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Habitual Physical Activity and Sleep in Adults with End-Stage Renal Disease

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ABSTRACT

Background: Treatment of end-stage renal disease (ESRD) is necessary to maintain life. However, it can cause physiological, psychosocial, and cognitive impairments, which may impact physical activity (PA) and sleep, although there is insufficient device-based data to elucidate such impacts.

Methods: PA, sedentary time (SED), and sleep were measured over 7 consecutive days in 12 adults with ESRD (9 dialyzing at home, 3 dialyzing in center) using wrist-worn accelerometers. Validated raw acceleration thresholds were used to quantify time spent in each PA intensity domain and SED, and sleep duration and efficiency.

Results: Adults with ESRD engaged in little moderate-to-vigorous PA (MVPA; 6.9 ± 9.7 min·d^{-1}) and spent 770.0 ± 68.6 min·d^{-1} SED. People dialyzing at home engaged in more light-intensity PA than those attending in center (131.2 ± 28.1 versus 106.9 ± 5.4 min·d^{-1}, respectively; P = 0.05); however, neither group met the recommended guidelines for daily MVPA. Individuals with ESRD slept for an average of 286.8 ± 79.3 min·night^{-1} with an efficiency of 68.4 ± 18.5%, although people dialyzing at home slept for longer and more efficiently (74.5% versus 50.0%, P = 0.07) than those attending in center.

Conclusion: In this study, we suggest that adults with ESRD engage in less total PA than recommended guidelines and are characterized by poor sleep duration and efficiency. Moreover, results indicate that dialysis mode may influence PA, SED, and sleep, with those dialyzing at home engaging in greater leisure time PA and achieving a greater sleep duration and efficiency. *J Clin Exerc Physiol*. 2022;11(2):38–43.

Keywords: haemodialysis, accelerometry, physical activity, sleep quality

INTRODUCTION

End-stage renal disease (ESRD), the final stage of chronic kidney disease (CKD), is characterized by an inability to filter toxins and excess fluid from the body. Consequently, people living with ESRD require a form of renal replacement therapy, which is usually dialysis. Given the prevalence of comorbidities such as diabetes (1) and cardiovascular disease (2) in people living with ESRD, maintaining a physically active lifestyle plays an important role in reducing the risk of cardiovascular events (3).

Previous researchers have shown that adults with ESRD do not meet the recommended minimum physical activity (PA) guidelines for health (4–6) of 150 min of moderate-to-vigorous PA (MVPA) per week (7). This is reportedly due, at least in part, to the time demands of dialysis, although tiredness, a lack of motivation, feeling unwell, and a lack of understanding of PA have also been suggested to contribute (8). Indeed, even in those reporting modest improvements in PA upon initiation of dialysis, PA behaviors remain below recommended guidelines (9). Although there is limited research comparing different dialysis modalities, such as

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in-center haemodialysis (ICHD) and home haemodialysis (HHD), initial evidence suggests that those who dialyze at home, using a more frequent but less intense regimen, report higher levels of PA than those who dialyze in center (10). However, this requires further investigation using device-based assessments of PA.

Although the use of accelerometry provides accurate and objective insight into PA engagement, self-reported measures can provide context into PA that may not be otherwise recorded, particularly following the recently proposed definition of PA as involving both movement and context (11). Therefore, a combination of accelerometry and self-reported measures would allow for device-based measurement to limit inaccuracies, with self-reported measures providing more contextual insight into PA behaviors (12). However, to date, evaluations in people living with kidney disease have primarily used self-reported measures and questionnaires in isolation, which often have limited completion rates and sensitivity and rely on individual recall (13). In addition to the more comprehensive and accurate insight into daily PA that accelerometry offers, it can also provide valuable sleep data in both healthy people (14,15) and those with long-term conditions (16–18).

The importance of sleep duration and quality in maintaining health in the general population is well documented (19). Researchers using self-reported measures suggest that people with ESRD have a high prevalence of disordered sleep (20), with people on dialysis reporting poor-quality sleep, which is associated with a reduced quality of life (21,22). Of particular concern, transition to treatment with dialysis is associated with more impaired and variable sleep quality (23,24). Given the evidence supporting a bidirectional relationship between PA and sleep in the general population (25) and those with long-term conditions (26), further investigation of sleep duration and quality alongside PA and indeed sedentary time (SED) in people with kidney disease would be valuable.

