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## The Effects of Prehabilitation Exercise Using Resistance Bands on Functional Performance in Total Knee Replacement: A Randomized Controlled Trial

Rahmatika <sup>1</sup>, Robin Novriansyah <sup>2</sup>, Lanny Indriastuti <sup>3</sup>

<sup>1</sup>Physical Medicine and Rehabilitation Resident, Faculty of Medicine, Diponegoro University / Dr. Kariadi General Hospital, Semarang

<sup>2</sup>Surgery Department, Dr. Kariadi General Hospital, Semarang

<sup>3</sup>Physical Medicine and Rehabilitation Departement, dr. Kariadi General Hospital, Semarang

## **Abstract**

**Background:** Despite the high success rate of Total Knee Replacement (TKR), there are still patients with permanent dysfunction and a longer period of rehabilitation that interfere with functional performance. Strengthening exercise before TKR namely prehabilitation exercise using resistance bands is expected to optimize the patient's condition before surgery that will increase functional performance after TKR and accelerate rehabilitation programs.

**Methods:** 16 eligible patients were allocated into the treatment group (n=8) and the control group (n=8). The treatment group received 4 weeks of prehabilitation exercise with a frequency of 2 times and one time as a home program. The control group only received conventional therapy. The TUG (Timed Up and Go) and WOMAC (Western Ontario and McMaster Universities Osteoarthritis) scores were measured 3 times; at baseline, after 4 weeks of prehabilitation exercise and at 8 weeks of rehabilitation after TKR.

**Results:** Before the intervention, there were no significant differences between groups for the TUG score (p=0.674) and WOMAC (p=0.928). After 4 weeks of intervention, there was a significant difference in the TUG score (p=0.003) and WOMAC (p=0.002), whereas at 8 weeks after rehabilitation programs there was a significant difference in the TUG score (p=0.009) while for the WOMAC score there was no significant difference (p=0.125).

**Conclusion:** Prehabilitation exercise using resistance band improved functional performances in patients undergone TKR

Keywords: Exercise, Functional Performance, Total Knee Replacement, TUG, WOMAC

Level of Evidence: II



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## Article history

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Faculty of Medicine, Diponegoro University / Dr. Kariadi General Hospital. Jl. Dr. Soetomo 16-18, Semarang 50231, Phone/Fax numbers: (024) 76530017, email:

tikafitria99@gmail.com

### Introduction

Osteoarthritis (OA) is the most common form of arthritis and is a major cause of musculoskeletal pain and disability<sup>1</sup>. Joints that support body weight especially the knee joint are the most commonly affected<sup>2,3</sup>. If conservative therapy in OA fails then the total knee replacement is the right therapeutic choice<sup>4,5</sup>. Despite the high success rate of a total knee replacement, there are still a small number of patients with persistent post-total knee replacement dysfunction that may result in severe functional performance disturbances arising from pain, instability, and the limitation of range of motion<sup>6</sup>. Yercan, et al reported a functional post-total performance disorder knee replacement of 5.3% while Gandhi, et al reported an incidence of 3.7%<sup>7,8</sup>. Pre-operative muscle strength, patient functional ability, and pain level are the main predictors of functional performance post-total knee replacement<sup>9</sup>. A training program like Prehabilitation exercise is expected to contribute to increasing the postoperative outcomes<sup>10</sup>. Prehabilitation exercise is a structured exercise process that optimizes physical functions prior to surgery thereby allowing the individual to maintain normal function levels during and after surgery and achieve faster recovery of functional status during post-operative inactivity<sup>11</sup>.

