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by Zanzabil Adwa Fitrian

POST-EXERCISE MASSAGE IMPROVES LOWER-LIMB RANGE OF MOTION FOLLOWING STRENUOUS PHYSICAL ACTIVITY: A RANDOMIZED CONTROLLED TRIAL

Zanzabil Adwa Fitrian[1]
Universitas Medika Suherman, Indonesia[1]
Abil.fitrian09@gmail.com

Abstract
Strenuous physical activity has a negative impact if optimal recovery is not implemented. One effect of Strenuous physical activity is the disruption of joint mobility, known as ROM (range of motion). In this case, it is necessary to implement good recovery, one of which is massage. This study aims to determine the effect of massage on improving joint mobility after strenuous physical activity. The research method used an experimental study with a randomized controlled trial design and a pretest-posttest approach. Data collection in this study used a goniometer to measure the ROM of the lower extremities. The results showed that the intervention group experienced changes in ROM after physical activity ($p < 0.05$), while the control group also experienced changes in ROM after physical activity ($p < 0.05$). Although both groups showed changes, the intervention group improved, while the control group worsened. The difference in posttest values between the two groups was statistically significant ($p < 0.05$). Thus, the study concludes that massage increases ROM after physical activity
Keywords: Massage; Effleurage; tapotement; ROM; Strenouos Physical Activity

INTRODUCTION

Recovery is the process of restoring the body to its normal condition. Good recovery is a process that allows athletes to recover from fatigue caused by training or competition and replenish their energy reserves. If complete recovery has not occurred, athletes may experience chronic fatigue and muscle weakness. High levels of fatigue cause athletes to temporarily or permanently stop exercising (Saba, 2024). Exercise has become an essential part of daily life, as physical activity can improve health and strength, both physically and mentally (Putra et al., 2024). Currently, athletes in most sports train very hard 2-3 times a day. Training can cause physiological and psychological stress in athletes. The same training load, more than three hours of training per day, an increase in training load of more than 30% per week, continuous overload, incorrect training intervals, and lack of rest will increase stress in athletes (Widiawati et al., 2024). In the context of athletes, they generally need optimal physical condition to achieve optimal performance; hence, the need for sufficiently intensive training (Ardiyanto & Sumartiningsih, 2023).

Fatigue due to suboptimal recovery has adverse effects on the body, including muscle pain and decreased motor function, as evidenced by reduced range of motion (ROM; also known as joint range of motion) (Fitrian et al., 2025). A decrease in ROM after exercise can affect performance, increase the risk of injury, and hinder subsequent physical activity (Daneshjoo et al., 2024; Graha et al., 2023). Range of motion (ROM) is defined as the maximum movement possible in a joint. Joint range of motion varies from person to person. It is influenced by gender, age, the presence or absence of disease, and the amount of physical activity a person typically engages in (Adriani & Sary, 2019). In this case, individuals who experience joint flexibility disorders will experience pain and limited movement that interferes with daily activities (Septian & Merijanti, 2018). Thus, individuals who have performed strenuous physical activity will experience decreased flexibility, limiting their ROM, interfering with performance, and increasing the risk of injury, thereby disrupting their daily activities.

To overcome problems and avoid adverse effects after physical activity, effective recovery techniques are needed to restore joint range of motion (ROM) quickly, safely, and measurably. Various studies have shown that several methods can be used to restore ROM after physical activity (Lesmana, 2019). One approach shown to be beneficial is massage therapy, which can help accelerate recovery of musculoskeletal function (Adji et al., 2024). Massage is a recovery technique that involves stroking (effleurage), kneading, and vibration on physical parts of the body (muscles and soft tissues), which provides benefits such as reducing muscle spasms and pain, improving blood circulation, lymphatic drainage, reducing adhesions in muscles and soft tissues, reducing neuromuscular irritability, releasing endorphins, increasing intramuscular warming, boosting the immune system, and promoting relaxation (MacSween et al., 2018). The effects of massage on activity include increased ROM, reduced muscle pain, and accelerated tissue recovery (Graha et al., 2023).

Various studies have reported that sports massage techniques can increase the range of motion (ROM) after physical activity (Ilmi et al., 2018). Based on the explanations and results of previous studies, it is evident that the recovery of body range of motion after physical activity still requires a more effective and straightforward method. Many people, especially those who engage in strenuous activities, need a fast and safe recovery method. Therefore, this study aims to test the effectiveness of applying effleurage and tapotement techniques alone in helping restore the body's range of motion after physical activity.

