Serum potassium and handgrip strength as predictors of sleep quality among hemodialysis patients in Malaysia

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Running title: Sleep quality of Malaysian hemodialysis patients

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ABSTRACT

Background and Objectives: Poor sleep quality is prevalent among hemodialysis (HD) patients and leads to adverse health outcomes. This study investigated the association of nutritional parameters with sleep quality among Malaysian HD patients. **Methods and Study Design:** A cross-sectional study was conducted among 184 Malaysian HD patients. Anthropometric measurements and handgrip strength (HGS) were obtained using standardized protocols. Relevant biochemical indicators were retrieved from patients' medical records. Nutritional status was assessed using the dialysis malnutrition score. The sleep quality of patients was determined using the Pittsburgh Sleep Quality Index questionnaire on both dialysis and non-dialysis days. **Results:** Slightly more than half of the HD patients were poor sleepers, with approximately two-third of them having a sleep duration of <7 hours per day. Sleep latency (1.5±1.2) had the highest sleep component score, whereas sleep medicine use (0.1±0.6) had the lowest score. Significantly longer sleep latency and shorter sleep duration were observed in the poor sleepers, regardless of whether it was a dialysis day or not (p<0.001). Poor sleep quality was associated with male sex, old age, small triceps skinfold, hypoproteinemia, hyperkalemia, hyperphosphatemia, and poorer nutritional status. In a multivariate analysis model, serum potassium (β=1.408, p=0.010), male sex (β=2.149, p=0.003), and HGS (β=−0.088, p=0.021) were found as independent predictors of sleep quality. **Conclusions:** Poor sleep quality was evident among the HD patients in Malaysia. The sleep quality of the HD patients was associated with nutritional parameters. Routine assessment of sleep quality and nutritional parameters indicated that poor sleepers have a risk of malnutrition and may benefit from appropriate interventions.

Key Words: hemodialysis, sleep quality, nutritional parameters, hyperkalemia, Pittsburgh Sleep Quality Index

INTRODUCTION

Sleep is the basic human physiological need that must be satisfied.[1] Poor sleep quality is more prevalent in hemodialysis (HD) patients than in the general population, ranging from 51% to 91% across studies.[2–7] Furthermore, poor sleep quality has been associated with several health consequences, including poor quality of life,[7] insomnia, irregularity in sleeping habits, poor nocturnal sleep, restless leg syndrome, sleep apnea, frequent awakening at night, early-morning awakening, daytime sleepiness, and others.[8] Sleep problems, such as sleep apnea and

insomnia, may contribute to the development of cardiovascular complications and affect the survival of HD patients adversely.[9]

Multiple factors have been associated with sleep quality in HD patients, including metabolic factors, such as age, sex, and metabolic abnormalities; physiological factors, such as disability, pain, pruritus, muscle cramps, restless leg syndrome, fatigue, and sleep apnea; psychological factors, such as depression; and malnutrition.[2,4,8,10,11] Despite the literature indicating that the causes of sleep problems are multifactorial, the etiologies of poor sleep quality among HD patients remain unclear.[6]

Although malnutrition has been reported to be highly prevalent among HD patients,[12,13] the relationship between their nutritional status and sleep is likely to be complex and can be different from that in the general population. To the best of our knowledge, all studies investigating the relationship between malnutrition and poor sleep quality have been conducted in Caucasian HD populations,[12,14,15] whose results may not be generalizable to non-Caucasian populations, including the Malaysian population. Therefore, this study investigated the potential effect of nutritional parameters and other factors on sleep quality among Malaysian HD patients.

MATERIALS AND METHODS

A cross-sectional study was conducted between February and June 2017 in four HD units in Sibu, which is an island town in Sarawak, the biggest state of Malaysia. Figure 1 shows the consort diagram of this study. Multistage sampling was performed using cluster sampling and stratified sampling methods, whereby cluster sampling was used to choose the division of Sibu. The number of patients chosen from each HD unit was proportional to the size of the HD unit. All patients in dialysis units were screened according to predefined criteria, and eligible patients were selected through simple random sampling. We included patients who were aged >21 years and had undergone regular HD treatment thrice weekly for at least 3 months. Patients who presented with psychosocial problems, such as mental illness and dementia, or had hepatitis or were hospitalized within a month before the study were excluded. This study was performed in accordance with the principles of the Declaration of Helsinki and was approved by the Medical Research and Ethics Committee of National Institutes of Health Malaysia with registration number NMRR-16-2238-33077. All patients provided informed consent to participate in the study, and patients' anonymity was preserved.

Sleep quality

The sleep quality of patients in the past month was ascertained using the validated Pittsburgh Sleep Quality Index (PSQI) with permission from the author.[16] The PSQI is composed of seven components: subjective sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbances, sleep medication use, and daytime dysfunction. In this study, sleep latency and sleep duration were measured for both HD days (HDDs) and non-HD days (NHDDs), and average values were used to compute the component score. Each sleep component has a scale factor from 0 to 3, and the seven components collectively form a global score ranging from 0 to 21. The higher the score is, the lower is the quality of sleep. A global PSQI score of ≤5 indicates satisfactory sleep quality, whereas a score of >6 indicates poor sleep quality.[16] Cronbach's alpha of this index was 0.752, indicating that the instrument has acceptable internal consistency.

