

Original Article

Effects of Low-Impact Strengthening Exercises on Limb Pain and Strength in Diabetic Patients with End-Stage Renal Disease

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Abstract

Background: Diabetic nephropathy becomes a disease with a high mortality rate in this modern era of technology. Dialysis in diabetic patients affects kidney functioning is the most common treatment for end-stage renal failure but had different musculoskeletal complications due to bone mineral metabolisms like muscular cramping, atrophy and muscular weakness, restless leg syndrome and limb pain that lowers the quality of life and physical function. **Objective:** To evaluate the effects of low-impact strengthening exercises on limb pain, strength, glycemic control, hypertension and quality of life of patients with end-stage renal disease. **Methods:** The randomized controlled study was designed to check the effectiveness of low-impact strengthening exercises on patients involved in the treatment and control group. Using non-probability purposive sampling, data was collected from different hospitals in Faisalabad by providing treatment for six consecutive weeks. Outcomes of measures were pain, strength, glucose level, blood pressure and quality of life which were estimated through the numeric pain rating scale, manual muscle testing, glucometer, sphygmomanometer and kidney disease quality of life questionnaire respectively. **Results:** Low-impact strengthening exercises in the treatment group showed improvement in muscle strength, blood pressure, glycemic level, pain and quality of life in diabetic patients with end-stage renal disease as compared to the control group. Mean values showed that there was a statistically significant difference in different variables between both groups. **Conclusion:** It was concluded that there is a statistically significant difference between both groups in the improvement of limb pain and limb muscle strength by low-impact strengthening exercises. These exercises have positive effects on diabetic patients with end-stage renal disease in the treatment group as compared to the control group.

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Introduction:

Diabetes Mellitus due to metabolic derangements causes glomerular pathology of kidneys that can be treated by long-term hemodialysis and kidney transplants. Diabetes alters micro-vascular hemodynamics that causes diabetic kidney disease due to hypertension and aging-related nephron loss that can be treated by managing glucose level and blood pressure.¹ Hyperglycemia induces changes in energy utilization and mitochondrial dysfunction causes metabolic alterations that can affect disease glucose control and reduce the risk of diabetic kidney disease.² Kidney function can be measured properly by glomerular filtration rate (GFR) and other testing including urine samples, imaging studies, blood culture and biopsy.

Age-related decline in GFR value is considered normal. In the United States, approximately 98 percent of patients start dialysis by GFR falling below 15 mL per minute per 1.73 m².³ The normal values of GFR are 120 to 130mL if the value is less than that of it, the patient can move to kidney failure.⁴ Diabetic nephropathy is classified as associated with proteinuria in diabetes and 20 to 30% of type 1 diabetic patients have micro-albuminemia with a mean duration of 15 years and less than half progress to macroalbuminemia that can progress to end-stage renal disease (ESRD) and prevalence estimated to renal failure lower in type-2 than in type-1.⁵

Diabetes type-1 and type-2 have similar prevalence in male and female but diabetic mortality rate and kidney complications are more in women due to hormonal fluctuations, obesity and dyslipidemia.⁶ Stages described with GFR which is greater than 90, considered normal and less than 15 considered kidney failure.⁴ About 20-40% of patients provenances with chronic kidney disease have diabetes with risk factors of hyperglycemia,

obesity, genetic locus and hypertension and kidney-diseased patient have the complication of urine albumin secretion or decrease in GFR.⁷ More than 50 % of dialysis patients facing musculoskeletal pain (diabetic patients are more prone to muscle wasting and accelerated lean body mass loss and prevalent patients 39% face muscle atrophy.⁸ Patients on dialysis with a metabolic syndrome like diabetes have a high prevalence of 69.3%.⁹ Muscle wasting pathogenesis in hemodialysis patients, including ubiquitin-proteasome system, caspase-3, insulin/insulin-like growth factor-1 (IGF-1) signaling, endogenous glucocorticoids, metabolic acidosis, inflammation, and sex hormones.¹⁰ Hemodialysis patients have muscle weakness and muscle atrophy that lessens physical performance.³