METHOD

The research method used in this study was an experimental randomized controlled trial. Subjects in this study were recruited based on the following inclusion criteria: active athletes, no injuries, willingness to follow the research protocol from start to finish, and no physical activity for 3 consecutive days. Exclusion criteria were illness or injury. The sample comprised 20 participants, divided into an intervention and a control group. Data collection used a goniometer to measure hip extension, knee flexion, and ankle dorsiflexion. ROM data were measured twice: first, 6 hours after physical activity, followed immediately by a massage combining effleurage and tapotement techniques, and second, immediately after the intervention. The physical activity provided was eccentric exercise, using a circuit-training model with 10 stations featuring explosive movements. Before the pretest, the subjects were given exercises involving strenuous physical activity and eccentric contractions. Data analysis in this study used SPSS Version 30.

RESULT

This section presents the research results in a sequential, systematic manner. The presentation of results begins with a descriptive analysis to illustrate the general characteristics of the research data. Next, a normality test is conducted as a prerequisite for selecting the appropriate statistical test. The next stage is hypothesis testing to determine the intervention’s effect and answer the research questions scientifically.

A. Descriptive Research Data

The research data obtained were in the form of ROM (hip, knee, and ankle joints). The research data were obtained at 6 hours after and immediately after treatment. The hip joint ROM measured was flexion. The knee joint ROM measured was flexion, while the ankle joint was dorsiflexion and plantar flexion. The following is a description of the ROM data for each part.

Table 1. ROM data description

Variabel	Goups	Mean±Pretest	Mean±Posttest	Mean Difference
Right Hip Flexion	Intervention	98.30±10.001	83.00±9.775	15.300
	Control	88.70±14.345	115.40±13.184	-26.700
Left Hip Flexion	Intervention	81.10±10.713	70.50±9.560	10.600
	Control	87.10±14.662	95.80±11.439	-8.700
Right Knee Flexion	Intervention	112.00±13.581	99.90±10.181	12.100
	Control	102.00±9.189	120.00±10.371	-18.000
Left Knee Flexion	Intervention	98.50±17.005	86.00±11.005	12.500
	Control	93.50±22.491	103.00±17.512	-9.500
Right Ankle Dorsiflexion	Intervention	20.70±2.214	17.90±2.132	2.800
	Control	17.40±2.757	20.70±1.636	-3.300
Left Ankle Dorsiflexion	Intervention	18.20±3.615	12.80±2.440	5.400
	Control	17.50±3.598	21.10±3.665	-3.600
Right Ankle Plantaflexion	Intervention	34.70±7.439	28.70±6.165	6.000
	Control	34.00±6.928	38.80±6.746	-4.800
Left Ankle Plantaflexion	Intervention	34.80±7.700	30.90±5.858	5.100
	Control	35.20±6.015	38.80±7.208	-4.400

Based on the table above, it can be seen that the pretest data for the intervention group had an average right leg hip flexion value of 98.30 and left leg of 81.10, right knee flexion of 112.00 and left of 98.50, right ankle dorsiflexion of 20.70 and left ankle dorsiflexion of 18.20, and right plantar flexion of 34.70 and left plantar flexion of 34.80. The pretest data for the control group showed an average right hip flexion value of 88.70. They left hip flexion value of 87.10, right knee flexion value of 102.00, and left knee flexion value of 93.50, right ankle dorsiflexion of 17.40, left ankle dorsiflexion of 17.50, and right ankle plantar flexion of 34.00, left ankle plantar flexion of 35.20. The posttest data for the intervention group showed an average right hip flexion value of 83.00 and left hip flexion of 70.50, right knee flexion of 99.90 and left knee flexion of 86.00, right ankle dorsiflexion of 17.90 and left ankle dorsiflexion of 12.80, and right ankle plantar flexion of 28.70 and left ankle plantar flexion of 29.70. The pretest data for the control group showed an average right hip flexion value of 115.40 and a left hip flexion value of 95.80, a right knee flexion value of 120.00 and a left knee flexion value of 103.00, right ankle dorsiflexion of 20.70 and left ankle dorsiflexion of 21.10, and right plantar flexion of 38.80 and left plantar flexion of 39.60.

Normality test

Before conducting hypothesis testing, data normality was first tested using the Shapiro-Wilk test. The results of the data normality test for each analysis group were analyzed using SPSS version 26 for Windows, with a significance level of 5% (0.05). The data were tested for normality using residual plots. The following summary is presented in the tables below:

Table 2. Test of Normality

Shapiro-Wilk		
ROM	**Group**	**Sig.**
Right Hip Flexion Pretest	Intervention	0.172
	Control	0.257
Left Hip Flexion Pretest	Intervention	0.727
	Control	0.787
Right Knee Flexion Pretest	Intervention	0.609
	Control	0.331
Left Knee Flexion Pretest	Intervention	0.554
	Control	0.292
Right Ankle Dorsiflexion Pretest	Intervention	0.176
	Control	0.378
Left Ankle Dorsiflexion Pretest	Intervention	0.794
	Control	0.194
Right Ankle Plantarflexion Pretest	Intervention	0.218
	Control	0.694
Left Ankle Plantarflexion Pretest	Intervention	0.504
	Control	0.947
Right Hip Flexion Posttest	Intervention	0.555
	Control	0.350
Left Hip Flexion Posttest	Intervention	0.564
	Control	0.091
Right Knee Flexion Posttest	Intervention	0.084
	Control	0.543
Left Knee Flexion Posttest	Intervention	0.079
	Control	0.190
Right Ankle Dorsiflexion Posttest	Intervention	0.594
	Control	0.208
Left Ankle Dorsiflexion Posttest	Intervention	0.051
	Control	0.063
Right Ankle Plantarflexion Posttest	Intervention	0.055
	Control	0.525
Left Ankle Plantarflexion Posttest	Intervention	0.516
	Control	0.816

