Literature

The Health Action Process Approach (HAPA) is a health behavior change theory focusing on an individual's action initiation and action maintenance as the outcome.[12] The HAPA, which Schwarzer developed, proposes a difference between the two phases: firstly, the motivation phase, where individuals intend to engage in a specific behavior, and secondly, the volition phase, during which people act on their intention.[12] According to HAPA, a person's final behavior is determined by a combination of factors: self-efficacy, outcome expectation, risk perception, intention, planning, and action control. Risk perception, outcome expectations, action self-efficacy, and intention were included in the motivation phase. In contrast, action and coping planning, action control, and coping and recovery self-efficacy were all part of the volition phase.[12,13] This study adopted HAPA as its conceptual framework to investigate the causal relationships influencing physical activity.

Self-efficacy is an individual's confidence in their ability to manage and perform the necessary actions to achieve specific goals or attainments.[14] Based on the HAPA, self-efficacy reflects an individual's perceived control over their conditions and ability to influence desired outcomes.[13] Schwarzer divided self-efficacy into action, coping, and recovery.[13] Due to its cross-sectional nature, motivational and volitional aspects of self-efficacy could not be separated. Consequently, a single self-efficacy factor encompasses action, coping, and recovery. Prior research has established a significant, positive association between self-efficacy and physical activity engagement in PW-ACS with and without PCI.[15,16] In addition, self-efficacy directly affects intention and planning among people with coronary artery disease (CAD),[17] hypertension (HTN),[17,18] type 2 diabetes (DM),[19] and survivors of colorectal and endometrial cancer.[20]

Outcome expectations represent an individual's thoughts about behavior contingencies with subsequent outcomes.[21] According to the HAPA, outcome expectation affects action initiation and maintenance through intention.[13] Individuals need to develop the capacity to modify their behavior in response to the probabilistic relationship between their actions and possible consequences and an awareness of health risks.[12] Previous research demonstrated a positive correlation between outcome expectations and physical activity in people with CAD[22] and HTN.[18] In addition, outcome expectation could predict intention factor in people with CAD,[17,22] HTN,[18] and DM.[19]

Risk perception is the subjective assessment of one's vulnerability to a particular health issue, including the perceived likelihood and severity of that threat.[21] The HAPA framework states that the most evident requirement for the incentive to abstain from risky activity is the perception of a health threat.[23] Past studies revealed that risk perceptions could predict the intentions to perform physical activity among people with HTN[18] and survivors of colorectal and endometrial cancer.[20] In contrast, a longitudinal survey with 6-month and 12-month follow-ups investigating patients with CAD and HTN revealed that the risk perception factors did not significantly predict intention in physical activity.[17]

Intention, a conscious decision to act, reflects the direction and strength of someone's motivation toward a goal.[21] When individuals create specific activity stages and foresee probable obstacles while taking on a challenging assignment, there is a natural and measurable increase in the likelihood that their good intentions will materialize into tangible actions.[14] They must plan their goals with an execution-friendly strategy in place. The primary tactic for deciding how to distribute intentions is planning. Previous studies showed that intention was correlated with physical activity in people with CAD[22] and survivors of breast cancer.[24] In addition, the intention was associated with planning in people with CAD,[17] HTN,[17,18] and DM[19] and indirectly influenced physical activity engagement through planning in people with HTN.[17]

Planning in the HAPA is usually subdivided into two dimensions: action planning and coping planning. Action and coping plans are viewed as direct agents that impact behavior; they serve as separate intermediaries that enhance the probability that intentions will materialize into actions.[12] Beyond only intentions, planning includes the how, where, and when of achieving a goal. Previous studies illustrated that planning was correlated and predicted with physical activity among people with CAD,[22] DM,[25] and survivors of breast cancer.[24]

Action control entails utilizing self-regulatory techniques to support the ongoing maintenance of behavior. Monitoring and regularly assessing one's behavior in relation to behavioral standards is required.[12] Self-monitoring tools like diaries and calendar-based checklists are frequently used in action control systems. By raising awareness of behavioral shifts, these techniques help people either maintain their positive actions or, in cases when they need to, adopt new strategies.[12] Previous studies found that action control was correlated with physical activity among people with cardiovascular disease (CVD)[26] and DM.[27] In addition, action control emerged as the most potent form of physical activity in people with CAD with and without PCI during cardiac rehabilitation phases II and III.[22]

In conclusion, the existing literature has identified several factors associated with physical activity among PW-ACS after PCI: self-efficacy, outcome expectation, risk perception, intention, planning, and action control. Notably, most previous research has primarily focused on adult and geriatric populations aged 31-84, with limited exploration of the connections between all these factors within the HAPA framework. Consequently, knowledge gaps remain regarding the intricate interplay of influencing factors and their pathways to physical activity within the Thai context, specifically among adults with ACS after PCI.

