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Comparison of Kinesiophobia, Upper Limb Function, and Grip Strength in Patients with Pacemakers and Coronary Artery Disease

ABSTRACT

Objective: To compare kinesiophobia, shoulder range of motion (ROM), functional disability, and handgrip strength (HGS) between patients with cardiac pacemakers and those with stable coronary artery disease (CAD).

Methods: This cross-sectional study enrolled 60 individuals aged ≥50 years with preserved left ventricular systolic function, including 30 patients with standard left-sided cardiac pacemakers and 30 individuals with CAD. Kinesiophobia was assessed using the validated Turkish version of the Tampa Scale for Kinesiophobia—Heart (TSK-Heart). Shoulder ROM, HGS, and upper limb function [quick disabilities of the arm, shoulder, and hand (QuickDASH)] were evaluated using standardized clinical protocols. Analysis of covariance was used for between-group comparisons.

Results: The TSK-Heart scores were similar between the pacemaker and CAD groups, with no statistically significant difference ($P=.061$). Internal rotation of the left shoulder was significantly more limited in the pacemaker group ($P=.031$, Cohen's $d=0.58$). No significant differences were observed in other shoulder ROM parameters, QuickDASH scores, or HGS between the groups.

Conclusion: Kinesiophobia levels were similarly elevated in patients with pacemakers and those with CAD, suggesting that fear of movement is a generalized phenomenon across chronic cardiac populations rather than a device-specific issue. The selective internal rotation limitation observed exclusively in pacemaker recipients highlights the importance of targeted musculoskeletal assessment during clinical follow-up. Recognition of such functional impairments, alongside awareness of elevated kinesiophobia, is critical for comprehensive patient management.

Keywords: Cardiac rehabilitation, cardiac pacemaker, handgrip strength, kinesiophobia, musculoskeletal function, shoulder mobility

INTRODUCTION

The annual incidence of permanent pacemaker implantation ranges from 260 to 469 per 100 000 individuals, a figure expected to rise further due to global population aging and expanding clinical indications.[1] The most commonly used method for cardiac implantable electronic device (CIED) placement is the transvenous subcutaneous pre-pectoral technique, in which leads are inserted through upper limb veins and a pulse generator is placed subcutaneously over the pectoralis major muscle.[2] Although CIEDs have demonstrated clear survival benefits and improvements in quality of life in patients with bradyarrhythmia, they may lead to musculoskeletal complications.

Cardiac implantable electronic device implantation is considered a minor surgical procedure, but it carries risks, especially concerning musculoskeletal complications related to postoperative activity restrictions. Given that the pulse generator is positioned adjacent to the pectoralis major muscle, movements that engage this muscle can apply mechanical stress to the leads, increasing the risk of dislodgement, insulation failure, or fracture, particularly in the early post-implantation period.[3-5] To mitigate these risks, physicians often advise patients to limit shoulder elevation beyond 90 degrees and avoid strenuous or repetitive

ORIGINAL INVESTIGATION

Benil Nesli Ata[1]
Zeynep Alev Özçete[1]
Barış Ünal[2]
Buğra İnce[3]

[1]*Department of Physical Medicine and Rehabilitation, İzmir City Hospital, İzmir, Türkiye*
[2]*Department of Cardiology, İzmir City Hospital, İzmir, Türkiye*
[3]*Department of Physical Medicine and Rehabilitation, Faculty of Medicine, University of Health Sciences, İzmir City Hospital, İzmir, Türkiye*

Corresponding author:
Benil Nesli Ata
drbenilnesli@gmail.com

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use of the ipsilateral arm during the initial recovery weeks.[4] In some cases, arm immobilization is also employed.[6] Despite such precautions, randomized controlled trials have shown that early mobilization does not raise the incidence of lead-related complications and is generally safe.[7,8] However, due to the lack of standardized postoperative guidelines, clinical practices vary widely between centers. Responding to actual or anticipated discomfort, patients may consciously restrict use of the ipsilateral upper limb to avoid device malfunction or pain.[3] Persistent avoidance can lead to secondary complications, such as soft tissue stiffness and adhesive capsulitis.[9] Despite previous studies investigating upper limb dysfunction in patients with CIEDs, detailed data on the effects of pacemaker implantation on shoulder range of motion (ROM), kinesiophobia, and handgrip strength (HGS) remain limited.

