**Early Mobilization of Older Adults with Acute Cardiovascular Disease**

Haroon Munir, BSc.

MSc. Candidate

Division of Experimental Medicine

Department of Medicine

McGill University, Montreal

March 2021

A thesis submitted to McGill University in partial fulfillment of the requirements of the degree of Master of Science in Experimental Medicine.

## Table of Contents

**English Abstract**

*Background:* Bedrest and immobility have historically been part of the care culture for people hospitalized with acute cardiovascular disease. Inactivity during hospitalization can result in muscle and strength loss, particularly in older adults, which can lead to disability and loss of functional independence following hospitalization. The amount of sedentary time that older adults spend during an acute cardiovascular hospitalization in contemporary care has yet to be explored. In addition, the post-hospitalization health-related quality of life of older adults with acute cardiovascular disease undergoing early mobilization has yet to be described.

*Methods:* First, a scoping review of the literature was performed to examine the evidence for early mobilization following myocardial infarction. Next, data from the early mobilization perspective cohort study was used to describe sedentary time in hospitalized older adults with cardiovascular disease using actigraphy and to describe 1-and 12-month health-related quality of life of older acute cardiovascular disease patients using the Short-Form 36 Health Survey.

*Results:* The scoping review revealed that there is evidence for the effectiveness of earlier mobilization following myocardial infarction in the pre-coronary revascularization era, however, contemporary data are lacking. Available contemporary evidence supports the safety of early mobilization. There were minimal current professional society recommendations for early mobilization following myocardial infarction identified. Cohort study 1 revealed older adults with acute cardiovascular disease spend 91.2% of their hospital stay in a sedentary position. People with increased sedentary time had significantly poorer 1-month health-related quality of

life. Finally, cohort study 2 showed that people with poorer prehospital status have significantly poorer physical and mental health-related quality of life at 1 and 12-months compared to age-matched norms.

*Conclusion:* Older adults with acute cardiovascular disease tend to spend the vast majority of their hospital stay in a sedentary position and may have poor posthospitalization mental and physical health-related quality of life. Future studies are needed to determine the impact of early progressive mobilization on immobility and post-hospitalization health-related quality of life.

**French Abstract**

*Contexte:* L'alitement et l'immobilité ont toujours fait partie de la culture des soins pour les personnes hospitalisées pour une maladie cardiovasculaire aiguë. L'inactivité pendant l'hospitalisation peut entraîner une perte de muscle et de force, en particulier chez les personnes âgées, ce qui peut entraîner un handicap et une perte d'autonomie fonctionnelle après l'hospitalisation. La quantité de temps sédentaire que les personnes âgées passent au cours d'une hospitalisation cardiovasculaire aiguë en soins contemporains n'a pas encore été explorée. De plus, la qualité de vie liée à la santé après l'hospitalisation des personnes âgées atteintes d'une maladie cardiovasculaire aiguë et faisant l'objet d'une mobilisation précoce n'a pas encore été décrite.

*Méthodes:* Tout d'abord, un examen de la portée de la littérature a été effectué pour examiner les preuves d'une mobilisation précoce après un infarctus du myocarde. Ensuite, les données de l'étude de cohorte sur la perspective de la mobilisation précoce ont été utilisées pour décrire le temps de sédentarité chez les personnes âgées hospitalisées atteintes d'une maladie cardiovasculaire à l'aide de l'actigraphie et pour décrire la qualité de vie liée à la santé à 1 et 12 mois des patients âgés atteints de maladies cardiovasculaires aiguës à l'aide de la méthode Short-Formulaire 36 Enquête sur la santé.

*Résults:* L'examen de la portée a révélé qu'il existe des preuves de l'efficacité d'une mobilisation précoce après un infarctus du myocarde à l'ère de la revascularisation pré-coronarienne, cependant, les données contemporaines font défaut. Les preuves contemporaines disponibles

soutiennent la sécurité de la mobilisation précoce. Il y avait peu de recommandations actuelles de la société professionnelle pour une mobilisation précoce après un infarctus du myocarde identifié. L'étude de cohorte 1 a révélé que les personnes âgées atteintes d'une maladie cardiovasculaire aiguë passent 91,2% de leur séjour à l'hôpital dans une position sédentaire. Les personnes dont le temps de sédentarité était prolongé avaient une qualité de vie liée à la santé significativement plus mauvaise à un mois. Enfin, l'étude de cohorte 2 a montré que les personnes dont le statut préhospitalier était moins bon ont une qualité de vie physique et mentale significativement plus mauvaise à 1 et 12 mois par rapport aux normes appariées selon l'âge.

*Conclusion:* Les personnes âgées atteintes d'une maladie cardiovasculaire aiguë ont tendance à passer la grande majorité de leur séjour à l'hôpital dans une position sédentaire et peuvent avoir une mauvaise qualité de vie post-hospitalisation liée à la santé mentale et physique. Des études futures sont nécessaires pour déterminer l'impact d'une mobilisation progressive précoce sur l'immobilité et la qualité de vie liée à la santé après l'hospitalisation.

**Acknowledgements**

I would first like to thank my supervisors, Drs. Michael Goldfarb and Jonathan Afilalo, for the countless hours spent mentoring, teaching and guiding me throughout the entirety of my master's. Their enthusiasm for patient-centered research and analytical skills as clinician-scientists served to inspire and instil abilities in me that I will no doubt carry forward in my research career.

I would like to thank the members of my thesis committee, Drs. Mark Eisenberg, Olivier Beauchet and Lorraine Chalifour for their recommendations and advice regarding my thesis. I want to thank all the contributors that participated in the investigation and review of the included manuscripts.

I also would like to thank the members of the Frailty Research Team and the Centre for Clinical Epidemiology at the Lady Davis Institute for welcoming me into their workspace and providing a supportive environment to conduct my research. I would like to thank the members of the Early Mobilization team at the Cardiovascular Unit of the Jewish General Hospital for assisting in the collection of data for the prospective cohort studies, management of the accelerometer devices, and assisting with data analysis.

I would like to extend my sincere gratitude to the Fonds de la recherche en santé du Québec (FRQS) for awarding me the Master's Training Research Award ($35 000) which allowed me to dedicate my time and energy towards achieving my research goals. I would also like to thank the Quebec Strategy for Patient-Oriented Research (SPOR) Support Unit for awarding me a research fellowship as a master's student. This recognition validated the research conducted towards improving patient centered outcomes throughout the length of my project.

**Contribution of Authors**

Haroon Munir, BSc.

Thesis candidate. Performed literature review. Conducted data analysis, data curation, and co-designed search strategy for scoping review manuscript. Constructed database of variables and performed chart review for cohort studies. Contributed to data analysis for cohort studies. Wrote two abstracts from cohort studies presented at major North American cardiovascular conferences. Wrote thesis document, and initial and revised manuscripts for scoping review, cohort study 1 and 2.

Michael Goldfarb, MD, MSc.

Thesis supervisor. Regularly provided mentorship, guidance, and support for all aspects of manuscripts and thesis progress. Developed study design for cohort studies, and generated research question for scoping review. Contributed to data analysis for cohort studies. Provided extensive feedback on manuscript and thesis document.

Jonathan Afilalo, MD, MSc.

Thesis co-supervisor. Regularly provided mentorship, guidance, and support for thesis progress. Provided office workspace to complete thesis project. Provided feedback for cohort study 2 manuscript and contributed to data analysis. Reviewed and provided feedback on thesis document.

Mark J Eisenberg, MD, MPH.

Member of the thesis committee. Contributed to feedback of thesis progress, results of cohort studies, and drafting of thesis document.

Olivier Beauchet, MD, PhD

Member of the thesis committee. Contributed to feedback of thesis progress, results of cohort studies, and drafting of thesis document.

Lorraine E. Chalifour, PhD

Member of the thesis committee. Chaired initial thesis committee meeting and wrote minutes of the meeting. Contributed to feedback of thesis progress and drafting of thesis document.

The following author contributed to scoping review manuscript:

Jake Fromowitz (data validation).

The following authors reviewed and contributed to Cohort Study 2 manuscript:

Jonathan Afilalo, MD, MSc. (data analysis), José A. Morais, MD (manuscript review).

## Chapter 1: Introduction

### *Bedrest as a Historical Part of Cardiology Care Culture*

Bedrest and immobility have been a part of the care culture for people with acute cardiovascular disease (CVD) for the past century.[1] "The word rest must be construed in an absolute sense" was an excerpt from a guideline detailing the treatment of patients with cardiovascular emergencies in 1937.[2] Healthcare provider concern for coronary ischemia and electrical instability have also shaped attitudes towards mobilizing people with acute CVD early during hospitalization.[1] Despite the evidence for the rapid loss of muscle mass and strength, as well as deconditioning in hospitalized patients, involuntary bedrest and delayed mobilization continue to be present in acute cardiac care, putting patients in a vulnerable position for further injury.[3, 4] There are several barriers towards mobilizing patients in the acute care setting including the lack of staff, risk of self-injury, and an increased reliance upon physiotherapy.[5] These mobilization barriers can result in prolonged periods of bedrest in acute CVD patients, which can potentially lead to adverse effects.

### *Impact of Bedrest During Acute Care Hospitalization*

Immobility and bedrest have a number of adverse effects for patients in the acute care setting. Disuse atrophy occurs, with each week of bedrest in healthy and nourished individuals resulting in a 4-5% loss in muscle mass and 5 days of bedrest shown to result in increased insulin resistance and microvascular dysfunction.[6] Impaired vascular tone and fluid shifts may occur with prolonged bedrest, contributing to postural hypotension and decreases in peak oxygen uptake, stroke volume and cardiac output, which are particularly relevant to patients with acute CVD.[6] The prevailing mobility cardiology care culture contributes to delayed mobilization

following hemodynamic stabilization and longer periods of bedrest. This may lead to extended hospital stays and higher rates of readmission in patients with acute CVD. This may have considerable public health implication since acute heart failure is the second most frequent cause for 30-day hospital readmissions in Canada.[7]

Bedrest and immobilization contribute to development of the posthospitalization syndrome. Posthospitalization syndrome is a transient period of acquired vulnerability in the 30-day period following the acute hospitalization. It is a consequence of the in-hospital stressors that afflict a patient in addition to recovering from their acute illness.[8] Posthospitalization syndrome also includes disturbances to circadian rhythms, pain and impaired stamina that lead to deconditioning of the patient. After discharge, patients are left in a highly decompensated and vulnerable state, placing them at risk for future injury, hospital readmission, and reduced health-related quality of life (HRQOL).[8] As a result of posthospitalization syndrome, patients may experience losses following hospitalization in independent function and increased reliance upon caregivers to complete activities of daily living (ADL) and instrumental activities of daily living (IADLs).[8] ADLs include basic tasks such as dressing and transferring from bed to chair, while IADLs include complex tasks such as handling finances and medications.[9] Low in-hospital mobility is associated with a decline in completing ADLs at discharge and 1-month following hospitalization.[10, 11] A study of more than 500 adults over 70 years old reported 46% of their cohort had a decline in their ADLs at hospital discharge and 49% at 1-month follow-up, and 56% of the cohort had a decline in IADLs at 1-month.[10, 11] The marked inability to complete an ADL that a person was able to fulfill prior to their hospitalization is known as hospital acquired disability (HAD).[12] HAD can persist beyond the transient period following hospitalization and occurs in approximately one-third of patients over 70 years old, with less than one-third of older

adults recovering to pre-hospital functioning 1 year after discharge.[12, 13] Addressing immobility early in the care process following hospital admission may mitigate the risk associated with post-hospitalization syndrome and consequent HAD.[12]

Older adults with acute CVD are more likely to have higher rates of muscle loss during hospitalization and reduced posthospital function and independence. Those admitted to the cardiovascular unit are older on average with a pre-existing cardiac disease.[14] There is a rapid loss in lower extremity muscle strength and mass with prolonged bedrest, with healthy young adults experiencing a loss of 5 to 9% in quadriceps muscle mass and 20% to 27% in quadriceps muscle strength.[15] These losses in muscle mass and strength are 3-6 fold greater in older adults.[15] Prolonged bedrest weakens cardiac function, with only 3 days of immobility contributing to decreased stroke volume, increased heart rate and orthostatic intolerance.[15] Acute hospitalization in older adults is also an onerous event that can precipitate further disability, as many are reliant upon relatives and caregivers in completing tasks of daily functioning. [12] Lastly, HAD occurs in one-third of patients above the age of 70, and may even be triggered after resolution of the acute illness necessitating hospitalization.[12]

*Early Mobilization and the Contemporary Mobility Care Culture*

Early mobilization (EM) involves initiating mobilization activities as soon as hemodynamic and respiratory stabilization is achieved, usually within the first 24-48 hours following hospital admission.[16] The objective of EM is to prevent losses in muscle strength and to maintain or restore prehospital mobility capabilities, which is one of the main contributors to posthospitalization syndrome and HAD.[8, 12, 17] EM improves muscle strength and physical function and decreases readmission rate and hospital length of stay in acute care settings.[18-20] EM

has been shown to safe and feasible in critically ill patients, reduces sarcopenia and minimizes hemodynamic instability.[21]

There is growing evidence supporting earlier mobilization in acute CVD in contemporary healthcare settings. A retrospective study of 285,653 patients with heart failure found that people who underwent ambulation by day 2 of hospital admission were less likely to have a longer length of hospital stay (defined as >4 days) and had lower rates of 30-day hospital readmissions.[22] EM following transfemoral transcatheter aortic valve implantation has also shown to be safe and feasible in the MobiTAVI randomized clinical trial, where 73 patients undergoing EM had lower combined incidences of delirium, infections and pain, with similar rates of post-operative vascular complications compared to usual post-operative bedrest.[23] The E-MOTION trial showed that EM 3-hours following pacemaker implantation is safe and feasible compared with immobilization, and was not associated with increased rates of complications.[24]

*Knowledge Gaps*

Despite the contemporary evidence, delayed mobilization continues to play a role in contemporary care culture. A disparity in the knowledge, attitudes and beliefs of cardiovascular physicians towards implementing EM into clinical practice exists. A survey of 142 health professionals working the cardiovascular intensive care unit or cardiovascular ward of 2 academic tertiary care centers revealed that physicians, compared to nurses and physiotherapists, have the highest overall barriers in knowledge, attitudes and beliefs towards mobilization and its implementation into clinical practice.[25] The top 3 mobilization barriers cited by physicians included physician orders, adequate staffing and time restraint for nurses.[25] A recent prospective study of general medicine hospitalized older adults revealed median daily activity time and step

counts of 1.1 hours/day and 1455.7 steps/day respectively, with an observed association between low hospital physical activity and HAD. [26] This association between HAD and sedentary time was observed in general medicine patients, however EM and HRQOL in the population of older patients with acute CVD can be delineated further. Among inpatient adults, a systematic review of 38 articles and metanalysis of 7 articles quantifying type and duration of physical activity revealed 87 % to 100% of the time is spent lying in bed or sitting.[27] These studies support increased sedentary time during hospitalization, however similar studies have yet to be explored in the acute setting of older patients with acute CVD. Despite the evidence of the dangers of prolonged bedrest on older adults with acute CVD, immobility continues to play a role in contemporary acute care culture.

The objectives of this thesis are to: (1) Perform a scoping review of the literature for EM following myocardial infarction, (2) Describe the sedentary time of hospitalized older adults with acute CVD undergoing EM and (3) Describe HRQOL up to 1-year post-hospitalization in older adults with acute CVD undergoing EM.

## Chapter 2: Rationale for Conducting a Scoping Review

The impact of prolonged bedrest on the physical and mental health of people with CVD was first described in 1950 by W. Irvin Jr. who wrote that "prolonged bedrest in MI is not only unnecessary but also potentially harmful to the mental and physical wellbeing of patients."[28] W. Irvin Jr also addressed the potential hazard of prioritizing the treatment of the acute illness without consideration to addressing bedrest as a potential mediator of poor posthospital outcomes. He advocated the twofold aim in the treatment of MI, both lifesaving treatment and preparation for further living, and noted that the former aim was often emphasized at the expense of the latter. A few decades later Kohn stated that it seemed "strange that in the 1980s we continue to debate the dangers of early ambulation for the patient with myocardial infarction."[29] In addition to the physical consequences of immobility and prolonged bedrest, a number of observations were made of the benefits for EM on HRQOL. Groden in 1970 noted that earlier mobilization produced optimism for patients who were mobilized within one to two weeks compared to three to four weeks, as per the EM protocol at the time.[30]

Studies in the pre-revascularization era were mostly case reports and case series. There was a paucity of studies with robust clinical designs to evaluate the effectiveness of EM on improving person-centred outcomes. The few prospective and randomized clinical trials from this period focused primarily on the safety and feasibility of EM. The potential benefits of EM were not yet defined through the use of robust clinical methodology.

To elicit maximal results in our search, we consulted with a medical research librarian and generated a series of research questions to drive our search strategy: 1) What is the historical evidence recommending EM for patients post-myocardial infarction; 2) Have the historical recommendations for EM post-MI been validated in the contemporary environment through

robust methodology; 3) Have the results for contemporary evidence for EM post-MI been translated to clinical recommendation; 4) What are the attitudes of clinicians towards EM post-MI and have professional guidelines played a role in influencing them. Our scoping review of EM post-MI is presented in the following chapter as a published manuscript.

## Chapter 3: Early Mobilization Post-Myocardial Infarction: A Scoping Review

Our scoping review of the literature of early mobilization post-myocardial infarction is presented as a manuscript below.

This manuscript was published in PLOS One on August 17th, 2020.

Munir H, Fromowitz J, Goldfarb M (2020) Early mobilization post-myocardial infarction: A scoping review. PLOS ONE 15(8): e0237866.https://doi.org/10.1371/journal.pone.0237866.

**Early mobilization post-myocardial infarction: A scoping review**

Haroon Munir, BSc,[1] Jake Fromowitz,[2] Michael Goldfarb, MD, MSc[1,3*]

[1] Division of Experimental Medicine, McGill University, Montreal, QC, Canada

[2] Nova Southeastern University, Fort Lauderdale, FL, USA

[3] Division of Cardiology, Jewish General Hospital, McGill University, Montreal, QC, Canada

*Corresponding author:

Michael Goldfarb, MD, MSc

Assistant Professor of Medicine, McGill University

Director of Quality of Care and Safety

Division of Cardiology, Jewish General Hospital

Email: michael.j.goldfarb@mcgill.ca (MG)

**Abstract**

Bedrest and immobilization following a myocardial infarction (MI) can lead to functional impairment that can persist following hospitalization. Early mobilization (EM) is associated with good functional and clinical outcomes in critical care, medical and surgical settings. However, the impact and current role of EM in post-MI care has not been well-defined. Our objective was to assess the evidence for post-MI mobilization, define current post-MI mobilization practice, and understand perspectives of cardiovascular professionals toward mobilization. A scoping review related to "early mobilization" and "myocardial infarction" was performed using the Joanna Briggs Institute Methodology. Pubmed, Embase, Google Scholar, Cochrane Library and CINAHL databases were included. Results were categorized into six topic areas. There were 59 references included in the analysis. There was evidence for the effectiveness and safety of earlier mobilization in experimental studies of the pre-revascularization era, but there was a lack of strong evidence for EM in contemporary post-MI care. Mobilization appears to be safe following arterial catheterization and is associated with minimal hemodynamic and respiratory compromise. Most people are delayed in mobilizing post-MI and spend the majority of the initial hospitalization period lying in bed. Only 1 of 7 current major cardiovascular professional societies guidelines recommend EM post-MI. There were no studies exploring the perspectives of cardiovascular professionals toward mobilization. EM may be beneficial in the post-MI care. However, there is an evidence gap for the impact of EM post-MI in the contemporary literature. More robust evidence from randomized clinical trials is required to inform clinicians and influence practice.

## Introduction

"The bed is not a resting place for the patient with cardiac disease" Drs. Levine and Lown (1952)[1].

Bedrest and immobility has been part of the culture of care following myocardial infarction (MI) for the past century [2]. Mobilization too soon following an MI was traditionally considered dangerous due to the risk of coronary ischemia, arrhythmia, and aneurysm formation [2]. Yet despite procedural and therapeutic advances that have decreased length of hospital stay and improved clinical outcomes, involuntary bedrest and delayed mobilization continue to be part of acute cardiology care culture [3, 4].

Bedrest and immobilization, in combination with acute illness, lead to muscle catabolism within hours of hospital admission, which results in rapid loss of skeletal muscle mass and reduced strength [5]. Older adults are particularly susceptible to muscle loss and are at increased risk of disability at hospital discharge [6]. This functional impairment can persist for years, impairing quality of life and reducing functional independence [7].

Early mobilization (EM) is a care process that involves initiation of mobilization activities as soon as hemodynamic and respiratory stabilization is achieved, typically with 1-2 days of admission [8]. The goal of EM is to prevent loss of muscle strength and prehospital mobility capabilities and to improve post-hospital functional status. In acute and intensive care settings, there is evidence that EM improves muscle strength and physical function, reduces rates of delirium, and decreases hospital length of stay and readmission rate [9-11]. The safety and feasibility of EM in critically ill patients has been established [12]. As a result of this evidence, critical care professional societies recommend EM as part of standard practice in intensive care

units [13, 14]. In the cardiovascular intensive care unit, major cardiovascular (CV) professional society guidelines do not provide recommendations for mobilization in hospital following an MI [15-17]. One exception is the European Society of Cardiology guidelines, which recommends EM for most post-ST segment elevation MI patients, but does not cite any evidence to support this recommendation [18].

To better understand the potential role and benefits of mobilization post-MI, we performed a scoping review of the literature to (1) assess the evidence for post-MI mobilization, (2) define current post-MI mobilization practice, and (3) understand current beliefs, attitudes, and knowledge of CV professionals toward mobilization. Knowledge gaps in our understanding of post-MI mobilization are presented to inform future research directions.

## Methods

### *Search strategy*

A comprehensive search strategy was devised in consultation with a medical research librarian and established a priori to ensure maximum sensitivity (S1 Fig.). We assessed papers containing the terms "early mobilization" and "myocardial infarction" either in the title, abstract or body of the paper. We also conducted searches that included "mobility OR mobilization" with "intensive care unit OR ICU." Selection of papers were based upon the population, concept and context guidelines specified in the Joanna Briggs Institute Methodology for JBI Scoping Reviews [19]. Papers selected included human patients without any age restriction, undergoing post-MI mobilization interventions with outcomes assessing the efficacy of these interventions. There were no geographic, gender, cultural, ethnic or specific language restrictions, however,

only non-English studies from the contemporary period (year 2000 and beyond) were included in the analysis.

*Information sources*

Sources of information included but were not limited to primary research studies, clinical trials, systematic reviews, case-studies, meta-analysis. Information sources were intentionally left open to prevent the possible omission of relevant records.

*Databases*

We consulted Ovid MEDLINE (Embase Classic + Embase (1947 to April 2019), Ovid Healthstar (1966 to May 2019) and Ovid MEDLINE (1946 to 2019), PubMed, Google Scholar, Cochrane Library and CINAHL databases. The selected search strategies for Ovid MEDLINE and CINAHL are outlined in S1 Fig..

*Search and selection of sources of evidence*

Our primary search consisted of records related to "Early mobilization and myocardial infarction." Additional searches were conducted on EM in the intensive care unit, mobilization with cardiac devices relevant to MI, and hemodynamic studies on EM, including those after MI. We compiled all the records we obtained from Ovid MEDLINE, CINAHL, Google Scholar and PubMed databases into EndNote X9. We began deduplication in EndnoteX9, exported the results into Microsoft Excel and selected relevant sources based upon the topic of interest of the review, narrowing it down to 343 records. Non-relevant references were excluded. Studies were reviewed by two independent reviewers (H.M. and J.F) for inclusion criteria. Disagreements

were resolved by a third reviewer (M.G.). Bibliographies of included studies were manually searched, and relevant studies were reviewed for inclusion.

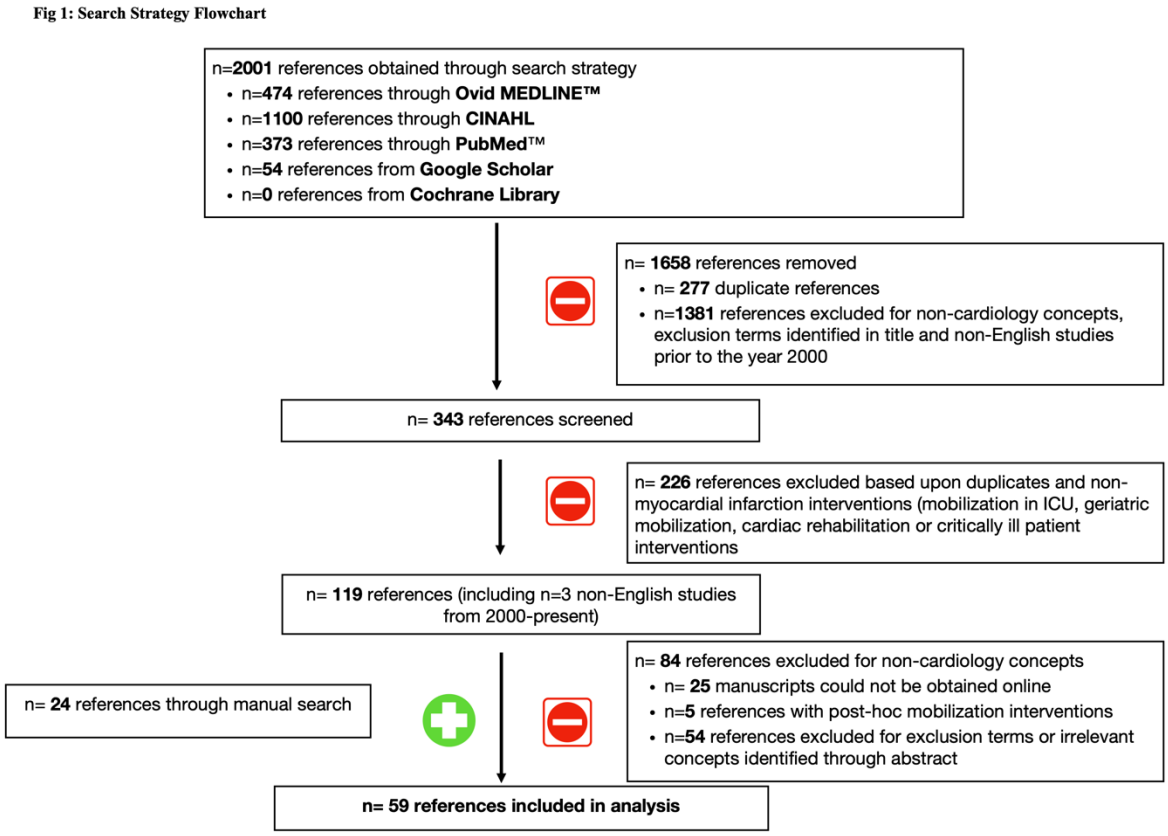
*Data charting process and synthesis of results*

We categorized the references into 6 topic areas: (1) Historical Evidence and Recommendations for EM Post-MI, (2) Modern EM Practices Post-Myocardial Infarction, (3) Hemodynamic Impact of EM Interventions, (4) Mobilization Practices with Cardiac Devices, (5) Professional CV Society Guidelines for EM, and (6) Current Beliefs, Attitudes, and Knowledge of CV Professionals Toward Mobilization. We defined contemporary literature pertaining to EM practices as papers dated after 2000, given the emergence of percutaneous coronary intervention procedure in the 1990s.