Study Aim

This study aimed to test a physical activity model and examine the direct and indirect effects of self-efficacy, outcome expectation, risk perception, intention, planning, and action control on physical activity among Thai adults with ACS after PCI. The hypothesized model is illustrated in **Figure 1.**

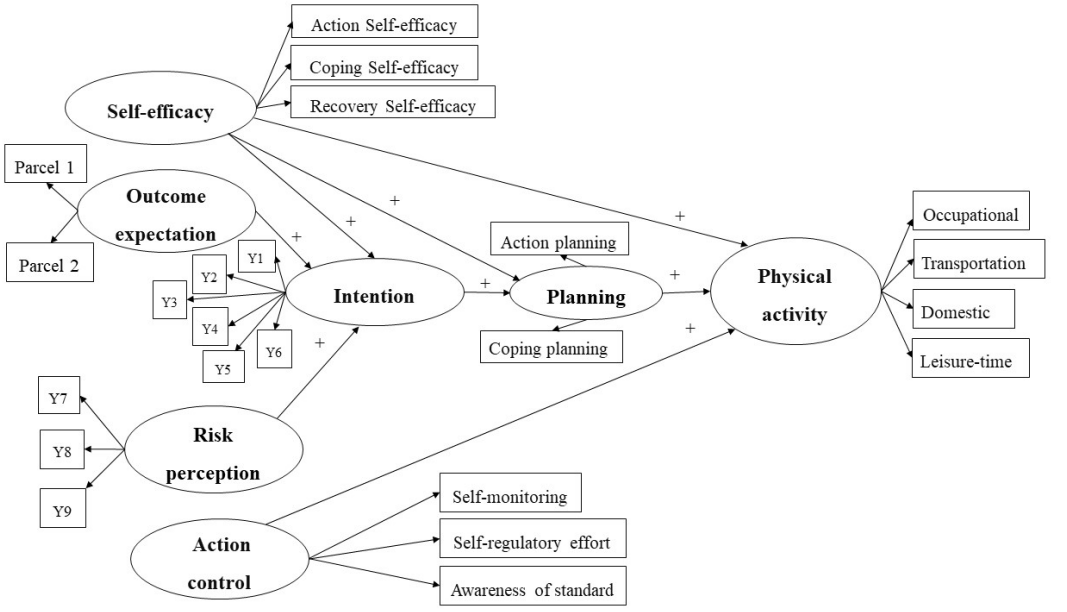


Figure 1. The hypothesized model of physical activity among PW-ACS after PCI

Note. ⬭ is latent variables; ▭ is observed variables; Y1-Y6 are items of intention; Y7-Y9 are items of risk perception; Parcels 1-2 are dimensions of outcome expectation.
This model does not incorporate the direct effect of outcome expectation and risk perception on physical activity reported in the literature review (Because this study focuses on testing the HAPA model).

Methods

Design: This study used a cross-sectional model testing design, and this report follows the STROBE guideline for cross-sectional studies.

Sample and Setting: The population of this study was PW-ACS who had undergone PCI and visited a medical clinic at an outpatient department in tertiary care hospitals in Thailand. This study's sample size was determined for structural equation modeling (SEM) by the commonly applied rule of thumb of five participants per model parameter.[28] In this study, the hypothesized model contained 77 free parameters (11 measurement errors, 23 intercepts, 16-factor loadings, four variances, 12 residuals, three residuals from the prediction of endogenous latent variables, and eight regression coefficients); thus, there were 385 subjects. A 10% sampling allowance (39 participants) was determined for attrition and missing data.[28] Therefore, this study requires a sample size of 424 participants.

This research employed a multi-stage random sampling method[29] with purposive sample selection.[30] The cluster method was used to select regions within Thailand. Tertiary hospitals in the northern, central,

northeastern, eastern, and southern regions were randomly chosen. Subsequently, seven tertiary hospitals were selected, and participants within each hospital were then selected using proportionate sampling. Since each hospital served 3,444 patients in 2020, the primary investigator (PI) calculated the number of participants from each of the seven hospitals by multiplying the total sample size (424 participants) by the percentage of patients each hospital served and dividing the result by the total number of patients (3,444) served by all seven hospitals. This resulted in sample sizes of 56, 65, 74, 50, 75, 60, and 44 participants for each facility, respectively (**Figure 2**).

These people were recruited based on the inclusion criteria that they were aged 18-60 years; diagnosed with ACS and received PCI; post-hospitalized for two months to one year; and were classified with severity of symptoms (Functional Class I: no limitations during activities, Functional Class II: slight limitations during usual activities, and Functional Class III: marked limitations during less than usual activities).[31] Further inclusion criteria were being able to perform activities of daily living independently, being willing to participate, and being able to read and write the Thai language. Exclusion criteria were people with heart failure and those who received treatment with a coronary artery bypass graft.

