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Factors Associated with Early Step Count of Patients After Total Knee Arthroplasty: A Prospective Cohort Study

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Abstract

Background: Research has indicated that early postoperative step counts are below the recommended levels for health-enhancing physical activity after total knee arthroplasty (TKA). This study aimed to evaluate the effects of preoperative individual characteristics, pain, physical function, and psychological factors on early postoperative physical activity, as measured by step counts, in 137 patients scheduled for TKA. **Methods:** Patients were preoperatively assessed for individual characteristics (age, sex, body mass index, employment status, smoking and drinking habits, long-term care insurance), pain, range of motion, muscle strength, timed 10-m walk test performance, pain catastrophizing scale (PCS) scores (rumination, helplessness, and magnification), and pain self-efficacy. The daily step count was analyzed 4 weeks postoperatively. Multivariate regression analysis was performed to analyze the relationships between postoperative step counts and individual characteristics, pain, physical function, and psychological factors. **Results:** Step counts were significantly influenced by preoperative PCS magnification scores (β= -0.31, p= 0.01) and the category of long-term care insurance (β= -0.24, p= 0.02). **Conclusions:** Preoperative evaluation of the long-term care insurance category and PCS magnification score may aid in predicting early postoperative step counts in patients receiving TKA, which may, in turn, improve clinical management during the early stages of treatment.

***Key Words**: longitudinal studies, walk test, range of motion, postoperative, long-term care*

INTRODUCTION

An epidemiological survey revealed that 15.4% of the Japanese population lives with chronic musculoskeletal pain, which is associated with a large increase in medical expenses and exerts a significant economic and social impact.[1] Therefore, rehabilitation that aims to minimize the occurrence of chronic pain is critical for patients with musculoskeletal disorders.

Total knee arthroplasty (TKA) aims to improve knee pain, physical activity, and quality of life (QOL) in patients with knee osteoarthritis.[2] However, reports indicate that 15% of patients experience chronic pain despite TKA, which results in reduced physical activity and poor QOL.[3] Levels of physical activity following TKA have been reported to be below 20% of the recommended level for health-enhancing physical activity (American Physical Activity Guidelines of the United States Insurance and Welfare Authority).[4] However, this physical activity has not been adapted for patients with chronic pain post-TKA. Since the postoperative levels of physical activity often do not reach the recommended levels in patients with TKA, it is important to identify the factors that affect physical activity in such patients. Individual characteristics such as age, body mass index (BMI),[5] sex,[6] employment status,[7] smoking and drinking habits,[8] and long-term care insurance[9] have been identified as factors that may affect postoperative levels of physical activity in patients who have undergone TKA. A study by Taniguchi et al.[10] also indicated that psychological factors such as self-efficacy and physical function based on performance in the Timed Up and Go test influenced levels of physical activity at 6 months postoperatively in patients with TKA.

According to the widely accepted fear-avoidance model, an individual experiences pain and expands its interpretation, leading to catastrophizing and avoidance of potentially painful stimuli, thereby leading to inactivity.[11] Sullivan et al.[12] defined pain catastrophizing as an exaggerated negative response to pain stimuli characterized by rumination (attention to pain), helplessness (helplessness in a painful situation), and magnification (overestimation of pain threats). It has also been reported that strong motor fear and depression affect postoperative results after TKA.[13-15] Moreover, post-TKA neglect and catastrophic thinking have been shown to affect postoperative pain.[16] Furthermore, it has been demonstrated that psychological factors in the early postoperative period affect long-term disability after surgery.[17]

With regard to the amount of activity in the early stage of TKA, it has become clear that the amount of physical activity preoperatively affects the outcome and QOL after surgery.[18,19] The importance of efforts to improve the amount of physical activity before surgery has also been reported.[20] Logically, it follows that it is also necessary to focus on the amount of physical activity in the early post-TKA period, which is defined as physical activity about 4 weeks after surgery.[21] In previous studies, steps were used as an outcome to measure physical activity.[22] It is also important to measure the number of steps in the early postoperative period.[23] Therefore, psychological factors may significantly influence step counts in the early postoperative period.[24] However, there are no reports on the association between preoperative physical or psychological factors and postoperative physical activity in patients undergoing TKA. Therefore, this study aimed to investigate the influence of preoperative pain (resting and walking), physical function (range of motion, quadriceps muscle strength, walking time), psychological factors (pain catastrophizing: 3 scales, pain self-efficacy), and individual characteristics (age, BMI, sex, employment status, smoking habits, drinking habits, long-term care insurance) on early postoperative physical activity, as measured by step counts, in patients undergoing TKA. This study can help increase the amount of physical activity in the early postoperative period.

