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Retrospective Study of the Hungarian National Transplant Team's Cardiorespiratory Capacity

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ABSTRACT

The low availability of donor organs requires long-term successful transplantation as an accepted therapy for patients with end-stage renal and liver diseases. The health benefits of regular physical activity are well known among healthy individuals as well as patients under rehabilitation programs. Our aim was to describe the cardiorespiratory capacity of the Hungarian National Transplant Team. Twenty-five kidney ($n = 21$) or liver ($n = 4$) transplant athletes participated in this study. Maximal cardiorespiratory capacity (VO_{2max}) was measured on a treadmill with the use of gas analysis. After a resting pulmonary function test, subjects completed a vita maxima test until exhaustion. Aerobic capacity of transplant athletes was higher than the age- and sex-predicted cardiorespiratory fitness (VO_{2max}, 109.9 ± 21.7% of the predicted values; $P = .0101$). Resting respiratory function indicators exceeded 80% of predicted age- and sex-matched normal values. There were positive correlations between VO_{2max} and workload ($r^2 = 0.40$; $P = .0463$), metabolic equivalent ($r^2 = 0.72$; $P < .0001$), and oxygen pulse ($r^2 = 0.30$; $P = .0039$). However, age showed negative correlation with VO_{2max} ($r^2 = 0.32$; $P = .0031$), and there was no significant correlation between graft age and maximal oxygen consumption ($r^2 = 0.15$; $P = .4561$). Although the small amount of participants can not represent the general kidney and liver transplant population, the excellent cardiorespiratory performance suggests that a normal level of physical capacity is available after transplantation and can be even higher with regular physical activity. This favorable physiologic background leads to a state that provides proper graft oxygenization, which is an important factor in long-term graft survival.

THE PREVALENCE rates of end-stage renal disease (ESRD) [1,2] and end-stage liver disease (ESLD) [3] have increased worldwide over the past decade. Successful liver (LT) or kidney (KT) transplantation is the recognized treatment to attain complete rehabilitation, including improvement in quality of life (QOL) and life expectancy. Hungary possesses a larger donor and recipient pool as a full member of Eurotransplant. However, the imbalance between the low availability of donor organs and the number of patients on waiting lists is an ongoing problem [3,4]. Several studies have focused on the ability to precisely predict future long-term graft survival, which is vital for assessing the benefits of transplantation [5–7].

Aerobic capacity (AC) represents the physical condition of an individual and is currently considered to be the best indicator for cardiorespiratory fitness [3]. VO_{2max} is a leading fitness marker for evaluating AC and relevant to defining the functional capacity of the body to respond to an increased oxygen demand [8,9]. VO_{2max} and maximal O_{2p} are already accepted tools for risk evaluation in several transplant centers and are strongly associated with mortality after transplantation [10,11]. These indicators are

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connected with graft function and graft survival after transplantation and therefore relevant to the prognosis of transplant recipients.

However, Gitt et al (2002) reported that owing to its less subject to motivation or premature cessation, anaerobic ventilatory threshold (VO_2AT) and ventilatory efficiency (ventilation [VE] versus carbon dioxide output [VCO_2] slope), combined were found to predict survival in patients with chronic heart failure (CHF) better than VO_{2max} [12]. These methods are used to identify high-risk patients among LT candidates, which is extremely important because LT patients show mostly impaired endurance capacity, probably owing to chronic deconditioning or myopathy related to immunosuppressive medication [13–15].

Physical exercise has a great potential for mortality reduction and to improve physical functioning and health-related QOL in the transplant population [14,16]. Various short-term studies have examined the effect of a rehabilitation training program either during waiting time or shortly after transplantation [15–18]. Few data exist to show whether benefits of regular physical activity can be achieved in the long term among KT and LT recipients. Only 1 American study investigated the level of physical capacity in a group of transplant recipients who participated in the national Transplant Games [19]. Although cardiorespiratory function of these patients usually does not reach the level of the normal healthy population, there are some organ transplant recipients who achieve high performance and are able to do sports similarly to their healthy counterparts.

The present retrospective study focused on the relationship between aerobic capacity and physical performance among KT and LT recipients. We investigated all of the members of the Hungarian Transplant Team who participated in the 2011 World Transplant Games.

