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The level of daily physical activity and methods to increase it in patients after liver or kidney transplantation

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Abstract

Introduction: Regular physical activity results in many health benefits, however many studies indicate that the level of activity of patients after transplantation is low. The purpose of the study was to assess the level of daily physical activity in patients after liver (LTx) or kidney transplantation (KTx) and the usefulness of a self-monitoring method in increasing their daily physical activity.

Material and methods: Patients after LTx or KTx (n = 100) has been enrolled to the study and were randomly assigned to either an intervention (IG) or control group (CG). Ninety-four participants completed the 3 month period of observation. Participants assigned to IG were monitoring their daily physical activity using a pedometer and were required to complete a diary of daily number of steps. The level of physical activity was also assessed by International Physical Activity Questionnaire (IPAQ). In the statistical analysis the parametric and non-parametric tests has been used in consistency with data distribution. A value of $p \leq 0.05$ was considered significant.

Results: The average daily number of steps in pre/posttest in both study groups was less than 7600. The study showed a significant relationship between the average daily number of steps and daily Total Physical Activity Score TPAS/day [MET-min/day] ($p < 0.001$; $r = 0.57$). The study did not revealed any effects of intervention.

Conclusions: Daily physical activity in patients after KTx or LTx is low, but it does not differ from healthy population (<7500 steps). In post-transplant comprehensive medical management, long-term physical activity recommendations could be included together with the early post-surgery physiotherapy.

Keywords: kidney, liver, transplantation, pedometer, IPAQ questionnaire

Introduction

Regular physical activity (PA) results in many health benefits, therefore it is also highly recommended for patients after transplantation [1]. However, many studies indicate that the level of activity of patients after kidney transplantation (KTx) or liver transplantation (LTx) is low. Only 20% to 36% of KTx patients and 50% of LTx patients declared that they participated in moderate or regular physical activity 1 year after the surgery [2–4]. In general, transplanted patients are characterized by low energy levels, fatigue, poor exercise capacity and a sedentary lifestyle. A low level of PA increases the risk of cardiovascular mortality and metabolic diseases or sarcopenia. Decreased muscle mass resulting from sarcopenia is associated with poor survival rate after KTx. A low level of PA could also result in weight gain, obesity, diabetes, hypertension and metabolic syndrome. These factors are associated with the worst outcomes of therapy, increased number of cardiac events and even graft loosening or death in transplanted patients [5].

In hepatic and pancreatic transplant recipients, cardiovascular complications are the leading cause of death. The 5-year mortality rate from cardiovascular disease in KTx patients is 15% [6]. Although there are many interventional studies using exercise programs in a group of patients after the transplantation that are reported in the literature, official guidelines for PA in the transplant setting are absent [6,7]. Guidelines for PA for patients with chronic diseases or older adults recommend similar levels of exercises as for healthy adults, guided by the individual's exercise capacity [8]. Available evidence on structured exercise interventions in KTx patients suggests that, in middle-aged adult patients without major comorbidities, an aerobic or resistance exercise training program lasting 3–6 months may be recommended as a part of their comprehensive medical management [5].

Nowadays, increasing ambulatory PA by monitoring daily steps is becoming very popular. Although a precise translation of public health guidelines in terms of steps per day is unknown, it was estimated that daily number of steps in special populations, like patients with chronic illness range between 1,200 and 8,800. Considering the common PA recommendations it was estimated that the minimal daily number of steps range between 5,500 and 4,600 during free-living behavior (considering that 2,500 steps/day is a general indicator of basal activity in individuals living with disability or chronic illness). Exercise interventions based on pedometers in special populations elicit an increase of more than 2,000 steps per day [9]. Moreover the use of a step diary or daily physical activity recording may be key motivational factors for increasing physical activity [10,11].

The aim of this study was to assess the level of daily physical activity in patients after liver or kidney transplantation and the usefulness of a self-monitoring method (pedometer) in increasing their daily physical activity. The secondary aim of the study was to assess the correlation between the measurement of physical activity using the subjective (International Physical Activity Questionnaire – IPAQ) and objective (pedometer) methods.

Material and methods

The Ethics Committee approved the experimental protocol (No. KB/7/A/2018).

