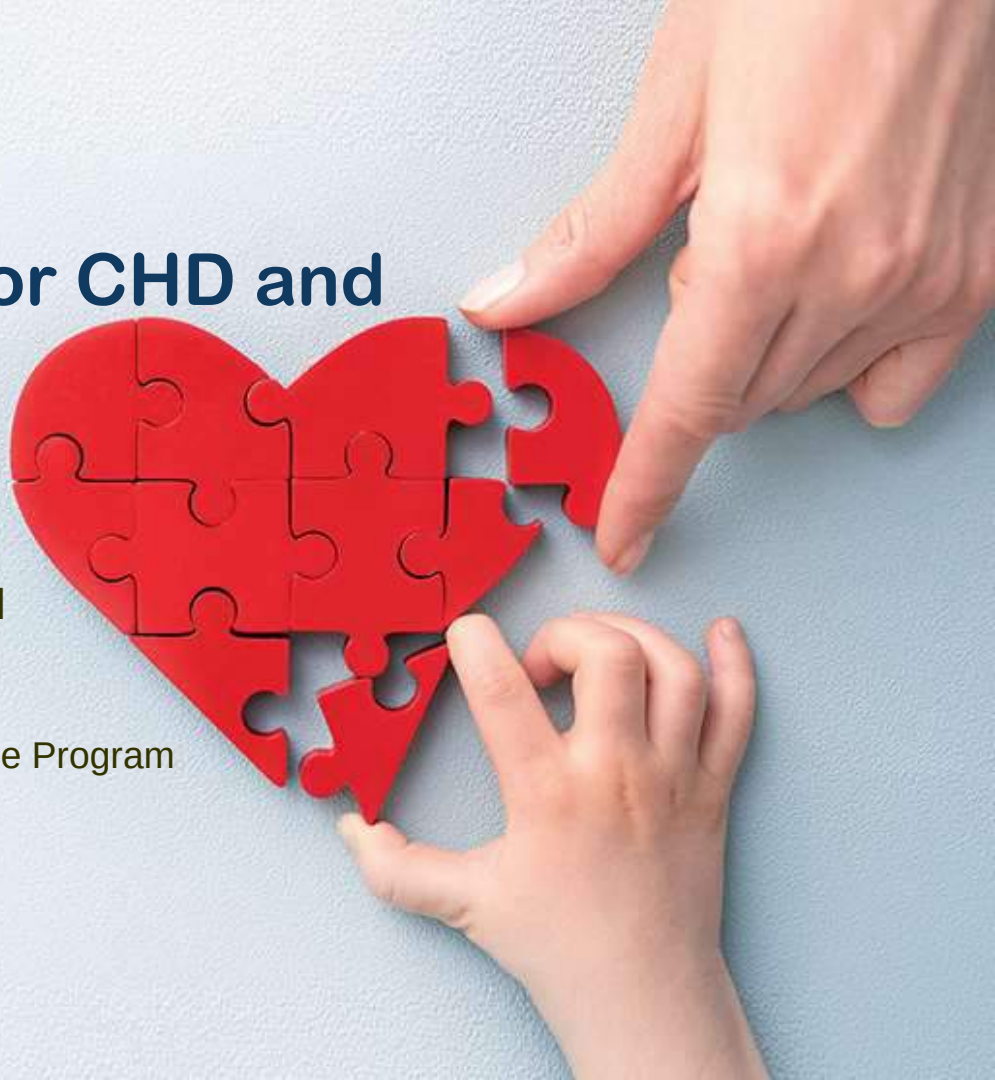
CARDIOLOGY 2024

eHealth Technologies for CHD and Pediatric Patients



David A. White, PhD, ACSM-CEP, FACSM

Ward Family Heart Center
Pediatric Physical Activity & Cardiac Exercise Science Program
Children's Mercy Kansas City

Cardiology 2024 – *Data Tells the Story*
February 15th, 2024

Disclosures

Ineligible Companies

- None

Funding

- NIH-NHLBI K23HL159325
- Additional Ventures – Single Ventricle Foundation (1019144)

Digital Healthcare Landscape

Chan. *J Med Libr Assoc,* 2021
Moss et al., *Eur J Hosp Pharm*, 2019
World Health Organization. eHealth [Internet]. <https://www.who.int/ehealth/en/>

Digital Healthcare

eHealth

The use of information and communication technologies for healthcare

- Patient administration systems
- Cloud-based storage systems
- Specialized Software
- Electronic health records

mHealth

The use of mobile digital devices to monitor, communicate, and deliver healthcare from a distance

- Telemedicine & Telehealth
- Mobile health apps.
- Remote patient monitoring
- Ambulatory monitoring devices

CARDIOLOGY 2024

Children's Mercy KANSAS CITY

PACES

Digital Healthcare Landscape

Chan. *J Med Libr Assoc,* 2021
Moss et al., *Eur J Hosp Pharm*, 2019
World Health Organization. eHealth [Internet]. <https://www.who.int/ehealth/en/>

Digital Healthcare

eHealth

The use of information and communication technologies for healthcare

- Patient administration systems
- Cloud-based storage systems
- Specialized Software
- Electronic health records

&

mHealth

The use of mobile digital devices to monitor, communicate, and deliver healthcare from a distance

- Telemedicine & Telehealth
- Mobile health apps.
- Remote patient monitoring
- Ambulatory monitoring devices

Physical Activity & Exercise Intervention (Pediatric Cardiac Rehab)

CARDIOLOGY 2024

Children's Mercy KANSAS CITY

PACES

White et al., *Front Cardiovasc Med*, 2023

mHealth for Delivering Cardiac Rehab

frontiers | Frontiers in Cardiovascular Medicine

TYPE Review
PUBLISHED 02 June 2023
DOI 10.3389/fcvm.2023

Check for updates

OPEN ACCESS

EDITED BY
Inga Voges,
University Medical Center Schleswig-Holstein, Germany

REVIEWED BY
Almudena Ortiz Garrido,
Regional University Hospital of Malaga, Spain
Lee Pyles,
West Virginia University, United States

