



Effects of Intradialytic Exercise on Adequacy, Depression, and Quality of Life in Hemodialysis Patients

Gusti Ayu Ary Antari^{a*}, Devia Putri Lenggogeni^b

^aDepartment of Nursing, Faculty of Medicine, Universitas Udayana, Denpasar, Bali, Indonesia

^bDepartment of Medical Surgical Nursing, Faculty of Nursing, Universitas Andalas, West Sumatra, Indonesia

*e-mail correspondence: aryantari@unud.ac.id

Received: 29 May 2025

Accepted: 2 October 2025

Available online: 11 November 2025

DOI: <https://doi.org/10.25077/njk.v21i2.329>

Abstract

There are three independent predictors related to dialysis mortality rates such as adequacy, depression and poor quality of life. Intradialytic exercises are a potential strategy to increase adequacy, overcome depression and improve quality of life. This study aimed to analyse the effectiveness of intradialytic exercise in addressing adequacy, depression, and quality of life. A quasi-experimental design was used in this study. The study was conducted at a hemodialysis clinic in Bali, from August to October 2020. A total of 60 samples involved in the research were selected using purposive sampling. Samples were randomly grouped into intervention ($n = 30$) and control ($n = 30$) groups. Patients in the intervention group were given intradialytic exercises for 30 minutes/day twice a week for four weeks. All patients underwent measurement of adequacy using Kt/V, depression using the Beck Depression Inventory-II and quality of life using Kidney Disease Quality of Life. Measurements were taken at baseline and after four weeks. The results showed there was a decrease in the mean depression score in patients after being given intradialytic exercise (p -value = 0.001). Intradialytic exercise significantly affects adequacy (p -value = 0.003). Regarding quality of life, this study did not find any significant effect from intradialytic exercises, but there was an increase in the average score on the mental health composite dimension. This study concludes that intradialytic exercise can be considered a therapeutic modality applied routinely in hemodialysis rooms. Apart from that, exercise is also safe, and there are no reports of side effects from exercise.

Keywords: Adequacy, Depression, Hemodialysis, Intradialytic Exercise, Quality of Life.

INTRODUCTION

Chronic Kidney Disease (CKD) constitutes a global health burden due to its increasing prevalence and high rates of morbidity and mortality. CKD affects approximately 10% of the global population (Jadoul, Aoun, & Masimango Imani, 2024; Kampmann et al., 2023). The rise in CKD cases is associated with the increasing prevalence of diabetes mellitus, hypertension, and ageing. Despite a decline in mortality rates for most chronic diseases over the past few decades, CKD remains one of the fastest-growing causes of death worldwide. Between 1990 and 2017, the all-age mortality rate for CKD increased by 41.5% (Bikbov et al., 2020; Jadoul et al., 2024). In the progression of CKD, when patients reach the stage of kidney failure (glomerular filtration rate <15 ml/minute/1.73m²), they require renal replacement therapy, such as dialysis, to improve life expectancy (Bello et al., 2022).



Hemodialysis is the most common form of renal replacement therapy, accounting for 69% of all renal replacement therapies and 89% of all dialysis treatments (Bello et al., 2022). Technological advancements in hemodialysis have improved the survival rates of patients with kidney failure. However, patient outcomes with hemodialysis have not reached optimal levels. Generally, the quality of life for hemodialysis patients remains low, and mortality rates are high (Bello et al., 2022; Kirkman, Scott, Kidd, & Macdonald, 2019; Pu et al., 2019). A study by Bossola et al. (2023) indicated that out of 6,997 hemodialysis patients (64.5% male, 66.1% over 65 years old), 923 died within one year, and 2,253 within three years (Bossola et al., 2023). Previous studies have identified several predictors related to high mortality rates in hemodialysis patients, such as dialysis dose and adequacy, as well as sedentary behaviour. Additionally, symptom burden, including fatigue, pain, and depression, contributes to the increased mortality risk among hemodialysis patients (Kirkman et al., 2019; Pu et al., 2019).