Participants

This study included 100 patients after liver (n = 28) or kidney transplantation (n = 72). Thirty-nine participants were female and sixty-one of them were male. The intervention group – IG (n = 49) consisted of patients who had undergone KTx (n = 37; 75.5%) or LTx (n = 12; 24.5%). The control group – CG (n = 51) also consisted of KTx patients (n = 35; 68.6%) and LTx patients (n = 16; 31.4%). Distribution of groups by gender was as following: 18 (36.7%) females and 31 (63.3%) males in IG; 21 (41.2%) and 30 (58.8%) in the CG, respectively. The mean age of patients in IG was 33.8 ± 7.1 years old and 36.2 ± 6 years old in CG. There was no statistical significant difference between the study groups at P0 in average daily number of steps ($p = 0.78$) and in the TPAS/day ($p = 0.85$).

To estimate the sample size the Harris's formula has been used. According which the number of participants should exceed the number of predictors by at least 50 [12]. The inclusion criteria of this study were: status after liver or kidney transplantation within 1 to 5 years after the surgery, age between 18 to 45 years old, written consent to participate in the study. From the study were excluded patients unable to move independently and patients unable to perform functional tests. The age range of the participants was established to select those of working age and exclude patients with the very low daily physical activity often observed in older adults.

Measurements

During the recruitment, every patient expressed written consent to participate in the study and the patients were randomly assigned to either the IG or CG using a random permuted blocks method of sizes 4. The sequence was generated automatically by computer. Allocation ratio was 1:1. The random allocation sequence was generated by the researcher, who did not contribute in recruitment process. The recruitment process lasted from January to June 2018. During the recruitment stage (point 0 – P0) all of the patients underwent the 7-days measurement of their daily number of steps, completed the long form of the International Physical Activity Questionnaire (IPAQ), and their body composition was measured using a bioimpedance method (Body Composition Analyser Maltron Bioscan 920, UK).

The level of daily activity, as measured by a pedometer (Beurer AS 80 Bluetooth activity sensor, Germany), was calculated using indicators for healthy people [13]. There are no precisely calculated intervals of the level of daily activity for special populations, like patients after organ transplantations. According to the literature, there appears to be no need to otherwise reduce physical activity guidelines for apparently healthy older adults or patients with chronic illness that do not challenge their physical abilities [9]. It is the reason why the level of daily physical activity of KTx and LTx patients was referenced to norms for healthy adults.

The long form of the IPAQ iclude details about the specific types of activities. The items were structured to provide separate domain-specific scores for walking, moderate-intensity and vigorous-intensity activity within each of the work, transportation, domestic chores and gardening, and leisure-time domains. Total time engaged in walking, moderate physical activity, and vigorous physical activity and level of daily activity were computed according to the guidelines. All cases in which the sum total of all walking, moderate and vigorous time variables was greater than 960 minutes (16 hours) were excluded from the analysis [14]. The long IPAQ questionnaire forms indicate very good repeatability (a repeatability coefficient of $\rho = 0.81$) [15]. The main result of the IPAQ, Total Physical Activity Score per week (TPAS/week) has been averaged to daily values (TPAS/day). All data were anonymized and collected on virtual database.

Intervention

Patients assigned to the IG were subjected to intervention, which involved self-monitoring their daily physical activity using a pedometer for three consecutive months. They were required every day to complete a diary of their daily number of steps. Data suggests that having access to daily step counts positively influenced to attain a higher number of steps per day [16,17] and the use of a step diary may be key motivational factors for increasing physical activity [10]. The patients from the CG received no intervention procedures. After three months from P0, all patients were invited to final tests (point 1 – P1), which were the same functional test and questionnaire, as in P0.

Statistical analysis

Ninety-four participants completed the 3 month period of investigation and only those data where analyzed. Six patients withdrew from the study. Collected data were calculated using the R package, version 3.4.3. Categorical variables were described by count and percentage, whereas continuous variables were described by arithmetic mean with standard deviation (SD). The consistency of the data with the normal distribution was assessed by the Shapiro-Wilk test. To verify study hypothesis, the data which distribution were consistent with normal (BMI, Fat%, FFM) were analyzed using parametric tests. In analysis data not consistent with normal the non-parametric tests has been used.

