Irish Journal of Medical Science (1971 -) (2024) 193:2733–2744
https://doi.org/10.1007/s11845-024-03811-5

ORIGINAL ARTICLE

Effects of early mobilization in elderly patients undergoing cardiac surgery

İsmail Ceylan[1] · **Azhar Hassan Mhmood**[2] · **Raed Qadri Khudhair Al-Janabi**[2]

Received: 27 August 2024 / Accepted: 16 September 2024 / Published online: 27 September 2024

Abstract

Background Although early mobilization is associated with improved outcomes in postoperative cardiac patients, implementation of early mobilization in elderly patients is still a challenge.

Aims In this study, we aimed to design and assess an early mobilization program for cardiac rehabilitation.

Methods We conducted a clinical trial in elderly patients aged over 65 years after coronary artery bypass graft surgery. Patients were randomly assigned to an early mobilization group (Group A) or a routine therapy group (Group B). Short-Form International Physical Activity Questionnaire (SF-IPAQ), to assessment balance Time Up and Go (TUG), to assessment functional capacity the 2-min walking test (2MWT) and the short physical performance battery (SPPB) were used as a reference to formulate and monitor the early mobilization regimen.

Results A total of 100 patients were enrolled ($n=50$ per group). The mean walking distance in Group A was significantly higher at 135.6 ± 9.29 than the mean walking distance in Group B which was lower at 123.4 ± 8.48. Also, the patients in Group B had a mean SF-IPAQ of 389.44 with an SD of 85.7, $P<0.001$, whereas the mean SF-IPAQ amount in Group A was 556.16 with an SD of 91.47. In early mobilization group, a strong positive connection was indicated by the correlation coefficient of $r=0.957$ between the amount of SF-IPAQ and 2 MWT and there was a significant negative association $r=-0.768$ between 2MWT and TUG.

Conclusion Our study's findings suggest that early mobilization and functional exercises enhanced balance, functionality, and life quality for older cardiac patients.

Keywords Cardiac rehabilitation · Cardiac surgery · Early rehabilitation · Elderly

Introduction

The global population is undergoing rapid aging, significantly impacting healthcare systems worldwide [1]. In 2000, there were 600 million individuals aged 60 and older. By 2025, this number is projected to double to 1.2 billion, and by 2050, it is expected to exceed 2 billion. This demographic transition presents a critical challenge for both industrialized and developing nations. Currently, approximately two-thirds of older adults reside in the developing world, a proportion expected to rise to 75% by 2025. Developed countries also witness a similar trend of population aging, with the elderly population, particularly those aged 80 and above, experiencing the most rapid growth. Notably, women tend to have longer lifespans than men across societies, resulting in a 2:1 female-to-male ratio at very old ages [2].

Aging is usually associated with a gradual loss of muscle mass, bone density, functionality [3], and a deterioration of oxygen uptake, which can explain these differences in addition to the impact of their high burden of comorbidities [4]. Currently, coronary heart disease stands as the primary cause of global mortality, with annual rates approximately at 9.2% for men and 7.0% for women. Moreover, advancements in medical care and technology have led to a decrease in cardiac-related mortality, resulting in longer survival for patients with cardiovascular disease. In routine clinical practice in Europe, individuals with arterial hypertension, acute coronary syndromes, heart failure, and atrial fibrillation are

✉ İsmail Ceylan
fztceylan@gmail.com

[1] Department of Hand Rehabilitation, School of Physical Therapy and Rehabilitation, Kirsehir Ahi Evran University, Kirsehir, Turkey

[2] Department of Physiotherapy and Rehabilitation, Al-Bitar Cardiac Surgery Hospital, Baghdad, Iraq

typically over the ages of 70, 75, and 80 years, respectively [5]. Coronary arterial bypass grafting (CABG) surgery is often deemed an optimal choice for elderly patients with coronary heart disease [6, 7]. Despite advancements in cardiac surgical techniques, postoperative complications remain prevalent and significantly impact both hospitalization duration and functional recovery [8].

Balance is regulated by a complex sensorimotor control system within the central nervous system, which integrates signals from visual, vestibular, and somatosensory centers. Nearly half of the global geriatric population experiences balance issues, often in conjunction with musculoskeletal or urological problems. After the age of 65, the prevalence of balance problems increases to 21% among older individuals, with an even higher prevalence observed during functional tasks [9].

Integrating early mobilization into postoperative care confers numerous benefits, including enhanced functional exercise capacity, emotional well-being, and muscle strength [10, 11]. Traditional postoperative protocols often require prolonged bed rest. In these protocols, patients generally spend approximately 83% of their time in supine, while only 4% of patients participate in early mobilization [12]. There persists a lack of consensus regarding the optimal intensity, delivery methods, and techniques about early mobilization for geriatric patients after cardiac surgery [13, 14]. In current literature, there are less studies that have comprehensively explored the advantages of implementing functional exercise and early mobilization for geriatric patients after cardiac surgery [15, 16]. Therefore, this study aims to address this gap in literature by investigating the impact of early mobilization and functional exercise on the physical activity, balance, and functional status of older individuals postcardiac surgery.

Methods

Study design

This is an experimental study that examined the effects of early mobilization on geriatric postoperative cardiac patients. The study proposal was approved by the local ethics committee (903–2023/14/12) and conducted in accordance with the tenets of the Declaration of Helsinki. Written and verbal informed consent was obtained from each participant before the study. However, due to an oversight, the study was subsequently registered before the data were analyzed (ClinicalTrials.gov Identifier: NCT06360146).

Participants

A total of 100 participants (69 men, 31 women) were enrolled in the study. The current study was conducted et al.-Bitar Cardiac Surgery Hospital, Baghdad, Iraq, and data were collected between December 2023 and January 2024.

Inclusion criteria were as follows: (1) previously had valve replacement procedures or CABG, (2) with ages ranging from 65 to 75, (3) who were awake, conscious, and able to communicate vocally as well as those who were able to understand and complete scales and questionnaires. Patients were excluded if they (1) were unable to complete the 2-min walk test 2MWT, scales, or questionnaires, (2) suffered from stroke, extensive bleeding, renal failure or insufficiency, atrial fibrillation, the necessity for a second operation, or a serious infection of the sternal wound following surgery.

Interventions

Group A received early mobilization and traditional cardiopulmonary physiotherapy program; Group B received only traditional cardiaopulmonary physiotherapy program (Table 1).

