Physical performance after pediatric solid organ transplantation

Mäenpää, Heidi

2022-03

Mäenpää , H , Tainio , J , Jalanko , H , Arokoski , J & Jahnukainen , T 2022 , ' Physical performance after pediatric solid organ transplantation ' , Pediatric Transplantation , vol. 26 , no. 2 , 14163 . https://doi.org/10.1111/petr.14163

http://hdl.handle.net/10138/353133
https://doi.org/10.1111/petr.14163

acceptedVersion

***Title**:* Physical Performance After Pediatric Solid Organ Transplantation

Running title: Physical Performance After Pediatric SOT

***Full names of all authors* & Orcid:**

Mäenpää Heidi 0000-0001-6436-6827

Tainio Juuso 0000-0003-0415-7403

Jalanko Hannu 0000-0002-3875-785

Arokoski Jari 0000-0001-7023-2235

Jahnukainen Timo 0000-0002-1815-7327

Authorship:

Heidi Mäenpää, performed research, collected data, analyzed data, wrote the paper.

Juuso Tainio analyzed data and wrote the paper.

Hannu Jalanko, designed the study, wrote the paper

Jari Arokoski, designed study, planned and decided contents of the article, participated in interpreting the data and revising critically on important part of the article.

Timo Jahnukainen, designed the study, interpreted the results, wrote the paper, financed the study.

Affiliations:

Heidi Mäenpää, Department of Rehabilitation, New Children’s Hospital, University of Helsinki and Helsinki University Hospital, Helsinki, Finland

Juuso Tainio, Department of Pediatric Nephrology and Transplantation, New Children's Hospital, University of Helsinki and Helsinki University Hospital, Helsinki, Finland

Hannu Jalanko, Department of Pediatric Nephrology and Transplantation, New Children's Hospital, Helsinki University Hospital, Helsinki, Finland and University of Helsinki, Finland

Jari Arokoski, Department of Physical and Rehabilitation Medicine, Helsinki University Hospital, Helsinki, Finland and University of Helsinki, Helsinki, Finland.

Timo Jahnukainen, Department of Pediatric Nephrology and Transplantation, New Children's Hospital, Helsinki University Hospital, Helsinki, Finland and University of Helsinki, Helsinki, Finland

Corresponding author contact information:

Heidi Mäenpää
Helsinki University Hospital, New Children's Hospital
PO Box 347, 00029 HUS, Helsinki, Finland
+358 50 427 9139, FAX -,
heidi.maenpaa@hus.fi

Acknowledgements: This study was supported by grants from the Foundation for Pediatric Research, the Päivikki and Sakari Sohlberg Foundation, and Helsinki University Central Hospital.

A conflict of interest statement:

The authors report no conflicts of interest to disclose.

Data availability statement:

Data available on request from the authors

Abbreviations:

Cardiovascular diseases (CVD)

Measured Glomerular filtration rate (mGFR)

Physical Activity (PA)

Physical Exercise (PE)

Solid Organ Transplant (SOT)

PHYSICAL PERFORMANCE AFTER PEDIATRIC SOLID ORGAN TRANSPLANTATION

Introduction: *Low physical activity is a well-recognized problem in pediatric solid organ transplant recipients, however, little is known about the differences between transplant groups. Physical performance testing was performed in a cohort of pediatric kidney, liver, and heart transplant recipients.*

Methods*: Fifty-one patients (54.9% boys), including 17 liver, 20 kidney, 2 combined liver-kidney, and 12 heart transplant recipients, were tested at the median age of 11.5 (7.5–14.9) years. The results were compared to a control group, which consisted of 425 healthy schoolchildren. The physical performance test included six different tests of endurance, strength, flexibility, and speed.*

Results: *The transplant recipients performed worse on most tests when compared to the control subjects (leg lift test 42.0 vs. 44.9 repetitions, p=0.002; repeated squatting 21.6 vs. 23.9 repetitions, p <0.001; sit-up test 9 vs. 17 vs. 9 repetitions, p<0.001, back extension 20 vs. 35 repetitions, p<0.001; and shuttle run test 26.5 vs. 23.7 seconds, p<0.001). None of the test results differed statistically significantly between the transplant groups.*

Conclusion: *The physical performance of pediatric solid organ transplant recipients is lower than that of their healthy peers but do not differ between different transplant groups. More systematic rehabilitation programs and follow-up are needed.*

