

## EFFICACY OF PHYSICAL REHABILITATION IN THE FIRST YEAR AFTER KIDNEY TRANSPLANTATION

SHELEKHOVA T.Y.<sup>1\*</sup>, ACHKASOV E.E.<sup>1</sup>, ZABOROVA V.A.<sup>1</sup>, KAGRAMANOVA J.A.<sup>1</sup>,  
TSIRULNIKOVA O.M.<sup>1,3</sup>, RUNENKO S.D.<sup>1</sup>, ROZHNOVA E.V.<sup>2</sup>

1 Department of sports medicine and rehabilitation, First Moscow State Medical University after Sechenov of the MH of Russia, Moscow, Russia

2 Department of therapeutic dentistry, First Moscow State Medical University after Sechenov of the MH of Russia, Moscow, Russia

3 Department of transplantology and artificial organs, Federal Research Center of Transplantology and Artificial Organs after Shumakov V.I., Moscow, Russia

Received 28/04/2018; accepted for printing 18/07/2018

### ABSTRACT

*Present study aimed to assess the efficacy of physical rehabilitation of donor kidney recipients in the first year after transplantation.*

*The functional state and adaptive body reserves were assessed using hardware-software complex "Sources of Health" for patients before and after kidney transplantation. The treatment results of 57 recipients (mean age 35.0±9.7) of donor kidney at different times of the postoperative period are presented. Depending on the physical rehabilitation program, 2 groups of patients were formed: I group (n=30) included patients for whom a physical rehabilitation was carried out during the year; II group (n=27) consisted of patients for who carried out physical rehabilitation in the first week after surgery for prevention of early postoperative complications. Group III included 30 relatively healthy people (15 women, 15 men; mean age 33.7±8.7 years), who did not need the organ transplantation, and didn't have regular physical activity. Functional state and adaptive body reserves were evaluated by hardware-software complex "Sources of Health" at 1, 3, 6 and 12 months after surgery.*

*Physical rehabilitation with a personalized approach for one year after kidney transplantation can significantly improve functional and adaptive body reserves of donor kidney recipients.*

*Physical rehabilitation is necessary for patients at least for a year after kidney transplantation in order to improve the functional state and adaptive body reserves.*

**KEYWORDS:** *transplantology, physical rehabilitation, functional state of the body, physical education, adaptive body reserves, period of rehabilitation, diffusion, chronic kidney disease, life quality, remedial gymnastics.*

### INTRODUCTION

There is an annual steady increase in the number of patients of end stage renal disease [Ageeva L et al., 2017]. In the last decades, renal replacement therapy such as hemodialysis, peritoneal dialysis and kidney transplantation to prolong the lives of many patients with end stage renal disease [Tomina N et al., 2017].

The life quality of such patients depends both on the manifestations of the disease itself and on the type of replacement therapy. Patients with such disease have to stay on dialysis for life or before kidney transplantation.

After transplantation of a donor organ, there may be side effects from taking immunosuppressive drugs, and the risk of transplant rejection may mean a return to dialysis [Pascual M et al., 2002; Djamali A et al., 2003; Kaplan B et al., 2004; Garcia G et al., 2012]. At the same time, it is known that people with transplanted organs can lead an active lifestyle,

### ADDRESS FOR CORRESPONDENCE:

**Tatiana Yu. Shelekhova**

I.M. Sechenov First MSMU

2-9 Bolshaya Pirogovskaya Street, Moscow 119435, RF

Tel.: +7 (926) 358-27-94

E-mail: tat1251@rambler.ru

engage in physical culture and sports. The use of immunosuppressants and steroids increases the risk of infections and malignant diseases. Also side effects of steroid therapy are: weight gain, osteopenia and osteonecrosis, cataract, ecchymosis, growth retardation in children, the appearance or progression of hypertension, hyperlipidemia and carbohydrate metabolism disorders leading to an increase in cardiovascular morbidity and mortality [Maalouf N, Shane E, 2005; Ojo A, 2006]. Side effects of immunosuppressive drugs: hypertension, hyperkalemia, tremor, impaired glucose tolerance, hypertrichosis and hyperplasia, nephrotoxicity and neurotoxicity (tremor, epileptic seizures, hallucinations, psychosis, coma) [Kasiske B et al., 2003; Painter P et al., 2003]. The negative influence of immunosuppressive therapy and dialysis significantly reduces the quality of life and physical activity of the kidney recipients. However, it can be corrected by various methods of physical rehabilitation [Kasiske B et al., 2003; Kasiske B et al., 2004; Armstrong K et al., 2005; Lentine K et al., 2005; Maalouf N, Shane E, 2005; Ojo A, 2006]. One of the main methods of preventing the risks of cardiovascular diseases is physical exercises [Surgeon General's Report, 1996; Zelle D et al., 2011]. Regular physical activity can help to reduce the risks of cardiovascular diseases, increase the overall level of physical, mental and adaptive health reserves in patients after kidney transplantation [Van den Ham E et al., 2007].