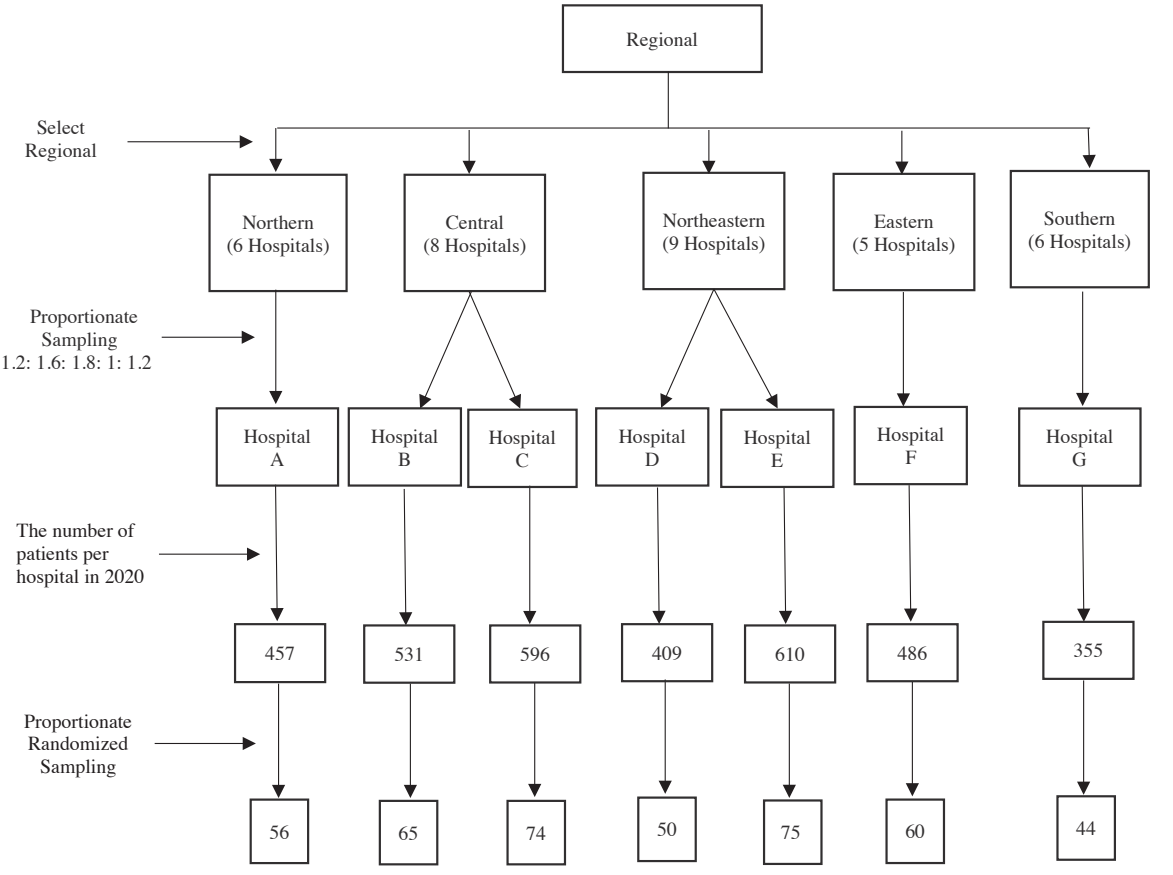


Figure 2. Multi-stage random sampling of this study

Ethical Considerations: Study approval was obtained from the Research Ethics Committee, Faculty of Nursing, Chiang Mai University (Research ID: 043/2565; Study Code: 2565-EXP025) and the institutional review boards of eight hospitals (one for the pilot study and seven for the main study). All eligible participants received verbal and written information about the study process, voluntary involvement, preservation of their right to confidentiality and anonymity, and the right to withdraw without repercussion. Written consent was obtained from each participant.

Instruments: The eight instruments used in this study were a demographic data form developed by the PI, the IPAQ Questionnaire (Thai version), the Self-Efficacy Questionnaire, the Outcome Expectation Questionnaire, the Risk Perception Questionnaire, the Behavior Intention Questionnaire, the Planning Questionnaire, and the Action Control Questionnaire. The latter six instruments were obtained from the authors with permission to translate from German into Thai. Two bilingual experts translated the questionnaire from German to Thai using a rigorous back-translation method.[32] In addition, six experts tested the content validity for all six instruments. The expert team included a cardiologist, a physician of rehabilitation, a physical therapist, a cardiology nursing lecturer, a research instrument nursing lecturer, and a cardiology advanced practice nurse. The scale-level CVI of each instrument was 1. The details of the instruments are as follows:

The Demographic Data Form collected data on age, gender, income, married status, educational level, multimorbidity, severity of disease using Functional Class, the type of PCI, duration of PCI, complication of PCI, and phase of cardiac rehabilitation.

The International Physical Activity Questionnaire-Long form (IPAQ-L) (Thai version) was modified and translated into Thai by Leethong-in et al.[33] The IPAQ-L has five domains consisting of 27 items, including 1) the occupational domain (seven items), 2) the transportation domain (six items), 3) the domestic domain (six items), 4) the leisure-time domain (six items), and 5) the time spent sitting (two items). Each item is an open-ended question about each activity's duration (minute and hour) and frequency (days). An example of an item was, "During the past seven days, how many days have you spent doing work that required heavy physical exertion, such as lifting heavy objects, digging, construction work, or walking up many flights of stairs for at least 10 minutes?" The total duration score is summed up from only 22 items. The rest of the five items are not calculated because they do not represent physical activity (one item from the occupational domain, two from the transportation domain, and two from the time spent sitting domain). The duration and frequency of activities from twenty-two items were transformed from minutes to MET (minute/week). Scores are classified into three categories: low level ≤ 600 METs-mins/week, moderate level 600-3,000 METs-mins/week, and high level ≥ 3000 METs-mins/week. The 2-week test-retest reliability for the pilot study was 0.90.

The Self-Efficacy Questionnaire was modified by Scholz et al.[34] based on the HAPA. It measured participants' confidence levels regarding their capacity to engage in physical activity. The 10-item consists of the following three dimensions: action self-efficacy (three items), coping self-efficacy (four items), and recovery self-efficacy (three items), which are all positive items. An example question was, "I am confident that I can do physical activity following the advice of medical personnel." This 4-point Likert scale (1 = not at all true, 4 = exactly true) measures agreement with physical activity confidence statements. The score ranges from 10-40, with a higher score indicating higher perceived confidence in participating in physical activity. Internal consistency and reliability of the instrument were investigated using Cronbach's alpha. The pilot and actual studies yielded scores of 0.88 and 0.89, respectively.