Nutritional parameters

Body height, dry weight, mid-upper arm circumference (MUAC), triceps skinfold (TSF), and handgrip strength (HGS) of patients were measured after dialysis to prevent the effect of excessive body fluids on body composition measurement. The MUAC and TSF were measured for the nonfistula arm at the midpoint of the upper arm between the acromion and olecranon process by using a nonstretchable measuring tape and Harpenden Skinfold Caliper, respectively. Mid-arm muscle circumference (MAMC) was calculated using the following formula: MUAC (cm) − [π × TSF (cm)]. Furthermore, body mass index (BMI) was computed using the following formula: dry weight (kg)/[height × height] (m^2). The HGS of the nonfistula arm rather than the fistula arm was assessed using Lafayette (Model 78010) Hand Dynamometer (Lafayette Instrument Company Inc., USA) to prevent bleeding of the arm with fistula due to overexertion after dialysis. Patients were instructed to perform warm-up exercises, such as shaking their hand three times before gripping the hand dynamometer with the maximum force.[17] The grip strength value reflected the muscle function of patients.

Biochemical indicators, including total protein, serum albumin, total cholesterol, serum creatinine, serum potassium, serum phosphorus, and hemoglobin levels, were retrieved from routine blood test records. All biochemical indicators were collected before dialysis. Three readings were documented to reflect the average reading of biochemical results for a period of 9 months, and mean values were calculated.

The nutritional status of patients was assessed subjectively by calculating the dialysis malnutrition score (DMS), a fully quantitative scoring system. The DMS consists of five

components of medical history (weight change, dietary intake, gastrointestinal symptoms, functional capacity, and comorbidity) and two components of physical assessments (loss of subcutaneous fat and signs of muscle wasting).[18] Each component has a score ranging from 1 to 5, where 1 is normal and 5 is severe malnutrition risk. Summation of scores from the seven components provides a continuous score ranging from 7 (normal) to 35 (severely malnourished). Hence, a lower DMS score indicates better nutritional status, whereas a higher score is an indicator of malnutrition or protein-energy wasting.

Statistical analysis

Data were analyzed using IBM SPSS Statistics version 22. Descriptive analysis was performed to describe the characteristics of patients, and results were expressed as the mean ± standard deviation and number (n, %). The normality of data was assessed using skewness and Kurtosis. Mean differences between the groups were analyzed and compared using the independent sample t-test, whereas differences among variables within a group were compared using the paired sample t-test. Differences among categorical variables were analyzed using the chi-square test or Fisher's exact test as appropriate. However, correlations between continuous variables were examined using the Pearson product–moment correlation coefficient or Spearman's rank correlation coefficient. Furthermore, to determine variables that were independently associated with the PSQI and sleep components, we performed multiple linear regression with stepwise selection of variables with a p value of <0.25 in the univariate analysis. A p value of <0.05 was considered statistically significant.

RESULTS

Sociodemographic variables

In total, 323 HD patients were screened, and 260 of them were eligible. Of 260 potential patients, 28 (10.8%) refused to participate, resulting in a response rate of 89.2%. A total of 186 patients agreed to participate, and two patients (1.1%) withdrew from the study. Thus, 184 sets of completed data were available. Table 1 shows the sociodemographic characteristics of the patients. The mean age of the patients was 54.3 ± 12.6 years, ranging from 22 to 81 years, and 61% of the patients were men. Elderly patients, defined as those aged ≥60 years, comprised 37% of the patients, which reflected the aging phenomenon in Malaysia. By contrast, despite 63% of the patients belonging to the productive age group (20 – 59 years), three quarter of them were unemployed due to chronic kidney disease and

chronic HD treatment. The majority of the patients were Chinese (52.7%), married (73.9%), qualified with equal or higher than secondary education level (65.2%), and having a low household income (66.8% of the bottom 40%). The median monthly household income of the patients was 30% lower than the median household income of approximately USD 1250 in Sarawak as reported by the Department of Statistics Malaysia.[19] The government was the main treatment funder. Due to economic downturn, subsidies from the government were limited to a certain amount, and patients had to pay the extra treatment fee on their own or from other funds. Compared with the good sleeper group, the poor sleeper group had more male, elderly, Chinese, married or divorced, and literate patients, with no significant differences between the groups. The distribution of patients according to employment status, household income, and source of treatment funding was similar in both the good and poor sleeper groups.

Nutritional parameters

Data in Table 2 depict information on the nutritional parameters of the patients. The mean height, dry weight, and BMI of the patients were 158.7±9.1 cm, 61.2±14.3 kg, and 24.2±4.6 kg/m^2, respectively. According to the World Health Organization classification, half of the patients had normal body weight status (BMI=18.5-24.9). By contrast, one and four of the 10 patients were underweight (BMI <18.5) and overweight or obese (BMI ≥25), respectively. A higher proportion of the underweight patients were poor sleepers compared with those with normal BMI, overweightness, and obesity. However, no significant difference in BMI was observed between the poor and good sleepers. Almost all the patients had an MUAC of ≥23 cm. The mean values of TSF and MAMC were 13.8±4.8 mm and 26.1±3.9 cm, respectively. No significant differences were observed between the good and poor sleepers in terms of MUAC, TSF, and MAMC. Nevertheless, a significantly higher proportion of the poor sleepers were observed to have an MUAC of <23 cm (p=0.035). The HGS of the patients had a mean of 20.9±9.0 kg with comparable mean HGS between the good and poor sleepers (p>0.05).

