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The impact of physical activity changes on exercise capacity and health-related quality of life in young patients with CHD: a 3-year follow-up study

Original Article

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Abstract

Objective: This study examined the relationship between changes in physical activity and their impact on exercise capacity and health-related quality of life over a 3-year span in patients with CHD. *Methods:* We evaluated 99 young patients with CHD, aged 13–18 years at the outset. Physical activity, health-related quality of life, and exercise capacity were assessed via questionnaires and peak oxygen uptake measurements at baseline and after 3 years; changes in measures were estimated between the two time points and categorised into quartiles. Participants were stratified according to achieved (active) or not-achieved (inactive) recommended levels of physical activity ($\geq$150 minutes/week) at both time points. *Results:* Despite increases in physical activity, exercise capacity, and health-related quality of life over 3 years, the changes were not statistically significant (all $p > 0.05$). However, a positive association was found between physical activity changes and exercise capacity (ß = 0.250, $p = 0.040$) and health-related quality of life improvements (ß = 0.380, $p < 0.001$). Those with the most pronounced physical activity increase showed notable exercise capacity ($p < 0.001$) and health-related quality of life increases ($p < 0.001$) compared with patients with the largest decline in physical activity. The active-inactive category demonstrated a notable decline in exercise capacity compared to the active-active group, while the inactive-active group showed health-related quality of life improvements. *Conclusions:* Over 3 years, increased physical activity was consistently linked to increases in exercise capacity and health-related quality of life in patients with CHD, highlighting the potential of physical activity augmentation as an intervention strategy.

Introduction

The prognosis for individuals with CHD has seen a remarkable shift in recent decades. Advances in early diagnosis, surgical techniques, and percutaneous interventions have significantly increased the survival rate of CHD patients.[1] As these individuals live longer, the emphasis on their comprehensive management across diverse aspects of life grows in importance.[2]

Physical activity plays a paramount role in this context. Regular engagement in physical activity and sports not only augments exercise capacity and musculoskeletal function but also reduces the risk of cardiovascular mortality and complications.[3] Acknowledging its significance, clinical guidelines for CHD management actively recommend assessing physical activity levels and advocate its promotion.[4,5]

Exercise capacity, denoted by peak oxygen uptake, has gained recognition as a holistic measure of cardiopulmonary function and a vital determinant of the health status of patients with CHD.[6–8] Reduced exercise capacity is commonly observed in patients with CHD.[9] A myriad of factors, ranging from chronic low cardiac output, prior surgeries, and neurocognitive deficits, to parental overprotection leading to limited physical activity, influence exercise capacity in this population.[10] Notably, exercise capacity has shown a stronger association with physical activity than even with cardiac structure in patients with CHD.[11]

Further broadening the perspective, health-related quality of life has emerged as a salient parameter to gauge the efficacy of therapeutic outcomes in CHD patients. Factors affecting health-related quality of life offer insights into patient perceptions and the effectiveness of disease interventions.[12] Though health-related quality of life's correlations with both physical activity and sedentary behaviours in patients with CHD are documented,[13,14] the strength of the relationship varies. For instance, Müller, Hess, and Hager[15] found a robust association of physical activity with exercise capacity but a weaker link with overall health-related quality of life in their study based on 147 Fontan patients (aged 7–18 years).[15]

While cross-sectional analyses have posited a positive relationship between higher physical activity and enhanced exercise capacity and health-related quality of life in patients with CHD, the influence of changing physical activity levels (increase, maintenance, decrease) over time on these parameters remains an open question. Given the natural variability in physical activity behaviours over an individual's life, understanding how these changes impact exercise capacity and health-related quality of life could unlock potential therapeutic interventions to mitigate mortality risks and improve life quality. We therefore sought to explore the longitudinal interplay between physical activity, exercise capacity, and health-related quality of life over a 3-year span in patients with CHD.

Materials and method

Study population

This retrospective longitudinal study derives from a baseline survey conducted between November 2015 and February 2016, which initially encompassed 228 patients (127 males, 101 females). A follow-up assessment took place between February 2019 and September 2019, during which participants returned to S Hospital for routine examinations. From the primary group of 228, only 104 were informed about this subsequent study. Out of those approached, five opted out, culminating in a final sample size of 99 participants (60 males and 39 females, aged 13–18 years). It is noteworthy that the exercise capacity metrics were based on 58 participants who partook in cardiopulmonary exercise tests both at baseline (2014–2017) and during the follow-up (2017–2019) periods.