Therefore, the aim of this study was to utilize accelerometry to quantify the levels and intensity of habitual PA and SED and to quantity the level and efficiency of sleep in adults with ESRD receiving either ICHD or HHD. It was hypothesized that adults with ESRD would engage in less PA and have greater SED and poorer sleep (duration and efficiency) than the recommended guidelines and that those currently receiving HHD would engage in more PA and have better sleep (quantity and quality) than those receiving ICHD.

METHODS

Participants

Twelve adults with ESRD, of whom 9 were receiving HHD (8 male, 54.4 ± 16.1 years; time on dialysis: 11.1 ± 6.8 months) and 3 were receiving ICHD (3 male; 49.3 ± 15.2 years; time on dialysis: 23.8 ± 4.9 months), under the care of the Wessex Kidney Centre, were recruited and provided fully informed written consent to participate in the study. All participants continued prescribed medications and dialysis regimens as usual throughout their involvement in the study. Ethics approval was granted by the South Central—Oxford B Research Ethics Committee (REC reference: 18/SC/0684). These data were collected as part of the FREDI-CAL trial, and the study was registered on ClinicalTrials.gov (NCT03925454).

Data Collection and Analyses

During an initial baseline visit, a wrist-worn accelerometer (GENEActiv, Activinsights, Kimbolton, Cambridge, UK), programmed to record at 100 Hz for 7 consecutive days, was attached to the participant's nonfistula arm.

PA and sleep analyses were performed in R (http://cran.r-project.org) using the GGIR package (version 2.4.0) to convert the tri-axial acceleration values to an omnidirectional acceleration in the form of the signal vector magnitude. Raw acceleration values were processed by the Euclidian norm minute 1 method (27), then reduced to 5-s epochs and expressed in milligravity-based acceleration units (*mg*) (28). To be included, data had to be available for a minimum of 16 $h \cdot d^{-1}$ of wake wear time on any 3 d, and the raw acceleration thresholds of Hildebrand et al. (29) were then used to determine the time spent in different PA intensity domains (<45.8 *mg* for SED; 45.8–93.2 *mg* for light PA (LPA); ≥93.2 *mg* for MVPA). The method of sleep quantification was based on the van Hees et al. (30) nocturnal sleep algorithm. Briefly, wrist-worn tri-axial accelerometers allow approximation of the angle of orientation of the arm relative to the horizontal plane. Time asleep was defined as nocturnal periods characterized by minimal movement frequency (no arm-angle change >5° for ≥5 min) and magnitude of changes to the angle of the arm, which does not include daytime sleep. Time in bed was defined as the first onset of this period of minimal movement frequency until the end of the last period of inactivity. Sleep efficiency was defined as the percentage of time in bed that was spent asleep (31). Sleep metrics derived using this method have demonstrated good levels of agreement with both self-report measures of sleep and polysomnography (the gold standard) (30).

Statistical Analyses

Statistical analyses were conducted using the statistical package for the social sciences (SPSS; version 27.0, IBM Corp, Armonk, New York), with significance set as $p \leq 0.05$ and statistical trend toward significance set at <0.1. All data are expressed as mean ± SD unless otherwise stated. Due to the low sample size, a Mann-Whitney *U* test was used to compare means in those receiving HHD and ICHD. The effect size (ES; *r*) was then calculated as $r = Z/\sqrt{N}$, with 0.1, 0.3, and 0.5 classified as a small, moderate and large effect, respectively.

RESULTS

Compared with recommended PA guidelines for adults with ESRD, our sample had higher amounts of daily SED and lower levels of both LPA and MVPA (Table 1). No significant differences were found between HHD and ICHD groups

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TABLE 1. Summary of accelerometer-derived daily physical activity and sleep in adults with end-stage renal disease.