Patients with ESRD have lower exercise capacity and physical activity as compared to healthy individuals so a proper exercise plan increases the level of physical activity and exercise capacity.¹¹ Resistance exercise produces an anabolic effect on hemodialysis patients.¹² Home-based exercise plan proves improvement in physical function in a stable dialysis patient.¹³ Resistance training affects glycemic control in diabetes patients.¹⁴ Large proportion of patients with diabetes even with normal micro albuminuria presented with kidney dysfunction.¹⁵ Elevated fructosamine serum level linked with kidney dysfunction in diabetes patients.¹⁶

Exercises can improve the physical functioning in hemodialysis patients.¹⁷ Level of kidney failure in kidney disease patients assessed by estimated glomerular filtration rate (eGFR).¹⁸ Diabetes leads to diabetic kidney disease and its initial treatments were controlling blood pressure, and glucose levels and inhibiting the renin-angiotensin system.¹⁹ Chronic musculoskeletal pain in kidney disease patients leads to affect the quality of life.²⁰

In Pakistan, despite urbanization, the population in rural areas is >60% in all four provinces due to the hot climate, especially in males working in agricultural fields who have histological appearance of tubulointerstitial nephritis. Diabetes mellitus has increased ESRD to 51% of patients.²¹ Drinking contaminated water containing cadmium and arsenic has been recognized as nephropathic due to its oxidative stress. Environmental and occupational agents such as heavy metals, industrial chemicals, elevated temperatures, and infections could enter the human body through oral, inhalational, or transdermal routes, and may exert deleterious effects on all organ systems.

The effects of agents might be controlled by genetic susceptibility and comorbid conditions may lead to chronic kidney disease.²² Stone disease found that 67% of the patients had renal failure, 13.33% remained on hemodialysis, 3.05% underwent a kidney transplant and 16.11% died from the disease prevalence of diabetes mellitus of 5.5%–22%, hypertension of 19.8% and chronic kidney disease of 5.0% to 31.2%.²³ Multiple exercise plans and management protocols have yet to be designed and used by different researchers and conclude different results. Many musculoskeletal complications arise in patients undergoing dialysis and have negative effects on functional status and quality of life.

To overcome these complications and for improvement in physical function, a well-developed exercise plan can be developed after dialysis in the ward and guide home exercise plan to meet the need of these patients. Moreover, there is very little research on these specific strengthening exercises on dialysis patients and their effects on quality of life. The study was designed to evaluate the effects of low-impact strengthening exercises on limb pain, strength, glycemic control, hypertension and quality of life of patients with ESRD.

Methods

A randomized controlled trial was conducted by forming two comparable groups from the selected sample using non-probability purposive sampling. Group A/Treatment group followed the exercise plan while the control group had been given the general care guidelines. All patients were chosen from the dialysis ward in the indoor patient department (IPD) of Madinah teaching hospital, Allied hospital, Rathore Hospital and Surayah Majeed Hospital, Faisalabad. It was taken 6 weeks' duration to collect and analyze data after approval of the synopsis.

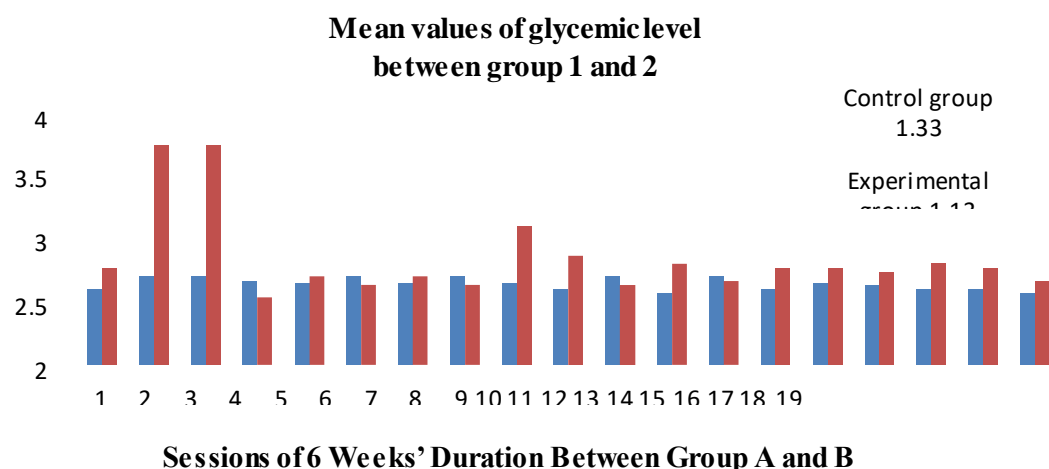
Almost 40 participants were selected from the dialysis wards and had 20 in each group.²⁴ The screening was done by using questionnaires formed on basis of inclusion and exclusion criteria, 80 patients were screened to get 30 patients according to study demand. A signed consent form was obtained from the participants before inclusion into the study. A data collection letter was taken from the university. Consent was obtained from the head of the department of dialysis ward and urology.