METHODS

Ethical Consideration. All study patients provided informed consent. The study design was approved by the ethics review board of Fukuoka Rehabilitation Hospital.

Study Design. This is a prospective cohort study measuring the effects of preoperative pain, physical function, psychological factors, and individual characteristics (age, BMI, sex, employment status, smoking habits, drinking habits, long-term care insurance) on the postoperative levels of physical activity of patients who underwent TKA.

Participants*.* This prospective cohort study included 153 Japanese patients who underwent TKA for osteoarthritis at Fukuoka Rehabilitation Hospital between April 2016 and June 2019. Patients were eligible to participate if they (1) were able to read and speak Japanese and provided informed consent, (2) had a diagnosis of knee osteoarthritis as evaluated by their orthopedic surgeons, and (3) were scheduled for unilateral TKA. Patients who met the following criteria were excluded: (1) lack of understanding of the explanation of the research due to dementia or mental disorders, (2) postoperative complications such as nerve injury or deep vein thrombosis, (3) any medical condition that interfered with postoperative rehabilitation, (4) and previous history of TKA (revised, opposite limb, and degenerative diseases [e.g., rheumatoid arthritis]). Preoperative screening of the baseline patient characteristics was done by an orthopedic surgeon. Ten (contralateral surgery, n=5; neurological disease, n=2; psychological disorder: n=3) of 153 participants were excluded, resulting in a final cohort of 143 participants (male= 22, female= 123; Mean age= 76.5 ± 7.0 years) (Figure 1).

The TKA surgeries were performed by four surgeons with a cumulative experience of ≥ 10 years. All patients received general anesthesia, and non-steroidal anti-inflammatory drugs were administered at a dose of 60 mg (three tablets per day) for 2 weeks post-operatively. The following parameters were measured by a physical therapist 3-5 days before the surgery: pain, physical functions, and psychological factors. All patients followed the same postoperative rehabilitation (physical therapy [PT] and occupational therapy [OT]) protocols after the operation. All patients began PT, including knee joint range of motion exercises (flexion-extension) and stretching, on the first day postoperatively. OT began at 1–2 weeks postoperatively to improve everyday life. Training in activities of daily living such as bathing, stair-climbing, and housework was conducted according to each patient's needs. Patients were discharged upon the physician's approval and on patient request at 4 weeks post-operatively

Power analysis. We used G*Power 3 to perform a preliminary test force analysis and estimate the required sample size.[25] The power was set at 0.95, and the significance level (α) was set at 0.05.26. The effect size (f^2) was set at 0.25, as shown in a previous study.[27] Effect size (f^2) was set at 0.25, which constitutes a moderate standard for multiple regression analysis. The power analysis indicated that 128 patients were required.

Outcome measures

Assessment of dependent variable: activity level in step counts. An activity meter (Active Style Pro; OMRON Corp., Kyoto, Japan) was used to measure physical activity during the early post-TKA period, which was defined as 4 weeks after surgery. The activity meter was worn on the waist for 7 days, and the step count was recorded.[28,29] It was possible to use this activity meter without any special training, and data collection was carried out by the physical or occupational therapist while the activity meter was connected to a personal computer for analysis. Previous research reported high reliability in the calculation of steps using the Active Style Pro, and the agreements in intra-class correlation coefficients (ICC) were high ($ICC \geq 0.94$).[30] There was also substantial epidemiological evidence for the use of these devices.[31]

