Clinical Transplantation

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Clinical TRANSPLANTATION
The Journal of Clinical and Translational Research

ORIGINAL ARTICLE OPEN ACCESS

Evaluating the Relationship Between Medication Adherence, Dietary Practices, and Physical Activity in Heart Transplant Recipients

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Received: 8 January 2025 | **Revised:** 31 January 2025 | **Accepted:** 19 February 2025

Funding: The authors received no specific funding for this work.

Keywords: dietary practices | habits | heart transplantation | medication adherence | physical activity

ABSTRACT

Introduction: Medication adherence is critical to improve quality of life, reduce transplant-related complications, and increase survival. Nonadherent health behaviors after heart transplantation lead to increased morbidity and mortality, decreased quality of life, increased medical costs, and overuse of healthcare services in heart transplant patients (HTR).

This study examined the relationship between heart transplant recipients' medication adherence, dietary practices, and physical activity.

Methods: This cross-sectional study was conducted at a university hospital's Heart and Lung Transplant Outpatient Clinic. The sample included adult HTR who had undergone transplantation at least 6 months prior. Data were collected using the Basel Assessment of Adherence to Immunosuppressive Medication Scale, a Nutritional Behaviors Questionnaire, and the International Physical Activity Questionnaire Short Form Statistical analyses using SPSS 24.0, with significance set at $p < 0.05$.

Results: Among 70 participants, 42.85% were non-adherent to immunosuppressive medications. Factors influencing adherence included age and time since transplantation. Dietary assessments revealed that while most patients practiced washing fruits and vegetables, adherence to other food safety measures was low. Physical activity levels indicated that 50% of participants were physically inactive, with high body mass index significantly correlating with lower activity levels. Patients with medication adherence had higher physical activity levels.

Conclusion: The study highlights the critical need for targeted interventions to improve medication adherence, dietary practices, and physical activity among HTR. Addressing these factors is essential for enhancing patient outcomes, reducing morbidity and mortality, and improving quality of life posttransplant. Further research is warranted to explore the barriers and facilitators influencing these health behaviors in diverse populations.

1 | Introduction

Heart transplantation is the best treatment for advanced end-stage heart failure. The World Center for Organ Transplantation and Donation reported that in 2021, 8409 heart transplants were performed worldwide, with 2350 of these occurring in Europe [[1]. Median survival for adult Heart Transplant Recipients (HTR) is reported to be approximately 10.7–12.2 years. Survival rates

are reported to be 82% at 1 year, decreasing to 69% at 5 years [2]. According to the International Society of Heart and Lung Transplantation report, the causes of death ($n = 270$) in patients transplanted for hypertrophic cardiomyopathy in 1995–2018 were graft failure 28.5%, infection 25.6%, multiple organ failure 17.4% in the first 1 year; graft failure 34.2%, malignancy 15. 8%, and acute rejection 11.8%; after 5 years, graft failure was 30.5%, malignancy 24.1%, and infection 12.1% [3]. In particular, rejection and infection are important and preventable causes of death. Appropriate use of immunosuppressive medications after heart transplantation prevents rejection and reduces the side effects of infection [4].

HTR receive lifelong immunosuppressive medications to prevent rejection. Adherence to immunosuppressive medications is critical for preventing rejection in solid organ transplant recipients and maintaining graft survival, one of the most vital outcomes of transplantation [5, 6]. Medication nonadherence in organ transplant recipients is defined as forgetting or taking the wrong medication at least once a month or taking the medication 2 or 3 h late at least once a month. Medication nonadherence includes not taking the correct dose every day or at the correct time, not starting the medication, and not taking the medication for the prescribed duration [5, 7]. Many studies have shown that nonadherence to immunosuppressive medications is a significant problem among solid organ recipients [8–11]. In a study covering four continents, 11 countries, and 36 transplant centers ($n = 1397$), non-adherence with immunosuppressive medications was found to be 34% among HTR [12].

Despite careful patient management, blood pressure and lipid levels often rise after transplantation. Five years after heart transplantation, the combined incidence of hyperlipidemia and hypertension approaches 92% and 88%, respectively [13]. Exercise and dietary adherence play an important role in preventing and managing cardiovascular disease. It has been reported that healthy eating habits should be established and maintained after heart transplantation. HTR are advised to consume a variety of fruits and vegetables, whole grains, healthy protein sources (mostly plant, fish and seafood, low-fat or fat-free dairy products, and lean meats), liquid vegetable oils, low-salt, or salt-free foods [14]. In addition, safe food and water consumption is important for preventing diet-related infections [15]. The incidence of documented foodborne infections in solid organ transplant recipients was reported to be 17.9% 5 years after transplantation, and these infections occurred only in patients who did not follow food safety recommendations [16]. Studies on dietary practices in HTR are limited, and one study found that patients lacked knowledge about safe food choices, and one-third consumed foods that were not recommended [17]. Therefore, assessing patients' dietary habits is important to prevent diet-related morbidity. In addition to a healthy diet, HTR are encouraged to be physically active. Exercise-based cardiac rehabilitation has been shown to reduce readmission rates in one year. For long-term cardiovascular health, 150 min of moderate-intensity exercise per week or 75 min of vigorous-intensity aerobic exercise per week are recommended [18]. A meta-analysis confirmed the effectiveness of exercise-based rehabilitation on oxygen consumption (peak VO_2) [19]. Moderate exercise increases peak heart rate, skeletal muscle oxidative capacity, blood pressure, endothelial function, and quality of life [20].

Nonadherent health behaviors after heart transplantation lead to increased morbidity and mortality, decreased quality of life, increased medical costs, and overuse of healthcare services in transplant patients [8]. Therefore, medication adherence (MA) is critical to improve quality of life, reduce transplant-related complications, and increase survival. Medication nonadherence is a global problem that must be investigated in each culture. A literature review did not identify a study that examined dietary practices, and physical activity in the context of MA in HTR. This study was designed to shed light on healthcare professionals managing the posttransplant process in HTR. This study aimed to examine the relationship between MA, diet, and physical activity in HTR.

2 | Methods

2.1 | Study Design

This is a cross-sectional and predictive study.

2.2 | Sample and Setting

The study was conducted in the Heart and Lung Transplant Outpatient Clinic of a university hospital's Department of Cardiovascular Surgery. It is one of 14 heart transplant centers in the country and the largest heart transplant center in the region. Many patients from outside the city also receive follow-up care at the center. If they have no problems, patients return to the outpatient clinic every 6 months for the long term after discharge.