Vitally stable patients on dialysis, during dialysis systolic blood pressure <130 and diastolic pressure <80-85 and temperature <100 degrees Fahrenheit. Patient's heart rates < 100 beats per minute while respiratory rates are <20 breaths per minute and patients on dialysis for a minimum of 3 months to reduce the complications of exercise, patients with diabetes of type-1 or type-2 aged between 30 to 45 years.²⁵ Patients with mild or moderate levels (1-7) of musculoskeletal pain on the numeric pain rating scale (NPRS) scale. Alcoholic patients or patients with drug abuse, malignancy, psychological disorders, and patients with other cardiovascular or kidney diseases were excluded from the trial. Primary outcome measures were glucose level, blood

pressure and pain intensity. A glucometer was used to assess glucose levels, Sphygmomanometer for measuring blood pressure²⁶ and a Musculoskeletal pain assessment was done using a numeric pain rating scale (NPRS).²⁷ Secondary outcomes were manual muscle testing (MMT) to assess strength²⁸ and kidney disease quality of life KDQOL-36 questionnaire. Quality of life is lowered in the majority of the patients with chronic hemodialysis. The exercise plan consisted of arm curl, arm extension, lower leg extension, straight leg extension, seated marching, back leg swing, heel raised, and side leg lift three times a week in 10-15 minutes with 5-10 repetitions.¹⁷ **Control group:** There was no exercise plan used for the control group. Only general health care was provided to this group. **Treatment group:** Low-impact strengthening exercises of upper and lower extremities with 10 repetitions during dialysis and these exercises were performed 3 days a week under observation in a controlled environment for 15 minutes duration.²⁹ After 1 week of exercises, guidance was given to patients about a home-based exercise plan regularly which was performed in research in 2009 that had positive outcomes on blood pressure management, exercise intolerance, heart rate and proteinuria and increase exercise tolerance, improved lipid and glucose

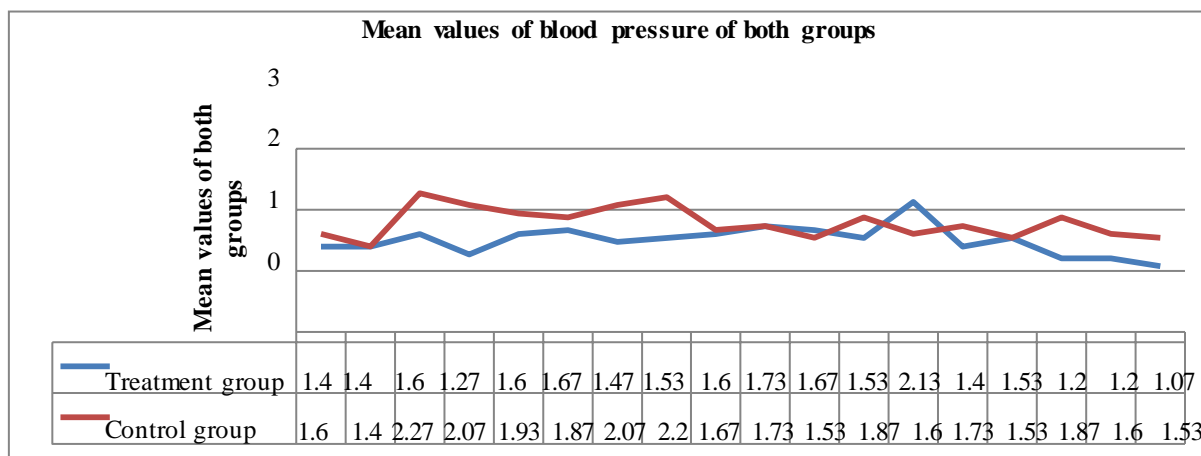
control.²⁶ Limb pain was measured on every session of dialysis 3 times a week by NPRS. Blood pressure and glucose level were measured on every session of dialysis 3 times a week by glucometer and sphygmomanometer. Quality of Life was assessed at the 1st session of the 1st week and the 18th session of the 6th week of study by KDQOL-36 questionnaires. Muscle strength was also assessed at the 1st session of the 1st week and the 18th session of the 6th week of study MMT. Treatment was provided 3 times a week for 6 weeks and a home exercise prescription followed regularly that is started after one week of study. Home exercises were guided and brochures were given to patients to remember those exercises. Follow-up of 6 weeks in 3 sessions a week, performed limb strengthening exercises with 10 repetitions of each exercise during dialysis recorded and then improvement in muscle strength, limb pain, glycemic level, blood pressure and quality of life of patients with kidney disease were measured. Statistical analysis was performed through SPSS version 20. Group statistics with an independent sample t-test was used in the between-group analysis. Repeated measures ANOVA has used within-group analysis for glucose level, blood pressure and pain. The paired sample t-test was used within groups for KDQOL and MMT.

