NEFROLOGIA 2022;42(3):265–272

Revista de la Sociedad Española de Nefrología
www.revistanefrologia.com

Review

Physical exercise and peritoneal dialysis: An area yet to be explored

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ARTICLE INFO

Article history:
Received 30 August 2020
Accepted 6 February 2021

Keywords:
Chronic kidney disease
Peritoneal dialysis
Physical exercise
Physical activity
Health-related quality of life

ABSTRACT

Health-related quality of life (HRQoL) of patients suffering from chronic kidney disease (CKD) is profoundly impaired by their frailty, disability and decreased physical capacity. Especially among older patients, a high prevalence of low physical activity levels and reduced functional performance has been reported. Physical exercise training has been shown to have a beneficial impact, counteracting these same hazardous consequences of inactivity and sedentarism both on CKD and end-stage kidney disease (ESKD) patients on hemodialysis (HD) treatment. The evidence-based knowledge on the effects of physical exercise on ESKD patients undergoing Peritoneal Dialysis (PD) treatment is scarce, even though this is a continually growing population that shares the same risk factors and desired clinical outcomes as the previously mentioned groups of patients. Further investigation will be necessary to clarify whether this exercise-based approach may be suitable for the PD population.

This paper's purpose is to review the available literature, including randomized controlled trials, reviews and meta-analysis results that assessed the impact of physical exercise on patients under PD treatment bearing in mind their HRQoL, physical functioning and cardiovascular parameters. Furthermore, it aims to evaluate the perceived significant barriers and limitations of the PD population in what concerns physical exercise practice and how nephrologists should address them.

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https://doi.org/10.1016/j.nefro.2021.02.007

Ejercicio físico y diálisis peritoneal: un área aún por explorar

Palabras clave:
Enfermedad renal crónica
Diálisis peritoneal
Ejercicio físico
Actividad física
Calidad de vida relacionada con la salud

RESUMEN

La calidad de vida relacionada con la salud (CVRS) de los pacientes que padecen enfermedad renal crónica (ERC) se ve profundamente afectada por su fragilidad, discapacidad y disminución de la capacidad física. Especialmente en pacientes de edad avanzada, existe una alta prevalencia en cuanto a la disminución de los niveles de actividad física y el rendimiento funcional. En este sentido, se ha demostrado que el ejercicio físico tiene un impacto beneficioso, previniendo los trastornos asociados a la inactividad y el sedentarismo tanto en pacientes con ERC temprana como en pacientes con enfermedad renal en etapa terminal (ERT) y en hemodiálisis (HD). Sin embargo, el conocimiento basado en la evidencia sobre los efectos del ejercicio físico en pacientes con ERC en Diálisis Peritoneal (DP) aún es escaso, a pesar de que se trata de una población en continuo crecimiento que comparte los mismos factores de riesgo y resultados clínicos que los grupos de pacientes mencionados previamente.

Por lo tanto, se necesitan realizar estudios adicionales para aclarar si este enfoque basado en el ejercicio podría ser adecuado para la población en DP. El objetivo de este trabajo es revisar la literatura disponible, incluyendo ensayos controlados aleatorizados, revisiones y resultados de metaanálisis que hayan evaluado el impacto del ejercicio físico en pacientes en DP teniendo en cuenta su CVRS, funcionamiento físico y parámetros cardiovasculares. Además, se evaluarán las barreras y limitaciones significativas percibidas por la población con DP en lo que respecta a la práctica del ejercicio físico y cómo los nefrólogos podrían abordarlas.

Introduction

The prevalence of chronic kidney disease (CKD) has been increasing steadily.[1,2] It must be seen as a significant health-related problem since it is associated with high morbidity and mortality, negative impacts on the health-related quality of life (HRQoL), high diagnostic and therapeutic cost and high disease burden over society.[3]

The decline in HRQoL can be linked to several factors such as anaemia, malnutrition, impaired cognitive function, deteriorated sleep quality, increased depression rate, worse cardiovascular condition and other metabolic disturbances characteristically found in CKD patients.[1,4] The treatment regimen, especially HD, may also require several weekly attendances to health-related facilities, which can be extremely time-consuming and stressful for patients.[5] Reduced physical performance due to frailty and disability also contributes to sedentarism and decreased quality of life.