Prehabilitation exercise in patients undergoing total knee replacement focuses on increasing preoperative muscle strength in the form of resistance training<sup>12</sup>. One form of resistance exercise is by using resistance bands (<sup>®</sup>Theraband). The effect gained using resistance bands is comparable to the effects obtained using other modalities such as leg press and pulley, but resistance bands have several advantages such as portable (easy to carry) and not expensive so that it can be used for the home program, not depend on gravity so it can be used in various patterns of exercise movement in the extremities and body, and safe<sup>13</sup>. So far in our hospital, rehabilitation

programs in TKR patients before surgery are only palliative with the aim of reducing knee pain and stiffness by using physical agents such as TENS (Transcutaneous Electrical Nerve Stimulation), cryotherapy, diathermy, also conventional

physical therapy such as stretching and ROM (Range Of Motion) exercise. There is no exercise

program designed to improve knee function before surgery. Throughout the knowledge of authors, study about prehabilitation exercise before total knee replacement surgery has not been done in Indonesia so we are interested in conducting this pilot study with the aim of knowing the effect of prehabilitation exercise on functional performance in OA patients undergoing TKR.

#### Methods

This study is a randomized controlled trial pre-test and post-test control group design that compares the effect of prehabilitation exercise in OA patients undergoing TKR. The study was conducted from May to September 2019 in the Orthopaedic Clinic and Medical Rehabilitation Installation, dr. Kariadi General Hospital, Semarang, Indonesia, as well as in the patient's house as part of the home training program. Ethical approval was obtained from The Health Research Ethics Committee Dr. Kariadi General Hospital No. 134/EC/KEPK-RSDK/2019. All subjects gave informed consent before participation.

## **Study Population**

Subjects were patients who scheduled to undergo a total knee replacement surgery that meets the criteria of research inclusion, i.e. patients scheduled to unilateral TKR with the cause of the knee OA Grade 3 and 4, aged 55-75 years, BMI (Body Mass Index) 18.5 - 29.9 kg/m2 (Asia Pacific criteria: Normal-Obesity Grade I), Q angle < 14 °, have a good balance (Functional Reach Test > 15 cm), Barthel index > 80, the patient can walk with or without tools, cooperative and willing to participate in the research by signing informed consent, and have communication tools in the form of WhatsApp (message and Video Call) for monitoring home program. The subjects were exluded if the patients are scheduled to second TKR or TKR revision, has a history of heart disease that prevents exercise with moderate intensity, patients with non-sedentary activity levels, history of severe hypertension (blood pressure ≥ 180/120 mmHg), history of uncontrolled Diabetes Mellitus

(blood sugar > 250 mg/dl), the history of either related or unrelated surgery with TKR 3 months earlier, consuming drugs such as nitrate, digitalis or Fenotiazide, MMSE (Mini Mental State Examination) < 24, muscular strength with MMT (Manual Muscle Strength)  $\leq$  4, as well as pain that cannot be tolerated during exercise (Numerical Rating Scale/NRS > 5). Patients categorized drop out if not come follow the schedule of prehabilitation exercise and rehabilitation post-TKR as much as 3 times not sequential or 2 times in sequence and do not come at a preliminary and final assessment of the study.

### Intervention

# Prehabilitation exercise using resistance bands (@Theraband) procedure

Sixteen eligible patients were allocated into the treatment group (n=8) and the control group (n=8). The treatment group received 4 weeks of prehabilitation exercise with a frequency of 2 times at Gymnasium in Medical Rehabilitation Installation, Dr. Kariadi General Hospital supervised by the researcher and one time as a home program. The red color of the resistance band was used in the first week as one set of 10 repetitions of 5 seconds hold and the second week as two sets of 20 repetitions of 5 seconds hold, while the green colour was used in the third week as one set of 10 repetitions of 5 seconds hold and the fourth week as two sets of 20 repetition of 5 seconds hold.

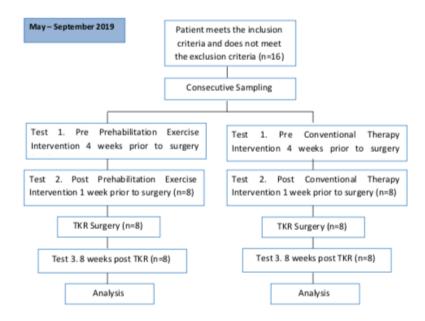


Figure 1. Flowchart of study participants

Subjects were given booklets and training videos in order to carry out home program dan compliance was monitored through videos and photos sent by subjects via WhatsApp application. To ensure that the subjects do the exercises at home correctly, we immediately provide correction for incorrect movements or lack of repetitions after the video was sent. We also conveyed the correction to the families of patients who assist the patients exercising at home. The patient then resends the exercise video that we corrected.