Figure 1: Comparison of Mean Values of Pre-Monitored Glycemic Level Before Every Session of 18



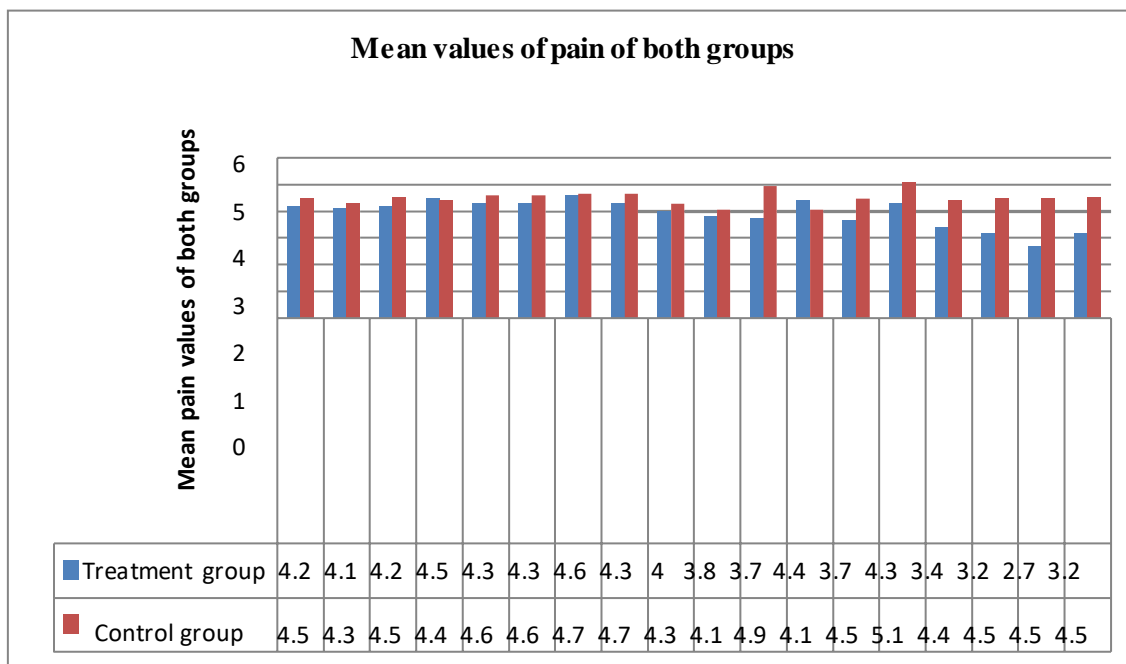
It represented a comparison of mean values of the glyceimic level before 1st session at baseline and after every session at every session of 18 sessions of 6 weeks duration between groups A and B. Mean values showed that there was no significant difference in glyceimic level between both groups. (Figure I)

Figure II: Comparison of Mean Values of Pre-Monitored Blood Pressure Before Every Session of 18 Sessions of 6 Weeks Duration Between Both Groups