Adult patients who underwent heart transplantation at this center and met the sampling criteria were included in the sample. In the sample size calculation, based on the regression analysis, which included five variables in the study of Shemesh et al. [21], the regression coefficient was 0.17, and the effect size was calculated as 0.20. With $\alpha = 0.05$ and 95% power, the required sample size was determined as 55 [21]. One hundred seventeen patients are being followed up at the center. At the end of the study, in the power analysis based on the difference in body mass index (BMI) according to the physical activity level in the Gpower 3.1 program, the effect size was calculated as 0.65, and the sampling power was calculated as 88%. Inclusion criteria: consent to participate in the study, at least 6 months posttransplant, over 18 years of age, literate, no hearing problem, no psychiatric diagnosis. Exclusion criteria: multiple organ transplantation and hospitalization.

2.3 | Data Collection

Data were collected face-to-face at the Heart and Lung Transplant Outpatient Clinic between November 2023 and November 2024, using the Sociodemographic-Clinical Characteristics Form, the Basel Assessment of Adherence to Immunosuppressive Medication Scale (BAASIS), the Nutritional Behaviors Questionnaire, and the International Physical Activity Questionnaire Short Form (IPSA).

2.3.1 | Sociodemographic-Clinical Characteristics Form

This was used to determine the sociodemographic and clinical characteristics of the patients. This form included questions about age, sex, marital status, educational status, employment status, date of transplantation, etiology of transplantation, medications used, occupation, smoking and alcohol use, financial status, chronic disease status, and number of medications used [7, 8, 12].

2.3.2 | The Basel Assessment of Adherence to Immunosuppressive Medication Scale (BAASIS)

A four-item questionnaire developed by **the Leuven-Basel Adherence Research Group** that assesses nonadherence to immunosuppressive medications over the past 4 weeks [22]. It examines medication nonadherence, medication holidays, timing of nonadherence, and dose reductions. The scale requires the patient to answer "yes" or "no" to each question. If the patient answers "yes" to the first and second questions, they are also asked to rate their answers as "one, two, three, four, and more than four." Answers are scored on a six-point scale (never, once a month, once every two weeks, once a week, more than once a week, and every day). Patients with any deviation from "never" in the four questions are considered nonadherent. Questions 1a, 1b, 2, and 3 assess the implementation and regularity of medication administration. Question 4 evaluates the continuation or discontinuation of immunosuppressive therapy. All questions begin with Yes/No. A "Yes" answer to questions 1a, 1b, or 2 requires a 5-point score for implementation issues. Question 1b is only answered if question 1a is answered Yes. A Yes response to questions 1a, 1b, 2, or 3 indicates an implementation problem, while a Yes response to question 4 indicates that immunosuppressive therapy has been discontinued. The Turkish validity and reliability of the scale was conducted by Oruc et al. The transculturally adapted questionnaire has a kappa coefficient of 0.915, indicating excellent reliability, and a Cronbach's alpha coefficient of 0.454, which demonstrates acceptable internal consistency. For construct validity, the factor loadings for questions 1a, 1b, 2, 3, and 4 are 0.756, 0.779, 0.829, 0.393, and 0.032, respectively [23].Permission for the scale was obtained from Sabina De Geest via email.

2.3.3 | Questionnaire on Dietary Practices

This form was prepared by the researchers. It consists of questions about food safety and healthy eating, considering the foods patients should avoid according to the American Transplantation Infectious Diseases Society guidelines for safe living strategies after solid organ transplantation and the American Heart Association guidelines [14, 15]. There are 15 questions about preventing foodborne infections and healthy diet headings. Regarding the prevention of foodborne infections, habits such as washing vegetables and fruits, wearing gloves when preparing raw meat, eating raw foods, eating canned foods, washing canned foods before opening, drinking unpasteurized milk or dairy products, eating delicatessen products, eating salads in restaurants, and eating food and beverages sold in the open are asked [24]. Healthy dietary habits are those that support a healthy lifestyle, such as consumption of low-fat or fat-free milk and yogurt, consumption of animal fats containing saturated fats, daily consumption of fruits and vegetables, daily consumption of 1.5 L of water, low-salt diet, and consumption of whole grains [14, 15]. To ensure content validity, the opinions of five experts—three academicians specializing in surgical nursing—were obtained. The content validity index (CVI) and content validity ratio (CVR) were calculated using Lawshe and Davis's method. Following the expert evaluations, the CVI and CVR of the questionnaire were found to be 1.0

2.3.4 | The International Physical Activity Questionnaire Short Form (IPAQ)

It was developed as a short and long-form to assess physical activity and sedentary behavior in adults. The international validity and reliability studies of this questionnaire were conducted by Craig et al. [25]. The criterion for physical activity in the IPAQ was to perform at least 10 min of physical activity at a time. The questionnaire was adapted into Turkish by Saglam et al. Criterion validity of the short version of the IPAQ was found to be 0.30. The test-retest reliability coefficient was 0.69 [26]. The duration of vigorous physical activity, moderate physical activity, walking, and sitting for one day in the last 7 days was assessed with the questionnaire. Durations are multiplied by the known metabolic equivalents (METs) for each activity, and the results are summed to obtain the overall physical activity score. The total physical activity score (MET-min/week) is calculated by converting vigorous, moderate, and walking times into METs, corresponding to the basal metabolic rate (1 MET = 3.5 mL/kg/min) using the following calculations. TFAS < 600 METs is defined as "not physically active," TFAS 600-3000 METs as "low level of activity," and TFAS 3000 METs as "adequate level of physical activity" [26, 27].

2.4 | Data Analysis

The SPPS 24.0 package was used to analyze the study. Number and percentage analyses were used for descriptive characteristics. Kolmogorov–Smirnov, Shapiro–Wilk, and kurtosis–skewness tests assessed the normal distribution of the data. As a result of the analysis, parametric and nonparametric tests were used in case some of the data were not normally distributed. The significance level was set at $p < 0.05$. The significance test of the difference between two means in independent groups was evaluated with the t-test when the variables were normally distributed and the Mann–Whitney U test when the variables were not normally distributed. The chi-squared test was used to analyze categorical data. Binary logistic regression analysis analyzed factors predicting MA and physical activity.

2.5 | Ethics

Ethical permission was obtained from the non-interventional ethics committees of a University Research and Application Hospital (Number: 8458-GOA Date: 29.11.2023) and written permission from the Department of Cardiovascular Surgery, where the study was conducted. In addition, informed consent was obtained from the patients who agreed to participate in the study.

