Congenital Heart Disease

Tech Science Press

Doi:10.32604/chd.2025.064662

ARTICLE

Predicting Factors of Physical Activity among Children with Congenital Heart Disease after Corrective Surgery

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Received: 21 February 2025; Accepted: 22 April 2025; Published: 30 April 2025

ABSTRACT: Objective: Many children with fully corrected congenital heart disease (CHD) avoid physical activity (PA). This descriptive study sought to determine child and parental factors that could predict PA levels in Thai children after corrective surgery. **Methods:** Ninety school-aged children with fully corrected CHD were recruited from a cardiology clinic at a university hospital in northern Thailand. Data collection involved five validated questionnaires: (1) the Modified Thai Adolescent's Physical Activity Questionnaire, (2) the Child Health Status Questionnaire-Forms I and II, (3) the Parental Knowledge on School-aged Children's Physical Activity Scale, (4) the Perceived Self-efficacy to Physical Activity Questionnaire, and (5) the Parental Bonding Instrument. The analysis included descriptive statistics and stepwise multiple regression. **Results:** Results showed that the physical activity (PA) levels, assessed through total energy expenditure, of children with CHD were below the recommended levels after treatment ($t = -8.33$, $p < 0.001$). There were significant correlations between PA and factors such as a child's perceived health status, PA self-efficacy, and parental overprotection ($r = 0.39$, $p < 0.050$; $r = 0.46$, $p < 0.050$; $r = 0.25$, $p < 0.050$, respectively). After adjustment for demographic data and CHD type, these factors had no association with a child's PA. Only two factors predicted childhood PA—the child's perceived health status and PA self-efficacy which could explain 27.3% of the variance of PA ($p < 0.001$). **Conclusion:** The study highlights the necessity for interventions to enhance children's perception of their health status and PA self-efficacy to increase their physical activity levels.

KEYWORDS: Heart defects; congenital; risk factors; exercise; child

1 Introduction

Congenital heart disease (CHD) is one of the most common congenital health issues, impacting up to one percent of the population [1–3]. The frequency in Thailand falls in the range of 0.8% to 1.13%, with 600 to 700 children successfully receiving heart surgery annually, about one-quarter of whom are school-aged children [4–7]. Despite corrective surgery markedly enhancing lifespan and prognosis, children with CHD continue to exhibit reduced levels of physical activity compared to their healthy counterparts and frequently fail to adhere to international guidelines for moderate to vigorous physical activity (MVPA) [7–9]. This trend of inactivity is prevalent across nations and age demographics [1,2], particularly for children aged 8 to 12 [3–5].

Engaging in moderately to vigorous exercise reduces risk, both of becoming obese and for chronic cardiovascular conditions [3,8,9], while also fostering psychological, emotional, and cognitive growth—improving children's self-esteem, social abilities, and academic achievement [10,11]. Recent

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longitudinal and controlled randomized studies [2,6] have shown that early physical therapy and structured physical activity programs can enhance cardiovascular and physical fitness in pediatric patients with heart defects. These findings highlight the necessity of identifying modifiable characteristics, especially perceived health and self-efficacy, which may affect physical activity engagement. Nevertheless, limited research has investigated the psychological and parental factors within the Thai pediatric congenital heart disease community, highlighting a significant need that this study seeks to fill.

Understanding these relationships may explain reduced PA levels in some children with CHD. The primary factors associated with PA in children after corrective CHD surgery have not been determined. In the CHD literature, moderate relationships have been found between PA and self-efficacy in children [4,7], children's perceived health status [8,9], the child's health status as perceived by the parents [3,10], and parents' knowledge of school-aged children's PA [10,11]. Findings from previous studies have also reported that parental factors have an impact on a child's PA. Self-efficacy theory has been used significantly in previous studies due to its predictive ability in determining PA health-related behaviors [4,12,13]. Therefore, it was also used to guide this study [14]. These previous findings have indicated that a child's confidence in their capability to effectively perform a specified task potentially demonstrates higher self-perceived physical activity levels, which has been found to be a significant determinant of PA [4–7]. PA ability may also depend on CHD type. The child's CHD may affect their exercise abilities, but their parents can significantly affect their engagement and psychological self-efficacy [3,4,6,15,16]. This reciprocal influence pointing to the importance of a child's parents was found to predict child's PA over time.

