Asian Nursing Research xxx (xxxx) xxx

Contents lists available at ScienceDirect

Asian Nursing Research

journal homepage: www.asian-nursingresearch.com

Research Article

Fatigue and Quality of Life Among Patients with Diabetes and Non-diabetes Receiving Primary Percutaneous Coronary Interventions

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ARTICLE INFO

Article history:
Received 5 April 2022
Received in revised form
31 January 2023
Accepted 23 February 2023

Keywords:
coronary artery disease
diabetes mellitus
fatigue
percutaneous coronary intervention
quality of life

SUMMARY

Purpose: Few studies have examined the effect of diabetes mellitus (DM) on patients with coronary artery disease. The relationships between quality of life (QoL), risk factors, and DM of patients receiving percutaneous coronary interventions (PCIs) are poorly understood. We investigated the influence of diabetes on fatigue and QoL over time among patients receiving PCIs.
Methods: An observational cohort study with a longitudinal, repeated-measures design was used to investigate fatigue and QoL among 161 Taiwanese patients with coronary artery disease with/without diabetes who received primary PCIs between February and December 2018. Participants provided demographic information and their Dutch Exertion Fatigue Scale and the 12-Item Short-Form Health Survey scores before the PCI and two weeks, three months, and six months post-discharge.
Results: Seventy-seven PCI patients were in the DM group (47.8%; mean age = 67.7 (SD = 10.4) years. The mean scores of fatigue, PCS, and MCS were 7.88 (SD = 6.74), 40.74 (SD = 10.05), and 49.44 (SD = 10.57), respectively. Diabetes did not affect the magnitude of change in fatigue or QoL over time. Patients with diabetes perceived similar fatigue as those without diabetes before PCI and two weeks, three and six months post-discharge. Patients with diabetes perceived lower psychological QoL than those without diabetes two weeks post-discharge. Compared to pre-surgery scores, patients without diabetes perceived lower fatigue at two weeks, three months, and six months post-discharge, and higher physical QoL at three- and six-months post-discharge.
Conclusions: Compared with DM patients, patients without diabetes had higher pre-intervention QoL and better psychological QoL two weeks post-discharge, and diabetes did not influence fatigue or QoL of patients receiving PCIs over six months. Diabetes may affect patients in the long term; therefore, nurses should educate patients to regularly take medication, maintain proper habits, notice comorbidities, and follow rehabilitation regimes after PCIs to improve prognosis.

Introduction

Diabetes mellitus (DM) is a serious chronic disease [1], affecting approximately 537 million adults worldwide [2]. DM, hyperglycemia, insulin resistance, and hyperinsulinemia often trigger vascular smooth muscle cell proliferation, inflammation, dyslipidemia, and endothelial dysfunction, resulting in a higher risk of cardiovascular disease [1]—a major independent risk factor for coronary artery disease (CAD) [3]. Reports show that around 68% of patients with DM aged older than 65 years die from heart disease [4].

CAD often causes myocardial ischemia, fatigue [5], and declining quality of life (QoL) [6]. Insulin resistance hinders protein to synthesize muscles, and high blood sugar promotes muscles to break down, which affects patients' activities of daily living. Thus, patients with DM experience increased feelings of fatigue [1]. Fatigue is defined as a subjective sense of tiredness and lack of energy that negatively influences physical and mental capacity [7]. Research shows that most patients with CAD perceive fatigue after heart attacks, which has a substantial adverse effect on QoL [8]. Therefore, early revascularization, which has been shown to have a certain effect on QoL, is vital for patients with CAD. Percutaneous

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https://doi.org/10.1016/j.anr.2023.02.001

Please cite this article as: Su S-F, Yeh W-T, Fatigue and Quality of Life Among Patients with Diabetes and Non-diabetes Receiving Primary Percutaneous Coronary Interventions, Asian Nursing Research, https://doi.org/10.1016/j.anr.2023.02.001

coronary intervention (PCI) has become the most effective revascularization therapy for CAD [9]. Fatigue is the most intense symptom experienced by patients with CAD six months after PCI [5]. Moreover, one year after PCI, both fatigue and depression affected the perception of illness in patients with CAD and subsequently influenced their QoL [6].

There are few studies about the effect of CAD on patients with DM, and the relationship between QoL, risk factors, and DM remains unclear. Pischke et al. found that patients with CAD and DM reported lower QoL than those without DM, especially women [10]. Their study also showed that men with DM had CAD and hypertension more often than men without DM [10]. However, this study is relatively old and recruited relatively few patients with DM; as such, the results might not accurately describe changes in QoL of patients with CAD and DM after PCI treatment. In 2013, national guidelines indicated that DM increases the risk of progression of CAD and causes cardiovascular complications [11]. Male patients with both DM and CAD had a mortality rate that was thrice than that of patients with CAD but without DM [11]; however, the aforementioned study is only a CAD guideline, not a research study.