3 | Results

The mean age of the patients included in the study was 48.25 ± 14.54 years, 71.28% (n = 50) were male, and the mean time since transplantation was 11.35 ± 4.53 years. The most common etiology of heart transplantation was dilated cardiomyopathy (77.14%), followed by ischemic cardiomyopathy (15.71%), hypertrophic cardiomyopathy (4.28%), and arrhythmogenic right ventricular cardiomyopathy (2.87%). The proportion of patients not living alone was 78.54% (n = 55) and the proportion of patients not working was 67.14% (n = 47). The mean number of chronic diseases was 2.60 ± 1.18, and hyperlipidemia (75.71%, n = 53) and hypertension (57.14%, n = 40) were the most common chronic diseases in HTR (Table 1). Among the patients, 4.25% (n = 3) smoked and 5.71% (n = 4) consumed alcohol.

The mean number of immunosuppressive medications in HTR was 1.65 ± 0.58, and the three most commonly used immunosuppressive medications were tacrolimus (94.28%, n = 66), mycophenolate mofetil (47.14%, n = 33), and everolimus (15.71%, n = 11). Among the medications continuously used for other chronic diseases in the heart transplant group, the most common were statins (75.71%, n = 53), antihypertensives (57.14%, n = 40), proton pump inhibitors (43.03%, n = 28), antidiabetics (21.46%, n = 15), and antithrombotics (aspirin) (15.71%, n = 11).

It was found that 42.85% (n = 30) of HTR were nonadherent to immunosuppressive medications (Figure 1). All non-adherent patients had problems with adherence, and no patients discontinued medication.

The dietary behaviors of HTR are shown in Table 2. When examining the protective behaviors of HTR against diet-induced infections, the most common behavior was washing vegetables and fruits, while the least common behavior was wearing gloves when handling raw meat. Regarding healthy eating, daily consumption of fruits and vegetables and daily consumption of 1.5 L of water were the two dietary behaviors to which patients paid the most attention (Table 2). Patients living alone had a lower rate of not consuming unpasteurized milk/dairy products (X^2 = 4.56, p = 0.04). Patients living alone were less likely to consume low-fat/skim milk/yogurt (X^2 = 5.01, p = 0.03). Patients with a higher total number of medications had a higher rate of not eating salad in cafes or restaurants (U = 387.50, p = 0.03). There was a difference in daily fruit and vegetable consumption according to age, and the mean age of patients who consumed fruit was statistically significantly higher (U = 260.00, p = 0.01). There was a difference in daily water consumption of 1.5 L according to education level, with primary school graduates having the lowest rate. Patients living alone had a statistically higher salt consumption rate (X^2 = 6.62, p = 0.01) (Table 3).

When MA of HTR was analyzed according to sociodemographic clinical characteristics, working patients and younger patients had significantly lower MA (Table 3).

The mean MET min/week was 1062.52 ± 1277.629 (min–max = 0–8106). Patients were divided into three groups according to mean MET min/week. The distribution of recipients according to physical activity categories was as follows: category 1 (physically

TABLE 1 | Sociodemographic and clinical characteristics of heart transplant recipients (n = 70).

Variables	$\bar{X}\bar{X}$ ± SD (min–max)
Age (years)	48.25 ± 14.54 (19–72)
Time since transplant (years)	11.35 ± 4.53 (1.95–19.93)
Total number of chronic diseases	2.02 ± 1.06 (0–6)
Number of immunosuppressive medications	1.65 ± 0.58 (1–3)
Number of total medications	4.25 ± 1.49 (2–9)
Body mass index	26.08 ± 2.93 (18.70–34.48)
	n (%)
Gender	
Male	50 (71.43)
Female	20 (28.57
Living alone	
Yes	15 (21.46)
No	55 (78.54)
Education	
Primary education	26 (37.14)
High school	22 (31.43)
Bachelor's degree	22 (31.43)
Employment status	
Full-time employee	16 (22.85)
Part-time employee	7 (10.01)
Unemployed	47 (67.14)
Perceived income	
Income exceeds expenses	17 (24.28)
Income equals expenses	16 (22.85)
Income is less than expenses	37 (52.87)
Body mass index (BMI)	
18.5–24.9	26 (37.14)
25–29.9	35 (50.00)
30–34.9	9 (12.86)
Rejection	
Yes	13 (18.58)
No	57 (81.42)
Chronic Diseases[a]	
Hypertension	40 (57.14)
Diabetes mellitus	15 (21.46)
Hyperlipidemia	53 (75.71)
Coronary artery disease	11 (15.71)
Other chronic diseases[b]	15 (21.46)

[a]A patient may have more than one chronic disease.
[b]Hypothyroidism, depression, dysrhythmia, kidney failure, cancer (bladder and skin).

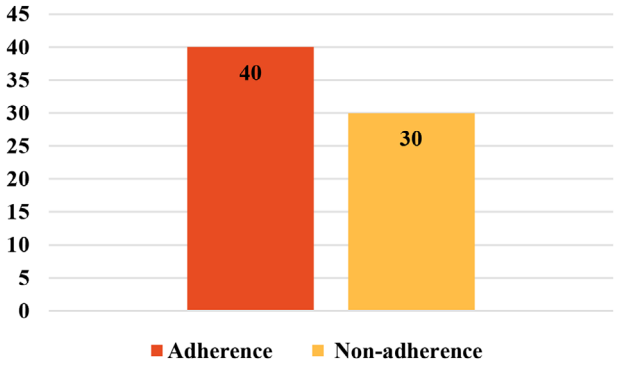

FIGURE 1 | Medication adherence among heart transplant recipients.

TABLE 2 | Investigation of dietary practices of heart transplant recipients ($n = 70$).