Assessment of demographic and disease-related characteristics

Demographic data for patients with CHD were ascertained through self-reported questionnaires covering age, gender, height, weight, body mass index, occupation, smoking and alcohol consumption habits, as well as the NYHA functional classification. Disease-specific details were collected from medical records, encompassing past interventions, surgical procedures, hospitalisations within the preceding 3 years, current medication regimen, ejection fraction, occurrence of arrhythmias, use of pacemakers, and diagnostic data. Disease type was classified according to the ACC/AHA 2008 guidelines.[16]

Physical activity assessment

For the assessment of physical activity, we utilised the Global Physical Activity Questionnaire, a tool that is widely used. The Korean adaptation of the Global Physical Activity Questionnaire incorporates 15 items, partitioned into domains: work-related activities (6 items), leisure-time sports activities (6 items), and transportation-related activities (3 items). An additional item addresses sedentary behaviour. Vigorous physical activity refers to intense activities that cause heavy breathing or a significant increase in heart rate. Moderate physical activity refers to activities of moderate intensity that cause slightly increased breathing or heart rate. Sedentary time refers to all time spent sitting or lying down, excluding sleeping hours. To compute the total physical activity level, metabolic equivalent values were attributed based on the activity's intensity. Vigorous activities were denoted as eight metabolic equivalents, while both moderate and transport-related activities were set at four metabolic equivalents.[17] Physical activity was calculated as change values at two different time points and categorised into increasing quartiles (Decreased, Little decreased, Little increased, Increased). Additionally, participants were stratified into four groups according to achieved (active) or not-achieved (inactive) recommended levels of physical activity (>150 minutes/week) at both baseline and follow-up time points: Active-active, active-inactive, inactive-active, and inactive-inactive groups.[17]

Exercise capacity assessment

Exercise capacity was determined through the quantification of peak oxygen uptake during a cardiopulmonary exercise test. Peak oxygen uptake and ventilatory equivalent for carbon dioxide were evaluated using data collected during exercise, while haemodynamic variables, including heart rate and blood pressure, were assessed at rest, during exercise, and during recovery phases of the cardiopulmonary exercise test. The cardiopulmonary exercise test in this study was performed using a Q-Stress TM55 treadmill (Quinton Cardiology Systems, Inc. USA) and a gas analyser (True One 2400 Parvo Medics, Salt Lake City, UT, USA). The modified Bruce protocol was employed for the test. Criteria for determining maximum exercise capacity were set at a rating of perceived exertion Borg scale of 17 or higher and a respiratory exchange ratio of 1.10 or higher. Only data meeting these criteria were included in the analysis.

Health-related quality of life assessment

Health-related quality of life was assessed using the validated Korean version of the PedsQL 4.0 Generic Core Scales, which has been shown to have reliability and validity for patients with CHD.[18] The assessment scale consists of a 5-point scale, with responses ranging from "Never a problem (1 point)" to "Almost always a problem (5 points)." Each item score was transformed into a scale ranging from 0 to 100, with scores closer to 100 indicating better health-related quality of life. Health-related quality of life is composed of four subscales: Physical function, Emotional function, Social function, and School function. Cronbach's alpha coefficient for the health-related quality of life questionnaire in this study was 0.86. To assess health-related quality of life, both at baseline and follow-up, the same researchers administered the questionnaire to each participant in a one-on-one setting. Completed questionnaires were collected immediately after completion, and any missing responses were reviewed and addressed before data aggregation.

Data analysis

The Kolmogorov-Smirnov test was utilised to confirm the normality of data distribution. Variables that did not follow a normal distribution were evaluated using non-parametric statistical analysis. Continuous variables were presented as mean ± standard deviation or median [interquartile range], and categorical variables were presented as counts (%). To examine differences over time in non-normally distributed changes in physical activity, Wilcoxon's signed-rank test was used. Changes in exercise capacity and health-related quality of life were evaluated using paired t-tests. Correlation analysis (Supplementary Table S1) was

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conducted to assess the associations between changes in moderate to vigorous physical activity, exercise capacity, and health-related quality of life. Multiple regression analysis (Supplementary Table S2) was performed to independently ascertain relationships among moderate to vigorous physical activity, exercise capacity and health-related quality of life. To examine associations between changes in physical activity levels (“Decreased,” “Little decreased,” “Little increased,” “Increased”) and changes in exercise capacity and health-related quality of life, one-way analysis of variance was performed, followed by Scheffe post hoc analysis. Additionally, changes in exercise capacity and health-related quality of life based on adherence to recommended levels of physical activity were assessed using one-way analysis of variance and paired t-tests. All statistical analyses were performed using SPSS-PC version 25.0 (SPSS Inc., Chicago, IL, USA), with a significance level (p) set at <0.05.