*CORRESPONDENCE
David A. White
dawhite@cmh.edu

RECEIVED 31 January 2023
ACCEPTED 18 May 2023
PUBLISHED 02 June 2023

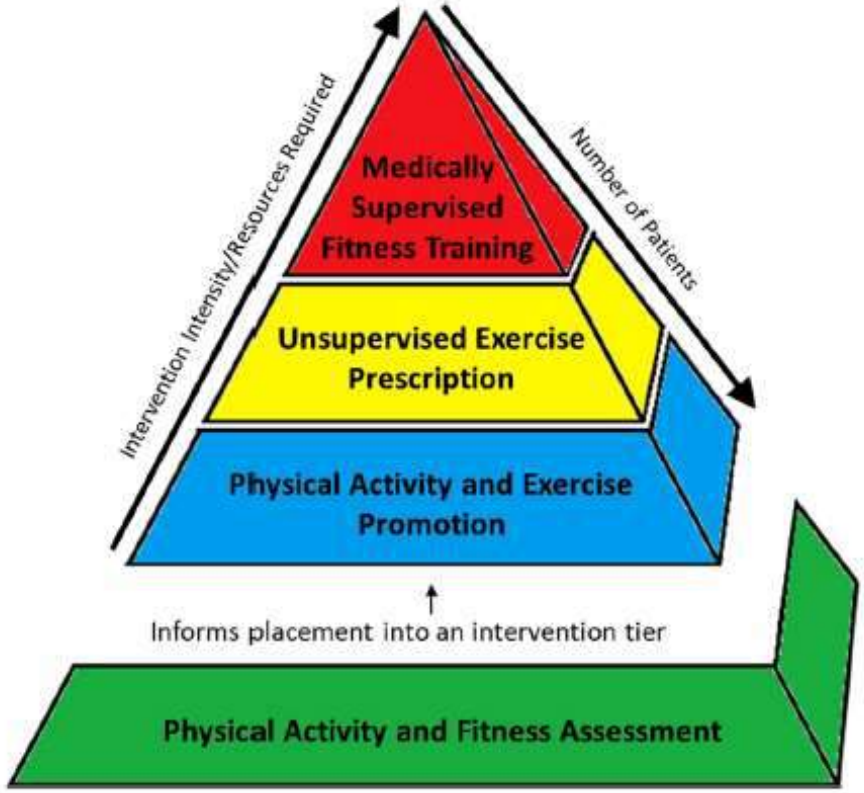
CITATION
White DA, Layton AM, Curran T, Gauthier N, Orr WB, Ward K, Vernon M, Martinez MN, Rice MC, Hansen K, Prusi M and Hansen JE (2023) ehealth technology in cardiac exercise therapeutics for pediatric patients with congenital and acquired heart conditions: a summary of evidence and future directions. Front. Cardiovasc. Med. 10:1155861. doi: 10.3389/fcvm.2023.1155861

ehealth technology in cardiac exercise therapeutics for pediatric patients with congenital and acquired heart conditions: a summary of evidence and future directions

David A. White[1,2*], Aimee M. Layton[3], Tracy Curran[4], Naomi Gauthier[4], William B. Orr[5], Kendra Ward[6], Meg Vernon[7], Matthew N. Martinez[8], Malloree C. Rice[9], Katherine Hansen[4], Megan Prusi[10] and Jesse E. Hansen[10] on behalf of The Technology Evaluation and Usage in Cardiac and Fitness Rehabilitation (TECH) working group from the Global Coalition for Fitness and Congenital Heart Disease (GLOCO)

[1]Ward Family Heart Center, Children's Mercy Kansas City, Kansas City, MO, United States, [2]School of Medicine, University of Missouri Kansas City, Kansas City, MO, United States, [3]Division of Pediatric Cardiology, Department of Pediatrics, Columbia University Irving Medical Center, New York, NY, United States, [4]Department of Cardiology, Boston Children's Hospital, Boston, MA, United States, [5]Division of Pediatric Cardiology, Department of Pediatrics, Washington University School of Medicine, St. Louis, MO, United States, [6]Division of Cardiology, Department of Pediatrics, Ann & Robert H. Lurie Children's Hospital of Chicago, Chicago, IL, United States, [7]Division of Cardiology, Department of Pediatrics, Seattle Children's Hospital, Seattle, WA, United States, [8]Division of Pediatric Cardiology, Department of Pediatrics, Hassenfeld Children's Hospital at NYU Langone, New York, NY, United States, [9]Division of Pediatric Cardiology, Heart Institute, Cincinnati Children's Hospital Medical Center, Cincinnati, OH, United States, [10]Division of Pediatric Cardiology, Department of Pediatrics, C.S. Mott Children's Hospital, Ann Arbor, MI, United States

Cardiac Exercise Therapeutics Model



White et al., *Front Cardiovasc Med*, 2023

mHealth for Delivering Cardiac Rehab

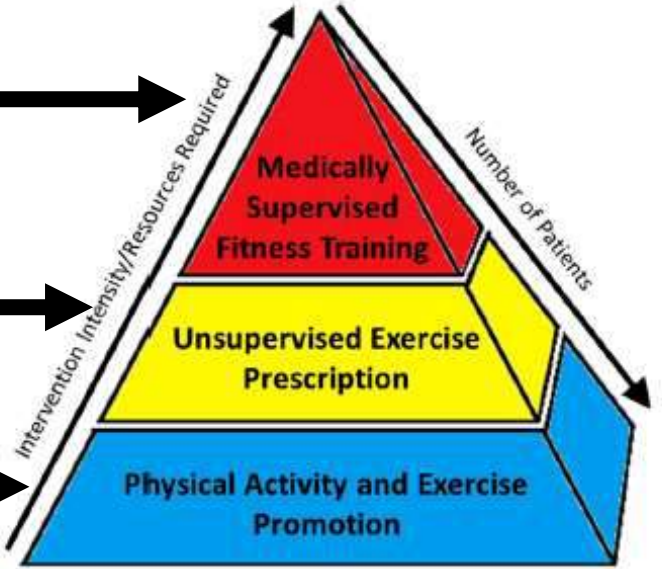
Cardiac Exercise Therapeutics Model

Intervention or Rehab Approach

Most Intensive
Live-supervised custom exercise training

Moderate Intensity
Customized exercise prescriptions to use at home

Least Intensive
Exercise/PA promotion for all patients



Informs placement into an intervention tier

Assessment

CARDIOLOGY 2024

Physical Activity & Exercise Promotion

Educating and encouraging patient/family to engage in physical activity and exercise

