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Feature Article

The impact of sleep duration on recovery post-hip fracture among older diabetic adults in Taiwan

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A B S T R A C T

This study explored postoperative changes in sleep duration and physical activity and their relationships with physical function recovery, the muscular strength of the affected side and blood glucose control in elderly adults ($n = 41$) with diabetes mellitus (DM) who underwent surgery for hip fracture. Thirty-two participants (78.0%) had abnormal sleep durations for at least two time points, and they all had low physical activity levels (an average of 1348.2 kcal/day for the first month, 1377.9 kcal/day for the third month, and 1389.1 kcal/day for the sixth month) during the six months post-hip fracture. The participants with normal sleep durations showed greater femoral muscle improvement on the affected side (adduction: $\beta = 3.70$, $p = 0.029$; abduction: $\beta = 7.25$, $p = 0.016$) and better blood glucose control before meals ($\beta = -73.29$, $p < 0.001$) and after meals ($\beta = -47.90$, $p = 0.007$) compared with those with abnormal sleep durations. Those with higher physical activity levels had better physical function recovery.

Introduction

Hip fracture is common among the elderly and usually results in serious health consequences.[1] As in other countries with an increasing aging population, hip fracture represents a major and growing health care problem in Taiwan. The age-adjusted incidence rates (per 100,000) of hip fracture in Taiwan were >150 for men and >300 for women in 2010; these numbers were ten times the incidence rates for the general population.[2] The risk of hip fracture has been found to be associated with the duration of diabetes mellitus (DM), DM-related complications and insulin use.[3–5] In the United States, 105 hip fractures occurred in 21,033 people (59,585 person-years) with type I diabetes; 1421 occurred in 180,841 people (462,120 person-years) with type II diabetes; and 11,733 occurred over 10,980,599 person-years in the non-diabetic population (3.66 million people). Diabetes increases the fracture risks for both men (hazard ratio = 1.18 [95% CI = 1.12–1.24], $p < 0.0001$) and women (1.11 [1.08–1.15], $p < 0.0001$) compared with the non-diabetic population.[6] Similarly increased risks of hip fracture among diabetic patients in other countries have been reported. For example, one study conducted in Norway has found that men with type I diabetes have an increased risk of hip fracture [RR = 17.8 (95% CI = 5.6–56.8)]. Diabetic women, regardless of the type of diabetes, have been reported be have significantly increased hip fracture risks [RR = 8.9 (95% CI = 1.2–64.4) and RR = 2.0 (95% CI = 1.2–3.6) for type I and type II diabetes, respectively].[3] Another study conducted in Sweden has reported markedly elevated risks of hip fracture in both men and women with type I diabetes (standardized hospitalization ratios = 7.6 [95% CI = 5.9–9.6] and 9.8 [7.3–12.9], respectively).[5] Studies performed in Taiwan have also reported that the overall incidences of hip fracture for diabetic men and women are 3.01 and 6.75/1000 person-years, respectively, which are higher than the incidences for those without diabetes.[7]

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Worse recovery and a higher mortality rate have been reported for hip-fracture patients with DM compared with those without DM.[8–10] Other adverse consequences include postsurgical complications and an elevated glycosylated hemoglobin level.[9] One study performed secondary data analysis and classified 79,526 hip-fractured elders from 915 rehabilitation facilities in the United States into the following three groups: no DM (77%), non-tier DM (18.3%), and tier DM (4.7%).[11] They found that the tier DM group had a longer hospital stay, worse functional status, and lower likelihood of discharge to home. Furthermore, the presence of tier DM increased the total cost of hip fracture hospitalization. Among the comorbidities of hip fracture, DM is associated with the highest cost of hospitalization for hip fracture.[12] A previous study has found that diabetes with hyperglycemia is associated with age-related muscle strength loss.[13] Therefore, the comorbidity of hip fracture and DM is an important health issue for older people.

The conceptual framework of this study was modified from Lawton's (1982) ecological model of aging.[14] Lawton believes that an individual's competence and environmental press are predictive of his/her behaviors and described the ecological equation $B = f(P, E)$, where B represents behavior, P is a person's competence, and E represents the environment; in other words, a person's behavior is influenced by his or her competence and the environment. In this model, competence is viewed as an individual's characteristics, such as biological health, sensory and perceptual capacities, motor skills, cognitive capacity and ego strength. Environmental press refers to an environmental force and includes physical, interpersonal, or social forces that tend to activate an intrapersonal need. Behavior is the outcome variable of the ecological equation; it can be either outwardly observable motoric behavior or an inner, affective response, such as morale or life satisfaction.[15] In this study, only competence indicators were explored. These competence indicators include sleep duration, physical activity level, duration of DM and pre-fracture activities of daily living (ADLs). Among them, the duration of DM and pre-fracture ADLs were treated as covariates. The outcome variables (B) explored were post-fracture muscle power, ADLs, instrumental ADLs (IADLs) and DM control.