The non-parametric Mann-Whitney U test was used to compare continuous variables between the IG and the CG. In order to verify if the differences individual variables between the final and the initial time point were significant different in the CG than in the IG the Wilcoxon Test or T-Student test has been used. For pairs of numerical variables, the Pearson's linear correlation coefficient or the Spearman's Rank correlation coefficient was used. The linear mixed models method was used to examine the influence of several factors (group, time of measurement and their interaction) on the patients' results (as a random factor was treated a patient-related factor). A value of $p \leq 0.05$ was considered significant.

Tab. 1. Results of functional test, questionnaire, and bioimpedance measures

Results of tests	IG	Mean ± SD	Test; P	CG	Mean ± SD	P
Average daily number of steps [steps/day]	P0	7094 ± 2635	$p > 0.05^1$	P0	7527 ± 4237	$p > 0.05^1$
	P1	7189 ± 3193		P1	7265 ± 3226	
IPAQ TPAS/day [MET-min/day]	P0	945.3 ± 664.5	$p > 0.05^1$	P0	1005 ± 750.5	$p > 0.05^1$
	P1	979.7 ± 701.2		P1	1418 ± 893.3	
Bioimpedance: BMI [kg/m^2]	P0	24.02 ± 4.11	$p > 0.05^2$	P0	25 ± 3.91	$p > 0.05^2$
	P1	24.02 ± 4.11		P1	24.98 ± 3.43	
Fat%	P0	22.83 ± 8.33	$p > 0.05^2$	P0	26.46 ± 7.41	$p > 0.05^2$
	P1	23.4 ± 8.65		P1	26.92 ± 6.58	
FFM [kg]	P0	53.39 ± 9.35	$p > 0.05^2$	P0	52.98 ± 10.84	$p > 0.05^2$
	P1	52.3 ± 9.16		P1	51.76 ± 10.18	

P0 – recruitment; P1 – final tests; CG – control group; IG – intervention group; SD – standard deviation; IPAQ – International Physical Activity Questionnaire; TPAS/day – Total Physical Activity Score/day; BMI – Body Mass Index; Fat% – percentage of body fat; FFM – Free Fat Mass; [1] Wilcoxon Test; [2] T-student Test.

Results

The average daily number of steps in IG at P0 was 7094 (±2635) and it increased in P0 to 7189 (±3193). In CG at P0 it was 7527 (±4237) and it decreased to 7265 (±3226) in P1. The detailed results of tests performed in IG and CG in P0 and P1 are included in Table 1.

Percent distribution of groups due to the level of PA calculated from the average daily number of steps and the level of activity calculated according the IPAQ guidelines are included in Table 2.

The validity test of the IPAQ questionnaires revealed that only 45% questionnaires from the CG and 63% from the IG at P0 and 33% from CG and 61% from IG

Tab. 2. Percent distribution of groups due to the level of PA calculated from the average daily number of steps and the level of activity calculated according the IPAQ guidelines

	P0		P1	
	IG [%]	CG [%]	IG [%]	CG [%]
Level of PA Average daily number of steps				
Sedentary	17	32	22	30
Low active	50	20	37	24
Somewhat active	23	22	29	29
Active	10	26	13	17
Level of PA IPAQ TPAS/day [MET-min/day]				
Low	37	18	36	35
Average	60	82	61	65
High	3	0	3	0

P0 – recruitment; P1 – final tests; CG – control group; IG – intervention group; SD – standard deviation; IPAQ – International Physical Activity Questionnaire; TPAS/day – Total Physical Activity Score/day; PA – Physical Activity; Sedentary – <5,000 steps/day; Low active – <7,499 steps/day; somewhat active – <9,999 steps/day; Active – ≥10,000 steps/day.