Dietary practices	Yes	No
Nutrition hygiene	*n* (%)	*n* (%)
Washing vegetables and fruits	67 (95.71)	3 (4.29)
Using gloves when handling raw meat	18 (25.71)	52 (74.29)
Avoiding raw food consumption	44 (62.85)	26 (37.15)
Avoiding canned food consumption	37 (52.85)	33 (47.15)
Washing lids of canned foods before opening	41 (58.57)	29 (41.43)
Avoiding unpasteurized milk/dairy products	31 (44.28)	39 (55.72)
Avoiding deli meats	22 (31.42)	48 (68.58)
Avoiding salads at cafes or restaurants	24 (34.28)	46 (65.72)
Avoiding street food consumption	40 (57.14)	30 (42.86)
Healthy nutritional behaviors		
Consuming low-fat or non-fat milk/yogurt	41 (58.57)	29 (41.43)
Avoiding saturated animal fats	38 (54.28)	32 (45.72)
Daily consumption of vegetables and fruits	54 (77.14)	16 (22.86)
Drinking at least 1.5 L of water daily	54 (77.14)	16 (22.86)
Following a low-sodium diet	51 (72.85)	19 (27.15)
Consuming whole-grain foods	23 (32.85)	47 (67.15)

inactive, $n = 35$, 50%), category 2 (low activity, $n = 32$, 46.00%), and category 3 (adequate activity, $n = 3$, 4%) (Figure 2). There was a difference between the physical activity levels according to the time elapsed after transplantation; the duration of transplantation was 12.44 ± 4.13 years in physically inactive patients and 10.26 ± 4.71 years in patients with low physical activity. Patients with high BMI had lower physical activity levels ($t = 2.69$, $p = 0.009$) (Table 3).

In the binary logistic regression analysis, age and time since transplantation explained 25% of the MA; age influenced MA 0.04-fold, and time since transplantation 0.15-fold ($p = 0.003$) (Table 4). The logistic regression model, including factors influencing physical activity, was significant ($R = 0.280$, $R^2 = 0.210$, $p = 0.02$). However, when individual factors were analyzed: Age ($B = -0.004$, $p = 0.86$), time since transplantation ($B = -0.06$, $p = 0.33$), total number of medications ($B = -0.29$, $p = 0.34$), living alone ($B = -0.34$, $p = 0.64$), employment status ($B = -0.01$, $p = 0.98$), and education level ($B = -1.25$, $p = 0.05$) did not significantly affect physical activity ($p > 0.05$). On the other hand, BMI ($B = -0.26$, $p = 0.01$) was an important factor influencing physical activity. It was found that BMI was effective in explaining physical activity level, high BMI decreased physical activity level by 0.26 times, and BMI alone explained 21% of physical activity.

This study analyzed the impact of MA and physical activity on patients' healthy eating habits. The results showed that MA did not significantly influence patients' healthy eating behaviors. There were no significant differences between adherent and non-adherent patients in terms of their consumption of low-fat or non-fat milk/yogurt ($X^2 = 1.59$, $p = 0.23$), avoidance of saturated animal fats ($X^2 = 1.73$, $p = 0.18$), daily intake of vegetables and fruits ($X^2 = 0.43$, $p = 0.51$), daily water consumption ($X^2 = 1.51$, $p = 0.21$), adherence to a low-sodium diet ($X^2 = 2.40$, $p = 0.17$), and consumption of whole-grain foods ($X^2 = 0.19$, $p = 0.65$). However, significant differences were found in the physical activity scores between adherent and nonadherent patients. Adherent patients had significantly higher physical activity scores (1324.02 ± 1581.31) compared to non-adherent patients (731.28 ± 614.62), with this difference being statistically significant ($t = 2.11$, $p = 0.03$). Additionally, physical activity did not significantly affect patients' healthy eating habits. No significant differences were observed between physically active and inactive patients regarding their consumption of low-fat or non-fat milk/yogurt ($X^2 = 0.53$, $p = 0.46$), avoidance of saturated animal fats ($X^2 = 0.92$, $p = 0.33$), daily intake of vegetables and fruits ($X^2 = 0.00$, $p = 1.00$), daily water consumption ($X^2 = 1.29$, $p = 0.25$), adherence to a low-sodium diet ($X^2 = 0.07$, $p = 0.78$), and consumption of whole-grain foods ($X^2 = 0.06$, $p = 0.79$).

4 | Discussion

This study examined HTR' immunosuppressive MA, physical activity, and dietary behaviors. It was found that 42.85% of HTRs were non-adherent to immunosuppressive medications. It was determined that patients had problems taking the medication and did not stop using the medication. Another study found that the rate of medication non-adherence in HTR was 27.6% and that medication non-adherence increased with age [17]. Another study using BAASIS ($n = 60$) reported that medication nonadherence in

TABLE 3 | Investigation of medication adherence, nutritional behaviors, and physical activity in heart transplant recipients according to selected variables.