Keywords: Physical Performance, Pediatric Solid Organ Transplantation, Kidney Transplant, Liver Transplant, Heart Transplant

INTRODUCTION

Solid organ transplantation is the generally accepted treatment modality for end-stage organ failure. Advancements in immunosuppressive therapy and increase in knowledge on post-transplantation care over the last decades have led to significantly improved graft and recipient survival. This has broadened the focus of research to evaluate the long-term treatment related effects and general outcomes of the recipients. The long-term (5 years) survival of pediatric solid organ transplant (SOT) recipients is generally over 90% after kidney transplantation [1] and liver transplantation [2], and around 80% among heart transplant recipients [3, 4]. With increased survival, quality of life and treatment-related side effects are now the major challenges for this population [5, 6].

Children with SOT have an increased risk for developing cardiovascular disease (CVD) [7], and especially left ventricular hypertrophy and hypertension have been reported as possible complications in pediatric (kidney) transplant recipients [8, 9]. CVD has been reported to be responsible for over 22% of the deaths following pediatric transplantation [10]. Immunosuppressive medication is likely to contribute to the risk of cardiovascular morbidity by increasing the likelihood of hypertension, dyslipidemia, and diabetes mellitus [11]. A recent study among pediatric transplant recipients showed that 25% of the recipients were obese at 5 years after transplantation [12]. Physical performance evaluation should be an important part of the post-transplant follow-up addressing the problem of low physical activity (PA) and physical deconditioning in pediatric SOT recipients.

Pediatric SOT recipients have reportedly significantly poorer physical functioning, general health, and more bodily pain compared to patients with other chronic childhood illnesses [13]. Fatigue is a common complaint in SOT recipients [14, 15] and it is suggested to be associated with frailty caused by chronic disease during childhood [13]. Sedentary lifestyle of pediatric SOT recipients, contributing to increased risk of development of CVD, is a valid concern, since PA has been shown to be lower in all pediatric SOT groups compared to healthy controls [16, 17, 18]. It has previously been reported that muscle strength is below normative values in pediatric kidney and liver transplant recipients [19, 20]; however, no studies comparing muscle strength in different pediatric SOT groups are available. To the best of our knowledge, this is the first study to evaluate physical performance in different pediatric SOT groups treated in the same center and with a same physical performance test.

The aim of this study was to evaluate the physical performance of pediatric transplant recipients and compare these results between kidney, liver and heart transplant recipients and to the historical reference values from age and gender matched healthy Finnish children. We hypothesized that exercise capacity would be lower among heart transplant recipients due to primary organ dysfunction and circulatory limitations and that pediatric transplant recipients' test results in general would be worse than those of healthy subjects.

2. RECIPIENTS AND METHODS

Recipients

All pediatric SOTs in Finland are performed at the study center and the recipients are followed up at our unit at least yearly. We enrolled the recipients to the study during their annual follow-up visit with the following inclusion criteria: 1) history of kidney, liver, or heart transplantation, 2) year of birth between 2004 and 2009, and 3) capability to perform the tests used. A total of 78 eligible recipients were identified; 8 of them were excluded for medical reasons (neurology (n=6), recent scoliosis operation (n=1), lack of co-operation at the time of the test (n=1)), and one for living abroad (n=1). An additional 19 recipients did not participate in the study due to other reasons, such as scheduling or logistic problems. One recipient born in 2010 was included in the study as tests had already been performed and due to the small size of the subgroup of heart transplant recipients.

Finally, 51 (65%) of the eligible recipients were enrolled between November 2016 and February 2020, including 17 (33%) liver transplant recipients, 20 (39%) kidney transplant recipients, 2 (4%) combined liver-kidney transplant recipients, and 12 (24%) heart transplant recipients. Pre-transplant diagnoses comprised congenital diseases (congenital anomalies of kidney and urinary tract (n=5), congenital nephrotic syndrome (n=11), congenital heart defects (n=4), cystic diseases (n=2), and biliary atresia (n=8)), acquired diseases (glomerular nephritis (n=1), cardiomyopathy (n=7)), and miscellaneous (tumors (n=4) and other (n=9)). Combined kidney-liver transplant recipients were analyzed in the liver transplant group because of the small subgroup size.