Tab. 3. The results of the impact of intervention. The comparison of values differences between recruitment point and final point

Results of tests	Group	Mean differences (±SD)	Test; P
Average daily number of steps [steps/day]	IG	–18.6 (±2994)	$p > 0.05^1$
	CG	–435.1 (±2721)	
IPAQ TPAS/day [MET-min/day]	IG	–78.5 (±556.5)	$p > 0.05^2$
	CG	396.7 (±796.9)	
Bioimpedance: BMI [kg/m^2]	IG	–0.2 (±1.3)	$p > 0.05^1$
	CG	–0.1 (±0.9)	
Fat%	IG	–0.5 (±4.6)	$p > 0.05^1$
	CG	0.1 (±3.2)	
FFM [kg]	IG	–0.5 (±3.6)	$p > 0.05^1$
	CG	0 (±2.2)	

CG – control group; IG – intervention group; SD – standard deviation; IPAQ – International Physical Activity Questionnaire; TPAS/day – Total Physical Activity Score/day; BMI – Body Mass Index; Fat% – percentage of body fat; FFM – Free Fat Mass; ^{1} Mann-Whitney Test; ^{2} T-student Test.

at P1 could be statistically analyzed. In most cases there was an overestimation of self-reported physical activity or the data were incomplete.

According to this study, the Spearman's Rank correlation coefficient revealed a significant relationship between the average daily number of steps and the result TPAS/day [MET-min/day] measured by IPAQ test ($p < 0.001$; $r = 0.57$).

The mixed model analysis confirmed that there was a strong relationship between the results of TPAS/day [MET-min/day] and the average daily number of steps ($p < 0.001$). The increase in the average daily number of steps by 100 was accompanied by the increase of the TPAS/day [MET-min/day] by about 13 units.

Analysis of the impact of the intervention

The analysis of the impact of the intervention used in the study on the differences between observation in P0 and P1 did not reveal any effects on the average daily number of steps ($p = 0.99$), TPAS/day [MET-min/day] ($p = 0.1$) body mass index (BMI) ($p = 0.64$), body fat percentage (Fat%) ($p = 0.53$) and free fat mass (FFM) ($p = 0.23$). This observation was confirmed in the analysis of mixed models, where the influence of the measurement time, the studied group and their interaction on the variable value was checked. The results of impact of the intervention are included in Table 3.

In the IG the decrease in values of TPAS/day [MET-min/day] has been noted, whereas in the CG there has been an average increase in this value, but observed differences was not statistically significant.

Discussion

The level of daily PA calculated from average daily number of steps observed in the group of patients after KTx or LTx in 1 to 5 years after the surgery could be in general described as low (from 5000 to 7499 steps/day), with regard to recommendations for healthy young or middle-aged populations [18]. On the other hand, considering the PA recommendations for patients with chronic diseases, average daily number of steps achieved by patients from both study groups indicates, that they are more active than patients qualified as 'older adults or special populations' [9]. It means that PA recommendations for young to middle-aged patients after KTx or LTx without the complications and after the post-surgery recovery time could be the same as for healthy individuals. Those results are consistent with Raymond et al., where the average daily number of steps achieved by KTx patients was more than 9000 [19]. Cross-sectional studies conducted on healthy populations indicate that without any motivational or interventional procedures, the level of pedometer-assessed PA is lower than recommended and depends on working or non-working days, as well as the season [20].

Most studies on assessment of PA in post-transplantation patients are based on subjective methods using standardized or self-prepared questionnaires. Those methods are burdened with a large measurement error and are usually overestimated, which has been previously proven [20,21]. This observation is partially reflected in the research presented here, where the high percentage of completed questionnaires was overestimated and did not meet the validity criteria, so those results could not be subjected to statistical analysis. The level of PA assessed by IPAQ indicates that self-perception of daily activity in both study groups is average. Moreover, there was a statistical significant correlation between the average daily number of steps and TPAS/day [MET-min/day] calculated on results, which were positively validated. It means that PA was assessed correctly in positively validated results, but the names of the levels of PA assessed by daily number of steps and IPAQ do not correspond with each other. It could be explained by mismatching in ranges of standards in determining the levels of activity between objective measurement methods and questionnaires, even standardized ones. Presented study revealed decrease in values of TPAS/day [MET-min/day] in the IG after the intervention, which could be caused by a better sense of patients own activity after using the self-monitoring objective method. It means that to PA assessment should be recommended using objective methods or both of them simultaneously (subjective and objective).