The relationship between QoL of patients with CAD, which is affected by several comorbidities [12], and fatigue, which influences QoL among patients with DM [13], is poorly understood. An underlying cause of CAD is DM, which often triggers vascular smooth muscle cell proliferation, inflammation, and endothelial dysfunction, resulting in deterioration of CAD progression. Therefore, this study examined the relationship between fatigue and QoL among patients with diabetes and non-diabetes receiving primary PCI.

Methods

Study design and participants

This was an observational cohort study using a longitudinal, repeated-measures design to investigate fatigue and QoL among 165 patients with CAD with/without DM who received primary PCIs between February and December 2018. Patients were recruited from coronary care units of one large hospital in Taiwan. The researcher checked the list of hospitalizations for primary PCI daily and explained the study aim to the PCI patients in order to obtain their informed consent letters. Then, the researcher reviewed PCI patients' medical records to confirm if patients have a diagnosis of DM under DM drugs. Participants were thereby allocated to two groups: DM ($n = 78$) and non-DM ($n = 87$). The inclusion criteria were as follows: (1) aged ≥20 years, (2) with/without DM and diagnosed by a cardiologist as requiring PCI, and (3) attended regular outpatient follow-ups. Exclusion criteria were (1) hemodynamic instability or (2) the presence of pregnancy, cancer, or severe heart failure.

G*Power version 3.1.9.2 was used to calculate the required sample size, given a two groups × four time points repeated-measures analysis of variance with a medium effect size (f) of 0.25 [14], α of .05, and power of 0.8. The minimum sample size in each group was calculated as 41 (82 for both groups). The total number of participants recruited was 165. Four patients did not complete the study because of heart surgery or death; therefore, 161 patients were included (DM group, $n = 77$; non-DM group, $n = 84$).

Instruments

Demographics questionnaire

This survey was conducted while patients were in hospital but before PCI. The questionnaire assessed 15 items: age, sex, body mass index (BMI), education, marital status, living situation, monthly income, smoking and alcohol habits, diagnosis, puncture site, number and degree of coronary artery occlusions, PCI stenting, and comorbidities. All 15 items were found to be related to CAD in the previous literature [15–17].

Dutch exertion fatigue scale (DEFS)

Tiesinga et al. developed the nine-item DEFS for self-evaluating fatigue while executing daily activities [18]. Each item is rated using a five-point Likert scale ranging from 0 (*never*) to 4 (*always*). Total score ranges from 0 to 36; higher scores indicate a higher level of fatigue. This questionnaire was translated verbatim into Chinese by the researchers (who speak both English and Chinese) and then back-translated to English for comparison according to the procedure proposed by Guillemin et al. [19]. To achieve optimal translation, two native English speakers and two Chinese nursing experts participated in the translation process. The content validity index (CVI) of this questionnaire was 93.8%, determined by using the ratings of item relevance and agreement among the five experts, including two cardiologists, two senior cardiovascular nurses, and one nursing professor. The number of items that were rated as a 3 or 4 were divided by the total number of items. Moreover, the authors separately read the response format reported by the content experts and evaluated the wording of each item. For face validity, we applied cognitive assessment to evaluate how the PCI patients understood and responded to items. Face validity was established by 10 PCI patients and one senior cardiovascular nurse. By using the verbal probe method, the cardiovascular nurse collected information about the respondents' understanding of each item and their questions. Ten PCI patients fully understood the items, and no changes were needed. The Cronbach's α coefficient was .89 in the pilot study and .71 in the main study.

The 12-item short-form health survey (SF-12)

This questionnaire comprises 12 questions that evaluate physical and mental health-related QoL. Ware et al. developed the 12-Item Short-Form Health Survey (SF-12), which comprises two subscales: the physical component scale (PCS) and the mental component scale (MCS) [20]. Each item response was converted into physical and mental standardized values and then summed to PCS and MCS scores. Both subscale scores ranged from 0–100. The higher the score, the greater the QoL. The SF-12 scale has been effectively used in many countries worldwide, with a wide range of applications, and is suitable for all age groups. The researchers obtained the Chinese version of SF-12 from the website of the Government Research Bulletin (GRB), Taiwan [21]. We searched the Chinese SF12 scale through the retrieval system (http://www.grb.gov.tw/search;keyword=Sf-12;type=GRB05), which is completely free and open to use [21]. Moreover, Lam et al. found that the Chinese version of SF-12 can be effectively applied to Asians, and its internal consistency and test-retest reliabilities are good (range 0.67–0.82) [22]. The Cronbach's α of in our present study was 0.92, showing good reliability.