The study was approved by the Ethics Committee of the *Helsinki University Hospital*. An information leaflet was given to all participants and their guardians, and all patients and parents approved participation in the study.

Control subjects

The age- and sex-matched control group consisted of 425 schoolchildren tested in primary and secondary school. These children were previously enrolled in a study evaluating physical performance in pediatric autologous stem cell transplant recipients [19].

Tests for physical performance

We tested the recipients during their routine outpatient visit. All recipients were free from any respiratory infections or other factors possibly affecting their test results. All the tests were performed by a trained pediatric physiotherapist at the study center. All recipients were asked about their physical activity, i.e. sports hobbies and attending physical exercise (PE) at school.

We evaluated physical performance using the same tests that have previously been described and used in studies evaluating outcomes of pediatric autologous stem cell transplantation [21] and non-transplanted childhood leukemia survivors [22]. The tests are modified from those generally used in healthy subjects [23]. The test set included six different tests measuring endurance, strength, flexibility, and speed (Figure 1). Endurance and strength were tested by leg-lift test, repeated squatting test, sit-up test, and back-extension test, and measured by repetitions per 30 seconds. Flexibility was tested with sit-and-reach test by centimeters. Speed, acceleration, and speed differentiation was tested with shuttle-run test and measured by time (s). In all tests except for the shuttle-run test, a higher score means better physical performance. In the shuttle-run test, a lower score means a faster (better) result. The tests used are described in Appendix 1. The shuttle-run test was not performed to a significant subset of patients (15/51) due problems with slipperiness of the floor (Table 1). All heart transplant recipients performed a 6-minute walk test prior to physical performance test, also as a warm up –method.

Clinical data, such as height, weight, systolic and diastolic blood pressure, and measured glomerular filtration rate (mGFR), were measured as part of the routine follow-up protocol and obtained from medical reports. All patients received triple-drug immunosuppression including calcineurin inhibitor (cyclosporine A or tacrolimus), antimetabolite (azathioprine or mycophenolate) and methylprednisolone. Rejections were detected at protocol biopsy (heart and kidney transplant recipients) or based on biopsies performed with clinical indication.

Statistical methods

All statistical analyses were performed using IBM SPSS Statistics 27 (SPSS Inc., Chicago, IL, USA). The results are presented as mean (SD) or median (range) or number of recipients (%), as appropriate. The comparisons of the recipients and controls were performed with the independent samples t-test or Fisher-Freeman-Halton exact two-sided test, as appropriate. The results of the recipient groups were compared with Anova or Kruskal-Wallis test regarding continuous variables and for categorical variables, by using the Chi-squared test or Fisher-Freeman-Halton exact two-sided test. In order to analyze the correlations between the time since transplantation and the test results, the results were indexed, by dividing the recipients test results with gender and age-matched mean. This was done to diminish the effect of age and gender. Spearman's correlation coefficient was used for correlations.

3. RESULTS

Recipient demographics

The median age at the time of the study was 11.5 (7.5–14.9) years and there were slightly more males 28 (54.9%). The transplant recipients were lighter ($p=0.001$) and shorter ($p<0.001$) than the controls.

The median age at transplantation was 3.3 (0.67–14.33) years and time from transplantation to the physical performance testing was 72.0 (2–157) months. The kidney transplant recipients were the youngest at the time of transplantation and they had the longest time between the transplantation and the study (Table 1).

Physical performance in transplant recipients and controls

Two (3.9%) recipients reported no physical activity, 17 (33.3%) recipients reported attending PE at school, 17 (33.3%) recipients reported attending PE at school in addition to a sports hobby once a week, and 15 (29.4%) recipients reported attending PE at school and a sports hobby twice or more per week. No such data of physical activity was obtained from the control subjects.

On all the tests measuring endurance and strength (leg lift test, repeated squatting, sit-up, and back extension), control subjects performed significantly better than recipients (Table 2). Especially on tests measuring core-muscle strength and endurance (sit-up and back extension) there was a significant difference between the control subjects and recipients. On sit-and-reach test measuring flexibility, the recipients seemed to perform slightly better than the controls, but the difference did not reach statistical significance. On the shuttle run test measuring speed, controls performed significantly better than recipients. (Table 2.)