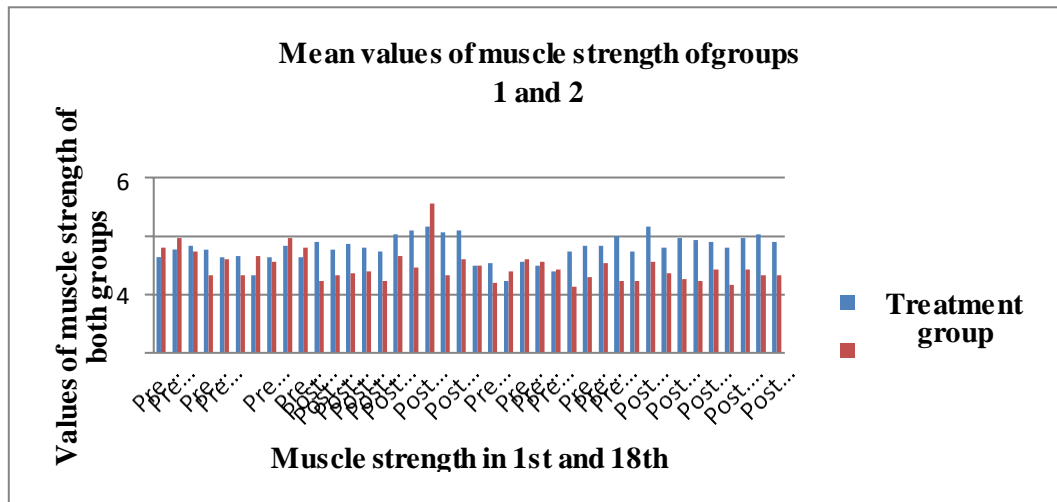


A comparison of mean values of pre-monitored blood pressure at every session of 18 sessions of 6 weeks duration between both groups was represented. Mean values showed that there was a statistically significant difference in blood pressure between both groups. (Figure II)

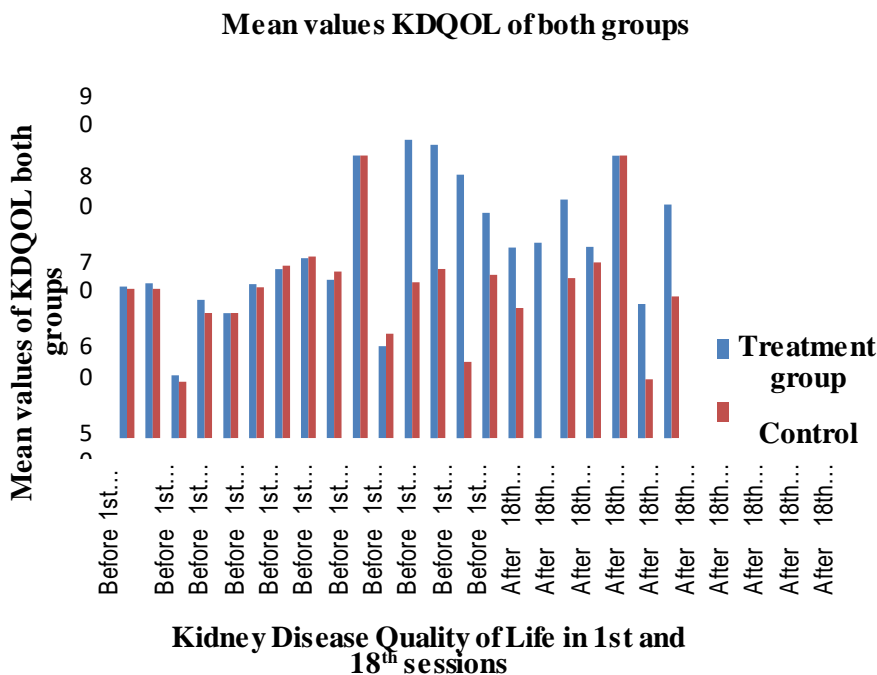
Figure III: Comparison of Mean Values of Pre-Monitored Pain Before Every Session of 18 Sessions of 6 Weeks Duration Between Group A and Group B



The figure represented a comparison of mean values of pre-monitored pain values at every session of 18 sessions of 6 weeks duration between groups A and B. Mean values showed that there was a statistically marked difference in pain especially in increasing sessions between both groups. (Figure III). Figure IV: Comparison of Mean Values of Muscle Strength Pre-Monitored at 1st Session and Post-Monitored at 18th Session of 6 Weeks Duration Between Both Groups.