Approximately one in four patients had hypoalbuminemia. Slightly more than half of the patients had total cholesterol levels within the recommended range, whereas one-third and one of six patients had hypocholesterolemia and hypercholesterolemia, respectively. It is not uncommon for patients with kidney failure to have high serum creatinine levels. Although HD imitates the functions of the kidneys, the process does not remove all metabolic wastes from the body. The mean values of electrolytes, such as serum potassium and phosphorus, were

within normal ranges. Approximately one-quarter of the patients experiencing hyperkalemia had failed to achieve the serum potassium level recommended by the Kidney Disease Outcomes Quality Initiative (K/DOQI) guidelines (2004).[20] Approximately 60% of the patients had serum phosphorus levels as per the K/DOQI recommendation, whereas one-third of them had hyperphosphatemia and 7% of them had hypophosphatemia. Furthermore, the mean hemoglobin level of the patients was 10.8±1.4 g/dL, which was slightly lower than the normal value. Thirty percent of the patients had a hemoglobin level of <10 g/dL, which indicated anemia, attributing to insufficient production of erythropoietin and red blood cells, as a health consequence of end-stage renal disease. In general, biochemical indicator readings of the good and poor sleepers were comparable. The nutritional status of the patients as assessed with DMS had a mean score of 11.3±2.3 and ranged from 7 to 21, suggesting a lower risk of malnutrition. No significant difference in mean DMS was observed between the good and poor sleepers.

Sleep quality and its component scores

The sleep quality and sleep component scores of the patients are summarized in Table 3. The mean PSQI score was 6.7±4.1 with a significantly higher PSQI score in the poor sleepers. Poor sleep quality was observed in >50% of the patients. Sleep latency had the highest PSQI sub-score, whereas sleep medicine use had the lowest score. The poor sleepers had significantly higher scores in all sleep components than did the good sleepers. In addition, sleep latency and sleep duration on both HDDs and NHDDs were determined. A paired sample t-test was conducted to compare sleep latency and sleep duration of the patients on NHDDs and HDDs. A significantly longer sleep latency was observed on NHDDs (53.1±57.6 minutes) than on HDDs (22.1±28.0 minutes) (p<0.001). Likewise, a significantly shorter sleep duration was noted on NHDDs (5.5±2.0 hours) than on HDDs (6.2±2.1 hours) (p<0.001). Similarly, significantly longer sleep latency and shorter sleep duration were noted on NHDDs in both the good and poor sleepers (p<0.001). These results suggested that HD treatment can affect sleep latency and sleep duration. Specifically, the results suggested that on HDDs, the patients could fall asleep faster and sleep longer. These results were supported by the finding that the patients took approximately 30 minutes less to fall asleep and had an extra 0.7 sleep hours on HDDs than on NHDDs. Moreover, the poor sleepers had significantly longer sleep onset time and shorter sleep duration than did the good sleepers, regardless of whether it was a HDD or NHDD. Thus, dialysis treatment may affect sleep quality.

Association between sleep quality and nutritional parameters

Demographic and nutritional parameters were explored for a potential correlation with sleep quality (Table 4). Age; sex; TSF; total protein, serum potassium, and serum phosphorus levels; and DMS were found to correlate significantly with sleep quality or its components. Old age was correlated with less sleep efficiency (r=0.157, p=0.033). Furthermore, compared with the women, the men had poorer sleep quality (r=0.160, p=0.030), shorter sleep duration (r=0.161, p=0.029), and lower sleep efficiency (r=0.150, p=0.043). Smaller TSF was correlated with poorer sleep quality (r=−0.147, p=0.047), whereas hypoproteinemia was correlated with poorer subjective sleep quality (r=−0.186, p=0.012). Hyperkalemia was correlated with poorer sleep quality (both global and subjective sleep quality scores) and longer sleep latency (r=0.150, p=0.042). Moreover, hyperphosphatemia was correlated with longer sleep latency (r=0.154, p=0.037). Poorer nutritional status (as indicated with higher DMS) was correlated with poorer sleep quality (r=0.152, p=0.039), less sleep efficiency (r=0.167, p=0.024), and more frequent daytime dysfunction (r=0.150, p=0.043). Other sleep components and nutritional parameters were not significantly correlated. In a nutshell, the current findings indicate that old age, men, and poor nutritional markers of low body fat, hypoproteinemia, hyperkalemia, hyperphosphatemia, and high DMS are factors for poor sleep quality.

Predictors of sleep quality

The multivariate analysis model indicated 8.1% variance in the global PSQI score. The significant independent predictors of sleep quality were serum potassium level (β=1.408, p=0.010), male sex (β=2.149, p=0.003), and HGS (β=−0.088, p=0.021) (Table 5). The global PSQI score was primarily predicted by HGS, followed by the serum potassium level and, to a lesser extent, male sex. On the basis of the multivariate analysis model, Figure 2 shows the proposed mechanism of determining independent predictors and sleep. The suggested equation for the global PSQI score is as follows:

Global PSQI = 0.694 + 1.408 serum potassium (mmol/L) + 2.149 if male patient
− 0.088 handgrip strength (kg).

