Journal of Southeast Asian Orthopaedics
ISSN 2821-9848 (Print)
ISSN 2821-9864 (Online)
https://doi.org/10.56929/jseaortho-023-0182 https://jseaortho.org

Efficacy of Post-Operative Logbook-Based Quadriceps Exercises on Functional Outcome after Total Knee Arthroplasty

Chatchapol Ongkosit, MD, Ruengsiri Panuwet, RN

Department of Orthopedic Surgery, Nong Bua Lamphu Hospital, Nong Bua Lamphu, Thailand

Purpose: Most patients who undergo total knee arthroplasty (TKA) are elderly. Some patients have recognition impairments and cannot correctly perform home-based rehabilitation effectively. This study aimed to compare the functional outcomes between logbook- and non-logbook-based quadricep exercises.

Methods: In this prospective cohort study with retrospective case controls scheduled for unilateral primary/bilateral TKA, we compared 57 patients who received post-operative home-based rehabilitation and seated knee extension exercises (non-logbook group) with 60 patients who received the same protocol but were provided a logbook with paper handouts containing the schedule, date, time, and record form (logbook group). The modified Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) scores and data pertaining to range of motion (ROM) were collected pre-operatively and at 6, 12, and 24 weeks post-operatively.

Results: The logbook group showed a significant improvement in the mean difference in function and total WOMAC scores at 6-weeks post-operatively ($p < 0.05$). There was no significant difference in the pre- and post-operative ROM at any follow-up time point between the groups.

Conclusions: Logbook-based quadriceps exercises resulted in significant early improvement in the functional outcomes. Logbooks may help patients who have undergone TKA to perform their home-based exercise regimens accurately.

Keywords: Total knee arthroplasty, knee exercise, rehabilitation, logbook, Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC).

Total knee arthroplasty (TKA) reduces pain, restores range of motion (ROM), and improves functional performance and quality of life of patients with end-stage knee osteoarthritis (OA). The post-operative functionality of TKA is closely related to appropriate physiotherapy. Rapid recovery of muscle function and early mobilization are key to successful rehabilitation following TKA[1]. Quadricep muscle strength is particularly crucial for functional performance, such as climbing stairs, rising from a seated position, walking, and survival of artificial implants. Finally, high lower limb muscle strength is associated with a lower mortality risk[2].

Article history:
Received: January 22, 2023 Revised: May 8, 2023
Accepted: May 17, 2023
Correspondence to: Chatchapol Ongkosit, MD
Department of Orthopedic Surgery, Nong Bua Lamphu Hospital, Nong Bua Lamphu, Thailand
E-mail: ongkosit.c@gmail.com

Home exercise programs (HEPs) are used to treat several musculoskeletal conditions. HEPs are usually provided to patients in the form of paper handouts[1]. The prescription of HEPs encourages patients to take responsibility for their rehabilitation and to self-manage their condition in the long term[3]. Most patients who undergo TKA are elderly and have multiple comorbidities. Some have recognition impairment and thus cannot always remember HEPs, and therefore cannot exercise correctly[4]. Beinart et al. reported that up to 70% of patients do not perform HEPs as prescribed, and adherence tends to decline over time[5]. Thiengwittayaporn et al. reported greater accuracy of quadriceps isometric exercises after using a quadriceps educational device (QED)[6].

Seated knee extension is an easy exercise for quadricep muscle strength, and is commonly used in patients following TKA[7]. It can also be used as HEPs. Early initiation of muscle strengthening exercises reduces pain and improves the ROM. Other studies have reported that post-operative rehabilitation prevents knee stiffness following TKA[8].

Maltz et al. reported that it usually takes a minimum of about 21 days for any perceptible change in a mental image. According to Maltz, "These, and many other commonly observed phenomena tend to show that it requires a minimum of about 21 days for an old mental image to dissolve and a new one to jell[9]."

In provinces where most of the people work in agriculture and have a relatively low socioeconomic status, paper handouts are easy and economical method to communicate information. If patients are provided a logbook that is easy to use and contains detailed explanation, schedule, time, and frequency of exercises for each day, it would remind them to perform their rehabilitation regimen correctly.

This study aimed to compare the functional scores of patients (following TKA) who performed logbook-based quadriceps exercises for 28 days with those of patients who did not. We hypothesized that patients who perform logbook-based quadriceps exercises for 28 days would remember them better and form a healthy habit that would be reflected in improved functional outcomes.