**Results**

There were 59 references included in our analysis (35 references related to our search strategy; 24 references via manual search; Fig 1).

*Fig 1: Search Strategy Flowchart.*




*Historical evidence and recommendations for early mobilization post-myocardial infarction*

In 1929, four to six weeks of bedrest was recommended for the management of acute coronary thrombosis (S1 Table) [20]. In the 1960s, Brummer et al. reported that mobilizing people post-MI at day 12 compared to day 16 was safe [21]. Irwin et al. postulated that routine prolonged bedrest post-MI may be unnecessary and potentially harmful to patients' mental and physical well-being [22]. Levine et al. suggested that sitting in an armchair post-MI could result in improved cardiac recovery compared to lying in a bed [1]. In the 1970s, several RCTs were performed evaluating earlier (7 to 10 days) vs. later (13 to 20 days) post-MI mobilization. These studies found no difference morbidity, mortality, and risk of complications [23-26]. There were anecdotal

reported that earlier mobilization out of bed post-MI resulted in improvements in patient's functional status and psychological benefit. However, there were no objective patient-centered outcomes reported in these studies [26].

*Contemporary evidence and practice of early mobilization post-myocardial infarction*

Published studies on post-MI mobilization strategies in the past three decades have been mainly systematic reviews of earlier studies; there was one RCT (Table 1). A 2003 systematic review and a 2009 Cochrane review looked at outcomes of post-MI patients undergoing shorter (2 to 7 days) vs. longer periods (8 to 12 days) of bedrest [27, 28]. These reviews found no evidence that shorter bedrest was more harmful than longer bedrest in terms of mortality, reinfarction, thromboembolic events or mortality. A systematic review with meta-analysis by Cortes et al. found 14 experimental studies of mobilization strategies post-MI and found a trend toward decreased mortality in the earlier mobilization group [29]. However, studies included in these reviews were mainly conducted prior to the coronary revascularization era.

To characterize current post-MI mobility practice, Cortes et al. conducted a pilot study of 31 acute MI patients in three academic cardiac care units in Canada [30]. They reported that the first attempt at mobilization occurred on average 50 hours post-symptom onset and 21 hours post-admission to the cardiac care unit. People with uncomplicated acute MIs spent nearly 70% of their time during the first 72-hours of admission in bed. Asgari et al randomized patients in a coronary care unit to receive either an EM intervention or usual bed rest care and found less depressive symptoms in the earlier mobilized group [31].

**Table 1. Modern Early Mobilization Practices Post-Myocardial Infarction.**

| Study / Year | Study Type | No. & Population | EM Intervention | EM Results/*Recommendation* |
|---|---|---|---|---|
| Herkner, H. **2003** | Systematic review & meta-analysis | 2658 pts. with uncomplicated MI | Short period of bedrest (2-12 days) or prolonged bedrest (5-28 days). | No evidence that shorter bedrest was more harmful than longer bedrest in terms of mortality, reinfarction, post-infarction angina or thromboembolic events. |
| Herkner, H. **2007** | Cochrane Review | 2958 pts. post-acute uncomplicated-MI | Short period of bedrest (median 6 days) or prolonged bedrest (median 13 days). | No evidence that shorter bedrest was more harmful than longer bedrest in terms of all-cause mortality, cardiac mortality or reinfarction. |
| Lopes, JL. **2008** | Literature Review | 2233 pts. with AMI | 2-10 days of bedrest in EM group; 5-28 days bedrest in long-resting group. | No evidence of complications related to short periods of bedrest in patients with acute MI. |
| Cortes, OL. **2009** | Systematic review & meta-analysis | 3148. pts. following AMI from 14 studies | Varied depending upon study. | Trend towards decreased mortality with EM after AMI. |
| Asgari, M **2014** | Randomized clinical trial | 38 pts. with AMI admitted to CCU | Pts. randomized to intervention group (mobilize 12-18 hours post-CCU admission) or routine care (48 hours post-CCU admission) | EM was effective in reducing depression in patients and recommended its use in the care of patients with AMI. |
| Cortes, OL. **2015** | Observational pilot study | 31 diagnosed AMI pts. admitted to CCU | Bedrest, semi-fowler, transfer to chair, and standing/walking. | Patients experiencing uncomplicated AMI spend majority of 72 hour stay in the CCU in bed. |

ACT, Acute coronary thrombosis; AMI, Acute myocardial infarction; CCU, Cardiovascular Care Unit; EM, Early Mobilization; MI, Myocardial Infarction; Pts, Patients.

*Hemodynamic impact of early mobilization interventions*

There were 5 studies evaluating the hemodynamic impact of EM; only one of the studies specifically focused on post-MI patients (Table 2). A prospective study of 31 intensive care patients who were deemed to have limited cardiac and respiratory reserve found heart rate and blood pressure increased and oxygen saturation was lower during mobilization, although changes were not considered significant [32]. A retrospective study of 31 critically obese patients showed that there were significant increases in respiratory rate, oxygen saturation, and respiratory reserve following mobilization as compared to initial values [33]. An observational study of 53 post-elective cardiac surgery patients undergoing an EM intervention consisting of early post-op chair sitting found reductions in right atrial pressure, but a decrease in central venous oxygen saturation and an increase in arterial lactate [34]. A retrospective study in Japan evaluated the physiological changes during EM sessions in mechanically ventilated patients and found no significant changes in heart rate or blood pressure, although there were improvements in oxygenation parameters [35].

**Table 2. Hemodynamic Impact of Early-Mobilization Interventions.**

| Study/ Year | Study Type | No. & Population | Place of Admission | EM Intervention | Hemodynamic Impact |
|---|---|---|---|---|---|
| Stiller, K. **2004** | Prospective study | 31 intensive care patients. | Intensive care unit | Sitting on the edge of the bed and standing | Significant increases in heart rate, blood pressure. Decreases in percutaneous oxygen saturation in early mobilization patients. |
| Genc, A. **2012** | Retrospective study | 31 critically obese patients. | Intensive care unit | 37 mobilization sessions in their physiotherapy program during intensive care unit stay. | Significant increase of $SpO_2$, respiratory rate and respiratory reserve in patients receiving mobilization sessions compared to initial values. |
| Cassina, T. **2016** | Observational study | 53 patients after elective cardiac surgery. | Cardiovascular intensive care unit | Patients placed sitting on the bed for 5 min, moved to an armchair for 30 min, and finally returned to the initial recumbent position on 1$^{st}$ post-operative day | Significant increases in arterial lactate along with reduction in right atrial pressure and $ScvO_2$; HR and $SpO_2$ unchanged in mobilization group. |
| Umei, N **2016** | Retrospective study | 23 patients requiring mechanical ventilation. | Intensive care unit | Progression from seated on edge of hospital bed, transfer to chair, then to ambulation. | No significant changes in heart rate, arterial blood pressure. Increase partial pressure ratio of arterial blood/inspired fraction of oxygen ratio—indicated improved lung function. |

*Mobilization practices with cardiac devices relevant to post-myocardial infarction care*

Studies reporting mobilization strategies following femoral and radial cardiac catherization were mainly performed in elective coronary angiography or percutaneous intervention (Table 3). In patients undergoing elective percutaneous transluminal coronary angioplasty, mobilization as soon as 6 hours after sheath removal was found to be safe and feasible [36] . Earlier mobilization post-7 French catheterization and percutaneous transluminal coronary angioplasty increased patient comfort and significantly reduced pain [36, 37]. Earlier mobilization following percutaneous coronary intervention had no effect on the incidence of either hematoma formation nor bleeding at the puncture site [38]. In the early 2000s the introduction of radial catherization for coronary angiography increased the potential to mobilize patients earlier post-procedure [39]. In a group of older adults post-MI, Kagoshima *et al*. compared a multidimensional protocol including a transradial approach and earlier mobilization with a transfemoral approach, bedrest and late mobilization, and found that the earlier mobilization group had shorter lengths of intensive care unit and hospital stay and lower rates of systemic complications, including delirium [40]. Mobilization in people with femoral central venous catheters in acute care settings was also shown to be safe [41, 42].

**Table 3. Mobilization Practices with Cardiac Devices.**

| Study/Year | Cardiac Device | No. & Population | EM Intervention | EM Results/*Recommendation* |
|---|---|---|---|---|
| Perme. **2013** | Femoral venous catheter | 77 pts. with femoral catheters in the cardiac intensive care unit | 210 physiotherapy activities with 630 mobility activities (sitting at bed side, standing at bedside, transfer to chair, walking). | No catheter related adverse events. Early mobilization after femoral catheter intervention is important in minimizing functional decline |
| Damluji, A. **2013** | Femoral venous catheter | 101 pts. with femoral catheters in the medical intensive care unit | In-bed exercises, supine cycle ergometry, sitting and standing/walking. | No catheter-related adverse events. |
| Fowlow, B. **1995** | Femoral arterial catheter | 85 pts. admitted to intensive care unit after elective percutaneous transluminal coronary angioplasty (PTCA) | Randomly assigned pts. to 6 or 8 hours after sheath removal | Ambulation 6 hours post-sheath removal resulted in no significant increases in hematoma formation at puncture site compared to group ambulated 8 hours post procedure. Early mobilization group had significantly lower pain scores than late group at 8 hours. |
| Mah, J. **1999** | 7 French (F) arterial catheter | 880 patients post-7F catheter procedure | 3-hour ambulation post procedure (early) or 5-hour ambulation (late) | Early mobilization group had significantly lower bleeding and hematoma formation compared to late mobilization group. Concluded that early mobilization post-cardiac catherization is safe, can decrease hospital stay and increase patient comfort. |
| Kagoshima, M. **2000** | Radial artery catheters Femoral arterial catheter | 89 patients, 32 of which treated with new transradial approach, 57 treated by old protocol | Rapid mobilization and discharge involve walking on ward on third day following procedure & encouragement of discharge within 2 weeks. | Shortened hospital stay with no increase in in hospital mortality, cardiac events or decline of left ventricular function. |
| Kim, K. **2013** | Various catheters and sheaths | Variable (metanalysis) | Variable bed rest durations and early mobilization protocols | Early mobilization following percutaneous coronary intervention had no effect on hematoma formation or bleeding at puncture site. |

AMI, Acute myocardial infarction; BP, Blood pressure; pts, Patients.

*Professional cardiovascular society guidelines for early mobilization post-myocardial infarction*

Only 1 out of 7 current CV professional society guidelines for acute MI has recommendations for EM post-MI (Table 4). The 2017 European Society of Cardiology ST elevation MI guidelines recommend mobilization of patients 1 day after an acute MI in the "majority of patients"[18]. These guideless allow that prolonged bedrest may be needed with patients with severe infarcts or major complications. No evidence is cited to support these recommendations.

**Table 4. Professional Cardiovascular Society Guidelines for Early Mobilization.**

| Professional Society, Author | Date of Recommendation | EM Guidelines, Recommendation |
|---|---|---|
| American College of Cardiology, STEMI Guidelines, O'Gara[43] | **2013** | No mention of mobilization or ambulation in the management of post-STEMI patients |
| American College of Cardiology, NSTEMI Guidelines, Amsterdam[17] | **2014** | No mention of mobilization or ambulation in the management of post-STEMI patients |
| European Society of Cardiology, NSTEMI Guidelines, Roffi[16] | **2015** | No mention of mobilization or ambulation in the management of post-STEMI patients |
| American College of Cardiology, American Heart Association. Society for Cardiovascular Angiography and Interventions, Levine et. Al [44] | **2015** | No mention of mobilization or ambulation in the management of post-STEMI patients |
| National Heart Foundation of Australia and Cardiac Society of Australia and New Zealand: Australian clinical guidelines for the management of acute coronary syndromes—Chew 2016[45] | **2016** | No mention of mobilization or ambulation in the management of acute coronary syndromes |
| European Society of Cardiology, STEMI Guidelines, Ibanez[18] | **2017** | Early ambulation (day 1) recommended in majority of patients. Bed rest recommended in patients with extensive myocardial damage, heart failure, hypotension, or arrhythmias.<br><br>No evidence given to specifically support these recommendations, however cardiac rehabilitation after STEMI is a Class I, Level A recommendation. |
| Canadian Cardiovascular Society, STEMI Guidelines, Wong[15] | **2019** | No mention of mobilization or ambulation in the management of post-STEMI patients |

NSTEMI, Non-ST-elevation myocardial infarction; STEMI, ST-Elevation Myocardial Infarction.

*Current beliefs, attitudes, and knowledge of CV professionals toward mobilization*

There were no studies that specifically focused on the beliefs, attitudes, or knowledge of CV providers towards mobilization.

**Discussion**

The aim of our study was to assess the evidence for EM post-MI, understand current post-MI mobility practice, and determine perspectives of CV healthcare professionals towards mobilization. We found that the majority of post-MI mobilization studies were from the pre-coronary revascularization era and there were few contemporary studies evaluating the role of post-MI mobilization. Many of the older studies were experimental, whereas recent studies were observational. Current CV professional society guidelines largely do not provide recommendations for post-MI mobilization. Evidence for current mobility practice was limited but suggested that bedrest and delayed mobilization is still common in post-MI care. There are a lack of studies exploring the perspectives of CV healthcare professionals towards mobilization.

In the early post-MI period, there is evidence that patients are not being mobilized. Cortes et al. looked at the time to first ambulation post-MI in three Canadian academic tertiary care centers [3]. Only one-quarter of patients walked during the first 48 hours of hospitalization and the majority of post-MI patients (>50%) did not ambulate by 4 days post-MI. Patients who were less likely to ambulate were older and had arrhythmias or were receiving inotropic drugs. The majority of both daytime and nighttime periods were spent in bed (61.5% morning, 64.5% afternoon, 79.9% night). Nearly half of post-MI patients received a prescription for involuntary bedrest. Despite a wide search strategy, there were no other published studies exploring post-MI

mobility practices. Whether this single study's findings are indicative of post-MI mobility care in other healthcare settings is uncertain.

Studies from the pre-coronary revascularization era showed the safety, feasibility and benefits of earlier mobilization post-MI. These studies found that earlier post-MI mobilization resulted in reduced length of hospital stay without an increase in in-hospital complications or short-term post-discharge complications [21, 46, 47]. However, these studies were performed when intensive care and hospital length of stay was considerably longer than in contemporary care. The length of hospital stay post-MI has decreased substantially in the United States with current median post-MI stay for all-comers at 3 days (interquartile range 2 to 6) [48]. Within this short timeframe, it is possible that earlier mobilization may not make a considerable difference in outcomes. However, older adults have a median duration of length of stay post-MI of 6 days and are more likely to have prolonged length of hospital stay (> 7 days) [49]. People with pre-hospital functional impairments have even longer length of hospital stays [50]. In contemporary datasets from other healthcare settings, median length of hospital stay post-MI can be as long as 13 days [51, 52]. Thus, there may be an opportunity for earlier mobilization to decrease length of hospital stay in certain populations.

Beyond resource utilization, EM has been shown in other clinical settings like the intensive care unit and the general medical ward to minimize functional decline, improve psychological wellbeing, prevent post-hospitalization syndrome, and decrease hospital readmission [9, 11, 53]. EM may also achieve these patient-important outcomes post-MI. However, our review highlighted the lack of high-quality studies exploring the timing and potential benefits of EM post-MI in the modern era. There is some observational evidence for EM in acute cardiac populations. A retrospective study of 264 older adults (mean age 77; 19% post-MI

patients) undergoing EM in a quaternary care American cardiac intensive care unit found that more than 40% of patients had improvements in functional status during unit stay [54]. The majority of patients had regained more than three-quarters of the prehospital functional level by the time of unit discharge. Frail older adults, who had lower functional abilities at baseline compared to their non-frail counterparts, had similar overall improvements in functional status. Importantly, there were no patient falls, dislodgement of lines, drains, or endotracheal tubes, or injuries to healthcare personnel related to EM activities in this acute cardiac population.

Our review found that EM resulted in small alterations in heart rate, blood pressure and oxygen saturation, but these changes did not seem to be of major clinical importance [32, 55]. These hemodynamic results serve to further support EM's safety in acute cardiac care. Mobilization with devices that may be relevant to post-MI care in complex patients, such as those receiving percutaneous mechanical ventilation, mechanical circulatory support and continuous renal replacement therapy, have also been shown to be safe [12, 56, 57]. Even mobilization in people receiving vasoactive medications is not associated with hemodynamic instability [58]. However, additional data are needed in people with ischemic heart disease, especially people who were not fully revascularized and may be at increased risk of active ischemia and arrhythmia. We also did not identify any recent studies investigating early mobilization following MI or percutaneous intervention by radial access. Understanding the potential role and safety of EM following radial access for MI has potential clinical practice implications. There is a need for RCTs to address these issues and explore the safety and benefits of EM in post-MI patients in contemporary care. These studies should investigate whether specific patient populations, such as older adults, frail patients, and people with pre-existing functional limitations may benefit from earlier attempts to mobilize.

Current mobilization practices following MI are unknown. With current radial access techniques, it may be safe to transfer the patient post-percutaneous intervention directly from the cardiac catheterization lab to a sitting position in an armchair or in bed. The current practice in our institution is to permit an uncomplicated MI patient who underwent radial arterial catheterization followed by use of a radial artery occlusive device to mobilize to the chair within 1 hour of procedure. Radial artery hemostasis clamp duration of 60 minutes is associated with a low rate of radial artery occlusion and could promote earlier post-MI mobilization [59].

Despite the weight of historical clinical evidence, the lack of a strong evidence base for post-MI mobilization may explain why there is a lack of CV professional society recommendations for mobilization. Of the 7 current CV professional society MI guidelines, only one, the European Society of Cardiology, had a recommendation for EM. However, this recommendation was not accompanied by supporting evidence. Interestingly, an older version (2004) of the American College of Cardiology ST-elevation MI guideline recommends that patients free of ischemic discomfort, symptoms of heart failure or serious arrhythmia should not exceed 12 to 24 hours of bedrest [60]. Stronger evidence for EM's effectiveness post-MI are likely needed to influence CV professional society guideline recommendations.

There were no studies identified that examined the beliefs, attitudes, and knowledge of CV providers towards mobilization. Barriers to mobilize have been identified in critical care providers that may be relevant to acute CV practice. Half of critical care providers do not perceive EM of patients as a top care priority [61]. Three-quarters of critical care physicians report that they lack adequate knowledge or training in mobilizing patients [62]. Common perceived barriers to EM amongst critical care physicians were safety concerns (hemodynamic instability, line dislodgements), medical instability, and limited staffing, and insufficient guidelines to

support mobilization [63, 64]. The most commonly cited barriers for implementation and performance of EM amongst critical care nurses were high workload, patients' inability to exercise, lack of time, inadequate nurse to patient ratio, and absence of relevant education [65]. In acute care cardiology, there is a need to understand and address structural, provider, and patient-level barriers to mobilization.

Knowledge gaps of the role of EM post-MI exist and should be addressed in future studies. Specific subgroups may stand to benefit more from earlier attempts to mobilize. These include older adults, particularly those with frailty, people with limitations in prehospital functional ability, and those with a longer predicted hospital length of stay. Further research is required to operationalize EM, as no consensus for a standardized definition exists in the literature. There is also a need to ascertain whether EM can improve patient-centered outcomes, such as post-hospital functional status and quality of life. Older adults, in particular, prioritize individual quality of life and functional independence over other more conventional societal measures [66]. In addition, whether involving family members in the mobilization process improves outcomes should also be explored. A study in the critical care setting showed that 84% of family members wish to be engaged in care [67]. Recent critical care society guidelines also recommend engaging family members in care to improve patient and family member outcomes (i.e., mental health) [68]. Nurse-driven approaches to EM in post-MI care may also be considered as a pragmatic approach in less resource rich settings [69, 70].

Many institutions transfer patients to intermediate or step-down units following ICU stay, which can provide further opportunity for mobility progression. While EM is practiced in 20-50% of ICUs, the current prevalence of EM in cardiac ICUs or intermediate care units is

unknown [71]. Further studies are needed to determine the optimal mobility trajectory following an MI.

There are limitations to our scoping review. First, despite our search strategy being designed for maximum sensitivity, one-third of the references were included from the manual search. Inclusion of these additional references were mutually agreed upon by two reviewers. Second, the strength of our conclusion was limited by the availability of studies in the published literature and thus were affected by the paucity of data in some sections. For example, only one study concerning current mobility practices post-MI was included in the analysis. There were 25 articles excluded because they were not published online. These articles were considered to be not relevant to the study based on examination of their title and abstract. There were no language restrictions, however, only non-English studies from the contemporary period (year 2000 and beyond) studies were included. Third, for some of the older studies, only the abstract and not the full manuscript was available for analysis.

**Conclusion**

The main body of evidence for EM post-MI comes from the pre-revascularization era and supports the efficacy of earlier mobilization. However, there is an evidence gap for the feasibility, safety, and outcomes for EM post-MI in contemporary care. More robust evidence is required from RCTs about the role of EM post-MI, particularly in subgroups that may stand to benefit the most, in order to inform professional CV society recommendations and influence clinical practice.

**References**


1. Levine SA and Lown B. "ARMCHAIR" TREATMENT OF ACUTE CORONARY THROMBOSIS. *Journal of the American Medical Association*. 1952;148:1365-1369.
2. Wenger NK. Early Mobilization After Myocardial Infarction: Historical Perspective and Critical Appraisal. In: A. Raineri, J. J. Kellermann and V. Rulli, eds. *Selected Topics in Exercise Cardiology and Rehabilitation* Boston, MA: Springer US; 1980: 21-31.
3. Cortes OL, DiCenso A and McKelvie R. Mobilization patterns of patients after an acute myocardial infarction: a pilot study. *Clin Nurs Res*. 2015;24:139-55.
4. Howie-Esquivel J and Zaharias E. Using Novel Technology to Determine Mobility Among Hospitalized Heart Failure Patients: A Pilot Study. *Cardiology Research*. 2013;4:15-25.
5. Winkelman C. Inactivity and inflammation in the critically ill patient. *Crit Care Clin*. 2007;23:21-34.
6. Bauer J, Biolo G, Cederholm T, Cesari M, Cruz-Jentoft AJ, Morley JE, Phillips S, Sieber C, Stehle P, Teta D, Visvanathan R, Volpi E and Boirie Y. Evidence-based recommendations for optimal dietary protein intake in older people: a position paper from the PROT-AGE Study Group. *J Am Med Dir Assoc*. 2013;14:542-59.
7. Dolansky MA and Moore SM. Older adults' early disability following a cardiac event. *West J Nurs Res*. 2008;30:163-80.
8. Adler J and Malone D. Early mobilization in the intensive care unit: a systematic review. *Cardiopulm Phys Ther J*. 2012;23:5-13.
9. Morris PE, Griffin L, Berry M, Thompson C, Hite RD, Winkelman C, Hopkins RO, Ross A, Dixon L, Leach S and Haponik E. Receiving early mobility during an intensive care unit admission is a predictor of improved outcomes in acute respiratory failure. *The American journal of the medical sciences*. 2011;341:373-7.
10. Burtin C, Clerckx B, Robbeets C, Ferdinande P, Langer D, Troosters T, Hermans G, Decramer M and Gosselink R. Early exercise in critically ill patients enhances short-term functional recovery. *Crit Care Med*. 2009;37:2499-505.
11. Zang K, Chen B, Wang M, Chen D, Hui L, Guo S, Ji T and Shang F. The effect of early mobilization in critically ill patients: A meta-analysis. *Nurs Crit Care*. 2019.
12. Nydahl P, Sricharoenchai T, Chandra S, Kundt FS, Huang M, Fischill M and Needham DM. Safety of Patient Mobilization and Rehabilitation in the Intensive Care Unit. Systematic Review with Meta-Analysis. *Annals of the American Thoracic Society*. 2017;14:766-777.
13. Gosselink R, Bott J, Johnson M, Dean E, Nava S, Norrenberg M, Schonhofer B, Stiller K, van de Leur H and Vincent JL. Physiotherapy for adult patients with critical illness: recommendations of the European Respiratory Society and European Society of Intensive Care Medicine Task Force on Physiotherapy for Critically Ill Patients. *Intensive Care Med*. 2008;34:1188-99.
14. Hodgson CL, Stiller K, Needham DM, Tipping CJ, Harrold M, Baldwin CE, Bradley S, Berney S, Caruana LR, Elliott D, Green M, Haines K, Higgins AM, Kaukonen KM, Leditschke IA, Nickels MR, Paratz J, Patman S, Skinner EH, Young PJ, Zanni JM, Denehy L and Webb SA. Expert consensus and recommendations on safety criteria for active mobilization of mechanically ventilated critically ill adults. *Critical care (London, England)*. 2014;18:658.
15. Wong GC, Welsford M, Ainsworth C, Abuzeid W, Fordyce CB, Greene J, Huynh T, Lambert L, Le May M, Lutchmedial S, Mehta SR, Natarajan M, Norris CM, Overgaard CB, Perry Arnesen M, Quraishi A, Tanguay JF, Traboulsi M, van Diepen S, Welsh R, Wood DA,

Cantor WJ, Armstrong PW, Bagai A, Bainey K, Cairns J, Cheskes S, Ducas J, Dzavik V, Jolly S, McVey J, Schampaert E, Schnell G and So D. 2019 Canadian Cardiovascular Society/Canadian Association of Interventional Cardiology Guidelines on the Acute Management of ST-Elevation Myocardial Infarction: Focused Update on Regionalization and Reperfusion. *Canadian Journal of Cardiology*. 2019;35:107-132.
16. Roffi M, Patrono C, Collet JP, Mueller C, Valgimigli M, Andreotti F, Bax JJ, Borger MA, Brotons C, Chew DP, Gencer B, Hasenfuss G, Kjeldsen K, Lancellotti P, Landmesser U, Mehilli J, Mukherjee D, Storey RF and Windecker S. 2015 ESC Guidelines for the management of acute coronary syndromes in patients presenting without persistent ST-segment elevation: Task Force for the Management of Acute Coronary Syndromes in Patients Presenting without Persistent ST-Segment Elevation of the European Society of Cardiology (ESC). *Eur Heart J*. 2016;37:267-315.
17. Amsterdam EA, Wenger NK, Brindis RG, Casey DE, Jr., Ganiats TG, Holmes DR, Jr., Jaffe AS, Jneid H, Kelly RF, Kontos MC, Levine GN, Liebson PR, Mukherjee D, Peterson ED, Sabatine MS, Smalling RW and Zieman SJ. 2014 AHA/ACC guideline for the management of patients with non-ST-elevation acute coronary syndromes: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. *Circulation*. 2014;130:e344-426.
18. Ibanez B, James S, Agewall S, Antunes MJ, Bucciarelli-Ducci C, Bueno H, Caforio ALP, Crea F, Goudevenos JA, Halvorsen S, Hindricks G, Kastrati A, Lenzen MJ, Prescott E, Roffi M, Valgimigli M, Varenhorst C, Vranckx P and Widimsky P. 2017 ESC Guidelines for the management of acute myocardial infarction in patients presenting with ST-segment elevation: The Task Force for the management of acute myocardial infarction in patients presenting with ST-segment elevation of the European Society of Cardiology (ESC). *Eur Heart J*. 2018;39:119-177.
19. Institute JB. The Joanna Briggs Institute reviewers' manual 2015: Methodology for JBI scoping reviews. *Joanne Briggs Inst*. 2015:1-24.
20. Levine SA. Coronary thrombosis: its various clinical features. *Medicine*. 1929;8:245-418.
21. Brummer P, Kallio V and Tala E. Early ambulation in the treatment of myocardial infarction. *Acta Med Scand*. 1966;180:231-4.
22. Irvin Jr CW and Burgess Jr AM. The abuse of bed rest in the treatment of myocardial infarction. *New England Journal of Medicine*. 1950;243:486-489.
23. Boyle DM, Barber JM, Walsh MJ, Shivalingappa G and Chaturvedi NC. Early mobilisation and discharge of patients with acute myocardial infarction. *Lancet*. 1972;2:57-60.
24. Lamers HJ, Drost WS, Kroon BJ, van Es LA, Meilink-Hoedemaker LJ and Birkenhager WH. Early mobilization after myocardial infarction: a controlled study. *Br Med J*. 1973;1:257-9.
25. Hutter Jr AM, Sidel VW, Shine KI and DeSanctis RW. Early hospital discharge after myocardial infarction. *New England Journal of Medicine*. 1973;288:1141-1144.
26. Bloch A, Maeder JP, Haissly JC, Felix J and Blackburn H. Early mobilization after myocardial infarction. A controlled study. *American Journal of Cardiology*. 1974;34:152-157.
27. Herkner H, Thoennissen J, Nikfardjam M, Koreny M, Laggner AN and Müllner M. Short versus prolonged bed rest after uncomplicated acute myocardial infarction: a systematic review and meta-analysis. *Journal of clinical epidemiology*. 2003;56:775-781.
28. Herkner H, Arrich J, Havel C and Mullner M. Bed rest for acute uncomplicated myocardial infarction. *The Cochrane database of systematic reviews*. 2007:Cd003836.