The prehabilitation exercise using resistance bands consist of warming up, squatting, knee curl, hip abduction, hip adduction, hip flexion, hip extension, ankle plantarflexion, ankle dorsoflexion, step up and downstairs, and cooling. The control group only received conventional therapy including knee ROM exercise as five-sets of 10 repetitions and TENS in the affected knee with pulse frequency 150 pps (pulse per second) and pulse duration 80μs for 15 minutes three times a week.

## TKR and Rehabilitation procedure

Surgery was done by a single orthopedic surgeon to uniform the surgical technique. Patients obtain the same analgesic medication before and after the TKR. The patient also underwent the same rehabilitation program protocol as per Clinical Practice Guidelines for rehabilitation after TKR dr. Kariadi General Hospital for 8 weeks<sup>14</sup>.

## Timed Up and Go Test procedure

The TUG test is a test of basic mobility function that is appealing in its simplicity and objective nature. It involves the subject getting up out of a standard height chair (seat height 46 cm, arm height 67 cm), walking safely and comfortably within 3 meters, rotating, walk back to the chair and sit down. The subject was allowed to use a walking aid only if it is not safe or if the patient is unable to complete the test without an assistive device. A stopwatch should be used to time the test (in seconds).

#### Outcomes

Functional performance assessment using Time Up and Go test and WOMAC (Western Ontario and McMaster Universities Osteoarthritis) scores were measured 3 times; At baseline, after 4 weeks of prehabilitation exercise and at 8 weeks after the rehabilitation program. All the outcome measurements were carried out by a physiotherapist blinded to group allocation.

### Sample Size

From the calculation of sample quantities, it takes at least 8 subjects in each treatment and control group. This is based on the sample size formula for the case-control study with numerical scales and related prior study about the effectiveness of prehabilitation exercise for surgical patients<sup>11,15</sup>. The subjects who met criteria were randomly allocated into the treatment and the control groups using consecutive sampling.

### Statistical analysis

Differences before and after treatment between groups for TUG value were using the Mann Whitney U test and in within-group analysis using paired t-test and wilcoxon test. The differences before and after treatment between groups for the functional score of WOMAC were analyzed using the Mann-Whitney U test and independent t-test and in within-group analysis using paired t-test and wilcoxon test. p < 0.05 was considered statistically significant.

Table 1.Demographic Data

|                    | G                  | Group          |                    |
|--------------------|--------------------|----------------|--------------------|
| Variable           | Treatment Group    | Control Group  |                    |
|                    | (n=8)              | (n=8)          |                    |
| Sex                |                    |                |                    |
| Male               | 0 (0%)             | 2 (25%)        | 0,467¥             |
| Female             | 8 (100%)           | 6 (75%)        |                    |
| Age                | 67 (57 – 75)       | 67.5 (56 – 70) | $0.916^{\ddagger}$ |
| ВМІ                | $26.04 \pm 3.67$   | 27.02 ± 2.45   | 0.540 <sup>§</sup> |
| NRS                | 4.25 ± 1.39        | 5.50 ± 1.51    | 0.107§             |
| ROM knee flexion   | $123.13 \pm 17.72$ | 118.13 ± 16.24 | $0.259^{\ddagger}$ |
| ROM knee extension | 3.75 ± 6.94        | 5.63 ± 7.29    | $0.522^{\ddagger}$ |
| TUG                | $15.45 \pm 3.90$   | 20.69 ± 14.85  | $0.674^{\ddagger}$ |
| WOMAC Score        | 51.75 ± 16.73      | 51.00 ± 15.69  | 0.928⁵             |