MATERIALS AND METHODS

We conducted a prospective cohort study with retrospective case-controls scheduled for unilateral primary/bilateral TKA between January 30, 2021 and February 25, 2022. This study was approved by the ethics committee of our hospital's institutional review board.

The inclusion criteria were patients (aged 50–80 years) with primary knee OA who consented to comply with the study protocols. The exclusion criteria were as follows: (1) any infection, (2) body mass index >40 kg/m^2, (3) uncontrolled hypertension and/or diabetes mellitus, (4)patients with renal insufficiency (creatinine clearance <30 mL/min) and/or active hepatic disease who did not receive the general peri- and post-operative pain medicine protocol, (5) patients with a brain disease and/or any symptoms that prevents them from exercising by themselves, and (6) patients with mental disorders with a score <14 on the Thai Mini-Mental State Examination.

All surgeries were performed by the first author using the same technique. Only spinal blocks were used in the present study. All patients received the same post-operative analgesic protocol.

Two weeks post-operatively, the patients were advised to perform home-based rehabilitation as usual, including seated knee extension exercises, sitting down on a chair, active extension and holding of the affected knee for 20 sec, which were to be performed ten times every 2 h (at 8 am, 10 am, 12 pm, 2 pm, and 4 pm).

We recruited participants who had received post-operative HEPs between January 30, 2021 and November 1, 2021 as the historical control group. This group constituted the 'non-logbook group.' Next, we conducted a prospective study of participants recruited between November 2, 2021 and February 25, 2022 who received the same protocols but were provided a logbook consisting of a paper handout containing schedule, date, time, record form (Appendix 1), and advised to return for an appointment for the next 4 weeks (6 weeks post-operatively). This group constituted the 'logbook

group.' All participants received the same medication for pain, including naproxen (250 mg twice a day), tolperisone (thrice a day), gabapentin (300 mg once a day), and acetaminophen (500 mg 2 tabs every 6–8 h). The medications were administered for two weeks in both groups. After the 2nd post-operative week and until the end of the study all participants received the same medications, including tolperisone (three times a day) and acetaminophen (500 mg 2 tabs every 6–8 h) for pain. None of the participants used any over-the-counter painkillers.

Outcome measurement

Primary outcome was assessed using the modified Western Ontario and McMaster Universities Arthritis Index (WOMAC), which was performed by a blinded outpatient department nurse pre-operatively and at 6th, 12th, and 24th week post-operatively. The secondary outcome was ROM, which was assessed in the patients pre-operatively and at 6th, 12th, and 24th week post-operatively. Active knee flexion and extension ROM were measured in degrees using a standard long-arm universal goniometer.

Data analysis

Sample size was calculated based on data collected from ten patients in our pilot study. The results showed that the mean difference in WOMAC between the logbook and non-logbook groups at post-operative 12th week was 46.04 (±13.94) and 39.12 (±15.24), respectively. The correlation between follow-up measurements was 0.7. The correlation between baseline and follow-up was 0.3 based on ANCOVA method. A multilevel regression model analysis was performed by considering repeated outcome measurements at multiple time points. We estimated that a sample size of at least 54 patients per group would have 80% power to detect mean differences. A two-sided alpha level of 0.05 was considered acceptable.

The mean differences in WOMAC scores were compared between the groups. Statistical significance was set at $p < 0.05$ for Fisher's exact test, two-sample t-test, and multilevel Gaussian regression for the WOMAC Score change (mixed-effects ML regression) adjusted for sex, age, body mass index (BMI), physical status class, number of knee replacements, operative time, pre-operative WOMAC score, and p-value for repeated measurement at multiple time points.