Hemodialysis adequacy refers to the therapy's ability to remove metabolic waste products from the patient's body. Adequate hemodialysis is essential for prolonging patient survival (Somji, Ruggajo, & Moledina, 2020). Previous studies have shown that achieving target hemodialysis adequacy can predict rehospitalization and mortality in hemodialysis patients (Aghsaeifard, Zendehdel, Alizadeh, & Salehnasab, 2022; Liu et al., 2022). The KDOQI clinical practice guidelines recommend hemodialysis adequacy (measured by Kt/V) of 1.2-1.4 for thrice-weekly hemodialysis and 2.1-2.3 for more frequent sessions (Daugirdas et al., 2015). According to Pernefri, the recommended Kt/V for thrice-weekly hemodialysis is 1.2 and 1.8 for twice-weekly sessions (Indonesian Renal Registry, 2017). Lower than recommended Kt/V values can increase mortality rates. A cohort study by Miller et al. demonstrated improved survival rates in patients with a Kt/V of approximately 1.6-1.8 (Miller et al., 2010).

Previous studies have highlighted that hemodialysis patient outcomes are not solely determined by mortality rates, cardiovascular burden, hospitalization, and infection but also by patient-reported symptoms related to their health condition and hemodialysis therapy, such as fatigue, anxiety, depression, pruritus, restless legs syndrome, cramps, pain, sexual dysfunction, and poor sleep quality. Depression is a common complaint among hemodialysis patients, with a prevalence of 20-30%. Depression is often linked to an increased risk of hospitalization and mortality, as well as non-compliance with hemodialysis therapy, poor health behaviors such as physical inactivity, and reduced quality of life (Goh & Griva, 2018; Kimmel, 2000; Lopes et al., 2002).

Poor hemodialysis adequacy, patient-reported symptoms, and low quality of life remain challenges for hemodialysis practitioners, necessitating new therapeutic approaches. One potential strategy is intradialytic exercise. Previous research has shown that intradialytic exercise effectively reduces the severity of fatigue, improves sleep quality, and enhances exercise tolerance (Kirkman et al., 2019; Pu et al., 2019). Systematic reviews and meta-analyses have also concluded that intradialytic exercise can improve hemodialysis adequacy and address depression (Pu et al., 2019). Physiologically, intradialytic exercise can increase blood flow to skeletal muscles, which are low-perfusion tissues, enhance solute clearance, and prevent post-dialysis urea rebound (Ferreira, Bohlke, Correa, Dias, & Orcy, 2019; Kirkman et al., 2019). Regarding depression, intradialytic exercise aids in relaxation supports neurogenesis in the cerebral hippocampus and acts as an antidepressant (Rezaei, Abdi, Rezaei, Heydarnezhadian, & Jalali, 2015; Yu et al., 2023). Another advantage of intradialytic exercise is patient compliance. The main challenge in preventing a sedentary lifestyle in hemodialysis patients is non-compliance with exercise routines. Therefore, intradialytic exercise can be a viable alternative, as it is performed regularly during each hemodialysis session.

The National Kidney Foundation has recommended the importance of exercise in managing disease complications; however, parameters such as exercise type, duration, intensity, and frequency remain unclear. Many studies have identified the benefits of intradialytic exercise for routine hemodialysis patients, including aerobic, resistance, and combined exercises (Huang et al., 2019; Jung & Park, 2011). Research findings on intradialytic exercise vary based on the type of exercise provided and the demographic and clinical conditions of the patients. Conversely, range of motion exercises during intradialytic sessions remain under-researched and require further study (Paluchamy & Vaidyanathan, 2018). This study aims to determine the effectiveness of intradialytic exercise on the adequacy, depression, and quality of life of patients with kidney failure undergoing routine hemodialysis.



METHODS

Research Design

It is quasi-experimental using a nonequivalent control group, pretest-posttest design.

Population and Sample

The study population comprised all kidney failure patients undergoing routine hemodialysis twice a week. A purposive sampling technique was used. Inclusion criteria included patients aged 20-65 years, undergoing hemodialysis for at least three months, without musculoskeletal barriers, with a $Kt/V \geq 1.2$, and not on antidepressant medication. Exclusion criteria included uncontrolled diabetes, severe anemia, ischemic heart disease, and unstable hemodynamics during hemodialysis. Patients were excluded from the study if they were non-compliant with therapy. A total of 60 samples were involved in the study, randomly assigned to the control group ($n = 30$) and the treatment group ($n = 30$). To strengthen the internal validity of the study and reduce selection bias, random assignment was still applied within the existing clinical framework to allocate participants into control and intervention groups. Randomization was conducted after participants met the inclusion criteria and provided informed consent, but prior to the implementation of the intervention. The randomization process utilized a random number generator to ensure unbiased group allocation.