Comparison between different transplant groups

The physical test performance did not differ significantly between the SOT groups. (Table 1.) However, in the tests measuring muscle strength and endurance of lower extremities (leg lift test, repeated squatting) and sit-ups, the results tended to be better in the kidney transplant recipients. The heart transplant recipients performed worst in the repeated squatting, sit-and-reach, back extension and shuttle run tests compared to other groups, however, none of these differences reached statistical significance (Table 1). Self-reported physical activity in the SOT groups was similar (p=0.16).

The key clinical parameters like height and weight of patients, systolic/diastolic blood pressures and mGFR were compared between the transplant groups at the time of the physical testing (Table 1). The size of the patients, systolic/diastolic blood pressures, or number of rejections did not differ between the SOT groups; however, the mGFR was significantly lower in the kidney transplant recipients than in the other groups (Table 1). The heart transplant recipients had shortest time from transplant to the physical testing (1.0; 0.2-13.1 years than the kidney (8.5, 0.1-11.1 years), and the liver (5.0; 0.2-12.0 years) transplant recipients. According to the Spearman's correlation coefficient analysis, the post transplant time did not have a significant influence on the test results (Appendix 2).

4. DISCUSSION

In this nationwide study, pediatric transplant recipients exhibited significantly lower physical performance compared to control subjects. Recipients performed below control subjects in all tests measuring muscle strength, muscle endurance and speed. In flexibility, the recipients' results were similar to those of control subjects. However, against our hypothesis, there were no significant differences between different transplant groups. To the best of our knowledge, this is the first study comparing physical performance of patients having undergone either pediatric kidney, liver, or heart transplantation in the same center with the same physical performance test.

Chronic diseases and solid organ transplantation are connected to increased risk of bodily pain, frailty, and cardiovascular diseases, which may in turn weaken physical performance even in pediatric population. The decrease in physical performance, especially diminished muscle strength and endurance, has previously been recognized in pediatric kidney and liver transplant recipients [17, 19, 20, 24]. In a study of pediatric recipients (mean age 8.4 years) by Unnithan et al. [20], only 35% of the transplant group achieved the standards of partial curl-up and 0% achieved the standards for the pacer test, but 88% achieved the criterion standards for flexibility. Adolescent kidney and liver transplant recipients showed decreased muscle strength as well, but as in younger recipients, flexibility was reported to be within the normal range [19]. Additionally, physical fitness in pediatric liver transplant recipients is reported to be decreased, and children with antihypertensive medication seem to suffer most from deconditioning [24]. These previously reported results of diminished muscle strength, but flexibility within the norms in pediatric kidney and liver transplant recipients, were confirmed in our study. We also expected that middle body strength would be lower in the liver transplant recipients due to history of major abdominal surgery. However, no such difference could be found in the present study.

Our hypothesis was that exercise capacity would be lower among heart transplant recipients compared to other transplant groups due to primary organ dysfunction, circulatory limitations, and denervation, but we found no difference between the groups. Our results, however, support the previous data showing low to normal exercise capacity among pediatric heart transplant recipients [25, 26, 27]. Even though in our study cohort, the heart transplant recipients were oldest at the time of the transplantation and had the shortest time between the transplantation and the study, they did not perform significantly worse compared to other patients. Previously, younger age at the time of transplantation has been found to predict greater exercise capacity, VO_2max [26], as well as increased physical activity [27]; each additional year of age at the time of transplantation has been associated with a decrease in physical activity by 1.9 min/day. Surprisingly in our study, time since the transplant was not associated with any physical performance test result in any transplant subgroup. This result is controversial to previous studies, indicating exercise capacity in pediatric heart transplant recipients to improve with time [26]. It has to be taken into account, that in the present study, the number of patients was limited and therefore these results have to be interpreted with caution.

Decreased physical exercise capacity and low PA pose a challenge to the treatment of pediatric transplant recipients. Fatigue and aches [28] affect the quality of life of a significant subset of recipients years after transplant. Increased sedentary lifestyle [17] of recipients is a cause of concern due to the elevated risk of developing CVD, with CVDs being a major cause of deaths in this population [10]. Active physiotherapy and exercise programs have been shown to improve exercise performance of pediatric

SOT recipients after discharge [29, 30]. Pediatric SOT recipients would benefit from continuous support and physiotherapy check-ups after discharge to promote recovery and physical conditioning after transplant [31]. Development of rehabilitation programs and follow-up routines to facilitate optimal physical health may reduce physical impairment and improve overall health-related quality of life outcomes of pediatric SOT recipients [30]. Physical activity should be promoted with various methods, including recipient and parental education, peer support and specific training programs. Continuous monitoring of physical activity and physical performance should be a standard of care throughout childhood and youth.