At the preoperative stage, regular exercise increases the chances of a successful operation by increasing the adaptive reserves of the body. The condition of the cardiovascular system in patients before transplantation is low [Goldberg A et al., 1983]. It is shown that more than 80% of patients before kidney transplantation showed a decrease in active physical activity; 62-79% of patients experience difficulties when performing exercises with minimal energy such as walking or climbing stairs. Even after surgery, 40% of these patients remain limited in exercise. There is evidence that 67-82% of dialysis patients and 43% of recipients have symptoms of mild fatigue and fatigue [Evans R et al., 1985].

Physical exercise in the early period after transplantation significantly improves functionality compared to their preoperative state, but exercise tolerance remains below normal. At the same time,

in seriously ill patients, the improvement of functional capabilities may not occur immediately [Painter P et al., 2003].

After surgery, patients cannot always lead an active lifestyle and endure physical activity in full. Limitations in physical activity are associated with many factors: cardiac muscle dysfunction, glucocorticosteroid and immunosuppressive therapy, high levels of uremic toxins, anemia, vegetative dysfunction, and muscle fatigue. Found that patients with anemia in the stage of terminal renal failure muscle weakness due to the violation of tolerance to physical exercise. Painter P.L. and co-authors (1986) also reported that Vo<sub>2</sub>max (maximum oxygen uptake – IPC) in dialysis patients was half the normal value in healthy individuals of the same age.

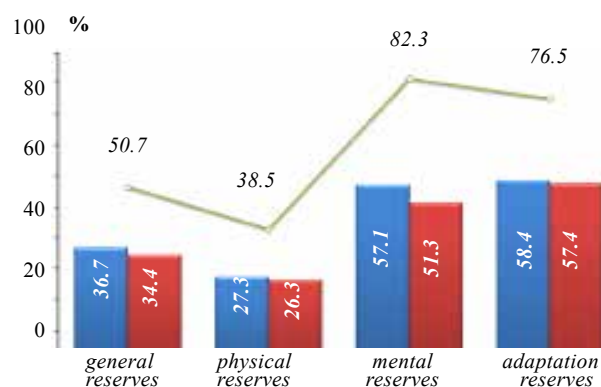
Physical exercises carried out during or in the intervals between hemodialysis sessions improve the performance of IPC. In a randomized study of patients after kidney transplantation, the role of exercise in increasing exercise tolerance was established. Exercises help to increase the strength of skeletal muscles, improve joint flexibility and balance [Painter P et al., 2003].

There is a close physiological and functional connection between muscle activity and the work of the urinary system. It is known that the kidneys, like any organ of our body, need training.

Hypodynamia disrupts the activity of the urinary system and adversely affects the human condition as a whole. Therefore, physical therapy is an important component of treatment and rehabilitation of people with kidney disease. Regular physical exercises increase the functional capacity of the patient, thus increasing the physical performance necessary for successful rehabilitation [Painter P et al., 2003; Van den Ham E et al., 2007].

Thus, physiological changes, that are specific for patients with chronic kidney disease, as well as for recipients with a donor kidney, determine the need to include physical exercises in the program of medical rehabilitation [Romano G et al., 2017].

The study of the functional state and adaptive reserves of the body depending on the level of physical activity at the stages of medical rehabilitation is an actual problem, and its solution helps to optimize the development of complex rehabilitation programs.