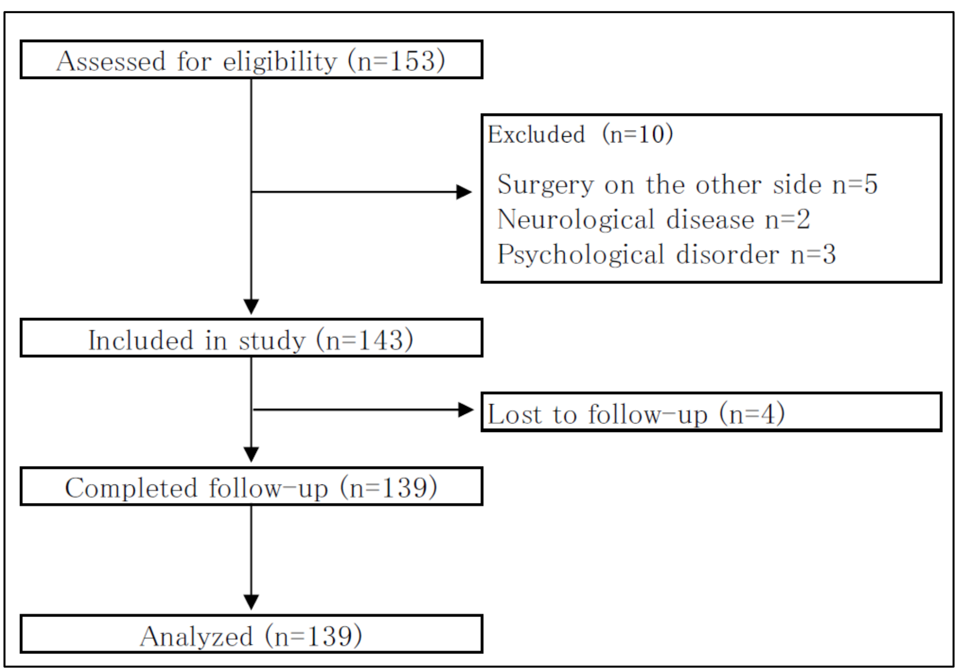

Figure 1. Flow diagram of this study showing the enrollment process.

Assessment of independent variables: pain, physical function, psychological factors. The independent variables were measured 3–5 days before surgery, based on a framework set by the research institute.

Pain. The numerical rating scale (NRS)32 was used to evaluate pain on an 11-point scale (0 = no pain; 10 = worst imaginable pain) (*Cronbach's α* = 0.888). Resting and walking pain were assessed using the NRS. The NRS was used as two predictors in the multiple regression.

Physical function factors.

Range of motion: To assess range of motion (ROM), the maximum range of joint flexion was measured during active movement. Participants were assessed in the supine position using the method specified by previous research.[16] The femoral axis was regarded as the baseline axis, while a line connecting the fibular head and lateral malleolus was regarded as the axis of movement. Using a goniometer (GS100, OG Wellness Technologies Ltd, Japan, Okayama city), the angle formed by the baseline axis and axis of movement on the dorsal side was measured to the nearest degree (*Cronbach's α* = 0.85-0.89).[33]

Quadriceps muscle strength: Patients sat on a table, and the maximum isometric muscle strength (kg) of the knee extensors with knee joint flexed at 60° was measured using a micro total analysis system (μTAS F-1; Anima Corporation, Japan, Tokyo). The measurement pad was attached to the distal part of the tibia. The non-operative knee, followed by the operative knee, was measured in triplicate, with a rest period of 30 s between measurements. The maximum force output from three trials was recorded (*ICC*= 0.95).[34]

Walking time: The timed 10-meter walk test was performed to assess walking speed.[35] The following verbal instructions were given by the therapist: "I will say ready, set, go. When I say go, walk as fast as you safely can until I say stop." The time taken to walk 10 m was recorded using a stopwatch (*ICC*= 0.93-0.91).

Psychological factors.

Pain catastrophizing: The Pain Catastrophizing Scale (PCS)12 was used to quantify the pain experienced by the individual. The PCS is a self-evaluation method that includes 13 items across the three subscales of rumination, helplessness, and magnification. Patients evaluate each item (rumination, helplessness, and magnification) on a five-point scale (0 = never, 4 = all the time) (*Cronbach's α:* PCS = 0.87, rumination = 0.86, helplessness = 0.66, and magnification = 0.87).[36] A high score indicates strong pain catastrophizing.

Pain self-efficacy: Patients were also asked to complete the pain self-efficacy questionnaire (PSEQ)37 by scoring the 10 items of the questionnaire on a seven-point scale (0 = not at all confident; 6 = completely confident) (*Cronbach's α* = 0.81).

Confounding variables

Participant Characteristics. Age, sex, BMI, employment status (pre-operative), smoking and drinking habits, and long-term care insurance information were obtained from the electronic medical records of Fukuoka Rehabilitation Hospital. A new, public long-term care insurance system was launched in Japan in 2000. Long-term care insurance is provided for patients requiring support (I, II) or long-term care (I, II, III, IV, V). There are seven levels of long-term care certification: support levels I to II and care need levels I (least disabled) to V (most disabled).

Statistical Analysis. The Shapiro-Wilk test was used for the distribution of normality. Multiple regression analysis was performed using the level of physical activity as a dependent variable after adjusting for independent variables (NRS rest pain, NRS walk pain, ROM-flexion, muscle strength, 10-m walking time, PCS rumination, PCS helplessness, PCS magnification, PSEQ) and confounding factors (age, sex, BMI, employment status, smoking and drinking habits, and long-term care insurance). In both models, the coefficients (β) and 95% confidence-intervals (95% *CI*) were calculated. Multi-collinearity was assessed using the variance inflation factor (VIF) test. Statistical analyses were performed using the JMP statistical package version 14 (SAS Institute Co., Ltd.; https://www.jmp.com/ja_jp/home.html). A p-value <0.05 was considered statistically significant.