The Outcome Expectation Questionnaire was modified by Sniehotta et al.[35] based on the HAPA. It was used to evaluate outcome expectancy regarding

physical activity. This questionnaire has two subscales and consists of eight items, including 1) parcel 1 (four items included daily life, health, illness, and preventing heart failure) and 2) parcel 2 (four items included quality of life, HTN, body weight, and dyslipidemia), which are all positive items. An example of an item was, "If I have physical activity regularly, my daily life will be more balanced." This 4-point Likert scale (1 = not at all true, 4 = exactly true) measures agreement with physical activity outcome expectation statements. The score ranges from 8-32, with a higher score indicating higher perceived anticipated benefits from participating in physical activity. Internal consistency and reliability of the instrument were investigated using Cronbach's alpha. The pilot and actual studies yielded scores of 0.87 and 0.89, respectively.

The Risk Perception Questionnaire was modified by Sniehotta et al.[36] It was used to assess the risk perception for performing physical inactivity. This questionnaire has three items, which are all positive. An example of an item was, "If I live my daily life as before the acute treatment, I may have heart problems in the future." This 4-point Likert scale (1 = not at all true, 4 = exactly true) measures agreement with physical inactivity risk perception statements. The score ranges from 3 to 12, with a higher score indicating a high-risk perception for performing physical inactivity. Internal consistency and reliability of the instrument were investigated using Cronbach's alpha. The pilot and actual studies yielded scores of 0.79 and 0.95, respectively.

The Behavior Intention Questionnaire was modified by Sniehotta et al.[36] based on the HAPA. It measured intention for physical activity. This questionnaire has six items, all of which are positive. An example of an item was, "I intend to continue to be as active as I have been during my recovery." This 4-point Likert scale (1 = not at all true, 4 = exactly true) measures agreement with physical activity statements. The score ranges from 6 to 24, with a higher score indicating a strong interest in being physically active. Internal consistency and reliability of the instrument were investigated using Cronbach's alpha. The pilot and actual studies yielded scores of 0.84 and 0.86, respectively.

The Planning Questionnaire was modified by Sniehotta et al.[36] based on the HAPA. It was used to evaluate planning for physical activity. The 9-item consists of the following two dimensions: action planning (four items) and coping planning (five items), all positive items. An example of an item was, "I have clearly planned when I will be physically active." This 4-point Likert scale (1 = not at all true, 4 = exactly true) measures agreement with physical activity planning statements. The score ranges from 9 to 36, with a higher score indicating an increased propensity for physical activity planning. Internal consistency and reliability of the instrument were investigated using Cronbach's alpha. The pilot and actual studies yielded scores of 0.91 and 0.94, respectively.

The Action Control Questionnaire was modified by Sniehotta et al.[35] based on the HAPA. It was used to evaluate the self-regulatory strategy of physical activity engagement. The 6-item consists of the following three domains: self-monitoring (two items), awareness of standards (two items), and self-regulatory effort (two items), which are all positive items. An example of an item was, "Over the past four weeks, I did everything I could to follow the prescribed physical activity plan." This 4-point Likert scale (1 = not at all true, 4 = exactly true) measures agreement with self-regulatory strategy statements for physical activity. The score ranges from 6 to 24, with a higher score indicating a stronger tendency to use vigorous self-regulation in physical activity. Internal consistency and reliability of the instrument were investigated using Cronbach's alpha. The pilot and actual studies yielded scores of 0.91 and 0.88, respectively.

Data Collection: Data collection for this study spanned from November 2022 to April 2023 by the PI and seven research assistants (RAs) who were registered nurses with experience in taking care of PW-ACS after PCI and worked at the outpatient

department in a research setting. The PI conducted the following steps in the training process: gathering data, obtaining informed consent, and selecting an appropriate sample. The RAs in each hospital gathered information on their own. Participants who fulfilled the requirements were contacted, and an invitation was extended. After agreeing to participate, they were asked to sign a consent form and were invited to a private room in the outpatient department unit to complete the surveys. Responding to the questionnaires took 60-90 minutes, and the participants were free to discontinue at any point if they felt fatigued or had to see a doctor. After the participants completed the questionnaire, they were thanked for their time and given 100 Baht (3 USD) to show their appreciation for their participation.

Data Analysis: The data were analyzed using the SPSS version 20.0 and Mplus software version 8.10. Descriptive statistics were used to analyze participants' characteristics, and Pearson's correlation coefficients were utilized to evaluate the bivariate relationships between all study variables. Before applying SEM, the study rigorously evaluated crucial statistical assumptions: the presence of missing data, potential outliers, normality of the data, linearity of relationships, homoscedasticity, and multicollinearity. Notably, none of the assumptions were found to be significantly violated. The hypothetical model was tested with a maximum likelihood estimation method to evaluate a good overall model fit. Assessment of a model's overall fit relies on five key indicators: relative chi-square (χ^2/df) ≤ 3, root mean square error of approximation (RMSEA) ≤ 0.08, comparative fit index (CFI) and Tucker-Lewis index (TLI) ≥ 0.90, and standardized root mean square residual (SRMR) < 0.10.[37]