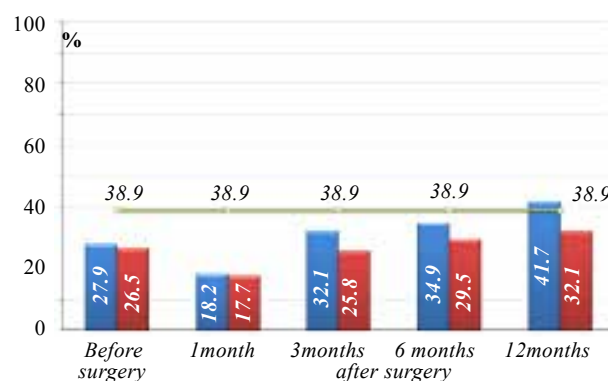
**FIGURE 1.** Comparative evaluation of the functional state of the organism in groups I (left column) and II (right column) before surgery with group III (curve) with the components of the integral health score scale (general reserves, physical reserves, mental reserves, adaptation reserves).

#### MATERIAL AND METHODS

A total of 57 recipients of donor's kidney (25 women, 32 men, average age  $35 \pm 9.65$  years) were observed. In all cases end-stage renal disease was the reason of transplantation. Depending on the programs of physical rehabilitation, patients were categorized into 2 groups: 30 participants, ranging in age from 21 to 55 years and passing all 3 stages of rehabilitation, formed I group; II group consisted of 27 patients, ranging in age from 20 to 57 years, who had only 1 stage of medical rehabilitation. Group III included 30 relatively healthy people at the age of 19-56, who did not need an organ transplant, had a normal lifestyle and did not do sports and fitness. All groups were comparable by sex and age, and I and II groups were also comparable due to the causes of end-stage renal disease, the length of time spent on substitutive renal therapy before surgery and the function of the transplant after the operation.

According to the evaluation of the functional state of the patients after transplantation, an algorithm of physical rehabilitation was developed. Each phase of this algorithm included a complex of exercise therapy and "dosed" walking, which were limited and changed depending on the functional state of the recipient and the phase of postoperative rehabilitation.

The physical load was dosed using the Borg's scale of perceived exertion. To estimate the effectiveness of physical rehabilitation at 1, 3, 6 and 12 months after transplantation, the functional condi-



**FIGURE 2.** Dynamics of physical reserves indices of groups I and II (left and right columns correspondingly) at different times of the postoperative period, and group III (curve).

tion and adaptive reserves of the organism were assessed using the hardware-software complex "Sources of Health". Group III was also tested for comparison.

The result of testing is a comprehensive assessment of health reserves – an "integral health score". The components of the integral health score scale are general reserves (GR), physical reserves (PR), mental reserves (MR), and adaptation reserves (AR) [Balandin Yu, Generalov V, 2004].

Dynamics of the integral health score, expressed as a percentage of the maximum possible value, allows an objective assessment of the effectiveness of treatment and rehabilitation events and training activities. In this case, the effect of the spent recovery or treatment is dependent on the increase in the "amount of health", and not on the decrease in the "amount of disease" [Patcai J et al., 2013; Crouch R, 2013].

Statistical analysis was performed using SPSS Statistics 17.0 and MS Excel. Whereas normal sampling distribution was not obtained at a given sample size, a nonparametric Mann-Whitney U criterion was used to determine the significance of differences between the three groups ( $p < 0.05$ ). The arithmetic mean and standard deviation were calculated.

#### RESULTS AND DISCUSSION

According to the values of general, physical, mental and adaptive health reserves indices, there were no significant differences across all scales in groups I and II before surgery (Fig. 1). However,

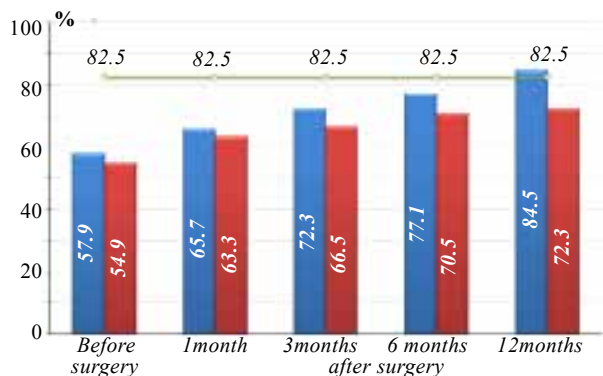


FIGURE 3. Dynamics of mental reserves indices of groups I and II (left and right columns correspondingly) at different times of the postoperative period, and group III (curve).