Variable	Combined (ICHD + HHD)	ICHD	HHD	*P* Value	ES
SED (min·d^{-1})	770.0 ± 68.6	783.0 ± 63.9	765.7 ± 73.2	0.64	0.13
LPA (min·d^{-1})	125.1 ± 26.5	106.9 ± 5.4	131.2 ± 28.1	0.05*	0.56
MVPA (min·d^{-1})	6.9 ± 9.7	8.4 ± 14.6	6.5 ± 8.6	0.63	0.14
Sleep duration (min·night^{-1})	286.8 ± 79.3	213.8 ± 69.8	311.1 ± 68.9	0.12	0.45
Sleep efficiency (%)	68.4 ± 18.5	50.0 ± 22.2	74.5 ± 13.3	0.07**	0.51

ES = effect size (0.1 = small effect, 0.3 = moderate effect, 0.5 = large effect); HHD, home haemodialysis; ICHD = in-center haemodialysis; LPA = light physical activity; MVPA = moderate-to-vigorous physical activity; SED = total sedentary time
*Statistical significance at the $P \leq 0.05$ level
**Statistical trend toward significance (i.e., $P = 0.05–0.1$)

for SED (p = 0.64, ES = 0.13) or MVPA (p = 0.63, ES = 0.14); however, people receiving HHD tended to engage in significantly more LPA (25 ± 5 min·d^{-1}; p = 0.05, ES = 0.56) than those attending ICHD.

Adults with ESRD also exhibited short sleep durations and poor sleep efficiency, with individuals receiving HHD sleeping an average of 98 min·night^{-1} more than those receiving ICHD (p = 0.12; ES = 0.45), with an absolute difference of 24.5% in sleep efficiency also shown between the ICHD and HHD dialysis modality subgroups. Sleep duration between HHD and ICHD was not different (p = 0.12); however, a moderate ES occurred (0.45). A trend toward significance and a large ES was also found for sleep efficiency in those dialyzing at home versus ICHD (p = 0.07, ES = 0.51), with those on HHD sleeping more efficiently.

DISCUSSION

In this study, we found that adults with ESRD engaged in low levels of daily PA, particularly MVPA. Those who dialyzed at home engaged in significantly more LPA than those receiving ICHD; however, neither group met the recommended guidelines for daily PA, irrespective of intensity (7). Furthermore, in this study, we found that adults with ESRD sleep for short durations each night, with an average sleep efficiency of only 68.4%; however, those receiving HHD are tentatively suggested to achieve a greater sleep duration and efficiency than those undergoing ICHD.

Regular PA directly contributes to health status and physical performance (32), with sedentariness estimated to cause between 6% and 10% of chronic disease, such as CKD (33). Authors of the recently published clinical practice guidelines for exercise and lifestyle in CKD recommend 150 min of moderate-intensity PA (or 75 min vigorous PA) per week (7). In line with previous research (4–6), participants in this study, on average, spent 770 ± 68.6 min·d^{-1} SED, and 125.1 ± 26.5 min·d^{-1} and 6.9 ± 9.7 min·d^{-1} in LPA and MVPA, respectively. Previous evidence using accelerometry has shown that only 35% of participants with CKD met the recommended PA levels, with significantly less PA taking place on dialysis days (34). Common barriers identified included dialysis-related fatigue, comorbidities, and/or a lack of motivation (34, 35, 36), which may, at least in part, contribute to the low PA levels found in the present study. Nonetheless, it is pertinent to note the analysis process employed through GGIR tends to give fairly low PA levels (37), which may contribute to the lower PA levels reported.

In this study, we found that people dialyzing at home engaged in significantly more LPA (25 ± 5 min·d^{-1}) than those receiving ICHD. Previous evidence has characterized individuals receiving HHD as having fewer comorbidities, generally better physical function (10), and experiencing fewer dialysis-related complications, which may account for their higher PA levels. Moreover, individuals receiving HHD engage in shorter and less demanding HD sessions and do not spend time travelling to their clinics, which may allow more time for PA. Despite this, PA levels, irrespective of group, failed to meet the recommended guidelines of 150 min·d^{-1} of MVPA and indeed total PA. Behavior change interventions are therefore required to enhance PA levels.