Results

Participants' characteristics

Of the 424 participants, most were male (n = 301, 71.00%) and married (n = 313, 73.28%). The participants were between 23 and 60 years old, averaging 53.6 (SD = 6.61). Almost half had completed elementary school, and 23.35% (n = 99) had a monthly income between 5,001 and 10,000 baht (152 to 303 USD). For health status, most of them had multimorbidity (n = 341, 80.40%) and HTN (n = 244, 71.55%). About half had the severity of the disease assessed by Functional Class I (n = 250, 58.96%) and underwent PCI by the Balloon method (n = 184, 43.40%). The duration since receiving PCI varied from 2 to 12 months, with a mean of 5.69 (SD = 3.67). Most participants did not experience complications after PCI (n = 384, 90.10%). Additionally, the numbers of participants in cardiac rehabilitation phases II (n = 204, 48.10%) and phase III (n = 220, 51.90%) were quite similar.

Descriptive characteristics of study variables

As shown in **Table 1**, the average scores of the study variables were 8,385.48 (SD = 10,895.16) for physical activity, 30.77 (SD = 3.89) for self-efficacy, 25.62 (SD = 4.04) for outcome expectation, 8.21 (SD = 2.74) for risk perception, 17.39 (SD = 3.36) for intention, 27.29 (SD = 4.57) for planning, and 17.82 (SD = 2.95) for action control.

Table 1. Means and standard deviations of the study variables (n = 424)

Variables	Range	Mean	SD
Self-efficacy	18-40	30.77	3.89
Outcome expectation	14-32	25.62	4.04
Risk perception	3-12	8.21	2.74
Intention	6-24	17.39	3.36
Planning	14-36	27.29	4.57
Action control	11-24	17.82	2.95
Physical activity	0-63,642	8,385.48	10,895.16

Note. SD = Standard deviation

Correlation coefficients of study variables

As noted in **Table 2**, outcome expectation (r = 0.22, p < .01), risk perception (r = 0.11, p < .05), and intention (r = 0.23, p < .01) had low positive relationships with physical activity. Planning (r = 0.34, p < .01) and action control (r = 0.41, p < .01) had moderate positive relationships with physical activity, while self-efficacy (r = 0.52, p < .01) had a high positive relationship with physical activity.

Table 2. The correlation coefficient matrix of the study variables (n = 424)

Variables	1	2	3	4	5	6	7
1. Self-efficacy (SF)	1.00						
2. Outcome expectation (OE)	0.34**	1.00					
3. Risk perception (RP)	-0.01	0.33**	1.00				
4. Intention (IN)	0.32**	0.44**	0.20**	1.00			
5. Planning (PL)	0.41**	0.26**	-0.01	0.29**	1.00		
6. Action control (AC)	0.44**	0.36**	0.11*	0.52**	0.36**	1.00	
7. Physical activity (PA)	0.52**	0.22**	0.11*	0.23**	0.34**	0.41**	1.00

Note. * p < .05, ** p < .01

Model testing

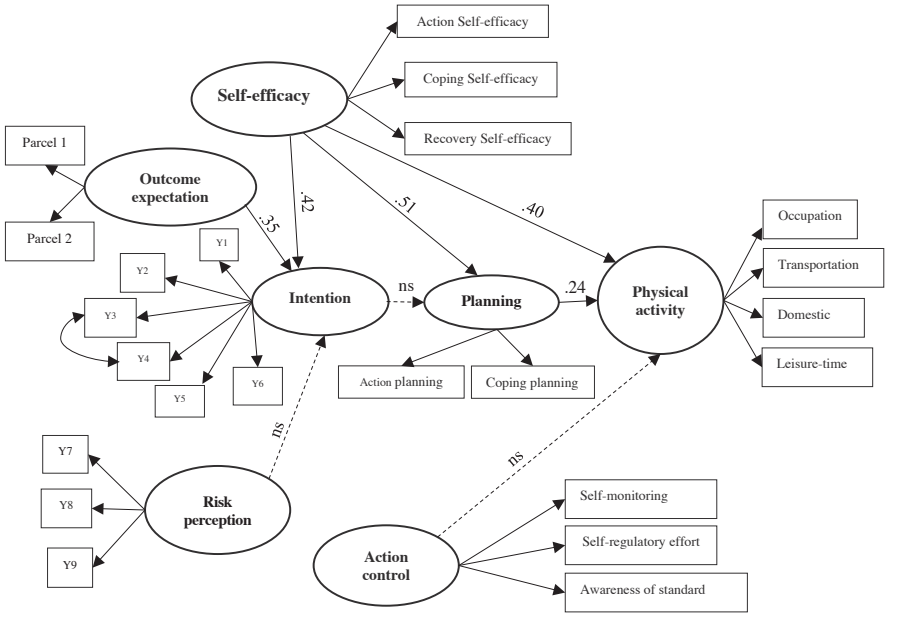
An investigation into the construct validity of the measurement models was conducted using confirmatory factor analysis (CFA). The results showed that each of the seven variables had an acceptable model fit, supporting construct validity consistent with the HAPA framework (**Table 3**). Then, the structural model was tested, and the results showed that the initial hypothesized model did not adequately fit the empirical data on risk perception, intention, and action control (**Figure 3**). Therefore, the PI incorporated modification indices by adding a total of 15 new paths (Parcel 1 and Parcel 2 attribute, leisure-time and transportation attribute, awareness action control and Parcel 2 attribute, leisure-time and occupation attribute, Y5 and Y2 attribute, Y3 and Y2 attribute, action and recovery self-efficacy attribute, occupation and Y4 attribute, Y2 and Parcel 2 attribute, Y6 and Y2 attribute, awareness action control and Y2 attribute, action and coping self-efficacy attribute, monitoring action control and action self-efficacy attribute, and occupation and Y8 attribute). The result in the final model showed a fit with the empirical data (**Figure 4**). Although the p-value did not meet the criterion (**Figure 4**), it is acceptable since it is sensitive to sample size; it typically decreases the p-value when it is significant.[38]