Place and Time of Research

The study was conducted in the hemodialysis room of the BHCC Main Clinic in Denpasar, from August to October 2020.

Data Collection

The intradialytic exercise intervention involved a range of motion exercises for 30 minutes during each hemodialysis session. The exercises were performed twice a week for four weeks. The exercises included extension, flexion, abduction, and adduction movements for all extremities except those with vascular access. Intradialytic exercises were conducted during the first two hours of hemodialysis. For the control group, patients received the standard care procedures routinely applied in the hemodialysis unit. Data were collected twice, at baseline and after the four-week intervention. The data collection instruments included the Beck Depression Inventory-II (BDI-II) for measuring depression and the KDQOL-SF for measuring quality of life. Kt/V was used to measure hemodialysis adequacy. The Beck Depression Inventory-II is a standardized tool validly measuring depression, with an alpha coefficient ranging from 0.83 to 0.96. The BDI-II consists of 21 items on a Likert scale of 0-3. The BDI-II interpretation guide defines scores of 0-13 as minimal range, 14-19 as mild depression, 20-28 as moderate depression, and 29-63 as severe depression.

The KDQOL-SF is a standard questionnaire used to measure the quality of life in hemodialysis patients. It consists of 43 kidney-disease-targeted items: 12 items on symptoms/problems, 8 items on the effects of kidney disease on daily activities, 4 items on the burden of kidney disease, 2 items on work status, 3 items on cognitive function, 3 items on the quality of social interaction, 2 items on sexual function, 4 items on sleep, 2 items on social support, 2 items on dialysis staff, and 1 item on patient satisfaction. Additionally, the KDQOL-SF includes the RAND 36-item health survey 1.0 or SF-36™, with 1 question on overall health. The KDQOL-SF can also yield Mental Health Composite (MHC) and Physical Health Composite (PHC) scores. The KDQOL-SF questionnaire has demonstrated established validity and acceptable internal consistency, with Cronbach's alpha coefficients for most subscales typically exceeding the threshold of 0.70, indicating reliable measurement properties.

Data Analysis and Processing

The collected research data will be analyzed descriptively, including mean and frequency distribution. Bivariate analysis will be conducted using independent t-tests and paired t-tests. with significance level ≤ 0.05 . Ethical Clearance number: 1385/UN14.2.2.VII.14/LT/2020.



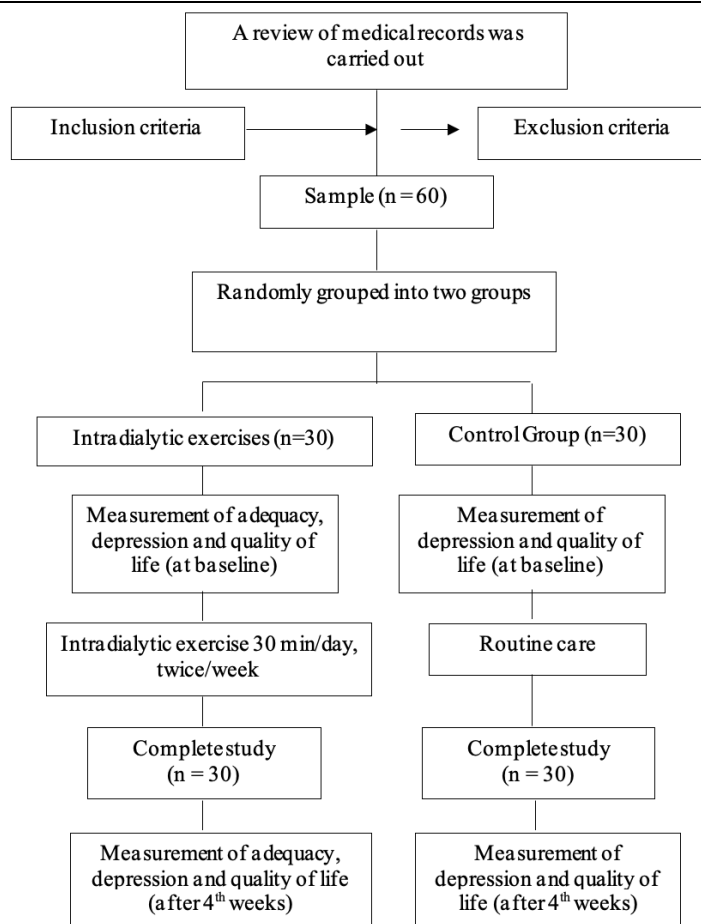


Figure 1. Research Flow Chart

RESULTS

The average age of respondents in the intervention group was 47.30 years (SD = 9.22), and in the control group, it was 48.43 years (SD = 10.41). Table 1 shows the characteristics of the study respondents.