STUDY LIMITATIONS

There are limitations to our study that should be acknowledged. An apparent limitation was with the shuttle run test. The test was not performed to all recipients because of problems with the floor in the physiotherapy unit. Another limitation is that the subgroup of heart transplant recipients was relatively small and transplanted quite recently, although it did not make a statistical difference to the kidney or liver transplant recipients. The PA of control subjects was not documented, so it is possible, that impaired physical performance of pediatric SOT recipients is partly explained by their lower PA.

5. CONCLUSIONS

Pediatric solid organ transplantation recipients' physical performance is impaired when compared to healthy controls. However, we did not find significant difference between the groups when comparing the results of pediatric kidney, liver, and heart transplant recipients. Pediatric SOT recipients would benefit from a routine rehabilitation program after transplantation and routine follow-ups with a physiotherapist through childhood and youth. Families need to be educated about the importance of exercise following transplant to prevent overprotection on the part of the caregiver, as well as to courage and promote the adoption of a physically active lifestyle. Routine physiotherapy follow-up should be a standard of care for pediatric solid organ transplant recipients.

Further studies are needed to determine the most effective rehabilitation programs and adequate follow-up of all pediatric transplant recipients.

6. FUNDING

This study was supported by grants from the Foundation for Pediatric Research, the Päivikki and Sakari Sohlberg Foundation, and Helsinki University Central Hospital.

7. DISCLOSURE

The authors report no conflicts of interest to disclose.

REFERENCES

1. Jahnukainen T, Bjerre A, Larsson M, et al. The second report of the nordic pediatric renal transplantation registry 1997–2012: More infant recipients and improved graft survivals. Pediatr Transplant 2016; 20: 364-371.
2. Ng VL, Horslen SP, Fioravanti V, et al. Society of pediatric liver transplantation: Current registry status 2011-2018. *Pediatric Transplantation; Pediatr Transplant 2020; 24*: e13605.
3. Dipchand AI. (2018). Current state of pediatric cardiac transplantation. *Annals of Cardiothoracic Surgery 2018, 7:* 31-55.
4. Cohen W, Combs P, El-Zein C, et al. (2020). Outcomes from three decades of infant and pediatric heart transplantation. *ASAIO Journal 2020, Publish Ahead of Print* doi:10.1097/MAT.0000000000001312
5. Mohammad S. Health status in young adults two decades after pediatric liver transplantation. Am J Transplant 2012; 12: 1486-1495.
6. Ng VL. Health status of children alive 10 years after pediatric liver transplantation performed in the US and Canada: Report of the studies of pediatric liver transplantation experience. J Pediatr 2012; 160: 820-826..
7. Derakhshan A, Derakhshan D, Amoozgar H, Shakiba MA, Basiratnia M, Fallahzadeh MH. Exercise test in pediatric renal transplant recipients and its relationship with their cardiac function. Pediatr Transplant 2014; 18: 246-253.
8. Matteucci MC, Giordano U, Calzolari A, Turchetta A, Santilli A, Rizzoni G. Left ventricular hypertrophy, treadmill tests, and 24-hour blood pressure in pediatric transplant patients. Kidney International 1999; 56: 1566-1570.

9. Filler G. Challenges in pediatric transplantation: The impact of chronic kidney disease and cardiovascular risk factors on long-term outcomes and recommended management strategies. Pediatr Transplant 2011; 15: 25-31.

10. Parekh RS, Carroll CE, Wolfe RA, Port FK. Cardiovascular mortality in children and young adults with end-stage kidney disease. J Pediatr 2002; 141: 191-197.

11. Dharnidharka VR, Araya CE, Benfield MR, Organ Toxities. In: Fine RN, Webber SA, Olthoff KM, Deirdre AK, Harmon WE. Pediatric Solid Organ Transplantation. 2nd ed. Blackwell Publishing, Oxford, 2007: 124.

12. Bondi BC, Banh TM, Vasilevska-Ristovska J, et al. Incidence and risk factors of obesity in childhood solid-organ transplant recipients. Transplantation 2020; 104: 1644-1653.