Klausen et al., 2016 – 'PReVaiL RCT' (Denmark)		Lemire et al., 2020 (Canada)	
Aim	Benefits and harms of adding an eHealth intervention to health education and individual counseling in adolescents with CHD.	**Aim**	Feasibility and impact of a tool kit of resources for providing outpatient physical activity counseling for children with CHD.
eHealth Approach	MinPuls.nu software tool and a personal home page (http://www.minpuls.nu/)	**eHealth Approach**	Web-based platform CHEO (www.cheoactive.ca)
Features	• Tailored interactive text encouragement (weekly) • Exercise-planning and monitoring tool • Motivation/encouragement	**Features**	• A physical activity tool kit • Simple, low-cost activity ideas/suggestions • Activities aligned with the child's restrictions
Outcomes	• Struggled with compliance • No change in Fitness • No change in Physical Activity	**Outcomes**	• Study Ongoing – None to report

Physical Activity & Exercise Promotion

Three arm RCT

Intervention Group 1

- "COOL Passport" mobile health app.

1. Personal health management	2. Eliminating endocarditis	3. My nutritional decisions	4. My progress
5. Understanding my medications	6. My physical fitness	7. My mood and feelings	8. My rights

Intervention Group 2

- "COOL Passport" **+** Health Promotion Cloud
  - Interactive gameplay
  - Step counts
  - CHD knowledge quizzes
  - Q&A with provider

Received: 29 July 2020 | Revised: 25 March 2021 | Accepted: 24 May 2021
DOI: 10.1111/jan.14924

ORIGINAL RESEARCH: CLINICAL TRIAL

JAN WILEY

Long-term effectiveness of an mHealth-tailored physical activity intervention in youth with congenital heart disease: A randomized controlled trial

Pei-Jung Lin[1] | Yong-Yi Fanjiang[2] | Jou-Kou Wang[3] | Chun-Wei Lu[3] | Kuan-Chia Lin[4] | In-Mei Cheong[5] | Kuan-You Pan[6] | Chi-Wen Chen[7]

[1]Department of Nursing, National Taiwan University Hospital, Taipei, Taiwan
[2]Department of Computer Science and Information Engineering, Fu-Jen Catholic University, New Taipei, Taiwan
[3]Department of Pediatrics, National Taiwan University Hospital, Taipei, Taiwan
[4]Institute of Hospital and Health Care Administration, National Yang Ming Chiao

Abstract

Aims: To evaluate the long-term effectiveness of the Care & Organize Our Lifestyle (COOL) programme, a self-regulation theory-based mHealth programme, on improving disease knowledge and physical activity in youth with congenital heart disease (CHD).

Design: A three-arm parallel-group randomized controlled trial.

No between group differences in change in physical activity after 12-months.

Physical Activity & Exercise Promotion

Phase I: Literature Review & Qualitative

- Strengths & weaknesses of other interventions
- Qualitative interviews

Phase II: Conceptualizing & Prototyping

- Building the platform

Phase III: Usability Evaluation

- Piloting in parent/child dyads

Phase IV: Randomized Controlled Trial

- Implementing the platform over 12-weeks
- Outcomes: Fitness, Physical activity, Feasibility, Acceptability, Satisfaction


Journal of Multidisciplinary Healthcare

Dovepress

STUDY PROTOCOL

A WeChat-Based Rehabilitation Platform for Children and Adolescents with Congenital Heart Disease to Promote Cardiac FITness (HeartFIT): Protocol for a Mixed-Methods Strategy from Evidence-Based Design to Pilot Study

Yuan Li[1–3,*], Yaxin Zhou[4,5,*], Miao Chen[6], Mei R Fu[7], Biru Luo[1–3], Pengming Yu[4,5,8], Hong Zheng[1,9], Fangfei Liu[1,9]

Children's Mercy KANSAS CITY

PACES

Meyer et al., *J Pediatr*, 2021
Meyer et al., *Front Pediatr*, 2018

Unsupervised Exercise Prescription

Customized exercise prescription that outlines the frequency, intensity, duration, and modality of a self-directed exercise routine performed at home

Randomized Controlled Trial

- Intervention Group (n=35)
- Control group (n=35)

Participants

- 10-18 yrs. old) w/ moderate to complex CHD

Web-based exercise/motor intervention

- 24-weeks
- 3x wk., 20-min/session


THE JOURNAL OF PEDIATRICS • www.jpeds.com ORIGINAL ARTICLES

E-Health Exercise Intervention for Pediatric Patients with Congenital Heart Disease: A Randomized Controlled Trial

Michael Meyer, MSc[1,2], Leon Brudy, MSc[1,2], Angeles Fuertes-Moure, MD[3], Alfred Hager, MD[2], Renate Oberhoffer-Fritz, MD[1,2], Peter Ewert, MD[1,2], and Jan Müller, PhD[1,2]

Objective To improve health-related physical fitness (HRPF) (primary outcome) and health-related quality of life (HRQoL) with a web-based motor intervention program in pediatric patients with congenital heart disease (CHD).

"One Hour a Week, Brings Mobility, Power and Speed!"