Table 1. Characteristics of Respondents

Characteristics	Intervention Group (n=30)	Control Group (n=30)	p-value
Age (year), mean (SD)	47.30 (9.22)	48.43 (10.41)	0.657
Gender, n (%)			
Male	19 (48.7%)	20 (51.3%)	0.787
Female	11 (52.4%)	10 (47.6%)	
Length of Hemodialysis, mean (SD)	21.40 (15.06)	20.03 (12.97)	0.708
Marital Status, n (%)			
Unmarried	1 (25%)	3 (75%)	0.301
Married	29 (51.8%)	27 (48.2%)	
Education, n (%)			
None	2 (66.7%)	1 (33.3%)	
Elementary School	2 (40%)	3 (60%)	
Junior High School	1 (33.3%)	2 (66.7%)	0,868
Senior High School	15 (48.4%)	16 (51,6%)	
Diploma	3 (42.9%)	4 (57.1%)	
Bachelor	7 (63.6%)	4 (36.4%)	
Occupation, n (%)			
None	5 (83.3%)	1 (16.7%)	
Private Employees	6 (42.9%)	8 (57.1%)	
Civil Servant	4 (66.7%)	2 (33.3%)	0.486
Retired	3 (37.5%)	5 (62.5%)	
Others	5 (41.7%)	7 (58.3%)	

Self-employed	7 (50%)	7 (50%)	
Hemodialysis Shift, n (%)			
Morning	24 (57.1%)	18 (42.9%)	0.091
Afternoon	6 (33.3%)	12 (66.7%)	
Symptoms, n (%)			
None	13 (38.2%)	21 (61.8%)	
Vomitus	7 (77.8%)	2 (22.2%)	0.077
Ichy	1 (25%)	3 (75%)	
Cramps	7 (77.8%)	2 (22.2%)	
Dizzy	2 (50%)	2 (50%)	
Underlying Disease, n (%)			
Hypertension	22 (45.8%)	26 (54.2%)	0.412
Diabetes Mellitus	4 (66.7%)	2 (33.3%)	
Hypertension and Diabetes Mellitus	3 (60%)	2 (40%)	

Table 1 indicates that the characteristics of respondents in both groups are homogeneous. The effectiveness of intradialytic exercise on the adequacy, depression, and quality of life of hemodialysis patients can be observed from the comparison of scores for adequacy, depression, and quality of life before and after the intervention, as well as the comparison of scores between the two groups (intervention and control), as shown in Table 2.

Table 2. Depression, Adequacy, and Quality of Life in Hemodialysis Patients

Variables	Intervention Group (n=30)	Mean Different (SD)	p-value	Control Group (n=30)	Mean Different (SD)	p-value
Depression, mean (SD)						
Pre test	5.07 (3.88)	2.367 (3.39)	0.001*	6.60 (7.93)	1.6 (6.01)	0.159
Post test	2.70 (2.34)			5 (5.94)		
Kt/V, mean (SD)						
Pre test	1.54 (0.26)	-0.088 (0.15)	0.003*			
Post test	1.63 (0.33)					
KDQOL - PHC, mean (SD)						
Pre test	43.12 (7.10)	0.79 (10.29)	0.679	43.45 (7.86)	1.03 (6.91)	0.420
Post test	42.39 (7.68)			42.42 (8.10)		
KDQOL - MHC, mean (SD)						
Pre test	52.62 (8.26)	-2.27 (9.15)	0.184	54.95 (9.46)	-1.12 (9.27)	0.514
Post test	54.89 (5.34)			56.06 (6.78)		

*Significant at $\alpha = 0.05$

Table 2 shows a decrease in the mean depression score after the intradialytic exercise intervention, with a reduction of 2.367 (SD = 3.39) in the intervention group compared to 1.6 (SD = 6.01) in the control group. In the intradialytic exercise group, there was a significant difference in the mean depression scores before and after the intervention ($p = 0.001$). In contrast, no significant difference was observed in the control group ($p = 0.159$). Changes in Kt/V were only observed in the intervention group, with results indicating a significant difference in mean Kt/V before and after the intervention (mean diff 0.088; p -value 0.003). Regarding quality of life, assessed through the PHC and MHC, no significant impact from the intradialytic exercise was found. However, an increase in the mean MHC score was observed after four weeks of intradialytic exercise, indicating improved mental health and quality of life.