<sup>¥</sup> Chi-square; <sup>‡</sup> Mann Whitney; <sup>§</sup> Independent t

BMI= Body Mass Index; NRS= Numerical Rating Scale; ROM= Range Of Motion; TUG= Timed Up and Go; WOMAC= Western Ontario and McMaster Universities Osteoarthritis

## Results

At the end of the study, there were 16 patients to be analyzed. There is no subject that neither drops out in this study nor noted any side effects during or after the administration of prehabilitation exercise either reported by the patient or found at the time of examination by the researcher. In this study, there was no significant difference in the beginning before the intervention between the control group and treatment for gender, age, BMI, pain scale measured by NRS, ROM knee flexion, and ROM knee extension. Based on this basic data, it can be said that all subjects are homogenous, and confounding factors can be controlled (Table 1).

After 4 weeks of intervention, there was a significant TUG increase in within-group analysis both in control group and treatment group (p=0.008 and p=0.012 respectively) whereas in between-group analysis there was a significant difference (p=0.003) which showed that

Although there were no significant differences in within-group analysis for treatment group and control group from 1-week pre-op until 8-week post-op, in between-group analysis at 8 weeks post-op there was a significant difference (p=0.009) with treatment group had a better result for TUG test. treatment group can conduct TUG tests in a faster time than the control group. The TUG and WOMAC scores were measured 3 times; at baseline, after 4 weeks of prehabilitation exercise and at 8 weeks of rehabilitation after TKR.

Table 2.Between-group analysis of TUG value

|                                | Group            |               |                    |
|--------------------------------|------------------|---------------|--------------------|
| TUG                            | Treatment Group  | Control Group | p                  |
|                                | (n=8)            | (n=8)         |                    |
| 4 weeks pre-op                 | 15.45 ± 3.90     | 20.69 ± 14.85 | 0.674 <sup>‡</sup> |
| 1- week pre-op                 | $11.28 \pm 2.40$ | 24.41 ± 20.78 | 0.003**            |
| 8 week post-op                 | 10.74 ± 2.30     | 23.09 ± 19.70 | 0.009**            |
| Δ4-1 weeks pre-op              | -4.17 ± 3.26     | 3.72 ± 5.98   | 0.001**            |
| Δ 1 week pre – 8 weeks post-op | -5.4 ± 1.07      | -1.31 ± 2.23  | 0.059 <sup>‡</sup> |
| Δ 4 weeks pre –8 weeks post-op | -4.71 ± 4.14     | 2.41 ± 5.22   | 0.001**            |

<sup>\*</sup> Significant (p < 0.05); \* Mann Whitney

Table 3. Within-group analysis of TUG value

| TUG                             | Group                 |                      |  |
|---------------------------------|-----------------------|----------------------|--|
|                                 | Treatment Group (n=8) | Control Group (n=8)  |  |
| 4 weeks pre op- 1-week pre-op   | 0.008 <sup>¶</sup> *  | 0.012 <sup>†</sup> * |  |
| 1 week pre op – 8 week post-op  | 0.193 <sup>¶</sup>    | 0.123 <sup>†</sup>   |  |
| 4 weeks pre op- 8 weeks post-op | 0.015 <sup>¶</sup> *  | 0.327 <sup>†</sup>   |  |