29. Cortes OL, Villar JC, Devereaux PJ and DiCenso A. Early mobilisation for patients following acute myocardiac infarction: a systematic review and meta-analysis of experimental studies. *International journal of nursing studies*. 2009;46:1496-504.
30. Cortés OL, DiCenso A and McKelvie R. Mobilization Patterns of Patients After an Acute Myocardial Infarction: A Pilot Study. *Clinical nursing research*. 2015;24:139-155.
31. Asgari MR, Jafarpoor H, Soleimani M, Ghorbani R, Jafaripour I and Askandarian R. Effects of early mobilization program on depression of patients with myocardial infarction hospitalized in CCU. [Persian]. *Koomesh*. 2014;16:175-184.
32. Stiller K, Phillips AC and Lambert P. The safety of mobilisation and its effect on haemodynamic and respiratory status of intensive care patients. *Physiotherapy Theory & Practice*. 2004;20:175-185.
33. Genc A, Ozyurek S, Koca U and Gunerli A. Respiratory and hemodynamic responses to mobilization of the critically ill obese patients. *Intensive Care Medicine*. 2010;2):S390.
34. Cassina T, Putzu A, Santambrogio L, Villa M and Licker MJ. Hemodynamic challenge to early mobilization after cardiac surgery: A pilot study. *Annals of Cardiac Anaesthesia*. 2016;19:425-32.
35. Umei N, Atagi K, Okuno H, Usuke S, Otsuka Y, Ujiro A and Shimaoka H. Impact of mobilisation therapy on the haemodynamic and respiratory status of elderly intubated patients in an intensive care unit: A retrospective analysis. *Intensive Crit Care Nurs*. 2016;35:16-21.
36. Fowlow B, Price P and Fung T. Ambulation after sheath removal: a comparison of 6 and 8 hours of bedrest after sheath removal in patients following a PTCA procedure. *Heart & lung : the journal of critical care*. 1995;24:28-37.
37. Mah J, Smith H and Jensen L. Evaluation of 3-hour ambulation post cardiac catheterization. *Canadian Journal of Cardiovascular Nursing*. 1999;10:23-30.
38. Kim K, Won S, Kim J, Lee E, Kim K and Park S. Meta-analysis of complication as a risk factor for early ambulation after percutaneous coronary intervention. *European journal of cardiovascular nursing : journal of the Working Group on Cardiovascular Nursing of the European Society of Cardiology*. 2013;12:429-36.
39. Kagoshima M. Acute myocardial infarction in elderly patients: Feasibility of transradial intervention and rapid mobilization. [Japanese]. *Journal of Cardiology*. 2000;36:251-262.
40. Kagoshima M. [Acute myocardial infarction in elderly patients: feasibility of transradial intervention and rapid mobilization]. *J Cardiol*. 2000;36:251-62.
41. Damluji A, Zanni JM, Mantheiy E, Colantuoni E, Kho ME and Needham DM. Safety and feasibility of femoral catheters during physical rehabilitation in the intensive care unit. *Journal of Critical Care*. 2013;28:535.e9-535.e15.
42. Perme C, Nalty T, Winkelman C, Kenji Nawa R and Masud F. Safety and Efficacy of Mobility Interventions in Patients with Femoral Catheters in the ICU: A Prospective Observational Study. *Cardiopulmonary Physical Therapy Journal*. 2013;24:12-7.
43. O'Gara PT, Kushner FG, Ascheim DD, Casey DE, Jr., Chung MK, de Lemos JA, Ettinger SM, Fang JC, Fesmire FM, Franklin BA, Granger CB, Krumholz HM, Linderbaum JA, Morrow DA, Newby LK, Ornato JP, Ou N, Radford MJ, Tamis-Holland JE, Tommaso CL, Tracy CM, Woo YJ, Zhao DX, Anderson JL, Jacobs AK, Halperin JL, Albert NM, Brindis RG, Creager MA, DeMets D, Guyton RA, Hochman JS, Kovacs RJ, Kushner FG, Ohman EM, Stevenson WG, Yancy CW and American College of Cardiology Foundation/American Heart Association Task Force on Practice G. 2013 ACCF/AHA guideline for the management of ST-elevation

myocardial infarction: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines. *Circulation*. 2013;127:e362-425.
44. Levine GN, Bates ER, Blankenship JC, Bailey SR, Bittl JA, Cercek B, Chambers CE, Ellis SG, Guyton RA, Hollenberg SM, Khot UN, Lange RA, Mauri L, Mehran R, Moussa ID, Mukherjee D, Ting HH, O'Gara PT, Kushner FG, Ascheim DD, Brindis RG, Casey DE, Jr., Chung MK, de Lemos JA, Diercks DB, Fang JC, Franklin BA, Granger CB, Krumholz HM, Linderbaum JA, Morrow DA, Newby LK, Ornato JP, Ou N, Radford MJ, Tamis-Holland JE, Tommaso CL, Tracy CM, Woo YJ and Zhao DX. 2015 ACC/AHA/SCAI Focused Update on Primary Percutaneous Coronary Intervention for Patients With ST-Elevation Myocardial Infarction: An Update of the 2011 ACCF/AHA/SCAI Guideline for Percutaneous Coronary Intervention and the 2013 ACCF/AHA Guideline for the Management of ST-Elevation Myocardial Infarction: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines and the Society for Cardiovascular Angiography and Interventions. *Circulation*. 2016;133:1135-47.
45. Chew DP, Scott IA, Cullen L, French JK, Briffa TG, Tideman PA, Woodruffe S, Kerr A, Branagan M and Aylward PE. National Heart Foundation of Australia and Cardiac Society of Australia and New Zealand: Australian clinical guidelines for the management of acute coronary syndromes 2016. *Medical Journal of Australia*. 2016;205:128-133.
46. Adgey AA. Prognosis after early discharge from hospital of patients with acute myocardial infarction. *British heart journal*. 1969;31:750-752.
47. Tiso B and Wolf R. [Early mobilization following myocardial infarct. A report on long term experiences]. *Munchener medizinische Wochenschrift (1950)*. 1971;113:1406-11.
48. Krumholz HM, Normand S-LT and Wang Y. Twenty-Year Trends in Outcomes for Older Adults With Acute Myocardial Infarction in the United States. *JAMA Network Open*. 2019;2:e191938-e191938.
49. Toleva O, Ibrahim Q, Brass N, Sookram S and Welsh R. Treatment choices in elderly patients with ST: elevation myocardial infarction—insights from the Vital Heart Response registry. *Open Heart*. 2015;2:e000235.
50. Fimognari FL, Pierantozzi A, De Alfieri W, Salani B, Zuccaro SM, Arone A, Palleschi G and Palleschi L. The Severity of Acute Illness and Functional Trajectories in Hospitalized Older Medical Patients. *The Journals of Gerontology: Series A*. 2016;72:102-108.
51. Li Q, Lin Z, Masoudi FA, Li J, Li X, Hernández-Díaz S, Nuti SV, Li L, Wang Q, Spertus JA, Hu FB, Krumholz HM and Jiang L. National trends in hospital length of stay for acute myocardial infarction in China. *BMC Cardiovascular Disorders*. 2015;15:9.
52. Węgiel M, Dziewierz A, Wojtasik-Bakalarz J, Sorysz D, Surdacki A, Bartuś S, Dudek D and Rakowski T. Hospitalization Length after Myocardial Infarction: Risk-Assessment-Based Time of Hospital Discharge vs. Real Life Practice. *J Clin Med*. 2018;7:564.
53. Joseph I and McCauley R. Impact of Early Mobilization in the Intensive Care Unit on Psychological Issues. *Crit Care Nurs Clin North Am*. 2019;31:501-505.
54. Goldfarb M, Afilalo J, Chan A, Herscovici R and Cercek B. Early mobility in frail and non-frail older adults admitted to the cardiovascular intensive care unit. *Journal of critical care*. 2018;47:9-14.
55. Vollman KM. Understanding critically ill patients hemodynamic response to mobilization: Using the evidence to make it safe and feasible. *Critical Care Nursing Quarterly*. 2013;36:17-27.

56. Ferreira DDC, Marcolino MAZ, Macagnan FE, Plentz RDM and Kessler A. Safety and potential benefits of physical therapy in adult patients on extracorporeal membrane oxygenation support: a systematic review. *Rev Bras Ter Intensiva*. 2019.
57. Toonstra AL, Zanni JM, Sperati CJ, Nelliot A, Mantheiy E, Skinner EH and Needham DM. Feasibility and Safety of Physical Therapy during Continuous Renal Replacement Therapy in the Intensive Care Unit. *Ann Am Thorac Soc*. 2016;13:699-704.
58. Rebel A, Marzano V, Green M, Johnston K, Wang J, Neeman T, Mitchell I and Bissett B. Mobilisation is feasible in intensive care patients receiving vasoactive therapy: An observational study. *Aust Crit Care*. 2019;32:139-146.
59. Lavi S, Cheema A, Yadegari A, Israeli Z, Levi Y, Wall S, Alemayehu M, Parviz Y, Murariu BD and McPherson T. Randomized trial of compression duration after transradial cardiac catheterization and intervention. *Journal of the American Heart Association*. 2017;6:e005029.
60. Antman EM, Anbe DT, Armstrong PW, Bates ER, Green LA, Hand M, Hochman JS, Krumholz HM, Kushner FG and Lamas GA. ACC/AHA guidelines for the management of patients with ST-elevation myocardial infarction—executive summary: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Writing Committee to Revise the 1999 Guidelines for the Management of Patients With Acute Myocardial Infarction). *Journal of the American College of Cardiology*. 2004;44:671-719.
61. Anekwe DE, Koo KK, de Marchie M, Goldberg P, Jayaraman D and Spahija J. Interprofessional Survey of Perceived Barriers and Facilitators to Early Mobilization of Critically Ill Patients in Montreal, Canada. *J Intensive Care Med*. 2017:885066617696846.
62. Koo KK, Choong K, Cook DJ, Herridge M, Newman A, Lo V, Guyatt G, Priestap F, Campbell E, Burns KE, Lamontagne F and Meade MO. Early mobilization of critically ill adults: a survey of knowledge, perceptions and practices of Canadian physicians and physiotherapists. *CMAJ Open*. 2016;4:E448-e454.
63. Koo KKY, Choong K, Cook DJ, Herridge M, Newman A, Lo V, Guyatt G, Priestap F, Campbell E, Burns KEA, Lamontagne F, Meade MO and the Canadian Critical Care Trials G. Early mobilization of critically ill adults: a survey of knowledge, perceptions and practices of Canadian physicians and physiotherapists. *CMAJ Open*. 2016;4:E448-E454.
64. Harrold ME, Salisbury LG, Webb SA and Allison GT. Early mobilisation in intensive care units in Australia and Scotland: a prospective, observational cohort study examining mobilisation practises and barriers. *Critical care (London, England)*. 2015;19:336.
65. Kim C, Kim S, Yang J and Choi M. Nurses' perceived barriers and educational needs for early mobilisation of critical ill patients. *Australian critical care : official journal of the Confederation of Australian Critical Care Nurses*. 2018:S1036-7314(18)30116-4.
66. Forman DE, Rich MW, Alexander KP, Zieman S, Maurer MS, Najjar SS, Cleveland JC, Jr., Krumholz HM and Wenger NK. Cardiac care for older adults. Time for a new paradigm. *Journal of the American College of Cardiology*. 2011;57:1801-1810.
67. Azoulay E and Pochard F. Communication with family members of patients dying in the intensive care unit. *Current opinion in critical care*. 2003;9:545-50.
68. Davidson JE, Aslakson RA, Long AC, Puntillo KA, Kross EK, Hart J, Cox CE, Wunsch H, Wickline MA, Nunnally ME, Netzer G, Kentish-Barnes N, Sprung CL, Hartog CS, Coombs M, Gerritsen RT, Hopkins RO, Franck LS, Skrobik Y, Kon AA, Scruth EA, Harvey MA, Lewis-Newby M, White DB, Swoboda SM, Cooke CR, Levy MM, Azoulay E and Curtis JR.

Guidelines for Family-Centered Care in the Neonatal, Pediatric, and Adult ICU. *Crit Care Med*. 2017;45:103-128.
69. Hunter OO, George EL, Ren D, Morgan D, Rosenzweig M and Klinefelter Tuite P. Overcoming nursing barriers to intensive care unit early mobilisation: A quality improvement project. *Intensive & critical care nursing*. 2017;40:44-50.
70. Dima D, Valiquette J, Berube-Dufour J and Goldfarb M. Level of Function Mobility Scale for Nurse-Driven Early Mobilization in Patients with Acute Cardiovascular Disease. *Journal of clinical nursing*. 2019.
71. Bakhru RN, McWilliams DJ, Wiebe DJ, Spuhler VJ and Schweickert WD. Intensive Care Unit Structure Variation and Implications for Early Mobilization Practices. An International Survey. *Annals of the American Thoracic Society*. 2016;13:1527-37.

**Supporting information**

**S1. Fig. Selected Search Strategies & PRISMA Checklist**

**Ovid MEDLINE Search Strategy**

Database(s): **Embase Classic+Embase** 1947 to 2019 July 09**, Ovid Healthstar** 1966 to May 2019**, Ovid MEDLINE(R) ALL** 1946 to July 09, 2019

| # | Searches | Results |
|---|---|---|
| 1 | (coronary adj3 syndrome*).tw,kf. | 110423 |
| 2 | myocardial infarction*.tw,kf. | 585916 |
| 3 | exp Myocardial Infarction/ | 708314 |
| 4 | 1 or 2 or 3 | 924230 |
| 5 | ((early or earlie$ or accelerat$ or immediat$ or fast track or timing or rapid$) adj5 (mobil$ or ambulat$ or rehab$ or physiotherapy or physical therapy or physical activity or movement or sitting or standing or walking or semi recumb$ or out of bed)).tw. | 114220 |
| 6 | [(bedrest/ or immobilization/ or rest/ or bedrest or bedrest or bed bound or bedbound).tw. and (time factors/ or time/ or early.tw,kf.)] | 0 |
| 7 | 5 or 6 | 114220 |
| 8 | 4 and 7 | 2251 |
| 9 | early mobilization/ or mobility/ or mobilization/ | 41464 |
| 10 | 8 and 9 | 391 |
| 11 | Exercise/ or exercise/ or training.mp. | 1676966 |
| 12 | Rehabilitation/ or Rehab.mp. [mp=ti, ab, hw, tn, ot, dm, mf, dv, kw, fx, dq, nm, kf, ox, px, rx, ui, sy] | 132114 |
| 13 | 11 or 12 | 1789248 |
| 14 | 7 or 13 | 1890744 |
| 15 | 4 and 14 | 23911 |
| 16 | **9 and 15** | **474** |

**CINAHL Search Strategy:**

*””( ""( ""exp Myocardial Infarction OR (coronary adj3 syndrome*).tw,kf. OR myocardial infarction*.tw,kf. OR ( bedrest/ or immobilization/ or rest/ ) OR ( (bedrest or bedrest or bed bound or bedbound).tw. ) OR ( ((early or earlie$ or accelerat$ or immediat$ or fast track or timing or rapid$) adj5 (mobil$ or ambulat$ or rehab$ or physiotherapy or physical therapy or physical activity or movement or sitting or standing or walking or semi recumb$ or out of bed)).tw. ) OR ( exp Intensive Care Units/ or Critical Illness/ or exp Critical Care/ or (critical* adj3 (ill* or care*)).tw. or intensive care.tw. or (icu or icuaw).tw ) OR (Early mobility/ or early mobilization.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms] ) OR ( Exercise/ or exercise/ or training.mp. ) OR ( Rehabilitation/ or Rehab.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique*

*identifier, synonyms] ) OR ( respiratory/ or respiration/ ) OR pulmonary"" ) AND ( time factors/ or time/ or early.tw. )"" ) AND ( exp Intensive Care Units/ or Critical Illness/ or exp Critical Care/ or (critical* adj3 (ill* or care*)).tw. or intensive care.tw. or (icu or icuaw).tw. )"*

**Search and Selection of Sources of Evidence**

We began with Ovid MEDLINE, using a search strategy consisting of terms search in either for keyword, abstract or in the title of the paper. Generating a search list of terms began after consulting the methodology section of two Cochrane Reviews[93, 94] regarding rehabilitation interventions after myocardial infarction. Nine versions of combining these search terms were constructed to reveal results most representative of the papers we sought to review.

We applied a similar search strategy of terms to CINAHL with a number of limiters. We began searching with records using the terms *"(myocardial infarction or heart attack or mi) AND (early mobilization or early ambulation or early mobility)"* with a number of limiters. The limiters to the search query included age limits (restricted to Adolescent: 13-18 years, Adult: 19-44 years, Middle Aged: 45-64 years, Aged: 65+ years, Aged, 80 and over), journal subjects (Allied Health, Alternative/Complementary Therapies, Asia, Australia & New Zealand, Biomedical, Blind Peer Reviewed, Canada, Continental Europe, Core Nursing, Double Blind Peer Reviewed, Editorial Board Reviewed, Europe, Expert Peer Reviewed, Health Promotion/Education, Health Services Administration, Nursing, Peer Reviewed, Public Health, USA), clinical subjects (Human) and language (English).

With our search strategy on CINAHL, we generated 1110 records in total, and screened these records in Endnote X9, eliminating records with irrelevant terms or topics. Using the search function in Endnote X9, we removed records with the following terms: *stroke, neuro, diabetes, achilles, spinal, amputation, knee, multiple sclerosis, heel cancer, amputee, hip, ankle, limb, bone, fractures, laparo, fall, cerebral, rheu, polio, delirium, HIV, syndrome, chondrocyte, Alzheimer, child, visual, ligament, postpartum, onco, tendon, parkinson, infants, muscular dystrophy, arachnoid, bowel, pediatric.* This narrowed the total number of records down to 428.

We then consulted Google Scholar using the search term *early mobilization after myocardial infarction* and screened the first 100 records for relevancy and included 13 records in our review. Three additional separate searches were conducted on Google Scholar using different search terms: 1) *early mobilization/ or mobility/ or mobilization) AND (intensive care unit/ or ICU),* 2) *(myocardial infarction/ or heart failure) AND (mobilizing/ or mobility)* and 3) *Intensive Care Unit Outcomes*. We obtained 19, 900 search results for 1) and went through the first 50 pages and selected 39 records in total that were relevant. For 2), we obtained 18, 700 results and went through the first 20 pages to obtain 1 relevant result. Lastly, for 3) we obtained 2, 410, 000 results and went through the first 15 pages to obtain 1 relevant result.

We ran a search through Cochrane Library using the search term *early mobilization AND myocardial infarction* and obtained 0 Cochrane reviews.

Lastly, we consulted PubMed® using the search term "*myocardial infarction"[MeSH Terms] OR ("myocardial"[All Fields] AND "infarction"[All Fields]) OR "myocardial infarction"[All Fields] and early mobilization* and generated 373 records.

Combining all records from into EndNote, we categorized references based upon certain limiters in order to exclude irrelevant or out-of-scope records, as well as references not in English or French:

| Exclusion Category | Terms |
|---|---|
| Language | Polish, German, Italian, Persian, Hebrew, Spanish, Russian, Japaneese, Norwegian, Swedish, Korean, Czech |
| Terms (excluded records containing these terms in title) | Stroke, neuro, diabetes, achilles, spinal, amputation, knee, multiple sclerosis, heel cancer, amputee, hip, ankle, limb, bone, fractures, laparo, fall, cerebral, rheu, polio, delirium, HIV, chondrocyte, Alzheimer, child, visual, ligament, postpartum, onco, tendon, Parkinson, infants, muscular dystrophy, arachnoid, bowel, pediatric |
| Non-Cardiology Concepts/Out of Scope | Cellular cardiology (endothelial cell progenitors), cellular biology cholecystitis, gait training, paraplegic, neurological disorders, grafting pain management, music, anesthesia, stroke, pharmacology, pain management, cardiac catheterization, cardiac boomers, gastrointestinal disorders, tuberculosis, technological mobility devices, orthopaedics, prosthesis, injuries and trauma, stem cell mobilization, pneumonia and other respiratory diseases, gynaecology, general mobility in geriatric populations |

After applying these limiters in EndNote, we narrowed the references down to 343. Using Microsoft Excel, we categorized these 343 records based upon differing topics of interest. We began excluding records with the following criteria:

Duplicates
Irrelevant Record
Excluded for Language
ICU= Mobilization in the ICU (Mobilization, Early Rehabilitation, Ambulation, mechanically ventilated) or ICU topics
GM=Geriatric Mobilization (general mobilization/ambulation/movement in older adults)
CR= Cardiac rehabilitation (general mobility/ambulation/exercise after non-MI cardiac procedures
CIP=Critically Ill Patient Interventions (mobilization, ambulation, exercise)

With 117 records remaining of relevant interest, we then grouped references into 10 categories:

1. EMPMI=Early Mobilization Post MI (Mobilization, Early Rehabilitation, Ambulation)
2. HDM= Hemodynamics of Mobilization Post-MI
3. HMI=History of Early Mobilization Post-MI

4. MCD=Mobilizing with Cardiac Critical Care Devices and Therapies
5. PG=Cardiovascular Professional Guidelines
6. MIM=MI Mobilization/ambulation/Rehabilitation (not early movements)
7. ICU= Mobilization in the ICU (Mobilization, Early Rehabilitation, Ambulation, mechanically ventilated) or ICU topics
8. GM=Geriatric Mobilization (general mobilization/ambulation/movement in older adults)
9. CR= Cardiac rehabilitation (general mobility/ambulation/exercise after non-MI cardiac procedures
10. CIP=Critically Ill Patient Interventions (mobilization, ambulation, exercise)

**Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist**

| SECTION | ITEM | PRISMA-ScR CHECKLIST ITEM | REPORTED ON PAGE # |
|---|---|---|---|
| **TITLE** | | | |
| Title | 1 | Identify the report as a scoping review. | 1 |
| **ABSTRACT** | | | |
| Structured summary | 2 | Provide a structured summary that includes (as applicable): background, objectives, eligibility criteria, sources of evidence, charting methods, results, and conclusions that relate to the review questions and objectives. | 2 |
| **INTRODUCTION** | | | |
| Rationale | 3 | Describe the rationale for the review in the context of what is already known. Explain why the review questions/objectives lend themselves to a scoping review approach. | 3 |
| Objectives | 4 | Provide an explicit statement of the questions and objectives being addressed with reference to their key elements (e.g., population or participants, concepts, and context) or other relevant key elements used to conceptualize the review questions and/or objectives. | 4 |
| **METHODS** | | | |
| Protocol and registration | 5 | Indicate whether a review protocol exists; state if and where it can be accessed (e.g., a Web address); and if available, provide registration information, including the registration number. | 4 |
| Eligibility criteria | 6 | Specify characteristics of the sources of evidence used as eligibility criteria (e.g., years considered, language, and publication status), and provide a rationale. | 4 |
| Information sources* | 7 | Describe all information sources in the search (e.g., databases with dates of coverage and contact with authors to identify additional sources), as well as the date the most recent search was executed. | 5 |
| Search | 8 | Present the full electronic search strategy for at least 1 database, including any limits used, such that it could be repeated. | 1 of S1 Fig. |
| Selection of sources of evidence† | 9 | State the process for selecting sources of evidence (i.e., screening and eligibility) included in the scoping review. | 5 |
| Data charting process‡ | 10 | Describe the methods of charting data from the included sources of evidence (e.g., calibrated forms or forms that have been tested by the team before their use, and whether data charting was done independently or in duplicate) and any processes for obtaining and confirming data from investigators. | 5 |
| Data items | 11 | List and define all variables for which data were sought and any assumptions and simplifications made. | 5 |
| Critical appraisal of individual sources of evidence§ | 12 | If done, provide a rationale for conducting a critical appraisal of included sources of evidence; describe the methods used and how this information was used in any data synthesis (if appropriate). | N/A |
| Synthesis of results | 13 | Describe the methods of handling and summarizing the data that were charted. | 5 |
| **RESULTS** | | | |

| SECTION | ITEM | PRISMA-ScR CHECKLIST ITEM | REPORTED ON PAGE # |
|---|---|---|---|
| Selection of sources of evidence | 14 | Give numbers of sources of evidence screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally using a flow diagram. | 5, 6 |
| Characteristics of sources of evidence | 15 | For each source of evidence, present characteristics for which data were charted and provide the citations. | 6-15 |
| Critical appraisal within sources of evidence | 16 | If done, present data on critical appraisal of included sources of evidence (see item 12). | N/A |
| Results of individual sources of evidence | 17 | For each included source of evidence, present the relevant data that were charted that relate to the review questions and objectives. | 6-15 |
| Synthesis of results | 18 | Summarize and/or present the charting results as they relate to the review questions and objectives. | 6-15 |
| **DISCUSSION** | | | |
| Summary of evidence | 19 | Summarize the main results (including an overview of concepts, themes, and types of evidence available), link to the review questions and objectives, and consider the relevance to key groups. | 15-20 |
| Limitations | 20 | Discuss the limitations of the scoping review process. | 20 |
| Conclusions | 21 | Provide a general interpretation of the results with respect to the review questions and objectives, as well as potential implications and/or next steps. | 20 |
| **FUNDING** | | | |
| Funding | 22 | Describe sources of funding for the included sources of evidence, as well as sources of funding for the scoping review. Describe the role of the funders of the scoping review. | 21 |

JBI = Joanna Briggs Institute; PRISMA-ScR = Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews.