DISCUSSION

This study explored determinants for sleep quality among the HD patients. The mean global PSQI score of this study is in agreement with those reported in previous studies conducted in HD patients in Canada[21] and Turkey[22] but is lower than that reported by studies conducted in Iran.[3,6] Using the same sleep measure, the literature has consistently shown a high prevalence

of poor sleep quality among HD patients (51%–91%) throughout the decade. The prevalence of poor sleep quality in the current study is comparable to that reported in studies conducted by Chang and Yang[2] and Köse et al[4] but lower than that reported in other studies.[3,5-7,21] The discrepancy could be due to social and lifestyle diversities. Although the current studied cohort had a lower prevalence of poor sleep quality, preventive measures are required to improve the sleep quality of patients because poor sleep quality is universally associated with decreased quality of life through negative impacts on energy, emotional balance, and health status.[23]

The sleep latency and sleep duration of the patients in this study are comparable to those reported in a previous study conducted by Mehrabi et al.[7] In this study, the poor sleepers had a significantly longer sleep latency and shorter sleep duration than did the good sleepers. Such phenomenon has also been observed in non-HD patients, such as students of tertiary institutions and Caucasians with type 2 diabetes.[24,25] Furthermore, the patients in this study had less sleep onset latency and longer sleep duration on HDDs. This could be due to rapid physiological changes such as rapid fluid, electrolyte, and acid–base changes during chronic daytime HD treatment and induced fatigue.[26] As a result, the patients usually could fall asleep faster and sleep more on HDDs to get adequate rest. Conversely, physiological changes due to HD treatment may increase daytime sleep, which can reduce the quantity and quality of subsequent nocturnal sleep.[26] This can explain why the patients had a shorter sleep duration on NHDDs. Furthermore, a shorter sleep duration on NHDDs could be due to longer sleep latency at night and waking up early on the next day, especially for those with a morning dialysis session to prepare for HD treatment. In addition, shorter sleep on the night before an HD session (NHDD), especially during a long interdialytic interval, could be the possible effect of high interdialytic weight gain.

The study finding of the association of old age with poor sleep quality is in congruence with the findings reported by Tel.[27] Less engagement in daily or physical activities, primary sleep disorders, changes in the sleeping habit, shorter sleep duration, increased sleep latency and arousals, and psychological disorders are factors that can interfere with sleep among elderly people and reduce sleep quality.[2,5,23] Although studies have consistently reported a higher prevalence of poor sleep in women,[2,3,6,11] the current study results showed a higher prevalence of sleep quality in the men. This discrepancy could be due to a higher proportion of older men than women in the study. Furthermore, the uniqueness of the biological conditions of women, for example, female hormones and menstrual cycle, may regulate the

sleep pattern and sleep duration of each individual differently.[28] More studies are warranted to delineate how sex may influence sleep quality.

In the current study, TSF, total protein, serum potassium, serum phosphorus, and DMS were associated with sleep quality. TSF is commonly used to estimate the subcutaneous fat of the body[29] and is negatively associated with DMS (data not shown), indicating that patients with a higher TSF value had a lower DMS value and hence better nutritional status.[29,30] To the best of our knowledge, the association between TSF and sleep quality among HD patients is underexamined. However, the result may suggest that a high TSF value is an indication of a good nutritional status, which could result in better sleep. Nutritional status as assessed subjectively with a reliable DMS tool revealed a lower DMS associated with better sleep quality. However, the pathological relationship between nutritional status and sleep quality is unclear. Bilgic et al[12] reported that malnourished HD patients were more depressed and had lower sleep quality than normal HD patients. Although depression is not examined in this study, it can be postulated that poor sleep quality among malnourished HD patients is due to depression because Firoz et al[3] reported that depression was one of the predictors of poor sleep quality in HD patients. More studies are needed to confirm and explore the plausible associations of TSF and nutritional status with sleep quality, specifically among HD patients.

Total protein is a parameter that is under investigated in HD patients as compared with serum albumin. The association between total protein and sleep quality is unexplored. Possible mechanisms that could explain the relationship between low total protein (hypoproteinemia) and sleep quality include edema, inadequate dietary intake, and immune function. Protein loss through HD and inadequate dietary protein intake could result in hypoproteinemia.[31] Reduction in the oncotic pressure due to hypoproteinemia increases tissue hydrostatic pressure and leads to accumulation of fluid in the body or edema.[31] Edema increases blood pressure, and edema in the lungs leads to difficulty in breathing and thus influences sleep quality. Moreover, sleep deprivation or a shorter sleep duration could suppress the immune function through the upregulation of circulating proinflammatory mediators.[32] The inflammation status due to kidney failure itself and sleep deprivation depletes the serum protein for antibody production. Nevertheless, additional studies are warranted to confirm the proposed mechanisms.

The relationship between hyperphosphatemia and poor sleep quality observed in the HD patients in this study is consistent with the findings reported by Sabry et al[33] and Zeydi et al[34] but contradicts those reported by Köse et al[4] and Mehrabi et al.[7] Despite inconsistent findings, patients with hyperphosphatemia may have poor sleep quality due to sleep disturbances and

prolonged sleep onset time. Frequent reported symptoms of sleep disturbances related to hyperphosphatemia are itchiness, joint pain, and restless leg syndrome.[33] Excessive dietary phosphorus intake may lead to hyperphosphatemia as Kalantar-Zadeh[35] and colleagues noted an interrelationship between serum phosphorus and dietary phosphorus. The significant correlation between serum potassium and sleep quality observed in this study contradicts previous findings.[36] Poor sleep quality in hyperkalemic patients is probably due to hyperkalemia-related sleep disturbances, such as fatigue, limb muscle numbness or cramps, and palpitation, which might affect the quality of sleep at night.[33] Compliance to medication and dietary restriction could however be the confounders of hyperphosphatemia and hyperkalemia. Therefore, future studies may explore patients' compliance while investigating the association between sleep quality and serum phosphorus and potassium.