Cardiovascular morbidity is the leading cause of morbidity and mortality in the CKD and ESKD population.[6] The status of the cardiovascular system is critical in determining the functional capacity, and it may be the most limiting factor over the success and efficacy of the rehabilitation efforts.[7]

It is well established that regular exercise bestows substantial benefits in the management of cardiovascular risk factors, such as obesity, type 2 diabetes mellitus and hypertension, as it can promote control over blood glycaemia, blood pressure and the patient's nutritional status respectively. Exercise training can also improve exercise tolerance in individuals, allowing them to increase their physical fitness levels.[6] It is therefore expected that this same beneficial impact can be observed in the CKD and ESKD population.

The 2005 NFK-KDOQI (National Kidney Foundation – Kidney Disease Outcomes Quality Initiative) guidelines had already recommended that exercise should be considered as one of the cornerstones of the therapeutic approach for adults receiving dialysis, especially when aiming to control cardiovascular risk factors and outcomes.[8]

In that sense, it is essential that nephrologists have access to evidence-based knowledge about which health outcomes may be affected by these exercise-based approaches, and which training designs are best to influence and achieve the desired endpoints. Most of the research made have mainly focused on HD patients, showing some beneficial impact of regular exercise training over the cardiorespiratory functional capacity and HRQoL.[9]

The purpose of this paper is to review the available literature, including randomized controlled trials, reviews and meta-analysis that evaluated in PD patients the impact of physical exercise on HRQoL, physical functioning and cardiovascular parameters. Perceived barriers to physical exercise practice in PD population are discussed.

Physical activity in PD patients

Similarly to other chronic diseases, a decline in the exercise capacity, measured by peak oxygen consumption (peak VO_2), and muscle wasting are frequent and progressive in patients with CKD and ESKD and are associated with higher morbidity and mortality risk.[1] The leading cause of death in the PD population, as in CKD and HD patients, is still cardiovascular events.[10] People with CKD have an 18–20-fold increased risk of cardiovascular disorders, which is even further heightened after starting a dialysis regimen.[11] There is consistent evidence supporting that this increase in cardiovascular morbidity may be due to potentially modifiable risk factors such as sedentarism, nutrition status, dyslipidaemia and hypertension. Therefore, interventions focused on counteracting these factors are important. Studies on exercise-based approaches have already reported a beneficial impact over physical functioning levels and HRQoL of CKD and ESKD patients undergoing HD treatment. However, studies exclusively involving PD patients are scarce, and the lack of well-designed randomized controlled trials does not allow for a significant and valid evidence-based causality on exercise and PD patients' oriented outcome measures. To further discuss the matter, a comparison between PD and HD patients seems of utmost relevance. The primary observation and intervention studies analyzed for this review are summarized in Appendix A, Tables 1 and 2, respectively.

Sedentarism

In 2014, a cross-sectional study by Cobo et al.[12] revealed that both PD and HD patients presented a high prevalence of sedentary behaviour. A pedometer-based approach revealed that 63% of the PD patients and 71% of the HD patients were considered sedentary (<5000 steps/day), thus reporting no significant differences between both these populations' physical activity levels.

Also, in 2017, Painter et al.[13] were the first to compare physical functional capacity between HD and PD populations directly, showing similar results in both groups of low levels of physical functioning and PD patients had a higher gait speed.

This conclusion conforms with a previous review by Cupisti et al.[14] who also noted the same high prevalence of low physical function and sedentarism amongst older patients undergoing PD. Another pertinent finding by Cupisti et al.[14] was that a matching pre-dialysis CKD patients cohort did not show any significant differences in terms of physical functioning and performance when compared to the previous PD population. Therefore, even though it lacks confirmation, it was suggested that the initiation of a dialysis-based treatment, in this case, PD, was not *per se* a significant determinant in the decline of these patients' physical capacity. Instead, it is a deteriorating process that starts in earlier stages of CKD and progresses together with the disease.