Outcome measurements

The SF-IPAQ, 2MWT, TUG, and SPPB were measured in both groups on the seventh day following cardiac surgery.

Primary outcome

International physical activity questionnaire

The Short Form of the International Physical Activity Questionnaire was used to measure physical activity (PA). Participants were asked to describe how many days they had spent performing vigorous, moderate, and walking activities over the course of the previous week, as well as the duration of those activities. They were applied to each activity in order to assign an approximate metabolic equivalent of task (MET) value. Based on their SF-IPAQ scores, participants were classified as having high, moderate, or low levels of physical activity basics [17]

Secondary outcomes

Two-minute walking test

The 2MWT was performed over a 50-ft (15.2-m) out-and-back course. Participants were instructed to walk as fast as they could until asked to stop. Participants stopped walking at 2 min, and the distance covered was documented [18].

Table 1 Therapy program for Groups A and B

Group A	On the 1st and 2nd postoperative days	In the ICU: shoulder and neck mobilization, head control, good hand grasp, balance in sitting position with breathing exercises by spirometry and postural drainage by cupping (8 times per day)
	On the 3rd and 7th postoperative days	Breathing exercises, inspiratory muscle training[14], postural drainage, functional exercise (stand up and sitting down on the chair, walking inward, back-ward, and sideways), weight shifts from left to right, step up inside the patch, one leg stand, squatting leaning against wall) for three times per day and repetition fifteen times (3 times per day for 15 repetition) and supervised walking with increments of 2 min, as tolerated up to 6 min or more at the morning, afternoon, evening, and night
Group B	On the 1st and 2nd postoperative days	In the ICU: breathing exercises by spirometry and postural drainage by cupping (4 times per day)
	On the 3rd and 7th postoperative days	Breathing exercises, inspiratory muscle training, postural drainage, walking as tolerated up to 5 min at the morning and the evening

ICU ıntensive care unit

Time up and go test

The TUG was performed from a standard chair (height = 43 cm) according to the instructions. Participants were to stand up from the chair, walk 3 m at a comfortable pace, turn and walk back to the starting point, and sit down again. Participants wore their regular footwear. The ordinary stopwatches were used for recording test time in seconds. The time was started with "go" word and stopped when the participant sat down. The test time was used as the main outcome of the analysis [19].

Short physical performance battery

The short physical performance battery (SPPB) consists of three tests: (i) static standing balance, where participants are required to maintain three different positions (side-by-side, semi-tandem, and tandem) for 10 s each; (ii) gait speed, which involves walking a distance of 4 m and recording the best time out of two trials; and (iii) chair rise, where participants must stand up and sit down five times consecutively as quickly as possible. The scoring of each individual test ranges from 0 to 4 points, with higher scores indicating better performance. The three test scores are then summed to calculate an overall SPPB performance score, which can range from 0 to 12 points. This score is then separated into four groups (G1-G4) based on certain cut points [20].

Sample size

The sample size was determined using the G* Power 3.1.7.9 software tool developed by Heinrich-Heine-Universitas in Düsseldorf, Germany. The sample size calculation was conducted to determine the minimum number of participants needed to detect a medium effect size of 0.3 for the difference in the primary outcome between the two groups. A minimum of 41 patients is required per group in order to detect this difference with a significance level (α) of 0.05 and a study power of 80%. In order to account for potential attrition of up to 17%, we made the decision to enroll 50 patients in each group. The determination of the sample size was determined by considering the 2-sided difference between the two groups using an independent samples test [21].

Statistical analysis

The statistical data is displayed as numerical values and percentages for the categorical variables, and examined through the utilization of the chi-square test. The mean and standard deviation (SD) were used to show quantitative parametric data, which were examined using an independent samples Student *t*-test. The median and interquartile range were used to present quantitative non-parametric variables, which were evaluated using the independent-samples Mann–Whitney *U* test. Pearson's and Spearman's correlation coefficients were employed to assess the relationship between various variables. The study was conducted using the IBM SPSS 28 program for Windows. A *P*-value less than 0.05 is deemed to be statistically significant.

Results

The sample size for the study was 100 people, whose average age was 67.08 years. Sixty-nine percent of the participants were male, and seventy-six percent had completed elementary school. 170.49 cm was the average length, 79.70 kg was the average weight, and 27.78 (kg/m^2)was the average BMI (Body Mass Index) (Table 2).

Regarding weight and BMI, there was a statistically significant difference between the groups. The patients in Group B had a mean weight of 84.08 kg with a standard deviation of 9.39, which was higher than the mean weight of 75.32 kg in Group A ($P < 0.001$). The patients in Group B

Table 2 Characteristics of the patients

	Mean	SD
Age	67.08	2.87
Length	170.49	7.13
Weight	79.70	11.26
BMI (kg/m^2)	27.78	3.33
	N	%
Sex		
Male	69	69
Female	31	31
Marital status		
Married	100	100.00
Educational level		
Primary	76	76.0
Secondary	9	9.0
College	15	15.0

BMI Body Mass Index, *N* number, % Percentage, *SD* Standart Deviation

had a mean BMI of 29.04 kg/m^2 with (SD = 2.85), $P < 0.001$, higher than the mean BMI of Group A, which was 26.51 (kg/m^2) with (SD = 3.32) (Table 3).

Regarding the distance walked in 2 min, there was a statistically significant difference between the groups. The mean walking distance in 2 min revealed a statistically significant difference: the mean walking distance in Group A was higher at 135.6 ± 9.29 than the mean walking distance in Group B which was lower at 123.4 ± 8.48; $P < 0.001$ (Table 4).

Regarding the type of physical activity, TUG, and SPPB, there was a statistically significant difference between the groups. Also, the patients in Group B had a mean SF-IPAQ of 389.44 with an SD of 85.7, $P < 0.001$, whereas the mean SF-IPAQ amount in Group A was 556.16 with an SD of 91.47 (Table 5).