RESULTS

Participant characteristics. During the study, four participants withdrew. A final sample of 139 participants completed the study (Figure 1). The demographic characteristics, such as mean age, sex, BMI, employment status, smoking and drinking habits, and long-term care insurance of all participants, are shown in Table 1.

Table 1. Participant Characteristics

Variables	*n* = 139
Age (years)	76.6±7.0
Female, n (%)	115 (82.7)
BMI	26.2±3.8
Worker (%)	16 (13.6)
Smoker (%)	11 (7.9)
Drinker (%)	23 (16.5)
Long-term care insurance	
No care (%)	124 (89.2)
Required support I (%)	6 (4.3)
Required support II (%)	2 (1.4)
Requiring long-term care I (%)	5 (3.6)
Requiring long-term care II (%)	2 (1.4)
Requiring long-term care III (%)	0 (0.0)
Requiring long-term care IV (%)	0 (0.0)
Requiring long-term care V (%)	0 (0.0)
NRS rest pain	1.5±1.4
NRS Walk pain	5.4±2.3
ROM-flexion (°)	122.8±16.3
Strength (kg)	12.7±10.3
10-m (s)	13.1±6.0
PCS rumination score	13.2±5． 2
PCS helplessness score	9.2±5.2
PCS magnification score	5.3±3.5
PSEQ	36.2±13.5
Daily step count (steps)	1965.4±1627.3

Note: Values are expressed as Means ± Standard Deviation; BMI= Body Mass Index, NRS= Numeric Rating Scale, PCS= Pain Catastrophizing Scale, PSEQ= Pain Self-Efficacy Questionnaire, ROM= Range Of Motion, strength= the strength of knee extension

Influence of preoperative parameters on early postoperative physical activity. The results of the multiple regression analysis are shown in Table 3. In the multivariate analysis, the PCS magnification score was significantly associated with daily step count when adjusted for the independent variables. The correlation was stronger when adjusted for long-term care insurance (PCS magnification score: β= -0.25, 95% *CI*= -225.42 to -10.06, and the long-term care insurance: β= -0.19, 95% *CI*= -779.81 to -18.72, R^2 = 0.19; *p*= 0.04). Furthermore, when the final model was analyzed by multiple regression analysis using only the PCS magnification score and long-term care insurance (PCS magnification score: β= -0.31, 95% *CI*= -202.13 to -8.52, and the long-term care insurance: β= -0.24, 95% *CI*= -700.82 to -15.11, R^2= 0.25; *p*= 0.02) (Table 3)

DISCUSSION

This study aimed to evaluate the effects of preoperative pain, physical function, psychological factors, and individual characteristics (age, BMI, sex, employment status, smoking habits, drinking habits, long-term care insurance) on postoperative levels of physical activity in patients who underwent TKA. The preoperative PCS magnification score, which reflects pain catastrophizing, significantly influenced postoperative physical activity. Moreover, when included, the PCS magnification score and long-term care insurance classification influenced postoperative activity in the multiple regression analysis.

According to previous studies, chronic pain that results in inactivity (excessive avoidance of pain) is strongly correlated with PCS magnification.[38] Furthermore, it has been demonstrated that PCS capacitance affects inactivity in chronic pain in the elderly in the community.[39] Therefore, it is considered that PCS capacitance affects the amount of physical activity even in post-TKA patients. Moreover, long-term care insurance has also been reported to influence postoperative activity, as most of the care recipients in a previous study had low or poor physical activity.[40,41] Patients in need of long-term care experience difficulties in performing physical activity; we therefore believe that long-term care