Disturbed and disordered sleep are very common within ESRD, with typical complaints including restless legs or insomnia (38). Previously, self-reported measures such as questionnaires (39) have been used to describe sleep in this population. However, in this study, we aimed to describe sleep duration and efficiency in adults living with ESRD using wrist-worn accelerometers, thereby providing more accurate and consistent data. Indeed, individuals with ESRD were shown to sleep, on average, 286.8 ± 79.3 min·night^{-1}, with a sleep efficiency of 68.4 ± 18.5%. Similar to Intas et al. (2020), in this study, we demonstrate that poor sleep duration and quality is characteristic of adults with ESRD, regardless of dialysis modality. Moreover, the findings are consistent with data obtained using an activity tracker, which identified 58% of participants having poor sleep (349 min·night^{-1}), with a notable barrier to sleep being timings of dialysis sessions (40). The presence of CKD (23) and the progression to ESRD (24) have been shown to result in highly variable and disturbed sleep patterns, which is of particular importance as these reductions in sleep quality have been shown to contribute toward perceived reductions in health-related quality of life in this population (21). Given the low PA levels and poor sleep duration and quality, future researchers should seek to investigate whether a bidirectional relationship between PA and sleep exists.

In this study, we report a 98-min difference in mean sleep duration between those receiving HHD and ICHD and, although not statistically significant with only 3 participants receiving HHD, a moderate ES was evident, thereby warranting further investigation in a larger sample size. In this study, we also showed a trend toward a difference and a large effect in the sleep efficiency between those receiving HHD (74.5%) and those receiving ICHD (50%), which may contribute to explaining the differences in PA levels between those receiving HHD and ICHD. A moderate ES (0.45) in sleep duration and large ES (0.51) in sleep efficiency suggest that, while statistical significance has not been met, the practical implications of HHD when compared with ICHD may contribute toward better sleep and PA engagement, which may aid in enhancing quality of life. Conversely, when assessing individuals receiving shorter, more frequent ICHD (6 times per week) compared with conventional ICHD (3 times per week) and nocturnal HHD, no significant differences in self-reported sleep quality at baseline were found. Minimal change was found after 12 months (41), suggesting a need for larger trials using a more device-based sleep measurement technique, such as accelerometry.

In adults receiving ICHD, a 6-month program of intradialytic cycling resulted in significant reductions in left ventricular mass and was well tolerated, providing a safe and deliverable way to increase PA engagement and health outcomes in this population (42). Authors of a recent study (35) showed self-reported low habitual PA levels in adults with ESRD across all dialysis modalities, with another recent qualitative study highlighting further reductions in PA engagement throughout the COVID-19 pandemic (42). Given the benefits of PA and the potential relationship between PA levels and sleep, it is important to highlight the need for further PA-based interventions to increase PA, particularly in the aftermath of the COVID-19 pandemic (43). Sleep quality in adults with ESRD has typically decreased (44,45); however, the potential impact of the bidirectional relationship between sleep and PA has yet to be elucidated. This study is supported by the use of accelerometry to assess PA habits, SED, sleep duration and efficiency within this population.

While numerous strengths are associated with this research, such as the use of accelerometry to enhance the accuracy of quantifying levels of habitual PA and sleep, limitations need to be acknowledged. First, although key findings were consistent among all participants, the sample size limits the generalizability of the results and precludes firm intergroup conclusions being drawn. We performed a post hoc power analysis based upon the differences in LPA because of the statistical significance and largest ES. For 90% power and an α level set at $P = 0.05$ (two tailed) with a mean difference and SD of 24.3 and 9.9 $\text{min}\cdot\text{day}^{-1}$, 18 individuals would be needed. Future trials should therefore aim to recruit at least 20 participants to account for loss to follow up. It is also pertinent to note that, currently, no specifically established and validated accelerometer cut points delineate activity intensity in adults with ESRD. The cut points used in the present study were developed using a nonclinical population which likely had a slightly higher level of cardiorespiratory fitness. This could increase the likelihood of misclassification of PA intensity (46). Therefore, larger studies are required that use device-based methods to investigate the PA habits and sleep of adults with ESRD, focusing on the discrepancies highlighted between those receiving HHD and ICHD.

CONCLUSION

In conclusion, this device-based study has provided insight into the low PA levels, as well as poor daily sleep, characterizing adults living with ESRD. Furthermore, our findings offer early evidence to suggest better PA and sleep in those dialyzing at home versus in center. Further research is warranted to investigate the potential bidirectional relationship between PA and sleep in adults with ESRD as well as any differences between dialysis modalities and regimens which may benefit the quality of life of the kidney disease community.

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