Table 3. The goodness-of-fit indices statistics of variables in confirmatory factor analysis

Goodness-of-fit indices	Variables						
	SF	OE	RP	IN	PL	AC	PA
χ^2	0.000	0.000	0.000	1.242	0.000	0.000	1.282
Degree of freedom	0	-1	0	2	-1	0	1
p-value	< .001	< .001	< .001	0.537	< .001	< .001	0.257
χ^2/df	0.000	0.000	0.000	0.621	0.000	0.000	1.282
RMSEA	0.000	0.000	0.000	0.000	0.000	0.000	0.026
CFI	1.000	0.996	1.000	1.000	0.996	1.000	0.999
TLI	1.000	1.00	1.000	1.000	1.000	1.000	0.995
SRMR	0.000	0.000	0.000	0.004	0.000	0.000	0.008

Note. Self-efficacy (SF), Outcome expectation (OE), Risk perception (RP), Intention (IN), Planning (PL), Action control (AC), Physical activity (PA)

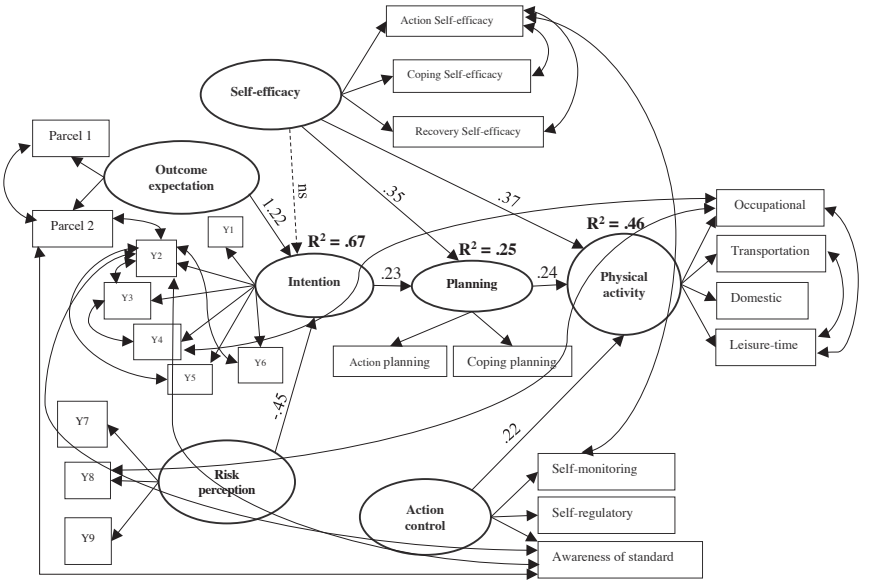
χ^2 = Chi-square, χ^2/df = relative chi-square, RMSEA = Root Mean Square Error of Approximation, CFI = Comparative Fit Index, TLI = Tucker-Lewis Index, SRMR = Standardized Root Mean Square Residual



→ = significant pathway, - - - →, ns = non-significant pathway, ↷ = added correlation paths

Figure 3. The first model modification of physical activity among PW-ACS after PCI

Note. Result of goodness of fit indices: Chi-square (χ^2) = 881.658, Degrees of freedom = 215, p-value < 0.001; The relative Chi-square (χ^2/df) = 4.10, Comparative Fit Index (CFI) = 0.880, Tucker-Lewis Index (TLI) = 0.859, Root Mean Square Error of Approximation (RMSEA) = 0.086, Standardized Root Mean Square Residual (SRMR) = 0.085



→ = significant pathway, - - - →, ns = non-significant pathway, ↷ = added correlation paths

Figure 4. The final model modification of physical activity among PW-ACS after PCI

Note. Result of goodness of fit indices: Chi-square (χ^2) = 577.962, Degrees of freedom = 200, p-value < 0.001; The relative Chi-square (χ^2/df) = 2.87, Comparative Fit Index (CFI) = 0.932, Tucker-Lewis Index (TLI) = 0.915, Root Mean Square Error of Approximation (RMSEA) = 0.067, Standardized Root Mean Square Residual (SRMR) = 0.067

In the final model (**Table 4**), three predicting variables, including self-efficacy, planning, and action control, explained 46% of the variance in physical activity. Self-efficacy ($\beta = 0.37$, $p < .001$) was the most potent positive effect on physical activity among PW-ACS after PCI, followed by planning ($\beta = 0.24$, $p < .01$), and action control ($\beta = 0.22$, $p < .01$).