			Nutrition hygiene							Healthy nutritional behaviors					
	Medication adherence	**Physical activity**	**Using gloves when handling raw meat**	**Avoiding raw food consumption**	**Avoiding canned food consumption**	**Avoiding unpasteurized milk/dairy products**	**Avoiding deli meats**	**Avoiding salads at cafes or restaurants**	**Avoiding street food consumption**	**Consuming low-fat or non-fat milk/yogurt**	**Avoiding saturated animal fats**	**Daily consumption of vegetables and fruits**	**Drinking at least 1.5 L of water daily**	**Following a low-sodium diet**	**Consuming whole-grain foods**
Age (years)	***t* = 2.10, *p* = 0.04**	$t = 1.37$, $p = 0.17$	$U = 396.50$, $p = 0.33$	$U = 566.50$, $p = 0.94$	$U = 455.50$, $p = 0.06$	$t = 0.85$, $p = 0.39$	$U = 435.50$, $p = 0.23$	$U = 548.00$, $p = 0.96$	$t = -1.90$, $p = 0.05$	$U = 556.00$, $p = 0.64$	$U = 476.00$, $p = 0.12$	***U* = 260.00, *p* = 0.01**	$U = 297.00$, $p = 0.05$	$U = 467.00$, $p = 0.81$	$U = 488.500$, $p = 0.51$
Time since transplant (years)	$t = -1.63$, $p = 0.11$	***t* = 2.05, *p* = 0.04**	$U = 433.50$, $p = 0.64$	$U = 567.00$, $p = 0.95$	$U = 519.50$, $p = 0.28$	$t = 0.52$, $p = 0.61$	$U = 525.50$, $p = 0.97$	$U = 500.50$, $p = 0.52$	$t = -1.19$, $p = 0.84$	$U = 565.50$, $p = 0.72$	$U = 445.00$, $p = 0.05$	$U = 405.50$, $p = 0.71$	$U = 295.500$, $p = 0.05$	$U = 457.50$, $p = 0.72$	$U = 446.500$, $p = 0.24$
Total number of medications	$T = -0.51$, $p = 0.60$	$t = 0.96$ $p = 0.34$	$U = 335.50$ $p = 0.06$	$U = 497.00$ $p = 0.34$	$U = 510.50$ $p = 0.22$	$t = 0.15$, $p = 0.87$	$U = 525.50$ $p = 0.97$	***U* = 387.50, *p* = 0.03**	$t = -0.11$, $p = 0.90$	$U = 574.00$ $p = 0.79$	$U = 600.00$, $p = 0.92$	$U = 411.00$, $p = 0.76$	$U = 424.50$, $p = 0.91$	$U = 465.00$, $p = 0.78$	$U = 401.00$, $p = 0.06$
Number of immunosuppressive medications	$t = -0.11$, $p = 0.90$	$t = -1.64$, $p = 0.10$	$U = 420.00$, $p = 0.46$	$U = 515.00$, $p = 0.43$	$U = 553.50$, $p = 0.44$	$t = -0.25$, $p = 0.79$	$U = 519.00$, $p = 0.89$	$U = 408.00$, $p = 0.04$	$t = -0.11$, $p = 0.90$	$U = 489.50$, $p = 0.15$	$U = 518.00$, $p = 0.22$	$U = 375.00$, $p = 0.46$	$U = 393.00$, $p = 0.53$	$U = 433.500$, $p = 0.44$	$U = 453.500$, 0.21
Body mass index	$t = -1.49$, $p = 0.12$	***t* = 2.69, *p* = 0.009**	$U = 402.50$, $p = 0.37$	$U = 451.50$, $p = 0.14$	$U = 567.50$, $p = 0.61$	$t = 1.12$, $p = 0.26$	$U = 467.00$, $p = 0.44$	$U = 529.00$, $p = 0.77$	$t = -1.51$, $p = 0.13$	$U = 549.500$, $p = 0.59$	$U = 605.000$, $p = 0.97$	$U = 397.500$, $p = 0.62$	$U = 337.00$, $p = 0.18$	$U = 383.500$, $p = 0.18$	$U = 475.500$, $p = 0.41$
Gender	$X^2 = 1.89$, $p = 0.19$	$X^2 = 0.28$, $p = 0.99$	$X^2 = 0.47$, $p = 0.35$	$X^2 = 0.09$, $p = 0.78$	$X^2 = 1.85$, $p = 0.19$	$X^2 = 0.006$, $p = 1.00$	$X^2 = 0.95$, $p = 0.39$	$X^2 = 0.006$, $p = 1.00$	$X^2 = 0.58$, $p = 0.44$	$X^2 = 0.84$, $p = 0.42$	$X^2 = 0.20$, $p = 0.79$	$X^2 = 2.34$, $p = 0.20$	$X^2 = 0.14$, $p = 1.00$	$X^2 = 0.87$, $p = 0.40$	$X^2 = 0.05$, $p = 1.00$
Living alone status	$X^2 = 0.11$, $p = 0.77$	$X^2 = 0.76$, $p = 0.56$	$X^2 = 3.62$, $p = 0.09$	$X^2 = 2.40$, $p = 0.14$	$X^2 = 0.002$, $p = 1.00$	***X*² = 4.56, *p* = 0.04**	$X^2 = 0.20$, $p = 0.76$	$X^2 = 0.49$, $p = 0.55$	$X^2 = 0.06$, $p = 1.00$	***X*² = 5.01, *p* = 0.03**	$X^2 = 1.17$, $p = 0.38$	$X^2 = 0.08$, $p = 1.00$	$X^2 = 1.18$, $p = 0.27$	***X*² = 6.62, *p* = 0.01**	$X^2 = 1.43$, $p = 0.35$
Education	$X^2 = 3.46$, $p = 0.17$	$X^2 = 8.39$, $p = 0.01$	$X^2 = 3.006$, $p = 0.22$	$X^2 = 0.57$, $p = 0.75$	$X^2 = 2.97$, $p = 0.22$	$X^2 = 1.56$, $p = 0.45$	$X^2 = 1.37$, $p = 0.50$	$X^2 = 2.08$, $p = 0.35$	$X^2 = 0.09$, $p = 0.95$	$X^2 = 1.22$, $p = 0.54$	$X^2 = 4.54$, $p = 0.10$	$X^2 = 4.16$, $p = 0.12$	***X*² = 8.25, *p* = 0.01**	$X^2 = 1.62$, $p = 0.44$	$X^2 = 0.47$, $p = 0.79$
Employment status	***X*² = 6.99, *p* = 0.01**	$X^2 = 0.06$, $p = 1.00$	$X^2 = 0.52$, $p = 0.74$	$X^2 = 0.001$, $p = 1.00$	$X^2 = 0.69$, $p = 0.57$	$X^2 = 2.78$, $p = 0.15$	$X^2 = 0.35$, $p = 0.55$	$X^2 = 0.09$, $p = 0.77$	$X^2 = 0.007$, $p = 1.00$	$X^2 = 0.13$, $p = 0.78$	$X^2 = 0.15$, $p = 0.77$	$X^2 = 0.82$, $p = 0.49$	$X^2 = 0.05$, $p = 1.00$	$X^2 = 0.17$, $p = 0.75$	$X^2 = 0.58$, $p = 0.55$
Perceived income	$X^2 = 1.65$, $p = 0.43$	$X^2 = 3.80$, $p = 0.14$	$X^2 = 2.37$, $p = 0.30$	$X^2 = 0.36$, $p = 0.83$	$X^2 = 0.32$, $p = 0.85$	$X^2 = 0.72$, $p = 0.69$	$X^2 = 3.52$, $p = 0.17$	***X*² = 6.02, *p* = 0.04**	$X^2 = 0.02$, $p = 0.98$	$X^2 = 0.45$, $p = 0.79$	$X^2 = 0.47$, $p = 0.78$	$X^2 = 0.07$, $p = 0.96$	$X^2 = 3.16$, $p = 0.20$	$X^2 = 1.12$, $p = 0.56$	$X^2 = 0.36$, $p = 0.83$

Bold values indicate that the relevant statistical test is significant ($p < 0.05$).