Procedure and data collection

Measurement reliability and validation was verified through a pilot study of 10 PCI patients whose data were not used in the main study. For reliability, in the pilot study, the coefficients of internal consistency of Chinese DEFS and SF-12 were good (0.89 and 0.8), indicating good interrelatedness of the items. Therefore, the author did not need to modify the content of the questionnaires. For validity, we used content validity and face validity. The content validity index (CVI) was 93.8%, as determined by a panel of five experts, showing good content validity. Face validity was established by 10 PCI patients. They fully understood the items of each

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Table 1 *Participants' Demographics Characteristics.*

Variable	DM ($n = 77$)		Non-DM ($n = 84$)		Total ($N = 161$)		t/χ^2	p
	n	%	n	%	n	%		
Sex								
Men	53	68.8	62	73.8	115	71.4	.488	.485[a]
Women	24	31.2	22	26.2	46	28.6		
Education level							1.09	.161[a]
< Junior high school	32	41.6	26	31.0	58	36.0		
≥ Junior high school	45	58.4	58	69.0	103	64.0		
Marital status							4.83	.028[*,a]
Married	60	77.9	76	90.5	136	84.5		
Single, divorced, widowed	17	22.1	8	9.5	25	15.5		
Living situation							4.52	.211[a]
Living alone	4	5.2	4	4.8	8	5.0		
Living with family	69	89.6	80	95.2	149	92.5		
Living with friends	1	1.3	0	00.0	1	0.6		
Living with caretaker	3	3.9	0	00.0	3	1.9		
Monthly income (US dollars)							5.19	.075[a]
<1,275	61	79.2	53	63.9	114	71.3		
1,276–2,234	12	15.6	19	22.9	31	19.4		
>2,235	4	5.2	11	13.3	15	9.4		
Smoking							.20	.652[a]
No	67	87.0	71	84.5	138	85.7		
Yes	10	13.0	13	15.5	23	14.3		
Drinking alcohol							1.66	.198[a]
No	68	88.3	68	81.0	136	84.5		
Yes	9	11.7	16	19.0	25	15.5		
Age, mean (SD)	67.7 (10.4)		64.5 (10.8)		66.0 (10.7)		−1.87	.063[b]
Body Mass Index, mean (SD)	27.1 (3.9)		26.3 (4.0)		26.7 (3.9)		−1.27	.208[b]
Diagnosis							3.84	.147[a]
Unstable angina	45	58.4	61	72.6	106	65.8		
Myocardial infarction	4	5.2	4	4.8	8	5.0		
Coronary artery disease	28	36.4	19	22.6	47	29.2		
Puncture site							6.00	.050[*,a]
Transfemoral	20	26.0	13	15.5	33	20.5		
Transradial	57	74.0	67	79.8	124	77.0		
Both	0	00.0	4	4.8	4	2.5		
Number of coronary artery occlusions							4.51	.034[*,a]
< 3	51	66.2	68	81.0	119	73.9		
≥ 3	26	33.8	16	19.0	42	26.1		
Degree of coronary artery occlusion							.25	.616[a]
< 70%	2	2.6	3	3.6	5	3.1		
70–89%	51	66.2	52	61.9	103	64.0		
> 90%	24	31.2	29	34.5	53	32.9		
PCI stenting	52	70.3	53	66.3	105	68.2	.29	.593[a]
Comorbidities								
Hyperlipidemia	17	22.1	13	15.5	30	18.6	1.15	.283[a]
Hypertension	57	74.0	48	57.1	105	65.2	5.05	.025[*,a]
Stroke	12	15.6	2	2.4	14	8.7	8.82	.003[*,a]
Kidney disease	3	3.9	0	0.0	3	1.9	3.34	.068[a]

Note. DM: diabetes mellitus; PCI: percutaneous coronary intervention; SD: standard deviation.
[*] $p < .05$, two-tailed.
[a] Chi-square.
[b] Independent t-test.

questionnaire, and advised no changes were needed. The main data were collected from February to December 2018. A total of 161 participants with PCIs completed the self-rated questionnaires, consisting of demographic characteristics, the DEFS, and the SF-12 at Time 1 (T1; during hospitalization, one day before receiving PCI), Time 2 (T2; two weeks after discharge), Time 3, (T3; three months after discharge), and Time 4 (T4; six months after discharge). Measurements at T2 to T4 were obtained when participants visited the outpatient department or through phone calls by the researchers.

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Table 2 *Difference in Fatigue and Quality of Life at Each Time Point.*

Variable		DM (n = 77)	Non-DM (n = 84)	*T*	*p*
		Mean (SD)	Mean (SD)		
Fatigue					
T1	Baseline	8.40 (7.41)	7.40 (6.06)	−0.93	.349
T2	Two weeks	6.58 (6.52)	5.56 (4.35)	−1.18	.239
T3	Three months	4.84 (4.10)	4.81 (4.22)	−0.053	.958
T4	Six months	4.71 (4.54)	4.14 (3.71)	−.88	.381
SF-12					
PCS					
T1	Baseline	38.94 (10.48)	42.39 (9.40)	2.21	.029*
T2	Two weeks	41.01 (9.83)	43.02 (8.98)	1.36	.176
T3	Three months	43.34 (9.53)	45.21 (8.93)	1.29	.201
T4	Six months	44.83 (9.23)	46.72 (8.42)	1.36	.176
MCS					
T1	Baseline	47.68 (11.15)	51.06 (9.79)	2.05	.042*
T2	Two weeks	48.66 (9.47)	51.45 (7.78)	2.04	.043*
T3	Three months	49.30 (9.01)	51.41 (7.86)	1.59	.115
T4	Six months	49.49 (8.60)	50.73 (8.33)	0.94	.351