Table 4. The causal effects for the final model of physical activity among PW-ACS after PCI (n = 424)

Variables	R^2	Independent variables	DE	IE	TE
PA	0.46	SF	0.37***	0.06*	0.43***
		PL	0.24**	-	0.24**
		AC	0.22**	-	0.22**
		OE	-	0.07*	0.07*
		RP	-	-0.02	-0.02
		IN	-	0.05*	0.05*
PL	0.25	SF	0.35***	-	0.35***
		IN	0.23***	-	0.23***
IN	0.67	SF	-0.38	-	-0.38
		OE	1.22***	-	1.22***
		RP	-0.45*	-	-0.45*

Note. Physical activity (PA), Self-efficacy (SF), Planning (PL), Action control (AC), Outcome expectation (OE), Risk perception (RP), Intention (IN), Direct effect (DE), Indirect effect (IE), Total effect (TE)
* $p < .05$, ** $p < .01$, *** $p < .001$

Discussion

Overall, our findings confirmed the HAPA theory, in which self-efficacy, planning, and action control directly affect physical activity; self-efficacy and intention indirectly affect physical activity through planning, and outcome expectation indirectly affects physical activity through intention and planning. However, self-efficacy and risk perception were found not to indirectly affect physical activity through intention and planning.

Results supporting the hypothesized model

Self-efficacy directly affected physical activity among PW-ACS after PCI and indirectly affected physical activity through planning. A possible rationale is that patients with increased self-efficacy feel more capable, making them more likely to engage in healthy behaviors and work towards achieving their goals.[39] Among PW-ACS undergoing PCI, those with higher confidence in their ability to engage in physical activity are more likely to craft comprehensive strategies for setting activity-based goals, thereby leading to their participation in physical activity. This was consistent with previous studies demonstrating that self-efficacy directly affected physical activity among people with HTN[18] and DM,[19] and it showed a significant indirect effect through planning among people with CAD and HTN.[17]

Planning directly promoted physical activity: mediating the influence of factors like self-efficacy, outcome expectation, and intention. Planning for physical activity can be more effective when individuals consider potential obstacles upfront. This involves scheduling when, where, and how they will optimally perform the desired behavior and anticipating the difficulties and barriers that might hinder their success.[23] Anticipating these situations, they develop possible alternative methods and responses, ultimately enabling them to remain on track as desired.[12] PW-ACS after PCI establish goals by identifying when, where, and how to engage in physical activities and by developing a plan to address potential issues that may arise during

physical activities. The current results align with existing literature, which showed that planning emerged as the significant predictor of the physical activity engagements of people with DM[25] and cancer survivors.[20,24]

Action control directly affected physical activity among PW-ACS after PCI. Action control represents a self-regulatory mechanism characterized by continually assessing ongoing behavior relative to established standards.[12] PW-ACS will increase or maintain their physical activity by implementing strategies for monitoring and self-assessing their activity during each phase of cardiac rehabilitation. This result confirmed previous studies, which showed that action control strongly affected physical activity in people with CAD with or without PCI[22] and DM.[27]

Intention indirectly affected physical activity via planning. HAPA posits that individuals' intentions to engage in behavior are more likely to translate into actual behavior when accompanied by detailed planning, positive self-imagery of success scenarios, and preparatory strategies for overcoming potential obstacles.[13] Among PW-ACS after PCI, those with the willingness and capability to participate in physical activity are likelier to engage in such activities. This study, similar to a previous one, revealed that intention significantly indirectly affected physical activity through planning in people with HTN.[17]

Outcome expectation indirectly affected physical activity through intention and planning. This finding supports the HAPA framework in that people must be aware of health risks and know how to adjust their behavior in response to the probabilistic relationship between their actions and possible consequences.[13] PW-ACS after PCI perceive a positive perspective on physical activity, leading to positive expectations regarding improved physical activity levels. As a result, they become motivated to make behavioral changes and set goals to enhance their physical activity. Subsequently, PW-ACS after PCI may translate these goals into action. The findings were consistent with previous studies; outcome expectation significantly affected physical activity through intention or planning among people with CAD[22] and HTN.[17,18]

Results not supporting the hypothesized model

Self-efficacy did not indirectly influence physical activity through intention and planning. This could be attributed to the moderate correlations between self-efficacy and intention, suggesting they may not be strong enough to affect intention. A probable reason for the non-significant findings could be the failure to categorize participants according to their behavioral stages. Alternatively, the lack of differentiation between participants' behavioral stages might explain the insignificant result. According to the theoretical framework,[12] three stages of behavior change are proposed: Action stage, individuals are motivated to begin the behavior but have not yet acted; Coping stage, individuals focus on maintaining the behavior and overcoming challenges; Recovery stage, individuals learn to bounce back from setbacks and regain motivation. Each stage has distinct social-cognitive factors and mechanisms. Accounting for these stages, future research could provide valuable insights into how different social-cognitive factors influence intention and behavior toward physical activity in diverse populations.

Risk perception did not indirectly influence physical activity through intention and planning, which is inconsistent with the HAPA. The explanation may be due to low correlations between risk perception and intention, as well as between intention and planning. This low relationship might not be strong enough to influence intention and planning on physical activity. Another possible explanation could be that our participants may have already passed the motivation phase because this study was a cross-sectional study. The risk perception may not be as relevant and essential as indicators of willingness to change behavior within this group.[22]

Limitations

This study used a cross-sectional design. Thus, interpreting causal relationships among variables must be done with caution.