The few previous studies were conducted in Western and Asian countries with no studies done yet in Thailand. The current research cannot be easily generalized to this location due to typical Thai cultural precepts that may influence child-parent dynamics. Based on existing evidence, PA levels for children with CHD were recently investigated, but self-efficacy and parental attitudes, especially in Thai culture, have not. This study fills a need by identifying physical activity predictors to potentially inform the creation of family-inclusive psychosocial interventions designed to raise children's PA levels.

2 Material and Methods

2.1 Participants and Sample Size

The main aim of this cross-sectional research was to evaluate the factors that inspired and enabled children with CHD to participate in MVPA, post-corrective surgery. For determining the minimum necessary number of samples for the regression analysis, we employed the widely accepted guideline that 10 to 20 participants are needed for every variable with explanation [17]. Considering our intention to incorporate 8 explanatory factors, we sought to enlist a minimum of 80 participant pairings [17]. A prior comparative study identified a medium effect size through a comparison of PA levels of CHD and non-CHD children in Thailand [18]. Ninety school-aged children, having completely corrected CHD, along with the parents of the children were purposely gathered from the cardiology department of a university medical center in northern Thailand.

Eligibility for participation was determined by the application of inclusion and exclusion criteria. The criteria for including eligible subjects in the recruitment process included the following: (1) aged 8–12 years and enrolled in grade 2 to 6; (2) diagnosed by a cardiologist with congenital heart

disease and no other significant illnesses, such as asthma or neuromuscular disorders (specifically Down syndrome), that would hinder physical activity; (3) having undergone total corrective cardiac surgery for conditions which included atrial septal defect (ASD), ventricular septal defect (VSD), patent ductus arteriosus, or Tetralogy of Fallot (TOF) more than six months prior; (4) capable of speaking and comprehending the Thai language; (5) willingly participated in the study; and (6) possessing their parents' written consent (father, mother, or a primary caregiver). Participants who had obtained a pacemaker or some other mechanical heart rhythm regulation device, or who exhibited a significant residual lesion with right ventricular pressure exceeding 50% of systemic pressure as determined by echocardiogram, or a maximum gradient over the right ventricular output tract of $\geq$30 mmHg in cases of Tetralogy of Fallot, were excluded due to safety concerns regarding pulmonary artery intervention.

2.2 Instruments

Five questionnaires (in Thai) were employed: the Modified Thai Adolescent Physical Activity Questionnaire (MTAPAQ); the Child Health Status Questionnaire–Forms I and II (CHSQ); the Perceived Self-efficacy about Physical Activity Questionnaire (PSEPAQ); the Parental Knowledge about School-aged Children's Physical Activity Scale (PK Scale); and the Parental Bonding Instrument (PBI). For the children, they completed the MTAPAQ first, followed by a break (15 min); after this, they completed the CHSQ-Form I and the PSEPAQ. The CHSQ-Form II, the PK scale, and the PBI were distributed to their parents. Participants were asked to give the finished questionnaires to either the researcher or an assistant. In the case of questionnaires returned containing incomplete items, participants were requested, by the researcher or assistant, to complete them.

2.3 Self-Reported Physical Activity

The MTAPAQ, a Thai-language, self-administered instrument [19], was utilized for measuring children's total energy expenditure (TEE) and contained 37 items which were used to measure children's PA for three days. Children were requested to report the frequency of activities completed and the daily length of time allocated to specific tasks over the most recent three days. The MTAPAQ has demonstrated strong concurrent validity in previous research, with significant correlations between MET-minutes from self-reports and accelerometer data ($r = 0.74$, $p < 0.001$), as well as high test-retest reliability over a one-week interval ($r = 0.88$, $p < 0.001$) [14]. Due to practical and financial limitations, this study did not use objective accelerometer data. Earlier studies illustrating concurrent validation of MTAPAQ score with accelerometer results from comparable populations provided the reasoning for the tool's utilization [15].

