Music-paced physical activity intervention for patients with coronary heart disease: abridged secondary publication

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KEY MESSAGES

1. The combination of music with exercise enhances short-term exercise capacity and long-term self-efficacy.
2. Music-paced physical activity intervention is more effective but more expensive than the usual care for improving quality-adjusted life years. The intervention is considered cost-effective based on World Health Organization criteria.
3. The information-motivation-strategy model and the self-determination theory are practical frameworks for motivating the maintenance of exercise behaviour.

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Introduction

Exercise to promote cardiac rehabilitation (CR) is beneficial for patients with coronary heart disease (CHD). Nevertheless, exercise adherence is difficult to maintain after CHD onset. The combination of music with physical activity (PA) can enhance affective valence and physical performance, while reducing perceived exertion.[1] Memories and enjoyment induced by music are sources of intrinsic motivation for PA. Thus, music-paced PA may promote CR among patients with CHD.[2] We examined the cost-effectiveness and effects of music-paced physical activity (MPPA) on cardiac outcomes among patients with CHD.

Methods

This randomised controlled trial was conducted from August 2017 to September 2021. Patients with CHD aged ≥18 years participating CR at Tung Wah Eastern Hospital were recruited. Patients were excluded if they had physical impairment that prohibited exercise, cognitive impairment, a history of head trauma or seizure (contraindications to rhythmic auditory stimulation), or the inability to wear earbuds/headphones.

All participants completed the first 6 weeks of a CR programme at our centre to increase their exercise capacity. During weeks 7 and 8, the intervention group completed four sessions of MPPA, whereas the control group received the usual care.

In the intervention group, the information-motivation-strategy model[3] was used to motivate participants to perform moderate-intensity PA; personalised, tempo-synchronised music was used to enhance PA maintenance and clinical outcomes. A list of music with a pre-defined tempo (beats per minute [bpm]) was prepared for each patient to determine the range of bpm that the patient could use to achieve moderate intensity (60% to 75%) of maximum heart rate. Additionally, the self-determination theory[4] was applied during eight telephone calls to provide ongoing support for participants to make autonomous decisions on PA maintenance.

The control group completed four education sessions on performing moderate-intensity PA at home, along with telephone follow-up calls.

The primary outcome was exercise capacity in terms of 10-m incremental shuttle walk test. Secondary outcomes included exercise self-efficacy and self-determination, cost-effectiveness of the intervention, and clinical outcomes (eg, fasting blood glucose, haemoglobin A1c, total cholesterol, low-density and high-density lipoprotein cholesterol, triglycerides, blood pressure, waist circumference, body fat mass percentage and body mass index, high sensitivity C-reactive protein, PA level, and health-related quality of life [HRQoL]). PA level was evaluated using an accelerometer and the validated International Physical Activity Questionnaire-Short Form. Exercise self-efficacy was assessed using the validated Chinese version of the Cardiac Exercise Self-Efficacy Instrument. Exercise self-determination was evaluated using the Behavioural Regulation in

Exercise Questionnaire-3. Disease-specific HRQoL was measured using the 37-item Chinese version of the Cardiovascular Limitations and Symptoms Profile. The Chinese version of the EuroQol five dimensions questionnaire (EQ5-D) was used to analyse cost-effectiveness. Health-related costs were defined as direct medical and interventional costs. Outcomes were measured at baseline (T0), 3 months (T1), 6 months (T2), and 15 months (T3).

Bootstrapping and cost-effectiveness curves were plotted. Baseline characteristic homogeneity was compared between intervention and control groups using independent t-tests, the Chi-squared test, and Fisher's exact test, as appropriate. Generalised estimating equation models were used to compare differential changes at T1, T2, and T3 relative to T0 between the intervention and control groups. The intention-to-treat approach was used. Missing data were estimated using a model-based approach based on a quasi-maximum likelihood method.

Cost-effectiveness analyses were performed for total costs (medical + intervention/programme service costs) and incremental cost-effectiveness ratio (ICER), expressed as the incremental cost per quality-adjusted life year (QALY) gained over 15 months. The MPPA intervention was considered cost-effective if the ICER was <3 times the gross domestic product per capita (US$49 660.6 in 2021),[5] according to the World Health Organization.[6] The utility scores of EQ5-D at T0, T1, T2, and T3 were integrated using the trapezoidal method to calculate QALYs. All medical and programme service costs incurred were estimated for each participant using the method of Thompson and Barber, and the mean cost difference between intervention and control groups was used to derive the incremental total costs. A bias-corrected and accelerated bootstrapping method with 10 000 iterations was used to estimate 95% confidence intervals (CIs) for incremental total costs. The mean difference in QALYs between the two groups was regarded as the incremental effect.