Table 3. Mean Difference in Depression and Quality of Life Scores between Intervention and Control Group

Parameter		Mean (SD)	p-value
Depression	Intervention group	2.70 (2.34)	
	Control group	5 (5.94)	0.05*
PHC	Intervention group	42.39 (7.68)	
	Control group	42.42 (8.10)	0.99
MHC	Intervention group	54.89 (5.34)	
	Control group	56.06 (6.78)	0.46

*significant at $\alpha = 0,05$

Table 3 shows the differences in mean depression and quality of life scores between the two groups after four weeks of intradialytic exercise intervention. The results indicate a significant difference in the mean depression scores between the intradialytic exercise group and the control group ($p = 0.05$). However, no significant differences were found in the mean PHC and MHC scores.



DISCUSSION

This study aims to investigate the effectiveness of intradialytic exercise in improving dialysis adequacy, alleviating depressive symptoms, and enhancing the quality of life among patients with end-stage renal disease undergoing maintenance hemodialysis. Hemodialysis patients tend to avoid physical activity and lead sedentary lifestyles. This is partly due to a need for more motivation for physical exercise and concerns about potential complications from exercise, which reduces the number of patients who engage in regular physical activity. Various studies have reported that physical exercise can improve physical function and well-being. Intradialytic exercise, performed during hemodialysis, has been developed to address this challenge. Research findings indicate that intradialytic exercise can improve patient adequacy, measured by Kt/V values. This study's results align with those of Mohseni et al., (2013) and Paluchamy and Vaidyanathan (2018), who found improvements in adequacy (URR and Kt/V values) after eight weeks of intradialytic exercise. Other studies also reported similar findings, with significant increases in Kt/V of up to 20% following low-intensity intradialytic exercises. Mohseni et al. reported a 38% increase in Kt/V after eight weeks of intervention. In this study, Kt/V increased by 5.8% after four weeks of intradialytic exercise, indicating a significant improvement in Kt/V within four weeks of regular intradialytic exercise. The characteristics of the study populations might influence the variation in percentage changes.

In addition to improving adequacy, intradialytic exercise has been reported to have no side effects (Giannaki et al., 2011), making it relatively safe for patients. Rohmah et al., (2024) also found a significant increase in Kt/V after intradialytic exercise. During intradialytic exercise, blood flow to the muscles increases, which enhances urea flux from tissues to blood vessels, followed by increased serum urea clearance (Kirkman et al., 2019; Mohseni et al., 2013). Although many studies indicate that intradialytic exercise can improve adequacy, the evidence regarding its effect on urea removal must be confirmed. The effectiveness of intradialytic exercise in small solute clearance or protein-bound solute clearance has yet to be determined. Therefore, it is uncertain whether the increase in Kt/V is a direct effect of intradialytic exercise or a general effect of routine exercise. Existing studies show that intradialytic exercise can improve phosphate clearance but not for smaller molecules. De Vos et al. found no significant impact of intradialytic exercise on small solute clearance and protein-bound solutes. Additionally, the optimal timing for intradialytic exercise to achieve maximal clearance benefits remains to be determined (De Vos et al., 2021; Kirkman et al., 2019). Further studies are needed to determine intradialytic exercise's most effective intensity, timing, and duration for optimal clearance.

Depression is an essential psychological parameter for hemodialysis patients and can affect their quality of life. Depression is reported to increase mortality in hemodialysis patients. This study found that intradialytic exercise can reduce patient depression, consistent with a systematic review that found intradialytic exercise can reduce depression severity (Pu et al., 2019). A study by Chung et al., (2017) found that intradialytic exercise could alleviate patient depression and improve the physical quality of life by increasing oxygen consumption, hemoglobin levels, and physical function. For routine hemodialysis patients, factors contributing to depression include physical and emotional stress, physical limitations, dependence on hemodialysis, vascular access issues, and economic problems. Hemodialysis patients are vulnerable to depression due to increased levels of inflammatory mediators. Intradialytic exercise can reduce serum TNF- α , a marker of depression, thereby decreasing depression symptoms in hemodialysis patients (Rhee et al., 2019; Sanad et al., 2022).