Kinesiophobia refers to an excessive, irrational fear of physical activity, often linked to anticipated pain or risk of reinjury.[10] Initially described by Kori in patients with chronic pain, the concept has since expanded to include various musculoskeletal and systemic conditions such as chronic low back pain, osteoarthritis, fibromyalgia, and generalized musculoskeletal pain syndromes.[11] In recent years, this issue has been observed among people with cardiovascular conditions, significantly reducing their participation in physical activities and decreasing their commitment to cardiac rehabilitation programs.[12] According to the cognitive-behavioral avoidance model, patients with cardiac conditions may avoid movement due to actual physical limitations and fear-driven beliefs concerning potential cardiovascular harm, which can lead to functional decline and reduced quality of life.[13] Previous studies reported that approximately 20% of patients with coronary artery disease (CAD) exhibited clinically significant kinesiophobia 6 months after acute coronary syndrome.[12] Although kinesiophobia is gaining recognition in cardiac populations, its prevalence and functional impact among pacemaker recipients remain inadequately understood and merit further exploration.

Handgrip strength, defined as the maximal isometric force generated by the muscles of the hand and forearm, is a clinically relevant biomarker of musculoskeletal function. Handgrip strength has a strong correlation with overall health status, and it predicts adverse outcomes more robustly than chronological age alone.[14,15] Reduced HGS has been associated with a broad spectrum of adverse health outcomes, including cardiometabolic disorders, myocardial infarction, neurologic diseases, frailty, and premature mortality.[16,17] Moreover, HGS independently predicts all-cause and cardiovascular mortality.[18] These findings highlight HGS as a robust indicator of global health status, particularly in populations with chronic disease.

Despite growing interest in kinesiophobia and musculoskeletal function in cardiac populations, data regarding the interplay between pacemaker implantation, upper limb function, kinesiophobia, and HGS remain scarce. This study aims to elucidate these relationships to inform rehabilitation protocols and improve clinical outcomes in pacemaker recipients.

HIGHLIGHTS

- Kinesiophobia was similarly elevated in both patients with pacemakers and those with coronary artery disease.
- A selective limitation in shoulder internal rotation was observed among pacemaker recipients.
- Handgrip strength and self-reported upper limb function showed no significant group differences.
- Combining subjective scales and objective measures enhanced methodological validity.
- Findings suggest that kinesiophobia reflects a general cardiac response rather than device implantation.

METHODS

This cross-sectional observational study was conducted between September 2024 and February 2025. Written informed consent was obtained from all participants. The study protocol was approved by the institutional ethics committee (Decision No: 2024/68) and conducted in accordance with the ethical principles of the Declaration of Helsinki.

Participants with pacemakers had undergone implantation at least 6 months before enrollment. Participants were randomly selected among patients attending routine follow-up visits at a tertiary cardiology department of the hospital. A total of 60 patients aged ≥50 years with left ventricular ejection fraction >50% were enrolled. The sample comprised 30 individuals with pacemakers and 30 patients diagnosed as having CAD without pacemakers. To ensure inclusion of patients with at least moderate functional capacity, only those with a Duke Activity Status Index (DASI) score of 26 or higher were included. The DASI score is strongly correlated with functional performance and estimated peak oxygen consumption, making it a valid and practical tool for assessing aerobic capacity in clinical research.[19] Patients who had undergone device implantations other than routine pacemaker procedures were excluded. Patients with pre-existing shoulder pathologies were excluded based on a detailed medical history and standardized physical examination findings, including a history of shoulder surgery, rotator cuff tears, adhesive capsulitis, or other clinically diagnosed shoulder disorders. Advanced imaging modalities such as magnetic resonance imaging or ultrasound were not routinely performed to exclude subclinical shoulder pathology. Cardiac resynchronization therapy (CRT) and implantable cardioverter-defibrillator (ICD) recipients were excluded due to multiple confounding factors such as prolonged implantation time, larger device pocket volume, and increased lead number. Exclusion criteria included neurologic conditions (e.g., neuromuscular disorders causing immobility or limb weakness), psychiatric illness, mastectomy, and arteriovenous fistulas for dialysis. Additionally, patients with non-standard implantation techniques (e.g., axillary vein access, venous cutdown, generator revision, or replacement) were excluded.