2.4 The Child's Health Status as Perceived by Children and Parents

The CHSQ Forms I and II. These two self-reporting scales, having 10 items and developed by the researcher [15], were utilized to assess a child's health status in terms of the child's and parents' perceptions. For example, one question asked "When you had activities with your friends at home or school, how often did you feel sick?" prompting children to reply using a 4-level rating scale, with scoring ranges from 'never' (1) to 'very often' (exceeding four times a month) (4), with total scores between 10 to 40. High scores signified enhanced perceived health relative to that of one's contemporaries. Acceptable internal consistency and stability were provided via Cronbach's α

levels of 0.77 for Form I and 0.84 for Form II [18]. The concurrent and construct validity of the new development scale met acceptable criteria, with correlation coefficients of 0.97 ($p < 0.001$) and 0.91 ($p < 0.001$), respectively [18]. These values indicate that the instrument meets acceptable psychometric standards for assessing physical activity.

2.5 Child PA Self-Efficacy

The PSEPAQ was utilized to assess the children's PA self-efficacy. Initially created by Wu and Pender, it has been translated into the Thai language [20]. The PSEPAQ has 14 items which use a 10-level system of rating from 'not at all confident' (0) to 'extremely confident' (100) by soliciting children's grades of their confidence in surmounting obstacles to physical activity. A sample item includes: "I exercise even though I feel tired." Higher scores demonstrated greater confidence in doing physical activity. The Cronbach's α coefficient was 0.84, establishing internal consistency reliability for this study.

2.6 Parents' Knowledge of PA

The PK Scale, consisting of 13 items and developed by the researchers, was utilized to assess parents' understanding of school-aged children's physical activity [15]. A sample item stated: "To strengthen muscles, school-aged children should engage in physical activity for a minimum of 30 to 60 min daily." Participants were instructed to choose one of three options (Yes, No, or Do not know). Thirteen was the highest possible rating and higher scores indicated enhanced parental knowledge. The internal coherence coefficient for the PK Scale was 0.75 while the instrument's dependability was evaluated using the test-retest method, achieving a correlation of $r = 0.92$, $p < 0.001$.

2.7 Parental Caring and Overprotection

The Parental Bonding Instrument (PBI) [21] is a 25-item self-reporting questionnaire that measures parental attitudes and actions including parental care and parental overprotecting. It was translated into Thai language by Vatanasin and colleagues [22]. The questionnaire is completed by a mother and a father, separately, and they are instructed to provide a description of the relationship between them over time, from the growing-up period up to the present time during which they are completing the questionnaire. They rated each other on a caring subscale (12 items) and on an overprotection subscale (13 items). Items are rated using a 4-level scale (0 = very unlikely to 3 = very likely). From the total of 25 items, there were six items scored negatively for each dimension, with scores being reversed and added to the scores for the rest, resulting in summary scores ranging from 0.00–36.00 (care dimension) and 0.00–39.00 (overprotection dimension). Higher scores on the care scale represented higher positivity of parental behavior (a higher level of perceived care) while a higher score on the overprotection scales meant decreased positive parental behavior (a higher level of perception of parental intrusiveness and over-control) [21]. The PBI has demonstrated good construct validity and reliability; Cronbach's α reliability ranged from 0.91 to 0.99 [21,22], and a Cronbach's α coefficient of 0.88 was obtained for this study.

2.8 Procedure of Data Collection

The period for this study spanned from January 2021 to December 2021. Data were collected from all participants under similar circumstances to ensure accuracy and reliability. After obtaining

authorization, collection of the data was conducted in an enclosed space under scrutiny of the individuals accountable within the study setting. Children participated in this study under the appropriate authority for this study setting; data collection was conducted in a private room. Children completed the relevant questionnaires following a reading by the researcher and receiving instructions on how to fill out the scales. The MTAPAQ was administered initially, followed by a 15-min interval, after which the CHSQ-Form I and PSEPAQ were conducted. Upon completion, individuals were directed to give them to one of the research team members or their assistants. In the event that answers were not completed, the researcher or an assistant would follow up with participants to obtain the necessary information. Three questionnaires, namely the CHSQ-Form II, PK, and PBI, were administered to the parents at a clinic. The primary investigator was available to clarify misunderstandings and invited parents to complete any missing forms.