A strong positive connection was indicated by the correlation coefficient of $r = 0.957$ ($p < 0.001$) between the amount of SF-IPAQ and 2 MWT. This result implies that the amount of SF-IPAQ grows in proportion to the distance walked in 2 min. Additionally, there was a significant negative association (correlation coefficient of $r = -0.768$; $p < 0.001$) between 2MWT and TUG. This finding suggests

Table 3 Comparison of patients' characteristics across the two groups

		Group A (*N* = 50)	Group B (*N* = 50)	*P*-value
		Mean ± SD	Mean ± SD	
Age		66.92 ± 2.86	67.24 ± 2.91	0.580
Length		169.52 ± 7.50	171.46 ± 6.67	0.175
Weight		75.32 ± 11.35	84.08 ± 9.39	**< 0.001***
BMI		26.51 ± 3.32	29.04 ± 2.85	**< 0.001***
		***N* (%)**	***N* (%)**	***P*-value**
Gender	Male	31 (62%)	38 (76%)	0.13
	Female	19 (38%)	12 (24%)	
Educational level	Primary	35 (70%)	41 (82%)	0.229
	Secondary	7 (14%)	2 (4%)	
	College	8 (16%)	7 (14%)	

*Significant as *P* value ≤ 0.05; *N* number

Table 4 Comparison of 2MWT across early mobilization and functional exercise

	Group A (*N* = 50)	Group B (*N* = 50)	*P*-value
Distance walked in 2 min	135.6 ± 9.29	123.4 ± 8.48	< 0.001*
Vital signs			
SPO2 before	95.92 ± 1.41	92.94 ± 11.63	0.078
SPO2 after	98.34 ± 0.89	98.22 ± 1.3	0.592
PR before	83.26 ± 5.17	82.68 ± 3.89	0.527
PR after	93.96 ± 5.19	93.5 ± 5.33	0.663
Systolic BP before	126.74 ± 6.51	126.3 ± 6.31	0.732
Diastolic BP before	84.6 ± 5.42	84.4 ± 5.01	0.849
Systolic BP after	130.48 ± 7.3	130.16 ± 8.97	0.845
Diastolic BP after	85.6 ± 5.12	85.72 ± 5.57	0.911

*Significant as *P* value ≤ 0.05, *PR* pulse rate, *SPO2* saturation pulse oxygen level, *BP* blood pressure

Table 5 Association of physical activity levels and functional performance measures in older adults across early mobilization and functional exercise groups

		Group A ($N=50$)	Group B ($N=50$)	*P*-value
Type of physical activity	Low	10 (20%)	45 (90%)	< 0.001*
	Moderate	40 (80%)	5 (10%)	
		Mean ± SD	Mean ± SD	*P*-value
SF-IPAQ		556.16 ± 91.47	389.44 ± 85.7	< 0.001*
TUG		11.01 ± 1.24	12.31 ± 1.21	< 0.001*
		Median (IQR)	Median (IQR)	*P*-value
SPPB		12.0 (0.0)	10.0 (0.0)	< 0.001*

*Significant as *P* value ≤ 0.05

increased mobility and balance because it shows that the time required to complete the TUG test tends to decrease as the distance walked in 2 min increases. Additionally, SF-IPAQ value and TUG were shown to be strongly correlated negatively (correlation coefficient: $r = -0.826$; $p < 0.001$). This result indicates that the TUG test takes less time to complete the higher the MET quantity, demonstrating improved mobility and balance. Between SPPB and 2 MWT and SF-IPAQ, a strong positive association was discovered; the correlation coefficients were $r = 0.918$ ($p < 0.001$) and $r = 0.955$ ($p < 0.001$), respectively. With a correlation coefficient of $r = -0.631$ ($p < 0.001$), a moderately negative association was discovered between SPPB and TUG (Table 6) (Figs. 1, 2, 3, 4, 5 and 6).

Additionally, SF-IPAQ value and TUG were found strongly correlated negatively (correlation coefficient: $r = -0.826$; $p < 0.001$). This result indicates that the TUG test takes less time to complete the higher the MET quantity, demonstrating improved mobility and balance. Between SPPB and 2 MWT and SF-IPAQ, a strong positive association was discovered; the correlation coefficients were $r = 0.918$ ($p < 0.001$) and $r = 0.955$ ($p < 0.001$), respectively. With a correlation coefficient of $r = -0.631$ ($p < 0.001$), a moderately negative association

Table 6 Correlation of 2MWT, SF-IPAQ, TUG, and SPPB in Group A

Group A ($N=50$)		2 MWT	SF-IPAQ amount	TUG	SPPB
2MWT	Pearson's correlation	–			
	P-value				
SF-IPAQ amount	Pearson's correlation	0.957	–		
	P-value	< 0.001*			
TUG	Pearson's correlation	− 0.768	− 0.826	–	
	P-value	< 0.001*	< 0.001*		
SPPB	Spearman's correlation	0.918	0.955	− 0.631	–
	P-value	< 0.001*	< 0.001*	< 0.001*	