This physical inactivity and mobility limitation profoundly influence PD patients' independence status and capacity for performing everyday tasks, including self-care needs. On the other hand, sedentarism will also promote a vicious cycle of poor health, in which an imbalance of energy expenditure can exacerbate comorbidities such as hypertension, diabetes mellitus, coronary artery disease and depressive mood disorders,[4] which can also be seen as the determinants of this same physical inactivity. Therefore, since each of these conditions can further increase the morbidity and mortality rates, as well as intensify the decline in the quality of life of these patients,[1] an intervention strategy oriented towards ending this sedentary lifestyle may be of interest amongst some patients.

Nutritional and inflammatory status

Studies assessing the nutritional status in elderly patients under PD treatment and its impact on their physical functions have reported that the malnutrition-inflammation score (MIS) was markedly higher in PD patients when compared with matching CKD pre-dialysis patients. In 2017, Cupisti et al.[14] were also able to hypothesize that PD patients' physical capacity, measured by simple methods as the Rapid Assessment of Physical Activity (RAPA) test and the 30s sit to stand (STS) chair test, had an inverse correlation with the MIS of these patients, suggesting once again that the malnutrition-inflammation score was a significant physical impairment factor. Previously, in 2014, Wakamiya et al.[15] used the Geriatric Nutritional Risk Index (GNRI) to assess the nutritional status of patients under PD treatment. Wakamiya also showed evidence that the low-GNRI group was associated with decreased levels of physical activity. Thus, both MIS and GNRI may be seen as potential predicting tools of reduced Physical Activity capacity and function. This result may be of particular relevance when considering the PD population, since it is, simultaneously, at high risk of protein depletion and of obesity.

Moreover, in a recent systematic review, Thangarasa et al. demonstrated that the number of daily steps taken by PD patients, measured by a pedometer, had an inverse correlation with serum C-reactive protein (CRP) values.[11] Since exercise has already been associated with noticeable anti-inflammatory effects in pre-dialysis CKD patients,[14] a comparable beneficial impact over PD patients MIS and GNRI scores may be anticipated, even though further studies are still necessary.

Sarcopenia and dynapenia

Physical deterioration starts early and progresses across the CKD lifespan. The uremic milieu and the increased protein catabolism contributes to the muscle atrophy with loss of strength (dynapenia) and mass (sarcopenia).[16] According to an Iranian study from 2018, the PD population presented dynapenia and sarcopenia rates of 43% and 11.5%.[17] After age-adjustments, these results were comparable to the values of dynapenia and sarcopenia found in a much older non-dialysis population. Besides that, at that age, only 8% of the PD population remained independent enough to perform their daily living and self-care activities.[17] It was also clear that the loss of muscle strength happened more rapidly than the loss of muscle mass. Thus, dynapenia cannot be exclusively justified by muscle atrophy. The increased malnutrition-inflammation scores with higher protein-energy waste, the oxidative stress and metabolic acidosis from the uremic milieu, the increased insulin resistance and the hormonal deregulation are all factors that must be taken into consideration. Another major contributor to dynapenia is the increased fat infiltration into PD patients' muscles, which lowers their muscle tissue quality and, therefore, their muscle strength.[17]

In the Iranian study mentioned above, the loss of muscle strength and mass had a significant inverse correlation with physical activity levels in PD patients. Concurrently, it has been shown that exercise-based approaches, especially resistance exercise training, have a beneficial impact in counteracting, controlling and managing dynapenia and sarcopenia both in a healthy population and in patients with chronic conditions such as the oncologic or CKD populations.[18,19] A recent systematic review from 2018 has also reported that a higher lean body mass index was associated with increased tertiles of physical activity.[11] For that reason, it is plausible to infer that better body composition seems to be positively associated with higher physical capacity in CKD and PD patients. Meaning that, once again, increasing physical activity levels in PD patients may be seen as a relevant strategy in preventing further functional impairment and in reducing the associated risk of falls, fractures, hospitalization and death.