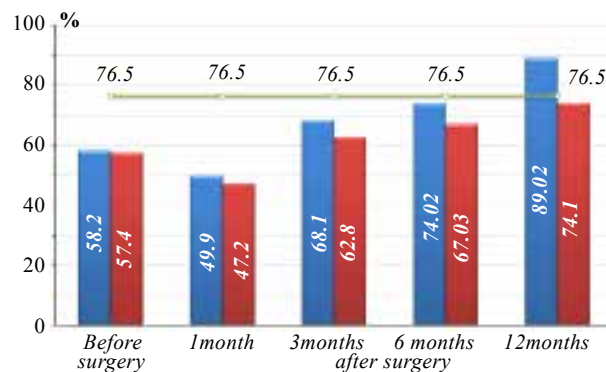


FIGURE 4. Dynamics of adaptation reserves indices of groups I and II (left and right columns correspondingly) at different times of the postoperative period, and group III (curve).

all indices of I and II groups are lower than the corresponding parameters in III group. It confirms the negative effect of chronic renal failure and dialysis on the functional state and adaptive reserves of the body.

Comparing the average indices of PR of patients in I and II groups before surgery, as well as after 1, 3, 6 and 12 months after transplantation, the following results were obtained (Fig. 2). PR index before the operation in I ( $27.9 \pm 3.4$ ) and II ( $26.5 \pm 3.8$ ) groups did not differ significantly ( $p > 0.05$ ), and was lower by 11.7% than the same parameter in healthy people ( $p < 0.05$ ). One month after the operation, a decrease of PR index in I ( $18.2 \pm 3.5$ ) and in II ( $17.7 \pm 3.02$ ) groups was observed, with no significant difference between the groups ( $p > 0.05$ ). Three months after the operation, a significant increase of PR index (by 6.3%) was observed in I group compared to II ( $p < 0.05$ ), and after 6 months, this index remained significantly

higher (by 5.4%) in I group compared to II. Twelve months after the operation, PR index of I group increased ( $41.7 \pm 6.0$ ) ( $p < 0.05$ ) by 9.6% compared to II group, that was obviously related to the extension of rehabilitation period to 12 months after surgery in this group. In I group, the dynamics of PR index was found to be higher than the mean values in III group; however, these data were not statistically significant. This achievement and increase of PR indices of patients in comparison with practically healthy people convincingly proved the efficacy of a long program of physical rehabilitation using an individualized approach during the first year after surgery.

Before surgery, MR index in I ( $57.9 \pm 3.9$ ) and II ( $54.9 \pm 5.6$ ) groups did not differ ( $p > 0.05$ ), but it was significantly lower (by 26.1%) than in III group ( $p < 0.05$ ). In one month after surgery, the increase of MR index was 7.8% and 8.4% (I and II

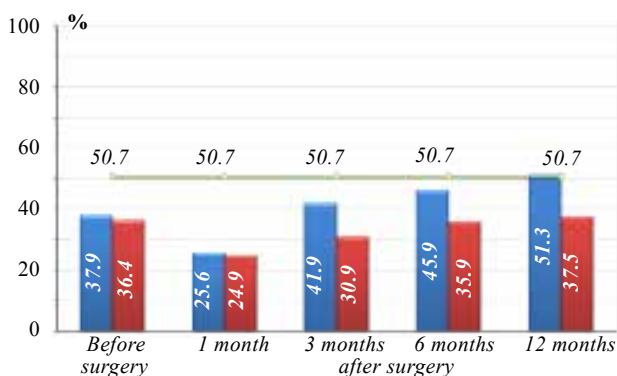


FIGURE 5. Dynamics of general reserves indices of groups I and II (left and right columns correspondingly) at different times of the postoperative period, and group III (curve).