*Significant as *P* value ≤ 0.05

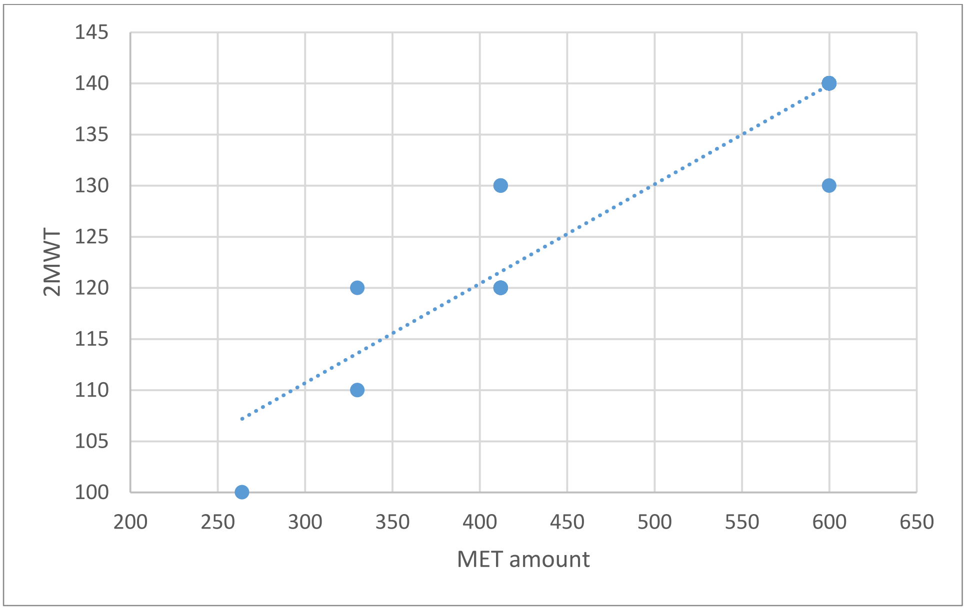


Fig. 1 Scatterplot for 2MWT and SF-IPAQ amount for Group A patients

Fig. 2 Scatterplot for 2MWT and TUG for Group A patients

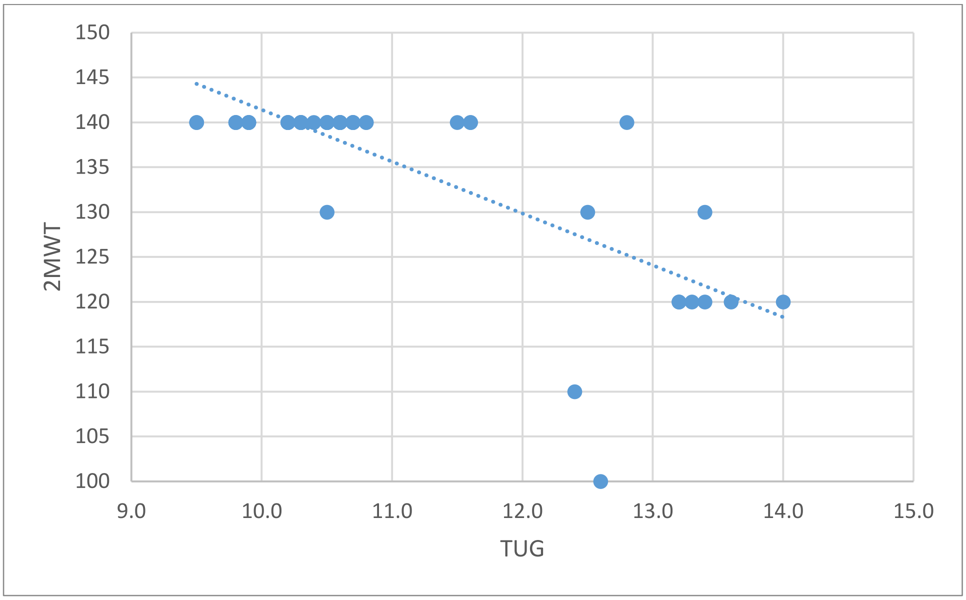
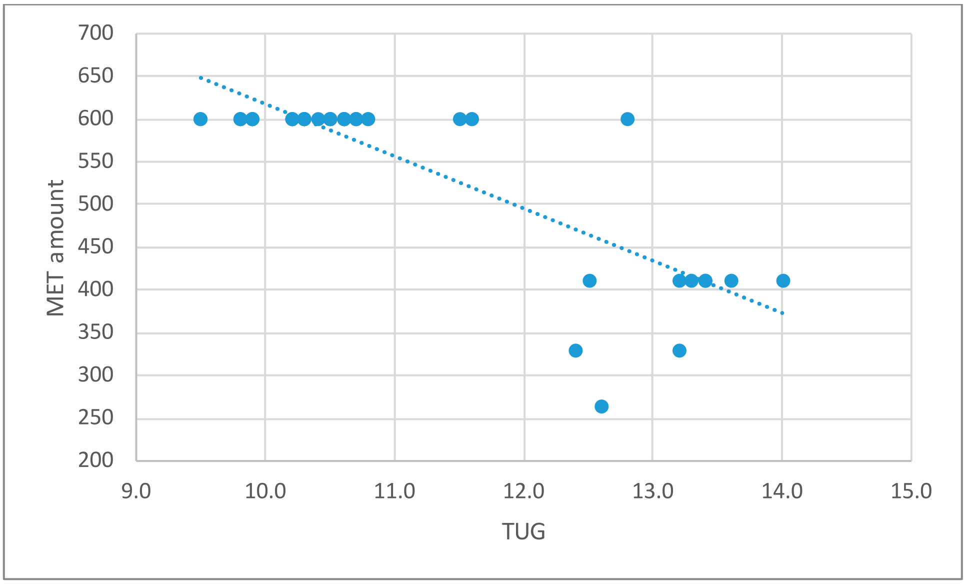


Fig. 3 Scatterplot for SF-IPAQ amount and TUG for Group A patients



was discovered between SPPB and TUG (Table 7) (Figs 7, 8, 9, 10).

Discussion

In this study, we examined how early mobilization and functional exercises affected patients' physical activity, functional ability, and balance after heart surgery. In terms of the distance walked in 2 min, there was a statistically significant difference between the groups in favor of Group A. Additionally, there was a statistically significant difference in the type of physical activity, SF-IPAQ, TUG, and SPPB scores between the groups in favor of the early mobilization group.

Cui et al. [15] found that participants in the precision early ambulation group demonstrated significantly greater walking distances on day 3 postcardiac surgery compared to those in the control group. Similarly, our study's findings align with this, despite assessing participants on the seventh day post various heart surgeries in older individuals, as opposed to Cui et al.'s evaluation on the third day postcardiac surgery. Kanejima et al. [22] conducted a meta-analysis wherein the primary variable of interest was the distance covered during the 6MWT upon discharge. Their comprehensive analysis revealed a consistent and significant enhancement in mobility with