13. Endén K, Tainio J, Jalanko H, Jahnukainen K, Jahnukainen T. Lower quality of life in young men after pediatric kidney transplantation when compared to healthy controls and survivors of childhood leukemia—a cross-sectional study. Transpl Int. 2018; 31:157-164.

14. BosJ, Lelieveld O, Scheenstra R, Sauer PJJ, Geertzen JHB, Dijkstra PU. Physical activity and aerobic fitness in children after liver transplantation. Pediatr Transplant 2019; 23: e13465.

15. Chan W, Jones D, Bosch JA, et al. Cardiovascular, muscular and perceptual contributions to physical fatigue in prevalent kidney transplant recipients. Transpl Int. 2016; 29: 338-351.

16. Lui S, de Souza A, Sharma A, et al. Physical activity and its correlates in a pediatric solid-organ transplant population. Pediatr Transplant 2020; 24: e13745.

17. Clark CG, Cantell M, Crawford S, Hamiwka LA. Accelerometry-based physical activity and exercise capacity in pediatric kidney transplant patients. Pediatr Nephrol 2012; 27: 659-665.

18. Hamiwka LA. Physical activity and health related quality of life in children following kidney transplantation. Pediatr Transplant 2009; 13: 861-867.

19. Krasnoff JB, Mathias R, Rosenthal P, Painter PL. The comprehensive assessment of physical fitness in children following kidney and liver transplantation. Transplantation 2006; 82: 211-217.

20. Unnithan VB. Fitness testing of pediatric liver transplant recipients. Liver Transpl 2001; 7: 206-212.

21. Hovi L, Kurimo M, Taskinen M, Vettenranta J, Vettenranta K, Saarinen-Pihkala U. Suboptimal long-term physical performance in children and young adults after pediatric allo-SCT. Bone Marrow Transplant 2010; 45: 738-754.

22. Taskinen M. Physical performance of nontransplanted childhood ALL survivors is comparable to healthy controls. J Pediatr Hematol Oncol 2013; 35: 276-280.

23. Aho J, Häkkinen K, Kallinen M, Keskinen KL. Kuntotestauksen käsikirja. Liikuntatieteellinen seura, Helsinki: 2004. In Finnish.

24. Vandekerckhove K, Coomans I, De Bruyne E, et al. Evaluation of exercise performance, cardiac function, and quality of life in children after liver transplantation. Transplantation 2016; 100: 1525-1531.

25. Pastore E, Turchetta A, Attias L, et al. Cardiorespiratory functional assessment after pediatric heart transplantation. Pediatr Transplant 2001; 5: 425-429.

26. Dipchand AI, Manlhiot C, Russell JL, Gurofsky R, Kantor PF, McCrindle, BW. Exercise capacity improves with time in pediatric heart transplant recipients. J Heart Lung Transplant 2009; 28: 585-590.

27. Banks L, Dipchand AI, Manlhiot C, Millar K, McCrindle BW. Factors associated with low physical activity levels following pediatric cardiac transplantation. Pediatr Transplant 2012; 16: 716-721.

28. Feldman AG, Neighbors K, Mukherjee S, Rak M, Varni JW, Alonso EM. Impaired physical function following pediatric LT. Liver Transpl 2016; 22: 495-504.

29. Patel JN, Kavey R, Pophal SG, Trapp EE, Jellen G, Pahl E. Improved exercise performance in pediatric heart transplant recipients after home exercise training. Pediatr Transplant 2008; 12: 336-340.

30. Deliva RD, Hassall A, Manlhiot C, Solomon M, McCrindle BW, Dipchand AI. Effects of an acute, outpatient physiotherapy exercise program following pediatric heart or lung transplantation. Pediatr Transplant 2012; 16: 879-886.

31. Brosig C, Pai A, Fairey E, Krempien J, McBride M, Lefkowitz DS. Child and family adjustment following pediatric solid organ transplantation: Factors to consider during the early years post-transplant. Pediatr Transplant 2014; 18: 559-567.

FIGURE LEGENDS

Figure 1. Tests used for Physical performance.

A. Leg-lift test, B. Repeated squatting, C. Sit-up test, D. Sit-and-reach test, E. Back-extension test

TABLE LEGENDS

Table 1. Recipient characteristics and test results in 51 pediatric solid organ transplant recipients

Table 2. Physical test results in all 51 pediatric solid organ transplant recipients and 425 control subjects.