Although HGS did not show a significant correlation with sleep quality in the correlation analysis, it appeared to be an independent negative predictor of sleep quality in the multivariate analysis. Studies on the association between grip strength and sleep quality among HD population are scant. Studies have documented the association between HGS and sleep duration.[37-39] It is speculated that sleep affects muscle strength through hormonal regulation.[38] Insufficient sleep reduces anabolic hormones and thus muscle mass synthesis, which leads to decreased muscle strength and causes muscle weakness, possibly impairing daytime functioning. However, the relationship between sleep and HGS appears to be a causality dilemma; hence, more studies are required to rule out the association between HGS and sleep.

The current study has several limitations. First, the cross-sectional study design could not determine whether poor nutritional markers caused poor sleep quality, or vice versa. Prospective longitudinal studies are required to confirm the association between sleep quality and nutritional markers while controlling for confounding variables. Second, biochemical data were collected from routine blood test records of each HD unit; thus, the values of biochemical indicators might have slight differences due to different laboratory test kits used in the biochemistry analysis. Future studies should consider collecting blood samples and performing standardized biochemistry analyses. Third, assessments of MUAC, TSF, and HGS were performed on the nonfistula arm and not the dominant hand, which may have contributed to variations in results. Dietary intake was not included in this study due to limited human resources. Lastly, gold standards, such as polysomnography and actigraphy, were not used for sleep measurements owing to financial constraints. However, the PSQI,

which is validated as a high accuracy and reliable subjective sleep measurement tool, was used in this study.

Conclusion

This study emphasizes the high prevalence of poor sleep quality among HD patients and suggests that routine evaluation of sleep quality is required. Furthermore, parameters, namely TSF, total protein, serum potassium, serum phosphorus, and nutritional status, were found to affect the sleep quality of dialysis patients. Therefore, appropriate interventions should be formulated to improve nutritional status and other aspects, such as diet, physical activity, psychological factors, and sleep hygiene, to enhance sleep quality among HD patients.

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CONFLICT OF INTEREST AND FUNDING DISCLOSURE

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Table 1. Socio-demographic characteristics of patients stratified by sleep quality

Variables	Good sleepers (n=90)	Poor sleepers (n=94)	Total (n=184)	Statistics (*p* value)
Sex				χ^2=2.548 (0.110)
Male	49 (54.4)	63 (67.0)	112 (60.9)	
Female	41 (45.6)	31 (33.0)	72 (39.1)	
Age group	53.2±13.2	55.3±12.0	54.3±12.6[†]	t=-1.123 (0.263)
21–35 years old	12 (13.3)	8 (8.5)	20 (10.9)	χ^2=1.655 (0.437)
36–59 years old	48 (53.4)	48 (51.1)	96 (52.1)	
≥60 years old	30 (33.3)	38 (40.4)	68 (37.0)	
Ethnicity				χ^2=1.358 (0.244)
Chinese	43 (47.8)	54 (57.4)	97 (52.7)	
Non-Chinese	47 (52.2)	40 (42.6)	87 (47.3)	
Marital Status				χ^2=3.235 (0.375)
Married	65 (72.2)	71 (75.5)	136 (73.9)	
Single	18 (20.0)	11 (11.7)	29 (15.8)	
Widow/ Widower	1 (1.1)	2 (2.2)	16 (8.7)	
Divorced/ Separated	6 (6.7)	10 (10.6)	3 (1.6)	
Educational level				χ^2=1.980 (0.577)
No formal education	8 (8.9)	4 (4.3)	12 (6.5)	
Primary school	23 (25.6)	29 (30.8)	52 (28.3)	
Secondary school	49 (54.4)	51 (54.3)	100 (54.3)	
Tertiary	10 (11.1)	10 (10.6)	20 (10.9)	
Employment status				χ^2=0.000 (1.000)
Unemployed	75 (83.3)	78 (83.0)	153 (83.2)	
Employed	15 (16.7)	16 (17.0)	31 (16.8)	
Household size	4.5±2.5	4.6±2.2	4.6±2.4	t=-0.148 (0.882)
Household monthly income (RM)[‡]			2,950[§]	χ^2=0.153 (1.000)
B40 (< 3,860)	60 (66.7)	63 (67.0)	123 (66.8)	
M40 (3,860 – 8,319)	26 (28.9)	63 (67.0)	52 (28.3)	
T20 (≥ 8,320)	4 (4.4)	5 (5.3)	9 (4.9)	
Per capita			890±1,085	
Source of treatment funding[¶]				
Government funded	78 (86.7)	80 (85.1)	158 (85.9)	
Self-funding	52 (57.8)	57 (60.6)	109 (59.2)	
NGO funded	6 (6.7)	6 (6.4)	12 (6.5)	
Employer subsidized	3 (3.3)	0 (0.0)	3 (1.6)	
Insurance	0 (0.0)	3 (3.2)	3 (1.6)	

Data was presented as mean±SD or n (%).
B40: bottom 40%; M40: middle 40%; T20: top 20%; NGO: non-government organization.
[†]Age ranged from 22 to 81 years.
[‡]Classified based on Eleventh Malaysia Plan (2016–2020), RM 1 was equivalent to approximately USD 0.3 at the time of data collection.
[§]Data was presented in median.
[¶]Multiple responses.