Children's Mercy KANSAS CITY

P.A.C.E.S

Meyer et al., *J Pediatr*, 2021
Meyer et al., *Front Pediatr*, 2018

Unsupervised Exercise Prescription

Web-based e-Learning platform: “Einstein”

- Exercise videos transmitted to their homes
  - Exercise in-home at their convenience
- Videos served as a “Virtual training partner”
- Adherence: monitored with video tracking tool included in the exercise platform
- Can complete surveys and report RPE through the platform

CARDIOLOGY 2024

Children's Mercy KANSAS CITY

PACES

Unsupervised Exercise Prescription

Table II. Mean differences between intervention and control group after 24 weeks of exercise intervention

HRPF	Intervention group (n = 31)			Control group (n = 30)			*P* value*
	Baseline evaluation	24 weeks' follow-up	Difference, mean ± SD	Baseline evaluation	24 weeks' follow-up	Difference, mean ± SD	
Total, z score	−0.73 ± 0.46	−0.57 ± 0.58	0.15 ± 0.38	−0.84 ± 0.43	−0.75 ± 0.61	0.09 ± 0.38	.560
Curl-ups, z score	−0.98 ± 0.65	−0.67 ± 0.98	0.30 ± 0.83	−0.92 ± 0.85	−0.57 ± 1.12	0.34 ± 0.77	.830
Trunk-lift, z score	−0.67 ± 0.81	−0.40 ± 1.03	0.26 ± 0.95	−0.97 ± 0.81	−0.82 ± 0.85	0.15 ± 0.85	.621
Push-ups, z score	−0.23 ± 0.99	−0.08 ± 1.21	0.15 ± 0.97	−0.30 ± 0.74	−0.08 ± 1.03	0.21 ± 0.73	.771
Shoulder stretch, z score	−0.87 ± 1.08	−0.75 ± 1.23	0.12 ± 0.63	−1.30 ± 1.11	−1.16 ± 0.98	0.14 ± 0.73	.912
Sit and reach, z score	−0.86 ± 1.31	−0.96 ± 1.43	−0.10 ± 0.81	−0.69 ± 1.29	−1.10 ± 1.39	−0.40 ± 0.80	.150
HrQoL							
Total	77.38 ± 9.63	76.20 ± 9.82	−1.73 ± 8.33	77.84 ± 11.31	79.37 ± 9.32	1.31 ± 7.85	.160
Physical well-being	79.03 ± 16.58	76.11 ± 16.92	−2.90 ± 16.00	76.62 ± 16.11	76.45 ± 14.92	0.83 ± 15.28	.367
Emotional well-being	81.85 ± 9.92	84.15 ± 9.84	2.00 ± 9.32	81.87 ± 12.64	85.69 ± 12.17	3.82 ± 10.86	.500
Self-esteem	67.54 ± 16.88	64.73 ± 16.24	−4.01 ± 18.72	65.30 ± 18.92	66.04 ± 18.25	0.01 ± 17.50	.406
Family	86.69 ± 13.57	86.85 ± 12.86	−0.43 ± 12.93	87.28 ± 19.15	88.54 ± 12.18	0.86 ± 16.93	.745
Friends	77.82 ± 19.01	77.44 ± 19.28	−2.08 ± 19.07	79.95 ± 15.25	82.11 ± 12.24	2.23 ± 17.28	.375
School	71.37 ± 17.43	69.19 ± 16.57	−2.23 ± 16.51	77.08 ± 15.12	76.56 ± 15.92	−0.96 ± 15.78	.774

Fitness

QoL

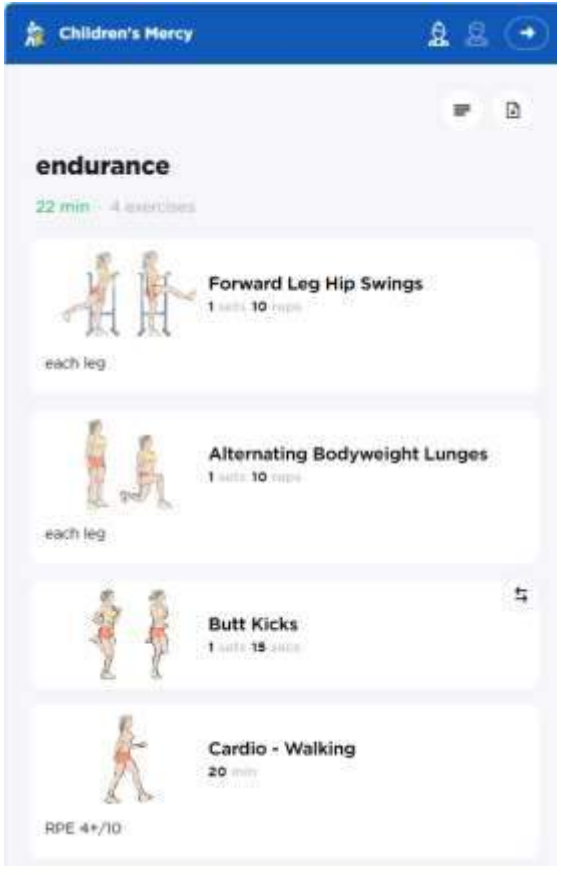
*Student *t* test difference between intervention group and control group with *P* values < .05 considered significant.

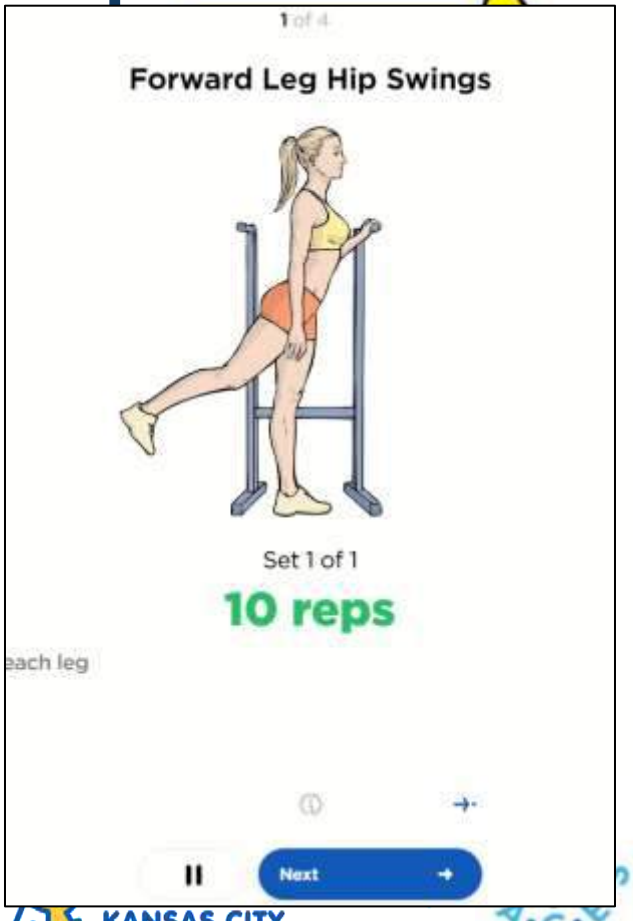
Unsupervised Exercise Prescription

WorkoutLabs mobile app.