Results

The demographic and disease-related characteristics of the study participants are presented in Table 1. Although there was a general increase in physical activity, exercise capacity, and health-related quality of life over the 3-year period, the changes were not statistically significant (all $p > 0.05$). No significant differences were observed in the classification based on physical activity guidelines over time ($p = 0.441$). Additionally, there was no statistically significant difference in relative peak exercise capacity (32.5 ± 7.9 ml/kg/minute versus 31.9 ± 7.1 ml/kg/minute, $p = 0.452$), and health-related quality of life (78.7 ± 15.1 versus 79.8 ± 15.6, $p = 0.386$), and similar patterns were observed in all subdomain scores over time (Table 2).

The changes in moderate to vigorous physical activity positively correlated with changes in exercise capacity and health-related quality of life (Supplementary Table S1), while the change in moderate to vigorous physical activity was positively associated with the changes in exercise capacity (ß = 0.250, $p = 0.040$) and health-related quality of life (ß = 0.380, $p < 0.001$) (Supplementary Table S2 and S3). Changes in exercise capacity were significantly lower in the Decreased physical activity and Little decreased physical activity groups (Q1, Q2), compared to the Little increased physical activity and Increased physical activity groups (Q3, Q4) (Fig 1). The group with the greatest increase in physical activity (the Increased group, Q4), showed an exercise capacity change that was approximately 9.7 ml/kg/minute higher than that of the group with the greatest decrease in physical activity (the Decreased group, Q1) (−7.0 ± 4.4 versus 2.7 ± 5.3 ml/kg/minute, $p < 0.001$) (Table 3).

Changes in health-related quality of life were significantly higher in the Increased physical activity group (Q4), compared to the Decreased physical activity and Little decreased physical activity groups (Q1, Q2) (Fig 1). The group with the greatest increase in physical activity (the Increased group, Q4) exhibited a 13.5-point higher improvement in health-related quality of life, compared to the group with the greatest decrease in physical activity (the Decreased group, Q1) (9.7 ± 9.9 versus −3.8 ± 10.3, $p < 0.001$) (Table 3).

The Inactive-Inactive (II) group, which did not meet the recommended physical activity levels, showed notable differences in NYHA functional classification and number of medications ($p = 0.007$, $p = 0.003$), compared to the Active-Active and Active-Inactive groups. Furthermore, based on the disease type, marked differences were identified between the Active-Active and Inactive-Active groups ($p < 0.001$) (Table 4). Of particular interest, the

Table 1. Demographic characteristics of patients with CHD.

	Mean ± SD or n (%)
Age (years)	19.4 ± 1.9
16–18	37 (37.4)
19–23	62 (62.6)
Sex	
Male	60 (60.6)
Female	39 (39.4)
Height (cm)	164.1 ± 9.6
Weight (kg)	58.5 ± 13.0
Body mass index (kg/m^2)	21.5 ± 3.8
Occupation	
Student	70 (70.7)
Employed	15 (15.2)
Unemployed	14 (14.1)
Current smoking status*	
No	95 (96.0)
Yes	4 (4.0)
Alcohol consumption#	
Yes	26 (26.3)
No	73 (73.7)
NYHA functional classification	
NYHA I	53 (53.5)
NYHA II	41 (41.4)
NYHA III	5 (5.3)
Number of surgical during the follow-up period	
0	90 (90.9)
1	17 (7.1)
2	1 (1.0)
Number of procedures during the follow-up period	
0	81 (81.8)
1	112 (11.2)
2	24 (4.4)
Number of hospitalisations during the follow-up period	
0	63 (63.6)
1	24 (24.2)
2	11 (11.2)
Medications (Yes)	63 (63.6)
Number of medications	1.5 ± 1.7
Aspirin	37 (37.5)
β-blockers	23 (23.2)
ACEI/ARB	39 (39.4)
Diuretics	12 (12.1)
Anticoagulant	2 (2.0)

(Continued)

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Table 1. (*Continued*)