Note. DM: diabetes mellitus; MCS: mental component scale; PCS: physical component scale; SD: standard deviation; SF-12: The 12-Item Short-Form Health Survey; T1: hospitalization (baseline); T2: two weeks after discharge; T3: three months after discharge; T4: six months after discharge. *$p < .05$, two-tailed.

Ethical considerations

Prior to conducting this study, approval from the institutional review board of an appropriate hospital (*blinded for review*) was obtained (no. SE17198 A). All participants provided written, informed consent prior to beginning the first questionnaire.

Data analysis

SPSS 24.0 (IBM, Armonk, NY) was utilized to analyze the data. The Chi-square and Independent t-test analyzed the demographic variables and found that five types of demographic data (marital status, puncture site, the number of coronary artery occlusions, hypertension, stroke) were to be heterogeneous and regarded as control variables that acted as covariates in the generalized estimating equation (GEE) analysis into three measurements. Independent t-tests were used to measure differences in fatigue and QoL between groups (DM versus non-DM) at each time point. A generalized estimating equation (GEE) was used to analyze the changes in fatigue and QoL over the four time points. The GEE mode included the main effects of group (DM = 1 vs. non-DM = 0), time point (T1, T2, T3, T4), and interaction effect (group × time point), and the previously mentioned five demographic variables as covariates. The main effects and interaction were utilized to measure the extent of changes in fatigue and QoL of patients with PCI over time. A p-value of less than 0.05 was used as the criterion for statistical significance.

Results

Demographic characteristics

Table 1 shows that the 77 PCI patients in the DM group (47.8%) had a mean age of 67.7($SD = 10.4$) years and BMI of 27.1($SD = 3.9$). A total of 161 participants with PCIs were included; most participants were men (71.4%), married (84.5%), had a monthly income of less than US$ 1,275 (71.3%), lived with family (92.5%), did not smoke (85.7%) or drink alcohol (84.5%), had a diagnosis of unstable angina (65.8%), had 70–89% coronary artery occlusion (64.0%), had hypertension (65.2%), and had PCI through a radial artery (77%). The mean scores of fatigue, PCS, and MCS of all participants were 7.88 ($SD = 6.74$), 40.74 ($SD = 10.05$), and 49.44 ($SD = 10.57$), respectively.

There were significant differences in the demographic data of marital status, puncture site, the number of coronary artery occlusions, hypertension, and stroke (all ps < .05) between DM and non-DM groups, indicating that the two groups were heterogeneous.

Differences in fatigue and QoL at each time point

Independent *t*-tests were utilized to measure the differences in fatigue and QoL between patients with/without DM at the four time points (Table 2). Although the fatigue scores of the DM group were slightly higher than non-DM group, no significant differences were found in fatigue between both groups at T1 ($p = .349$), T2 ($p = .239$), T3 ($p = .958$), or T4 ($p = .381$) (all $ps > .05$). QoL (PCS and MCS) scores were lower for the DM group than for the non-DM group; there were significant differences between DM and non-DM groups in PCS at T1 ($p = .029$) and in MCS at T1 ($p = .042$) and T2 ($p = .043$) (all ps < .05).

Table 3 *Magnitude of Change in Fatigue at Each Time Point By Group.*

Variable	β	SE	95% CI	Wald test	*p*
Marital status	−2.20	1.16	−4.47, .068	3.615	.057
Puncture site	−1.613	.98	−3.53, .34	2.72	.099
Number of coronary artery occlusions	.226	.87	−1.47, 1.93	.068	.794
Comorbidities-Hypertension	.583	.75	−0.89, 2.06	.599	.439
Comorbidities-Stroke	−1.066	1.26	−3.53, 1.40	.720	.396
DEFS of Non-DM patients at T1 (reference)	7.405	0.66	6.12, 8.69	127.004	<.001***
DEFS at T1 (DM patients compared to non-DM patients)	0.998	1.07	−1.09, 3.09	0.877	.349
DEFS of Non-DM patients (T2 compared to T1)	−1.845	0.39	−2.61, −1.09	22.687	<.001***
DEFS of Non-DM patients (T3 compared to T1)	−2.595	0.53	−3.63, −1.56	24.048	<.001***
DEFS of Non-DM patients (T4 compared to T1)	−3.262	0.54	−4.33, −2.20	35.986	<.001***
DEFS of DM patients at T1 (reference)	8.403	0.84	6.76, 10.05	100.071	<.001***
DEFS of DM patients (T2 compared to T1)	−1.818	0.52	−2.83, −0.80	12.223	<.001***
DEFS of DM patients (T3 compared to T1)	−3.558	0.65	−4.84, −2.28	29.963	<.001***
DEFS of DM patients (T4 compared to T1)	−3.688	0.68	−5.03, −2.35	29.415	<.001***
Magnitude of change in DEFS in both groups from T1 to T2	0.027	0.65	−1.24, 1.30	0.002	.253
Magnitude of change in DEFS in both groups from T1 to T3	−0.963	0.84	−2.61, 0.68	1.314	.252
Magnitude of change in DEFS in both groups from T1 to T4	−0.426	0.87	−2.14, 1.28	0.239	.625