Conclusions and Implications for Nursing Practice

This study's findings supported the hypothesized model, indicating that self-efficacy was the strongest predictor of physical activity in PW-ACS after PCI. Self-efficacy had positive direct and indirect effects on physical activity. Planning and action control exerted direct and positive influences on physical activity. Conversely, outcome expectation and intention indirectly affected physical activity through intention and planning. Therefore, to promote physical activity in PW-ACS after PCI, nurses should develop nursing interventions by motivating the people to set positive outcome expectations and strengthen intentions to plan physical activity. In addition, to maintain physical activity, nurses should develop strategies for improving self-efficacy, action plans, and action control.

Regarding theoretical considerations, the result showed that self-efficacy was the most potent predictor. However, the HAPA theory did not prescribe a specific strategy for increasing self-efficacy. Therefore, other theories that specify improving a person's self-efficacy should be gathered to develop an intervention program. In addition, this study found that only 46% of the variance was explained in the final model. Other factors influencing physical activity might not have been included in this study. Therefore, future studies should employ a cross-sectional model to test different factors, including social support, family support, and environmental factors.

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แบบจำลองเชิงสาเหตุของกิจกรรมทางกายในผู้ที่มีภาวะหัวใจขาดเลือดเฉียบพลันภายหลังการถ่างขยายหลอดเลือดหัวใจ : การศึกษาภาคตัดขวาง

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บทคัดย่อ: กิจกรรมทางกายถือได้ว่าเป็นองค์ประกอบหลักสำคัญของโปรแกรมการฟื้นฟูสมรรถภาพหัวใจ และมักได้รับการแนะนำให้ใช้เป็นแนวทางในการเพิ่มผลลัพธ์การป้องกันทุติยภูมิในผู้ที่มีภาวะหัวใจขาดเลือดเฉียบพลันภายหลังการถ่างขยายหลอดเลือดหัวใจ อย่างไรก็ตาม ระดับกิจกรรมทางกายของประชากรกลุ่มนี้ค่อนข้างต่ำ การศึกษาวิจัยส่วนใหญ่มุ่งเน้นที่ประชากรผู้สูงอายุและโรคเรื้อรังเป็นหลัก การวิจัยเชิงพรรณนาแบบภาคตัดขวางนี้มีวัตถุประสงค์เพื่อทดสอบแบบจำลองเชิงสาเหตุของกิจกรรมทางกายในผู้ใหญ่โดยใช้กรอบแนวคิดทฤษฎีกระบวนการกระทำด้านสุขภาพ กลุ่มตัวอย่างจำนวน 424 ราย ถูกคัดเลือกโดยใช้วิธีการสุ่มแบบหลายขั้นตอนจากแผนกผู้ป่วยนอกของโรงพยาบาลระดับตติยภูมิจำนวน 7 แห่งในประเทศไทย เก็บรวบรวมข้อมูลโดยใช้แบบสอบถามข้อมูลส่วนบุคคล แบบสอบถามการมีกิจกรรมทางกายนานาชาติฉบับยาว แบบสอบถามการรับรู้สมรรถนะแห่งตน แบบสอบถามความคาดในหวังผลลัพธ์ แบบสอบถามการรับรู้ความเสี่ยง แบบสอบถามความตั้งใจเชิงพฤติกรรม แบบสอบถามการวางแผน และแบบสอบถามการควบคุมการกระทำ วิเคราะห์ข้อมูลโดยใช้สถิติพรรณนาและการสร้างแบบจำลองสมการโครงสร้างด้วยโปรแกรม Mplus

ข้อค้นพบที่ได้จากการศึกษานี้ถือได้ว่ามีความสำคัญยิ่งต่อการดูแลผู้ป่วย แบบจำลองที่ได้รับการทดสอบนี้สามารถอธิบายความแปรปรวนของกิจกรรมทางกายได้ร้อยละ 46 โดยการรับรู้สมรรถนะแห่งตน การวางแผน และการควบคุมการกระทำเป็นตัวแปรหลักสำคัญที่มีอิทธิพลทางตรงต่อกิจกรรมทางกาย โดยเฉพาะอย่างยิ่ง การรับรู้สมรรถนะแห่งตนนั้น พบว่าเป็นตัวแปรที่มีอิทธิพลมากที่สุด ความคาดหวังในผลลัพธ์มีอิทธิพลทางอ้อมต่อกิจกรรมทางกายผ่านความตั้งใจและการวางแผน การวิจัยนี้ชี้ให้เห็นว่า พยาบาลควรออกแบบการดูแลโดยส่งเสริมการรับรู้สมรรถนะแห่งตน การวางแผน และกลยุทธ์การควบคุมการกระทำของตนเอง ซึ่งกลยุทธ์เหล่านี้สามารถช่วยให้ผู้ป่วยสามารถก้าวข้ามความท้าทายในการฟื้นฟูสมรรถภาพหัวใจและคงไว้ซึ่งกิจกรรมทางกาย อันจะส่งผลต่อการเพิ่มผลลัพธ์ทางสุขภาพตามมา อย่างไรก็ตาม มีความสำคัญอย่างยิ่งที่ต้องนำรูปแบบที่ได้นำเสนอไว้ไปทดสอบประสิทธิผลอย่างเข้มงวดก่อนนำไปปฏิบัติ

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คำสำคัญ: ภาวะหัวใจขาดเลือดเฉียบพลัน แบบจำลองเชิงสาเหตุ แนวคิดทฤษฎีกระบวนการกระทำด้านสุขภาพ การถ่างขยายหลอดเลือดหัวใจ กิจกรรมทางกาย การรับรู้สมรรถนะแห่งตน การควบคุมการกระทำของตนเอง

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