<sup>\*</sup> Significant (p < 0.05); ¶ Paired t; † Wilcoxon

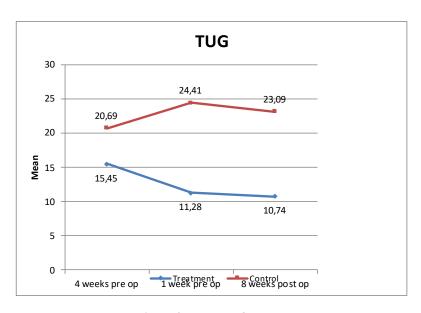


Figure 2. Mean TUG

Table 4.Between-group analysis of WOMAC score

|                                 | Group           |                |                    |  |
|---------------------------------|-----------------|----------------|--------------------|--|
| WOMAC                           | Treatment Group | Control Group  | p                  |  |
|                                 | (n= 8)          | (n= 8)         |                    |  |
| 4 weeks pre-op                  | 51.75 ± 16.73   | 51.00 ± 15.69  | 0.928 <sup>§</sup> |  |
| 1 week pre-op                   | 32.63 ± 7.07    | 48.13 ± 9.22   | 0.0029*            |  |
| 8 weeks post-op                 | 17.88 ± 11.03   | 29.13 ± 16.10  | 0.125 <sup>§</sup> |  |
| Δ4-1 weeks pre-op               | -19.13 ± 15.54  | -2.88 ± 14.95  | 0.051§             |  |
| Δ 1 week pre – 8 weeks post-op  | -14.75 ± 9.00   | -19.00 ± 15.64 | 0.519§             |  |
| Δ 4 weeks pre – 8 weeks post-op | -33.88 ± 19.90  | -21.88 ± 26.99 | 0.329§             |  |

<sup>\*</sup> Significant (p < 0.05); § Independent t; ‡ Mann Whitney

Table 5. Within-group analysis of WOMAC score

| WOMAC                           | Group                |                    |  |
|---------------------------------|----------------------|--------------------|--|
|                                 | Treatment (n=8)      | Control (n=8)      |  |
| 4 weeks pre op- 1-week pre-op   | 0.010¶*              | 0.603 <sup>¶</sup> |  |
| 1-week pre op – 8 weeks post-op | 0.002¶*              | 0.011**            |  |
| 4 weeks pre-op- 8 weeks post-op | 0.002 <sup>¶</sup> * | 0.056 <sup>¶</sup> |  |

<sup>\*</sup> Significant (p < 0.05); ¶ Paired t; † Wilcoxon

The WOMAC score on 1 week of pre-op in between-group analysis is statistically significant (p = 0.002), and the WOMAC score is lower in the treatment group than the control group. It indicates that the treatment group has a better functional score compared to the control group after the prehabilitation exercise with resistance bands.

The analysis of the WOMAC score within-group at 8 weeks showed a significant increase in the treatment group (p = 0.002), however, in between groups analysis showed no significant difference (p= 0.125).

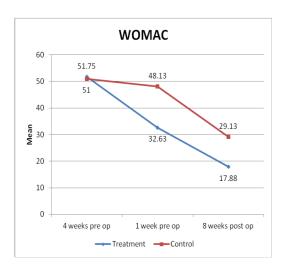


Figure 3. Mean WOMAC score

### Discussion

According to a study conducted by Kennedy, et al minimum detectable change (MDC90) for the value of TUG patients undergoing a total joint arthroplasty in the study with a confidence interval of 90% in the sixth week after surgery was 2.49 seconds<sup>16</sup>. In this study, functional mobility assessment measured by TUG in the treatment group after 4 weeks of prehabilitation exercise with resistance bands showed the difference of TUG value at 4 weeks pre-op up to 1 week pre-op  $(4.17 \pm 3.26 \text{ seconds})$ , the difference in the value of TUG on 1-week preop up to 8 weeks of post-op  $(5.4 \pm 1.07 \text{ seconds})$ and the difference in TUG value at 4 weeks pre-op up to 8 weeks of post-op  $(4.71 \pm 4.14 \text{ seconds})$ which has exceeded 2.49 seconds and achieved MDC90.

The result of this study has similar results with a study conducted by Desmeules, et al who gave prehabilitation exercise for 6 weeks with p < 0.001 with a difference of TUG -4.2 seconds. Desmeules, et al also mention that the TUG value of < 20 seconds indicates good functional mobility, 20-30 seconds indicates moderate functional mobility, and TUG > 30 seconds indicates poor functional mobility obtained in this study was also influenced by other factors such as balance, ROM, flexibility, and muscle strength.