Note. β: beta coefficients; CI: confidence interval; DEFS: Dutch Exertion Fatigue Scale; DM: diabetes mellitus; SE: standard error; T1: hospitalization (baseline); T2: two weeks after discharge; T3: three months after discharge; T4: six months after discharge. *p < .05, **p < .01, ***$p < .001$, two-tailed.

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Table 4 *Magnitude of Change in Physical Component Scale (PCS) Scores at Each Time Point By Group.*

Variable	β	SE	95% CI	Wald test	*p*
Marital status	2.69	2.23	−1.69, 7.06	1.452	.228
Puncture site	1.539	1.71	−1.82, 4.90	.808	.369
Number of coronary artery occlusions	.314	1.61	−2.83, 3.46	.038	.845
Comorbidities-Hypertension	−3.28	1.41	−6.05, −.52	5.404	.020*
Comorbidities-Stroke	.941	2.42	−3.80, 5.69	.151	.697
PCS of non-DM patients at T1 (reference)	42.393	1.02	40.39, 44.39	1727.585	<.001***
PCS at T1 (DM patients compared to non-DM patients)	−3.455	1.56	−6.52, −0.39	4.877	.027*
PCS of Non-DM patients (T2 compared to T1)	0.629	0.65	−0.65, 1.91	0.928	.335
PCS of Non-DM patients (T3 compared to T1)	2.819	0.80	1.26, 4.38	12.529	<.001***
PCS of Non-DM patients (T4 compared to T1)	4.326	0.78	2.80, 5.86	30.719	<.001***
PCS of DM patients at T1 (reference)	38.938	1.19	36.61, 41.26	1070.664	<.001***
PCS of DM patients (T2 compared to T1)	2.072	0.75	0.61, 3.54	7.632	0.006**
PCS of DM patients (T3 compared to T1)	4.404	0.80	2.85, 5.96	30.305	<.001***
PCS of DM patients (T4 compared to T1)	5.890	0.83	4.27, 7.51	50.359	<.001***
Magnitude of change in PCS in both groups from T1 to T2	1.443	0.99	−0.50, 3.39	2.113	.146
Magnitude of change in PCS in both groups from T1 to T3	1.585	1.13	−0.62, 3.79	1.986	.159
Magnitude of change in PCS in both groups from T1 to T4	1.564	1.14	−0.67, 3.80	1.889	.169

Note. β: beta coefficients; CI: confidence interval; MCS: physical component scale (MCS); DM: diabetes mellitus; SE: standard error; T1: hospitalization (baseline); T2: two weeks after discharge; T3: three months after discharge; T4: six months after discharge. *p < .05, **p < .01, ***p < .001, two-tailed.

Magnitude of change in fatigue and QoL at each time point

Table 3 presents the change in fatigue between four time points through GEE analysis. Considering the non-DM group's T1 fatigue score (7.405) as the reference, the DM group's fatigue score at T1 was 0.998 units higher than that of the non-DM group ($p = .349$), indicating no significant pre-surgery difference between the groups. At T2, T3, and T4, the fatigue scores of the non-DM group were significantly lower (all $ps < .001$) than those at T1, showing that the growth effect decreased over time. Considering the DM group's T1 fatigue score (8.403) as the reference, at T2, T3, and T4, the fatigue scores of the DM group were significantly lower (all $ps < .001$) than those at T1, showing that the growth effect decreased over time. After adjusting for the pre-test differential effect and growth effects, the magnitude of changes in the DM group's fatigue scores were .027, −.963, and −.426 compared to those of the non-DM group from T1 to T2 ($p = .253$), T1 to T3 ($p = .252$), and T1 to T4 ($p = .625$) (all $ps > .05$), respectively. This indicates that the extent of change in fatigue was not significantly higher in the DM group than in the non-DM group from hospitalization (baseline) to two weeks, three months, and six months after discharge.