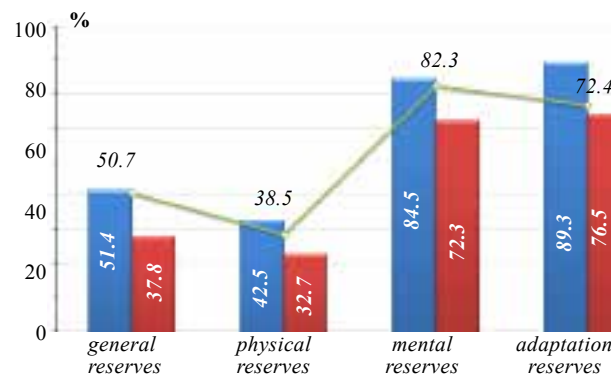


FIGURE 6. Comparative evaluation of the functional state of the organism in groups I (left column) and II (right column) before surgery with group III (curve) with the components of the integral health score scale (general reserves, physical reserves, mental reserves, adaptation reserves) in a year.

groups, respectively;  $p < 0.05$ ), which can be explained by the positive attitude and high motivation of patients. Three months after surgery, a significant increase of MR index (5.8%) was noted in I group in comparison with II ( $p < 0.05$ ). After 6 months, MR index remained significantly higher (by 6.6%) in I group compared to II group. One year after the operation, the level of MR index increased by 12.2% ( $p < 0.05$ ) in I group in comparison with II, which was obviously related to the extension of physical rehabilitation period to 12 months in this group. In I group, changes of MR index were higher than the mean values of III group, however, they were not statistically significant (Fig. 3). The observed dynamics of MR indices in the kidney recipients compared to practically healthy people also demonstrate the effectiveness of physical rehabilitation methods in patients of I group.

Before surgery, AR index in I ( $58.2 \pm 3.7$ ) and II ( $57.4 \pm 5.4$ ) was higher than in a month after the operation ( $49.9 \pm 4.3$  and  $47.2 \pm 7.8$ , respectively;  $p < 0.05$ ). Three months after operation, AR index increased in I (by 5.3%) group in comparison with II ( $p > 0.05$ ), and after six months AR index increased significantly (by 7.0%) in I group compared to II. Twelve months after the operation, AR index increased by 14.9% in I group compared to II group ( $p < 0.05$ ), which is obviously related to the extension of physical rehabilitation during the first year after surgery in this group. In group IAR index was higher than the mean values of III group by 12.5% ( $p < 0.05$ ) (Fig. 4).

Before surgery GR index did not differ in I, II groups and was lower (by 13.5%) in comparison with the corresponding parameter of III group ( $p < 0.05$ ). One month after the operation, a decrease of GR index was noted in I ( $25.6 \pm 4.01$ ) and II ( $24.9 \pm 3.6$ ) groups, with no significant differences between the groups ( $p > 0.05$ ). Three months after surgery, an increase of GR index (by 11%) was observed in I group, compared with II group ( $p < 0.05$ ). After six months GR index remained higher (by 10%) in I group than the same one in II group. After twelve months GR index value increased by 13.8% in I group compared with the same parameter of II group and did not differ statistically from the value of healthy people group ( $p < 0.05$ ) (Fig. 5).

One year after the operation, there was a sig-

nificant improvement of all health indices in I group in comparison with II group ( $p < 0.05$ ): GR by 13.6%, PR by 9.8%, MR by 12.4%, and AR by 15.5%. At different times after the operation, II group showed improvement in the components of the integral index of health compared to the preoperative period, but a year later the indices were lower ( $p < 0.05$ ) than in III group: GR by 12.9%, PR by 5.8%, MR by 10.2% and AR by 2.7% (Fig. 6).

It was shown that integral health indices of patients in I group became higher in a year after surgery (GR 0.7%, PR 4%; AR 12.8%), that is related with either efficacy of physical activity or kidney normal function after transplantation. Increase of MR index (2.2%) can be due to development of physical strength and the ability to feel a full-fledged workable person in the contrast of sensations before surgery. There were no significant differences in usual life of participants of III group because these people didn't have a necessity to do physical education and to lead a healthy life, that is related with the lack of disease, surgery, risk of death, feelings of helplessness, etc., that's why indices of I group patients became significantly higher ( $p < 0.05$ ) (Fig. 6).

#### DISCUSSION

In accordance with the obtained results, there were no statistically significant differences in physical and mental health indicators in patients from I and II groups in the preoperative period. However, all the indicators were significantly lower than in the group of healthy people, which confirms the negative effect of chronic renal failure and dialysis on the functional state and adaptive reserves of the body. These data correspond to previous studies. Thus, there is evidence that chronic renal failure is associated with long-term psychological effects on patients undergoing hemodialysis [Anees M et al., 2008]. A chronic disease, such as kidney failure, is a continuous and usually lengthy process. In the pre-operative period, the patients need to adapt their lifestyle to dialysis treatment. Patients with kidney disease undergoing regular dialysis have decreased indicators of both the physical and mental health components [Koutsopoulou-Sofikiti E et al., 2009]. The complexity and chronic nature of the disease affect the life quality of patients with chronic kidney failure and reduce their life expectancy [Anees M et al., 2011].