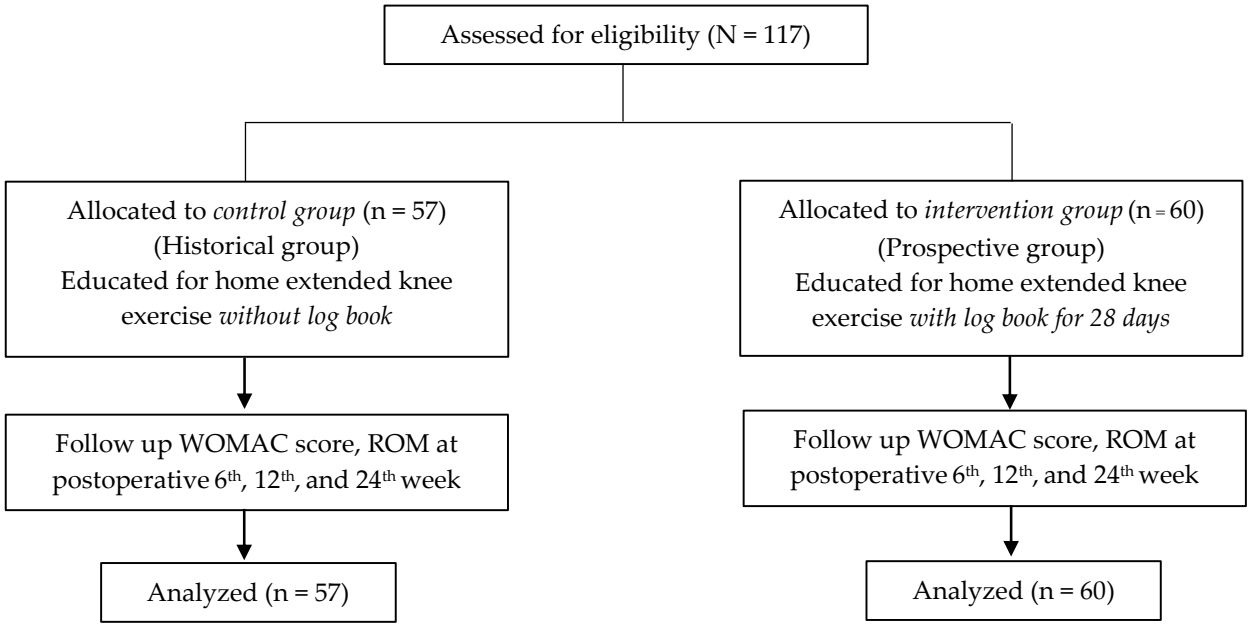


Fig. 1 Flow diagram.

Table 1 Demographic information.

Characteristics	Non-logbook (n = 57)		Logbook (n = 60)		p-value
	n	%	n	%	
Sex					0.262
Male	9	15.8	5	8.3	
Female	48	84.2	55	91.7	
Age (yrs), mean (±SD)	64.7 (±9.0)		65.9 (±9.0)		0.440
BMI, mean (±SD)	27.2 (±4.1)		26.3 (±3.6)		0.243
Physical status class (A)					0.202
I	7	12.3	14	23.3	
II	31	54.4	24	40.0	
III	19	33.3	22	36.7	
Number of knee replacements					1.000
Unilateral	38	66.7	40	66.7	
Bilateral	19	33.3	20	33.3	
Operative time (min), mean (±SD)	90.0 (±35.9)		91.6 (±35.2)		0.812
Pre- Operative WOMAC Score					
Pain	9.8 (±4.1)	10.4 (±3.4)	0.366	9.8 (±4.1)	10.4 (±3.4)
Stiffness	4.5 (±1.6)	4.7 (±1.7)	0.544	4.5 (±1.6)	4.7 (±1.7)
Function	36.0 (±14.0)	38.9 (±12.2)	0.223	36.0 (±14.0)	38.9 (±12.2)
Total WOMAC Score	50.3 (±18.1)	54.1 (±15.4)	0.224	50.3 (±18.1)	54.1 (±15.4)
Pre-operative ROM, mean (±SD)	121.5 (±11.9)	118.5 (±15.1)	0.238	121.5 (±11.9)	118.5 (±15.1)

Fisher exact probability test for proportions independent t-test for two independent mean.

Table 2 Clinical outcome.