- Design workouts
- Schedule workouts
- Notifications sent to mobile device
- Tracking for adherence

No research…yet

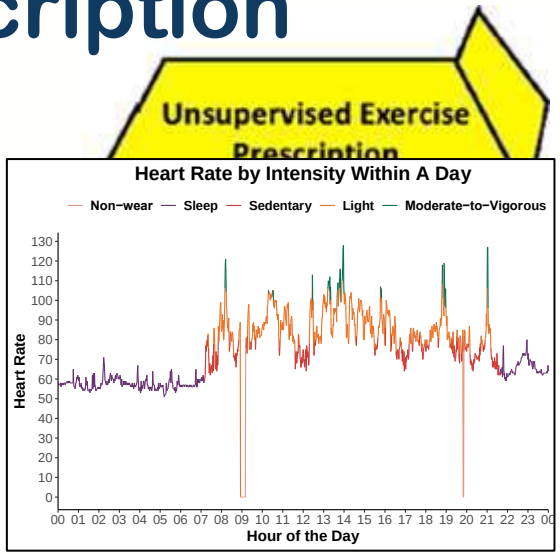




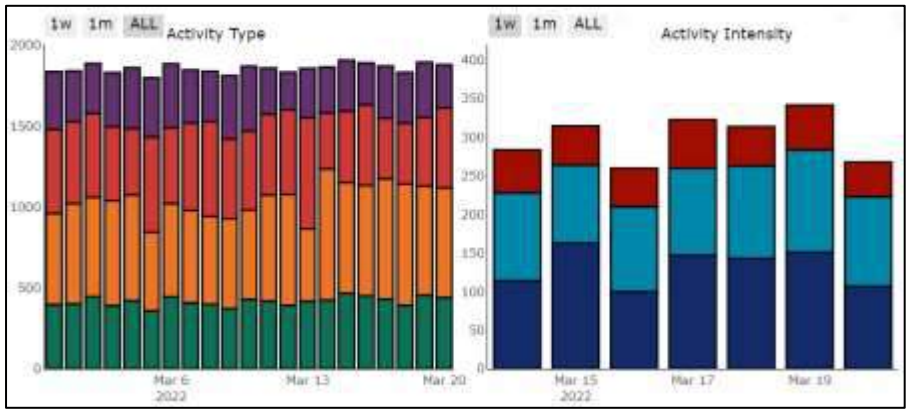
Images curtsey of Dr. Brian Helsel, PhD

Unsupervised Exercise Prescription

Adherence to in-home exercise prescription?
→ Wearable *Data Tells the Story*



- Application programming Interface (API) – remote retrieval of data and events from wearables
- Software Development Kit (SDK) – custom programming to communicate directly with the devices, retrieve data, and manipulate the device remotely.



Medically Supervised Fitness Training

A structured and supervised exercise program, beyond exercise prescription, designed to provide advanced monitoring and support for the most deconditioned patients.

Healthy Hearts via Live Videoconferencing

Participants

- n=14 (8-19 yrs. old)
- ≥1 year post heart transplant

Healthy Hearts via Live Videoconferencing: An Exercise and Diet Intervention in Pediatric Heart Transplant Recipients

Angela C. Chen, BS; Faustine D. Ramirez, MD; David N. Rosenthal, MD; Sarah C. Couch, PhD, RD; Samuel Berry, MS; Katie J. Stauffer, RDCS; Jerrid Brabender, RDCS; Nancy McDonald, NP; Donna Lee, NP; Lynsey Barkoff, NP; Susan E. Nourse, MD; Jeffrey Kazmucha, MS, CES, CSCS; C. Jason Wang, MD, PhD; Inger Olson, MD; Elif Seda Selamet Tierney, MD

Background—Pediatric heart transplant recipients have high-risk cardiovascular profiles that can affect their long-term outcomes; however, promoting exercise and healthy diet has not been a major focus in the field. The objective of this study was to test the feasibility and impact of a supervised exercise and diet intervention delivered via live videoconferencing in this population.

Objectives

1. Feasibility and impact of an exercise and nutrition intervention
2. The use of live videoconferencing to deliver the intervention

CARDIOLOGY 2024

Chen & Tierney et al., *J Am Heart Assoc*, 2020
Chen & Tierney et al., *Pediatr Transplant*, 2019

Children's Mercy KANSAS CITY

P.A.C.E.S

Medically Supervised Fitness Training

Healthy Hearts via Live Videoconferencing

Diet:

- *Dietary Approaches to Stop Hypertension (DASH)*
- 1x wk. nutrition sessions via telehealth

Exercise:

- 3x wk. for 60 min (In-home)
- 1-on-1 sessions w/ health coach via videoconferencing

Tablet computer with internet connection

Sessions delivered using the Vsee™ telemedicine platform

CARDIOLOGY 2024

Chen & Tierney et al., *J Am Heart Assoc*, 2020
Chen & Tierney et al., *Pediatr Transplant*, 2019

Children's Mercy KANSAS CITY

P.A.C.E.S

Medically Supervised Fitness Training

Healthy Hearts via Live Videoconferencing

Outcome	Post-Intervention Testing (Median Change)
BMI Percentile	↓ 27 %ile points
Endothelial Function	↑ 0.29 Reactive Hyperemia index
VO2peak (% predicted)	↑ 6.4 percentage points
Functional Movement Screen	↑ 2.5 (FMS score)
Daily consumption of saturated fat	↓ 6 grams