Table 4 shows the change in PCS at each time point. Considering the T1 PCS score (42.393) of the non-DM group as the reference, T1 PCS scores of the DM group were 3.455 points lower than those of the non-DM group ($p = .027$), indicating there was a significant pre-surgery difference between the groups. At T3 and T4, the PCS scores of the non-DM group were significantly higher (all $ps < .001$) than those at T1, showing a growth effect over time. Considering the T1 PCS score (38.938) of the DM group as the reference, at T2, T3, and T4, the PCS scores of the DM group were significantly higher (all $ps < .01$) than those at T1, showing a growth effect over time. After adjusting for the pre-test effect and growth effects of the control group, the DM group's PCS were 1.443, 1.585, and 1.564 units lower than those of the non-DM group from T1 to T2 ($p = .146$), T1 to T3 ($p = .159$), and T1 to T4 ($p = .169$) (all $ps > .05$), respectively. This indicated that there was no significant difference in the extent of change in PCS scores between the two groups from hospitalization (baseline) to two weeks, three months, and six months after discharge.

Table 5 shows the change in MCS at each time point. Considering the T1 MCS scores (51.057) of the non-DM group as the reference, T1 MCS scores of the DM group were 3.377 points lower than those of the non-DM group ($p = .041$), indicating there was a significant difference between the groups at T1. The non-DM group exhibited a slight increase in MCS at T2 (0.389, $p = .556$) and T3 (0.356, $p = .688$), and a decrease at T4 (0.322, $p = .714$) (all ps > .05) than those at T1, showing no growth effect over time. Considering the T1

Table 5 *Magnitude of Change in Mental Component Scale (MCS) Scores at Each Time Point By Group.*

Variable	β	SE	95% CI	Wald test	*p*
Marital status	2.38	2.07	−1.67, 6.43	1.325	.250
Puncture site	.698	1.61	−2.46, 3.86	.187	.665
Number of coronary artery occlusions	−.615	1.59	−3.73, 2.50	.150	.699
Comorbidities-Hypertension	−1.475	1.38	−4.18, 1.23	1.141	.285
Comorbidities-Stroke	1.747	2.22	−2.60, 6.09	.621	.431
MCS of non-DM patients at T1 (reference)	51.057	1.06	48.98, 53.14	2312.988	<.001***
MCS at T1 (DM patients compared to non-DM patients)	−3.377	1.65	−6.61, −0.14	4.190	.041*
MCS of Non-DM patients (T2 compared to T1)	0.389	0.66	−0.90,1.68	0.346	.556
MCS of Non-DM patients (T3 compared to T1)	0.356	0.87	−1.382,2.093	0.161	.688
MCS of Non-DM patients (T4 compared to T1)	−0.322	0.88	−2.05,1.40	0.134	.714
MCS of DM patients at T1 (reference)	47.680	1.26	45.21, 50.16	1431.962	<.001***
MCS of DM patients (T2 compared to T1)	0.985	0.61	−0.21, 2.18	2.607	.107
MCS of DM patients (T3 compared to T1)	1.625	0.85	−0.04, 3.29	3.655	.056
MCS of DM patients (T4 compared to T1)	1.808	0.94	−0.03, 3.65	3.699	.054
Magnitude of change in MCS in both groups from T1 to T2	0.596	0.90	−1.17,2.36	0.439	.098
Magnitude of change in MCS in both groups from T1 to T3	1.269	1.23	−1.14, 3.68	1.068	.301
Magnitude of change in MCS in both groups from T1 to T4	2.130	1.28	−0.39, 4.65	2.742	.099

Note. β: beta coefficients; CI: confidence interval; MCS: mental component scale (MCS); DM: diabetes mellitus; SE: standard error; T1: hospitalization (baseline); T2: two weeks after discharge; T3: three months after discharge; T4: six months after discharge. *p < .05, **p < .01, ***p < .001, two-tailed.

Please cite this article as: Su S-F, Yeh W-T, Fatigue and Quality of Life Among Patients with Diabetes and Non-diabetes Receiving Primary Percutaneous Coronary Interventions, Asian Nursing Research, https://doi.org/10.1016/j.anr.2023.02.001

MCS scores (47.680) of the DM group as the reference, the DM group exhibited a slight increase in MCS at T2 (0.985, $p = .107$) and T3 (1.625, $p = .056$), and at T4 (1.808, $p = .054$) (all ps > .05). After adjusting for the pre-test value and growth effects in the non-DM group, the extent of changes in the MCS scores of the DM group were 0.596, 1.269, and 2.130 points higher than those of the non-DM group from T1 to T2 ($p = .098$), T1 to T3 ($p = .301$), and T1 to T4 ($p = .099$) (all $ps > .05$), respectively. This indicated that there was no significant difference in the extent of change in MCS in both groups from hospitalization (baseline) to two weeks, three months, and six months after discharge.