Kinesiophobia was assessed using the Turkish version of the Tampa Scale for Kinesiophobia—Heart (TSK-Heart), which has demonstrated good validity and reliability in cardiac populations.[20] The TSK-Heart is a 17-item instrument rated on a 4-point Likert scale (1 = strongly disagree to 4 = strongly agree), with total scores ranging from 17 to 68. It evaluates cognitive and behavioral dimensions of kinesiophobia, including perceived cardiac danger, fear of injury, exercise avoidance, and dysfunctional self-image during rehabilitation.[21] Higher scores indicate greater fear of movement, and scores >37 are considered clinically significant.[22]

All patients underwent a standardized baseline evaluation conducted by a multidisciplinary team including a cardiologist and a physiatrist. All shoulder ROM and HGS measurements were performed by the same physiatrist to ensure consistency. Shoulder ROM was assessed with patients seated with their arms in a neutral position. Handgrip strength was measured using a Jamar hydraulic hand dynamometer (Sammons Preston, Inc., Bolingbrook, IL, USA) and recorded in kilograms. Participants were instructed to perform a maximal isometric contraction for 5 seconds with the elbow flexed at 90° and the forearm and wrist in a neutral position.[23] Three consecutive trials were performed on each hand, starting with the dominant side. The mean of the 3 measurements was used for analysis, with at least 1 minute of rest between trials.

Upper limb function was assessed using the Turkish version of the Quick disabilities of the arm, shoulder, and hand (QuickDASH) questionnaire, a validated 11-item instrument that evaluates upper limb symptoms and functional status on a 5-point Likert scale, with higher scores indicating greater disability.[24]

Statistical Analysis

All statistical analyses were performed using the SPSS version 25.0 statistics software package (IBM Corp., Armonk, NY, USA). Continuous variables are presented as mean ± SD. Categorical variables are reported as frequencies and percentages. Differences between categorical variables were assessed using Fisher's exact test.

Age was included as a covariate in the outcome analyses because it significantly differed between the groups. To compare kinesiophobia scores between the groups, analysis of covariance (ANCOVA) was conducted. To assess whether there were differences in the ROM and functional scores of the left upper limb, a 2-way mixed-design ANCOVA was performed. This model included measurements from both the left and right shoulders of the same individual to reduce within-subject variability and enhance statistical power. In cases where a significant group × side interaction was found, differences in left upper limb function between groups were further explored using independent samples t-tests. For the analysis of grip strength, sex was included as an additional factor in the ANCOVA model. Additionally, due to the wide variability in pacemaker duration, subgroup analyses were performed. The pacemaker group was divided into 2 subgroups based on the median duration (23.5 months). Analysis of covariance analyses were repeated for the Tampa Scale, internal rotation, and QuickDASH scores across 3 groups: pacemaker duration ≤ 23.5 months, pacemaker duration > 23.5 months, and the control group. In cases where a significant group × side interaction was found, differences in left upper limb function between groups were further explored using one-way ANCOVA analysis.

RESULTS

Sixty participants were enrolled and evenly allocated to the pacemaker group (n = 30) and the CAD group (n = 30). Of the total sample, 26 (43.3%) were female and 34 (56.7%) were male. Demographic comparisons revealed that the pacemaker group was significantly older than the CAD group (P = .010). No significant between-group differences were observed in sex distribution (P = .602), body mass index (P = .370), or dominant limbs (P = .432). However, educational status differed significantly, with a higher proportion of primary school graduates in the pacemaker group compared with the CAD group (P = .003). The demographic and baseline clinical characteristics of the participants are presented in Table 1.