	Mean ± SD or n (%)
Left ventricle ejection fraction (%)	60.5 ± 9.1
Poor (<30%)	1 (1.0)
Mild decreased (30–50%)	15 (15.1)
Normal (>50%)	83 (83.8)
Arrhythmia (yes)	4 (4.0)
Pacemaker	2 (2.0)
Disease	
Simple (n = 14)	
Aortic valve stenosis	1 (1.0)
Atrial septal defect	1 (1.0)
Bicuspid aortic valve	3 (3.0)
Mitral valve regurgitation	3 (3.0)
Mitral valve stenosis	1 (1.0)
Ventricular septal defect	5 (5.1)
Moderate (n = 36)	
Anomalous pulmonary venous connection	1 (1.0)
Atrioventricular septal defect	1 (1.0)
Bicuspid aortic valve + subaortic valve stenosis	1 (1.0)
Coarctation of aorta	6 (6.1)
Congenital coronary aneurysm	1 (1.0)
Interruption of aorta arch	2 (2.0)
Pulmonary stenosis	1 (1.0)
Subaortic stenosis with ventricular septal defect	1 (1.0)
Tetralogy of Fallot	22 (22.2)
Complex (n = 49)	
Double outlet right ventricle	3 (3.0)
Functional single ventricle	31 (31.3)
Pulmonary atresia with ventricular septal defect	9 (9.1)
Persistent truncus arteriosus	3 (3.0)
Pulmonary hypertension	1 (1.0)
Transposition of the great arteries	2 (2.0)

*Current smoking status = No means that "have never smoked cigarette before" or "past smoker," Yes means that "current smoker,"; #Alcohol consumption = No means that "have never drunk alcohol before" or "less than one glass of alcohol consumed in a month in a recent year," Yes mean that "more than one glass of alcohol a month in a recent year"

Active-Inactive group showed a marked decline in exercise capacity changes, while the Inactive-Active group exhibited a significant increase in health-related quality of life (Fig 2).

Discussion

In our study, we noted upward trends in physical activity, exercise capacity, and health-related quality of life over a span of 3 years, though these variations lacked statistical significance. Nonetheless, we found that changes in physical activity over time were independently associated with changes in exercise capacity and health-related quality of life. Furthermore, a decrease in adherence to recommended levels of physical activity was associated with reduced exercise capacity, while an increase in adherence to recommended levels of physical activity was linked to improvements in health-related quality of life.

Generally, levels of physical activity, exercise capacity, and health-related quality of life are factors that can change over time. For patients with CHD, these metrics often rise post-surgery due to symptomatic relief but can wane as they approach adulthood.[19–21] Notably, the transition from teenage years to early adulthood represents a crucial phase where individuals shift from parental dependence to preparing for self-reliance.[22] This shift is especially distinct for CHD patients who, from early childhood or even infancy, have lived under the intense protective gaze of their parents due to their critical cardiac conditions.[23] As a result, during this transformative phase, some CHD patients might grapple with anxiety. Compounded by the psychological stress of their chronic and potentially fatal conditions, they might drift into social isolation and reduced activity participation, subsequently impacting their quality of life.[24] On the contrary, our study's observations showed that as participants navigated from adolescence to early adulthood, there was not a significant decline in physical activity, exercise capacity, and health-related quality of life. This hints that, in a Korean context, CHD patients might experience only subtle fluctuations in these parameters during this transitional phase. Nevertheless, it is important to note that this study's limited sample size and the relatively short 3-year follow-up period may hinder the generalisability of these findings. Further studies with larger sample sizes and longer follow-up durations would be necessary to support and validate these results.

It is commonly understood that exercise capacity in CHD patients typically decreases post-adolescence, notably in those who have had Fontan surgery, with reported yearly declines varying between 0.8% and 2.6%.[20,25] Surprisingly, our study did not observe any significant shifts in exercise capacity over time, a finding that diverges from prior research by Atz, Zak, Mahony et al[25] and Jenkins, Chinnock, Jenkins et al.[20] The variations in outcomes between our study and earlier research might be attributed to the heterogeneous cardiac conditions represented in our participant pool. Moreover, an important factor to consider is that the CHD patients in our study displayed consistently high levels of physical activity from the outset and throughout the follow-up period. It is conceivable that maintaining such active physical activity levels might have countered potential decreases in exercise capacity over the span of the study.