TABLE 1. Baseline characteristics between the intervention and control groups and between the completer and dropout groups

Characteristic	Control (n=65)*	Intervention (n=65)*	P value	Completers (n=104)*	Dropouts (n=26)*	P value
Age, y	63.7±9.3	64.8±10.7	0.511	64.2±9.8	64.5±10.8	0.882
Sex						
Male	48 (73.8)	53 (81.5)	0.292	81 (77.9)	20 (76.9)	0.916
Female	17 (26.2)	12 (18.5)		23 (22.1)	6 (23.1)	
Marital status						
Single/divorced/separated/widowed	13 (20.3)	15 (23.8)	0.635	19 (18.8)	9 (34.6)	0.083
Married	51 (79.7)	48 (76.2)		82 (81.2)	17 (65.4)	
Education level						
Primary or below	13 (25.5)	16 (27.6)	0.946	26 (30.6)	3 (12.5)	0.019
Secondary	28 (54.9)	30 (51.7)		39 (45.9)	19 (79.2)	
Tertiary	10 (19.6)	12 (20.7)		20 (23.5)	2 (8.3)	
Have full/part-time job						
No	36 (56.3)	38 (58.5)	0.800	58 (56.3)	16 (61.5)	0.630
Yes	28 (43.8)	27 (41.5)		45 (43.7)	10 (38.5)	
Living alone						
No	49 (76.6)	57 (87.7)	0.099	87 (84.5)	19 (73.1)	0.249
Yes	15 (23.4)	8 (12.3)		16 (15.5)	7 (26.9)	
Type of housing						
Public	12 (19.0)	16 (25.0)	0.660	19 (18.6)	9 (36.0)	0.148
Subsidised	15 (23.8)	16 (25.0)		25 (24.5)	6 (24.0)	
Private	36 (57.1)	32 (50.0)		58 (56.9)	10 (40.0)	
Monthly family income, HK$						
<10 000	15 (23.8)	19 (29.7)	0.503	27 (26.7)	7 (26.9)	0.604
10 000-29 999	18 (28.6)	23 (35.9)		34 (33.7)	7 (26.9)	
≥30 000	21 (33.3)	16 (25.0)		30 (29.7)	7 (26.9)	
Receiving social assistance	9 (14.3)	6 (9.4)		10 (9.9)	5 (19.2)	

* Data are presented as mean ± standard deviation or No. (%) of participants

TABLE 2. Generalised estimating equation models for comparisons over time between the intervention and control groups in terms of cardiac outcomes