2.9 Data Analysis

Data analysis included all participants who completed the questionnaires. Data reporting was done with descriptive analyses for continuous variables, using both mean and standard deviation. Comparisons for PA variables with recommended levels were assessed using independent *t*-test. Prior to data analysis, the violation of statistical assumptions, including normality, linearity, and homoscedasticity were tested.

Data were evaluated by employing descriptive statistics to encapsulate the demographic and clinical attributes of individuals. Initial inferential analyses involved doing bivariate associations to ascertain significant links between a dependent variable and key clinical/demographic factors, utilizing either Pearson's correlations or sample-independent *t*-tests. Pearson's correlations were performed to assess the strength of links between the dependent variable (PA) and the other outcome measures (independent variables) in the study. Multiple linear regression was used to examine the relationships between the demographic factors and physical activity levels in children with CHD. To find significant physical activity predictors, all categorical variables were converted into dummy variables and screened to verify linear regression assumptions were met. The model comprised the demographic factors shown to be associated with PA in previous studies and five predictor variables: children's perceived health status, PA self-efficacy, parental overprotection, parent-reported child health status, and parental knowledge. Data analysis was conducted using SPSS, version 22, with a significance level of $p < 0.05$.

2.10 Ethical Considerations

The Chiang Mai University Research Ethics Review Committee approved this study, and approval was gained from the Ethics Committee for Biomedical Research for Chiang Mai University Hospital (Approval no. 077/02865). All participants, including parents and children, received information concerning the research objectives and methods; anonymity and confidentiality considerations; and the possibility of risk and/or benefit. Participants also had their rights explained to them, in terms of participation or withdrawal from the study with no repercussions. Subsequently, the written consent of the parents and the assent of the juvenile's parental consent to participate was also obtained, while the children's consent was also confirmed by the children themselves. Upon obtaining authorization from the relevant authorities within the study environment, data collection was conducted discreetly using a designated room. The study included the one-time completion of questionnaires using paper

versions. Children and their guardians were instructed to respond to all five questionnaires following the researcher's verbal reciting of each question in sequence, and having the questionnaire scales explained to them.

3 Results

3.1 Results for the Overall Sample

Ninety children with congenital heart disease and parents (180 participants overall) were solicited for the study. All participants consented to engage, obtaining a response rate of 100%. Children were school-aged, and split evenly between boys and girls, half of whom were aged 8–10 while the other half were 11–12 years old. Most of the parents were mothers (61.1%). Nearly all parents worked as farmers or employees and had a low income. Among the 90 children were some with ASD (n = 30), VSD (n = 32), PDA (n = 12), and pink tetralogy (n = 22). Total corrected surgery was performed for 35.5% of closure VSD patients, 24.4% of total correction TOF patients, 26.6% of closure ASD patients, and 13.3% of PDA ligation patients with most having surgery a single time. Nearly half had waited over 37 months for surgery. Only 23.7% underwent their initial surgery during the first 12 months, with ages for that surgery being in the range of 6 to 125 months, with an average of 34.5 months. More than three quarters had undergone the operation over three years prior.

3.2 Physical Activity Level

Physical activity (PA) in CHD children was classified by MET values into four intensity categories: inactive (1.00–1.90 METs), low (2.00–2.90 METs), moderate (3.00–5.90 METs), and vigorous (>6.00 METs). In the prior 3 days, 67% and 57% of the children reported having participated in moderate to vigorous-intensity activities, respectively, whereas 97% were categorized as mostly sedentary or exhibiting low levels of physical activity.

Sedentary behaviors were predominant, with 56% of the population indicating frequent ($\geq$3 days) screen use, encompassing television viewing and engagement in computer or video games. Low-intensity activities, like sedentary gaming and dishwashing, were done frequently over the three-day period. Conversely, doing laundry was reported everyday by only 10.13% of individuals.