CARDIOLOGY 2024

Chen & Tierney et al., *J Am Heart Assoc*, 2020
Chen & Tierney et al., *Pediatr Transplant*, 2019

Children's Mercy KANSAS CITY

PACES

Medically Supervised Fitness Training

Adherence/Compliance

	Healthy Hearts *via Live Videoconferencing* Chen & Tierney et al., 2019, 2020	Exercise/Motor Intervention *via Pre-recorded Videos* Meyer et al., 2018, 2021
Exercise Sessions	**89.6 ± 11%** % of scheduled sessions attended	**33% (IQR 8%-60%)** Mean weekly exercise adherence
Nutrition Sessions	**88.4 ± 10%**	-

Medically Supervised Fitness Training

Ongoing Work: MedBIKE™

- Custom telemedicine cycle ergometer youth with CHD
- Video game platform

Gamification

Images courtesy of Dr. Michael Khoury, MD

Khoury et al., *Cardiol Young*, 2020
Khoury et al., *C J Cardiol*, 2020
Boulanger et al., MedBIKE: Virtual Reality for Remote Cardiac Rehab. In Assistive and Rehabilitation Engineering, 2019

CARDIOL 2024

Children's Mercy KANSAS CITY

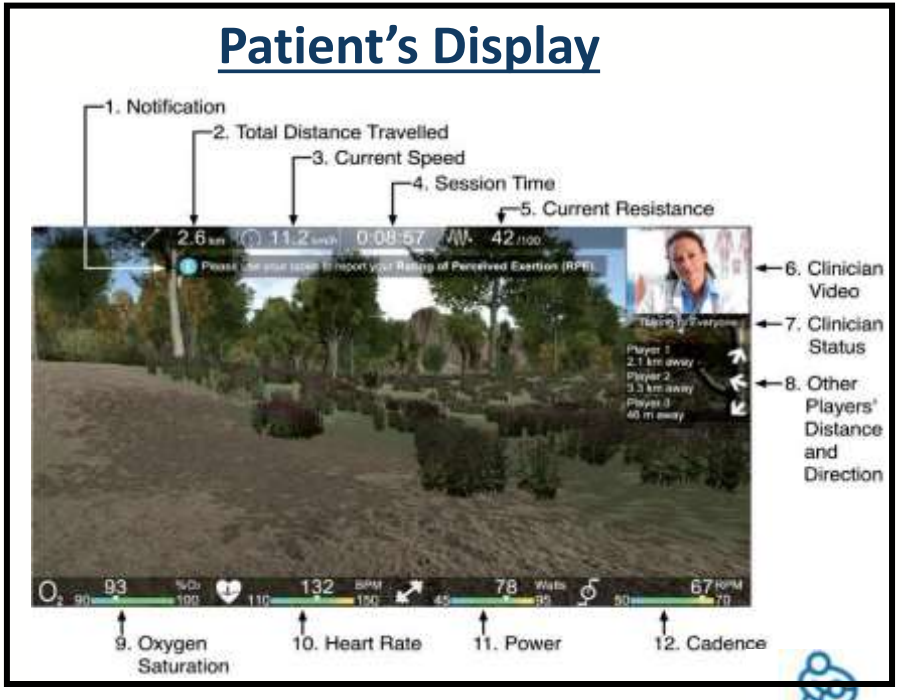
PACES

Medically Supervised Fitness Training

Ongoing Work: MedBIKE™

Provider's Display

Patient's Display



Images courtesy of Dr. Michael Khoury, MD

Khoury et al., *Cardiol Young*, 2020
Khoury et al., *C J Cardiol*, 2020
Boulanger et al., MedBIKE: Virtual Reality for Remote Cardiac Rehab. In Assistive and Rehabilitation Engineering, 2019

CARDIOLOGY 2024

Children's Mercy KANSAS CITY

PACES

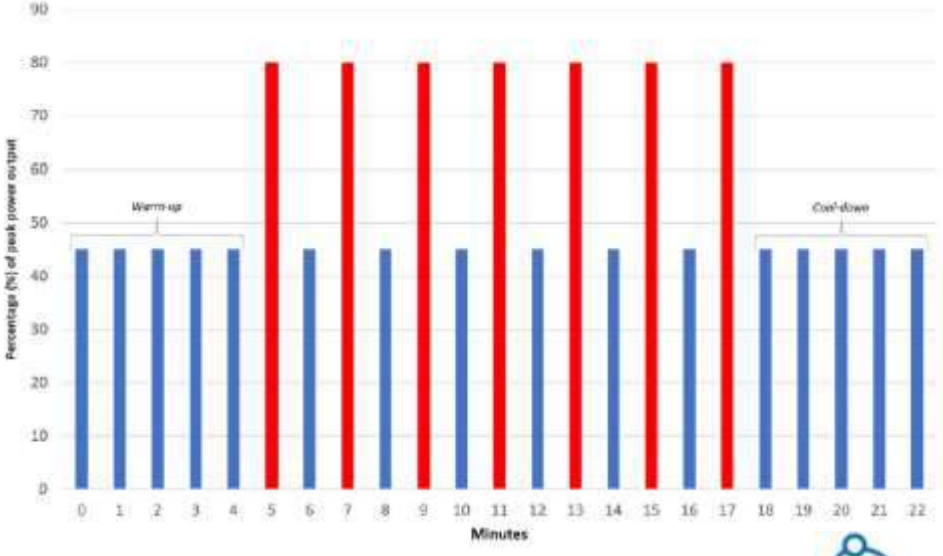
Medically Supervised Fitness Training

Cardiac rehabilitation in the paediatric Fontan population: development of a home-based high-intensity interval training programme

Michael Khoury[1], Devin B. Phillips[2], Peter W. Wood[3], William R. Mott[4], Michael K. Stickland[2], Pierre Boulanger[4], Gwen R. Rempel[5], Jennifer Conway[1], Andrew S. Mackie[1] and Nee S. Khoo[1]