The quality of life for hemodialysis patients is closely related to hemodialysis adequacy and depression. Inadequate dialysis leads to persistent uremic symptoms, fatigue, and poor physical functioning, directly impairing QoL. Depression, common in this population, worsens treatment adherence, increases symptom burden, and diminishes psychological well-being. Together, both factors critically shape patients' overall health perception and daily functioning. This study found no significant impact of intradialytic exercise on the quality of life for patients with end-stage renal disease undergoing hemodialysis. However, there was an increase in the average MHC score before and after the intervention. This finding differs from previous studies that found intradialytic exercise generally improves PHC levels but not MHC. A systematic review and meta-analysis of 20 randomized controlled trials found that exercise enhances aerobic capacity, walking ability, and overall health-related quality of life (Huang et al., 2019). Another meta-analysis found that intradialytic exercise only significantly impacts the physical aspect of quality of life, not the mental aspect (Sheng et al., 2014). These varying results may be due to differences in respondent characteristics, intradialytic exercise protocols, and measurement tools (Pu et al., 2019). This study observed an increase in the average MHC score after intradialytic



exercise, possibly related to reduced patient depression scores. Various literatures mention that quality of life can be influenced by factors such as the duration of hemodialysis, the physical burden of kidney disease, and patients' social-psychological conditions. Quality of life is multidimensional, and observing changes in patient quality of life may require a longer time frame, whereas this study was conducted over four weeks (Huang et al., 2019; Sheng et al., 2014).

The findings of this study suggest that range-of-motion intradialytic exercise benefits hemodialysis patients. Regular intradialytic exercise is a therapeutic modality for managing hemodialysis patients. According to this study, patients did not report any complications or side effects related to intradialytic exercise. Additionally, range-of-motion exercises are easy to implement and do not require specific equipment. The effects on adequacy and depression were observed within four weeks of intervention, although more extended observation may be necessary for quality of life. This study has limitations, such as measuring Kt/V only in the intervention group due to variations in available hemodialysis machines. Potential confounders may be challenging to control since the intervention involved intradialytic exercise.

CONCLUSION

Intradialytic exercise can be recommended as a routine therapeutic intervention in hemodialysis units. It effectively improves dialysis adequacy, reduces depression, and enhances the quality of life in the MHC domain. Based on the results of this study, larger-scale, multicenter research with a greater sample size is needed to reach more comprehensive conclusions. Moreover, this study has clear clinical implications for hemodialysis patients. Incorporating regular intradialytic exercise into dialysis sessions demonstrates positive effects on clinical indicators, as reflected by improved Kt/V values, reduced levels of depression, and enhanced quality of life.

ACKNOWLEDGEMENTS

This work is supported by LPPM Universitas Udayana.

REFERENCES

- Aghsaeifard, Z., Zendejdel, A., Alizadeh, R., & Salehnasab, A. (2022). Chronic hemodialysis: Evaluation of dialysis adequacy and mortality. *Annals of Medicine and Surgery*, 76, 103541. <https://doi.org/10.1016/J.AMSU.2022.103541>.
- Bello, A. K., Okpechi, I. G., Osman, M. A., Cho, Y., Htay, H., Jha, V., ... Johnson, D. W. (2022). Epidemiology of haemodialysis outcomes. *Nature Reviews. Nephrology*, 18(6), 378-395. <https://doi.org/10.1038/S41581-022-00542-7>.
- Bikbov, B., Purcell, C., Levey, A. S., Smith, M., Abdoli, A., Abebe, M., ... Vos, T. (2020). Global, regional, and national burden of chronic kidney disease, 1990-2017: a systematic analysis for the Global Burden of Disease Study 2017. *Lancet (London, England)*, 395(10225), 709. [https://doi.org/10.1016/S0140-6736\(20\)30045-3](https://doi.org/10.1016/S0140-6736(20)30045-3).
- Bossola, M., Di Napoli, A., Angelici, L., Bargagli, A. M., Cascini, S., Kirchmayer, U., ... Marino, C. (2023). Trend and determinants of mortality in incident hemodialysis patients of the Lazio region. *BMC Nephrology*, 24(1), 1-13. <https://doi.org/10.1186/S12882-023-03170-W/FIGURES/2>.
- Chung, Y. C., Yeh, M. L., & Liu, Y. M. (2017). Effects of intradialytic exercise on the physical function, depression and quality of life for haemodialysis patients: a systematic review and meta-analysis of randomised controlled trials. *Journal of Clinical Nursing*, 26(13-14), 1801-1813. <https://doi.org/10.1111/JOCN.13514>.
- Daugirdas, J., Depner, T. A., Inrig MHS, J., Mehrotra, R., Rocco MSCE, M. V, Suri FRCPC, R., ... Brereton, L. (2015). KDOQI CLINICAL PRACTICE GUIDELINE FOR HEMODIALYSIS ADEQUACY: 2015 UPDATE. *American Journal of Kidney Diseases*, 66, 884-930. <https://doi.org/10.1053/j.ajkd.2015.07.015>.
- De Vos, C., Lemarcq, L., Dhondt, A., Glorieux, G., Van Biesen, W., & Eloit, S. (2021). The impact of intradialytic cycling on the removal of protein-bound uraemic toxins: A randomised cross-over study. *The International Journal of Artificial Organs*, 44(3), 156-164. <https://doi.org/10.1177/0391398820949880>.