Until now, studies examining the relationship between physical activity, exercise capacity, and health-related quality of life in CHD patients have mostly employed cross-sectional designs or have been based on physical activity interventions.[3,14,26]

Only a longitudinal study has demonstrated that CHD patients engaging in physical activity more than twice a week led to significantly greater improvements in exercise capacity, compared to those engaging less frequently (△peak VO2 = 1.63 ± 2.67 versus 0.06 ± 2.1 ml/kg/minute) after 2 years.[27] However, this study presented exercise capacity changes based on a specific physical activity frequency (twice a week), which may limit a comprehensive understanding of actual physical activity changes and their direct relationship with exercise capacity. In the

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Table 2. Changes in physical activity, exercise capacity, and health-related quality of life over time.

	Baseline	Follow-up	*t*/χ^2	*p*
Physical activity				
Total PA (METs-minutes/week)*	1060 [600–2040]	1200 [720–2200]	−1.64	0.100
MVPA (METs-minutes/week)*	560 [200–1440]	600 [160–1200]	−0.954	0.340
Vigorous PA (METs-minutes/week)*	0 [0–0]	0 [0–0]	−0.47	0.639
Moderate PA (METs-minutes/week)*	480 [180–880]	560 [0–1080]	−1.32	0.187
Transport-related PA (METs-minutes/week)*	400 [120–800]	400 [120–720]	−0.93	0.926
Sedentary time (hour/day)*	10 [8–11]	10 [7–11]	−1.22	0.222
Recommendations for PA ≥ 150 minutes/week				
Active	43 (43.4%)	44 (44.4%)	0.594	0.441
Inactive	56 (56.6%)	55 (55.6%)		
CPET variables (n = 58)				
Rest HR (beats/minute)	76.2 ± 10.7	76.1 ± 14.6	0.088	0.930
Rest SBP (mmHg)	119.5 ± 23.6	113.3 ± 15.9	1.584	0.119
Rest DBP (mmHg)	69.5 ± 11.5	72.5 ± 9.7	−1.920	0.060
Peak HR (beats/min)	181.2 ± 19.9	177.7 ± 24.4	1.822	0.074
Peak SBP (mmHg)	144.6 ± 21.3	153.2 ± 21.0	−2.781	0.007
Peak DBP (mmHg)	63.6 ± 11.1	69.1 ± 13.0	−2.445	0.018
Peak SpO2 (%)	90.1 ± 6.1	90.4 ± 5.0	−0.414	0.680
Peak RPE	16.8 ± 1.6	16.5 ± 1.1	1.324	0.191
Peak RER	1.16 ± 0.10	1.17 ± 0.09	−0.753	0.454
VE/VCO2	34.5 ± 7.2	33.3 ± 5.0	1.814	0.075
Peak VO2 (L/minute)	1.6 ± 0.6	1.9 ± 0.6	−4.087	<0.001
Peak VO2 (ml/kg/minute)	32.5 ± 7.9	31.9 ± 7.1	0.758	0.452
HRQoL_score				
HRQoL	78.7 ± 15.1	79.8 ± 15.6	−0.87	0.386
Physical function_HRQoL	78.7 ± 17.5	80.3 ± 17.1	−1.04	0.298
Emotion function_HRQoL	77.7 ± 20.0	77.4 ± 21.4	0.15	0.879
Social function_HRQoL	84.8 ± 15.9	85.2 ± 17.0	−0.27	0.787
School function_HRQoL	74.0 ± 17.7	76.2 ± 18.9	−1.34	0.183

Data = median [interquartile range], mean ± standard deviation or n (%); *Mann-Whitney.
PA = physical activity; MVPA = moderate to vigorous physical activity; HR = heart rate; SBP = systolic blood pressure; DBP = diastolic blood pressure; MET = metabolic equivalent of task; CPET = cardiopulmonary exercise test; SpO2 = saturation of percutaneous oxygen; RPE = rating of perceived exertion; RER = respiratory exchange ratio; VE/VCO_2 = minute ventilation/minute carbon dioxide production; peak VO_2 = peak oxygen uptake; HRQoL = health-related quality of life.