Exercise and glycaemic control

The current commercially available PD dialysate hyperosmotic solutions are composed by glucose, icodextrin or amino acids as osmotic agents. Glucose-based solutions are the most frequently used option in clinical practice. The glucose concentration of the PD dialysate surpasses by far the patients' blood glycaemic load resulting in a 50–80% of glucose being absorbed, thus rising patients' serum glucose levels.[20] The average glucose uptake by patients undergoing PD therapy can range from 100 g to 300 g per day.[20]

There is still limited knowledge of whether glucose solutions in PD therapy can induce an increase in the number of patients with new-onset diabetes. So far, there was only one study with statistically significant results, showing that 8% of nondiabetic patients developed diabetes after initiating PD.[20] Further studies will be needed to confirm this hypothesis. Other studies have also shown that the use of an icodextrin-based dialysate solution can be linked to a significant reduction in blood glucose levels, as well as insulin needs.[21]

Another hazardous effect of this excessive glucose uptake is the consequent metabolic complications brought by excessive calory intake and the subsequent weight gain that characterizes the quite high prevalence of dyslipidaemias amongst PD patients.[22] Then, it could be assumed that this uncontrolled peritoneal glucose absorption, together with the hyperglycaemia and hyperinsulinemia associated, will contribute to an undesired rise of the cardiovascular events risk labelled to the PD population, majorly as a result of the increased risk of atherogenesis and hyperlipidaemia. Thus, it would be reasonable to restrain the use of hypertonic glucose dialysate solutions, given the availability of other glucose-sparing dialysate solutions, or, at least, to propose interventions that would counteract the initial glucose uptake by these patients.

Apart from the increased uptake, PD patients' impaired glucose metabolism is mainly due to an increase in glucose intolerance, associated with decreased peripheral insulin sensitivity, hyperinsulinemia and hyperglycaemia.[22] Taking also into consideration its impact over cardiovascular outcomes, the increase of physical activity levels in PD patients has been proposed as a strategy to address this issue. Exercise, especially aerobic exercises, can improve skeletal muscle sensitivity towards serum glucose, both by enhancing the muscles capillary bed and increasing the concentration of insulin receptors. Since recruited muscles will have a higher sensibility towards insulin when compared with resting muscles, its hormonal effect will be maximized, thus lowering PD patients' glucose blood count more efficiently.[22]

In a study conducted in Iran on the impact of exercise over serum glucose levels in 22 PD patients, Shangholian et al.[22] revealed significant beneficial results in their glycahemic control. In this study, PD patients were submitted to a training regimen consisting of 40 min. of stationary cycling twice a week and were reevaluated after 16 training sessions. The revaluation reported a significant reduction in both fasting blood glucose (93.6 ± 12.5 mg/dl vs 117.0 ± 15.3 mg/dl; $P = 0.001$) and 2 h postprandial blood glucose levels (162 ± 15.1 mg/dl vs 182.0 ± 18.6 mg/dl; $P = 0.010$) when compared to the control subgroup. In another study with 13 patients undergoing PD, similar results were found, with evidence of a reduction in fasting blood glucose levels after 12 weeks of treadmill workout when compared to the control group.[23]

As long as the daily caloric and glucose load is determined based on individual patients' PD dialysates, it is possible to prescribe a customized exercise regimen. Further studies are needed in order to evaluate the best exercise-based strategies to counteract the caloric load absorption of glucose-based solutions

Exercise and HRQoL

HRQoL is an important aspect of patient-centered clinical outcomes and must be taken into account when assessing renal care service's quality and effectiveness.[24]

In 2018, a cross-sectional observational study by Uchiyama et al evaluated an association between exercise capacity and quality of life.[25] Exercise capacity was measured by the incremental shuttle walk test (ISWT) – it guides an individual to walk at a progressively faster pace every minute; quality of life was assessed by the Kidney Disease Quality of Life – Short Form questionnaire (KDQoL-SF). Multivariate analysis revealed a positive correlation between exercise capacity and HRQoL so that patients among higher tertiles of ISWT scores were also associated with improved scores in several domains of the KDQoL questionnaire, such as kidney-specific, physical and mental domains. The skeletal mass index (SMI) had a positive association with handgrip and quadriceps strength. However, no significant relation was found between SMI and HRQoL scores.[25] Thus, it was hypothesized that PD patients' aerobic capacity is a better factor to determine their HRQoL than muscle strength *per se*.