The bar graph represented a comparison of mean values of muscle strength pre-monitored at 1st session and post-monitored at the 18th session of 6 weeks' duration between both groups. Mean values showed that there was a statistically marked difference in strength, especially in increasing sessions between both groups. (Figure IV) Figure V: Comparison of Mean Values of KDQOL Pre-Monitored at 1st Session And Post-Monitored at 18th Session of 6 Weeks' Duration Between Both Groups



It represented a comparison of mean values of KDQOL pre-monitored at 1st session and post-monitored at the 18th session of 6 weeks' duration between both groups. Mean values showed that there was a statistically significant difference in kidney disease quality of life, especially in increasing sessions between both groups. (Figure V)

Discussion

The primary purpose of this study was to examine and compare the effects of low-impact strengthening exercises in diabetic dialysis patients with ESRD. Strengthening exercises have positive results in decreasing pain, maintaining blood pressure, controlling glycemic levels and enhancing the strength of muscles and also affect positively the quality of life in patients who had diabetic kidney disease. Likewise, a cross-sectional study of diabetic polyneuropathy (DPN) patients and non-DPN patients showed reduced lower extremity muscle strength (in older type 2 diabetes patients and also decreased mobility. The study concluded that by properly monitoring glycemic levels, the quality of life in DPN patients can be maintained.³⁰

Another previous research that documented Diabetic Polyneuropathy patients and 39 diabetic non-polyneuropathy patients and 19 healthy subjects performed isometric and isokinetic lower limb muscle strength tests and 19 healthy subjects performed isometric and isokinetic lower limb muscle strength test to test the effects of both diabetes mellitus type 2 and diabetic polyneuropathy (DPN) on mobility, muscle strength and health-related quality of life (HR-Quality of Life). Mobility was tested by a timed up and go test (TUGT), a 6 min walk test and the physical activity scale HR-Quality of Life tested by the SF36 questionnaire. Both types of patients with and without polyneuropathy of diabetes have decreased maximal muscle strength in the lower limbs and

less mobility. These abnormalities cause in loss of health-related quality of life. Previous research proved beneficial effects on the blood circulation of dialysis patients by generating anti-inflammatory actions, interleukin-6 is generated by muscle fibers. Interleukin-6 induces the appearance in the circulation of other anti-inflammatory cytokines interleukin-1 receptor antagonists and interleukin-10 and inhibits the production of the pro-inflammatory cytokine tumor necrosis factor- α . Interleukin-6 enhances lipid turnover, enhances lipolysis and fat oxidation.

Regular exercise-induced suppression of Tumor Necrosis Factor- α and protection against TNF- α -induced insulin resistance. Recently, IL-6 was released by contracting skeletal muscle fibers, and beneficent in low-grade inflammation such as diabetes and cardiovascular diseases.³¹ Identically, a study was conducted that documented as physical exercise is the non-pharmacological strategy in the treatment of hypertension because of its effects on oxidative stress and endothelial function due to decreased bioavailability of nitric oxide in its pathogenesis. Studies found that aerobic exercise decreases blood pressure and oxidative stress in hypertensive subjects and intense aerobic exercise can also injure endothelial cells.

Isometric exercise decreases systolic blood pressure. Aerobic training proved beneficial in the prevention and treatment of hypertension and cardiovascular disease through a reduction in oxidative stress.³² Muscle weakness and wasting are common in hemodialysis (HD) patients and hand grip and pinch grip tests to measure muscle strength in 209 adult hemodialysis patients. Pinch strength is a more valid and easier tool to measure strength in hemodialysis patients than hand grip strength.³³ It is recommended to conduct studies on large scale with an increased sample size and compare the effects of low-impact strengthening

exercises pre and post-dialysis patients. The alternate hypothesis has been accepted and the null hypothesis rejected.

Conclusion

It is concluded that low-impact strengthening exercises have positive effects on diabetic patients with ESRD in the treatment group as compared to the control group. There is a significant statistical difference between treatment and control groups in the improvement of limb pain and muscle strength by low-impact strengthening exercises.

Declarations

Consent to participate: Written consent had been taken from patients. All methods were performed following the relevant guidelines and regulations.

Availability of data and materials: Data will be available on request. The corresponding author will submit all dataset files.

Competing interests: None

Funding: No funding source is involved.

Authors' contributions: All authors read and approved the final manuscript.

CONSORT Guidelines: All methods were performed following the relevant guidelines and regulations.

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