Sixty-seven percent of youngsters participated in moderate to rigorous physical activities, including jumping, running, and cycling, at least once throughout the three-day period. Nonetheless, regular engagement in organized sports activities was restricted: just 15% engaged in moderate-intensity sports and 13.5% in vigorous-intensity sports during a three-day period.

CHD Children engaged in an average of 42.00 mins per day (SD = 42.19) of moderate-to-vigorous physical activity, which was considerably below the recommended daily standard (t = –8.58, $p < 0.001$). Engagement in vigorous exercises averaged 30.12 min daily (SD = 39.75), which is similarly below the suggested standard of 60 min a day (SD = 56.87). The average total energy expenditure (TEE) for children with CHD was 6822.95 MET-minutes (SD = 2602.27), significantly below the recommended amount of 11,016.99 MET-minutes (SD = 4762.78).

3.3 Predicting Factors Related to Physical Activity

Table 1 presents the corresponding Pearson correlation coefficients for the studied variables. The child's perceived health status (CH) and physical activity self-efficacy (PASE) exhibited a substantial positive correlation with all three measures of movement exertion: MPA, VPA, and MVPA. The child's health status exhibited a moderate association with MVPA ($r = 0.39$, $p < 0.05$), while PASE demonstrated the highest relation with MVPA ($r = 0.46$, $p < 0.05$). Parental overprotection had a weak correlation with VPA ($r = 0.22$, $p < 0.05$) and MVPA ($r = 0.25$, $p < 0.05$), but parental knowledge and parent-perceived child health showed no significant correlation with PA.

Table 1: Correlation of study variables of children with CHD and parents and energy expenditure on physical activity.

Variables	CH	PASE	CHP	PK	Overprotection
MPA	0.29*	0.36*	0.21	0.10	0.19
VPA	0.32*	0.40*	0.13	–0.01	0.22*
MVPA	0.39*	0.46*	0.19	0.04	0.25*

Note: *$p < 0.050$; PA, physical activity; CH, child's perceived health status; PASE, child's PA self-efficacy; CHP, child's health status as perceived by parents; PK, parental knowledge on PA of school-aged children; MPA, moderate physical activity; VPA, vigorous physical activity; MVPA, moderate-to-vigorous physical activity.

To identify PA predictors in CHD children, a forced-entry multiple-linear regression study (Table 2) was performed. Gender, age, CHD type, and modifiable psychological and parental characteristics (PA self-efficacy, perceived health status, parental overprotection, and parent-reported child health status) were all included in the model. The model explains 27.3% of PA levels variance (adjusted $R^2 = 0.27$) and is highly significant ($F = 5.36$, $p < 0.001$). Perceived health status and PA self-efficacy revealed significant predictors for PA ($B = 305.03$, $\beta = 0.40$, $t = 22.97$, $p < 0.001$). Gender, age, CHD type, parental overprotection, and parent-perceived child health status were still included within the model in order to adjust for possible confounding factors and ensure a full analysis, even though they were not statistically significant.

Table 2: Linear regression for variables independently of children with CHD and parents associated with energy expenditure on physical activity.

Variable	B	Std. Error	Beta	*t*	*p*
Gender	12.45	15.23	0.07	0.82	0.415
Age	3.67	2.88	0.11	1.27	0.208
CHD type	–9.34	16.11	–0.05	–0.58	0.564
PASE	6.32	2.74	0.31	2.31	<0.001
CH	305.03	13.28	0.40	22.97	<0.001
Overprotection	2.14	3.92	0.09	0.55	0.582
CHP	4.76	3.22	0.10	1.48	0.142
PK	1.85	2.95	0.07	0.63	0.53

Note: CH, child's perceived health status; PASE, child's PA self-efficacy; CHP, child's health status as perceived by parents; PK, parental knowledge on PA of school-aged children. $R = 0.55$, $R^2 = 0.30$, Adjust $R^2 = 0.27$, $F = 5.36$, $p < 0.001$.