Table 2. Nutritional parameters of subjects stratified by sleep quality

Parameters	Good sleepers (n=90)	Poor sleepers (n=94)	Total (n=184)
Anthropometric data			
Height (cm)	157.4±9.3	159.8±8.7	158.7±9.1 (134–184)
Dry weight (kg)	60.8±13.1	61.5±15.5	61.2±14.3 (33.3–102.8)
BMI (kg/m^2)†	24.5±4.4	23.9±4.7	24.2±4.6
<18.5	3 (3.3)	13 (13.8)	16 (8.7)
18.5–24.9	49 (54.5)	43 (45.8)	92 (50.0)
25.0–29.9	28 (31.1)	29 (30.9)	57 (31.0)
30.0–34.9	7 (7.8)	8 (8.5)	15 (8.1)
≥35.0	3 (3.3)	1 (1.1)	4 (2.2)
MUAC (cm)	30.8±4.6	30.0±4.9	30.4±4.7 (19.6–40.4)
<23	1 (1.1)	8 (8.5)‡	9 (4.9)
≥23 ref	89 (98.9)	86 (91.5)	175 (95.1)
TSF (mm)	14.3±4.8	13.3±4.8	13.8±4.8 (2.4–31.0)
MAMC (cm)	26.4±3.9	25.9±3.9	26.1±3.9 (17.8–35.6)
Handgrip strength (kg)§	20.9±9.6	20.8±8.5	20.9±9.0 (0.5–51.0)
Low	19 (21.8)	28 (30.4)	47 (26.3)
Normal	68 (78.2)	64 (69.6)	132 (73.7)
Biochemical data			
Total protein (g/L)	72.7±4.7	72.3±4.9	72.5±4.8 (61.3–88.0)
Serum albumin (g/L)¶	40.1±3.2	40.0±3.5	40.0±3.3 (26.3–46.7)
<40	35 (38.9)	37 (39.4)	72 (39.1)
≥40 ref	55 (61.1)	57 (60.6)	112 (60.9)
Total cholesterol (mmol/L)¶, ††	4.3±0.8	4.3±1.0	4.3±0.9 (2.3–6.7)
<3.9	29 (32.2)	31 (33.0)	60 (32.6)
3.9–5.2 ref	50 (55.6)	45 (47.9)	95 (51.6)
>5.2	11 (12.2)	18 (19.1)	29 (15.8)
Serum creatinine (µmol/L)	959.4±212.7	938.4±258.3	948.7±236.7 (395.7–1621.7)
Serum potassium (mmol/L)‡‡	4.6±0.5	4.7±0.6	4.6±0.6 (3.2–6.3)
≤5.0 ref	68 (75.6)	68 (72.3)	136 (73.9)
>5.0	22 (24.4)	26 (27.7)	48 (26.1)
Serum phosphorus (mmol/L)§§	1.7±0.4	1.7±0.4	1.7±0.4 (0.8–3.0)
<1.13	7 (7.8)	6 (6.4)	13 (7.1)
1.13–1.78 ref	52 (57.8)	56 (59.6)	108 (58.7)
>1.78	31 (34.4)	32 (34.0)	63 (34.2)
Hemoglobin (g/L) ¶¶	106.2±13.0	108.9±14.7	107.6±13.9 (69.3–150.0)
<100	30 (33.3)	26 (27.7)	56 (30.4)
100–120 ref	50 (55.6)	49 (52.1)	99 (53.8)
>120	10 (11.1)	19 (20.2)	29 (15.8)
Dialysis Malnutrition Score	11.0±2.0	11.6±2.4	11.3±2.3 (7–21)

Data was presented as mean ± SD, range or n (%).
BMI: body mass index; MUAC: mid-upper arm circumference; TSF: triceps skinfold; MAMC: mid-arm muscle circumference.
†BMI classification based on WHO.
‡Significant association between MUAC (p=0.035) with sleep quality was determined by Fisher's Exact Test at 0.05 level of significance.
§Total subjects=179, Low HGS: ≤20 kg for male, ≤10 kg for female.
¶National Kidney Foundation Kidney Disease Outcomes Quality Initiative (K/DOQI) Clinical Practice Guidelines for nutrition in chronic renal failure (2000)
††National Kidney Foundation K/DOQI Clinical Practice Guidelines for management of dyslipidemias in patients with kidney disease (2003)
‡‡National Kidney Foundation K/DOQI Clinical Practice Guidelines on hypertension and antihypertensive agents in chronic kidney disease (2004)
§§National Kidney Foundation K/DOQI Clinical Practice Guidelines for bone metabolism and disease in chronic kidney disease (2003)
¶¶Renal Association Clinical Practice Guidelines (2009–2012) (5th edition) (Mactier, Davies, Dudley, Harden, & Jones, 2011)