Although the study revealed an increase in the average daily number of steps in IG after the intervention and decrease in that value in the CG, the impact of intervention did not revealed significant differences in study groups at P1. This intervention was based on using the self-monitoring method with a step diary, but without a recommended goal of daily steps. The effectiveness of self-monitoring activity by pedometer with step diary use in increasing the daily number of steps has been previously proven. However, the use of the self-monitoring method with goal setting or feedback (e.g. 10,000) seems to be even more effective, which was impossible to apply to the study group due to the lack of appropriate recommendations [9].

Many authors emphasize the role of motivation in increasing PA. Their methods derived from cognitive-behavioral and motivational approaches to increase the likelihood of enduring behavior change by increasing motivation, self-efficacy, and sense of control over physical activity, using a personalized approach, with social support and setting of meaningful goals [22]. Some studies have identified text messages as a method for promoting PA. One of these is a SDT-informed text messages method emphasizing the basic psychological needs based on a theory of motivation – the Self Determination Theory [23]. Other method considered as effective in PA promotion is the daily physical activities recording [11]. Those observations may prove that using step goals or other methods to increase PA in KTx or LTx may be effective, but studies on larger populations are necessary to determine their safety, e.g. the safe ranges of the daily number of steps recommended in this group of patients.

Taking into account the consequences of transplantation and immunosuppressive therapy, as well as the high risk of cardiovascular diseases and metabolic syndrome among KTx or LTx patients, the sedentary lifestyle and low level of PA is particularly undesirable. Moreover, many researchers confirm the positive impact of the exercises interventions on muscle strength and cardiorespiratory fitness in KTx or LTx patients. Van der Ham et al. observed a statistical significant improvement in VO2 peak and muscle strength in KTx patients after the 12-weeks endurance and strength training [24]. Similar observations have been observed by Greenwood et al. [25]. Karelis et al. noticed an improvement in muscle strength but not in cardiometabolic risk factors [26], whereas Kouidi et al. noted an improvement in maximal oxygen uptake [27]. Very little data on the impact of exercise training comes from research on patients after LTx. Moya-Nayera et al. observed a significant improvement in maximal oxygen consumption, overall and regional maximal strength [28] and van den Berg-Emons noticed improvement in aerobic capacity and knee flexion strength in LTx patients following a training program [29]. All of the above studies have shown that exercise training is very important in improving cardiorespiratory fitness or muscle strength in early rehabilitation after transplantation. However, all of them were conducted in the range of 2-12 months period after the transplantation, which means that the achieved effects could be short-term. Therefore, in the standard post-transplant care, in addition to exercise programs, preparing for a quicker return to social and professional life, important elements should be the recommendations of daily physical activity used to reduce the risk of cardiovascular disease, in force for the rest of the patient's life.

In the study did not reveal any changes in bioimpedance parameters. Although Cai et al. in meta-analysis confirmed the impact of pedometer intervention on BMI and weight but among obese and overweight adults [30]. The BMI of the participants of our study was within the normal range. In addition, there were no daily step goal in the study, which may have resulted in no observed effects on body weight components.

Study limitations

One of the limitations of our study could be the number of completed questionnaires (IPAQ) that met the validity criteria; however this number was sufficient to derive valid conclusions from the statistical analysis. Another limitation is lack of the step goal in the intervention procedure, but it was caused by the lack of appropriate criteria for those groups of patients. The use of such a goal could strengthen the impact of intervention used in the presented study.

Conclusions

In conclusion, we have shown that daily PA in patients after KTx or LT is low, but it does not differ from healthy populations. It means that PA recommendations for young to middle-aged patients after KTx or LTx without complications and after the post-surgery recovery time may be the same, as for a typical healthy individuals. Moreover, to increase PA in KTx and LTx patients, using daily step-goals may be effective, but further studies on larger populations are necessary to determine the safe ranges of the daily number of steps recommended in this group of patients. Due to the overestimation observed in IPAQ results we conclude that PA assessment should be recommended using objective methods or both, subjective and objective simultaneously. We also conclude that, in post-transplant comprehensive medical management, long-term PA recommendation could be included on a par with the early post-surgery physical therapy.

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Confict of Interest
The authors have no conflict of interest to declare.

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