For the primary outcome, no statistically significant difference was found in the ANCOVA analysis between the pacemaker and CAD groups in TSK-Heart scores, F (1, 57) = 3.66, P = .061, partial η^2 = 0.060.

Regarding secondary outcomes, a significant group × side interaction was found for shoulder internal rotation (F (1, 57) = 4.37, P = .041, partial η^2 = 0.071) and QuickDASH scores (F (1, 57) = 7.90, P = .007, partial η^2 = 0.122). However, post-hoc comparisons focusing on left upper limb function revealed a statistically significant difference only in internal rotation, with the pacemaker group demonstrating reduced internal rotation compared with the CAD group (t (47.97) = −2.22, P = .031, Cohen's d = 0.58). For QuickDASH, post-hoc analyses indicated that the significant interaction was driven by a within-group right–left difference in the pacemaker group,

Table 1. Demographic Characteristics and Baseline Clinical Findings of the Study Participants

	CPM Group n = 30	CAD Group n = 30	P
Age, years, mean (SD)	67.2 (9.12)	60.6 (9.89)	.010
Gender, n (%)			.602
Female	14 (46.7)	12 (40)	
Male	16 (53.3)	18 (60)	
BMI, kg/cm², mean (SD)	28.1 (5.14)	29.2 (4.48)	.370
Pacemaker duration, months, mean (SD)	45 (49.4)	–	–
Dominant extremity, n (%)			.432
Right	30 (100)	28 (96.7)	
Left	0 (0)	2 (3.3)	
Educational status, n (%)			.003*
Primary school	24 (80)*	10 (33.3)*	
Middle school	1 (3.3)	4 (13.3)	
High school	2 (6.7)	7 (23.3)	
University	3 (10)	9 (30)	

*Statistically significant difference; P < .05
BMI, body mass index; CPM, cardiac pacemaker group.

Table 2. The Primary and Secondary Outcome Scores and Comparisons of the Groups

	CPM Group n = 30	Control Group n = 30	Group Comparison Test Statistic	–
Primary outcome				
Tampa score, mean (SD)	41.7 (4.84)	40.0 (4.55)	F (1, 57) = 3.66, *P* = .061, η^2 = 0.060	–
Secondary outcomes			Group × Side interaction	Post-hoc group comparison of left shoulder joints Test statistic
Flexion, mean (SD)			F (1, 57) = 2.46, *P* = .123, η^2 = 0.043	
Right	174.6 (7.30)	173.3 (4.49)		–
Left	168 (8.05)	175 (6.29)		
Extension, mean (SD)			F (1, 57) = 0.94, *P* = .337, η^2 = 0.016	–
Right	45 (0)	44.5 (2.73)		
Left	41.8 (7.48)	43.5 (4.57)		
Abduction, mean (SD)			F (1, 57) = 0.45, *P* = .503, η^2 = 0.008	–
Right	175 (7.76)	178.6(3.45)		
Left	168.6 (8.19)	173.1 (24.7)		
Adduction, mean (SD)			F (1, 57) = 1.23, *P* = .271, η^2 = 0.021	–
Right	45 (0)	44.5 (2.73)		
Left	43.3 (6.34)	44.5 (2.73)		
External rotation, mean (SD)			F (1, 57) = 2.46, *P* = .122, η^2 = 0.041	–
Right	89 (4.02)	88.3 (5.30)		
Left	84.1 (11.6)	87.6 (6.26)		
Internal rotation, mean (SD)			F (1, 57) = 4.37, *P* = .041, η^2 = 0.071	*t* (47.97) = −2.22, *P* = .031, *d* = 0.58
Right	84.3 (9.35)	84.6 (8.19)		
Left	77.6 (14.0)	84.3 (8.58)		
QuickDASH score, mean (SD)			F (1, 57) = 7.90, *P* = .007, η^2 = 0.122	*t* (58) = 1.18, *P* = .242, *d* = 0.31
Right	17.5 (16.7)	17.0 (17.8)		
Left	23.4 (19.1)	17.7 (18.0)		
			Gender × Group × Side interaction	
Hand grip, mean (SD)			F(1, 55) = 1.674, *P* = .201, η^2 = 0.030	–
Female				
Right	19.9 (4.82)	20.1 (7.33)		
Left	18.6 (4.32)	26.8 (21.5)		
Male				
Right	28.2 (7.31)	49.2 (76.8)		
Left	35.6 (35.8)	29.7 (6.9)		