Table 3. Comparison of sleep quality and sleep components scores of subjects

Sleep components	Good sleepers (n=90)	Poor sleepers (n=94)	Total (n=184)	t value
Global PSQI score	3.2±1.5	10.0±2.8	6.7±4.1 (0–19)	-20.646**
≤5 (Good sleepers)			90 (48.9)	
>5 (Poor sleepers)			94 (51.1)	
Subjective sleep quality	0.7±0.5	1.3±0.7	1.0±0.7 (0–3)	-6.303**
Sleep latency	0.7±0.9	2.2±1.0	1.5±1.2 (0–3)	-10.833**
On NHDD (minutes)	25.4±32†	79.7±63†	53.1 ± 57.6 (2–360)†	-7.346**
On HDD (minutes)	13.2±15.3	30.6±34.2	22.1 ± 28.0 (2–240)	-4.475**
Sleep duration	0.4±0.7	2.3±1.0	1.4±1.3 (0–3)	-14.814**
On NHDD (hours)	7.0±1.3‡	4.1±1.6‡	5.5±2.0 (1.0–11.5)‡	13.158**
On HDD (hours)	7.7±1.5	4.7±1.6	6.2±2.1 (1.0–12.0)	12.696**
Sleep efficiency	0.3±0.7	2.3±1.0	1.3±1.3 (0–3)	-15.569**
Sleep disturbances	0.9±0.3	1.2±0.5	1.1±0.5 (0–3)	-4.708**
Use of sleep medicine	0.0±0.0	0.2±0.8	0.1±0.6 (0–3)	-2.902*
Daytime dysfunction	0.2±0.4	0.6±0.8	0.4±0.6 (0–3)	-4.287**

Data was presented as mean ± SD, range or n (%).
NHDD: non-hemodialysis day; HDD: hemodialysis day.
Difference between continuous data was determined by independent sample t-test at significance level of 0.05.
†Paired sample t-test were used to compare sleep latency on NHDD and HDD, with significant differences shown for good sleepers ($t(89) = 4.578$, $p < 0.001$), poor sleepers ($t(93) = 7.774$, $p < 0.001$) and all subjects ($t(183) = 8.321$, $p < 0.001$), respectively.
‡Paired sample t-test were used to compare sleep duration on NHDD and HDD, with significant differences shown for good sleepers ($t(89) = -6.671$, $p < 0.001$), poor sleepers ($t(93) = -5.883$, $p < 0.001$) and all subjects ($t(183) = -8.879$, $p < 0.001$), respectively.
*$p < 0.01$; **$p < 0.001$

Table 4. Correlation between variables and sleep components

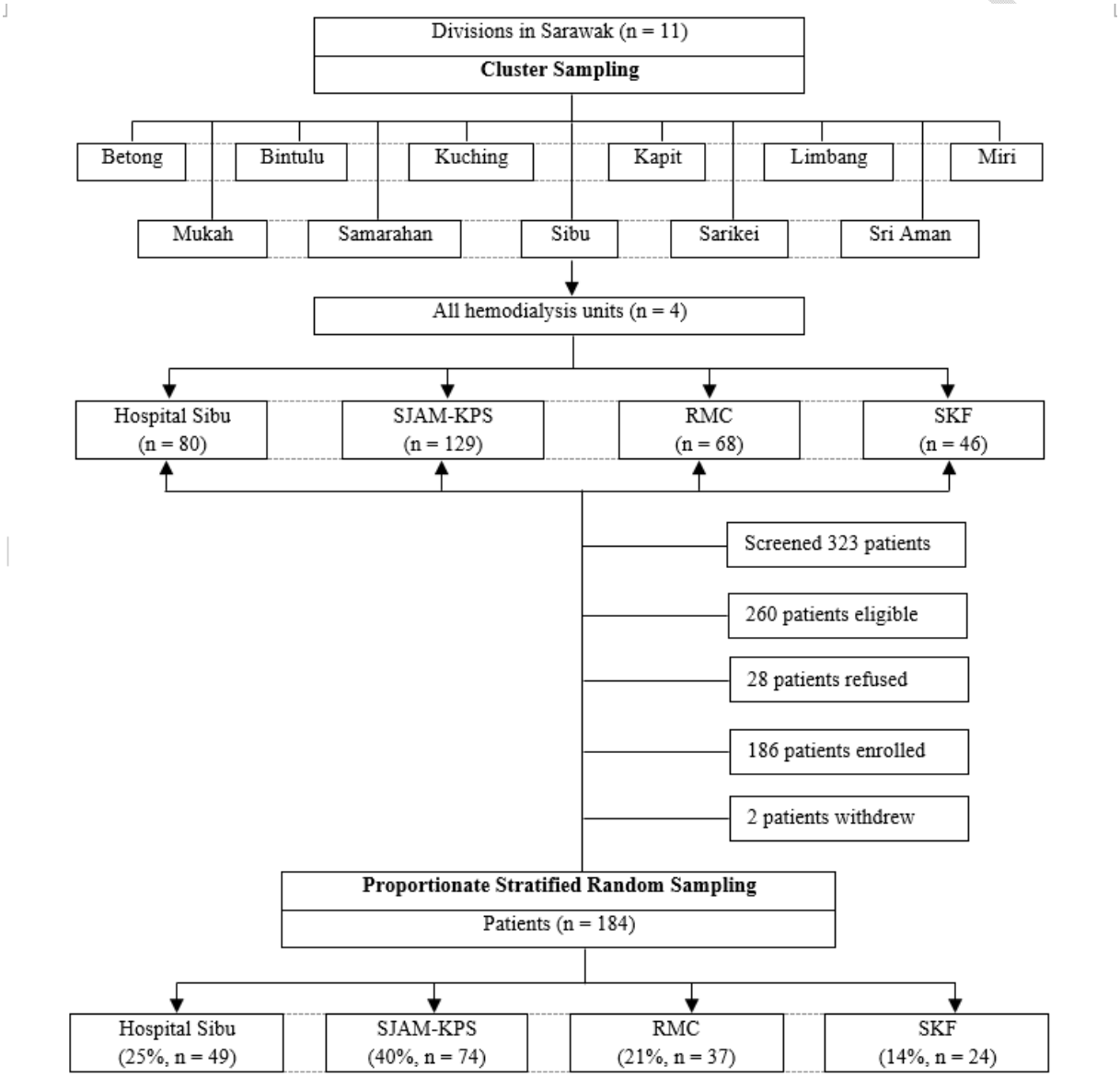
Variables	Global PSQI	SSQ	SL	SD	SE	SDB	SM	DD
Socio-demographic								
Age	0.112	-0.053	0.115	0.103	0.157*	0.049	0.075	-0.066
Sex (male)	0.160*	0.023	0.047	0.161*	0.150*	0.039	0.008	0.134
Anthropometric data								
BMI	-0.086	-0.091	0.004	-0.098	-0.110	0.009	-0.087	0.015
MUAC	-0.117	-0.100	-0.025	-0.094	-0.117	-0.020	-0.128	-0.066
TSF	-0.147*	-0.115	-0.061	-0.123	-0.134	-0.062	-0.123	-0.048
MAMC	-0.082	-0.078	-0.009	-0.056	-0.090	-0.002	-0.111	-0.068
Handgrip strength	-0.060	0.018	-0.040	-0.018	-0.026	-0.010	-0.110	-0.144
Biochemical data								
Total protein	-0.110	-0.186*	-0.070	0.014	-0.099	-0.123	-0.100	-0.081
Serum albumin	0.031	0.112	-0.052	0.032	-0.033	0.066	0.036	0.083
Total cholesterol	0.046	-0.004	0.027	0.109	0.064	-0.006	0.048	-0.065
Serum creatinine	-0.027	-0.027	0.009	0.001	-0.071	-0.045	-0.008	-0.045
Serum potassium	0.161*	0.154*	0.150*	0.099	0.069	0.095	0.137	0.023
Serum phosphorus	0.098	0.019	0.154*	0.066	0.050	0.137	0.093	-0.062
Hemoglobin	0.027	-0.007	0.047	0.057	0.058	-0.022	0.062	-0.121
Dialysis Malnutrition Score	0.152*	0.089	0.097	0.103	0.167*	0.079	-0.020	0.150*