A *t*-test of independent samples was performed to evaluate significant differences in PA levels in children with acyanotic heart defects (ventricular septal defect, atrial septal defect, patent ductus arteriosus) vs. those with cyanotic congenital heart disease (tetralogy of Fallot). Results showed no

statistically significant difference between groups ($t = 1.02$, $p = 0.311$), implying CHD type is not significantly associated with PA levels. Secondly, patients were categorized by surgical age using an average split ($\leq$34.5 months vs. >34.5 months). PA levels were not significantly different between late and early surgery groups ($t = 1.18$, $p = 0.242$), supporting the previously found non-significant correlation ($r = -0.12$, $p = 0.24$). Finally, children were placed into two different ages (8–10 and 11–12 years) to assess developmental influences. In this sample, age in years, as a measure for stages of development, was not significantly related to PA behavior ($t = 0.94$, $p = 0.349$). Similar to the regression analysis results, CHD type, age at surgery, and age in years did not predict physical activity.

4 Discussion

This research assessed PA types, frequency, duration, and total energy expenditure in 90 Thai children with CHD. While the type and frequency of PA did not show significant differences, the duration of PA was notably below the recommended levels [9,23]. These CHD-affected children engaged in PA for shorter periods than advised indicating that the majority of children with CHD may be limited in doing vigorous exercise post-corrective surgery due to the discomfort prior to corrective surgery, which may inhibit participation [15,24]. In this research, the majority of children with a condition known as congenital had their operation relatively late, after one year of age. Children were often out of breath and fatigued during the surgical waiting period, resulting in physical limitations [24–26]. Thai parents may limit their children's PA before surgery [15]. Therefore, many children continue these PA limitations post-surgery and do not dare to try normal activities in the way healthy children do [27,28]. Moreover, some studies have shown how a majority of children think of themselves differently compared with their peers following their corrective surgery and retain restrictions in terms of their duration of high-intensity activity [27,29].

Our research also found higher levels of sedentary behavior, which could be seen via their relative lack of activity, with children playing video games and watching TV which led to PA inactivity [15,24,25]. Thus, Thai children may face health concerns from idleness. Lower MVPA and TEE in children with CHD, when in contrast with suggested PA levels, are consistent with prior studies. Lower PA in CHD youngsters is supported by two studies in Asia and three in Western contexts [1,13,15,30,31]. In this study, the TEE of CHD participants reported is also consistent with prior study findings. It is essential to acknowledge that the findings from this research show that the severity of CHD in the sample affects the physical and psychological restrictions on physical activity. Consequently, some children perceive themselves as having long-term unhealthiness. This may support the idea that Thai children with CHD, post-operative surgery, might not have the ability to overcome their previous physical effects experience and uncertainty about operation scars, or parents' worries concerning the children's safety. Furthermore, long-term unhealthiness may help explain why CHD children display breathlessness and tiredness when exerting themselves [24–29]. This may reinforce the idea that Thai CHD youngsters may not recover from corrective surgery, which can contribute to low self-efficacy. As a result, persuasion, offered verbally, and encouragement comprise PA techniques for parents of school-aged children's significant others. In addition, Thai parental overprotection has an important relationship with MVPA. This study demonstrates more positive parental intrusiveness and over-control. Even if parents' perception of their child's health status is that they are healthy, most parents believed

that their child's tolerance for exercise and activity limits characterized the condition. It seems reasonable to consider that this parental overprotection is triggered due to uncertainty over operation scars or concern for their child's safety [8,24,25,32–36]. Thus, after surgery, surgical scars and concerns about safety may cause Thai parents to overprotect in terms of their CHD child's physical activity. This could explain how Thai children with CHD, post-corrective surgery, rarely undertake MVPA or do it in a more restricted way. Thai parents typically tend towards overprotection with children with CHD due to the disease complications. Post-surgery scar concerns about their child's safety may lead Thai parents to exhibit reluctance regarding PA [24–29]. Even though nurses at outpatient cardiology clinics provide general PA information, they may neglect to promote more details on "when" or "how" to perform PA after an operation. This may help explain why Thai children with CHD perform little PA or MVPA after their corrective surgery.