Ferreira, G. D., Bohlke, M., Correa, C. M., Dias, E. C., & Orcy, R. B. (2019). Does Intradialytic Exercise Improve Removal of Solutes by Hemodialysis? A Systematic Review and Meta-analysis. *Archives of Physical Medicine and Rehabilitation*, 100(12), 2371-2380. <https://doi.org/10.1016/j.apmr.2019.02.009>.

Giannaki, C. D., Stefanidis, I., Karatzaferi, C., Liakos, N., Roka, V., Ntente, I., & Sakkas, G. K. (2011). The effect of prolonged intradialytic exercise in hemodialysis efficiency indices. *ASAIO Journal (American Society for Artificial Internal Organs : 1992)*, 57(3), 213-218. <https://doi.org/10.1097/MAT.0B013E318215DC9E>.

Goh, Z. S., & Griva, K. (2018). Anxiety and depression in patients with end-stage renal disease: impact and management challenges - a narrative review. *International Journal of Nephrology and Renovascular Disease*, 11, 93. <https://doi.org/10.2147/IJNRD.S126615>.

Huang, M., Lv, A., Wang, J., Xu, N., Ma, G., Zhai, Z., ... Ni, C. (2019). Exercise Training and Outcomes in Hemodialysis Patients: Systematic Review and Meta-Analysis. *Translational Research: Review Article Am J Nephrol*, 50, 240-254. <https://doi.org/10.1159/000502447>.

Indonesian Renal Registry. (2017). *10th Report of Indonesian Renal Registry 2017*.

Jadoul, M., Aoun, M., & Masimango Imani, M. (2024). The major global burden of chronic kidney disease. *The Lancet Global Health*, 12(3), e342-e343. [https://doi.org/10.1016/S2214-109X\(24\)00050-0](https://doi.org/10.1016/S2214-109X(24)00050-0).

Jung, T.-D., & Park, S.-H. (2011). Intradialytic Exercise Programs for Hemodialysis Patients. *Chonnam Medical Journal*, 47(2), 61. <https://doi.org/10.4068/CMJ.2011.47.2.61>.

Kampmann, J. D., Heaf, J. G., Mogensen, C. B., Mickley, H., Wolff, D. L., & Brandt, F. (2023). Prevalence and incidence of chronic kidney disease stage 3-5 - results from KidDiCo. *BMC Nephrology*, 24(1), 1-9. <https://doi.org/10.1186/S12882-023-03056-X/TABLES/4>.

Kimmel, P. L. (2000). Psychosocial factors in adult end-stage renal disease patients treated with hemodialysis: Correlates and outcomes. *American Journal of Kidney Diseases*, 35(4 SUPPL. 1), S132-S140. [https://doi.org/10.1016/S0272-6386\(00\)70240-X](https://doi.org/10.1016/S0272-6386(00)70240-X).

Kirkman, D. L., Scott, M., Kidd, J., & Macdonald, J. H. (2019). The effects of intradialytic exercise on hemodialysis adequacy: A systematic review. *Seminars in Dialysis*, 32(4), 368-378. <https://doi.org/10.1111/SDI.12785>.

Liu, S. X., Wang, Z. H., Zhang, S., Xiao, J., You, L. L., Zhang, Y., ... Zhang, Y. N. (2022). The association between dose of hemodialysis and patients mortality in a prospective cohort study. *Scientific Reports 2022 12:1*, 12(1), 1-9. <https://doi.org/10.1038/s41598-022-17943-0>.