Mean difference of WOMAC Score	Non-logbook (n=57)		Logbook (n=60)		Mean difference regression	95%CI	p-value*
	mean	(SE)	mean	(SE)			
Pain WOMAC Score							
WOMAC Score at 6-week	-5.8	(0.4)	-6.4	(0.3)	-0.6	-1.5, 0.4	0.255
WOMAC Score at 12-week	-7.5	(0.5)	-7.9	(0.5)	-0.4	-1.8, 0.9	0.519
WOMAC Score at 24-week	-8.4	(0.9)	-9.2	(0.8)	-0.8	-3.2, 1.6	0.523
Stiffness WOMAC Score							
WOMAC Score at 6-week	-2.4	(0.2)	-2.9	(0.2)	-0.5	-1.1, 0.4	0.067
WOMAC Score at 12-week	-3.0	(0.3)	-3.2	(0.3)	-0.2	-0.9, 0.6	0.645
WOMAC Score at 24-week	-3.6	(0.5)	-3.7	(0.4)	-0.1	-1.4, 1.2	0.876
Function WOMAC Score							
WOMAC Score at 6-week	-22.0	(1.2)	-26.1	(1.1)	-4.1	-7.3, -0.8	0.014†
WOMAC Score at 12-week	-28.7	(1.7)	-31.8	(1.6)	-3.2	-7.8, 1.4	0.176
WOMAC Score at 24-week	-32.3	(3.2)	-33.1	(2.9)	-0.8	-9.2, 7.6	0.852
Total WOMAC Score							
WOMAC Score at 6-week	-30.2	(1.5)	-35.4	(1.4)	-5.2	-9.3, -1.1	0.013†
WOMAC Score at 12-week	-39.1	(2.1)	-42.9	(2.1)	-3.8	-9.7, 2.1	0.209
WOMAC Score at 24-week	-43.9	(3.7)	-45.8	(3.7)	-1.9	-12.9, 9.1	0.734

*p-value for Mixed-effects REML regression for WOMAC score change adjusted for sex, age, BMI, physical status class, number of knee replacement, operative time, and pre- operative WOMAC score.

† Denotes significance at the $p < 0.05$ level.

Table 3 Mean ROM pre-operatively and at 6, 12, and 24 weeks post-operatively.

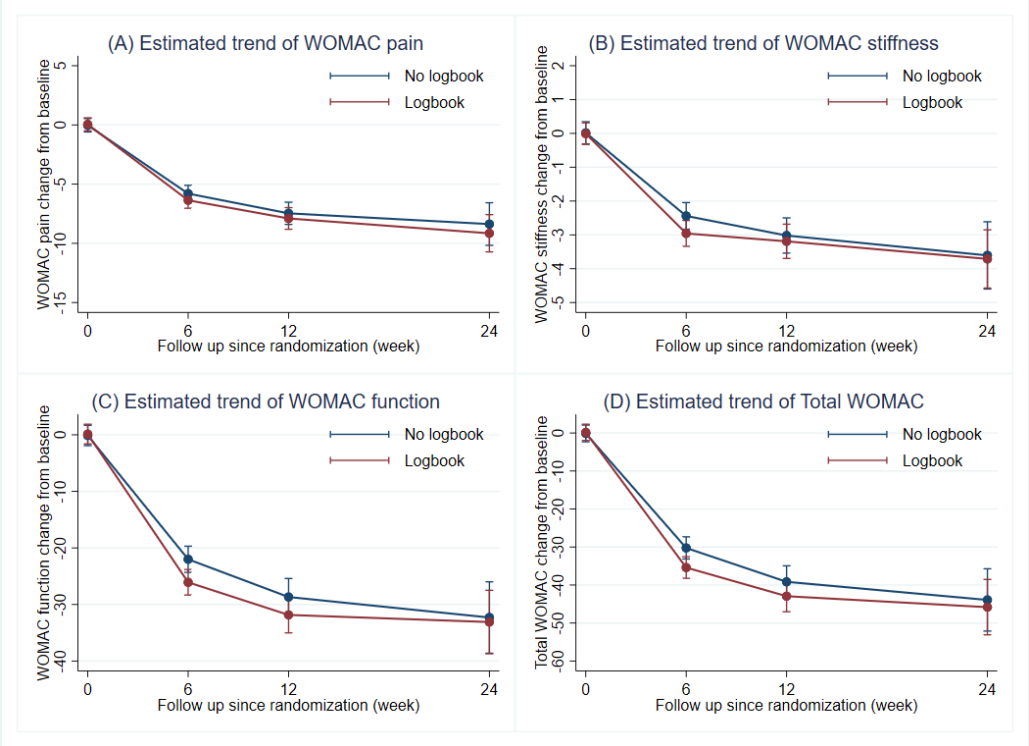
Clinical outcome	Non-logbook (n = 57)		Logbook (n = 60)		p-value
	mean	(±SD)	mean	(±SD)	
Pre- operative range of motion (ROM)	121.5	±11.9	118.5	±15.1	0.238
Post-operative ROM					
At 6-week	114.8	±14.4	114.9	±11.9	0.952
At 12-week	120.1	±10.7	120.6	±11.5	0.778
At 24-week	120.0	±7.1	127.5	±9.1	0.263