* Where *sources of evidence* (see second footnote) are compiled from, such as bibliographic databases, social media platforms, and Web sites.

† A more inclusive/heterogeneous term used to account for the different types of evidence or data sources (e.g., quantitative and/or qualitative research, expert opinion, and policy documents) that may be eligible in a scoping review as opposed to only studies. This is not to be confused with *information sources* (see first footnote).

‡ The frameworks by Arksey and O'Malley (6) and Levac and colleagues (7) and the JBI guidance (4, 5) refer to the process of data extraction in a scoping review as data charting.

§ The process of systematically examining research evidence to assess its validity, results, and relevance before using it to inform a decision. This term is used for items 12 and 19 instead of "risk of bias" (which is more applicable to systematic reviews of interventions) to include and acknowledge the various sources of evidence that may be used in a scoping review (e.g., quantitative and/or qualitative research, expert opinion, and policy document).

*From:* Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA Extension for Scoping Reviews (PRISMAScR): Checklist and Explanation. Ann Intern Med. 2018;169:467–473. doi: 10.7326/M18-0850.

**S1 Table. Historical Evidence and Recommendations for Early Mobilization Post-MI.**

| Study/Year | Results | EM Recommendation |
|---|---|---|
| Levine, S. A. **1929** | N/A | Bedrest is most "rigid application" of ACT, when the patient is placed flat in bed for three to six weeks. |
| Levine, S. A. **1944** | N/A | *"It has been our view that recumbency in bed affords less rest to the heart than the sedentary position in a chair with the feet down."* |
| T. R. Harrison. **1944** | N/A | *"Under controlled experimental conditions excessive restriction of muscular activity was harmful, while the return to normal activity within a few days seemed to exert no detectable injurious effects."* |
| W. Irvin Jr.. **1950** | N/A | *"It is our considered opinion that routine prolonged bedrest in MI is not only unnecessary but also potentially harmful to the mental and physical well-being of the patients."* |
| Brummer, P. **1956** | Report on 322 pts from 1952-1954 indicates increased ambulation is not associated with greater hazard to pts. Was higher than normal incidence of recurrent MI after 1-month DC. | *"It is our impression that the patients have maintained their physical condition better and have regained their normal activity considerably sooner than patients under the old regimen of prolonged bedrest."* |
| Brummer, P. **1961** | Continued earlier ambulation therapy (mobilizing on day 12 instead of 16), with continued anticoagulant therapy (previous studies discontinued upon mobilization). Mobilized on 12th day. MIs dropped during 1st month of hospital DC from 9.3 to 2.5%, concluding that anticoagulants + mobilization rather than mobilization alone is beneficial. | *"Results from study of both series of cases clearly indicate that early ambulation is not accompanied by an increased risk to the patient with myocardial infarction."* |
| Miller, R.L. **1965** | N/A | *"In contrast to simple bedrest, the major loss of red cell mass was noted at the end of bedrest and not during ambulation following bedrest."* |

| | | |
|---|---|---|
| Brummer, P. **1966** | Retrospective survey of 1682 MI patients in Finland found that the average length of bedrest was reduced from 16.2 days in 1952-54 to 10.2 days in 1962-64, with no difference in the complication-rate | N/A |
| Groden et al. **1966** | Found no difference in the frequency of complications of post-MI patients in a group treated with 14 days' bedrest compared with CG treated with 25 days' bedrest. | N/A |
| A. A. J. Adgey. **1969** | N/A | *"It is suggested that in the management of myocardial infarction the emphasis should be on early admission rather than on a prolonged period in hospital."* |
| J. Takkunen. **1970** | Compared mortality of two series of 254 patients post-MI divided into early (7-14 days bedrest) or late series (21 -28 days bedrest) and found no significant differences at 7- or 30-days post-MI, favoring early ambulation than generally stated in the literature | *"Results are in favour of early ambulation and suggest that the appropriate length of stay may be shorter than generally stated in the literature."* |
| B. M. Groden. **1970** | Two groups of male patients post-MI treated by alternative regimes of early or late mobilisation were given psychological tests on discharge and ~1yr follow up. Results show EM group had lower neuroticism scores at DC; no significant difference between early and late mobilised groups in extroversion and neuroticism scores at 1 yr FU. | *"It is suggested that the initial advantages of earlier mobilisation in producing optimism in the patient may be lost when the patient is returned to his home environment."* |
| R. F. DeBusk. **1971** | 10 pts. post-MI participated in rehabilitation program 3-days post-MI consisting of mild, graded exercise, early sitting posture and early ambulation. No complications found in any of the patients after the program. | *"In selected patients, this (early mobilization) program is safe, simple, does not prolong hospitalization, and may contribute to earlier and more complete rehabilitation."* |
| Harpur. **1971** | CG (104 pts): 21 days of bedrest, mobilization day 21, discharge on day 28. Intervention (95pts): 7 days of bedrest, "EM" starting day 8, discharge on day 14. Follow-up 8 months post-DC: no difference in mortality, complication rates and ventricular aneurysm or return to work. | *"It is, therefore, advantageous from many aspects - psychological, economic, and social-to mobilise patients who have sustained an acute cardiac infarct after a shorter period of time than has generally been practised."* |

| | | |
|---|---|---|
| M. Duke. **1971** | Evaluated bedrest physician practices in acute MI patients <65. Mean duration of bedrest ordered was 7.4 to 15.2 days (with similar patient populations). Mean duration of LOS 24 days. | *"Many patients still appear to be kept in bed and probably in the hospital for excessive and arbitrary periods of time that are not dictated by known facts"* |
| Shah. **1972** | 111 pts post-MI. in India were not prescribed bedrest upon admission. First-four-weeks mortality was 13%,<br>one-year mortality 21.4%, and two-year mortality 29%. Concluded that physical activity post-MI was associated with reduced mortality. | "*We concluded that physical activity after myocardial infarction was associated with reduced mortality."* |
| G. R. Royston. **1972** | 200 consecutive males post-MI treated with minimal bedrest and early return to work. 40% DC within 2wks, 87% within a month, with no ill effects during hospital or 6-month follow up. Concluded rapid rehab is safe and desirable. | *"Rapid rehabilitation is both possible and desirable."* |
| J.A. Boyle. **1972** | 538 pts. AMI randomly allocated to either mobilize on day 7 with DC @ day 21 or mobilize on day 21 with DC @ day 28. Found no differences between groups in mortality @ day 28, 3 months and 1 yr. Suggests EM in AMI patients may be taken 7-days post-admission. | *"Mobilisation of patients less than seventy years of age with acute but uncomplicated myocardial infarction may be safely undertaken on the seventh day after admission to hospital."* |
| Lamers HJ. **1973**. | 203 patients post-MI mobilized either on day 10 (intervention) or day 20 (control). Patients kept in hospital for total of 30 days. Found no difference in clinical outcomes between the groups. Concluded post-MI pts. can be safely mobilized after 1-2 weeks and DC after ~3 weeks. | *"Patients with an uncomplicated myocardial infarction may safely be mobilized after 9 days and discharged after three weeks."* |
| AM Hutter Jr. **1973** | Prospective randomized control study comparing 2 or 3-week hospital stay in 138 pts. with uncomplicated MI. Observed no difference between patients mobilized "early" or "late" in terms of morbidity or mortality. | *"It appears that an abbreviated hospital stay for appropriately selected patients would yield substantial savings in medical-care dollars and hospital-bed utilization without diminishing the quality of clinical care for the individual patient."* |

| | | |
|---|---|---|
| H. H. Tucker. **1973** | 342 pts. admitted to CCU with AMI assessed results EM and DC. 22.2% mortality, 7.6% of pts. readmitted. Authors conclude that results justify short hospital stay for acute MI. | *"We conclude that a shorter period in hospital and more rapid mobilization than are normally practised are justified."* |
| A Bloch**. 1974** | RCT of 193 pts <age 70 with uncomplicated MI. EM is either 24 hours or 48 hours post-MI. Control is 3 weeks. Found decreased length of stay (mean of 21.3 days in intervention, vs. 32.8 in control), and no statistically significant between groups in hospital or follow-up mortality, rate of reinfarction, arrhythmias, heart failure, angina pectoris or ventricular aneurysm, or results of an exercise test. Was significantly greater disability in control that treated group on follow-up examination. | *"Early mobilization is not responsible for any of the classically described complications of myocardial infarction. It allows considerably shorter periods of hospitalization without greater risk, and it offers a wide range of advantages-physical, psychological, economic and professional."* |
| Hayes MJ. **1974** | RCT of 189 pts. with uncomplicated MI. CG mobilized at 9 days, DC at 16 days. Intervention mobilized at 48 hours, discharge at 9 days. FU 6-weeks post-DC shows no difference in mortality or morbidity. | *"Clinical assessment of myocardial infarction patients at 48 hours is a reliable means of selecting the uncomplicated cases and that immediate mobilization of these patients is not associated with any increase in mortality."* |
| N. C. Chaturvedi. **1974** | Prospective study of 232 pts. with AMI that were safely allowed home on the 7$^{th}$ day in hospital. 40% of these patients survived to the 6$^{th}$ day, and 68% of these patients discharged the 7$^{th}$ day. No deaths in these patients during 3-month FU. | *"We feel that our simple selection procedure allows a significant group of patients to be allowed home safely after only a week in hospital, and so permits a unit to concentrate its resources on patients early in the infarction stage, and for longer periods on patients at an increased risk."* |
| Abraham. **1975** | Prospective RCT AMI pts... 64 pts. mobilized on day 6, DC day 12. 65 patients mobilized on day 13, DC 19. FU showed early ambulation is beneficial irrespective of complications | *"We conclude that early ambulation is beneficial irrespective of complications on admission."* |

| | | |
|---|---|---|
| Swan HJ. **1976** | Ad hoc review of clinical and laboratory findings of acute MI pts.. Recommend that EM program with progressive activity over 5 to 10 days should reduce LOS to less than current average of 17.5 to 20.8 days for AMI pts. | *"If by the 5th hospital day no complication is evident, mobilization by the 7th to 10th day and discharge from the hospital by approximately the 14th day is not associated with increased risk."* |
| Jelinek, V. **1977** | Defined low-risk after MI. 30/189 pts. met these criteria. Gave early exercise testing 1-5 weeks post- admission; conclude early exercise provide useful guidelines for returning to work and recommend it as integral part in rehab. | *"Early exercise testing proved useful in providing guidelines for return to most work, leisure, and sexual activities within four weeks of admission to hospital… we recommend it as an integral part in the rehabilitation of these patients."* |
| McNeer JF. **1978** | 67 pts. with acute-MI in trial for DC within 1 week. 33/67 pts. discharged within 1 week. Found no serious complications in either groups at 3-weeks FU and no deaths or difference in functional status at 6-months FU in either groups. | *"It is feasible and ethically justified to discharge such uncomplicated patients at one week after an acute myocardial infarction. The potential economic savings through earlier discharge in these patients are of major importance."* |
| Beamish, R. **1977** | 32 patients post-MI remained ambulant and observed for 6 months. After 6 months, all but 2 were well before their MI. Suggest moderate activity for pts. to avoid "undesirable consequences" of bedrest | *"Our experience suggests that selected patients can be allowed moderate activity without ill effects and thus avoid the undesirable consequences of enforced bedrest."* |
| Thornley, P. **1977** | 142 men <65 years of age after acute-MI in the CCU divided into 3 mobilization times: 1. 2-4 days in bed (n=74), 2. 5-10 days in bed (n=42) or 3. >10 days in bed (n=11). Mean bed-rest period was 5.4 days. Rapid mobilization led to earlier DC. | *"It is clear that rapid mobilization and early discharge after myocardial infarction should now be standard practice and there is no need of further evidence of its safety."* |
| Lindvall. **1979** | n=184 pts in the CCU (48 hrs). 2 groups: 1) Rapidly mobilized (RM) (n=55) 2) CG (n=129). 42 RM patients mobilized and discharged in a mean stay of 9 days in contrast to mean of 19 days in the CG group. Early exercise test in selected patients is safe in AMI pts. | *"Early exercise test in selected good risk patients is safe and identifies a group prone to complications during the early follow-up period."* |
| West, R. **1979** | n=742 pts in 13 hospitals randomly allocated to EM either on 5$^{th}$ or 10$^{th}$ day after MI. Found no difference in 1$^{st}$ year mortality or morbidity between groups | *"Early mobilization in practice thus led to earlier discharge and resulted in lower costs"* |

| | | |
|---|---|---|
| Kohn, R. M.. **1982** | N/A | *"It seems strange that in the 1980s we continue to debate the dangers of early ambulation for the patient with myocardial infarction."* |
| Wenger, N. K. **1982** | Questionnaires sent to 6000 physicians to determine pattern in changes of care between 1970-1980 for pts. with uncomplicated AMI. Found early ambulation and return to work are more common practices | N/A |
| Magder, S. **1985** | Measured HR, BP, and rhythm in n=32 pts during sitting, standing and walking within first 2 days post-MI. Ambulatory activities caused small changes in HR, BP unchanged or decreased. Concluded that mild ambulatory activities within first few days of MI can be permitted, as long as BP monitored. | *"Mild ambulatory activities produce little stress for the myocardium and can be permitted in the first few days following infarction as long as blood pressure is measured."* |

*ACT*, Acute coronary thrombosis; *AMI*, Acute myocardial infarction; *BP*, Blood pressure; *CCU*, Cardiac care unit; *CG*, Control group; *DC*, discharge; *EM*, Early mobilization; *FU*, Follow-up; *HR*, Heart rate; *IG*=Interventional group; *LOS*= Length of stay; *MI*, Myocardial infarction; *Pts*, Patients; *RCT*, Randomized control trial.

## Chapter 4: Commentary on Scoping Review

The scoping review revealed a broad number of publications pertaining to older studies investigating mobilization strategies post-MI. However, there was a lack of contemporary evidence. We initially sought to use a search strategy aimed at capturing EM studies in older adults with CVD. Most of the literature involved evidence for EM in patients that were mechanically ventilated, undergoing rehabilitation from strokes or other populations beyond the scope of cardiology. We consulted with a medical research librarian to reframe our search strategy to search for EM specifically in the cardiovascular setting. Our scoping review identified several historical recommendations advocating for EM post-MI; however, these came primarily from case studies and observational trials, with minimal experimental and randomized trials. There was a lack of contemporary evidence for EM strategies post-MI, as well as its implementation in patient care. The evidence gap was reflected in the dearth of professional society recommendations for mobilization. This lack of evidence and society recommendations may directly influence the beliefs, attitudes, and knowledge of cardiovascular professionals towards EM post-MI.

A few observations can be made from the results of our scoping review. First, high-quality contemporary data are needed to understand the impact of early mobilization post-MI. Second, to influence knowledge into practice, professional cardiovascular societies should combine historical evidence for EM post-MI with contemporary study data when formulating recommendations. Lastly, the prevailing attitudes and sentiments regarding EM post-MI is incongruent with the bulk of historical and contemporary evidence. Cardiovascular physicians tend to have higher barriers in knowledge, beliefs and attitudes towards the implementation of

EM programs to benefit post-MI patients.[25] Professional guidelines backed with clinical evidence, may serve to reduce the reluctance that cardiovascular healthcare providers may have in implementing EM into their regular practice. Moreover, contemporary high-quality randomized control trial evidence and professional guidelines may sensitize clinicians and bring a renewed sentiment towards EM post-MI and in patients with acute CVD.

## Chapter 5: Transition from Scoping Review to Prospective Cohort Studies

The results of our scoping review reveal a lack of contemporary evidence for EM post-MI. Two clarifying points emerged for further research: 1) Historical evidence suggests patients were largely sedentary during the initial hospitalization period when admitted for an acute cardiac illness, but the minimal contemporary evidence has yet to validate this in the contemporary setting; 2) EM may be associated with the HRQOL of acute CVD patients.

There is a need to understand the amount of time that acute CVD patients spend in sedentary positions during hospitalization, as well as the impact of sedentary time upon HRQOL. The following two studies describe results from the EM cohort: A prospective cohort of older adults with acute CVD undergoing a nurse-driven early mobilization program at the Jewish General Hospital, an academic, tertiary care hospital in Montreal, Quebec, Canada. Patients admitted to the cardiovascular intensive care unit or cardiovascular ward underwent a structured care program where prehospital, admission, and discharge functional status were assessed. Follow-up calls were conducted following hospitalization at 1- and 12-months posthospitalization to assess HRQOL using the validated Short-Form 36 (SF-36) health survey. The SF-36 provides data on the physical and mental health stratified across 8 subscales and is valid, reliable, and the most widely used instrument in measuring HRQOL in cardiac patients.[31]

Sedentary time of older patients with acute CVD could be done retrospectively through chart review, however this would not be the optimal method to do so, as it largely relies on caregiver, patient, and health care provider report, which are subject to various biases. To determine average sedentary time spent, the use of actigraphy Bluetooth technology was used. A subgroup of patients from the EM cohort enrolled from April 2019 to March 2020 were equipped

with the ActiGraph GT9X Bluetooth activity monitor, a small portable accelerometer actigraphy device capable of accurately and reliably providing long-term data on the mobility positions, step counts, and metabolic expenditure of acute care inpatients.[32, 33] The use of the ActiGraph GTX9 has several benefits over traditional activity monitoring methods. Actigraphy is capable of differentiating sedentary, light, moderate and vigorous mobility states using validated algorithms in the companion ActiLife software, accounting for variances in the level of activity that patients may engage while in hospital.[34] The device also contains a wear-time sensor to monitor compliance in the event patients chose to remove or tamper with device and consequently interfere with data collection. [32] Lastly, the device is light, portable and small, weighing in at 14 grams and measuring 3.5 x 3.5 x 1cm fastened to the thigh or waist of the patient.[32] Thus, the ActiGraph GT9X was used to measure average sedentary time in older adults with acute CVD as it is a validated, objective, and reliable instrument. The results of our study in describing average sedentary time in hospitalized older adults with acute CVD is presented in the following chapter.

## Chapter 6: Cohort Study 1: Submitted manuscript

### "Sedentary time in Hospitalized Older Adults with Acute Cardiovascular Disease"

Our prospective study describing the sedentary time in hospitalized older adults with acute cardiovascular disease is presented as a manuscript below.

This study was presented as an abstract at the American Heart Association's Scientific Sessions on November 13-17, 2020. This manuscript is currently in submission.

**Sedentary Time in Older Adults with Acute Cardiovascular Disease**

Haroon Munir, BSc,[1] Michael Goldfarb, MD, MSc[2]

[1] Division of Experimental Medicine, McGill University, Montreal, QC, Canada

[2] Division of Cardiology, Jewish General Hospital, McGill University, Montreal, QC, Canada

**Short Title: Sedentary Time in Older Adults with Acute CV Disease**

Corresponding author:

Michael Goldfarb, MD, MSc

Assistant Professor of Medicine, McGill University

Director of Quality of Care and Safety

Division of Cardiology, Jewish General Hospital

3755 Cote Ste Catherine Road, Office E-212, Montreal, QC, Canada H3T 1E2

Tel: (514) 340-8222 ext 25801 | Fax: (514) 340-7534 | Email: michael.j.goldfarb@mcgill.ca

**Background:** Older adults may be subject to prolonged bedrest during hospitalization for acute cardiovascular disease, which can contribute to poor functional outcomes posthospitalization. Our objective was to describe mobility status in hospitalized older adults with acute cardiovascular disease.

**Methods:** Patients aged ≥ 60 years old in the cardiac intensive care unit and cardiovascular ward at a tertiary care academic centre in Montreal, Quebec were prospectively enrolled from April 2019 to March 2020. Activity levels were measured with an accelerometer (ActiGraph GT9X Link). Sedentary was defined as lying in bed or in a sitting position. Health-related quality of life (HRQOL) was measured with the Short-Form 36 (SF-36) questionnaire by telephone at 1-month post-hospital discharge. The primary outcome was percentage of sedentary time during hospital stay. Secondary outcomes were step counts, steps per minute, and kcal/day consumption.

**Results:** There were 35 patients included in the analysis (75.7 ± 6.9 years old; 45.7% females; 22.9% ischemic heart disease; 20.0% heart failure). Patients spent 91.2% ± 5.5 in the sedentary position during their hospital stay (range 80.0-100%). There was no difference in percentage sedentary time by primary diagnosis or sex. Mean overall step counts were 5,965.3 ± 124.5 and mean kcals consumed per day were 116.6 ± 124.5. In the multivariable analysis, a higher percentage of sedentary time and lower steps per minute were each associated with lower total SF-36 scores at 1-month posthospitalization (both $P<0.05$).

**Conclusion:** Older adults with acute cardiovascular disease are sedentary for a large part of their hospital stay. Increased sedentary time is associated with worse self-reported posthospital

HRQOL. Future studies are needed to determine whether interventions to increase activity during hospitalization improve posthospital HRQOL and functional outcomes.

**Keywords:** Accelerometer, early mobilization, cardiovascular disease, geriatrics, older adults.

## Introduction

Older adults often endure prolonged periods of bedrest during hospitalization due to acute illness, physician prescription, medical tests, and lack of medical support staff.[1, 2] People with acute cardiovascular disease are particularly subject to lengthy periods of bedrest due to the need for invasive monitoring, as well as the concern for electrical and hemodynamic instability.[3] Bedrest is associated with poor outcomes such as pressure ulcers, edema, and increased length of hospital stay.[1, 2, 4] Bedrest also results in the loss of muscle mass and strength leading to functional decline that remains well beyond the index hospitalization period.[5, 6] Following hospitalization there is a transient period of vulnerability, known as posthospitalization syndrome, when the hospital-acquired deconditioning leads to impaired functional ability and increases the risk of hospital readmission.[5, 7]

Structured mobilization programs designed to increase physical activity may decrease sedentary time during acute care hospitalization and may impact post-hospitalization function outcomes.[8] Older adults may prioritize their independence, as well as functional measures such as mobility and maintenance of quality of life over standard clinical outcomes.[9]

There are limited data describing the amount of sedentary time that older adults with cardiovascular disease spend during an acute care hospitalization. Actigraphy devices equipped with accelerometers can track time spent in varying mobility positions and estimate metabolic expenditure during hospitalization.[10] Actigraphy has been shown to provide accurate and valid data on the mobility status of critically ill inpatients.[11] Thus, our objectives were to (1) describe the time older adults spend in sedentary positions during hospitalization for acute cardiovascular disease and (2) to explore the association between sedentary time and posthospitalization person-centered outcomes. Data from this study can be used to design interventions aimed to reduce in-

hospital sedentary behaviour, which could then improve posthospitalization outcomes in older adults with acute cardiovascular disease.

## Methods

### *Study Design, Participants and Setting*

Patients aged ≥ 60 years admitted to the cardiovascular intensive care unit (CICU) or cardiovascular ward were prospectively enrolled an observational cohort study at the Jewish General Hospital, a tertiary care academic centre in Montreal, Canada from April 1, 2019 to March 1, 2020. Exclusion criteria were projected hospital stay ≤ 24 hours, patients with a poor prehospital level of function (LOF) status (defined as levels 0, 1 or 2), or a scheduled cardiac surgery during the index hospitalization.

### *The Early Mobility Program*

The early mobility (EM) program is a pragmatic, nurse-driven mobilization program where patients are mobilized as soon as hemodynamic stability is achieved, typically within the first day or two following unit arrival. The EM program has been previously shown to be safe and feasible people with acute cardiovascular disease.[12, 13] Mobility is measured in the EM program using the validated LOF Mobility Scale, which ranges from 0 (bed mobility) to 5 (able to walk > 20 meters).[12] Bedside nurses assess the prehospital and admission LOF score upon unit arrival and then subsequently twice daily. Prehospital LOF status is determined by nurses through patient history or by contacting the family. Patients undergo morning and evening activities as specified by their current LOF status. Nurses document contraindications to mobilization, adverse events, activities performed, and the LOF. Adverse events were defined as

life threatening (cardiac arrest or severe respiratory distress), major (syncope, falls, line displacement, healthcare personnel injury, persistent chest pain, or hypotension), or minor (transient, self-resolving hemodynamic, arrhythmic or respiratory events).

*Study Variables and Outcome Measures*

The primary outcome was percentage of sedentary time during hospital stay. Secondary outcomes were total step counts, steps per minute, kcal consumption per day, and Short-Form (SF)-36 scores at 1-month post-hospitalization. The SF-36 Health Survey is a 36-item health-related quality of life (HRQOL) survey self-reported by patients. Mental and physical component scales are scored from 0 to 100, with lower values indicating greater disability.[14] A mean score of 50 standardized to Canadian Normative values was used in this study.[15] It is the most-widely used HRQOL instrument, is feasible to administer in-person and by phone, and has been validated in older patient populations.[16] Covariates of interest included age, sex, primary admission diagnosis, length of unit stay and LOF scores at 3 intervals (prehospital, admission, and unit discharge). Additional outcomes of interest were in-hospital mortality, 30-day hospital readmission, and discharge destination.

*Study Instruments*

Patients enrolled in the study were outfitted with a 3-axis accelerometer and inclinometer—the ActiGraph GT9X Link Bluetooth Activity Monitor (ActiGraph, Pensacola, Florida). The ActiGraph is a small portable activity device weighing 14 grams and measuring 3.5 x 3.5 x 1cm that is fastened to a belt that on the patients' thigh or waist. A member of the research team swaps out the devices daily to charge and transfer data, sterilizing with isopropyl

alcohol in between. The device has been shown to provide accurate and reliable long-term data in acute care inpatients of time spent in mobility positions (standing, sitting, lying), time spent in activity intensities (sedentary, moderate, light, vigorous), step counts, steps per minute and kcal per day consumption.[11] Through Bluetooth technology, the ActiGraph devices connect to the ActiLife software to extract the data.[17]

*Data Collection*

The following data were obtained from the electronic medical records of each subject: age, sex, primary admission diagnosis, length of CICU or cardiovascular ward hospital stay, discharge destination, vital status at discharge and at 30-days, and mobility metrics (LOF scores, contraindications to mobilization, total activities completed, adverse events). Primary admission diagnosis was codified into the following categories: ischemic heart disease, heart failure, atrial fibrillation, other arrhythmia, other cardiovascular disease, other non-cardiovascular disease, and valvular disease. Discharge destination was defined as home, rehabilitation facility or acute care hospital, or long-term care facility. HRQOL was ascertained at 1-month by a member of the research team administering the SF-36 Health Survey by telephone.