Variable	Regression coefficient (95% confidence interval)	P value	Regression coefficient (95% confidence interval)	P value	Regression coefficient (95% confidence interval)	P value	Regression coefficient (95% confidence interval)	P value
	10-m ISWT		CESEI total score		CLASP		EQ5-D VAS	
Group	-28.15 (-89.62 to 33.31)	0.369	-1.15 (-4.77 to 2.47)	0.534	-0.37 (-4.21 to 3.47)	0.851	3.60 (-1.95 to 9.15)	0.204
T1	-14.64 (-33.93 to 4.65)	0.137	-0.22 (-3.72 to 3.28)	0.900	-5.38 (-9.27 to -1.49)	0.007	3.07 (-0.63 to 6.76)	0.103
T2	-2.20 (-20.84 to 16.44)	0.817	1.54 (-0.91 to 3.99)	0.217	-0.98 (-4.37 to 2.42)	0.573	4.32 (-1.57 to 10.20)	0.150
T3	-21.48 (-43.41 to 0.44)	0.055	1.06 (-1.80 to 3.91)	0.468	-1.42 (-4.69 to 1.85)	0.395	3.95 (0.02 to 7.89)	0.049
Group×T1	35.68 (2.69 to 68.68)	0.034	3.95 (-0.63 to 8.54)	0.091	2.87 (-2.07 to 7.81)	0.256	-3.67 (-8.70 to 1.37)	0.154
Group×T2	26.94 (-7.44 to 61.31)	0.125	3.72 (0.11 to 7.32)	0.043	0.91 (-3.64 to 5.46)	0.695	-1.85 (-9.08 to 5.38)	0.616
Group×T3	13.08 (-24.43 to 50.59)	0.494	4.87 (0.95 to 8.79)	0.015	-1.00 (-5.52 to 3.51)	0.663	-0.96 (-6.45 to 4.53)	0.732
	Vigorous MET		Moderate MET		Walking MET		Total MET	
Group	1.62 (-5.54 to 8.79)	0.657	0.88 (-4.63 to 6.39)	0.755	1.88 (-4.58 to 8.33)	0.569	2.00 (-6.63 to 10.62)	0.650
T1	10.95 (0.90 to 21.00)	0.033	5.52 (-1.03 to 12.07)	0.098	2.71 (-2.72 to 8.13)	0.328	24.02 (14.50 to 33.54)	<0.001
T2	0.99 (-5.49 to 7.46)	0.766	7.77 (2.64 to 12.89)	0.003	7.81 (1.45 to 14.17)	0.016	10.75 (3.71 to 17.78)	0.003
T3	10.65 (3.78 to 17.51)	0.002	10.10 (3.15 to 17.04)	0.004	5.51 (-0.36 to 11.38)	0.066	13.25 (5.91 to 20.59)	<0.001
Group×T1	-4.78 (-17.03 to 7.47)	0.444	-3.21 (-11.43 to 5.01)	0.444	-2.03 (-10.22 to 6.16)	0.627	-4.93 (-17.94 to 8.08)	0.458
Group×T2	2.96 (-6.44 to 12.36)	0.537	-3.97 (-10.66 to 2.72)	0.244	-6.25 (-14.90 to 2.40)	0.157	-4.95 (-14.97 to 5.07)	0.333
Group×T3	7.65 (-6.14 to 21.45)	0.277	-3.69 (-12.60 to 5.23)	0.418	-0.98 (-9.42 to 7.46)	0.820	4.02 (-9.38 to 17.41)	0.557
	Amotivation		External regulation		Introjected regulation		Identified regulation	