Multiple studies have shown that poor sleep results in poor health outcomes, including increased risks of physical impairment, obesity, diabetes, hypertension, and cardiovascular disease,[16,17] poor blood glucose control in people with DM,[18] impaired glucose tolerance,[19] worse cognitive function and a higher 5-year mortality rate in elderly people.[20,21] An improved sleep duration has also been found to be associated with improved average daily METs ($r = 0.48$, $p = 0.04$) in obese adults.[22]

Several studies have supported the positive influences of physical activity and physical functioning in community-dwelling older people. Higher self-reported activity levels have been associated with increased independence in ADLs and increased energy.[23,24] One study has also found that after controlling for self-reported activity levels, a higher physical activity level (10^5 counts/day) was associated with increases in ADLs and IADLs in community-dwelling older people.[25]

Few studies have examined how sleep duration and the physical activity level are associated with DM and physical recovery after hip fracture. This information can improve health care providers' understanding of the factors that influence recovery following hip fracture for DM patients and can provide a basis for the development of assessment and intervention protocols. Therefore, the present study aimed to explore the postoperative changes in sleep duration and the physical activity level and the relationships between these changes and physical function recovery and diabetes control in hip-fractured elderly adults with DM. The outcome variables examined in this study were physical function recovery, muscular strength of the affected side and blood glucose control. It was hypothesized that patients with an abnormal sleep duration would have worse physical function recovery, reduced muscular strength on the affected side and worse blood glucose control compared with those with a normal sleep duration. It was also hypothesized that a lower physical activity level would be associated with decreased recovery of physical function, including ADLs and IADLs.

Materials and methods

Study design and participants

A prospective longitudinal study using convenience sampling was implemented to explore the research question. The inclusion criteria for elderly patients with DM who were hospitalized with hip fracture were as follows: 1) an age of 60 years or older; 2) a diagnosis of DM; 3) admission to the emergency department of Chang Gung Memorial Hospital for hip fracture; and 4) living in Northern Taiwan. A total of 55 potential participants were approached, and 49 consented to participate. Among them, five were unable to participate in the study because of changes in their clinical conditions (such as chronic heart failure), one died (two months after discharge), and two had incomplete data. Because sleep duration and the physical activity level over a 24-h period were important independent variables in this study, complete data on these two variables were required in this study. Therefore, two participants were excluded because they only wore the SenseWear armband for 14 and 16 h, respectively. A total of 41 participants were ultimately included. All of the included participants had data for at least one time point. The sample size ($n = 41$) was calculated by posterior power analysis using parameters estimated from the current generalized estimating equation (GEE) model. This analysis showed that a sample size of 41 would result in 99% power in this study.[26]

Data collection

Ethical approval was obtained from the Institutional Review Board of Chang Gung Memorial Hospital (98-3322C) before data collection. Participants were recruited from the emergency department and trauma wards by research nurses who screened the admission list twice daily from August 2009 to July 2012. Those who agreed to participate and signed an informed consent form were assessed by a research nurse at one, three and six months after discharge; thus, each participant was assessed three times in total. Each participant wore a SenseWear armband for 24 h to enable the measurement of sleep duration and the physical activity level at each time point, and it was returned to the same research nurse who performed the assessment (Fig. 1).

Measures

Sleep duration and physical activity level

Sleep duration and the physical activity level were both measured daily using a body monitoring system (Bodymedia, SenseWear armband Pro 2, USA, http://sensewear.bodymedia.com/SW-Company/SW-Mission-and-Values). Each participant wore a SenseWear armband for 24 h to enable the measurement of these variables at each visit, and it was then returned to the same research nurse who performed the assessment. The participants were asked to wear the device for one day before hospital discharge to familiarize themselves with it and to address any problems that arose. For those who were not able to wear it for 24 h, the problems were discussed and resolved, and they were asked to wear it for another 24 h for familiarization. Because many of the participants reported that wearing the SenseWear armband for more than 24 h at a time was inconvenient, the device was worn for only 24 h at