Table 2. Results of the Multiple Linear Regression Analysis

Dependent variable	Independent variable	*β*	(95% *CI*)	*p*	VIF
Out confounding factor					
Daily step count	(Constant)				
	NRS rest pain	-0.05	(-158.32 to 84.13)	0.54	1.24
	NRS Walk pain	-0.07	(-174.01 to 71.38)	0.41	1.21
	ROM-flexion (°)	0.15	(-3.95 to 68.38)	0.08	1.09
	Strength (kg)	0.12	(-9.31 to 67.01)	0.13	1.06
	10-m (s)	-0.12	(-85.09 to 15.45)	0.17	1.30
	PCS rumination score	0.11	(-48.12 to 119.23)	0.41	2.70
	PCS helplessness score	-0.01	(-92.55 to 88.00)	0.96	3.14
	PCS magnification score	-0.21	(-207.04 to -2.87)	0.03	1.91
	PSEQ	0.02	(-19.21 to 25.86)	0.77	1.31
	R^2 = 0.11, p= 0.03				
In confounding factor					
Daily step count	(Constant)				
	Age (years)	-0.06	(-55.72 to 27.22)	0.49	1.23
	Female, n (%)	0.00	(-727.04 to 738.91)	0.98	1.11
	BMI	0.01	(-69.88 to 78.18)	0.91	1.14
	Worker (%)	0.11	(-301.01 to 1116.64)	0.19	1.11
	Smoker (%)	0.03	(-830.33 to 1222.01)	0.71	1.12
	Drinker (%)	0.08	(-359.83 to 1116.64)	0.32	1.13
	Long-term care insurance	-0.19	(-779.81 to -18.72)	0.03	1.26
	NRS rest pain	-0.03	(-146.55 to 99.89)	0.71	1.30
	NRS Walk pain	-0.12	(-209.84 to 44.78)	0.21	1.32
	ROM-flexion (°)	0.16	(-2.41 to 70.11)	0.06	1.12
	Strength (kg)	0.12	(-11.43 to 67.95)	0.16	1.17
	10-m (s)	-0.02	(-60.04 to 47.71)	0.82	1.52
	PCS rumination score	0.11	(-50.03 to 119.86)	0.41	2.82
	PCS helplessness score	0.02	(-84.33 to 99.50)	0.87	3.30
	PCS magnification score	-0.25	(-225.42 to -10.06)	0.03	2.04
	PSEQ	0.09	(-22.15 to 24,51)	0.91	1.42
	R^2= 0.19, p= 0.04				

Note: β= Standardized Coefficient, 95% *CI*= 95% confidence interval, VIF= variance inflation factor, BMI= body mass index; NRS= Numeric Rating Scale, ROM= Range of Motion, strength= the strength of knee extension, PCS= Pain Catastrophizing Scale, PSEQ= Pain Self-Efficacy Questionnaire

Table 3. The Most Appropriate Model of the Multiple Linear Regression Analysis

Dependent variable	Independent variable	*β*	(95% *CI*)	*p*	VIF
Daily step count	(Constant)				
	Long-term care insurance	-0.24	(-700.82 to -15.11)	0.02	1.01
	PCS magnification score	-0.31	(-202.13 to -8.52)	0.01	1.96
	R^2 = 0.25, p = 0.02				

Note: β= Standardized Coefficient, 95% CI= 95% Confidence Interval, VIF= Variance Inflation Factor, PCS= Pain Catastrophizing Scale

insurance has an effect. Therefore, preoperative certification of long-term care insurance may lead to a reduction in physical activity postoperatively.

The mean daily step count at 4 weeks after surgery was approximately 1,965. Tsonga et al.[41] recorded a value of approximately 2,693 and 3,518 steps at 3 and 6 months after TKA, respectively, while Franklin et al.[42] reported about 2,881 steps at 6 months post-surgery. In a study by Lützner et al.,[5] the daily step count at 1 year after surgery ranged from 5,400 to 7,400 steps. None of the reports had recorded daily steps in the early postoperative period; therefore, a direct comparison of the steps recorded here, at 4 weeks postoperatively, was not possible. Further studies are required to ascertain whether this level of physical activity is appropriate at one-month post-surgery in patients who underwent TKA for osteoarthritis.

Limitations. A major limitation of this study is that the amount of exercise and medication could not be controlled. Although a set PT and OT program was given to the participants, voluntary exercise done at home could not be determined. Voluntary home exercises could have affected step count performance at four weeks postoperatively. Additionally, voluntary and unsupervised medication intake, particularly analgesics, could have affected pain perception and hence influenced the step count performance. It is necessary to consider these factors when interpreting the results. Investigations considering these factors are warranted.

CONCLUSION

This study aimed to examine the effect of preoperative individual characteristics, pain, physical function, and psychological factors on the postoperative levels of physical activity in post-TKA patients. The results suggest that physical activity is affected by long-term care insurance and PCS magnification. Preoperative evaluation of these two factors may aid in planning return to step counts in the early postoperative period of TKA patients, which may improve clinical management during the early stages of recovery.

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Individual Author's Contributions

Y. H., R. H; Designed and performed experiments, analyzed data and co-wrote the paper. Y. H., R. H.; Performed experiments. Y. H., R. H.; Supervised the research. Y.H., Y. H, S. H.; Designed the experiments and co-wrote the paper.

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Conflicts of interest

The authors of this paper declare no conflicts of interest.

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