MATERIALS AND METHODS

Twenty-five subjects (14 male, 11 female) who had undergone orthotopic LT or KT at Semmelweis University Transplantation and Surgery Clinic were included in the study. All of them were registered members of the Hungarian National Transplant Team. One of the participation criteria of the 2011 World Transplant Games was to perform a cardiopulmonary exercise test (CPET). With permission from their team physician, subjects who could perform ergometer testing and without severe neurologic or musculoskeletal diseases were included. Exclusion criteria consisted of nonsolid organ transplantation, uncontrolled hypertension, unstable angina, and active infection within the previous 3 weeks. Informed consent approved by the Institutional Review Board of the Semmelweis University was obtained from each subject.

Pulmonary function testing was performed with the use of Schiller Gashorn Power Cube. Inspiratory vital capacity (IVC), forced vital capacity (FVC), forced expiratory volume in the 1st second (FEV_1), and FEV_1/FVC were recorded.

All athletes underwent an incremental treadmill test to exhaustion (Schiller ITAM ERT-100). Starting speed was 4 km/h for 4 minutes. Velocity increased by one km/h every other minute. A 2% starting slope ascended by 1% every other minute. During the test, breath-by-breath measurements of VO_2, VCO_2, respiratory exchange ratio (RER), and O_{2p} were used. Because of the unique population, besides the primary and secondary criteria of a true VO_{2max} [20,21], signs of subjective fatigue were also taken into consideration. Tests were terminated if a subject achieved maximal oxygen uptake criteria, was unable to continue (volitional fatigue), or reported dizziness or muscle fatigue. Therefore, peak VO_2 values were regarded as VO_{2max}. To be able examine the life expectancy and QOL of the transplant recipients, their maximal cardiovascular capacity was compared with the expected values of a healthy sedentary population.

Table 1. Baseline Characteristics of the Study Group at Inclusion

Characteristic	Male	Female	Total
n	14	11	25
Age (y)	41.0 ± 14.5	37.3 ± 18.4	39.4 ± 16.1
Kidney Tx	12	9	21
Liver Tx	2	2	4
SBP (mm Hg)	155 ± 26	139 ± 27	148 ± 27
DBP (mm Hg)	82 ± 16	83 ± 18	82 ± 17
Weekly training hours	8.4 ± 6.8	6.6 ± 3.3	7.6 ± 5.5
Hypertension	8	2	10
Diabetes mellitus	0	1	1
Creatinine (μmol/L)	130.0 ± 32	111.5 ± 40.7	121.8 ± 36.5
Hemoglobin (g/dL)	139.2 ± 17.7	117.4 ± 35.3	129.5 ± 28.4
Bilirubin (μmol/L)	9.9 ± 4.4	8.3 ± 3.2	9.2 ± 3.9
Smoker	4	0	4
Graft age (y)	9.2 ± 7	11.3 ± 5.7	10.1 ± 6.6

Note. Values are expressed as mean ± SD or number of subjects.
Abbreviations: SBP, systolic blood pressure; DBP, diastolic blood pressure; Tx, transplantation.

Maximal oxygen pulse was expressed in milliliter per beat and as a percentage of the predicted value. Normal values were defined by peak O_{2p} >80% of predicted. VO_{2max} was expressed in relative values (milliliters of oxygen per kilogram per minute) and as a percentage of the predicted value. Normal values were defined by VO_{2max} >84% of predicted [11]. Age- and sex-predicted VO_2 was determined with the use of formulas reported for sedentary normal individuals by Wassermann [22]. Blood pressure was measured before and after the test. Workload and metabolic equivalents (MET) were continuously registered. Twelve-lead electrocardiography was monitored throughout the test.

Anaerobic threshold (AT) was determined by means of respiratory measurements [23] based on the ventilation equivalent (EqO_2-AT) method [24].

General information that included age, sex, body mass index, weekly exercise (h/wk), and other factors, such as graft age, relevant comorbidities (history of ischemic heart disease, hypertonia, diabetes mellitus) was recorded. Critical laboratory values (hemoglobin, creatinine, bilirubin levels) were also collected.

Statistical Analysis

Statistical analysis was performed with the use of Statistica 11.0 for Windows. Student *t* tests for independent samples were used to compare variables at rest and during the exercise test between the sexes. The predicted and measured maximal oxygen uptake was analyzed with the use of dependent *t* test for paired samples. Pearson correlation analysis was used to assess the possible relationships between peak VO_2 and age, workload, MET, O_{2p}, and graft age. The effective level of random error was set at 5% in all tests of significance.