Discussion

Participants' characteristics regarding sex and presence of hypertension were consistent with the previously reported data, which indicated that patients with CAD often have hypertension and men have a higher CAD prevalence rate than women [5,15]. However, our results contradict those that showed that female PCI patients receiving a drug-eluting stent had a higher incidence of DM than male PCI patients ($p = .485$) [5]. The prevalence of radial artery puncture in this present study differs from Faridi et al.'s study, which found that in the US, >80% of patients with CAD received PCI in the femoral artery [16]. Su et al. indicated that when patients with CAD have acute myocardial ischemia onset or narrow coronary arteries, the transfemoral approach is often chosen for PCI [9]. Although the participants in Faridi et al.'s study and the present study involved non-emergency PCIs, the major puncture sites were different [16]. Thus, this requires further study.

Our results regarding smoking and alcohol habits among patients with CAD were consistent with a prior study that found that 53% of patients with CAD ($n = 200$) were non-smokers [17]. However, our results contradict those of Ram and Trivedi's study, which indicated that smokers in Turkey had a higher prevalence of CAD (around 3.72 times higher) than those who had quit smoking [23]. A possible reason for these differences is that most studies simply investigated current smoking or non-smoking and rarely focused on patients' history of smoking, daily use of cigarettes, and time since quitting smoking, which may also affect the prevalence of CAD. Moreover, Su and He found that Type D personality is associated with CAD prevalence and may raise the mortality rate [24]. The risk factors for triggering CAD may also include personality traits or comorbidities such as DM.

Difference and magnitude of change in fatigue at each time point

Fatigue scores at T1 indicated that before PCI, patients with CAD experienced mild-to-moderate fatigue irrespective of DM comorbidity. This is consistent with a study that found that fatigue was the most common symptom experienced by patients with CAD [25]. The present study also found no significant differences in fatigue between DM and non-DM groups at T2, T3, and T4; although, both groups' fatigue scores decreased compared to pre-PCI (T1). Our results contradict a study that found that fatigue was the most intense symptom in the first month after PCI [5]. Duijndam et al. indicated that within a year after PCI, fatigue continued to affect the perception of illness and QoL [6]. Patients' perceived concentration problems were associated with decreased QoL, possibly owing to fatigue, negative mood, and older age [6]. However, these two studies were subject to some limitations: the participants in Kim et al.'s study were all outpatients with acute coronary syndrome [5], and the time points assessed in Duijndam et al.'s study were after PCI (baseline), and at one-month and one-year follow-ups [6]. They did not consider the influence of DM in patients with CAD who received PCI, although DM damages the vascular system and nerves [1] and is detrimental to patients with CAD [11]. When the vascular endothelial cells are damaged, patients with CAD are prone to fatigue [5]. Therefore, longitudinal studies are needed to examine the degree of fatigue and seriousness of DM among patients with CAD before and after receiving PCI.

Notably, our GEE analyses indicated that fatigue scores in the DM and non-DM groups at T2, T3, and T4 were significantly lower than those at pre-PCI (T1), showing that fatigue significantly decreased over time. This result is consistent with a study that found that patients with myocardial infarction immediately felt well and perceived a decrease in fatigue after PCI [8]. This may be because PCI is the most effective revascularization therapy for CAD as it can quickly destroy arterial plaque and subsequently relieve fatigue [9], no matter CAD patients with or without DM. Ayton et al. found that patients with CAD ($n = 32$) perceived physical symptoms (e.g., fatigue) and psychological symptoms (e.g., anxiety, depression, and uncertainty) and were relieved after PCI, but continued to worry about mortality and incapability of performing daily physical activities [26]. Therefore, we suggest that clinical nurses should enhance patients' awareness and management of physical and psychological symptoms after PCI and possible comorbidities, as education regarding lifestyle changes, taking medication regularly, and following rehabilitation regimes after PCI improves prognosis.

Our study revealed that the magnitude of change in fatigue was not significant in the DM group compared to the non-DM group from T2 to T1, T3 to T1, and T4 to T1. This result contradicts Ayton et al.'s study, which found that six months after PCI, patients perceived a significant improvement in fatigue, shortness of breath, and angina [26]. A possible reason for this discrepancy could be that they conducted a qualitative study with a small sample size and considered neither DM nor fatigue change at different time points after PCI, which may have influenced their outcomes. Moreover, fatigue may be caused by a variety of factors: lifestyle-related, nutritional, medical, psychological, glycemic/diabetes-related, endocrine, and iatrogenic [27]. Thus, we suggest that further studies consider these related factors and the influence of time to better understand the efficacy of PCI for patients with CAD and DM.

Difference and magnitude of change in QoL at each time point

Patients' QoL decreased because of CAD, especially for patients with CAD and DM. This is consistent with Srivastava et al.'s study, which found that the CAD group's physical and social QoL were significantly lower than a healthy control group [28].