PSQI: Pittsburgh Sleep Quality Index; SSQ: subjective sleep quality; SL: sleep latency; SD: sleep duration; SE: sleep efficiency; SDB: sleep disturbance; SM: use of sleep medication; DD: daytime dysfunction; BMI: body mass index; MUAC: mid-upper arm circumference; TSF: triceps skinfold; MAMC: mid-arm muscle circumference.
*$p<0.05$.

Table 5. Multiple linear regression model with global PSQI score as variable outcome (n = 178)

Variables	β	SE	Beta	R	R2	ΔR2	*p* value
Constant	0.694	2.596					
Serum potassium	1.408	0.543	0.189	0.164	0.027	-	0.010
Sex (Male)	2.149	0.703	0.254	0.229	0.053	0.026	0.003
Handgrip strength	-0.088	0.038	-0.193	0.284	0.081	0.028	0.021

PSQI: Pittsburgh Sleep Quality Index; SSQ: subjective sleep quality; SL: sleep latency; SD: sleep duration; SE: sleep efficiency; SDB: sleep disturbance; SM: use of sleep medication; DD: daytime dysfunction; BMI: body mass index; MUAC: mid-upper arm circumference; TSF: triceps skinfold; MAMC: mid-arm muscle circumference.
$^{*}p<0.05$.



SJAM-KPS, St. John Ambulance Malaysia – *Kawasan Pantai Selangor*; RMC, Rejang Medical Centre; SKF, Sibu Kidney Foundation

Figure 1. Consort diagram of the study

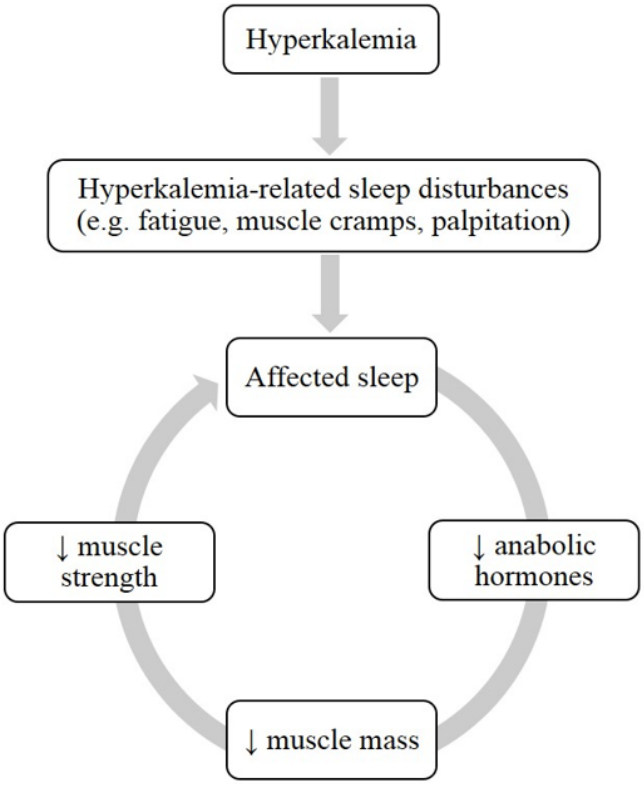


Figure 2. Proposed mechanism of hyperkalemia, handgrip strength and sleep quality