The current study demonstrated no significant correlation between physical activity levels and CHD type, age at surgery, or age group in school-aged children with CHD. PA levels were similar in children with acyanotic defects (VSD, ASD, PDA) and those with a cyanotic abnormality (TOF), suggesting that defect complexity may not predict physical activity results after surgery. Both correlation and group comparison studies revealed that age at surgery, grouped in a median ($\leq$34.5 vs. >34.5 months), did not predict PA. Surgery scheduling may not directly affect long-term physical activity due to intervening factors like medical follow-up, rehabilitation, or psychosocial adaptation. No significant variations in PA behavior were seen between 8–10-year-olds and 11–12-year-olds, showing that chronological age or developmental stage did not matter. According to regression analysis, none of these clinical or demographic characteristics predicted PA. Overall, these findings suggest that some of the modifiable psychosocial factors that have significant relationships with PA levels, including perceived health status and self-efficacy, could be targets for future family-inclusive interventions and that non-modifiable clinical and demographic characteristics have little influence on PA levels following CHD surgery in children.

Higher self-efficacy and child health status were related to more physical activity in children. Children who trust in their capacity to exercise and be healthy are prone to participate in PA. However, parental overprotection initially decreased PA levels but did not after controlling for other aspects. While parental practices may promote PA, a child's confidence and health perspective are more likely to motivate movement. According to Bandura's self-efficacy hypothesis, one's confidence in their ability substantially influences their actions. It also supports earlier research that children with CHD who feel independent and healthy are more willing to participate in PA, despite their parents' reservations. This emphasizes the importance of self-efficacy in health perception approaches above parental views. In addition, this particular finding parallels that of many other studies which have found these two variables to be stronger predictors of a child's PA. The present findings demonstrate that a child's perceived health status, PA self-efficacy, and parental overprotection were related to MVPA (overprotection ($r = 0.39$, $p < 0.050$; $r = 0.46$, $p < 0.050$; $r = 0.25$, $p < 0.050$, respectively), and the strength of the relation within the regression model was substantially stronger ($\beta = 0.40$ and 0.30, respectively) than meta-analysis results ($\beta = 0.05$) [37,38].

This finding is consistent with an interpretation that children's beliefs about physical activity may be stronger among Thai school-aged children. Both physical activity self-efficacy and child's perceived health status mediate the physical activity relationship, and they explained 27.3% of the variance. These types of results reflect prior studies on physical activity self-efficacy and child's

perceived health status [4–6,39]. This model helps to explain the PA performance relationship which applies Bandura's (1997) theory through which self-efficacy [14] will determine behavior when the requisite PA skills are established, with outcomes indicating that a child's perceived health determination is partially explained by physical activity competence's determination of physical activity self-efficacy [7,12,13,31,37].

As hypothesized, a child's PA self-efficacy could promote the idea that Thai CHD youngsters may overcome their physical symptoms after corrective surgery and achieve greater self-efficacy. As such, PA requires persuasive speaking and encouragement from parents as well as from other important people around these school-aged children. The high level of self-efficacy in these cases of children born with heart disease may have originated from the parents, which were then activated in the children because of concerns for their safety [8,12,32,36]. Their parental encouragement increased the child's capability to perform the activity [8,36], which could explain why self-efficacy correlated with MPA, VPA, and MVPA.

In addition, this study found that CHD children's perceived health status was similar to that of healthy children. Children's health state could explain their physical activity, which is congruent with findings showing children who perceive their health status to be better engaged in more physical activity [1,12,33,40,41]. These findings show that, after surgery, CHD children can participate in the same types of physical activity and with the same frequency as regular physical activity to MVPA, as the belief that one is in good physical condition benefits physical activity. This result implies that children who have better perceived health status had more physical activity which is also consistent with previous research findings [8,10,12,29,33,36,40,41]. Linde et al. [35] and Linde et al. [34] found that parents allowed their children to play and perform regular physical activity because they perceived the return to normal function of cardio-respiratory and physical health.