Fig. 4 Scatterplot for 2MWT and SPPB for Group A patients

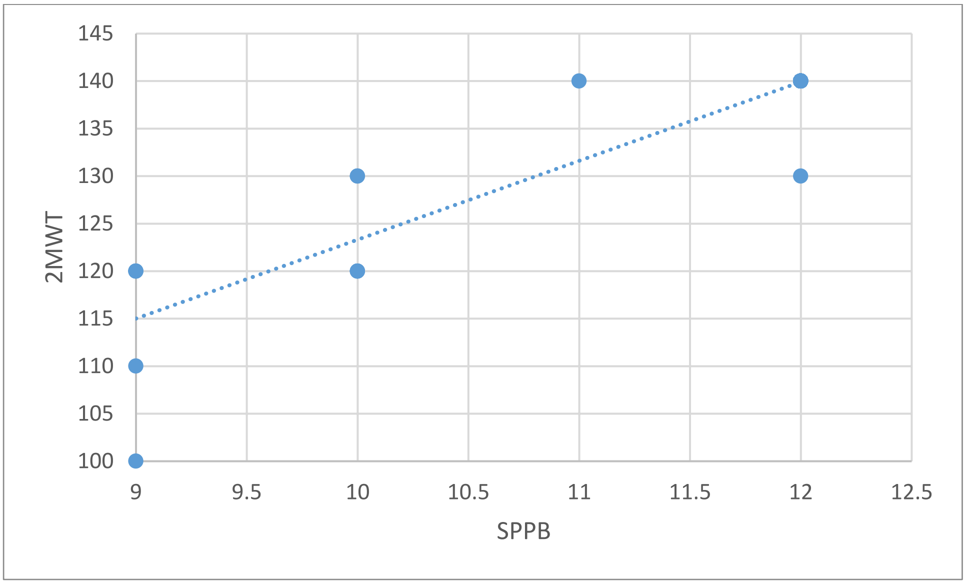
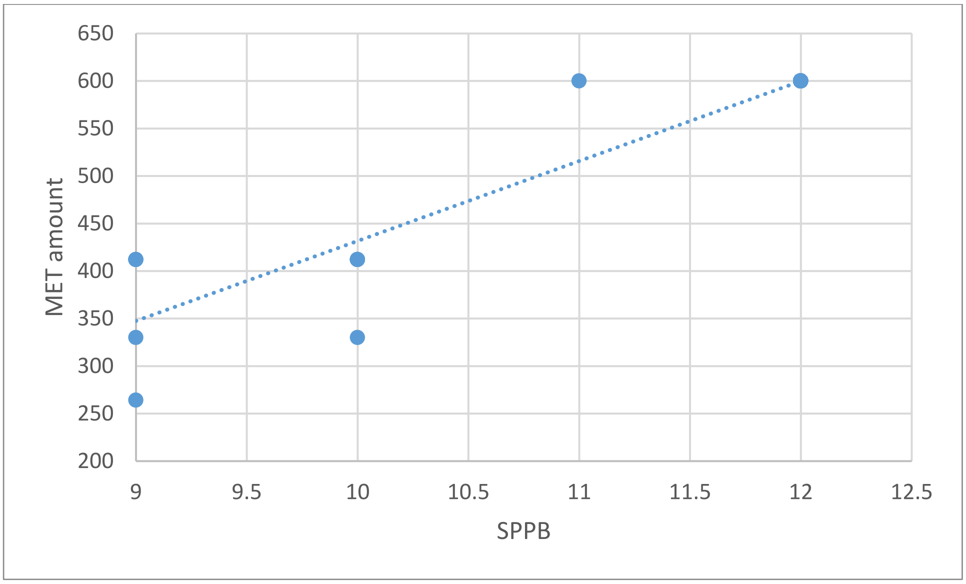


Fig. 5 Scatterplot for SF-IPAQ amount and SPPB for Group A patients



early mobilization across all included trials. Specifically, patients in the intervention groups consistently outperformed those in the control groups, exhibiting increased distance and duration during the 6MWT. The mean difference analysis indicated a substantial increase of 54.0 m (95% confidence interval: 31.1–76.9 m) in the 6MWT distance at discharge attributable to early mobilization. A separate study highlighted gender-based disparities in postoperative 6MWT performance, with men exhibiting superior functional capacity compared to women by the sixth day postsurgery. Though employing different assessment tools, this finding resonates with our investigation's focus on elderly patients evaluated via the 2MWT on the seventh postoperative day. Fiorina et al. [23] underscored the 6MWT as a reliable indicator of functional capacity, particularly postcardiac surgery. Notably, repeated 6MWT assessments in a subgroup of patients postsurgery revealed significant improvements attributed to cardiac rehabilitation programs. Our research aligns with this, demonstrating enhanced functional capacity among patients assessed via 2MWT on the seventh postoperative day, akin to Fiorina et al.'s study, which focused on participants undergoing cardiac rehabilitation and assessed by 6MWT 15 days postsurgery. Andrew D et al. [24] reported that both walking and walking/breathing exercise groups exhibited significantly greater 6MWT distances at discharge compared to conventional interventions. Similarly, our findings suggest that a moderate-intensity walking program supervised by physical therapists during the inpatient CABG surgery

Fig. 6 Scatterplot for TUG and SPPB for Group A patients

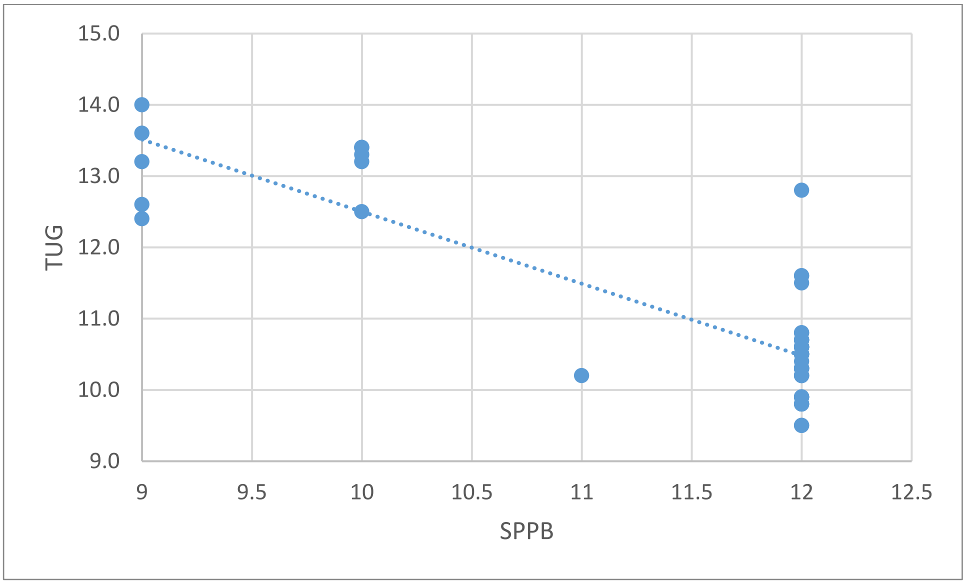
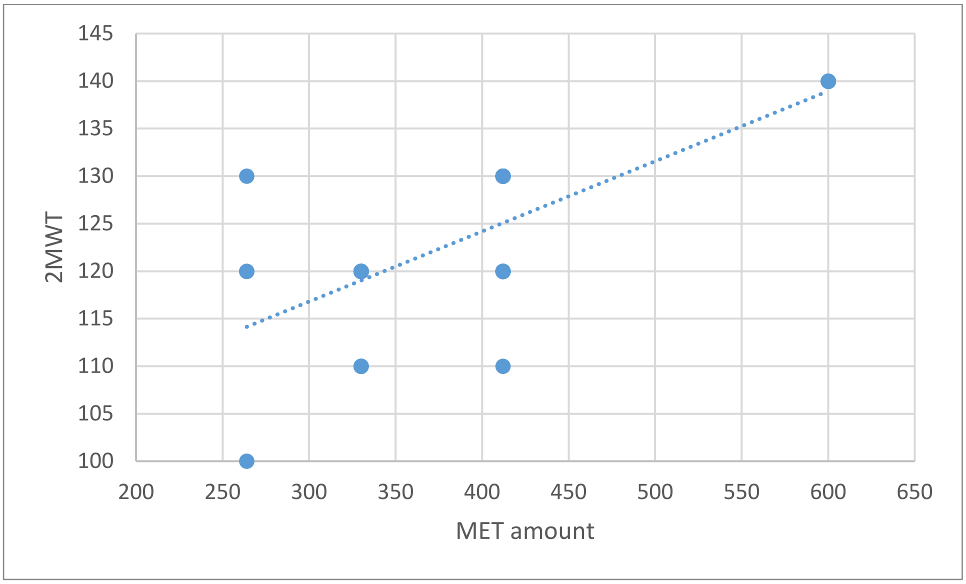