*Data Analysis*

Continuous variables are summarized as mean ± standard deviation, with between group differences tested using the student's t-test. Categorical variables are summarized as frequencies and percentages. Length of stay in the CICU and hospital in days are reported as median values with interquartile ranges. Comparisons were done using the chi-squared test or Fisher exact test where appropriate. Bivariate Pearson's correlation was performed to correlate step counts with

mobility activities and percentage of sedentary time. A multivariable linear regression model was used to determine the predictor variables of age, sex, primary admission diagnosis, and mobility levels, with the total SF-36 score at 1-month. A p-value of ≤0.05 was considered to be statistically significant. Data analysis was done using the SPSS 24.0 statistical software (Armonk, New York: IBM Corp.). This study was approved by the institutional research ethics board. All participating subjects signed a written informed consent form prior to enrolment in the study.

**Results.**

There were 35 patients included in this analysis (**Table 1)**. The mean age was 75.7 ± 6.9 years old and 16 were female (45.7%). The median length of stay was 3.0 days in the CICU and 11.0 days in the hospital. The majority of patients were discharged home (N=33; 94.3%). There were 4 patients (11.4%) readmitted to the hospital within 30 days. There were three adverse events (3 events/791 activities; 0.4%). All (N=3) were minor and transient. There were no patient falls.

Patients spent 91.2% ± 5.5 of their time during hospital stay in a sedentary position, 7.5% ± 4.8 in moderate activity, and 0.8% ± 1.9 in vigorous activity. The average percentage of sedentary time during hospital stay ranged from 80.0% to 100% (**Figure 1**). The percentage of sedentary time was highest during the first day of CICU stay (95.7% ± 0.0008; N=2) and decreased by the third day of hospital day (89.5% ± 0.06; N=19; **Figure 2**). The mean Kcals burned per day was 116.6 ± 124.5, peaking on day 3 with 92.6 kcals/day burned. The mean overall step count was 5,965.3 ± 8,091.4 and mean steps per minute was 1.0 ± 1.2. Peak mean step counts for patients occurred on day 6 of their hospital stay with 1792.4 steps. Patients with a

hospital stay more than 7 days tended to be more sedentary throughout their entire CICU stay compared to patients with a CICU length of stay less than 7 days **(Figure 3).**

Steps per minute and percentage of mobility activities completed by patients were correlated with one another (P=0.05; r=-0.04) and negatively associated with percentage of sedentary time (P=0.01; r=-0.8). In the multivariable regression analysis, prehospital LOF and percentage of sedentary time were significantly associated with total SF-36 score at 1-month (**Table 2**; P=0.02).

When steps per minute was added to the multivariable model and percentage of sedentary time was removed, steps per minute was an independent predictor of total SF-36 score at 1-month (P=0.003). There was no significant difference between average sedentary time by diagnosis (P=0.3), as well as average sedentary time difference by sex (P=0.5). When the average sedentary time was split by quartile (quartile 1 had the least sedentary time; quartile 4 had the most sedentary time), there was a 30.6-point difference in total SF-36 scores between the 1$^{st}$ and 4$^{th}$ quartiles (**P=0.02; Additional File 1, Figure S1**).

**Table 1**. Cohort Characteristics

| Variable | Number in Cohort N = 35 |
|---|---|
| **Demographic** | |
| Age (years) | 75.7 ± 6.9 |
| Female (%) | 16 (45.7%) |
| | |
| **Primary Admission Diagnosis** | |
| Ischemic heart disease | 8 (22.9%) |
| Heart failure | 7 (20.0%) |
| Atrial fibrillation | 6 (17.1%) |
| Other CV disease | 4 (11.4%) |
| Valvular disease | 9 (25.7%) |
| | |
| **Clinical Outcomes** | |
| CICU length of stay, days | 3.0 (1.0 – 5.0) |
| Hospital length of stay, days | 11.0 (5.0 – 23.0) |
| In-hospital death | 0 (0.0%) |
| 30-day hospital readmission | 4 (11.4%) |
| 30-day mortality | 1 (0.0%) |
| | |
| **Discharge destination** | |
| Home | 33 (94.3%) |
| Rehabilitation or acute care hospital | 2 (5.7%) |
| Long term care facility | 0 (0.0%) |
| | |
| **Mobility** | |
| Prehospital LOF | 4.6 ± 0.6 |
| CICU Admission LOF | 3.3 ± 1.3 |
| CICU Discharge LOF | 3.9 ± 0.8 |
| Adverse events | 3 |
| Number of activities completed | 791 |
| Opportunities used | 284 |
| Contraindications | 9 (25.6%) |

**Legend**

Abbreviations: CICU, Cardiovascular intensive care unit; CV, cardiovascular; LOF, level of function.

Continuous variables are included as mean ± standard deviation

Categorical variables are included as number (percentage)

CICU length of stay and hospital length of stay in days reported as median

**Figure 1.** Percentage of Sedentary Time in People with Acute Cardiovascular Disease

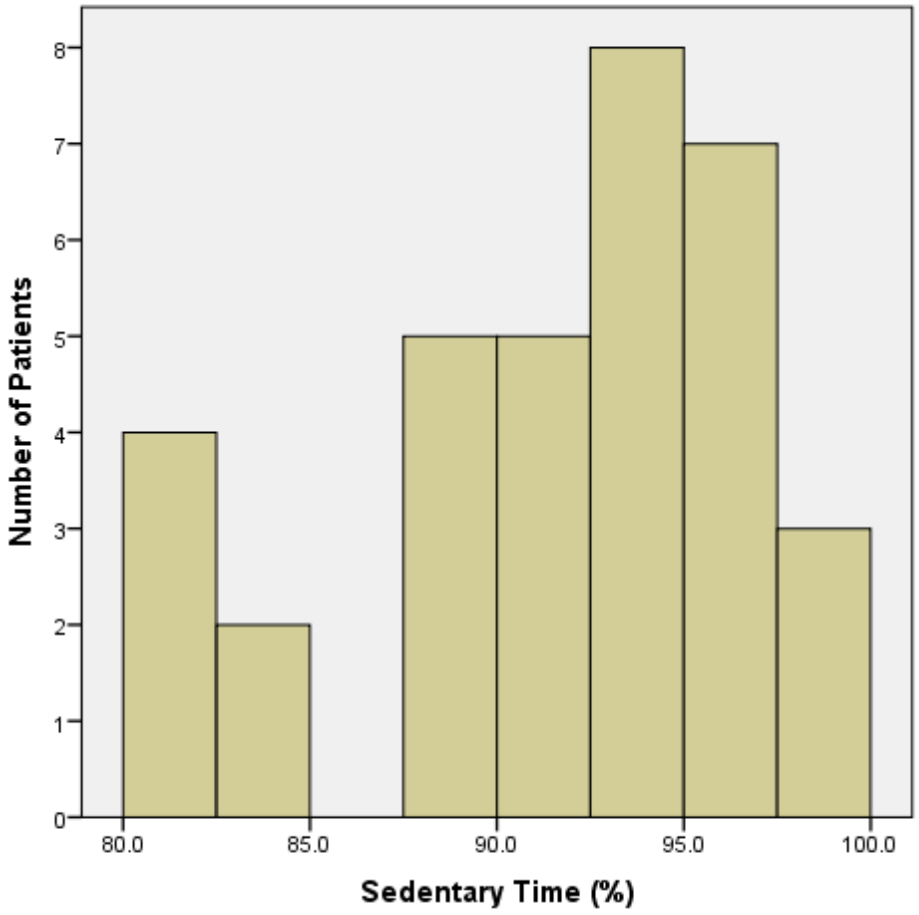
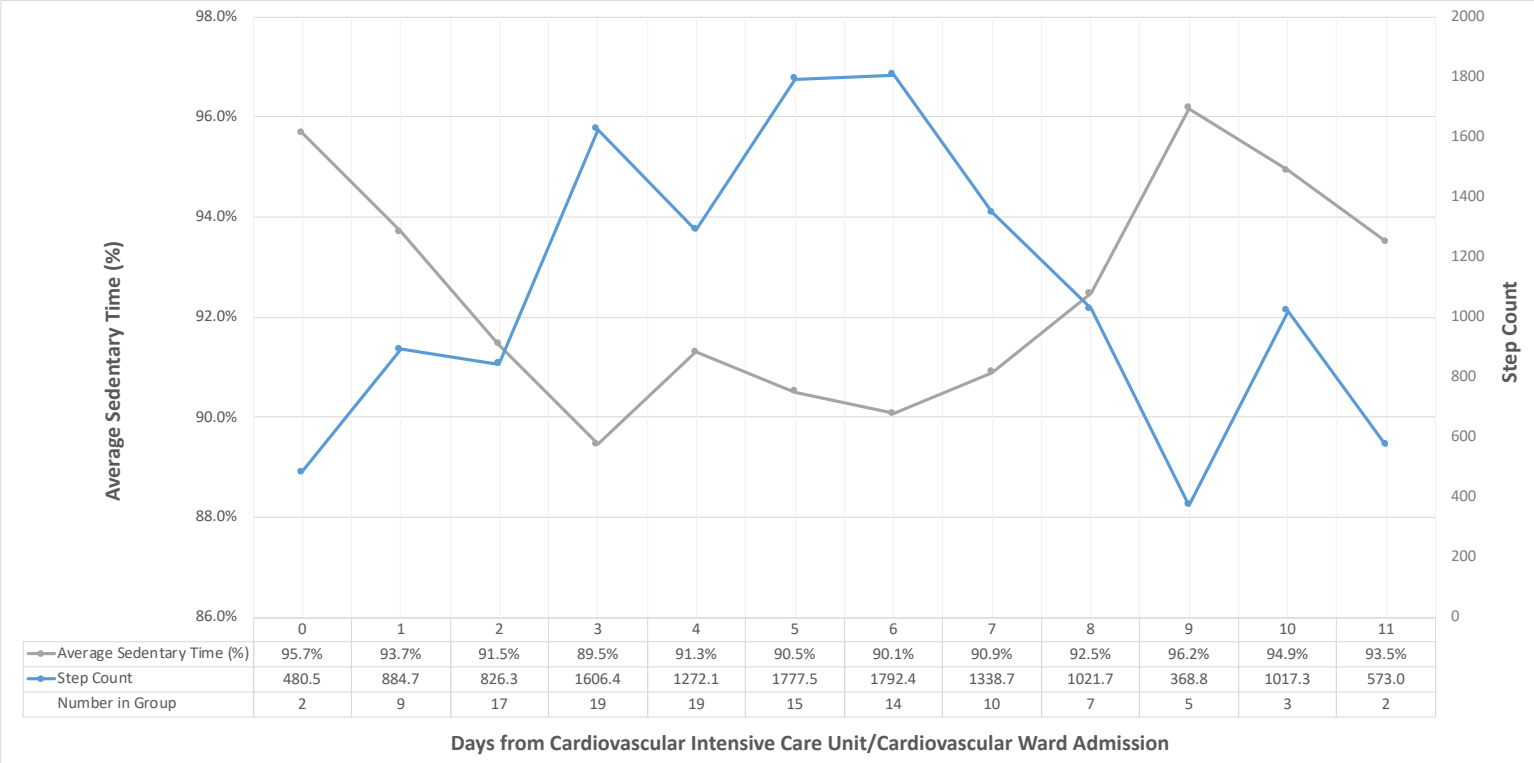


**Figure 2.** Distribution of Sedentary Time and Step Count During Unit Stay




| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Average Sedentary Time (%) | 95.7% | 93.7% | 91.5% | 89.5% | 91.3% | 90.5% | 90.1% | 90.9% | 92.5% | 96.2% | 94.9% | 93.5% |
| Step Count | 480.5 | 884.7 | 826.3 | 1606.4 | 1272.1 | 1777.5 | 1792.4 | 1338.7 | 1021.7 | 368.8 | 1017.3 | 573.0 |
| Number in Group | 2 | 9 | 17 | 19 | 19 | 15 | 14 | 10 | 7 | 5 | 3 | 2 |

**Figure 3.** Average Sedentary Time Split by One Week Hospital Length of Stay

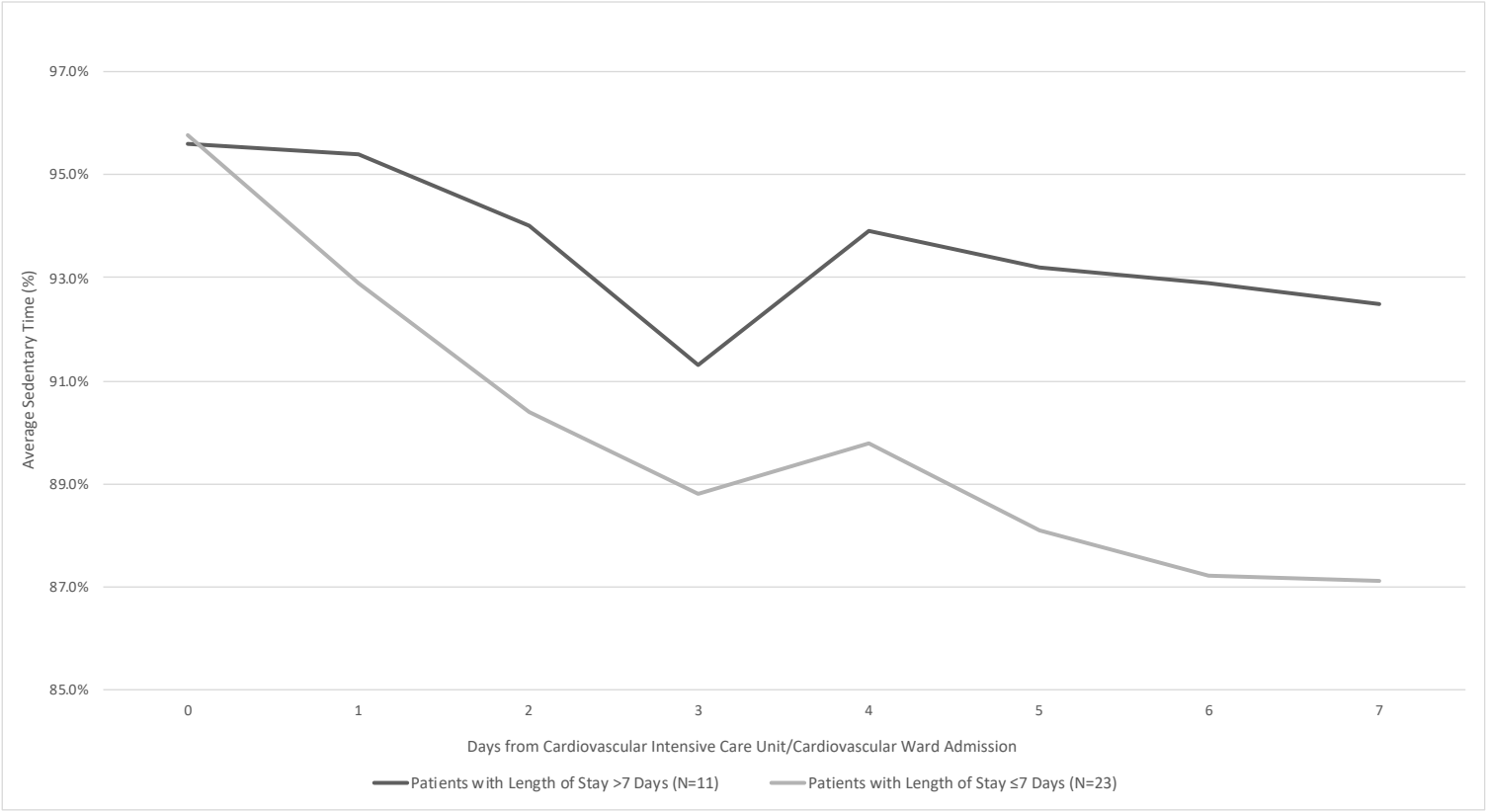


**Table 2**. Multivariable Linear Regression

| Variable | Regression coefficient | 95% Confidence Interval | P-Value |
|---|---|---|---|
| **Age** | -0.3 | -1.3 to 0.7 | 0.6 |
| **Sex** | -1.4 | -14.5 to 11.6 | 0.82 |
| **LOF Prehospital** | 18.2 | 7.3 to 29.0 | 0.002 |
| **Sedentary Percentage Time** | -1.5 | -2.9 to -0.2 | 0.02 |

**Legend**
Abbreviations: LOF, level of function.

**Discussion.**

*Key Findings*

Our study found that older adults with acute cardiovascular disease spend on average more than 90% of their hospital stay sedentary. Patients were most sedentary during the first day of CICU admission. Patients that had a hospital stay greater than one week tended to remain more sedentary throughout the entirety of their stay compared to patients with a hospital stay less than one week. The EM program was safe with no major adverse events. Notably, a relationship between sedentary time and step count was observed; older patients that were predominately sedentary and took fewer steps had significantly poorer HRQOL measures at 1-month, with lower step counts being a predictor of decreased HRQOL 1-month following hospitalization. Functional status before hospitalization was also associated with HRQOL outcomes at 1-month.

*Sedentary Time and Patient Outcomes*

An observational study by Brown and colleagues of 45 patients in a general medical unit found that patients spent 83% of their time spent lying in bed.[1] Brown described a variety of admission diagnoses resulting in barriers to mobilization including restraining medical devices, concern for falls by patients and providers and lack of staff and assistive device availability.[1] Bedrest is often an involuntary occurrence, with a study of acute hospitalized patients revealing 60% of bedrest episodes had no documented medical indication, and 33% of patients had involuntary bedrest ordered.[4] Pedersen et al. used accelerometers to quantify mobility in a cohort of older medical patients and found that they spent a median of 17 hours/day in a sedentary position.[18] In contrast, our study found that older adults with acute cardiovascular disease spent an average of 21.6 hours in a sedentary position despite participation in a mobility program. The

increased average sedentary time in our study may reflect a more acutely ill cohort, the nature of people with acute CV disease, or, less likely, inadequate opportunities for mobility. Our findings suggest that more is needed to be done within mobility programs to reduce the amount of sedentary time in older adults with acute CV disease. Increased time spent in bedrest during hospitalization has been associated with an increased risk of hospital-associated pneumonia, lower cardiac output, a longer hospital length of stay, and increased likelihood of institutionalization.[1, 4] Low mobility during acute hospitalization is associated with a decline in the ability to perform activities of daily living and greater functional decline following hospital discharge.[7] In-hospital deconditioning puts patients at greater risk for falls during and following hospitalization, which can prolong length of stay, affect discharge location, and lead to readmission.[5]

Health care providers may emphasize treatment of the acute illness that burden patients at the expense of the in-hospital stressors of low immobility and increased sedentary time.[5] These stressors can decompensate patients, leading to a transient period of vulnerability in the 30-day period following hospital discharge, known as posthospitalization syndrome.[5] Addressing the immobility of patients during their hospital stay by reducing sedentary time has the potential to mediate this contributor to posthospitalization syndrome and improve functional outcomes. A recent study by Baldwin observing 40 adults requiring mechanical ventilation in the intensive care unit reported better physical function and muscle strength in patients that spent increased time sitting upright and sit to stand, had longer sessions of upright bouts, and decreased time sitting. [19] In a cohort of 100 hospitalized older medical patients, Brown and colleagues found that addressing mobility barriers and assistance with ambulation twice daily prevented loss of community mobility 1 month following hospital discharge.[7] Moreover, with each 10% increase

in hospital lying time, Floegel et al. observed an associated 0.7 second longer time required to complete a timed-up and go test for patients at 30 days, while an additional 1000 steps/day was associated with a higher short-performance battery score at 30 days.[20]

Given that posthospitalization syndrome leaves patients physically deconditioned and ill prepared to mitigate the stressors posthospitalization, describing in-hospital sedentary time of older adults with cardiovascular disease is a relevant metric to assess. There are also limited data on the association between in-hospital sedentary time and post-hospitalization person-centered outcomes. Our study found that the percentage of sedentary time was predictive of 1-month post-hospitalization HRQOL. This indicates that patients that spend more time in the lying or sitting position during their acute hospitalization were more likely to have worse self-reported HRQOL at 1 month following their hospital discharge.

Interventions to decrease the percentage of sedentary time present a clinically relevant and modifiable target for improving post-discharge HRQOL. Care programs designed to promote mobility during acute care hospitalization may prevent the persistent functional impairment many patients experience after discharge. In a general medical inpatient cohort, Hoyer and colleagues reported that a mobility intervention improved mobility status and reduced hospital length of stay.[21] The improvement in mobility status was sustained 4 months following completion of the mobility intervention.[21] EM has also been shown to be safe, feasible and effective in older adults with acute cardiovascular disease.[22] In addition to reducing in hospital sedentary time, EM may also improve mood and cognitive outcomes, as well as reduce the functional decline associated with posthospitalization syndrome.[23] However, the bulk of the current evidence base for mobility programs is for mechanically ventilated patients in critical care units. There is a need for studies exploring the role of mobility intervention delivery in

acute, but non-critically ill populations, such as in acute cardiovascular care. Future randomized clinical studies can be used to ascertain the effectiveness of an EM program at decreasing sedentary time and measuring important post-hospitalization clinical and patient-centered outcomes in older adults with acute cardiovascular disease.

There are a few limitations for this study. First, the small sample size and single-site nature of the study reduces the generalizability to other healthcare regions and settings. Second, all patients enrolled in this study had received the EM program and no control group exists. Thus, whether an EM program, compared to usual mobility care, decreases the time spent in a sedentary position cannot be determined from the current study. The type of mobility intervention offered (i.e., one vs three sessions per day; family member involvement) also may impact the amount of time spent in sedentary positions. These evidence gaps should be explored in future studies.

*Conclusion*

Older adults with acute cardiovascular disease remain sedentary for a large portion of their stay in the CICU. Increased sedentary time was associated with poor post-hospital HRQOL at 1-month. Future studies are required to determine whether a interventional programs designed to promote mobility and decrease bedrest impact sedentary time during hospital stay, promote posthospital HRQOL and improve functional status.

**Declarations.**

*Ethics Approval and Consent to Participate*

This study had been reviewed and approved by the Research Ethics Board of the Jewish General Hospital. All participating subjects had provided explicit written informed consent. All methods were carried out in accordance to relevant guidelines and regulations.

*Consent for Publication*

Any details regarding patient data were obtained with explicit written informed consent. There is no identifying patient information published in this study. All identifying information was coded and kept strictly confidential to other parties except the investigators and delegates. Participating subjects were informed upon consent that they will not be identified in any publication of this study.

*Availability of Data and Materials*

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

*Competing Interests*

*The authors declare that they have no competing interests.*

*Funding*

H.M. had been supported by a grant by the Fonds de Recherche du Québec – Santé (FRQS) (Grant: 292023). No other competing funding interests exist.

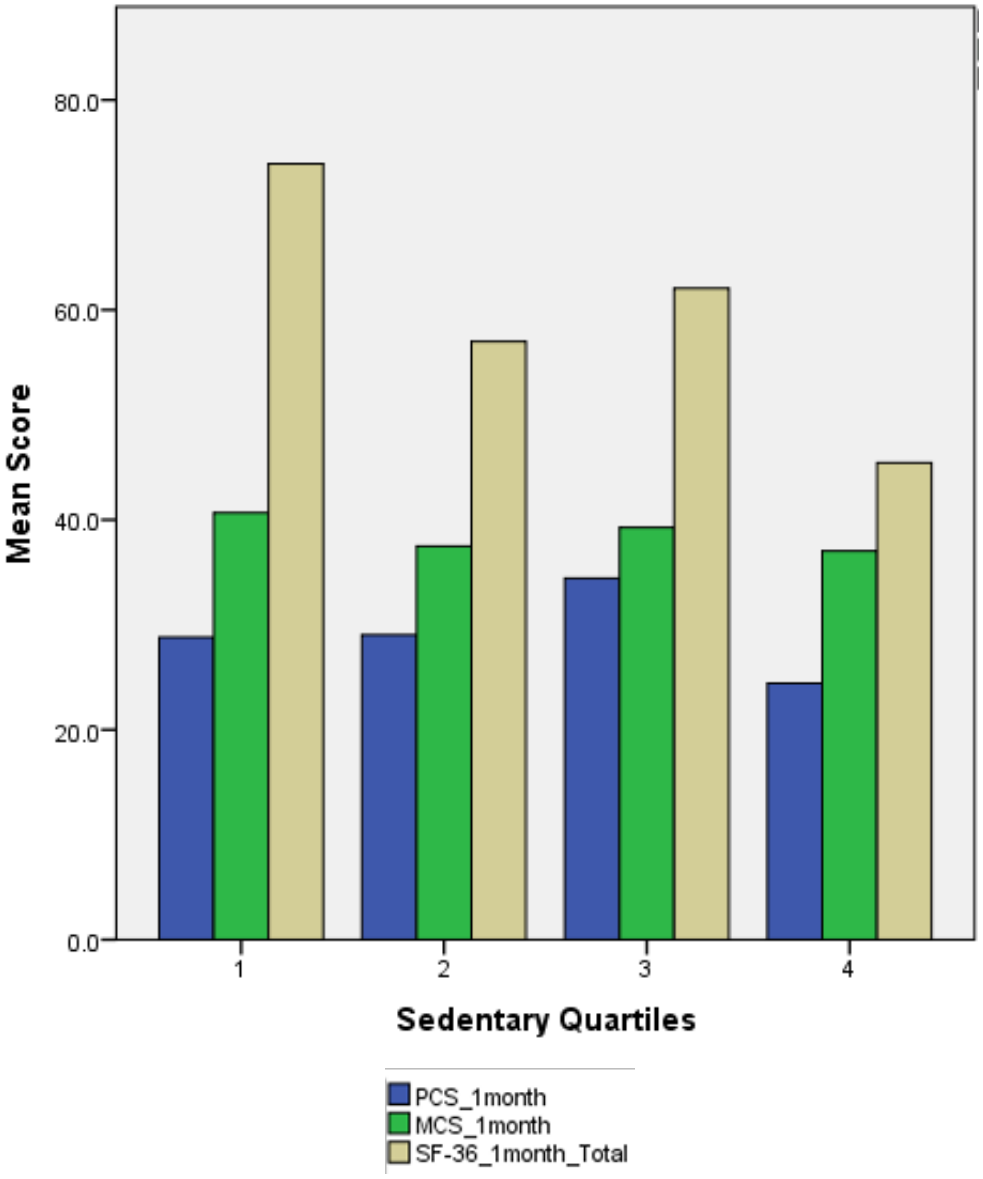
*Authors' Contribution*

H.M. and M.G. were involved in writing the original draft, reviewing & editing, investigation and formal data analysis. H.M. was involved in data curation and preparation of all figures and tables. M.G. was involved in study conceptualization, methodology, validation and supervision. All authors reviewed the manuscript and approved of the final version.