Group	-0.04 (-0.30 to 0.22)	0.765	0.04 (-0.29 to 0.38)	0.810	-0.17 (-0.54 to 0.20)	0.370	0.03 (-0.20 to 0.26)	0.811
T1	2.46 (2.17 to 2.76)	<0.001	0.28 (-0.07 to 0.62)	0.113	0.11 (-0.22 to 0.45)	0.507	0.07 (-0.19 to 0.33)	0.601
T2	2.74 (2.44 to 3.05)	<0.001	0.12 (-0.20 to 0.43)	0.458	0.30 (-0.02 to 0.62)	0.069	0.23 (0.06 to 0.39)	0.007
T3	2.61 (2.32 to 2.89)	<0.001	0.17 (-0.14 to 0.48)	0.278	0.15 (-0.15 to 0.44)	0.330	0.06 (-0.14 to 0.26)	0.543
Group×T1	0.16 (-0.28 to 0.59)	0.477	-0.03 (-0.49 to 0.42)	0.886	0.24 (-0.23 to 0.70)	0.317	-0.01 (-0.34 to 0.31)	0.936
Group×T2	0.04 (-0.43 to 0.50)	0.870	-0.04 (-0.50 to 0.42)	0.853	0.14 (-0.32 to 0.60)	0.561	0.02 (-0.22 to 0.26)	0.888
Group×T3	0.03 (-0.41 to 0.48)	0.885	0.08 (-0.38 to 0.54)	0.731	0.36 (-0.10 to 0.81)	0.124	0.15 (-0.14 to 0.44)	0.303
	Integrated regulation		Intrinsic regulation					
Group	-0.09 (-0.40 to 0.23)	0.581	0.06 (-0.26 to 0.38)	0.717				
T1	0.36 (0.05 to 0.66)	0.022	0.26 (-0.01 to 0.52)	0.057				
T2	0.32 (0.08 to 0.56)	0.010	0.18 (-0.14 to 0.49)	0.268				
T3	0.21 (-0.05 to 0.48)	0.114	0.13 (-0.10 to 0.37)	0.269				
Group×T1	0.02 (-0.42 to 0.45)	0.945	0.08 (-0.32 to 0.48)	0.690				
Group×T2	0.07 (-0.33 to 0.46)	0.744	-0.02 (-0.47 to 0.42)	0.915				
Group×T3	0.13 (-0.29 to 0.55)	0.541	0.32 (-0.06 to 0.70)	0.101				
	Body weight		BMI		Waist circumference		Body fat	
Group	-0.27 (-3.84 to 3.31)	0.884	0.04 (-1.15 to 1.22)	0.954	-0.01 (-3.01 to 2.99)	0.993	-0.21 (-2.34 to 1.92)	0.849
T1	0.32 (-1.09 to 1.73)	0.660	0.30 (-0.24 to 0.84)	0.280	1.68 (0.19 to 3.17)	0.027	2.62 (1.31 to 3.93)	<0.001
T2	0.86 (-0.55 to 2.27)	0.230	0.52 (0.00 to 1.05)	0.050	0.99 (-0.47 to 2.46)	0.185	2.84 (1.60 to 4.08)	<0.001
T3	0.73 (-0.62 to 2.08)	0.288	0.37 (-0.13 to 0.87)	0.147	0.46 (-1.17 to 2.08)	0.582	2.07 (0.82 to 3.33)	0.001
Group×T1	-0.28 (-1.93 to 1.36)	0.736	-0.19 (-0.85 to 0.47)	0.572	-1.08 (-2.98 to 0.82)	0.264	-1.19 (-2.82 to 0.44)	0.153
Group×T2	-0.74 (-2.41 to 0.92)	0.381	-0.46 (-1.08 to 0.15)	0.140	-1.24 (-3.19 to 0.70)	0.210	-0.90 (-2.50 to 0.70)	0.271
Group×T3	-0.15 (-1.82 to 1.52)	0.861	-0.15 (-0.77 to 0.46)	0.627	-0.33 (-2.51 to 1.84)	0.763	0.41 (-1.25 to 2.07)	0.625