RESULTS

The study included 117 patients, who were divided into two groups: non-logbook (n = 57; 9 males, 48 females) and logbook (n = 60; 5 males and 55 females) groups. There were no significant differences in age, BMI, American association of anesthesiologist (ASA) classification, or operative time between the groups. Nineteen patients in the non-logbook and 20 in the logbook group underwent bilateral TKA. There were no significant differences in the pre-operative 5-point Likert WOMAC score (pain, stiffness, daily activity, and total score) or ROM between the groups (Table 1).

The logbook group showed a greater mean difference in function and total WOMAC scores at 6-week post-surgery ($p < 0.05$). Both the groups (non-logbook and logbook) showed no statistically significant improvement in pain and stiffness WOMAC scores in all dimensions following TKA (Table 2). There was no significant difference in pre- and post-operative ROM between the groups at all follow-up time points evaluated. There was no significant difference between the time points ($p < 0.952$) (Table 3).

Fig. 2 Mean difference in WOMAC pre-operatively and at 6, 12, and 24 weeks post-operatively.



DISCUSSION

The results showed that patients who performed logbook-based quadricep exercises improved their mean difference in function and total WOMAC scores compared with those in the control group at 6-week post-operatively. These results differ from that reported in the Kauppila et al. study that compared a 10-day multidisciplinary outpatient rehabilitation program with conventional care. They reported no significant difference in the improvement of the early WOMAC scores[10].

For early and superior functional outcome following TKA, the process of post-operative rehabilitation is crucial. However, it has multifactorial influences, including patient education, perceptions, socioeconomic status, and mental status all of which remain challenging, especially in developing countries owing to lower patient educational and economic status, and difficulty in visiting physical therapists. Moreover, the ongoing COVID-19 pandemic, low contact time, and overcrowding in outpatient departments may have all contributed to lower functional outcomes. The limited options for face-to-face training sessions affects patient rehabilitation outcomes. Smith et al. identified that the barriers to engagement in physical activity included lack of the information on recovery, expected capabilities, and fear of 'damaging' the recovery process and implant[11]. A previous study by Thiengwittayaporn et al. compared mobile applications and paper handouts for home-based exercises for knee OA. The results showed significantly higher overall exercise accuracy, daily activity, quality of life, and ability to perform sports and recreational activities in the mobile application group[12]. Although the study showed marked benefit of technology in helping patients adhere to home-based exercise programs, paper handouts continue to play significant a role in patient recovery, particularly in rural areas where technology may be inaccessible. Additionally, our study showed that paper handouts are applicable and adaptable to everyone, and may be used to remind patients to perform the home-based exercises.

In our study, both groups demonstrated similar yet significant post-operative improvement in active knee flexion. The mean pre-operative knee flexion in the two groups were 121.5° and 118.5°, respectively. Both groups achieved pre-operative knee flexion levels at 12-week post-operatively. The improvement in knee flexion was better in the logbook group than that in the non-logbook group at 24-week post-operatively, although the difference was not statistically significant ($p = 0.263$). Similarly, McGinn et al. studied early outpatient physical therapy within six weeks and found that early post-operative physical therapy resulted in greater knee flexion and extension than late physical therapy[13].

The main limitations of our study were its non-blind nature and lack of long-term follow-up. Furthermore, we did not thoroughly evaluate the intensity of self-physical therapy, mental status, educational level of individual caregivers, or other environmental factors.

CONCLUSIONS

Our study demonstrated that logbooks constitute an effective method that may help patients to perform home-based exercises accurately following TKA. The study demonstrated a statistically significant difference in the total WOMAC scores between the intervention and control groups at 6-week post-operatively.

ACKNOWLEDGEMENTS

We gratefully thank Weerachai Kosuwan, Varah Yuenyongviwat, NP for their invaluable guidance, support, and expertise throughout this research. We also thank all participants for providing the data used in this study.

CONFLICTS OF INTEREST

The authors had no conflicts of interest to declare in relation to this article.

REFERENCES

1. Hardt S, Schulz MRG, Pfitzner T, et al. Improved early outcome after TKA through an app-based active muscle training programme-a randomized-controlled trial. Knee Surg Sports Traumatol Arthroscopy 2018;26:3429-37.