*Acknowledgements*

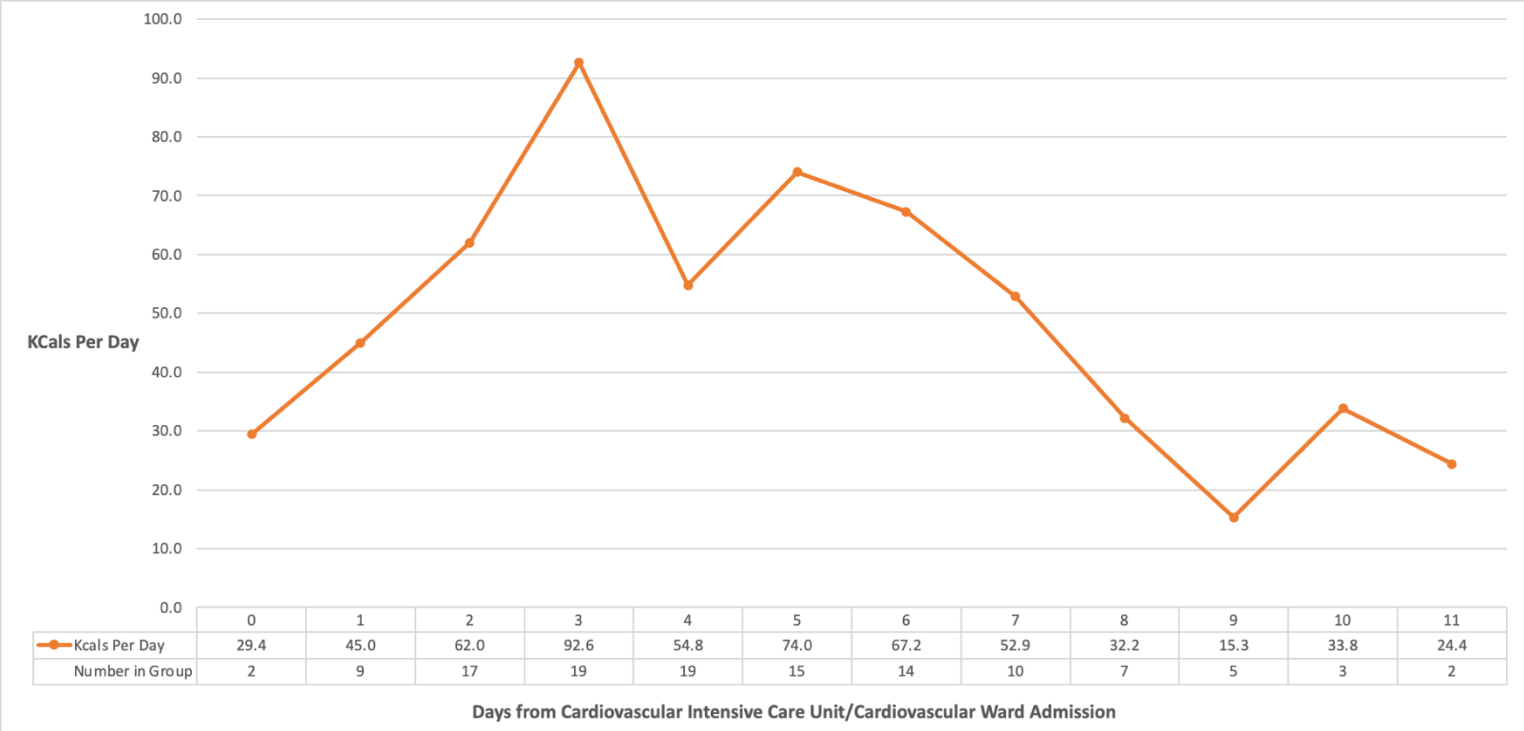
We would like to thank the Early Mobilization Team of the Cardiovascular Unit at the Jewish General Hospital for their time and efforts in helping conduct this study.

**Figure S1**. Mean Scores by Quartile




P-value for comparison of total SF-36 score in **1st vs. 4th quartile**

**Figure S2.** Kcal Per Day Consumption During Unit Stay




| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Kcals Per Day | 29.4 | 45.0 | 62.0 | 92.6 | 54.8 | 74.0 | 67.2 | 52.9 | 32.2 | 15.3 | 33.8 | 24.4 |
| Number in Group | 2 | 9 | 17 | 19 | 19 | 15 | 14 | 10 | 7 | 5 | 3 | 2 |

References

1. Brown CJ, Redden DT, Flood KL and Allman RM. The underrecognized epidemic of low mobility during hospitalization of older adults. *Journal of the American Geriatrics Society*. 2009;57:1660-1665.
2. Cortes OL, DiCenso A and McKelvie R. Mobilization patterns of patients after an acute myocardial infarction: a pilot study. *Clinical nursing research*. 2015;24:139-55.
3. Dubb R, Nydahl P, Hermes C, Schwabbauer N, Toonstra A, Parker AM, Kaltwasser A and Needham DM. Barriers and strategies for early mobilization of patients in intensive care units. *Annals of the American Thoracic Society*. 2016;13:724-730.
4. Brown CJ, Friedkin RJ and Inouye SK. Prevalence and outcomes of low mobility in hospitalized older patients. *Journal of the American Geriatrics Society*. 2004;52:1263-1270.
5. Krumholz HM. Post-hospital syndrome–a condition of generalized risk. *The New England journal of medicine*. 2013;368:100.
6. English KL and Paddon-Jones D. Protecting muscle mass and function in older adults during bed rest. *Current opinion in clinical nutrition and metabolic care*. 2010;13:34.
7. Brown CJ, Foley KT, Lowman Jr JD, MacLennan PA, Razjouyan J, Najafi B, Locher J, Allman RM and Lowman JD, Jr. Comparison of Posthospitalization Function and Community Mobility in Hospital Mobility Program and Usual Care Patients: A Randomized Clinical Trial. *JAMA Internal Medicine*. 2016;176:921-927.
8. Adler J and Malone D. Early Mobilization in the Intensive Care Unit: A Systematic Review. *Cardiopulmonary Physical Therapy Journal*. 2012;23:5-13.
9. Covinsky KE, Palmer RM, Fortinsky RH, Counsell SR, Stewart AL, Kresevic D, Burant CJ and Landefeld CS. Loss of independence in activities of daily living in older adults hospitalized with medical illnesses: increased vulnerability with age. *Journal of the American Geriatrics Society*. 2003;51:451-458.
10. Anderson J, Green A, Hall H and Yoward S. Criterion validity of an ankle or waist mounted Actigraph GT3X accelerometer in measurement of body position and step count. *Physiotherapy*. 2016;102 (Supplement 1):e79-e80.
11. Anderson JL, Green AJ, Yoward LS and Hall HK. Validity and reliability of accelerometry in identification of lying, sitting, standing or purposeful activity in adult hospital inpatients recovering from acute or critical illness: a systematic review. *Clinical rehabilitation*. 2018;32:233-242.
12. Dima D, Valiquette J, Berube-Dufour J and Goldfarb M. Level of function mobility scale for nurse-driven early mobilisation in people with acute cardiovascular disease. *J Clin Nurs*. 2020;29:778-784.
13. Semsar-Kazerooni K, Dima D, Valiquette J, Berube-Dufour J and Goldfarb M. Early Mobilization in People With Acute Cardiovascular Disease. *Can J Cardiol*. 2020.
14. McHorney CA, Ware Jr JE and Raczek AE. The MOS 36-Item Short-Form Health Survey (SF-36): II. Psychometric and clinical tests of validity in measuring physical and mental health constructs. *Medical care*. 1993:247-263.
15. Hopman WM, Towheed T, Anastassiades T, Tenenhouse A, Poliquin S, Berger C, Joseph L, Brown JP, Murray TM and Adachi JD. Canadian normative data for the SF-36 health survey. *Cmaj*. 2000;163:265-271.
16. Stadnyk K, Calder J and Rockwood K. Testing the measurement properties of the Short Form-36 Health Survey in a frail elderly population. *Journal of Clinical Epidemiology*. 1998;51:827-835.

17. Pfister T, Matthews CE, Wang Q, Kopciuk KA, Courneya K and Friedenreich C. Comparison of two accelerometers for measuring physical activity and sedentary behaviour. *BMJ Open Sport & Exercise Medicine*. 2017;3:e000227.
18. Pedersen MM, Bodilsen AC, Petersen J, Beyer N, Andersen O, Lawson-Smith L, Kehlet H and Bandholm T. Twenty-four-hour mobility during acute hospitalization in older medical patients. *J Gerontol A Biol Sci Med Sci*. 2013;68:331-7.
19. Baldwin CE, Rowlands AV, Fraysse F and Johnston KN. The sedentary behaviour and physical activity patterns of survivors of a critical illness over their acute hospitalisation: An observational study. *Aust Crit Care*. 2020;33:272-280.
20. Floegel TA, Dickinson JM, DerAnanian C, McCarthy M, Hooker SP and Buman MP. Association of posture and ambulation with function 30 days after hospital discharge in older Adults with heart failure. *Journal of cardiac failure*. 2018;24:126-130.
21. Hoyer EH, Friedman M, Lavezza A, Wagner-Kosmakos K, Lewis-Cherry R, Skolnik JL, Byers SP, Atanelov L, Colantuoni E, Brotman DJ and Needham DM. Promoting mobility and reducing length of stay in hospitalized general medicine patients: A quality-improvement project. *Journal of Hospital Medicine*. 2016;11:341-347.
22. Dima D, Valiquette J, Berube-Dufour J and Goldfarb M. Level of function mobility scale for nurse-driven early mobilisation in people with acute cardiovascular disease. *Journal of Clinical Nursing*. 2020;29:778-784.
23. Martínez-Velilla N, Casas-Herrero A, Zambom-Ferraresi F, de Asteasu MLS, Lucia A, Galbete A, García-Baztán A, Alonso-Renedo J, González-Glaría B and Gonzalo-Lázaro M. Effect of exercise intervention on functional decline in very elderly patients during acute hospitalization: a randomized clinical trial. *JAMA internal medicine*. 2019;179:28-36.

## Chapter 7: Transition from Cohort Study 1 to Cohort Study 2

The primary finding of cohort study 1 is that older adults spend an overwhelming majority of their hospital stay in the CICU and cardiovascular ward in sedentary positions. Other studies have similarly found that older adults with CVD spend more time in bedrest than general medicine patients.[17, 35, 36] Moreover, an important relationship was observed between sedentary time percentage and HRQOL: a higher sedentary percentage was associated with lower HRQOL at 1-month. Improving the percentage of sedentary time is a potentially modifiable target, which may then improve posthospitalization HRQOL. Identification of people with higher sedentary time may also provide clinicians with knowledge of a particularly vulnerable patient population that may benefit from EM.

Increasing daily step counts and reducing time spent in bed may benefit posthospital physical function of older adults. A study by Floegel et. al. of 27 older patients with heart failure noted that each additional 1000 steps per day resulted in a near one-point increase in physical performance battery tests one month following discharge.[37] This group also noted for every 10% increase in time spent in bed, patients spent 0.7 seconds longer completing sit-to-stand performance tests.[37] Structured EM care programs may also improve person-centered outcomes, such as HRQOL. A randomized clinical trial by Asgari, M et al. in 2014 involving 38 patients with acute MI found that EM was significantly effective in reducing depression, noting a 5 point reduction in the hospital anxiety and depression scale between the intervention and control group ($P<0.001$).[38] A meta-analysis done by Okada et.al. of 11 randomized clinical trials showed significant differences in HRQOL at 6 months between critically ill patients mobilized early within 1 week of ICU admission, compared to usual care, reporting a pooled difference of nearly 5 points in SF-36 physical functioning scores. People that underwent an EM program also spent

an average of 1.5 days less in the ICU, and nearly 3 days less in the hospital compared to patients that did not undergo an EM program.[39] This meta-analysis provides evidence of the clinical and HRQOL benefits for critically ill patients undergoing a structured EM care program. However, these studies were primarily in critically ill patients and not in older adults, nor in people with acute CVD.[40]

Concurrent to the acute illness afflicting patients, the physical burden of prolonged bedrest contributes to decreased cardiac reserve, orthostatic hypertension and venous thromboembolism.[41] These clinical implications of prolonged bedrest may be amplified in patients with acute CVD, who in addition to their acute illness, are burdened with the cardiovascular effects of bedrest. Cohort study 1 aimed to describe sedentary time in patients with acute CVD, providing a snapshot of the mobility patterns of this population during recovery in the CICU or cardiovascular ward. With patients spending over 90% of their stay sedentary, one can only infer from the literature of the cardiovascular implications of this inactivity during recovery. The next research questions involved assessing whether an EM program is safe and feasible in this population and to describe the post-hospitalization HRQOL. The hypothesis was an association may be demonstrated between HRQOL and a structured EM program in this patient population. Moreover, we anticipated this population having lower HRQOL overall compared to age-matched norms given their acute CVD. Thus, cohort study 2 aims to examine the HRQOL 1 and 12-months post hospital discharge of acute CVD disease patients undergoing a structured EM care program. A total of 147 patients aged ≥ 60 years from the EM cohort were prospectively enrolled in this study from January 2018 to January 2020. Patients underwent the EM program currently in place in the CICU and cardiovascular ward at the Jewish General Hospital, an academic tertiary care center in Montreal, Quebec. HRQOL was ascertained through

the Short-Form 36 (SF-36) questionnaire at 1 and 12-months following hospital discharge. The results of our study describing HRQOL in older adults with acute CVD undergoing the EM program is presented in the following chapter.

## Chapter 8: Cohort Study 2: Published Manuscript

### "Health-Related Quality of Life in Older Adults with Acute Cardiovascular Disease undergoing Early Mobilization"

Our prospective study describing the health-related quality of life of older adults with acute cardiovascular disease undergoing a structured EM care program is presented as a manuscript below.

This study was presented as an abstract at the Canadian Cardiovascular Congress on October 21-24, 2020. This manuscript was published in the Canadian Journal of Cardiology (Open) on February 28, 2021.

**Health-Related Quality of Life in Older Adults with Acute Cardiovascular Disease Undergoing Early Mobilization**

Haroon Munir, BSc,[a] José A. Morais, MD[b], Michael Goldfarb, MD, MSc[c]

[a] Division of Experimental Medicine, McGill University, Montreal, QC, Canada

[b] Division of Geriatric Medicine, Jewish General Hospital, McGill University, Montreal, QC

[c] Division of Cardiology, Jewish General Hospital, McGill University, Montreal, QC, Canada

**Short Title: HRQOL in Older Adults with Acute CVD Undergoing EM**

Word count: 5082

Tables: 3

Figures: 2

Corresponding author:

Michael Goldfarb, MD, MSc

Assistant Professor of Medicine, McGill University

Director of Quality of Care and Safety

Division of Cardiology, Jewish General Hospital

3755 Cote Ste Catherine Road, Office E-212, Montreal, QC, Canada H3T 1E2

Tel: (514) 340-8222 ext 25801 | Fax: (514) 340-7534 | Email: michael.j.goldfarb@mcgill.ca

**Background**

Early mobilization (EM) is safe and feasible in older adults with acute cardiovascular disease (CVD) and may improve post-hospitalization patient-centred outcomes. Our objective was to assess post-hospitalization health-related quality of life (HRQOL) in older adults with acute CVD undergoing EM.

**Methods**

Patients ≥60 years old with acute CVD undergoing EM at an academic tertiary centre in Montreal, Quebec were prospectively enrolled from January 2018 to January 2020. Functional status was measured using the validated Level of Function Mobility Scale. HRQOL was measured using the Short-Form 36 (SF-36) questionnaire 1- and 12-months post-hospitalization. The primary outcome was the SF-36 physical component summary (PCS) score 1-month post-hospitalization.

**Results**

There were 147 patients included in the analysis (75.0±8.7 years old; 44.6% female; 48.6% ischemic heart disease). The mean 1-month PCS score was 34.7±9.7, which was 11.5 points and 8.4 points lower compared to age-matched Canadian normative data for people between 65-74 years old and ≥75 years old, respectively. The mean PCS score at 12-months (36.5±9.2) and the mean mental component summary scores at 1- and 12-months (36.9±11.1; 40.5±11.5) were lower than the age-matched population (all $P<0.0001$). In the multivariable analysis, increased age and worse prehospital function were associated with lower PCS at 1-month.

## Conclusion

Older adults with acute CVD had lower HRQOL 1- and 12-months post-hospitalization than age-matched Canadian norms. Prehospital functional status was predictive of poor post-hospitalization HRQOL. The EM program was safe and feasible in this patient population. Further studies are needed to determine whether EM can improve post-hospitalization patient-centred outcomes in older adults, particularly those with poor prehospital functional status.

**Brief Summary**

Early mobilization (EM) is safe and feasible in older adults with acute cardiovascular disease (CVD) and may improve post-hospitalization patient-centred outcomes. We assessed post-hospitalization health-related quality of life (HRQOL) using the Short-Form 36 questionnaire 1-and 12-months post-hospitalization in 147 patients ≥60 years old with acute CVD undergoing EM. Patients had lower HRQOL 1- and 12-months post-hospitalization than age-matched Canadian norms. Prehospital functional status was predictive of poor post-hospitalization HRQOL.

## Introduction

Older adults are at risk of posthospital syndrome following hospitalization for acute cardiovascular disease.[1] Posthospital syndrome is characterized by a period of increased vulnerability to physical, cognitive, and emotional stressors, and is associated with an increased risk of hospital readmission.[1, 2] Involuntary bedrest and immobility during hospitalization can lead to a rapid loss of muscle mass and strength, which in turn leads to a functional decline that can persist well-beyond hospitalization.[2-4]

Early mobilization (EM) consists of progressively ambulating patients as soon as they are hemodynamically stable, typically within 24 to 48 hours of hospital admission.[5] Nurse-driven EM has been shown to be feasible and effective in people with older adults with acute cardiovascular disease (CVD) and provides early physical rehabilitation that may prevent the physical deconditioning found in posthospital syndrome.[6] Physical activity may also improve posthospitalization mood and cognitive outcomes.[7]

Older adults may prioritize functional independence and quality of life measures over other more standard outcome measures.[8] Geriatric professional societies have responded by advocating for the use of person-centred outcomes in studies involving older adults.[9] Assessment of person-centered outcomes, such as health-related quality of life (HRQOL), can provide insight on the effect of interventions upon patient care, provide evidence-based decision making in the care of older adults, and influence practice guidelines for future patient care.[10]

There are limited data on posthospital HRQOL in older adults with acute cardiovascular disease. Moreover, although the feasibility and efficacy of a nurse-driven EM in older adults has been established, the association of EM and posthospital HRQOL in older adults with acute cardiovascular disease has yet to be explored. Thus, our objective was to assess

posthospitalization HRQOL in older adults with acute cardiovascular disease undergoing EM. Data obtained from this study can inform future studies to assess whether EM interventions can improve posthospital outcomes for older adults with acute cardiovascular disease.

## Methods

### *Study Design, Participants and Setting*

Patients aged ≥60 years admitted to the cardiovascular intensive care unit (CICU) or the cardiovascular ward were prospectively enrolled at the Jewish General Hospital, an academic tertiary care centre in Montreal, Quebec, from January 1, 2018 to January 31, 2020. Exclusion criteria were projected CICU length of stay less than 24 hours, undergoing cardiac surgery during index hospitalization, and very poor prehospital functional status (as defined by a Level of Function 0, 1 or 2). The study was registered at ClinicalTrials.gov (NCT03616873).

### *The Early Mobility Program*

The EM program is a nurse-driven, structured care program initiated on admission to the CICU. The EM program for acute cardiac care has been previously described.[6] The objective of the EM program is to prevent in-hospital deconditioning by progressively mobilizing patients as soon as hemodynamic stabilization has occurred, typically within 24 to 48 hours following unit admission. Patient are considered hemodynamically stable if they do not meet any of the hemodynamic or respiratory exclusion criteria for mobilization. The EM program uses the validated Level of Function (LOF) scale to assess the patient's maximal functional capacity to guide tailored mobilization activities.[6] The LOF score ranges from 0 (maintain range of motion) to 5 (increase general endurance and mobility). Bedside nurses assess the LOF score on unit

arrival and then subsequently twice daily (morning and evening shift) and administer three level-specific activities per shift. Nurses also determine the prehospital LOF at the time of admission based on patient and/or corollary history from family members. Nurses may also instruct willing family members on how to perform the mobilization activities with their relatives. During each shift, the bedside nurse documents the LOF, contraindications to mobilization, activities performed, and adverse events. Patients are excluded from mobilization during that nursing shift if they meet any of the following contraindications. Contraindications to mobilization include device-related (femoral sheaths, intra-aortic balloon pumps, transvenous pacemakers), hemodynamic (systolic blood pressure less than 90mmHg or more than 200mmHg, active ischemia, uncontrolled arrhythmia, increasing vasoactive medication needs), respiratory (rate less than 10 or more than 35 breaths per minute, and fraction of inspired oxygen more than 60%), and neurological (seizures within 24 hours) criteria.

*Study Variables and Outcome Measures*

Covariates of interest included age, sex, primary admission diagnosis, length of CICU and hospital stay, LOF scores at 3 intervals (pre-hospital, hospital admission, and CICU discharge). The primary outcome of interest was the physical component summary (PCS) Short-Form 36 (SF-36) score at 1-month post-hospital discharge. Secondary outcomes were total SF-36 scores at 1- and 12-months, SF-36 PCS at 12-months, SF-36 mental component summary (MCS) scores at 1- and 12-months. Other outcomes of interest were SF-36 subsection scores at 1- and 12-months, mortality in-hospital and at 1- and 12-months, hospital readmission at 1-month, and discharge destination.

*Study Instrument*

**Description of Short Form-36 Scale**

The Short-Form 36 (SF-36) Health Survey is a patient-reported 36 item questionnaire of HRQOL.[11] Physical and mental summary components are scored from 0-100.[11] Low scores indicate high disability with a mean score of 50 standardized to Canadian normative values.[12] Data on patient physical and mental health is stratified across 8 domains: vitality, physical functioning, bodily pain, general health perceptions, physical role functioning, emotional role functioning, social role functioning, and mental health.[11] The SF-36 is the most widely used HRQOL instrument, is easy to administer in-person and by telephone, and has shown to be valid and reliable in elderly populations.[13]

*Data Collection*

For each subject the following data were obtained from the electronic medical record: age, sex, primary admission diagnosis, length of CICU and hospital stay, discharge location, vital status at discharge, mobility assessments (LOF scores, contraindications, activities completed, and adverse events). Acute cardiovascular disease was operationalized with the following primary admission diagnoses and International Statistical Classification of Diseases and Related Health Problems (ICD Codes): Ischemic heart disease (ICD I20- I25), Heart failure (ICD I50), Arrhythmia (ICDs I47.0, I47.1, I47.2, I47.9, I48.0, I49.0 - I49.5, I49.8, I49.9), Valvular disease (ICDs I33-39. I34.x, I37.x, I05.x, I08.x, I09.9, T82.0) or Other (all other I-codes). Severity of disease burden was assessed using the diagnostic-related group (DRG) coding system, which determines severity of disease burden based on age, admission diagnosis and medical comorbidities, rated from 0 (least severe) to 4 (most severe). Discharge destinations were

categorized as home, rehabilitation facility or acute care hospital, or a long-term care facility. Patients were contacted by a member of the research team at 1- and 12-months after hospital discharge by telephone to assess HRQOL with the SF-36 Health Survey and to ascertain vital status.

*Data Analysis*

Continuous data are presented as mean ± standard deviation with differences between groups tested using the student's t-test. Categorical data are reported as frequencies and percentages and were compared using the chi-squared test or the Fisher exact test, as appropriate. PCS and MCS scores were calculated from subscale scores for comparison against the general population (considered to have a mean of 50 and standard deviation of 10) using Canadian normative data and the methodology described by Taft et al.[12, 14] Continuous data was compared to Canadian normative data using the student's t test on the GraphPad QuickCalcs Web site: https://www.graphpad.com/quickcalcs/ttest1.cfm (accessed April 2020). The minimally clinically important difference in PCS score is 3 points.[15] A linear multivariable regression model was used to evaluate the relationship between the PCS score at 1-month (a continuous variable) and predictor variables of interest (age, sex, admission diagnoses, and mobility levels). Multiple imputation was used to account for missing 1-month SF-36 scores. A P-value of ≤0.05 was considered to be statistically significant. Data was analyzed using the statistical software SPSS 24.0 (Armonk, New York: IBM Corp.) and STATA/SE 16 (College Station, Texas: StataCrop LLC). Institutional research ethics approval was obtained for this study. All subjects signed an informed consent form prior to participation in the study.

## Results

*Cohort Characteristics*

A total of 147 patients were included in the study, 116 of which with 1-month SF-36 data, and 104 with 1 and 12-month SF-36 data (**Figure 1**). The mean age was 75.0 ± 8.7 years old and 66 (44.6%) were female (**Table 1**). The most common primary admission diagnoses were ischemic heart disease (N=72; 48.6%), heart failure (N=19; 12.8%), and arrhythmia (N=22; 14.8%). The mean length of stay in the CICU was 3.4 ± 3.4 days and total hospital length of stay was 11.0 ± 7.0 days. One-fifth of patients (N=27; 20.3%) had contraindications to mobility at some point during hospitalization; all of these patients were eventually mobilized. Patients were mobilized during 93% (655/703) of mobility opportunities and 87% (1,835/2,109) of prescribed mobility activities were completed. Mean LOF of patients was 4.7 ± 0.5 pre-hospital, 3.4 ± 1.3 on admission, and 4.3 ± 0.9 on CICU discharge. There were 8 adverse events during mobilization out of 1,835 mobility activities (adverse event rate = 0.4%; dyspnea/tachypnea/desaturation, N=4; tachyarrhythmia, N=3; chest pain, N=1), all of which were transient and none that affected clinical management.

*Outcomes*

For the primary outcome, the mean 1-month PCS score for patients was 34.7±9.7. (**Figure 2**; **Table 2**). For the secondary outcomes, the mean total SF-36 score was 60.4 ± 21.9 at 1-month and 69.3 ± 21.7 at 12-months, the mean PCS score was 36.5 ± 9.2 at 12-months, and the mean MCS score was 36.9 ± 11.1 at 1-month and 40.5 ± 11.5 at 12-months.

The discharge location was home (N=122; 82.4%), acute care facility or rehabilitation center (N=14; 9.5%), and long-term care facility (N=3; 2.0%; Table 2). There were 9 patients who died in-hospital, 6 patients at 1-month, and 4 patients at 12-months. There were 10 patients (6.8%) readmitted at 1-month.