Abbreviations: BMI=body mass index, CESEI=Cardiac Exercise Self-Efficacy Instrument, CLASP=Cardiovascular Limitations and Symptoms Profile, CRP=C-reactive protein, DBP=diastolic blood pressure, EQ5-D VAS=EuroQol five dimensions questionnaire visual analogue scale, HDL=high-density lipoprotein, ISWT=incremental shuttle walk test, LDL=low-density lipoprotein, MET=metabolic equivalent of task, SBP=systolic blood pressure, TC=total cholesterol

TABLE 2. (cont'd)

Variable	Regression coefficient (95% confidence interval)	P value	Regression coefficient (95% confidence interval)	P value	Regression coefficient (95% confidence interval)	P value	Regression coefficient (95% confidence interval)	P value
	10-m ISWT		CESEI total score		CLASP		EQ5-D VAS	
	SBP		**DBP**		**Pulse rate**		**Haemoglobin A1c**	
Group	-3.55 (-8.48 to 1.37)	0.157	-1.79 (-5.07 to 1.50)	0.287	0.40 (-3.72 to 4.52)	0.849	-0.09 (-0.36 to 0.18)	0.524
T1	4.67 (-0.32 to 9.65)	0.066	0.88 (-1.63 to 3.39)	0.493	-0.88 (-4.23 to 2.48)	0.608	-0.03 (-0.12 to 0.07)	0.592
T2	7.64 (2.83 to 12.45)	0.002	0.67 (-1.72 to 3.07)	0.582	-2.40 (-5.02 to 0.22)	0.073	0.07 (-0.02 to 0.16)	0.140
T3	3.58 (-2.08 to 9.24)	0.215	-1.44 (-3.68 to 0.80)	0.207	-1.20 (-4.49 to 2.09)	0.475	0.09 (-0.02 to 0.20)	0.117
Group×T1	-0.52 (-6.86 to 5.82)	0.872	-0.88 (-4.35 to 2.59)	0.619	-0.70 (-5.16 to 3.77)	0.760	0.13 (-0.02 to 0.27)	0.086
Group×T2	-1.21 (-8.17 to 5.75)	0.734	-0.16 (-3.50 to 3.18)	0.925	-0.82 (-4.75 to 3.12)	0.685	0.04 (-0.13 to 0.21)	0.639
Group×T3	0.10 (-7.05 to 7.24)	0.979	1.87 (-1.33 to 5.07)	0.251	-1.12 (-5.59 to 3.36)	0.624	0.06 (-0.12 to 0.25)	0.498
	Fasting blood glucose		**Total cholesterol**		**HDL-cholesterol**		**TC to HDL-cholesterol ratio**	
Group	-0.46 (-0.94 to 0.03)	0.066	0.05 (-0.23 to 0.32)	0.743	0.01 (-0.08 to 0.11)	0.771	0.04 (-0.26 to 0.33)	0.815
T1	-0.14 (-0.39 to 0.11)	0.277	-0.05 (-0.23 to 0.14)	0.616	0.00 (-0.03 to 0.04)	0.887	0.03 (-0.22 to 0.27)	0.838
T2	0.13 (-0.07 to 0.33)	0.196	-0.09 (-0.22 to 0.04)	0.167	0.00 (-0.04 to 0.05)	0.925	-0.06 (-0.18 to 0.06)	0.328
T3	0.22 (-0.08 to 0.52)	0.156	0.04 (-0.12 to 0.20)	0.616	0.03 (-0.02 to 0.07)	0.307	-0.05 (-0.21 to 0.11)	0.548
Group×T1	0.15 (-0.17 to 0.47)	0.354	0.09 (-0.14 to 0.31)	0.451	0.02 (-0.04 to 0.07)	0.619	-0.06 (-0.35 to 0.22)	0.660
Group×T2	-0.09 (-0.40 to 0.21)	0.548	0.12 (-0.09 to 0.33)	0.248	0.05 (-0.02 to 0.12)	0.155	-0.04 (-0.26 to 0.17)	0.684
Group×T3	0.09 (-0.32 to 0.50)	0.665	0.02 (-0.21 to 0.25)	0.844	0.04 (-0.02 to 0.11)	0.193	-0.13 (-0.36 to 0.11)	0.288
	LDL-cholesterol		**Triglyceride**		**High-sensitivity CRP**			
Group	0.05 (-0.19 to 0.30)	0.663	0.00 (-0.25 to 0.25)	0.994	0.20 (-0.21 to 0.61)	0.340		
T1	-0.09 (-0.25 to 0.08)	0.317	0.09 (-0.09 to 0.26)	0.336	-0.19 (-0.53 to 0.15)	0.265		
T2	-0.08 (-0.19 to 0.02)	0.113	-0.01 (-0.16 to 0.14)	0.889	-0.19 (-0.49 to 0.11)	0.210		
T3	0.01 (-0.12 to 0.14)	0.881	0.02 (-0.18 to 0.22)	0.839	-0.22 (-0.51 to 0.06)	0.129		
Group×T1	0.11 (-0.09 to 0.31)	0.270	-0.13 (-0.35 to 0.08)	0.227	-0.02 (-0.46 to 0.42)	0.923		
Group×T2	0.09 (-0.10 to 0.27)	0.361	-0.07 (-0.31 to 0.17)	0.552	0.02 (-0.40 to 0.44)	0.925		
Group×T3	0.02 (-0.19 to 0.22)	0.874	-0.12 (-0.40 to 0.16)	0.388	0.01 (-0.39 to 0.41)	0.963		
Regression coefficient	**Lightly active activity**		**Fairly active activity**		**Very active activity**		**Total activity**	
Group	0.61 (-1.00 to 2.22)	0.459	0.57 (-0.19 to 1.33)	0.140	0.73 (-0.16 to 1.61)	0.110	1.03 (-0.80 to 2.86)	0.270
T1	-0.02 (-1.94 to 1.90)	0.983	-0.17 (-0.97 to 0.63)	0.680	-0.42 (-1.45 to 0.60)	0.419	-0.19 (-2.42 to 2.03)	0.867
T2	1.28 (-0.10 to 2.67)	0.069	0.42 (-0.06 to 0.89)	0.084	0.68 (-0.03 to 1.39)	0.059	1.55 (0.05 to 3.05)	0.043
T3	-0.64 (-2.34 to 1.06)	0.460	-0.02 (-0.74 to 0.71)	0.969	0.13 (-0.81 to 1.07)	0.780	-0.49 (-2.45 to 1.47)	0.621
Group×T1	0.71 (-1.71 to 3.13)	0.566	0.24 (-0.79 to 1.27)	0.652	0.08 (-1.16 to 1.32)	0.900	0.71 (-2.03 to 3.45)	0.613
Group×T2	0.06 (-2.04 to 2.15)	0.959	0.24 (-0.88 to 1.36)	0.671	-0.84 (-1.92 to 0.24)	0.126	-0.12 (-2.47 to 2.23)	0.920
Group×T3	0.18 (-2.13 to 2.48)	0.881	-0.47 (-1.43 to 0.50)	0.342	-1.09 (-2.28 to 0.10)	0.073	-0.45 (-3.05 to 2.14)	0.732