A randomized controlled trial, also conducted by Uchiyama et al., was able to clarify the beneficial impact of exercise-based approaches on an exclusively PD population cohort. The intervention group was submitted to a 12-week home-exercise program composed by both anaerobic and resistance training components. When reevaluated after 12 weeks, significant improvement was noted in the ISWT when compared to the usual care group without the intervention.[26] Other predictor exercise parameters were also measured, such as handgrip and quadriceps strength. However, no significant differences were reported.

Furthermore, the HRQoL of these patients was also assessed before and after the 12 weeks of intervention, using the 36-Item Short Form Health Survey (SF-36). According to the SF-36, significant improvements were seen in physical role functioning, emotional role functioning and social component summary domains. Other categories, such as bodily pain and vitality also tended to improve. However, they lost significance after adjusting the results for potential interaction factors. Unfortunately, since the referred trial was designed with a short follow-up period, it was not possible to prove whether these interventions would improve more critical outcomes such as PD patients' mortality rate or survival of the technique.[26]

Exercise and mental health

Patients with ESKD under PD therapy experience difficulties such as functional limitations, reduced mobility, fatigue, higher age-related morbidity and other burden factors of the chronic disease which ultimately contribute to an impairment of their HRQoL. Furthermore, a lot of these patients have their scores of emotional and mental health affected by these same limitations.[11]

PD requires a certain degree of knowledge and practical qualifications, especially since patients may lack direct supervision of health-related staff. Patients' ability to self-manage their disease may not only be seen as a crucial step in terms of reducing the Kidney disease burden over society and medical and healthcare resources, but also as a positive effect on their psychological adjustment and acceptance towards their chronic condition.[27]

Besides that, physically impaired patients with functional limitations and reduced mobility are often forced to withdraw from activities that previously pleased them, thus intensifying their depressive disorders and impairing their psychological well-being[27,28] even further. The prevention of this fragility will also foster the preservation of these patients' independence and their capacity to maintain an active lifestyle. Thus, the promotion of regular exercise habits may be seen as a feasible strategy to improve and maintain physical health and mobility status. Several previous studies have also stated that physical exercise *per se* has the potential to relieve anxiety and depression symptoms, as well as the ability to improve these patients' mood and humour.[29]

The decreased score of emotional and mental health, as well as depression and anxiety, have also been associated with a negative impact on exercise and therapeutic programs' compliance from PD patients. A physical activity reinforcement program based on verbal persuasion through a telephone call or a face-to-face interview for 12 weeks was performed. This study showed a positive effect on exercise compliance - increase in exercise frequency, duration and intensity, as well as on the depression score.[30] Another study by Klang et al.,[31] showed that patients with a better psychological status were more able to participate in their healthcare decisions actively and were more engrossed in understanding and dealing with disease specific-symptoms.

Considering that not all of the identified risk factors for reduced physical activity levels and sedentarism amongst PD patients are potentially modifiable, it is fundamental to focus on strategies meant to enhance patients' participation, adherence and compliance towards the proposed exercise-based therapeutic programs. As such, an approach aimed at the mental and emotional status of this population, such as education and counselling, may have the desired beneficial impact.