2. Husby VS, Foss OA, Husby OS, et al. Randomized controlled trial of maximal strength training vs. standard rehabilitation following total knee arthroplasty. Eur J Phys Rehabil Med 2018;54:371-9.
3. Lambert TE, Harvey LA, Avdalis C, et al. An app with remote support achieves better adherence to home exercise programs than paper handouts in people with musculoskeletal conditions: a randomised trial. J Physiother 2017;63:161-7.
4. Tseng MY, Yang CT, Liang J, et al. A family care model for older persons with hip-fracture and cognitive impairment: A randomized controlled trial. Int J Nurs Stud 2021;120:103995.
5. Beinart NA, Goodchild CE, Weinman JA, et al. Individual and intervention-related factors associated with adherence to home exercise in chronic low back pain: a systematic review. Spine J 2013;13:1940-50.
6. Thiengwittayaporn S, Wetpiryakul P, Foosakun Y, et al. Comparison of the accuracy of quadriceps isometric exercise between using quadriceps education device (QED) and not using QED for osteoarthritic knee patients: a randomized controlled trial. J Med Assoc Thai 2009;92 Suppl 6:S33-8.
7. Kubota M, Kokubo Y, Miyazaki T, et al. Effects of knee extension exercise starting within 4 h after total knee arthroplasty. Eur J Orthop Surg Traumatol 2022;32:803-9.
8. Schiavone Panni A, Cerciello S, Vasso M, et al. Stiffness in total knee arthroplasty. J Orthop Traumatol 2009;10:111-8.
9. Maltz M. Psycho-cybernetics. New York, NY: Prentice Hall; 1960.
10. Kauppila AM, Kyllönen E, Ohtonen P, et al. Multidisciplinary rehabilitation after primary total knee arthroplasty: a randomized controlled study of its effects on functional capacity and quality of life. Clin Rehabil 2010;24:398-411.
11. Smith TO, Latham S, Maskrey V, et al. Patients' perceptions of physical activity before and after joint replacement: a systematic review with meta-ethnographic analysis. Postgrad Med J 2015;91:483-91.
12. Thiengwittayaporn S, Wattanapreechanon P, Sakon P, et al. Development of a mobile application to improve exercise accuracy and quality of life in knee osteoarthritis patients: a randomized controlled trial. Arch Orthop Trauma Surg 2023;143:729-38.
13. McGinn T, Chughtai M, Khlopas A, et al. Early outpatient physical therapy may improve range-of-motion in primary total knee arthroplasty. J Knee Surg 2017;30:618-21.

Appendix 1. Example of a logbook-based quadriceps exercise instructions.

แนวทางการกายภาพบำบัดผู้ที่ได้รับการผ่าตัดเปลี่ยน

โดย นพ. แผนกศัลยกรรมกระดูก
เชี่ยวชาญด้านการผ่าตัดข้อเข่าเทียมและข้อสะโพกเทียม
โรงพยาบาล

ข้อเข่าเทียม

1. ให้ผู้ป่วยนั่งที่เก้าอี้หรือเตียง เท้า 2 ข้างแตะถึงพื้น
2. ออกแรงเกร็งกล้ามเนื้อขาข้างที่ผ่าตัดให้เข่าเหยียดตรง
โดยออกแรงเกร็งกล้ามเนื้อค้างไว้ 20 วินาที แล้วคลายกล้ามเนื้อ
3. ทำซ้ำ 10 ครั้งต่อรอบ วันละ 5 รอบ และจดบันทึกในตาราง

ห้ามผู้ป่วยเตะขาหรือแกว่งขาเร็วๆ เพราะข้อเข่าจะเสียดสีกัน

ชื่อ - นามสกุล .....

กรุณาทำเครื่องหมาย O เมื่อท่านได้ออกกำลังกายท่านั้นๆตามจำนวนที่กำหนด

		1 รอบ 08.00 น.	2 รอบ 10.00 น.	3 รอบ 12.00 น.	4 รอบ 14.00 น.	5 รอบ 16.00 น.
1	วัน..... เดือน..... ปี.....	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10
2	วัน..... เดือน..... ปี.....	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10
3	วัน..... เดือน..... ปี.....	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10
4	วัน..... เดือน..... ปี.....	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10
5	วัน..... เดือน..... ปี.....	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10