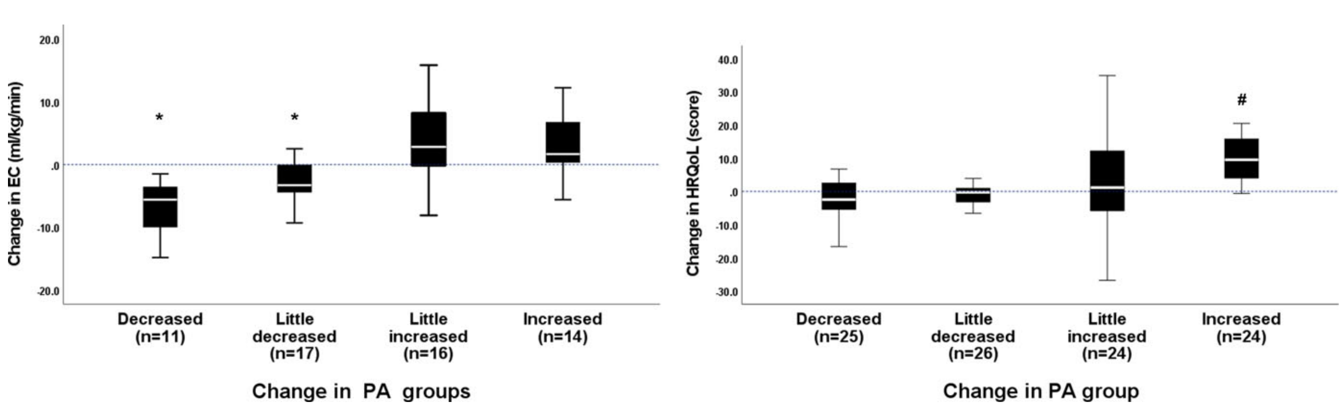

Figure 1. Changes in exercise capacity (EC) and health-related quality of life (HRQoL) by group of changes in physical activity. *p < 0.05 versus little increased group, increased group; #p < 0.05 versus decreased group, little decreased group, little increased group. Decreased = change in physical activity <–560.0 (METs-minutes/week); little decreased = change in physical activity –560.0 to 200.0 (METs-minutes/week); Little increased = change in physical activity 200.0–880.0 (METs-minutes/week); Increased = change in physical activity >880.0 (METs-minutes/week).

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Table 3. Comparison of follow-up variables between four groups classified by change in physical activity.

Variable	Decreased (Q1) (n = 25)	Little decreased (Q2) (n = 26)	Little increased (Q3) (n = 24)	Increased (Q4) (n = 24)	F/χ^2	*p*
Age (years)	19.2 ± 1.5	20.2 ± 1.8	18.7 ± 2.1	19.4 ± 2.0	2.904	0.039 (Q2 > Q3)
Sex (male/female)	18/7	11/5	16/8	15/9	5.411	0.144
BMI (kg/m^2)	22.1 ± 3.6	20.9 ± 3.3	20.9 ± 4.1	22.4 ± 4.0	1.067	0.367
NYHA (I, II, III) (n)	19/6/0	14/9/3	7/15/2	14/10/0	14.953	0.021
Number of surgical during the follow-up period	0.0 ± 0.2	0.1 ± 0.3	0.1 ± 0.4	0.1 ± 0.3	0.359	0.783
Number of procedures during the follow-up period	0.0 ± 0.2	0.4 ± 0.8	0.3 ± 0.6	0.3 ± 0.6	1.478	0.225
Number of admissions during the follow-up period	0.2 ± 0.5	0.6 ± 1.1	1.5 ± 3.7	0.5 ± 0.7	1.944	0.128
Medications (n)	0.9 ± 1.0	1.9 ± 1.0	2.5 ± 2.0	0.9 ± 1.2	5.654	0.001 (Q1, Q4<Q3)
LV EF (%)	60.8 ± 8.3	62.5 ± 7.7	59.5 ± 13.1	61.5 ± 7.3	0.393	0.758
Disease type (Simple, moderate, complex)	5/11/9	2/8/15	3/7/14	4/10/10	4.627	0.592
Δ EC (ml/kg/minute)	−7.0 ± 4.4	−3.2 ± 4.6	3.6 ± 6.2	2.7 ± 5.3	12.216	<0.001 (Q1, Q2<Q3, Q4)
Δ HRQoL	−3.8 ± 10.3	−3.8 ± 8.7	2.7 ± 14.0	9.7 ± 9.9	8.504	<0.001 (Q1, Q2<Q4)
Δ Physical function	−2.6 ± 12.9	−1.9 ± 14.3	2.3 ± 21.0	9.2 ± 10.3	3.196	0.027 (Q1<Q4)
Δ Emotion function	−5.8 ± 18.2	−6.3 ± 17.9	2.3 ± 22.5	9.4 ± 16.6	3.840	0.012 (Q1, Q2<Q4)
Δ Social function	−2.0 ± 11.1	−5.2 ± 12.8	0.8 ± 19.0	8.5 ± 12.6	4.258	0.007 (Q1, Q2<Q4)
Δ School function	−4.6 ± 16.6	−1.5 ± 14.0	4.0 ± 16.7	11.5 ± 13.0	5.301	0.002 (Q1, Q2<Q4)