Analysis of the health indices in I and II groups one month after the operation demonstrated that the physical health indices decreased significantly, that can be explained by influence of the serious surgery procedure of kidney transplantation. By contrast, the index of mental health significantly increased in both groups compared to the preoperative period, which is obviously due to the patient's high motivation for the long-awaited operation. At the same time, all indicators remained significantly lower in comparison with III group. In a previous randomized study, a significant effect of the kidney transplantation operation on both the psychological and physical components of health was shown, and the positive effect of physical exercise on patients with a donor kidney was also confirmed [Painter P et al., 2002].

We also observed an increasing difference between I and II groups at 3, 6 and 12 months after surgery in terms of GR, PR, MR, and AR indexes, which were better in I group ( $p < 0.05$ ). This observation confirms long-term benefits of regular physical activity in patients after kidney transplantation. A number of studies have shown that physical exercises improve physical performance, increase muscle strength, improve blood pressure control, etc. [Painter P et al., 2002; Van den Ham E et al., 2007; Romano G et al., 2017].

Thus, patients with regular physical activity have improved health indicators, and the presented data indicate the effectiveness of the developed

program of physical rehabilitation which results in positive dynamics of physical, adaptive, mental and general health reserves in I group patients. However, further research is needed to elucidate the role of physical exercises in patients after kidney transplantation in the prevention and treatment of cardiovascular risk factors aimed at preserving the favorable long-term outcome after the kidney transplantation operation.

#### CONCLUSION

The results of our survey made it possible not only to quantify the general health reserves in the selected groups of patients, but also to study the features of adaptation to physical activity in patients after transplantation. It was revealed that the decrease in general, physical and adaptive health reserves in the first month after the operation occurred both because of the operation itself and under the influence of rehabilitation procedures of the postoperative period. The growth of all indicators during the year in I group in comparison with II was due to prolonged physical rehabilitation. With regular sessions of therapeutic physical activity, the donor kidney recipients showed better health indexes relative to the general population. Thus, regular physical exercises during the first year after kidney transplantation tailored in accordance with the patient's functional state, increased physical and mental health indicators as well as the general efficacy of postoperative rehabilitation.

#### REFERENCES

1. Ageeva LI, Aleksandrova GA, Zaichenko NM, Kirillova GN, Leonov SA., et al. [Health insurance in Russia] [Published in Russian]. Stat. sb./Rosstat.- M., Z-46. 2017. 170p.
2. Anees M, Barki H, Masood M, Ibrahim M, Mumtaz A. Depression in hemodialysis patients. Pak J Med Sci. 2008; 24: 560-565.
3. Anees M, Hameed F, Mumtaz A, Ibrahim M, Nasir Saeed Khan MN. Dialysis – related factors affecting quality of life in patients on hemodialysis. Iran J Kidney Dis. 2011; 5(1): 9-14.
4. Armstrong KA, Campbell SB, Hawley CM, Nicol DL, Johnson DW, Isbel NM. Obesity is associated with worsening cardiovascular risk factor profiles and proteinuria progression in renal transplant recipients. Am J Transplant. 2005; 5(11): 2710-2718.
5. Balandin YuP, Generalov VS. [HSC “The Source of Life”. Patent RF, № 2004610012] [Published in Russian]. 2004.
6. Crouch RH. Rehabilitation for solid organ transplantation: physical therapy considerations Types of Patients Who May Benefit from Physical Therapy Involvement, PT,DPT,MS,CCS,FAACVPR Duke University APTA Combined Sections Meeting January, 2013.