Table 7 Correlation of 2MWT, SF-IPAQ, TUG, and SPPB in Group B patients without early mobilization and functional exercise

Group B (*N* = 50)		2MWT	SF-IPAQ amount	TUG	SPPB
2MWT	Pearson's correlation	–			
	P-value				
SF-IPAQ	Pearson's correlation	0.746	–		
	P-value	< 0.001*			
TUG	Pearson's correlation	− 0.278	− 0.233	–	
	P-value	0.051	0.104		
SPPB	Spearman's correlation	0.574	0.414	-0.464	–
	P-value	< 0.001*	< 0.001*	< 0.001*	

*Significant as *P* value ≤ 0.05

Fig. 7 Scatterplot for 2MWT and SF-IPAQ amount for Group B patients



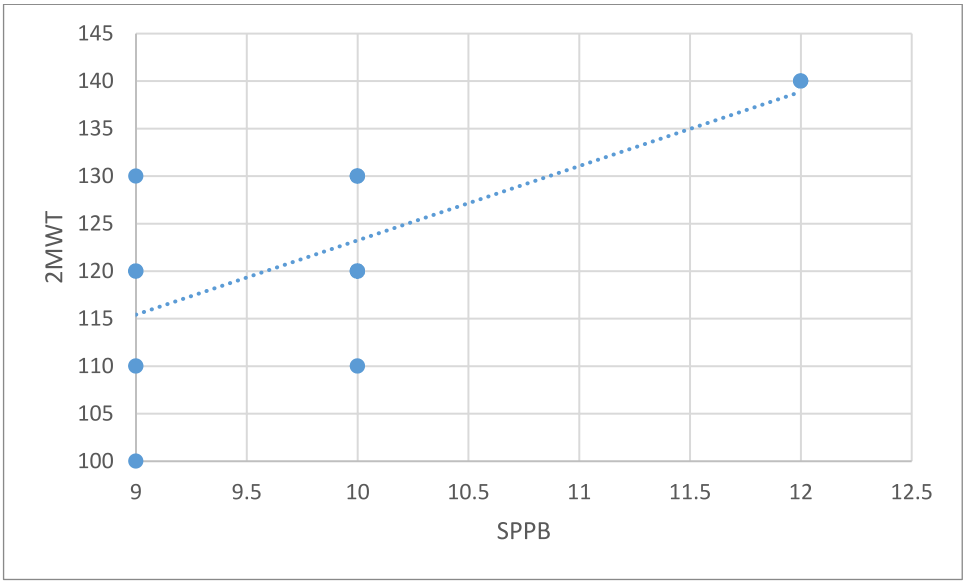


Fig. 8 Scatterplot for 2MWT and SPPB for Group B patients

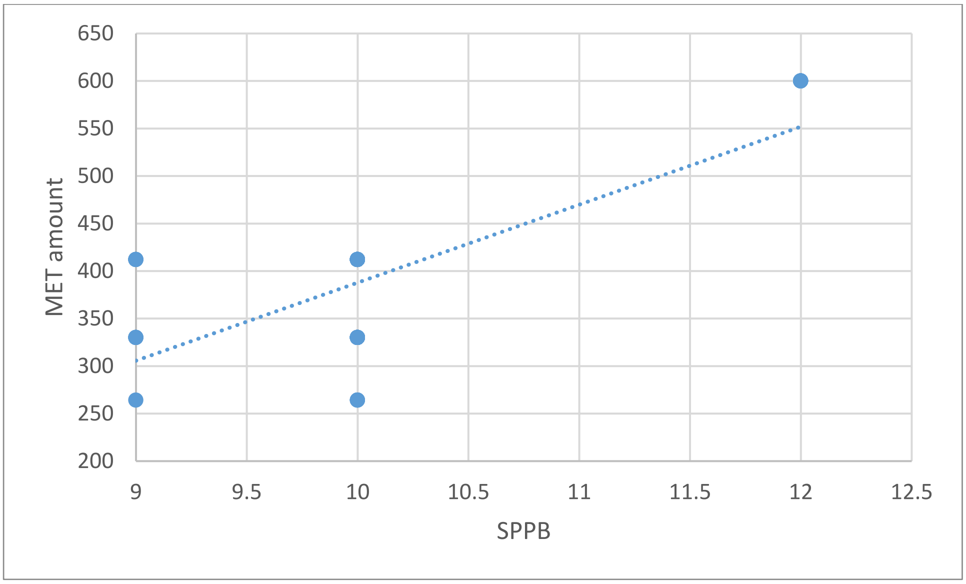


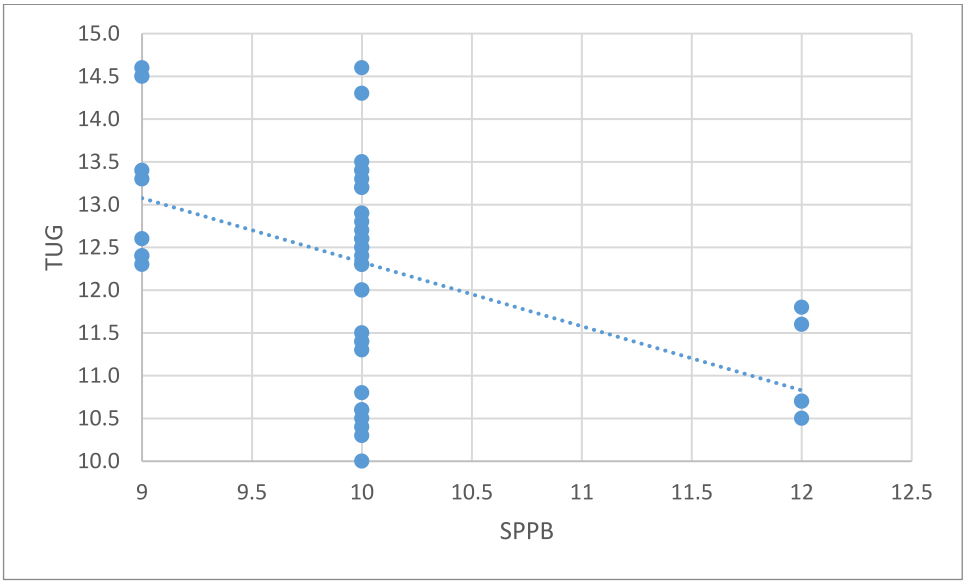
Fig. 9 Scatterplot for SF-IPAQ and SPPB for Group B patients

enhances functional ability by discharge, despite our use of the 2MWT for assessment instead of the 6MWT.

According to the findings of this study, a statistically significant disparity in physical activity levels, as assessed by the SF-IPAQ, was observed between the early mobilization program group and the control group. Notably, the distribution of physical activity types also exhibited significant differences, with a higher proportion of patients in Group A (80%) reporting moderate physical activity compared to only 10% in Group B. Conversely, a lower percentage of patients in Group A (20%) reported low physical activity compared to 90% in Group B. Mungovan et al. [25] reported a noteworthy increase in both supervised and independent physical activity step counts by postoperative day 5 (POD5) compared to POD1 for both genders. Similarly, there was a significant rise in the duration of physical activity with metabolic equivalents (METs) ≥ 3 at POD5 compared to POD1 for both males and females. Furthermore, men exhibited significantly higher step counts and METs ≥ 3 physical activity duration under supervised conditions at POD5 compared to women. In summary, both our study and Mungovan et al.'s findings underscore the significant augmentation in physical activity levels postoperatively, particularly by POD5. Moreover, gender differences in physical activity performance, particularly under supervised conditions, were evident.

In our study, a significant inverse relationship between SF-IPAQ scores and TUG test scores was observed. This indicates that as the level of physical activity measured by SF-IPAQ increases, there is a corresponding decrease in the time taken to complete the TUG test, suggesting

Fig. 10 Scatterplot for TUG and SPPB for Group B patients



improved mobility and balance. Furthermore, our findings revealed a strong positive correlation between scores on the 2MWT and SF-IPAQ scores. This suggests that higher levels of physical activity, as indicated by SF-IPAQ scores, correspond to covering greater distances within 2 min. Additionally, a significant negative correlation was found between the 2MWT and TUG test scores. This implies that as the distance walked in 2 min increases, there is a tendency for the time required to complete the TUG test to decrease, indicating improved mobility and balance. Given the absence of existing literature linking TUG test outcomes with SF-IPAQ scores following cardiac surgery, we elaborated on our findings concerning balance, basic mobility abilities, and physical activity across different scales. This highlights the novelty of our investigation within the context of postcardiovascular surgery rehabilitation.