In fact, the effect of a child's perceived health status and physical activity self-efficacy are significantly larger than other variables. The present findings support previous research in that both variables serve a significant role in increasing PA. These findings are consistent with similar research which has analyzed the contribution of a child's perceived health status and self-efficacy on physical activity performance [1,10,12,37,40,41]. Baiya et al. [15] highlight that the underestimation of health status and competence after corrective heart surgery is unfavorable, with low self-efficacy exerting a detrimental influence on children's perspective of health status irrespective of physical abilities. This study develops the increase, both of child's perceived health status and physical activity self-efficacy, via the suggestion that a child's perception of proficiency in their moving around constitutes a more crucial elucidation for self-assurance in engaging with peers throughout physical activities or the choice of physical activity over sedentary behavior, which are keys to physical activity self-efficacy.

As this research assesses the view of a child's health status and self-efficacy in doing things together in addition to explaining the determinants of MVPA, it facilitates the design and evaluation of interventions to be considered. This research highlights that both a child's view of their health status and physical activity self-efficacy are predicting factors of physical activity. The explanation of child's perceived health status and physical activity self-efficacy highlights the meaning of PA competence as a complete construct. Therefore, interventions must focus on, not only the physical

building necessary to be involved in MVPA, but the ability for children to obtain feedback, direction, and encouragement for their PA performance which can develop their belief in participation.

5 Limitations and Future Implications for Practice and Research

5.1 Limitations

When interpreting the findings of this study, certain limitations must be acknowledged. The purposive sampling method employed in this study restricts its generalizability. The participants, consisting of CHD patients and their parents, primarily represented a low- to middle-class urban demographic, potentially limiting the generalizability to the wider CHD patient population. To improve external validity, future research should include broader, wider samples, including rural and high-socioeconomic groups.

The use of the MTAPAQ for self-reported physical activity is an important limitation of this research. No objective measures were collected for this group, despite previous studies confirming the concurrent validation of the questionnaire with objective accelerometers. This may have caused social desirability and recall bias in schoolchildren. In future studies, researchers should consider using objective PA sensors or a mixed-methods approach with sub-sample comparisons to improve measurement precision. To minimize the influence of potential extraneous confounding factors more matched samples, and physiological and psychological indicators (blood pressure, height, weight) are needed in future investigations.

5.2 Future Implications for Practice and Research

The present study may be the first to report PA levels of Thai CHD children after correction comparative to recommendation levels. This study also spelled out the interpersonal, parental, and environmental factors that correlate and predict PA levels among children with CHD. These results could be used to promote interventions to enhance children's perception of healthy status and PA self-efficacy. Targeted interventions could then be planned and implemented to promote physical activity for this group of children. Future studies should use objective PA assessments, bigger populations, and intervention-based designs.

6 Conclusion

This study found that the total energy expenditure for PA in children with CHD was below recommended levels post-treatment. A child's perceived health status and PA self-efficacy were the only two significant predictors of PA in these children. To promote PA in CHD children, further interventions should focus on the building of physical activity required to participate in MVPA and the ability for children to obtain feedback, direction, and encouragement regarding their PA performance which will develop their belief in participating.

Acknowledgement: The authors express their gratitude to the pediatric cardiology patients and to the Faculty of Nursing for providing support.

Funding Statement: This study was funded and supported by the Chiang Mai University Junior Research Fellowship Program.

Author Contributions: The authors confirm their contributions to this paper as follows: development of the proposal, submission for funding, ethics submission, data collection, data analysis, results, and discussion

were done by Nuttanicha Sriboonyawattana. Approval of the proposal, data analysis, approval of results, and final report were undertaken by Thitima Suklerttrakul. All authors reviewed the results and approved the final version of the manuscript.

Availability of Data and Materials: The datasets collected and/or examined during this investigation are accessible via the corresponding author upon reasonable request.

Ethics Approval: The Chiang Mai University Research Ethics Review Committee approved this study, and approval was gained from the Ethics Committee for Biomedical Research for Chiang Mai University Hospital (Approval no. 077/02865). Subsequently, the written consent of the parents and the assent of the juvenile's parental consent to participate was also obtained, while the children's consent was also confirmed by the children themselves.

Conflicts of Interest: The authors declare no conflicts of interest to report regarding the present study.

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