CPM, cardiac pacemaker group.

whereas no significant between-group difference was observed for the left upper limb. No significant between-group differences were found for left shoulder flexion, extension, abduction, adduction, external rotation, HGS, or left-sided QuickDASH scores. These findings are summarized in Table 2. In the subgroup analysis, a significant group

Table 3. Subgroup Analysis Based on Pacemaker Implantation Duration

	Pacemaker ≤23.5 Months n=15	Pacemaker >23.5 Months n=15	Control Group n=30	Group Comparison Test Statistic	–
Primary outcome					
Tampa score, mean (SD)	40.7 (4.90)	42.4 (5.50)	40.0 (4.55)	F (2, 55) = 2.12, *P* = .129, η^2 = 0.070	–
Secondary outcomes				Group × Side interaction	Post-hoc group comparison of left shoulder joints Test statistic
Internal rotation, mean (SD)				F (2, 56) = 2.72, *P* = .074, η^2 = 0.089	–
Right	85.3 (9.90)	83.3 (8.9)	84.6 (8.19)		
Left	80.6 (10.9)	74.6 (16.6)	84.3 (8.58)		
QuickDASH score, mean (SD)				F (2,56) = 3.89, *P* = .026, η^2 = 0.122	F (2.56) = 1.627, *P* = .206, η^2 = 0.055
Right	12.1 (9.54)	22.8 (20.7)	17.0 (17.8)		
Left	18.1 (12.0)	28.6 (23.6)	17.7 (18.0)		

*Age was controlled as a covariate.
CPM, cardiac pacemaker group.

× side interaction was observed only for QuickDASH scores (F (2, 56) = 3.89, P = .026, partial η^2 = 0.122). However, post-hoc analyses revealed that this interaction was also driven by significant right–left differences within the pacemaker subgroups rather than by differences between groups (Table 3).

DISCUSSION

This study aimed to compare kinesiophobia, shoulder ROM, functional disability, and HGS between patients with cardiac pacemakers and those with stable CAD. Kinesiophobia levels were similarly elevated in both groups, whereas only a selective limitation in shoulder internal rotation was observed between the groups. Although the pacemaker group was older than the CAD group, age was included as a covariate in all analyses. The persistence of selective internal rotation limitation after adjustment suggests that this finding is unlikely to be explained by age alone. Educational status also differed between groups; however, its independent effect on kinesiophobia or upper limb function was beyond the scope of this study.

The absence of a statistically significant difference in TSK-Heart scores between the pacemaker and CAD groups is noteworthy because both groups exhibited elevated levels of kinesiophobia. This finding was consistent with the meta-analysis by Liu et al,[25] which demonstrated that kinesiophobia was prevalent across cardiac populations, including patients with CAD, heart failure, and atrial fibrillation, and with the study by Baykal Şahin et al,[26] showing high baseline kinesiophobia in patients with CAD that improved after exercise-based rehabilitation. These findings suggest that elevated kinesiophobia reflects a general cardiac-related fear-avoidance response and highlight the importance of addressing kinesiophobia in both pacemaker and CAD populations, regardless of device implantation status.[27]