Exercise and hard clinical outcomes

As mentioned earlier in this paper, the decreased physical capacity and the comorbid conditions secondary to CKD and ESKD patients such as cardiovascular diseases, diabetes mellitus, metabolic disturbances, frailty, inactivity and decreased mental health scores play an essential role in determining these patients' prognostic and survival rates. Moreover, in the later years, renal patients' HRQoL and its social and emotional aspects have been thoroughly studied as being major determinants concerning these same hard clinical outcomes.[32] Improvements in HRQoL have been seen not only as a treatment goal *per se* but also as a fundamental factor in decreasing CKD and ESKD number of hospitalizations and mortality.[24]

Trials support this conclusion. The ADEMEX trial conducted by Paniagua et al.[33] in a large cohort of PD patients, showed that lower HRQoL scores had a negative impact over PD patients' survival rates and that HRQoL improving measures had a significant predictive value in preventing the need of hospitalization. Comparable results on PD patients were obtained by other authors.[34–36]

Since they may have a beneficial impact over renal patients' comorbidities and HRQoL, exercise-based approaches may be of interest when addressing hard endpoints such as PD patients' hospitalization needs, mortality rate and technical survival.

However, even though this association between lower HRQoL scores and higher incidence of hard clinical outcomes is well-documented,[37] it is still too early to establish a proper causal relation between the increase in patients' exercise practice and hard adverse outcomes, so further studies are needed. This lack of causal relation may be due not only to the limited number of trials on this matter but also to the fact that most of the existing ones do not have a follow-up period that is long enough to assess whether exercise may improve some of the endpoints mentioned.[26]

Barriers to physical exercise practice in PD patients

Treatment compliance plays a decisive role in controlling and successfully managing the progression of renal failure. Even though PD patients are particularly compliant, the adherence rates to exercise initiatives are typically lower than what would be desirable, since the PD population is often discouraged from participating in specific physical training initiatives because of real or perceived barriers associated with their condition.[11]

In contrast with HD, PD is a home-treatment modality, requiring from patients a relevant degree of education, information and skills in order to manage their condition, especially from those who might already be more dependent of others to perform their daily living activities and self-care needs. One of the significant barriers presented to these patients is the lack of trustworthy information sources that could inform them about what best exercises to perform and what kind of training would be most recommended in order to achieve their specific desired outcomes.[16] Nonetheless, this matter might be an issue even for nephrologists, given the limited evidence-based knowledge on the subject due to the lack of well-design randomized controlled trials.

The non-existence of social interaction, together with the deterioration of mental health and physical condition, may result in reduced motivation towards maintaining appropriate physical activity levels. As stated, some studies focusing on physical activity reinforcement programs have already reported a positive impact on exercise compliance, which makes us believe that this may be a useful strategy to counteract these motivational issues.[30] Other studies have proposed that starting a new training plan with a set of short-term supervised periods preceding the official home training would be helpful and might guarantee higher adherence rates.[26]

PD treatment may imply some challenging and specific physical factors. Four of the most recurrent are the amount of dialysate fluid inside the peritoneal cavity during exercise, the hygiene precautions that must follow the PD catheter insertion, the related risk of infection on the catheter insertion site and the risk of developing abdominal herniae or leaks. Further barriers are mentioned in Appendix A, Table 3. The fear that comes from these potential complications is also an aspect to take into consideration when addressing PD patients' compliance rates and there is preliminary data that looked to clarify whether physical exercise practice may be considered a risk factor here. However, no serious adverse effects were associated with exercise, even in the most recent PD and exercise meta-analysis.[16]

Leaks and herniae have been reported as two of the most common concerns of the PD population when an exercise-based intervention is proposed, especially when considering resistance training with increased abdominal pressure. So far, no research has shown a significant association between an increased risk of developing herniae or leaks and physical exercise. Even patients with previous personal history did not show evidence of further leakage or herniation following exercise.[11] Some authors, such as Derici et al.,[38] have even hypothesized that reinforcing patients' abdominal musculature through specific exercises may prevent the incidence of herniae and leaks. Nevertheless, additional research is required.[11,39]

Another frequent concern is whether these patients should perform physical exercise involving swimming due to the potential infection risk surrounding the catheter insertion site. However, no study was able to provide essential data that would corroborate this hypothesis.[40] In most cases, patient's self-awareness and hygiene care towards their catheter will play an essential role in the prevention of this local infection.