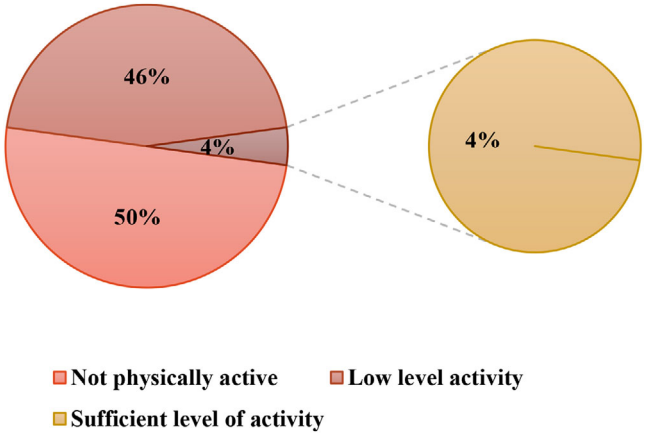

FIGURE 2 | The distribution of the heart transplant recipients according to MET categories.

TABLE 4 | Investigation of factors predicting medication adherence and physical activity in heart transplant recipients.

	Medication adherence		Physical activity	
	B	***p***	***B***	***p***
Time since transplant (years)	**−0.04**	**0.04**	−0.004	0.86
Total number of medications	**0.15**	**0.03**	−0.06	0.33
Body mass index	0.09	0.64	−0.29	0.34
Living alone status	0.15	0.13	**−0.26**	**0.01**
Education	0.25	0.71	−0.34	0.64
Employment status	−0.44	0.46	−1.25	0.05
Time since transplant (years)	0.69	0.33	−0.01	0.98
R	**0.19**		**0.28**	
R^2	**0.25**		**0.21**	
p	**0.03**		**0.02**	

Bold values indicate that the relevant statistical test is significant ($p < 0.05$).

HTR was 46.7% [11]. Another study has shown that having a heart transplant is risky due to medication incompatibility [28].

The study found that HTR were most concerned about washing fruits and vegetables to prevent infection but were not as concerned about other precautions, such as wearing gloves when handling raw meat. The most emphasized aspects of a healthy diet were adequate daily intake of fruits and vegetables and drinking at least 1.5 L of water. The rates of not consuming unpasteurized milk and dairy products and low-fat/skimmed milk and yogurt were also low among patients living alone. In addition, patients living alone were found to have lower rates of not adhering to a salt-restricted diet. Patients with more medications were more likely not to eat salad in cafes or restaurants. There was a difference in daily fruit consumption according to age, and it was found that the mean age of patients who consumed fruit was significantly higher. The educational level made a difference in daily water consumption of 1.5 L, and it was found that this rate was the lowest among primary school graduates. Notably, data on the dietary habits of HTR are limited in the literature. Practices and risk factors related to nutritional hygiene vary among studies. A study of organ transplant recipients reported that 17.7% of patients ($n = 197$) followed food safety recommendations, 22.0% avoided foods at risk of contamination, and 67.9% followed hygiene recommendations; patients within the first year of transplantation and women tended to follow food safety recommendations more strictly [16]. One study of healthy eating found that one-third of HTR ate foods not recommended [17]. Another study found that fruit, vegetable, and whole grain intake was generally lower than recommended [29]. On the other hand, differences in healthy eating behaviors among people living alone may be related to sociocultural and psychological factors, such as lack of social support and motivation, difficulties with shopping and meal preparation, or stress related to individual living arrangements. These findings suggest that individual, social, and clinical factors influence organ transplant recipients' dietary and hygiene habits and that various difficulties are encountered in adopting healthy eating habits after transplantation.

In this study, half of the HTR (50%) were physically inactive. Another study found that 58.3% of HTR exercised at least once a week [17]. In another study conducted on HTR, the mean time after HTR of 75 participants was 9.2 ± 7.0 years, 27 (36%) participants were considered extremely inactive (34.6%), and 22 (29.3%) were active. A qualitative study conducted among solid organ transplant recipients reported that the most important barriers to physical activity were comorbidities; the most common facilitators were motivation, coping, routine/habit, and goals/goal priority [30]. These findings can be interpreted as the factors determining the level of physical activity, which may vary in different populations depending on different variables such as cultural, socioeconomic, and individual health factors.

In binary logistic regression analysis, age and time since transplantation explained 25% of medication nonadherence; age and time influenced medication non-adherence 0.04 and 0.15 times, respectively. A literature review found that the MA rate in HTR varied, as did the factors that influenced it. Similar to our study, Shemesh et al. reported that medication non-adherence was higher in younger patients and longer since transplantation [21]. Although the total number of medications did not affect MA in our study, it was reported to be a valid factor in the Zhang 2020 study [8]. The daily responsibilities, work obligations, and social activities of young and working HTR may make it difficult to plan and adhere to regular medication intake. In addition, not fully realizing that medication use in the post-transplant period is a lifelong, long-term, and meticulous process may have caused these patients to not give due importance to their treatment plans and experience difficulties in MA.

It was found that high BMI decreased physical activity by 0.26 times, and BMI alone explained physical activity by 21%. Similar to this study, quadriceps strength and BMI were highlighted as factors independently associated with physical activity estimates [31]. Patient demographics, comorbidities, adverse effects of post-transplant medications, and general health status are also important in explaining these differences. Combining all these

factors may have led to this study's lower-than-expected physical activity levels.

This study found no significant impact between the participants' MA and healthy eating habits. The existing body of research on this topic is quite limited. One study revealed a positive relationship between MA, older age, and better mental quality of life but no connection to unhealthy eating habits [17]. Another study highlighted that HTRs did not adhere to a healthy diet [32]. These results suggest that MA alone may not fully explain healthy eating behaviors in heart transplant recipients.

In this research, higher levels of MA were associated with more significant physical activity among HTR. A study on solid organ transplant recipients found that high-intensity physical activity had a lower risk of health complications, and physical activity was inversely related to medication nonadherence [33]. Additionally, HTRs with more physical activity had better overall health outcomes and various health and functional measures than those with moderate or low activity levels [34]. This suggests that physically active patients might be more focused on their overall health and, as a result, more likely to follow their medication regimens.

In this study, physical activity did not significantly affect patients' healthy eating habits. Another study found that physical inactivity was associated with poor adherence to the Mediterranean diet among solid organ transplant recipients [35].Different factors influence physical activity, and for HTRs, strategies aimed at improving functional capacity and increasing motivation to exercise are likely to be the most effective in enhancing physical activity levels [36].

4.1 | Limitations

The results may be more positive because the study was conducted with HTR who attended regular check-ups. Patients with regular follow-ups may have better health outcomes, meaning better adherence rates. The results may not represent HTR, including regular outpatient follow-ups.