In the multivariable analysis, age and prehospital LOF were predictive of PCS at 1-month (**Table 3;** $p<0.05$). When patients only aged ≥ 75 years old were included (N=78), the PCS score at 1-month was 33.6 ± 10.4, compared to 42.0 in the age-matched normative data ($P<0.0001$; **Supplementary Table S1**). Patients with a prehospital LOF ≤ 4 had lower PCS and MCS scores at 1- and 12-months compared to age-matched normative data. Patients with a prehospital LOF ≤ 4 had lower PCS scores at 1- and 12-months, but no difference in the MCS at 1- and 12-months, compared to patients with prehospital LOF 5 (**Supplementary Table S2**).

During CICU admission, there were 69 (46.9%) patients with improved functional status, 70 (47.6%) who maintained the same function, and 2 (1.4%) with worsened function (**Supplementary Figure S1**). There were 81 (55.1%) patients who recovered to at least their prehospital level of function by CICU discharge. Patients who recovered their prehospital LOF by CICU discharge, as compared to those who did not, had no difference in their PCS score at 1-month (36.4 ± 7.9 vs. 33.1 ± 11.6, P=0.09). This remained true for PCS scores at 12-months for patients that recovered their pre-hospital LOF compared to those that did not (37.1 ± 8.0 vs. 35.9 ± 11.0, P=0.6). One- and 12-month MCS scores did not differ significantly either in those recovering to pre-hospital LOF: 1-month scores in those recovering to pre-hospital LOF compared to those not recovering was 36.3 ± 10.5 vs. 38.2 ± 11.7 (P=0.4), respectively, and 12-month scores in those recovering to pre-hospital LOF compared to those not recovering was 41.8 ± 10.9 vs. 39.4 ± 12.3 (P=0.4), respectively. There were no significant differences by primary

admission diagnosis in the mean PCS score at 1- or 12-months (**Supplementary Table S3**; P=0.48; P=0.62; respectively) or in the mean MCS score at 1- or 12-months (P=0.65; P=0.23; respectively). There was no difference by DRG group for PCS score at 1- or 12-month (P=0.65; P=0.26; respectively).

## Discussion

### *Key Findings*

The study found that a heterogenous group of acute CVD patients with diagnoses ranging from ischemic heart disease to valvular heart disease had much poorer physical and mental HRQOL at 1- and 12-months compared to age-matched population norms. The nurse-driven EM program in the CICU was feasible with more than 9 out of 10 mobility opportunities resulting in a mobility activity and with a similar percentage of mobility activities completed. The EM program was also safe with a low rate of adverse events and no major or life-threatening events. More than 80% of patients were discharged home and about 1 in 14 patients (7.1%) were readmitted within 30 days, which nears half of the expected readmissions among older adults in this population.[16] Patients' functional status improved from admission towards prehospital functional levels. Importantly, a relationship between prehospital functional status and posthospital HRQOL was observed; older patients with worse prehospital functional status were at higher risk for decreased HRQOL following hospitalization.

### *Early Mobility and Posthospital Syndrome*

Posthospitalization syndrome consists of a decline in patient ability to perform activities of daily living, an increased vulnerability to stressors, and decreased likelihood of successful recovery following discharge.[17] Healthcare providers and healthcare systems often primarily

focus upon the patient's acute illness and place less emphasis upon managing the stressors that accompany hospitalization, which include disturbances of circadian rhythm, bedrest leading to loss of muscle mass and strength, and depletion of physiological reserves that impair optimal patient recovery.[1] Ultimately, many patients are left in a decompensated state following hospital discharge, placing them at risk for further disability.[17] Patients may experience an inability to fulfill previously completed activities of daily living, along with experiencing further physical and cognitive functional decline.[1, 17, 18] Mobilizing patients, particularly early in their hospital course once hemodynamic and respiratory stability has been achieved, may combat the immobility and prolonged bedrest that is a primary contributor to posthospital syndrome. EM has been previously shown to be safe and feasible in people with acute cardiovascular disease and is associated with lower rates of discharge to healthcare institutions (i.e., rehabilitation, long term care facilities).[19, 20] Our current study similarly found that EM was safe and feasible. Adverse events were rare (0.4% of mobility activities), transient, and not clinically relevant. In addition, about one-fifth of patients had contraindications to mobilization during hospitalization and all of these patients were eventually able to be mobilized. However, a recent survey of healthcare providers found that safety concerns were a considerable barrier towards EM.[21] Physicians had much higher barriers to mobilization than nurses or physiotherapists in terms of beliefs, knowledge and attitudes towards mobilization. Other important provider barriers to mobilization include need for physician orders, inadequate staffing, and provider time restraints. For EM program implementation, efforts are needed to address these barriers.

Older adults are a patient population that is particularly susceptible to posthospitalization syndrome, especially in the physical domain of HRQOL. We found that the 1-month PCS scores for adults over age 75 in our cohort to be 7.3 points lower than the Canadian population age-

matched norm, which is greater than the minimally clinically important difference of 3 points.[15] Notably, the 1-month PCS scores obtained in this study were with an established nurse-driven EM program intervention in place and there was no comparator group. It is possible that the 1-month PCS scores could be worse without an EM program in place. Other studies have similarly showed that critically ill patients have lower posthospitalization PCS scores compared to population norms. A study in Germany following intensive care stay found that 1-month PCS scores were 10.3 points lower compared to population norms.[22] Future studies should explore whether an EM intervention improves posthospitalization functional and HRQOL outcomes. Within specific HRQOL domains, there are several important observations to note. Mental health and social functioning scores were lower than age-matched norms up to 12-months post-discharge (**Figure 2**). Emotional health was also lower shortly after discharge but was similar at 12-month follow-up. Indeed, there was a more of a marked difference in MCS than PCS scores. This underscores the importance of addressing the mental and emotional needs of older adults with acute cardiovascular disease.

*Predictors of Poor Posthospital Health-related Quality of Life*

We found that low prehospital LOF scores were associated with poorer HRQOL posthospitalization outcomes. Prehospital LOF was determined based on intake history from the patient and/or family member by the bedside nurse on admission. Thus, this suggests that an easy to perform functional history on admission can help to identify patients who have poorer functional status following hospital discharge. Patients at higher risk of poor longer-term outcomes may particularly benefit from earlier mobilization and focus on maintaining or improving functional capabilities during hospital stay. A study on EM in older adults in an

American quaternary care CICU found that mobilization was associated with improved functional status regardless of frailty status or initial functional status on admission.[5] Frail older adults had lower prehospital, admission and discharge functional status than the non-frail older adults, but both groups had similar overall improvements in functional status.

There is also likely a role for other interdisciplinary interventions to improve outcomes in people with poorer prehospital functional status (i.e., dietician, pharmacy, social work, specialized geriatric consultations) during acute cardiovascular admission. Care structures in the early posthospitalization period may also be of benefit to patients identified with poor prehospital function. Early post-discharge nursing or physician visits may identify issues and decrease emergency department visits and readmissions.[23] Cardiac rehabilitation has been shown to improve the quality of life and functional capabilities for people with coronary disease.[24, 25] However, cardiac rehabilitation in some geographical regions is often underutilized resource for people.[26] In particular, older, frail, and people with poorer functional status are often under-referred to cardiac rehabilitation programs. Thus, early identification of older patients with poor baseline functional status may help to prioritize patients who may benefit from structured posthospitalization care such as cardiac rehabilitation.

While cardiovascular medicine studies traditionally have focused on “hard” outcomes, such as myocardial infarction and mortality, older adults may deem functional independence and quality of life just as important.[8, 9] However, there currently are a lack of studies incorporating these geriatric-focused measures. Thus, a stronger evidence base is needed to understand the impact of interventions on patient-centred outcomes in older people with acute CVD. Our study provides a baseline for posthospitalization HRQOL using the widely reported, validated SF-36 score. Further randomized studies are needed to assess whether interventions targeting older

adults with acute CVD can improve patient-centred outcome measures. Understanding functional and HRQOL outcomes could be a clinically useful tool as part of a shared decision-making approach to care decisions in older adults with acute CVD, as well as can influence societal guidelines and impact clinical practice.

There are limitations to our study. First, this was a single-centre study at an academic tertiary care hospital in Canada and our results may not be generalizable to other healthcare settings or regions. Second, all patients in our study underwent EM and there was no control group in our study. While participants in our study had lower HRQOL scores than age-matched peers in the population, it is possible that EM improved or had no impact on HRQOL outcomes. In addition, the age-matched normative dataset involved non-hospitalized individuals, as there was no published dataset of hospitalized patients available. Our data can be used as a baseline in future studies on whether EM can improve HRQOL outcomes. Third, objective measures of sarcopenia, a condition of low muscle mass and strength, were not assessed, and could be a potential confounder since they potentially impact functional status. Fourth, data on specific comorbid disease were not collected. Pre-existing comorbid illness may negatively impact prehospital functional status, mobilization participation, and posthospitalization HRQOL outcomes. However, DRGs, which include pre-existing comorbid illness, were included in the analysis. There was no difference in the primary outcome by DRG score. Fifth, the time of first mobilization relative to admission was not captured. Time to mobilization may be a predictor of posthospitalization functional and HRQOL outcomes and is potentially modifiable. Time to first mobilization could be assessed in future EM studies. Lastly, HRQOL scores were not available for all patients at 1-month due to study withdrawal, loss to follow-up, or death. It is possible that these patients may have been sicker with poorer longer-term HRQOL scores. We were able to

ascertain vital status from the electronic medical record and the majority of these patients were alive at the 12-month follow-up.

## Conclusion

In a heterogenous group of older acute cardiovascular patients, posthospital HRQOL outcomes were lower than age-matched population norms. An EM program was safe and feasible in this population. Further studies are needed to investigate the impact of EM delivery on posthospital HRQOL in older adults with CVD.

## Acknowledgements

We would like to thank the Early Mobilization Team of the Cardiovascular Unit at the Jewish General Hospital for their time and efforts in helping conduct this study.

## Disclosures

None.

## Funding

H.M. was supported by a grant by the Fonds de Recherche du Québec – Santé (FRQS) (Grant: 292023). No other competing funding interests exist.

**References**


1. Krumholz HM. Post-hospital syndrome–a condition of generalized risk. *The New England journal of medicine*. 2013;368:100.
2. Hoyer EH, Needham DM, Atanelov L, Knox B, Friedman M and Brotman DJ. Association of impaired functional status at hospital discharge and subsequent rehospitalization. *Journal of hospital medicine*. 2014;9:277-82.
3. Dolansky MA and Moore SM. Older adults' early disability following a cardiac event. *West J Nurs Res*. 2008;30:163-80.
4. Pavon JM, Sloane RJ, Pieper CF, Colón-Emeric CS, Cohen HJ, Gallagher D, Hall KS, Morey MC, McCarty M and Hastings SN. Accelerometer-Measured Hospital Physical Activity and Hospital-Acquired Disability in Older Adults. *Journal of the American Geriatrics Society*. 2019.
5. Goldfarb M, Afilalo J, Chan A, Herscovici R and Cercek B. Early mobility in frail and non-frail older adults admitted to the cardiovascular intensive care unit. *Journal of critical care*. 2018;47:9-14.
6. Dima D, Valiquette J, Berube-Dufour J and Goldfarb M. Level of function mobility scale for nurse-driven early mobilisation in people with acute cardiovascular disease. *J Clin Nurs*. 2020;29:778-784.
7. Martinez-Velilla N, Casas-Herrero A, Zambom-Ferraresi F, Saez de Asteasu ML, Lucia A, Galbete A, Garcia-Baztan A, Alonso-Renedo J, Gonzalez-Glaria B, Gonzalo-Lazaro M, Apezteguia Iraizoz I, Gutierrez-Valencia M, Rodriguez-Manas L and Izquierdo M. Effect of Exercise Intervention on Functional Decline in Very Elderly Patients During Acute Hospitalization: A Randomized Clinical Trial. *JAMA internal medicine*. 2019;179:28-36.
8. Forman DE, Rich MW, Alexander KP, Zieman S, Maurer MS, Najjar SS, Cleveland JC, Jr., Krumholz HM and Wenger NK. Cardiac care for older adults. Time for a new paradigm. *Journal of the American College of Cardiology*. 2011;57:1801-1810.
9. Forman DE, Arena R, Boxer R, Dolansky MA, Eng JJ, Fleg JL, Haykowsky M, Jahangir A, Kaminsky LA, Kitzman DW, Lewis EF, Myers J, Reeves GR, Shen WK, American Heart Association Council on Clinical C, Council on C, Stroke N, Council on Quality of C, Outcomes R and Stroke C. Prioritizing Functional Capacity as a Principal End Point for Therapies Oriented to Older Adults With Cardiovascular Disease: A Scientific Statement for Healthcare Professionals From the American Heart Association. *Circulation*. 2017;135:e894-e918.
10. Chang S, Newton PJ, Inglis S, Luckett T, Krum H, Macdonald P and Davidson PM. Are all outcomes in chronic heart failure rated equally? An argument for a patient-centred approach to outcome assessment. *Heart Failure Reviews*. 2014;19:153-162.
11. McHorney CA, Ware Jr JE and Raczek AE. The MOS 36-Item Short-Form Health Survey (SF-36): II. Psychometric and clinical tests of validity in measuring physical and mental health constructs. *Medical care*. 1993:247-263.
12. Hopman WM, Towheed T, Anastassiades T, Tenenhouse A, Poliquin S, Berger C, Joseph L, Brown JP, Murray TM, Adachi JD, Hanley DA and Papadimitropoulos E. Canadian normative data for the SF-36 health survey. *Canadian Medical Association Journal*. 2000;163:265-271.
13. Stadnyk K, Calder J and Rockwood K. Testing the measurement properties of the Short Form-36 Health Survey in a frail elderly population. *Journal of Clinical Epidemiology*. 1998;51:827-835.

14. Taft C, Karlsson J and Sullivan M. Do SF-36 summary component scores accurately summarize subscale scores? *Qual Life Res*. 2001;10:395-404.
15. Samsa G, Edelman D, Rothman ML, Williams GR, Lipscomb J and Matchar D. Determining clinically important differences in health status measures: a general approach with illustration to the Health Utilities Index Mark II. *Pharmacoeconomics*. 1999;15:141-55.
16. Gruneir A, Fung K, Fischer HD, Bronskill SE, Panjwani D, Bell CM, Dhalla I, Rochon PA and Anderson G. Care setting and 30-day hospital readmissions among older adults: a population-based cohort study. *Cmaj*. 2018;190:E1124-e1133.
17. Brown CJ, Foley KT, Lowman Jr JD, MacLennan PA, Razjouyan J, Najafi B, Locher J, Allman RM and Lowman JD, Jr. Comparison of Posthospitalization Function and Community Mobility in Hospital Mobility Program and Usual Care Patients: A Randomized Clinical Trial. *JAMA Internal Medicine*. 2016;176:921-927.
18. Covinsky KE, Pierluissi E and Johnston CB. Hospitalization-associated disability:"She was probably able to ambulate, but I'm not sure". *Jama*. 2011;306:1782-1793.
19. Dima D, Valiquette J, Berube-Dufour J and Goldfarb M. Level of function mobility scale for nurse-driven early mobilisation in people with acute cardiovascular disease. *Journal of Clinical Nursing*. 2020;29:778-784.
20. Semsar-kazerooni K, Dima D, Valiquette J, Berube-Dufour J and Goldfarb M. Early Mobilization in People with Acute Cardiovascular Disease. *Canadian Journal of Cardiology*.
21. Najjar C, Dima D, de Boer J and Goldfarb M. Beliefs, attitudes and knowledge of cardiovascular healthcare providers on mobilization. *Nursing Open*. 2021.
22. Graf J, Koch M, Dujardin R, Kersten A and Janssens U. Health-related quality of life before, 1 month after, and 9 months after intensive care in medical cardiovascular and pulmonary patients. *Critical care medicine*. 2003;31:2163-2169.
23. Koehler BE, Richter KM, Youngblood L, Cohen BA, Prengler ID, Cheng D and Masica AL. Reduction of 30-day postdischarge hospital readmission or emergency department (ED) visit rates in high-risk elderly medical patients through delivery of a targeted care bundle. *J Hosp Med*. 2009;4:211-8.
24. Shepherd CW and While AE. Cardiac rehabilitation and quality of life: a systematic review. *International journal of nursing studies*. 2012;49:755-771.
25. Peixoto TCA, Begot I, Bolzan DW, Machado L, Reis MS, Papa V, Carvalho ACC, Arena R, Gomes WJ and Guizilini S. Early Exercise-Based Rehabilitation Improves Health-Related Quality of Life and Functional Capacity After Acute Myocardial Infarction: A Randomized Controlled Trial. *Canadian Journal of Cardiology*. 2015;31:308-313.
26. Grace SL, Turk-Adawi K, de Araújo Pio CS and Alter DA. Ensuring cardiac rehabilitation access for the majority of those in need: a call to action for Canada. *Canadian Journal of Cardiology*. 2016;32:S358-S364.

**Table 1**. Characteristics of the Overall Cohort

| Variable | Participants N = 147 |
|---|---|
| **Demographic** | |
| Age (years) | 75 ± 8.659 |
| Female (%) | 66 (44.6%) |
| **Primary Admission Diagnosis** | |
| Ischemic heart disease | 72 (48.6%) |
| Heart failure | 19 (12.8%) |
| Arrhythmia | 22 (14.8%) |
| Valvular disease | 8 (5.4%) |
| Other* | 27 (18.4%) |
| **Clinical** | |
| CICU length of stay, days | 3.4 ± 3.4 |
| Hospital length of stay, days | 11 ± 7.00 |
| **Mobility** | |
| Pre-hospital LOF | 4.7 ± 0.5 |
| Admission LOF | 3.4 ± 1.3 |
| CICU discharge LOF | 4.2 ± 0.7 |
| Mobility activities / activities possible | 87.0% (1,835/2,109) |
| Mobility opportunities used / total opportunities | 93.2% (655/703) |
| Adverse events | 8 (0.4%) |
| Contraindications to mobilization | 27 (20.3%) |
| Contraindications and eventual mobilization | 27 (100%) |

**Abbreviations**: CV, Cardiovascular; CICU, cardiovascular intensive care unit; LOF, level of function
The LOF score ranges from 0 (maintain range of motion) to 5 (increase general endurance and mobility).
*Myocarditis 4; Pericardial disease 4; Pulmonary hypertension 4; Cardiomyopathy 3; Hypertension 3; Cancer 2; Hypertrophic Cardiomyopathy 2; Infection 2; Aortic Dissection 1; Drug toxicity 1; Electronic device complications 1.

**Table 2**. Primary and Secondary Outcomes

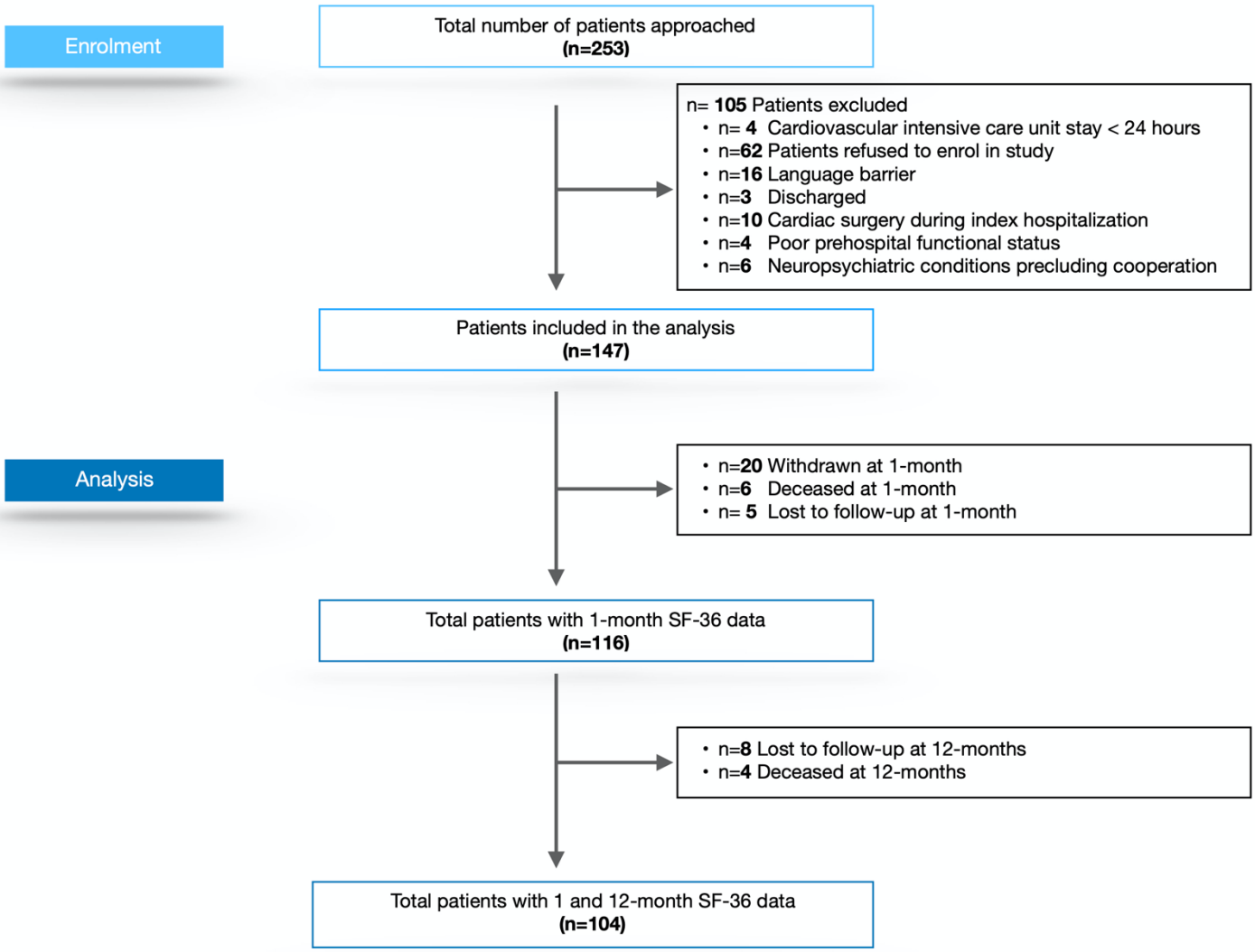
| **Primary Outcome** | **Mean ± SD** |
|---|---|
| PCS, 1-month | 34.7±9.7 |
| | |
| **Secondary Outcomes** | |
| Total SF-36 score, 1-month | 60.4 ± 21.9 |
| Total SF-36 score, 12-months | 69.3 ± 21.7 |
| PCS, 12-months | 36.5 ± 9.2 |
| MCS, 1-month | 36.9 ± 11.1 |
| MCS, 12-months | 40.5 ± 11.5 |
| | |
| **Death** | **N (%)** |
| In-hospital death | 9 (6.1%) |
| 1-month | 6 (4.1%) |
| 12-months | 4 (2.7%) |
| | |
| **Discharge destination** | **N (%)** |
| Home | 122 (82.4%) |
| Rehabilitation or acute care hospital | 14 (9.5%) |
| Long term care facility | 3 (2.0%) |
| | |
| **Hospital Readmission** | **N (%)** |
| 1-month | 10 (6.8%) |

**Abbreviations**: MCS, mental component summary; PCS, physical component summary

**Table 3**. Multivariable Linear Regression

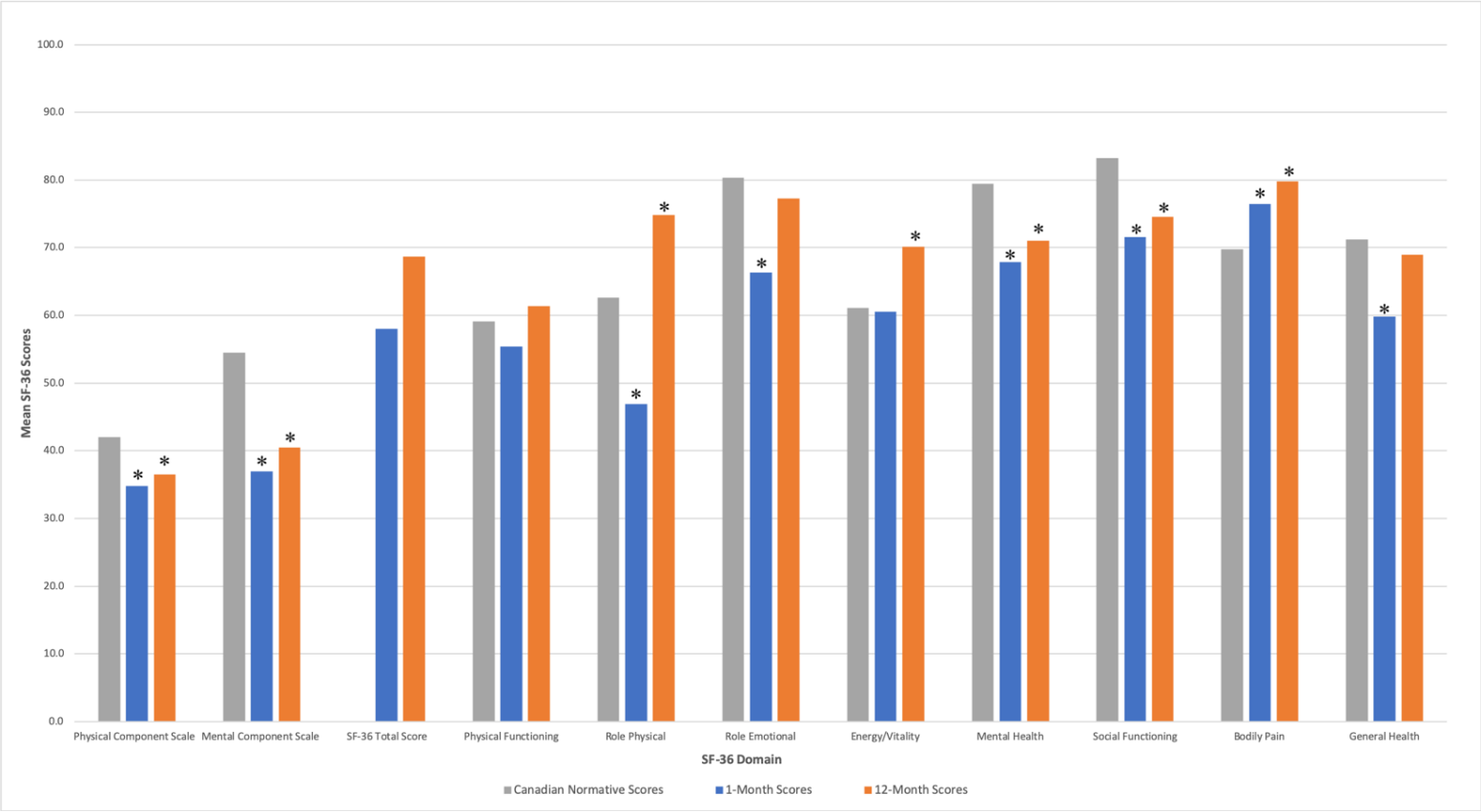
| Variable | Regression co-efficient | 95% Confidence Interval | P-Value |
|---|---|---|---|
| **Age** | -0.2 | -0.5 to -0.03 | 0.03 |
| **Sex** | 0.5 | -3.4 to 4.3 | 0.8 |
| **Admission Diagnosis** | | | |
| **Ischemic Heart Disease** | 3.8 | -1.2 to 8.8 | 0.1 |
| **Heart Failure** | 4.3 | -2.5 to 11.2 | 0.2 |
| **Arrythmia** | -0.8 | -6.7 to 5.0 | 0.7 |
| **LOF Prehospital** | 4.6 | 0.4 to 8.8 | 0.03 |