This study showed that Prehabilitation exercise with resistance bands may increase dynamic balance measured by TUG. Cut off point for risk of falling is if TUG ≥ 13.5 seconds, so that in 1-week pre-operation and on 8 weeks post op on the control group is at risk of falling, while the treatment group had low fall risk<sup>18</sup>. The increase of dynamic balance derived from improved flexibility, joint ROM, and propioseptic due to an increase in motor recruitment units that will stimulate the golgi tendon organs and muscle spindles as mechanoreceptors in muscles. Muscle spindle appears to be mostly responsible for providing the joint position sense, whereas the

primary role of the joint receptor is to assist the gamma motor system in regulating muscle tone and stiffness to provide anticipatory postural adjustments and to counteract unexpected postural disturbances and thus decrease the risk of falling<sup>19</sup>.

Insignificant results were obtained for the difference in TUG values between groups at 1week pre-op to 8 weeks post-op (p = 0.059) and the average TUG value in the group (p = 0.193 in the treatment group and p = 0.123 in the control group). This is due to the fact that postoperatively, there are several factors that cause the patient's functional ability has not reached a maximum, including pain, muscle strength especially during flexion movements, ROM limitations, and the process of wound healing. The wound healing process itself consists of four phases, i.e the haemostatic, inflammatory, proliferative, and remodelling phases which can last up to one year. Research conducted by Brandt, et al states that in obesity patients there was leptin deficiency which caused longer wound healing process, whereas most subjects in this study had obesity<sup>20,21</sup>.

The results of the WOMAC functional score assessment between groups at 1-week pre-op showed the treatment group experienced a decrease in WOMAC score (p = 0.002) while in within-group analysis 4 weeks pre-op to 1-week pre-op obtained p = 0.010 in the treatment group and p= 0.603 in the control group. It showed that prehabilitation exercise in the form of resistance training may improve joint integrity and ultimately reduce pain and increase functional activity as described in the WOMAC questionnaire.

The difference in of WOMAC score in between-groups analysis at 4 weeks pre-op to 1-week pre-op showed no significant difference (p = 0.051). It is due to the control group received TENS therapy to reduce pain so that it could affect the pain subscale in the WOMAC questionnaire. Similar results were also obtained in a study conducted by Brown, et al which gave prehabilitation exercise for 4 weeks before surgery and did not find any improvement in post-intervention WOMAC scores<sup>22</sup>.

At 8 weeks postoperatively there were no significant differences in WOMAC scores between groups with p=0.125 as well as differences in achievement of WOMAC scores between groups at 1 week pre-op to 8 weeks post-op with p = 0.519. Similar result was found by Rooks, et al found in their study that showed after 6 weeks of

prehabilitation exercise intervention there was no improvement in WOMAC scores at week 8 and week 26 after surgery<sup>23</sup>.

We assume that at 8 weeks after TKR the subject could perform simple functional mobility as described in the TUG value but still had difficulty in carrying out specific functional activities as described in the WOMAC questionnaire such as going up and downstairs, standing in long period of time, shopping, etc.

This study has several limitations. First, it did not measure changes in muscle strength or muscle diameter, especially the Quadriceps muscle which might affect improvements in functional performances. Second, the number of samples in this study was minimal and originated from one hospital. Larger samples and more hospitals involved in the research are strongly recommended. This study also mentioned the need for specific interventions in the form of individualized post-operative strengthening exercises to improve task specific skill of functional performances and shortened rehabilitation period.

### **Conclusions**

In our study, we found that prehabilitation exercise using resistance bands improved functional performances in TKR patients. We encourage future studies that compares the effectiveness of home programs of prehabilitation exercise using resistance bands to prehabilitation exercise in hospitals using entree or ergocycle. We believe the home program of prehabilitation exercise will be beneficial especially for TKR patients who live far from the hospital and could not attend training sessions at the hospital routinely.

## **Conflict of Interest**

The authors affirm no conflict of interest in this study

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