5 | Conclusion

In conclusion, evaluating the relationship between HTR reveals critical insights into medication, dietary practices, and physical activity. The study highlights a concerning 42.85% nonadherence rate to immunosuppressive medications. This is the first study conducted in Turkish culture using BAASIS on HTR. It was determined that patients had problems taking the medication and did not stop using the medication. Factors such as age and time since transplantation significantly influence MA, suggesting that younger and more recently transplanted patients may struggle with consistent medication management. Additionally, dietary practices show a mixed adherence to recommended guidelines, with patients demonstrating awareness of food safety but lacking in certain preventive behaviors, such as proper handling of raw meats. The findings also indicate that physical activity levels are alarmingly low, with half of the participants classified as physically inactive and BMI emerging as a significant barrier to maintaining an active lifestyle. Higher levels of MA were associated with more significant physical activity. These results underscore the necessity for targeted interventions that address the multifaceted challenges faced by HTR, including education on MA, dietary practices, and the importance of physical activity. By improving adherence to these critical health behaviors, healthcare providers can enhance HTR's quality of life and survival rates, ultimately leading to better health outcomes in this vulnerable population.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

References

1. GODT statistics. "The Global Observatory on Donation and Transplantation," December 01, 2024, https://www.transplant-observatory.org/Access.

2. C. Kourek, E. Karatzanos, S. Nanas, A. Karabinis, and S. Dimopoulos, "Exercise Training in Heart Transplantation," *World Journal of Transplantation* 11, no. 11 (2021): 466–479, https://doi.org/10.5500/wjt.v11.i11.466.

3. S. Elde, B. M. Baccouche, D. M. Mullis, et al., "Four Decades of Progress in Heart-Lung Transplantation: Two Hundred Seventy-One Cases at a Single Institution," *Journal of Thoracic and Cardiovascular Surgery* 168, no. 2 (2024): 581–592, https://doi.org/10.1016/j.jtcvs.2024.01.042.

4. J. Nelson, N. Alvey, L. Bowman, et al., "Consensus Recommendations for Use of Maintenance Immunosuppression in Solid Organ Transplantation: Endorsed by the American College of Clinical Pharmacy, American Society of Transplantation, and the International Society for Heart and Lung Transplantation," *Pharmacotherapy* 42, no. 8 (2022): 599–633, https://doi.org/10.1002/phar.2716.

5. Y. Sarigol Ordin, O. Karayurt, N. Ertan, and S. Yildiz, "Evaluation of Adherence to Immunosuppressive Treatment With Different Methods in Kidney Transplant Recipients," *Turkish Nephrology, Dialysis, and Transplantation* 27 (2018): 254–261.

6. T. Hussain, K. Nassetta, L. C. O'Dwyer, J. E. Wilcox, and S. M. Badawy, "Adherence to Immunosuppression in Adult Heart Transplant Recipients: A Systematic Review," *Transplantation Reviews* 35, no. 4 (2021): 100651, https://doi.org/10.1016/j.trre.2021.100651.

7. A. Gast and T. Mathes, "Medication Adherence Influencing Factors – An (updated) Overview of Systematic Reviews," *Systematic Reviews* 8, no. 1 (2019): 112, https://doi.org/10.1186/s13643-019-1014-8.

8. M. Zhang, H. Zhou, R. S. Nelson, et al., "Prevalence and Risk Factors of Immunosuppressant Nonadherence in Heart Transplant Recipients: A Single-Center Cross-Sectional Study," *Patient Prefer Adherence* 13 (2019): 2185–2193, https://doi.org/10.2147/PPA.S223837.

9. M. Gomis-Pastor, E. Roig Mingell, S. Mirabet Perez, et al., "Multimorbidity and Medication Complexity: New Challenges in Heart Transplantation," *Clinical Transplantation* 33, no. 10 (2019): e13682, https://doi.org/10.1111/ctr.13682.

10. B. M. Bryant, A. M. Libby, K. R. Metz, et al., "Evaluating Patient-Level Medication Regimen Complexity Over Time in Heart Transplant Recipients," *Annals of Pharmacotherapy* 50, no. 11 (2016): 926–934, https://doi.org/10.1177/1060028016657552.

11. N. V. G. Poltronieri, R. S. L. Moreira, J. Schirmer, and B. A. Roza, "Medication Non-adhErence in Heart Transplant Patients. Não Adesão Medicamentosa Nos Pacientes Transplantados Cardíacos," *Revista Da Escola De Enfermagem Da U S P* 54 (2020): e03644, https://doi.org/10.1590/S1980-220X20190092036447.

12. K. Denhaerynck, L. Berben, F. Dobbels, et al., "Multilevel Factors Are Associated With Immunosuppressant Nonadherence in Heart Transplant Recipients: The International BRIGHT Study," *American Journal of Transplantation* 18, no. 6 (2018): 1447–1460, https://doi.org/10.1111/ajt.14611.

13. L. H. Lund, L. B. Edwards, A. Y. Kucheryavaya, et al., "The Registry of the International Society for Heart and Lung Transplantation: Thirtieth Official Adult Heart Transplant Report–2013; Focus Theme: Age," *Journal of Heart and Lung Transplantation* 32, no. 10 (2013): 951–964, https://doi.org/10.1016/j.healun.2013.08.006.

14. American Heart Association, accessed November 01, 2024, https://www.heart.org/en/healthy-living/healthy-eating/eat-smart/nutrition-basics/aha-diet-and-lifestyle-recommendations.

15. R. K. Avery, M. G. Michaels, and AST Infectious Diseases Community of Practice, "Strategies for Safe Living Following Solid Organ Transplantation-Guidelines From the American Society of Transplantation Infectious Diseases Community of Practice," *Clinical Transplantation* 33, no. 9 (2019): e13519, https://doi.org/10.1111/ctr.13519.

16. M. Lindup, L. van den Bogaart, D. Golshayan, et al., "Real-Life Food-Safety Behavior and Incidence of Foodborne Infections in Solid Organ Transplant Recipients," *American Journal of Transplantation* 20, no. 5 (2020): 1424–1430, https://doi.org/10.1111/ajt.15725.

17. Y. Brocks, A. Zittermann, D. Grisse, et al., "Adherence of Heart Transplant Recipients to Prescribed Medication and Recommended Lifestyle Habits," *Progress in Transplantation* 27, no. 2 (2017): 160–166, https://doi.org/10.1177/1526924817699959.