**Figure 1**. Flow Diagram



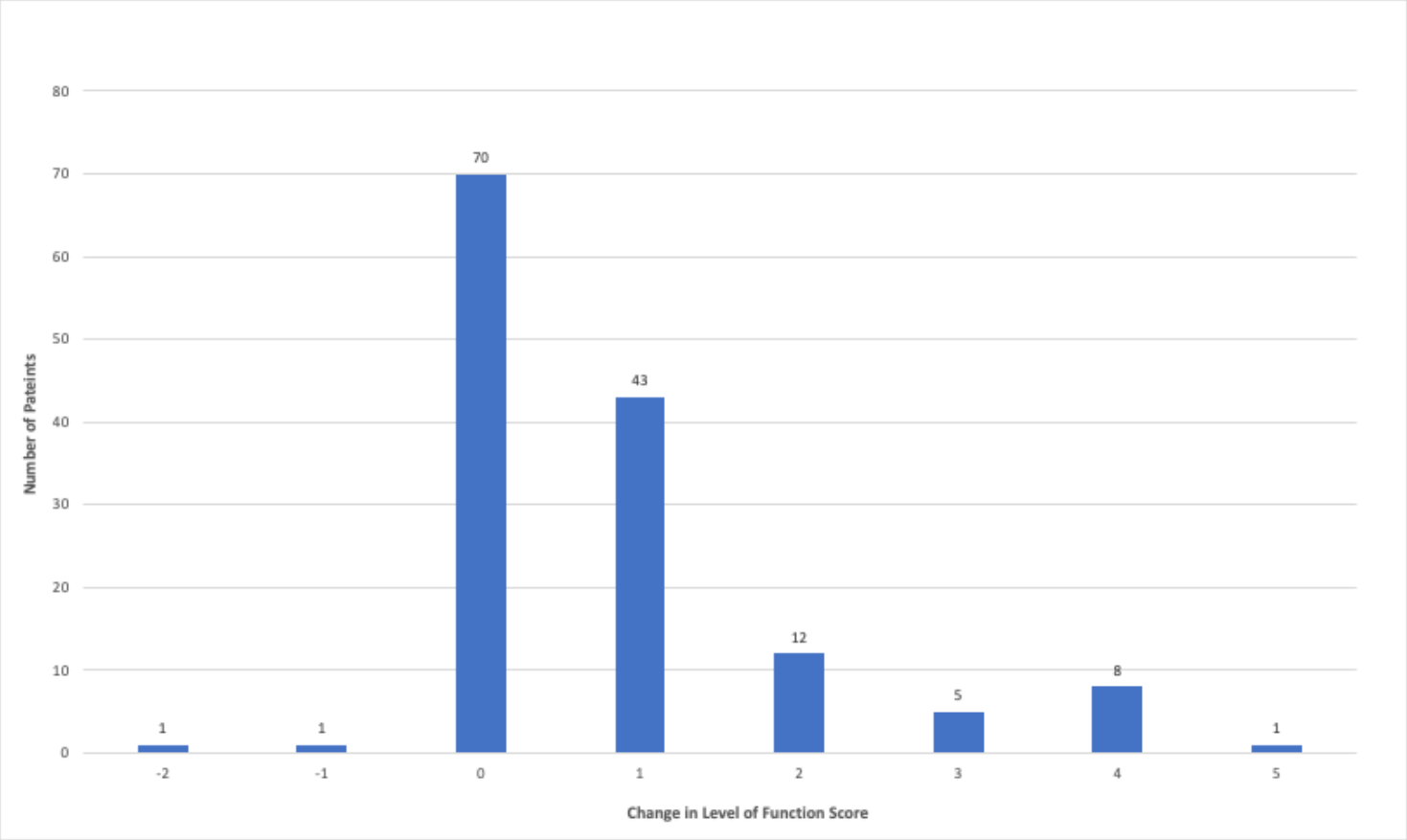

**Legend**
**Abbreviations**: HRQOL, Health-related quality of life; SF-36, Short-Form 36 Health Survey

**Figure 2**. Health Related Quality of Life Measures Post-Hospitalization at 1-and 12-month




**Legend.**
***** indicates a significant P-value ≤ 0.05 compared to Canadian normative data.
Canadian normative data was from Hopman WM, et al. Canadian normative data for the SF-36 health survey. *CMAJ.* 2000;163:265-271

**Supplementary Figure S1.** Change in Level of Function during Cardiovascular Intensive Care Unit Stay



**Supplementary Table S1.** 1-and 12-Month Short-Form 36 Health Survey Scores in 65-74 and >75-year Age Cohort

| | 65-74 years old | Canadian Normative Score* | P-Value | >75 years old | Canadian Normative Score* | P- Value |
|---|---|---|---|---|---|---|
| **1-month Total Score** | 63.4 ± 21.2 | N/A | | 58.0 ± 21.6 | N/A | |
| **12-month Total Score** | 70.0 ± 22.0 | N/A | | 68.7 ± 22.1 | N/A | |
| **1-month PCS** | 35.7 ± 9.1 | 47.2 ± 9.7 | P<0.0001 | 33.6 ± 10.4 | 42.0 ± 10.0 | P<0.0001 |
| **12-month PCS** | 36.9± 8.4 | 47.2 ± 9.7 | P<0.0001 | 35.8 ± 9.4 | 42.0 ± 10.0 | P<0.0001 |
| **1-month MCS** | 38.1 ± 9.1 | 53.7 ± 8.3 | P<0.0001 | 37.4 ± 11.6 | 54.5 ± 8.6 | P<0.0001 |
| **12-month MCS** | 39.1 ± 11.5 | 53.7 ± 8.3 | P<0.0001 | 41.8 ± 10.9 | 54.5 ± 8.6 | P<0.0001 |

**Legend**

**Abbreviations**: MCS, mental component scale; PCS, physical component scale

Continuous values represented as mean Score ± standard deviation

* Significant P-values compared to Canadian normative data for the corresponding age cohort.

Canadian normative data was from Hopman WM, et al. Canadian normative data for the SF-36 health survey. *CMAJ.* 2000;163:265-271

**Supplementary Table S2.** 1-and 12-Month Physical Component Scale and Mental Component Scale Scores Compared to Level of Function Scores

| SF-36 Score | LOF ≤ 4 | LOF=5 | P-Value |
|---|---|---|---|
| **1-month PCS** | 30.5 ± 9.7 | 36.2 ± 9.4 | P<0.01 |
| **12-month PCS** | 30.7 ± 10.1 | 38.2 ± 8.4 | P=0.04 |
| **1-month MCS** | 34.9 ± 10.6 | 37.7 ± 11.1 | P=0.28 |
| **12-month MCS** | 39.3 ± 11.7 | 41.3 ± 11.4 | P=0.50 |

**Legend**
**Abbreviations**: LOF, Level of function; MCS, mental component scale; PCS, physical component scale
Continuous values represented as mean score ± standard deviation

**Supplementary Table S3**. Physical Component and Mental Component Scale Scores at 1-and 12 Months by Primary Admission Diagnosis.

| Admission Diagnosis | 1-Month PCS Score | 12-Month PCS Score | 1-Month MCS Score | 12-Month MCS Score |
|---|---|---|---|---|
| Ischemic heart disease | 36.2 ± 9.4 | 37.4 ± 8.5 | 36.1 ± 11.7 | 38.8 ± 12.5 |
| Heart failure | 36.7 ± 6.6 | 34.4 ± 7.5 | 35.0 ± 10.5 | 43.1 ± 9.4 |
| Atrial fibrillation | 32.6 ± 11.1 | 36.6 ± 9.2 | 38.6 ± 9.9 | 40.0 ± 11.3 |
| Other arrhythmia | 28.2 ± 15.8 | 33.9 ± 18.0 | 42.7 ± 7.4 | 42.3 ± 8.1 |
| Other CV disease | 31.2 ± 8.0 | 41.2 ± 10.1 | 42.0 ± 11.2 | 46.8 ± 12.2 |
| Other non-CV disease | 34. 6 ± 10.3 | 35. 8 ± 4.6 | 38. 2 ± 8.0 | 38. 9 ± 14.8 |
| Valvular disease | 33.1 ± 7.5 | 36.3 ± 11.9 | 30.0 ± 13.3 | 49.0 ± 7.6 |

**Legend**
Continuous values represented as mean Score ± standard deviation
**Abbreviations**: CV, Cardiovascular; MCS, mental component scale; PCS, physical component scale.

## Chapter 9: Commentary on Cohort Study 2

The primary finding of cohort study 2 is that a heterogenous cohort of older adults with diagnoses ranging from ischemic heart disease to valvular disease had poorer physical and mental HRQOL at 1 and 12-months compared to age-matched, country-specific norms. Results from this study have important implications for clinicians. Firstly, it demonstrates that EM is feasible and safe in the CICU and cardiovascular ward settings, with 90% of mobility opportunities resulting in a mobility activity, minimal adverse events, and improvement of patients' functional status towards prehospital levels. Secondly, this study identified a potentially modifiable target for intervention by demonstrating the relationship between prehospital functional status and posthospital HRQOL: older adults with poorer prehospital functional status were more likely to have poorer posthospital HRQOL. Identification of this vulnerable population could allow clinicians to screen older adults with acute CVD on admission for poor prehospital functional status and then intervene early with interventions to increase mobility status and potentially improve posthospital HRQOL.

Older adults greater than 75 years had 1-month physical component summary (PCS) scores 7.3 lower than Canadian age-matched norms, which is well above the minimally clinically important PCS difference of 3 points.[42] Of note, this PCS score is with patients undergoing an established EM care program and there was no comparative PCS score for older adults undergoing usual mobility care in this study. Graf et. al. similarly showed patients recovering the intensive care unit having a 10.3-point difference in 1-month PCS compared to population norms.[43] Further randomized studies are needed to determine the impact of a structured EM program upon the HRQOL of patients with acute CVD, and upon other person-centered outcomes.

## Chapter 10: Conclusions and Future Directions

The scoping review found that earlier mobilization was safe and effective in people following an MI in the pre-revascularization era. However, there is a clear evidence gap for EM's effectiveness in the contemporary literature, both in practice guidelines and in high quality randomized studies. The first cohort study found that older adults with acute CVD spend 91.2% of their hospital stay in the CICU or cardiovascular ward in a sedentary position. Lower step counts and higher percentage of sedentary time were associated with a lower HRQOL 1-month posthospitalization. The second cohort study revealed poor HRQOL in older patients with acute CVD 1 and 12-months following hospital discharge compared to age-matched population norms, with poor prehospital functional status predictive of poor post-hospitalization HRQOL.

There is a paucity of data in the literature concerning sedentary time and HRQOL in the older acute CVD population. The cohort studies highlight two key points regarding hospitalized older adults: Older adults spend the majority of their hospital stay sedentary and that poor prehospital functional status and immobility is associated with worse person-centered HRQOL outcomes. Sedentary time is a potentially modifiable risk factor for posthospitalization syndrome and HAD. By addressing immobility early in the care process, clinicians may prevent further injury and disability and ensure that older adults have sufficient physical and mental reserves to cope with in-hospital stressors. As a result, older adults may be able to better withstand the vulnerable period following hospital discharge and avert further longer-term disability after recovering from the acute cardiovascular illness.

There are a number of pathophysiological implications of prolonged bedrest on older adults with acute CVD. In healthy adults, skeletal muscle atrophy is observed within 72 hours of immobilization.[5] During 2-3 weeks of enforced bedrest, there is a loss of 1.5% to 2.0% in muscle

mass per day.[44] This muscle atrophy disproportionate affects the lower limbs in older adults, with quadriceps muscle strength loss up to 3-6 fold greater in older adults than younger people.[15] The loss in muscle mass and strength due to immobility results primarily due to the decreased size of muscle fibres.[44] This increases the risk of further falls, injuries, and reduces the ability to mobilize during the acute hospitalization phase and following discharge.[5] This muscle loss also contributes to significant deficits in physical function, as measured by the 6-minute walk test.[44] There are also hemodynamic consequences to prolonged bedrest. Diuresis and natriuresis during prolonged periods of bedrest reduce circulating blood volumes and result in decreased preload, thereby reducing stroke volume and cardiac output.[45] Increased rates of orthostatic hypotension and episodes of syncope may develop given the impact of prolonged bedrest on carotid-cardiac baroreflexes.[45] There is also evidence that duration of bedrest is related to the frequency of venous thromboembolism.[46]

There remain knowledge gaps that future studies should address. Our studies found an association between poor prehospital function, lower step counts, and a higher percentage of sedentary time with poor post-hospitalization HRQOL. However, it is not known whether (1) interventions in older adults with acute CVD can reduce sedentary time and whether (2) reducing sedentary time can improve post-hospitalization person-centered outcomes. The observational cohort studies do not include a comparator group who received usual mobility care. Thus, the impact of EM compared to usual care on posthospital HRQOL in uncertain. Adequately powered RCTs that explore these evidence gaps are needed to establish whether EM is effective at improving person-centred outcomes, influence CV professional society guidelines and change CV mobility care culture. In addition, the mechanism by which structured mobilization programs may improve functional abilities and HRQOL needs to be delineated. Potential mechanisms by

which EM may act include preservation of muscle mass and strength, reduction of inflammation and improved mood. Further mechanistic studies are necessary to explore the impact of EM in older adults with acute CV disease. Lastly, in order to accurately determine the effects of EM upon HAD, studies should include measures of disability in the follow-up period posthospitalization.

Immobility is one contributor to the posthospitalization syndrome and HAD. Cognitive stressors, nutritional deficits and iron-deficiency anemia are frequently encountered by patients in-hospital and are key contributors to posthospitalization syndrome and HAD.[8, 12] These are key areas, in addition to EM, that researchers can address using a randomized control study design to adequately capture the effects of addressing the allostatic stressors that contribute to posthospitalization syndrome and HAD. In recognition of the limitations posed by the cohort studies, we have designed and initiated the TARGET-EFT Trial: MulTicomponent Acute Intervention in FRail GEriatric PaTients with Cardiovascular Disease Using the Essential Frailty Toolset (NCT04291690). This single center randomized clinical trial is presently recruiting patients at the Jewish General Hospital, a tertiary academic care center in Montreal, Quebec, with a target enrollment of 144 patients and tentative completion date of June 2021. Patients ≥65 years old admitted to the cardiovascular unit with evidence of pre-frail or frailty using the Essential Frailty Toolset (EFT) will be randomized either to a control group, receiving usual care as prescribed by the cardiovascular care unit, or the intervention group that will receive a multicomponent intervention targeted to the frailty deficit identified. The frailty deficits screened by the EFT mirror the stressors of posthospitalization syndrome and HAD closely, screening for physical weakness, cognitive impairment, malnourishment and iron-deficiency anemia.[47] The primary outcome of interest is change in HRQOL between randomization and hospital discharge

using the EQ-5D scale, assessing for mobility, self-care, mood, pain and physical activity metrics of quality of life. Change in HRQOL will also be determined from hospital discharge to 30-days, as well as the change in HAD using the Older Americans Resource Services ADL scale.

Data from the cohort studies and the TARGET-EFT randomized clinical trial can provide clinically meaningful data in establishing the relationship between EM, post-hospital HRQOL and other important person-centered outcomes. Incorporating the findings from these studies to influence practice guidelines in the care of patients with acute CVD can reduce the vulnerability patients experience following their hospitalization. Through EM and challenging the contemporary mobility culture, older adults with acute CVD may benefit from a hospital stay that is less disabling and debilitating, reducing the burden upon patients, caregivers and the health-care system.

**References (Chapters 1-2, 4-5, 7, 9-10)**


1. Wenger NK. Early Mobilization After Myocardial Infarction: Historical Perspective and Critical Appraisal. In: A. Raineri, J. J. Kellermann and V. Rulli, eds. *Selected Topics in Exercise Cardiology and Rehabilitation* Boston, MA: Springer US; 1980: 21-31.
2. FAULKNER JM. The Treatment of Cardiovascular Emergencies. *New England Journal of Medicine*. 1937;216:747-751.
3. Cortés OL, DiCenso A and McKelvie R. Mobilization Patterns of Patients After an Acute Myocardial Infarction: A Pilot Study. *Clinical nursing research*. 2015;24:139-155.
4. Howie-Esquivel J and Zaharias E. Using Novel Technology to Determine Mobility Among Hospitalized Heart Failure Patients: A Pilot Study. *Cardiology Research*. 2013;4:15-25.
5. Surkan MJ and Gibson W. Interventions to mobilize elderly patients and reduce length of hospital stay. *Canadian Journal of Cardiology*. 2018;34:881-888.
6. Needham DM. Mobilizing patients in the intensive care unit: improving neuromuscular weakness and physical function. *Jama*. 2008;300:1685-1690.
7. Canadian Institute for Health Information. *All-Cause Readmission to Acute Care and Return to the Emergency Department* 2012.
8. Krumholz HM. Post-hospital syndrome–a condition of generalized risk. *The New England journal of medicine*. 2013;368:100.
9. Katz S. Assessing self-maintenance: activities of daily living, mobility, and instrumental activities of daily living. *Journal of the American Geriatrics Society*. 1983;31:721-727.
10. Flood KL, Rohlfing A, Le CV, Carr DB and Rich MW. Geriatric syndromes in elderly patients admitted to an inpatient cardiology ward. *Journal of Hospital Medicine: An Official Publication of the Society of Hospital Medicine*. 2007;2:394-400.
11. Zisberg A, Shadmi E, Sinoff G, Gur-Yaish N, Srulovici E and Admi H. Low Mobility During Hospitalization and Functional Decline in Older Adults. *Journal of the American Geriatrics Society*. 2011;59:266-273.
12. Covinsky KE, Pierluissi E and Johnston CB. Hospitalization-associated disability:"She was probably able to ambulate, but I'm not sure". *Jama*. 2011;306:1782-1793.
13. Boyd CM, Landefeld CS, Counsell SR, Palmer RM, Fortinsky RH, Kresevic D, Burant C and Covinsky KE. Recovery of activities of daily living in older adults after hospitalization for acute medical illness. *Journal of the American Geriatrics Society*. 2008;56:2171-2179.
14. Goldfarb M, van Diepen S, Liszkowski M, Jentzer JC, Pedraza I and Cercek B. Noncardiovascular disease and critical care delivery in a contemporary cardiac and medical intensive care unit. *Journal of intensive care medicine*. 2019;34:537-543.
15. Damluji AA, Forman DE, van Diepen S, Alexander KP, Page RL, Hummel SL, Menon V, Katz JN, Albert NM and Afilalo J. Older adults in the cardiac intensive care unit: factoring geriatric syndromes in the management, prognosis, and process of care: a scientific statement from the american heart association. *Circulation*. 2020;141:e6-e32.
16. Adler J and Malone D. Early mobilization in the intensive care unit: a systematic review. *Cardiopulmonary Physical Therapy Journal*. 2012;23:5-13.
17. Brown CJ, Foley KT, Lowman Jr JD, MacLennan PA, Razjouyan J, Najafi B, Locher J, Allman RM and Lowman JD, Jr. Comparison of Posthospitalization Function and Community Mobility in Hospital Mobility Program and Usual Care Patients: A Randomized Clinical Trial. *JAMA Internal Medicine*. 2016;176:921-927.

18. Morris PE, Griffin L, Thompson C, Hite RD, Haponik E, Berry M, Winkelman C, Hopkins RO, Ross A and Dixon L. Receiving early mobility during an intensive care unit admission is a predictor of improved outcomes in acute respiratory failure. *The American journal of the medical sciences*. 2011;341:373-377.
19. Burtin C, Clerckx B, Robbeets C, Ferdinande P, Langer D, Troosters T, Hermans G, Decramer M and Gosselink R. Early exercise in critically ill patients enhances short-term functional recovery*. *Critical Care Medicine*. 2009;37:2499-2505.
20. Zang K, Chen B, Wang M, Chen D, Hui L, Guo S, Ji T and Shang F. The effect of early mobilization in critically ill patients: A meta-analysis. *Nursing in Critical Care*. 2019;20:20.
21. Nydahl P, Sricharoenchai T, Chandra S, Kundt FS, Huang M, Fischill M and Needham DM. Safety of Patient Mobilization and Rehabilitation in the Intensive Care Unit. Systematic Review with Meta-Analysis. *Annals of the American Thoracic Society*. 2017;14:766-777.
22. Fleming LM, Zhao X, DeVore AD, Heidenreich PA, Yancy CW, Fonarow GC, Hernandez AF and Kociol RD. Early ambulation among hospitalized heart failure patients is associated with reduced length of stay and 30-day readmissions. *Circulation: Heart Failure*. 2018;11:e004634.
23. Vendrik J, Vlastra W, van Mourik M, Delewi R, Beijk M, Lemkes J, Wykrzykowska J, de Winter R, Henriques J and Piek J. Early mobilisation after transfemoral transcatheter aortic valve implantation: results of the MobiTAVI trial. *Netherlands Heart Journal*. 2020:1-9.
24. Budano C, Garrone P, Castagno D, Bissolino A, Andreis A, Bertolo L, Mazzini D, Bergamasco L, Marra S and Gaita F. Same-day CIED implantation and discharge: Is it possible? The E-MOTION trial (Early MObilization after pacemaker implantaTION). *International Journal of Cardiology*. 2019;288:82-86.
25. Najjar C, Dima D, DeBoer J and Goldfarb M. BELIEFS, ATTITUDES, AND KNOWLEDGE OF CARDIOVASCULAR HEALTHCARE PROVIDERS ON MOBILIZATION. *Canadian Journal of Cardiology*. 2020;36:S116-S117.
26. Pavon JM, Sloane RJ, Pieper CF, Colón-Emeric CS, Cohen HJ, Gallagher D, Hall KS, Morey MC, McCarty M and Hastings SN. Accelerometer-Measured Hospital Physical Activity and Hospital-Acquired Disability in Older Adults. *Journal of the American Geriatrics Society*. 2019.
27. Fazio S, Stocking J, Kuhn B, Doroy A, Blackmon E, Young HM and Adams JY. How much do hospitalized adults move? A systematic review and meta-analysis. *Applied Nursing Research*. 2020;51:151189.
28. Irvin Jr CW and Burgess Jr AM. The abuse of bed rest in the treatment of myocardial infarction. *New England Journal of Medicine*. 1950;243:486-489.
29. Kohn RM. Early ambulation after myocardial infarction. The surgical model. *Advances in Cardiology*. 1982;31:147-51.
30. Groden B and Brown R. Differential psychological effects of early and late mobilisation after myocardial infarction. *Scandinavian journal of rehabilitation medicine*. 1970;2:60.
31. Hawkes AL, Nowak M and Speare R. Short Form-36 Health Survey as an evaluation tool for cardiac rehabilitation programs: is it appropriate? *Journal of Cardiopulmonary Rehabilitation and Prevention*. 2003;23:22-25.
32. ActiGraph. User Guide ActiGraph GT9X Link + ActiLife. 2019.
33. Anderson J, Green A, Hall H and Yoward S. Criterion validity of an ankle or waist mounted Actigraph GT3X accelerometer in measurement of body position and step count. *Physiotherapy*. 2016;102 (Supplement 1):e79-e80.

34. Pfister T, Matthews CE, Wang Q, Kopciuk KA, Courneya K and Friedenreich C. Comparison of two accelerometers for measuring physical activity and sedentary behaviour. *BMJ Open Sport & Exercise Medicine*. 2017;3:e000227.
35. Brown CJ, Redden DT, Flood KL and Allman RM. The underrecognized epidemic of low mobility during hospitalization of older adults. *Journal of the American Geriatrics Society*. 2009;57:1660-1665.
36. Dubb R, Nydahl P, Hermes C, Schwabbauer N, Toonstra A, Parker AM, Kaltwasser A and Needham DM. Barriers and Strategies for Early Mobilization of Patients in Intensive Care Units. *Annals of the American Thoracic Society*. 2016;13:724-30.
37. Floegel TA, Dickinson JM, DerAnanian C, McCarthy M, Hooker SP and Buman MP. Association of posture and ambulation with function 30 days after hospital discharge in older Adults with heart failure. *Journal of cardiac failure*. 2018;24:126-130.
38. Asgari MR, Jafarpoor H, Soleimani M, Ghorbani R, Askandarian R and Jafaripour I. Effects of Early Mobilization Program on the Heart Rate and Blood Pressure of Patients With Myocardial Infarction Hospitalized at the Coronary Care Unit. *Middle East Journal of Rehabilitation and Health Studies*. 2015;2:e24168.
39. Okada Y, Unoki T, Matsuishi Y, Egawa Y, Hayashida K and Inoue S. Early versus delayed mobilization for in-hospital mortality and health-related quality of life among critically ill patients: a systematic review and meta-analysis. *Journal of intensive care*. 2019;7:1-9.
40. Dubb R, Nydahl P, Hermes C, Schwabbauer N, Toonstra A, Parker AM, Kaltwasser A and Needham DM. Barriers and strategies for early mobilization of patients in intensive care units. *Annals of the American Thoracic Society*. 2016;13:724-730.
41. Dittmer D and Teasell R. Complications of immobilization and bed rest. Part 1: Musculoskeletal and cardiovascular complications. *Canadian Family Physician*. 1993;39:1428.
42. Hopman WM, Towheed T, Anastassiades T, Tenenhouse A, Poliquin S, Berger C, Joseph L, Brown JP, Murray TM and Adachi JD. Canadian normative data for the SF-36 health survey. *Cmaj*. 2000;163:265-271.
43. Graf J, Koch M, Dujardin R, Kersten A and Janssens U. Health-related quality of life before, 1 month after, and 9 months after intensive care in medical cardiovascular and pulmonary patients. *Critical Care Medicine*. 2003;31:2163-2169.
44. Brower RG. Consequences of bed rest. *Critical care medicine*. 2009;37:S422-S428.
45. Freeman R and Maley K. Mobilization of intensive care cardiac surgery patients on mechanical circulatory support. *Critical care nursing quarterly*. 2013;36:73-88.
46. Stuempfle KJ and Drury DG. The physiological consequences of bed rest. *Journal of exercise physiology*. 2007;10.
47. Afilalo J, Lauck S, Kim DH, Lefèvre T, Piazza N, Lachapelle K, Martucci G, Lamy A, Labinaz M and Peterson MD. Frailty in older adults undergoing aortic valve replacement: the FRAILTY-AVR study. *Journal of the American College of Cardiology*. 2017;70:689-700.