[1]Division of Pediatric Cardiology, Department of Pediatrics, Stollery Children's Hospital, University of Alberta, Edmonton, Alberta, Canada; [2]Division of Pulmonary Medicine, Department of Medicine, University of Alberta, Edmonton, Alberta, Canada; [3]Division of General Internal Medicine, Department of Medicine, University of Alberta, Edmonton, Alberta, Canada; [4]Department of Computing Science, Faculty of Science, University of Alberta, Edmonton, Alberta, Canada and [5]Faculty of Health Disciplines, Athabasca University, Alberta, Canada

MedBIKE HIIT Protocol



CARDIOLOGY 2024

Khoury et al., *Cardiol Young*, 2020

Children's Mercy KANSAS CITY

P.A.C.E.S

Medically Supervised Fitness Training

Remotely Delivered **Ca**rdiac **Re**habilitation for Adolescents with **C**ongenital **H**eart **D**isease

Remote CaRe CHD Trial

David A. White, PhD (PI)

NIH – NHLBI K23HL159325

CARDIOLOGY 2024

Children's Mercy KANSAS CITY

P.A.C.E.S

Medically Supervised Fitness Training

Remote CaRe CHD Trial

Randomized Controlled Trial

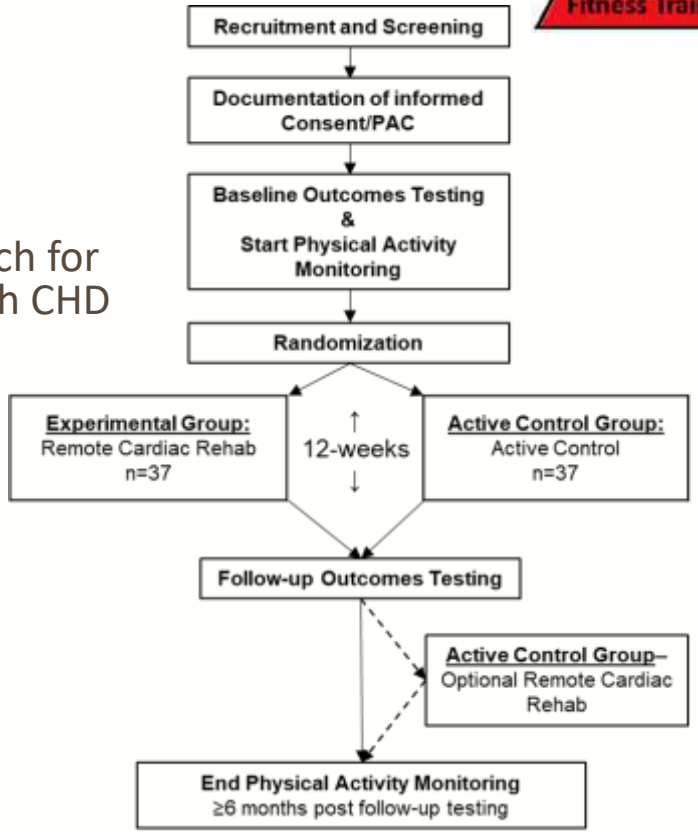
Purpose

To evaluate the effectiveness of video-based mHealth tech for the delivery of real-time CR to groups of adolescents with CHD in their homes.

Participants

Targeted Sample Size: n=74

- Ages 12-19 yrs. with:
  1. Fontan (n=26)
  2. Tetralogy of Fallot (n=24)
  3. Dextro-transposition of the great vessels (n=24)



CARDIOLOGY 2024

Medically Supervised Fitness Training

Remote CaRe CHD Trial

Primary Outcome

- Cardiorespiratory Fitness (VO2peak)

Secondary Outcomes

- Cardiac Function (Echocardiogram)
- Lean Body Mass (DXA)
- Frailty

Exploratory Outcomes

- Gross Motor Proficiency
- Quality of Life
- Physical Activity Self-Efficacy
- Physical Activity
- Program Satisfaction
- Skeletal Muscle Oxidative Capacity
- Cost Effectiveness

CARDIOLOGY 2024

Children's Mercy KANSAS CITY

PACES

Medically Supervised Fitness Training

Medically Supervised Fitness Training

Remote CaRe CHD Trial

Remote Cardiac Rehab Group

zoom

fitbit

CARDIOLOGY 2024

Children's Mercy KANSAS CITY

P.A.C.E.S

Medically Supervised Fitness Training

Remote CaRe CHD Trial

12-week Intervention

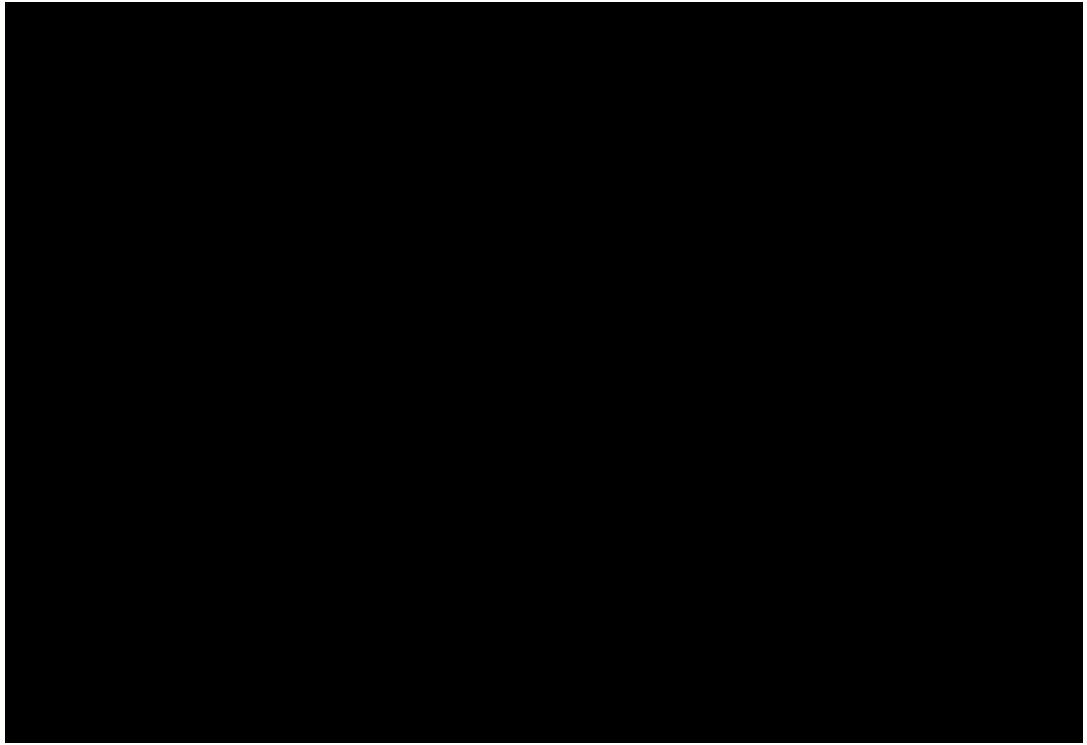
- 2-week Ramp-up
  - 1-1 with health coach (live)
- 10-weeks Group-based exercise
  - Up to 5 per group