Data = mean ± standard deviation.
BMI = body mass index; LVEF = left ventricular ejection fraction; EC = exercise capacity; HRQoL = health-related quality of life; Decreased group (Q1) = change in physical activity <−560.0 METs-minutes/week; Little decreased (Q2) = change in physical activity −560.0 to 200.0 METs-minutes/week; Little increased (Q3) = change in physical activity 200.0–880.0 METs-minutes/week; Increased (Q4) = change in physical activity >880 METs-minutes/week; Δ = change in value (follow-up − baseline).

present study, a longitudinal design was employed to investigate variations in daily-life physical activity, revealing that changes in physical activity play a crucial role in modifying exercise capacity. Furthermore, a positive correlation between changes in moderate to vigorous physical activity and exercise capacity was demonstrated, even after adjusting for several potential confounders. Therefore, this study extends the previous findings by emphasising the impact of longitudinal physical activity changes on exercise capacity alterations.

Health-related quality of life serves as a pivotal metric when gauging treatment outcomes from the patient's vantage point.[12] With the increasing longevity of CHD patients, attention has shifted from merely surgical treatments to also encompassing functional health aspects. This has amplified the importance of assessing how non-surgical measures, like lifestyle modifications, impact health-related quality of life. A systematic review by Williams, Wadey, Pieles, Stuart, Taylor and Long[26] reviewed 15 randomised controlled trials involving 924 CHD patients and posited that physical activity interventions moderately increased health-related quality of life.[26] However, there's a notable paucity of studies exploring the effects of daily-life physical activity changes, as opposed to structured physical activity programmes, on health-related quality of life alterations. Addressing this knowledge gap, our research underscores that shifts in moderate to vigorous physical activity bear a direct correlation with health-related quality of life changes, indicating the potential of everyday physical activity adjustments to influence health-related quality of life.

This study comes with several limitations. To begin with, the study did not factor in seasonal variations when analysing shifts in physical activity from the baseline to the follow-up. Additionally, the scope of the study did not capture the full spectrum of fluctuations in physical activity, exercise capacity, and health-related quality of life between these two points. Moreover, not all potential influencing variables for alterations in physical activity, exercise capacity, and health-related quality of life were taken into account. Furthermore, even though both adolescents and adults were part of the study, there is an inherent limitation in utilising adult benchmarks for recommended physical activity levels. Notwithstanding these constraints, this investigation stands out as the first effort to evaluate the longitudinal relationship between physical activity alterations and shifts in exercise capacity and health-related quality of life in the context of Korean CHD patients.

Conclusions

Over 3 years, increased physical activity was consistently linked to increases in exercise capacity and health-related quality of life in patients with CHD. These findings underscore the potential of increased physical activity as a key intervention to improve the exercise capacity and health-related quality of life in patients with CHD.

Table 4. Comparison of follow-up variables between groups classified by change in physical activity recommendation (150 minutes/week).