7. *Djamali A, Premasathian N, Pirsch JD.* Outcomes in kidney transplantation. *Semin Nephrol.* 2003; 23(3): 306-316.
8. *Evans R, Manninen DL, Garrison LP, Hart LG, Blagg CR, Gutman LP.* The quality of life of patients with end-stage renal disease. *New England Journal of Medicine.* 1985; 312(9): 553-559.
9. *Garcia GG, Harden P, Chapman J.* The global role of kidney transplantation. *J Nephropathol.* 2012; 1(2): 69-76.
10. *Giulio R, Lorenzon E, Montanaro D.* Effects of exercise in renal transplant recipients. *World J Transplant.* 2012; 2(4): 46-50.
11. *Goldberg AP, Geltman EM, Hagberg JM, Delmez JA, Haynes ME, Harter HR.* Therapeutic benefits of exercise training for hemodialysis patients. *Kidney Int.* 1983; 69(1): 75-159.
12. *Kaplan B, Meier-Kriesche HU.* Renal transplantation: A half century of success and the long road ahead. *J Am Soc Nephrol.* 2004; 15: 3270-3271.
13. *Kasiske BL, Anjum S, Shah R, Skogen J, Kandaswamy C., et al.* Hypertension after kidney transplantation. *Am J Kidney Dis.* 2004; 43: 1071-1081.
14. *Kasiske BL, Snyder JJ, Gilbertson D, Matas AJ.* Diabetes mellitus after kidney transplantation in the United States. *Am J Transplant.* 2003; 3: 178-185.
15. *Koutsopoulou-Sofikiti EB, Kelesi-Stavropoulou NM, Vlachou DE, Fasoi-Barka GG.* The effect of chronic dialysis in personality of patients with chronic renal failure. *Vima of Asklipiou.* 2009; 8(3): 240-254.
16. *Lentine KL, Brennan DC, Schnitzler MA.* Incidence and predictors of myocardial infarction after kidney transplantation. *J Am Soc Nephrol.* 2005; 16: 496-506.
17. *Maalouf NM, Shane E.* Osteoporosis after solid organ transplantation. *J Clin Endocrinol Metab.* 2005; 90: 2456-2465.
18. *Ojo AO.* Cardiovascular complications after renal transplantation and their prevention. *Transplantation.* 2006; 82: 603-611.
19. *Painter PL, Hector L, Ray K, Lynes L, Dibble S., et al.* A randomized trial of exercise training after renal transplantation. *Transplantation.* 2002; 74: 42-48.
20. *Painter PL, Hector L, Ray K.* Effects of exercise training on coronary heart disease risk factors in kidney transplant recipients. *Am J Kidney Dis.* 2003; 42: 362-369.
21. *Painter PL, Messer-Rehak D, Hanson P, Zimmerman S, Glass NR.* Exercise capacity in hemodialysis, CAPD and renal transplant patients. *Nephron.* 1986; 42(1): 47-51.
22. *Pascual M, Theruvath T, Kawai T, Tolckoff-Rubin N, Cosimi AB.* Strategies to improve long-term outcomes after renal transplantation. *N Engl J Med.* 2002; 346: 580-590.
23. *Patcai JT, Disotto-Monastero MP, Gomez M, Adcock LE.* Inpatient rehabilitation outcomes in solid organ transplantation: Results of a unique partnership between the rehabilitation hospital and the multi-organ transplant unit in an acute hospital. *Open Journal of Therapy and Rehabilitation.* 2013; 1(2): 52-61.
24. *Romano G, Lorenzon E, Montanaro D.* "Effects of exercise in renal transplant recipients. *World J Transplant.* 2012; 2(4): 46-50.
25. *Surgeon General's report on physical activity and health.* From the Centers for Disease Control and Prevention. *JAMA.* 1996; 276(7): 522.
26. *Tomilina NA, Andrusev AM, Peregudova NG, Shinkarev MB., et al.* Renal replacement therapy for End Stage Renal Disease in Russian Federation, 2010-2015. Russian National Renal Replacement Therapy Registry Report of Russian Public Organization of Nephrologists "Russian Dialysis Society": Part 1. *Nephrology and dialysis.* 2017; 19(4): 1-95. DOI: 10.28996/1680-4422-2017-4suppl-1-95
27. *Vanden Ham EC, Kooman JP, Schols AM, Nieman FH, Does JD., et al.* The functional, metabolic, and anabolic responses to exercise training in renal transplant and hemodialysis patients. *Transplantation.* 2007; 83: 1059-1068.
28. *Zelle DM, Corpeleijn E, Stolk RP, de Greef MH, Gans RO., et al.* Low physical activity and risk of cardiovascular and all-cause mortality in renal transplant recipients. *Clin J Am Soc Nephrol.* 2011; 6(4): 898-905.