✓ Supervision ✓ Live interaction

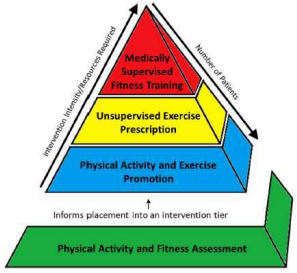
✓ Music ✓ Peer support

Group-Based Approach

↓ costs & may ↑ potential for implementation & dissemination



Closing



The use of eHealth and mHealth technologies are growing rapidly in the delivery of exercise and physical activity interventions.

eHealth and mHealth can..

- Reduce costs
- Increase access
- Provide opportunities to monitor patients from a great distance
- Facilitate communication
- Collect data (small and large scale)

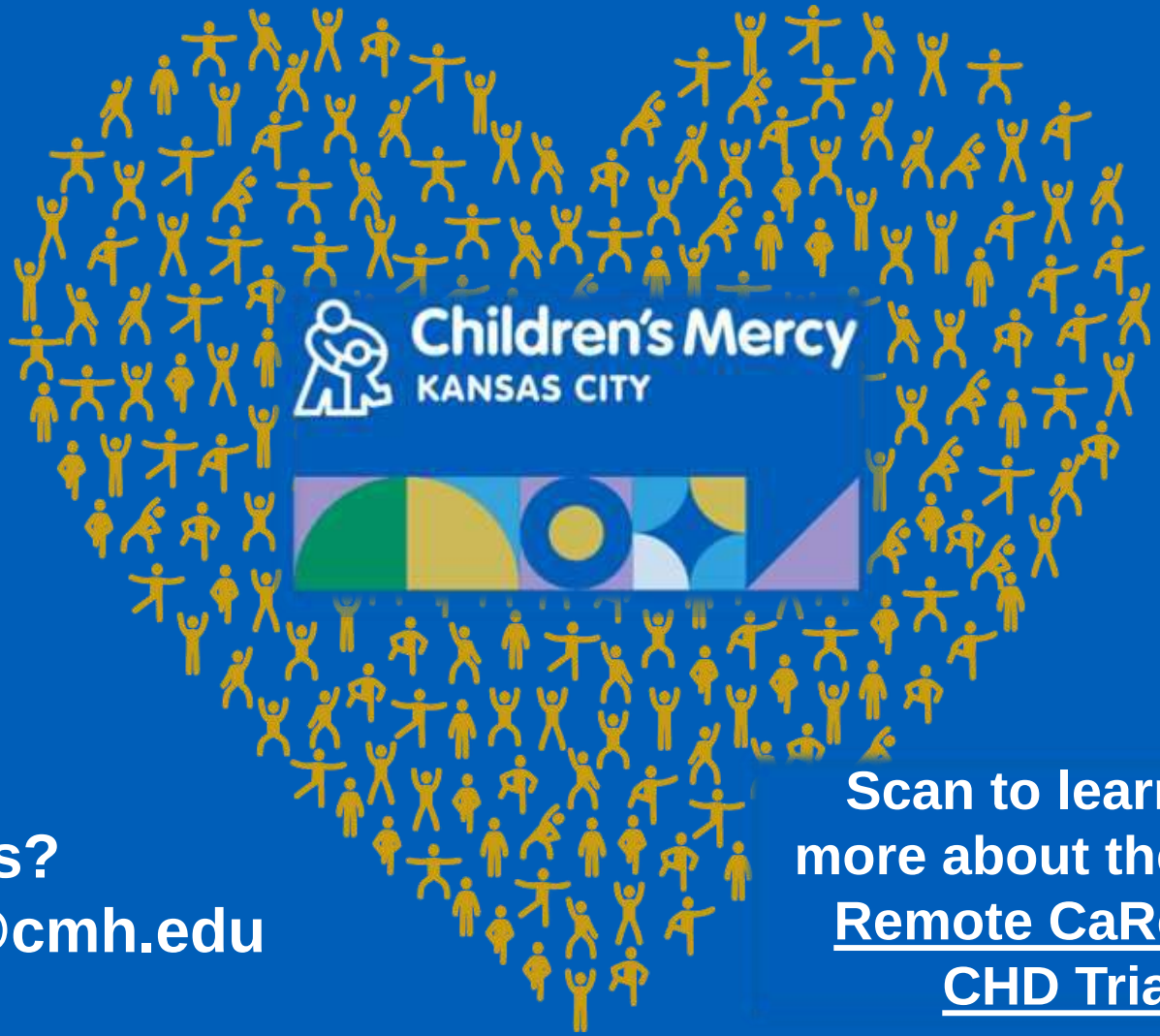
Applying mHealth and eHealth technologies alone ≠ NOT an intervention

The technology is ONLY the tool/method for which the intervention is delivered.

CARDIOLOGY 2024

Children's Mercy KANSAS CITY

PACES



Questions?
dawhite@cmh.edu

Scan to learn more about the Remote CaRe CHD Trial