The dialysate fluid inside the peritoneal cavity during exercise practice is another PD-specific physical factor that raises concern about the patients' well-being. However, there is no randomized controlled trial that gives us trustworthy evidence that this has a real impact on patients' physical performance. Without this knowledge, nephrologists usually recommend that more vigorous exercises should be done when "dry", while less strenuous activities, such as walking or cycling, may be performed either when "dry" or "wet".[16]

Even with these physical barriers, and even though these patients may lack the motivation to exercise, according to a recent survey from 2019, the majority of patients (74%) still believed that increasing their levels of physical activity would be beneficial for them.[41] Higher percentages were found among younger patients after age-adjusting the results. Another factor to keep in mind that may also have an impact on treatment compliance are the kind of outcomes desired by the patient. This study included patients from 3 different kidney replacement therapies, those being PD, home HD and in-center HD. It assessed the main goals of each group and their motivation towards the exercise program. Despite the treatment's modality, the significant benefits desired by these ESKD patients were improved energy and strength. The third priority chosen by the different groups was diverse, with the PD group prioritizing improved sleep quality. These desired benefits were also adjusted according to patients' age, which allowed the authors to infer that older patients were more concerned with maintaining their independence. In comparison, younger patients gave priority to enhancing their longevity and improving their renal transplant candidacy.[41]

Still, ESKD patients' recruitment, adherence to protocol, and permanence in exercise trials remain low, suggesting that further adjustments in these trials' designs may be needed to better resonate with these patients' physical capacity and limitations. When asked, the main reasons given for the low compliance rates were fatigue, frailty, weakness and shortness of breath, followed by lack of a proper personalized and fitting exercise program, lack of knowledge or instructions and the high economic burden associated with these training programs or infrastructures.[41]

If a nephrologist considers PD patients' desired exercise outcomes and designs an approach based on them, this approach may improve patient recruitment, compliance and permanence, both in terms of treatment strategies and future randomized controlled trials. Clinicians must not neglect training specificity in order to maximize their intervention's success rate.[40]

Future directions

Even though PD patients have their unique array of characteristics that set them apart from the HD and pre-dialysis patients, nephrologists' ultimate goal should be to identify potential barriers and limitations that this population might find towards the proposed interventions, instead of assuming a reluctant posture that drives them towards the defaulted conservative strategies. Not only does this not bring any advantage in terms of avoiding additional disease complications, but it may also potentiate other risk factors associated with poorer disease outcomes, such as inactivity and sedentarism. Since each PD patient may have his specific difficulties and limitations, nephrologists must be challenged to personalize and adapt their approach down to an individual basis.

A nephrologist should also look to advise, help and motivate patients so that they may enjoy an optimized quality of life, as well as reduce potential side effects both from the therapeutic interventions and from the chronic disease itself.

In order to improve clinicians' response capacity, further studies are required. Adapting former validated exercise-related HD trials to representative samples of the PD population might be a possible line of action in the future.

Also we believe that technology (as simple as a pedometer or complex as a comprehensive exercise app) could be better used to motivate PD patients to the physical activity and to the prescribed exercise plan.

Conclusion

Despite the most recent evidence of a significant impact on PD patients' improved aerobic capacity in terms of physical function, independence, glucose and metabolic control, mental health and health-related quality of life, few nephrologists routinely assess their patients' physical activity levels. Others are reluctant to prescribe exercise-based strategies. Further investigation is needed to guide clinicians' approach to frequency of training, intensity and type of exercise so that they have a material impact on specific outcomes according to each patient's condition.

Furthermore, better designed randomized controlled trials with an extended follow-up period and with more PD focused samples are needed in order to generate reliable evidence of the effect of physical activity levels on hard clinical outcomes such as PD patients' mortality rate and technical survival.

Conflict of interests

The authors declare that they have no conflict of interest.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.nefro.2021.02.007.

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