The selective limitation of shoulder internal rotation observed in the pacemaker group represents a key finding of the present study. Due to the anatomic proximity of the pacemaker pocket to the subscapularis and pectoralis major muscles, internal rotation—predominantly mediated by these muscles—may be notably vulnerable to local fibrosis, increased soft tissue rigidity, and compensatory movement patterns post-implantation. In contrast, shoulder flexion and abduction can be more readily compensated by scapulothoracic motion and accessory musculature, potentially explaining their relative preservation. This finding partially aligns with reports describing impairments in flexion, abduction, and internal rotation, but conflicts with studies demonstrating either predominant limitations in flexion/abduction or no significant side-related ROM differences.[2,28-33]Such discrepancies may reflect heterogeneity in patient- and device-related characteristics.

QuickDASH scores did not differ significantly between the pacemaker and control groups. This finding is consistent with reports showing no group-level differences between pacemaker recipients and healthy controls, but other studies have described mild or task-specific functional impairments in patients with more complex cardiac devices despite non-significant global QuickDASH scores.[2,3,28,29,34] Such variability may be related to device type and task-related demands. In addition, QuickDASH may lack sensitivity for detecting subtle or subclinical dysfunctions, particularly when compensatory strategies are present.[24]

Handgrip strength did not significantly differ between patients with cardiac pacemakers and those with CAD. This finding is consistent with studies reporting no marked reduction in HGS among older pacemaker recipients or patients with stable CAD and preserved cardiac function, despite its prognostic relevance when considered alongside frailty parameters.[35,36] In contrast, investigations in cardiac populations with reduced ejection fraction or acute decompensated states demonstrated that lower HGS was associated with malnutrition and increased short-term mortality.[37,38] Collectively, these findings suggest that pacemaker implantation or coronary pathology alone may not substantially impair peripheral muscle strength in the absence of advanced functional decline, and that the preserved systolic function and the good functional capacity of the sample may have contributed to the lack of intergroup differences in HGS.

A major strength of this study is its methodological rigor and strong internal validity. Almost all participants were right-hand-dominant and had standard left-sided pacemakers, and individuals with ICDs or CRTs were excluded, thereby minimizing confounding related to device type, implantation side, and limb dominance. The multidimensional assessment provides a comprehensive perspective on the musculoskeletal implications of pacemaker implantation and using patients with stable CAD as controls enables a clinically relevant comparison. To the best of current knowledge, this is the first comparative evaluation of kinesiophobia in pacemaker recipients.

Study Limitations

This study has several limitations. First, its cross-sectional design precludes causal inferences regarding the relationship between pacemaker implantation and upper limb dysfunction. Second, although group × side interaction effects were observed in secondary outcome analyses, the study was powered for the primary outcome (kinesiophobia) and may have been underpowered to detect small between-group differences in secondary outcomes (shoulder ROM, upper limb function, and HGS) as well as in exploratory subgroup analyses by pacemaker duration, which were additionally limited by small sample sizes within duration categories. Accordingly, non-significant findings in these outcomes should be interpreted with caution because they may reflect a potential Type II error. Moreover, advanced imaging modalities were not routinely performed to exclude subclinical shoulder pathology, which may have allowed occult abnormalities to remain undetected. Finally, the inclusion of only patients with preserved left ventricular systolic function may limit the generalizability of the findings.

CONCLUSION

Kinesiophobia was similarly elevated in pacemaker recipients and patients with CAD, suggesting a general cardiac-related response rather than being attributable to device implantation per se. Notably, the findings also point to a potential tendency toward reduced shoulder internal rotation in pacemaker recipients, reinforcing the value of early musculoskeletal assessment and patient education during routine follow-up. Longitudinal studies are warranted to clarify the persistence, determinants, and functional impact of these findings across stratified CIED populations.

Ethics Committee Approval: The study protocol was approved by the Non-Interventional Clinical Research Ethics Committee of İzmir City Hospital (Decision date: July 10, 2024; No: 2024/68) and conducted in accordance with the ethical principles of the Declaration of Helsinki.

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