In line with Molino et al. [26], our study suggests that older individuals undergoing elective cardiac surgery may forestall the onset of mobility limitations through organized physical activity interventions, thereby augmenting their SPPB scores. Notably, the intervention group (IG) demonstrated significant improvements in SPPB scores compared to the control group (CG), consistent with a higher percentage of individuals within the IG exhibiting at least a one-point enhancement in their SPPB scores, mirroring our study's outcomes. Similarly, Ferronato et al. [27] emphasized the immediate improvement in perceived functional ability (SPE) following SPPB assessments among older individuals undergoing cardiac surgery. Their study underscored the stability and minimal adverse effects associated with SPPB evaluations in this population. While our investigation involved comparing SPPB scores between two groups, their study focused on pre- and postoperative SPPB assessments within a single group undergoing heart surgery. Despite this difference, our findings and theirs were largely consistent, reinforcing the beneficial impact of physical activity interventions on postoperative functional outcomes in older adults.

Regardless of age and other risk factors, frailty in patients with cardiovascular disease significantly increases the risk of death, with a twofold increase observed [28]. Research indicates a correlation between frailty and an elevated risk of falls, with frail individuals at a higher risk compared to robust individuals and even those who are pre-frail [29]. Falls in the elderly often lead to severe complications, such as fractures, hospitalization, and increased mortality [30, 31]. In this study, the SPPB was used to assess balance. A strong positive association was found between SPPB scores and the 2MWT as well as the SF-IPAQ. Our findings suggest that early mobilization in geriatric patients undergoing cardiac surgery improves body balance, thereby reducing the risk of falls.

Limitations

Our study faced two primary limitations. Firstly, due to the unsuitability of performing isometric or isotonic strengthening exercises in the intensive care unit for patients postcardiac surgery, we were unable to incorporate these exercises to enhance hand grasp. Additionally, the time-consuming nature of the 6MWT rendered it impractical for some older individuals to complete, prompting the utilization of the 2MWT instead. Furthermore, certain patients had to be excluded from the functional exercise program due to their inability to meet the prescribed dosage.

In conclusion, our study highlights the positive impact of early mobilization and functional exercises on enhancing physical activity among elderly patients following cardiac surgery. Specifically, these interventions contribute to improved balance among this population, underscoring their importance in postoperative care.

Author contribution The Editors consider authorship to include the following: (1) conception and design or analysis and interpretation of data, or both; (2) performance of experiments or therapy; (3) drafting of the manuscript or revising it critically for important intellectual content; and (4) final approval of the manuscript submitted. Participation solely in the collection of data does not justify authorship but may be appropriately acknowledged in the Acknowledgment section.

Declarations

Conflict Interest The authors declare no competing interests.