The bootstrapping method was used to estimate 95% CIs for incremental effects. The bootstrapped 10 000 pairs of incremental costs and incremental effects were plotted on a cost-effectiveness curve to illustrate uncertainty surrounding the cost-effectiveness ratio. All statistical tests were two-sided, and the significance level was set at 0.05.

Results

Among 348 patients with CHD, 130 agreed to participate. The mean age of participants was 64.24 years. The intervention and control groups were comparable in terms of demographics (Table 1).

Compared with the control group, the intervention group demonstrated significantly greater improvements in exercise capacity at T1 (P=0.034) and in exercise self-efficacy at T2 (P=0.043) and T3 (P=0.015) [Table 2].

The mean overall QALY levels over 15 months were 1.2295 in the intervention group and 1.2262 in the control group. MPPA intervention led to a greater gain of 0.0033 (95% bootstrap CI= -0.0096 to 0.0164) QALYs and a higher total cost of HK$198 (95% bootstrap CI=71.5 to 338.3), compared with the control group. The mean cost per patient for 1 QALY gain by MPPA intervention was HK$60 182 (~US$7716), which was <3 times the gross domestic product per capita (US$ 49 660.6 in 2021). Thus, the MPPA intervention was considered cost-effective. The cost-effectiveness curve shows the ICERs of the bootstrapped results with 10 000 replications; 69% of the bootstrapped cost-effectiveness data indicated that the MPPA intervention was considerably more effective but more expensive than the usual care in terms of QALY improvement.

Discussion

MPPA can be an effective strategy to enhance exercise capacity for 3 months and exercise self-efficacy for 15 months. The lack of a long-term effect on exercise capacity may be attributed to the COVID-19 pandemic and corresponding infection control measures. Although the patients' indoor activities may not have been restricted, the reduced outdoor activity and negative behavioural changes could have led to a decrease in total PA time.[7]

There was no significant effect of MPPA intervention on PA level, compared with the usual care. However, the intervention group showed a greater improvement in accelerometer-measured PA level at T1, compared with the control group. This may have contributed to the significantly improved exercise capacity in the intervention group at 3 months. The lack of a significant effect on exercise capacity at 15 months may have been attributed to social restrictions during the pandemic and the high PA level that already contributed to great benefits.

There was no significant difference between groups regarding clinical parameters. Clinical outcomes are affected by many aspects other than exercise such as lifestyle modifications. Therefore, comprehensive CR programmes should focus on modifying cardiovascular risk factors and unhealthy lifestyles.

Compared with the control group, the intervention group did not exhibit significant effects on HRQoL. Nevertheless, in addition to changes observed in the control group, the intervention group displayed improvements in HRQoL at T1 and T2. There was no significant difference between groups regarding self-determination. Nevertheless, a trend toward improvement was present in both groups.

Conclusion

The combination of music with exercise training may enhance short-term exercise capacity and long-term exercise self-efficacy. The MPPA intervention is more effective but more expensive than the usual care for improving QALYs. There was no significant difference between groups regarding other outcomes; most outcomes showed a trend toward improvement.

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Disclosure

The results of this research have been previously published in:
1. Chair SY, Leung KC, Lo SWZ, et al. Exercise capacity and its determinants among postcardiac rehabilitation patients with coronary heart disease. Nurs Open 2023;10:2501-7.
2. Chair SY, Cheng HY, Lo SWS, et al. Effectiveness of a home-based music-paced physical activity programme on exercise-related outcomes after cardiac rehabilitation: a randomized controlled trial. Eur J Cardiovasc Nurs 2024:zvad115.

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