SUPPORTING INFORMATION

Appendix 1. Tests used for Physical Performance

Appendix 2. Correlation coefficient of indexed physical test results and time since transplant (months) in 51 pediatric solid organ transplant recipients

Figure 1. Tests used for Physical performance.

A. Leg-lift test, B. Repeated squatting, C. Sit-up test, D. Sit-and-reach test, E. Back-extension test

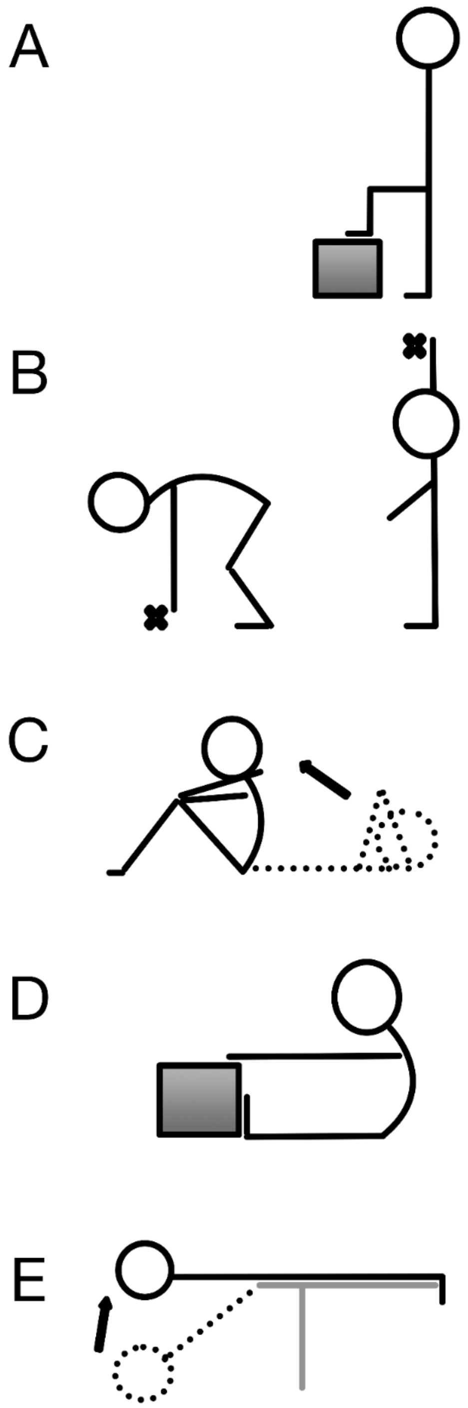

Table 1. Recipient characteristics and test results in 51 pediatric solid organ transplant recipients

	Kidney (N=20)	Liver (N=19)	Heart (N=12)	p-value
Median age, years	10.8 (7.5-13.4)	11.5 (9.7-14.2)	13.1 (8.9-14.9)	0.068
Median age at transplantation, years	1.6 (1.0-13.2)	6.8 (0.7-14.0)	11.1 (0.9-14.3)	0.012
Median years from transplantation to testing, years	8.5 (0.2-11.1)	5.0 (0.2-12.0)	1.0 (0.2-13.1)	0.051
Male gender, n (%)	15 (75.0%)	8 (42.1%)	5 (41.7%)	0.068
Weight, kilograms	35.47 (10.9)	43.27 (13.0)	38.78 (10.8)	0.125
Height, centimeters	139.4 (11.8)	145.2 (10.1)	147.2 (15.2)	0.167
Measured GFR, mL/min/1.73 m^2	57.8 (23.0)	89.5 (18.0)†	86.5 (20.2)	<0.001
Systolic blood pressure, mmHg	113.3 (10.1)	114.0 (10.4)	113.1 (7.7)	0.96
Diastolic blood pressure, mmHg	70.3 (8.7)	68.1 (7.4)	68.8 (6.6)	0.68
Median rejections	0.0 (0.0-2.0)	0.0 (0.0-2.0)	0.0 (0.0-3.0)	0.26
Physical test results				
Leg lift, repetitions	44.7 (6.6)	40.1 (4.7)	40.7 (8.3)	0.072
Repeated squatting test, repetitions	22.9 (3.9)	21.3 (2.5)	20.0 (3.6)	0.079
Sit-up test, repetitions	11.4 (7.7)	7.8 (7.7) †	9.7(6.7)	0.34
Sit-and-reach test, centimeters	56.0 (6.1)	58.6 (7.0)	54.8 (9.0)	0.31
Back extension test, repetitions	20.0 (10.2)	21.9 (4.5)†	19.0 (6.2)	0.45
Shuttle run test, seconds	26.4 (4.0)§	25.5 (2.6)‡	28.2 (4.1)§	0.45