Variable	Active-active (AA) (n = 21)	Active-inactive (AI) (n = 22)	Inactive-active (IA) (n = 23)	Inactive-inactive (II) (n = 33)	F/χ^2	*p*
Age (years)	20.0 ± 1.7	19.3 ± 1.8	19.2 ± 2.2	19.2 ± 1.9	1.124	0.343
Sex (male/female)	14/7	17/5	12/11	17/16	1.582	0.199
BMI (kg/m^2)	21.1 ± 2.3	21.6 ± 4.2	22.7 ± 4.6	21.0 ± 3.6	1.095	0.355
NYHA (I, II, III) (n)	14/7/0	15/7/0	13/10/0	12/16/5	4.284	0.007 (AA, AI < II)
Number of surgical during the follow-up period	0.1 ± 0.3	0.1 ± 0.3	0.1 ± 0.3	0.1 ± 0.4	0.002	1.000
Number of procedures during the follow-up period	0.1 ± 0.3	0.0 ± 0.2	0.2 ± 0.5	0.5 ± 0.8	3.070	0.032
Number of admissions during the follow-up period	0.3 ± 0.5	0.1 ± 0.4	0.4 ± 0.7	1.5 ± 3.2	2.771	0.046
Medications (n)	0.9 ± 1.2	1.0 ± 1.2	1.5 ± 1.2	2.4 ± 2.2	4.872	0.003 (AA, AI < II)
LVEF (%)	61.7 ± 6.4	61.7 ± 7.5	61.3 ± 11.2	58.5 ± 9.9	0.870	0.460
Disease type (simple, moderate, complex)	4/12/5	6/10/6	3/8/12	1/6/26	7.926	<0.001 (AA, IA < II)
Δ EC (ml/kg/minute)	0.2 ± 7.3	−8.7 ± 4.2	1.7 ± 5.7	−0.4 ± 5.4	5.334	0.003 (AI < AA, IA, II)
Δ HRQoL	3.8 ± 11.8	−3.9 ± 8.9	7.4 ± 13.1	−1.9 ± 11.4	4.901	0.003 (IA > AI, II)
Δ Physical function HRQoL	3.1 ± 10.9	−6.0 ± 14.3	9.5 ± 15.0	0.3 ± 17.1	4.233	0.007 (AI < IA)
Δ Emotion function HRQoL	1.0 ± 17.3	−5.0 ± 18.0	6.1 ± 24.3	−2.4 ± 18.3	1.396	0.249
Δ Social function HRQoL	4.3 ± 10.8	−1.1 ± 14.3	6.5 ± 14.8	−5.3 ± 15.6	3.795	0.013 (IA > II)
Δ School function HRQoL	6.9 ± 15.4	−4.8 ± 14.8	7.6 ± 14.0	0.0 ± 17.2	3.246	0.025

Data = mean ± standard deviation.
Active (A) = MVPA ≥ 150 minutes/week; Inactive (I) = MVPA < 150 minutes/week; BMI = body mass index; LVEF = left ventricular ejection fraction; EC = exercise capacity; HRQoL = health-related quality of life; Δ = change in value (follow-up − baseline).

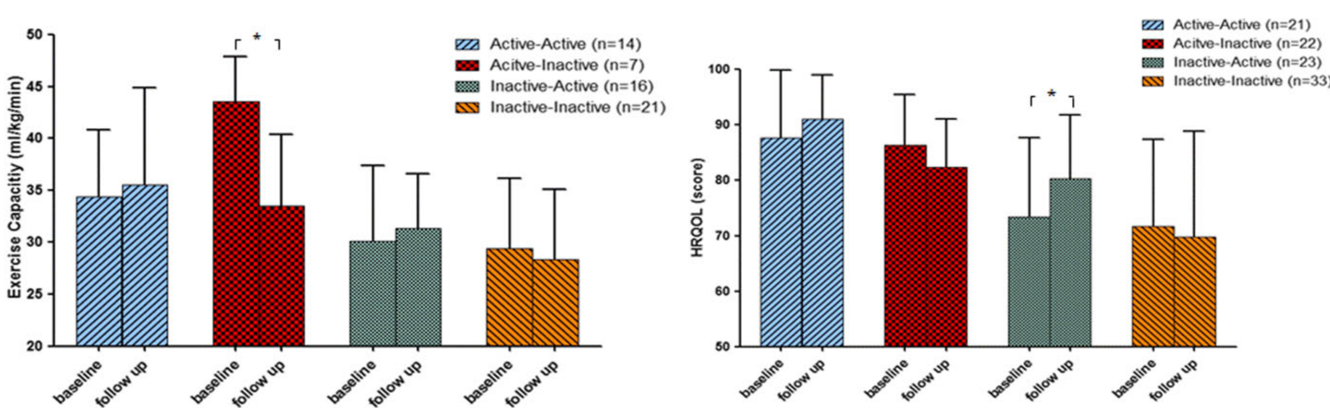

Figure 2. Comparison of baseline and follow-up between classified groups by change of physical activity recommendation (150 minutes/week). *p < 0.05 baseline versus follow-up. Active-Active = baseline MVPA & follow-up MVPA ≥ 150 minutes/week; Active-Inactive = baseline MVPA ≥ 150 minutes/week & follow-up MVPA < 150 minutes/week; Inactive-Active = baseline MVPA < 150 minutes/week & follow-up MVPA ≥ 150 minutes/week; Inactive-Inactive = baseline MVPA & follow-up MVPA < 150 minutes/week.

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