18. A. Velleca, M. A. Shullo, K. Dhital, et al., "The International Society for Heart and Lung Transplantation (ISHLT) Guidelines for the Care of Heart Transplant Recipients," *Journal of Heart and Lung Transplantation* 42, no. 5 (2023): e1–e141, https://doi.org/10.1016/j.healun.2022.10.015.

19. L. Anderson, N. Oldridge, D. R. Thompson, et al., "Exercise-Based Cardiac Rehabilitation for Coronary Heart Disease: Cochrane Systematic Review and Meta-Analysis," *Journal of the American College of Cardiology* 67, no. 1 (2016): 1–12, https://doi.org/10.1016/j.jacc.2015.10.044.

20. C. Kugler, D. Malehsa, U. Tegtbur, et al., "Health-Related Quality of Life and Exercise Tolerance in Recipients of Heart Transplants and Left Ventricular Assist Devices: A Prospective, Comparative Study," *Journal of Heart and Lung Transplantation* 30, no. 2 (2011): 204–210, https://doi.org/10.1016/j.healun.2010.08.030.

21. Y. Shemesh, A. Peles-Bortz, Y. Peled, et al., "Feelings of Indebtedness and Guilt Toward Donor and Immunosuppressive Medication Adherence Among Heart Transplant (HTx) Patients, as Assessed in a Cross-Sectional Study With the Basel Assessment of Adherence to Immunosuppressive Medications Scale (BAASIS)," *Clinical Transplantation* 31, no. 10 (2017): e13053, https://doi.org/10.1111/ctr.13053.

22. F. Dobbels, L. Berben, S. De Geest, Transplant360 Task Force, et al., "The Psychometric Properties and Practicability of Self-Report Instruments to Identify Medication Nonadherence in Adult Transplant Patients: A Systematic Review," *Transplantation* 27, no. 2 (2010): 205–219, https://doi.org/10.1097/TP.0b013e3181e346cd.

23. A. Oruç, A. Ersoy, F. E. Can, et al., "Transculturally Adaptation and Validation of the Basel Assessment of Adherence Toimmunosuppressive Medication Scale (BAASIS©) Interview Questionnaire Among Turkish Kidney Transplant Recipients," *Turkish Journal of Nephrology* 32, no. 3 (2023): 235–240.

24. Y. Sarıgöl Ordin and B. Karakılçık, "What Are the Infection Prevention Behaviors of Kidney Transplant Recipients, and What Are the Factors Related to These?," *Journal of Clinical Nursing* (2024), https://doi.org/10.1111/jocn.17522.

25. C. L. Craig, A. L. Marshall, M. Sjöström, et al., "International Physical Activity Questionnaire: 12-Country Reliability and Validity," *Medicine and Science in Sports and Exercise* 35, no. 8 (2003): 1381–1395, https://doi.org/10.1249/01.MSS.0000078924.61453.FB.

26. M. Saglam, H. Arikan, S. Savci, et al., "International Physical Activity Questionnaire: Reliability and Validity of the Turkish Version," *Perceptual and Motor Skills* 111, no. 1 (2010): 278–284, https://doi.org/10.2466/06.08.PMS.111.4.278-284.

27. E. Gorucu and Y. Sarigol Ordin, "Investigation of Factors Affecting Weight Gain and Physical Activity in Kidney Transplant Recipients," *Revista de Nefrología, Diálisis y Trasplante* 42, no. 2 (2022): 134–143.

28. A. Hugon, M. Roustit, A. Lehmann, et al., "Influence of Intention to Adhere, Beliefs and Satisfaction About Medicines on Adherence in Solid Organ Transplant Recipients," *Transplantation* 98, no. 2 (2014): 222–228, https://doi.org/10.1097/TP.0000000000000221.

29. K. Miura, R. Yu, T. R. Entwistle, S. C. McKenzie, and A. C. Green, "Association of Diet Quality and Weight Increase in Adult Heart Transplant Recipients," *Journal of Human Nutrition and Dietetics* 37, no. 2 (2024): 408–417, https://doi.org/10.1111/jhn.13263.

30. E. J. van Adrichem, W. P. Krijnen, R. Dekker, A. V. Ranchor, P. U. Dijkstra, and C. P. van der Schans, "Multidimensional Structure of a Questionnaire to Assess Barriers to and Motivators of Physical Activity in Recipients of Solid Organ Transplantation," *Disability and Rehabilitation* 39, no. 22 (2017): 2330–2338, https://doi.org/10.1080/09638288.2016.1224274.

31. R. L. Kelly, J. R. Walsh, J. D. Paratz, S. T. Yerkovich, S. C. McKenzie, and N. R. Morris, "Quadriceps Muscle Strength and Body Mass Index Are Associated With Estimates of Physical Activity Postheart Transplantation," *Transplantation* 103, no. 6 (2019): 1253–1259, https://doi.org/10.1097/TP.0000000000002488.

32. A. Mierzyńska, A. Kokoszka, G. Jerzak-Wodzyńska, M. Sobieszczańska-Małek, T. Zieliński, and R. Piotrowicz, "Involvement in Health Behavior After Heart Transplantation: The Role of Personal Resources and Health Status. Single-Center Observational Study," *Frontiers in Psychology* 12 (2021): 710870, https://doi.org/10.3389/fpsyg.2021.710870.

33. Q. Zhao, L. Dong, L. Wang, et al., "Immunosuppressant Medication Behaviours in Solid Organ Transplant Recipients: A Cross-Sectional Study From South-Central China During COVID-19 Reopening Period," *BMJ Open* 14, no. 3 (2024): e080998, https://doi.org/10.1136/bmjopen-2023-080998.

34. I. Salas-Reguera, J. I. Rodríguez-Barbosa, P. A. Federolf, and L. Santos, "Comparative Analysis of the Health Status of Heart Transplant Patients With Different Levels of Physical Activity," *Applied Sciences* 14, no. 18 (2024): 8379, https://doi.org/10.3390/app14188379.

35. S. Gitto, L. Golfieri, F. Gabrielli, et al., "Physical Activity in Liver Transplant Recipients: A Large Multicenter Study," *Internal and Emergency Medicine* 19, no. 2 (2024): 343–352, https://doi.org/10.1007/s11739-023-03474-7.

36. E. Marques-Sule, D. Hansen, L. Almenar, et al., "What Motivates Heart Transplantation Patients to Exercise and Engage in Physical Activity? A Network Analysis," *European Journal of Cardiovascular Nursing* 23, no. 2 (2024): 137–144, https://doi.org/10.1093/eurjcn/zvad051.