The results are presented as number of recipients (%), mean (SD) or median (range). †Data missing in one recipient, ‡Data missing in 11 recipients, §Data missing in 7 recipients. ANOVA, Kruskall-Wallis, and Chi-Squared tests were used for data analyses, as appropriate.

Table 2. Physical test results in all 51 pediatric solid organ transplant recipients and 425 control subjects.

	Recipients N=51	Controls (N=425)	p-value
Leg lift test, repetitions	42.0 (6.7)	45.0 (6.4)	0.002
Repeated squatting test, repetitions	21.6 (3.5)	24.0 (3.8)	<0.001
Sit-up test, repetitions	9.7 (7.5)†	17.6 (5.3)	<0.001
Sit-and-reach test, centimeters	56.7 (7.2)	56.0 (8.6)	0.55
Back extension test, repetitions	20.4 (7.6)	35.0 (8.5)	<0.001
Shuttle-run test, seconds	26.5 (3.6)‡	23.7 (2.9)	<0.001

The results are presented as mean (SD). † Data missing in one recipient; ‡ Data missing in 15 recipients. The p-values were calculated with independent samples t-test

Appendix 1. Tests used for Physical performance

Test-move	Description	Measured
A. Leg-lift test	The subject stands in front of a bench, which is adjusted for the height of the subject when hip and knee in 90° flexion, when one foot resting on the bench. The subject is asked to lift both feet alternatively onto bench as quickly as possible for 30 sec.	Repeats/30sec.
B. Repeated squatting	The subject is asked to stand feet hip-width apart, sideways to a wall, dominating hand on the wall side. The subject is asked to stretch the hand upwards to the wall and the place is marked. The subject is asked to squat touching the mark on the floor, and then rise touching the mark on the wall, as many times as possible for 30 sec.	Repeats/30sec.
C. Sit-up test	The subject lies supine, with knees in 90° flexion and hands with fingers interlocked on the back of the neck. The tester keeps the subject’s heels in contact with the floor. The subject is asked to rise to a sitting position until the elbows touch the knees, as many times as possible for 30 sec without a pause.	Repeats/30sec.
D. Sit-and-reach test	The subject sits on the floor, feet placed soles flat against a stable box, and while keeping knees straight, bends forward as far as possible. The tester ensures the knees are staying extended. The subject slides hands, with the palms facing down the box, reaching as far as possible and the distance of the slide is measured	Centimetres
E. Back-extension test	The subject lies prone on a back-extension bench, ankles supported, trunk flexed from waist to a 45° angle. From starting position, the subject is asked to lift the trunk into horizontal position (that is trunk/spine straight) and lower back down, so that chest touches the bench again, and repeat this lift as many times as possible for 30 sec.	Repeats/30sec.
F. Shuttle-run test	The subject makes 10x5 meters shuttle run as fast as possible (both feet over the line when turning)	Seconds

Appendix 2. Correlation coefficient of indexed physical test results and time since transplant (months) in 51 pediatric solid organ transplant recipients

	Kidney (N=20)		Liver (N=19)		Heart (N=12)	
	r_s	p-value	r_s	p-value	r_s	p-value
Leg lift, repetitions	-0.172	0.468	-0.047	0.847	0.214	0.504
Repeated squatting test, repetitions	-0.113	0.634	0.429	0.067	0.442	0.150
Sit-up test, repetitions	0.038	0.873	0.551	0.018	0.313	0.322
Sit-and-reach test, centimeters	-0.086	0.718	-0.058	0.814	0.109	0.377
Back extension test, repetitions	0.092	0.699	0.125	0.622	0.302	0.340
Shuttle run test, seconds	0.019	0.950	0.311	0.453	0.359	0.553

r_s=Spearman´s correlation coefficent was used, p-value two-tailed.