Lopes, A. A., Bragg, J., Young, E., Goodkin, D., Mapes, D., Combe, C., ... Port, F. K. (2002). Depression as a predictor of mortality and hospitalization among hemodialysis patients in the United States and Europe. *Kidney International*, 62(1), 199-207. <https://doi.org/10.1046/j.1523-1755.2002.00411.x>.

Miller, J. E., Kovesdy, C. P., Nissenson, A. R., Mehrotra, R., Streja, E., Van Wyck, D., ... Kalantar-Zadeh, K. (2010). Association of Hemodialysis Treatment Time and Dose With Mortality and the Role of Race and Sex. *American Journal of Kidney Diseases*, 55(1), 100-112. <https://doi.org/10.1053/j.ajkd.2009.08.007>.

Mohseni, R., Emami Zeydi, A., Ilali, E., Adib-Hajbaghery, M., & Makhlo, A. (2013). The effect of intradialytic aerobic exercise on dialysis efficacy in hemodialysis patients: a randomized controlled trial. *Oman Medical Journal*, 28(5), 345-349. <https://doi.org/10.5001/OMJ.2013.99>.

Paluchamy, T., & Vaidyanathan, R. (2018). Effectiveness of intradialytic exercise on dialysis adequacy, physiological parameters, biochemical markers and quality of life - A pilot study. *Saudi Journal of Kidney Diseases and Transplantation: An Official Publication of the Saudi Center for Organ Transplantation, Saudi Arabia*, 29(4), 902-910. <https://doi.org/10.4103/1319-2442.239661>.

Pu, J., Jiang, Z., Wu, W., Li, L., Zhang, L., Li, Y., ... Ou, S. (2019). Efficacy and safety of intradialytic exercise in haemodialysis patients: a systematic review and meta-analysis. *BMJ Open*, 9, 20633. <https://doi.org/10.1136/bmjopen-2017-020633>.



Rezaei, J., Abdi, A., Rezaei, M., Heydarnezhadian, J., & Jalali, R. (2015). Effect of Regular Exercise Program on Depression in Hemodialysis Patients. *International Scholarly Research Notices*, 2015, 1-6. <https://doi.org/10.1155/2015/182030>.

Rhee, S. Y., Song, J. K., Hong, S. C., Choi, J. W., Jeon, H. J., Shin, D. H., ... Oh, J. (2019). Intradialytic exercise improves physical function and reduces intradialytic hypotension and depression in hemodialysis patients. *The Korean Journal of Internal Medicine*, 34(3), 588-598. <https://doi.org/10.3904/KJIM.2017.020>.

Rohmah, S. N., Puspitasari, M., Prasanto, H., Wardhani, Y., Kuswadi, I., & Dhamarjati, A. (2024). Effect of intradialytic aerobic exercise intervention on dialysis adequacy and quality of life in patients with end-stage kidney disease undergoing hemodialysis at Dr. Sardjito General Hospital, Indonesia. *International Urology and Nephrology*, 1-10. <https://doi.org/10.1007/S11255-024-04100-X/METRICS>.

Sanad, E. A., El-Shinnawy, H. A. E. H., Hebah, H. A., Farrag, D. A., Soliman, E. R. A., & Abdelgawad, M. A. (2022). Effect of intra-dialytic physical exercise on depression in prevalent hemodialysis patients. *Egyptian Journal of Neurology, Psychiatry and Neurosurgery*, 58(1), 1-11. <https://doi.org/10.1186/S41983-022-00560-Z/TABLES/6>.

Sheng, K., Zhang, P., Chen, L., Cheng, J., Wu, C., & Chen, J. (2014). Intradialytic exercise in hemodialysis patients: a systematic review and meta-analysis. *American Journal of Nephrology*, 40(5), 478-490. <https://doi.org/10.1159/000368722>.

Somji, S. S., Ruggajo, P., & Moledina, S. (2020). Adequacy of Hemodialysis and Its Associated Factors among Patients Undergoing Chronic Hemodialysis in Dar es Salaam, Tanzania. *International Journal of Nephrology*, 2020. <https://doi.org/10.1155/2020/9863065>.

Yu, H., Huang, M., Tao, Y., Li, S., Wang, J., Li, P., ... Ni, C. (2023). The effects of exercise training interventions on depression in hemodialysis patients. *Frontiers in Psychiatry*, 14, 1321413. <https://doi.org/10.3389/FPSYT.2023.1321413/BIBTEX>.