References

1. Menezes AR, Lavie CJ, Milani RV et al (2012) Cardiac rehabilitation and exercise therapy in the elderly: should we invest in the aged? J Geriatr Cardiol: JGC 9(1):68
2. Vincent J-L, Wan S, Underwood M. Cardiovascular surgery in the aging world. Intensive Care Medicine: 2007 Annual Update: Springer; 2007. p. 417–30
3. Mccarthy A, Robinson K, Dockery F et al (2024) Long-term outcomes of older adults with acute COVID-19 following inpatient geriatric rehabilitation: a prospective cohort study from the Republic of Ireland. Ir J Med Sci (1971-) 1–9
4. Fontes-Oliveira M, Trêpa M, Rodrigues P et al (2020) Cardiovascular rehabilitation in patients aged 70-year-old or older: benefits on functional capacity, physical activity and metabolic profile in younger vs. older patients. J Geriatr Cardiol JGC 17(9):544
5. Parks AL, Fang MC (2016) Anticoagulation in older adults with multimorbidity. Clin Geriatr Med 32(2):331–346
6. Nicolini F, Contini GA, Fortuna D et al (2015) Coronary artery surgery versus percutaneous coronary intervention in octogenarians: long-term results. Ann Thorac Surg 99(2):567–574
7. Nicolini F, Molardi A, Verdichizzo D and others (2012) Coronary artery surgery in octogenarians: evolving strategies for the improvement in early and late results. Heart Vessels 27:559–567
8. Harskamp RE, Puskas JD, Tijssen JG and others (2014) Comparison of hybrid coronary revascularization versus coronary artery bypass grafting in patients≥ 65 years with multivessel coronary artery disease. Am J Cardiol 114(2):224–229
9. Zaninotto P, Huang Y-T, Di Gessa G et al (2020) Polypharmacy is a risk factor for hospital admission due to a fall: evidence from the English Longitudinal Study of Ageing. BMC Public Health 20:1–7
10. Ceylan İ, Al-Jaddah HAS, Al-Janabi RQK (2024) Correlation between functionality and quality of life in patients after cardiac surgery. J Clin Med Kaz 21(4):26–32
11. Gholami M, Zohrabi Salari F, Yarahmadi R et al (2024) Effects of balance training on cognitive function and activities of daily living in older adult patients with heart failure: a randomized controlled trial. Irish J Med Sci (1971-) 193(1):111–21
12. Pereira DE, Welch SA, Montgomery CD et al (2021) Low hospital mobility—resurgence of an old epidemic within a new pandemic and future solutions. Age Ageing 50(5):1439–1441
13. Li M, Zhang J, Gan TJ and others (2018) Enhanced recovery after surgery pathway for patients undergoing cardiac surgery: a randomized clinical trial. Eur J Cardiothorac Surg 54(3):491–497
14. Liu VX, Rosas E, Hwang J et al (2017) Enhanced recovery after surgery program implementation in 2 surgical populations in an integrated health care delivery system. JAMA Surgery 152(7):e171032-e
15. Cui Z, Li N, Gao C and others (2020) Precision implementation of early ambulation in elderly patients undergoing off-pump coronary artery bypass graft surgery: a randomized-controlled clinical trial. BMC Geriatr 20:1–10
16. Ettema RG, Van Koeven H, Peelen LM et al (2014) Preadmission interventions to prevent postoperative complications in older cardiac surgery patients: a systematic review. Int J Nurs Stud 51(2):251–260
17. Firat M, Vardar-Yagli N, Saglam M et al (2023) Quality of life and physical activity level in patients with chronic kidney disease during COVID-19 pandemic. Psychol Health Med 28(3):640–647
18. Yuksel E, Kalkan S, Cekmece S et al (2017) Assessing minimal detectable changes and test-retest reliability of the timed up and go test and the 2-minute walk test in patients with total knee arthroplasty. J Arthroplasty 32(2):426–430
19. Kahraman BO, Ozsoy I, Akdeniz B and others (2020) Test-retest reliability and validity of the timed up and go test and 30-second sit to stand test in patients with pulmonary hypertension. Int J Cardiol 304:159–163
20. Lin Y-T, Song C-Y (2024) Reliability and minimal detectable change of the Short Physical Performance Battery in older adults with mild cognitive impairment. Geriatr Nurs 57:91–95
21. Saeidi M, Mostafavi S, Heidari H, Masoudi S (2013) Effects of a comprehensive cardiac rehabilitation program on quality of life in patients with coronary artery disease. ARYA atherosclerosis 9(3):179
22. Kanejima Y, Shimogai T, Kitamura M et al (2020) Effect of early mobilization on physical function in patients after cardiac surgery: a systematic review and meta-analysis. Int J Environ Res Public Health 17(19):7091
23. Fiorina C, Vizzardi E, Lorusso R et al (2007) The 6-min walking test early after cardiac surgery. Reference values and the effects of rehabilitation programme. Eur J Cardio-Thoracic Surg 32(5):724–9
24. Hirschhorn AD, Richards DA, Mungovan SF et al (2012) Does the mode of exercise influence recovery of functional capacity in the early postoperative period after coronary artery bypass graft surgery? A randomized controlled trial. Int Cardiovasc Thorac Surg 15(6):995–1003
25. Mungovan SF, Singh P, Gass GC et al (2017) Effect of physical activity in the first five days after cardiac surgery. J Rehabil Med 49(1):71–77
26. Molino-Lova R, Pasquini G, Vannetti F and others (2013) Effects of a structured physical activity intervention on measures of physical performance in frail elderly patients after cardiac rehabilitation: a pilot study with 1-year follow-up. Intern Emerg Med 8:581–589
27. Ferronato L, Vieira D, Rodrigues A et al (2022) Short physical performance battery in the pre and postoperative myocardial revascularization surgery in older adults: reliability, hemodynamic responses, subjective perceived exertion, and adverse events. Physiother Theor Pr 1–11

28. Afilalo J, Karunananthan S, Eisenberg MJ et al (2009) Role of frailty in patients with cardiovascular disease. Am J Cardiol 103(11):1616–1621
29. Bandeen-Roche K, Xue Q-L, Ferrucci L and others (2006) Phenotype of frailty: characterization in the women's health and aging studies. J Gerontol A Biol Sci Med Sci 61(3):262–266
30. Büyükturan Ö, Demirci S, Büyükturan B, Yakut Y. Effects of using insoles of different thicknesses in older adults: which thickness has the best effect on postural stability and risk of falling? J Am Podiatr Med Assoc. 2020;110(6)
31. Büyükturan Ö, Ekici G, Yıldırım NÜ (2011) Yaşlı Bireylerde İzole Kas Kuvveti ve Oranı ile Denge ve Yaşam Kalitesi Arasındaki İlişkiler. Ergoterapi ve Rehabilitasyon Dergisi 3(2):87–94