The DM group's MCS scores were lower than those of the non-DM group at T2; however, there was no difference in PCS scores between groups at T2. Our results contradict Moriel et al.'s study, which found that PCI patients ($n = 78$) who had DM comorbidity experienced low physical and psychological QoL, especially women [29]. Moreover, Kim et al. found that the average QoL scores of patients with CAD with and without DM were not significantly different (67.81 ± 14.96 vs. 67.87 ± 16.70, $p > .05$) [5]. However, their study only explored postoperative QoL a month after PCI without comparing pre-PCI QoL and used a different measurement tool (Seattle Angina Questionnaire) to evaluate QoL. Thus, based on these contradictory results, we suggest that further studies consider DM and participants' sex, using consistent ways of assessing different aspects of QoL, to verify the influence of DM on the health-related QoL of patients with CAD.

Notably, our GEE analysis showed that PCS scores in the non-DM group at T3 and T4, and in the DM group at T2, T3, and T4 were significantly higher than those at T1; that is, both groups' PCS scores significantly increased over time. However, no significant changes in MCS scores were found among three time points in both

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groups. This result is consistent with Uchmanowicz et al.'s study, which evaluated the impact of DM on QoL of 120 patients with CAD [30]. Non-diabetic patients had better QoL than patients with DM at both baseline and six months after PCI. Negative predictors of PCS scores were diabetes, multivessel disease, high triglyceride level, and hypertension; regarding MCS, negative predictors were DM, history of myocardial infarction, and high triglyceride level. Edward et al. found that PCS scores six months after PCI (51.4 ± 10.5) were higher than those after 12 months (39.7 ± 10.8) among 40 Australian patients with CAD [31]. However, this study did not investigate the difference in QoL in patients with and without DM; thus, further study is still needed concerning QoL after patients with DM receive PCI.

Our study also revealed that the magnitude of change in QoL of PCI patients with/without DM did not significantly differ at T2, T3, and T4. This result is consistent with Pischke et al.'s study, which showed that there was no significant difference in QoL at a one-year follow-up among patients with CAD with/without DM who received PCI [10]. Tareen and Tareen proposed that DM is a debilitating chronic illness with a complex pathophysiology that often damages kidney and cardiovascular function, resulting in emotional distress and significantly affecting patients' QoL [32]. DM has been associated with lower QoL among patients with CAD [29]. However, Kim et al. found that QoL scores in patients with CAD with and without DM did not significantly differ (67.81 ± 14.96 vs. 67.87 ± 16.70, $p > .05$) [5]. This may be because after PCI treatment, patients' coronary arteries recanalize, and chest tightness and chest pain gradually improve. If patients with DM regularly take heart and DM medication along with implementing a proper cardiac rehabilitation exercise program, they may not perceive any noteworthy QoL improvement. Nevertheless, DM has been found to decrease cardiovascular function and induce heart disease, especially in Asia [33]. Current treatment and control of DM have improved. Thus, we suggest that future transnational studies related to PCI prognosis, DM comorbidity, and QoL in patients who receive PCI be conducted to increase the awareness of nurses' roles in CAD care, DM care, strengthen communication among interdisciplinary teams, and provide necessary support to help patient recovery after PCIs.

Limitations

This study took place in Taiwan; thus, our results may not be generalizable to global populations. Further, the time since DM diagnosis and condition of DM control were not explored in this study, and both may influence levels of fatigue and QoL. Moreover, living with one's extended family is common in traditional Chinese culture, especially older adults being looked after by their children (i.e., *filial piety*). However, whether living with family members and social support affect the fatigue or QoL of patients with DM receiving PCIs needs further study. In addition, other factors could be confounded with fatigue and QoL scores such as marital status; puncture site; number of coronary artery occlusions; and comorbidities such as hypertension, unstable angina, and stroke. Thus, further studies with a transnational, transcultural, and longitudinal design and longer follow-ups are recommended.

Conclusions

Patients with DM had lower pre-intervention QoL and lower psychological QoL two weeks after discharge than those with non-DM. By T3 or T4, DM did not affect the magnitude of changes in fatigue and QoL in patients who received PCIs over three or six months. Patients without DM perceived lower fatigue at two weeks, three months, and six months after discharge, and higher physical QoL at three and six months after discharge. DM may affect patients with CAD over the long term. Thus, nurses should educate patients to regularly take medication, notice blood sugar, change life habits, notice comorbidities, and follow rehabilitation regimes after PCIs for better prognosis.

Funding details

This work was supported by the Ministry of Science and Technology (MOST 108-2635-B-025-001), Taiwan. Q2

Conflict of interest statement

There are no relevant financial or non-financial competing interests to report.

Ethical approval

This study was performed after receiving approval (no. SE17198 A) from the research ethics committee of Taichung Veterans General Hospital. The researchers informed patients undergoing percutaneous coronary interventions about the aims, procedures, anonymity, and human rights associated with this study. All participants provided informed, written consent.

Acknowledgments

None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.anr.2023.02.001.

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