Based on the results of the Shapiro–Wilk normality test on the Range of Motion (ROM) data, it was found that all significance values in the pretest measurements for both groups, the intervention group and the control group, were above 0.05, indicating that the data were normally distributed. As for the posttest measurements, most variables also showed significance values above 0.05, thus still meeting the normality assumption, namely in right and left hip flexion, right and left knee flexion, right ankle dorsiflexion, and right and left ankle plantar flexion. Although there were two variables in the posttest, namely left ankle dorsiflexion in the intervention group (Sig. 0.051) and the control group (Sig. 0.063), which were close to the significance limit, in general, they could still be considered to be in the category of close to normal distribution. Overall, the test results indicate that the ROM data in both groups, both in the pretest and posttest, meet the assumption of normality, so the analysis can continue using parametric tests.

Homogeneity Test

Before testing the hypothesis, another prerequisite test is performed: the Levene test to determine data variance. The data is homogeneous if the p-value > 0.05. The results of the homogeneity prerequisite test are presented in the following table below:

Table 3. Homogeinity test

ROM	Levene Statistic	df1	df2	Sig.
Right Hip Flexion Pretest	1.565	1	18	0.227
Left Hip Flexion Pretest	1.500	1	18	0.236
Right Knee Flexion Pretest	1.761	1	18	0.201
Left Knee Flexion Pretest	0.534	1	18	0.474
Right Ankle Dorsiflexion Pretest	0.025	1	18	0.877
Left Ankle Dorsiflexion Pretest	0.013	1	18	0.912
Right Ankle Plantarflexion Pretest	0.504	1	18	0612
Left Ankle Plantarflexion Pretest	1.112	1	18	0.121
Right Hip Flexion Posttest	0.738	1	18	0.921
Left Hip Flexion Posttest	0.002	1	18	0.186
Right Knee Flexion Posttest	0.001	1	18	0.487
Left Knee Flexion Posttest	4.705	1	18	0.306
Right Ankle Dorsiflexion Posttest	0.266	1	18	0.402
Left Ankle Dorsiflexion Posttest	2.649	1	18	0.964
Right Ankle Plantarflexion Posttest	0.010	1	18	0.975
Left Ankle Plantarflexion Posttest	0.270	1	18	0.610

Based on the results of the homogeneity test using the Levene Test on the Range of Motion (ROM) data in both groups, it was found that all variables in the pretest measurements showed a significance value (Sig.) greater than 0.05, including Right Hip Flexion (Sig. 0.227), Left Hip Flexion (0.236), Right Knee Flexion (0.201), Left Knee Flexion (0.474), Right Ankle Dorsiflexion (0.877), Left Ankle

Dorsiflexion (0.912), Right Ankle Plantarflexion (0.612), and Left Ankle Plantarflexion (0.121), so it can be concluded that the variance of the two groups is homogeneous. In the posttest measurement, all variables also showed significance values above 0.05, namely Right Hip Flexion (0.921), Left Hip Flexion (0.186), Right Knee Flexion (0.487), Left Knee Flexion (0.306), Right Ankle Dorsiflexion (0.402), Left Ankle Dorsiflexion (0.964), Right Ankle Plantarflexion (0.975), and Left Ankle Plantarflexion (0.610). Overall, the ROM data met the assumption of homogeneity of variance, meaning that the variances between the intervention and control groups were equal, allowing parametric statistical analysis to proceed.

Hypothesis Testing

Based on the results of the basic assumption test, which showed that the data were normally distributed and had homogeneous variance, the analysis could proceed with a parametric hypothesis test to compare ROM changes between the groups. The following describes the paired t-test used to determine whether ROM changed in each group.

Table 4. Pair t-test Intervention Group

Intervention Group	t	df	One-Sided p	Two-Sided p
Right Hip Flexion Pre-Right Hip Flexion Post	-5.381	9	<0,001	<0,001
Left Hip Flexion Pre-Left Hip Flexion Post	-2.893	9	0.009	0.018
Right Knee Flexion Pre-Right Knee Flexion Post	-4.704	9	<0,001	0,001
Left Knee Flexion Pre-Left Knee Flexion Post	-2.578	9	0.015	0.030
Right Ankle Dorsiflexion Pre-Right Ankle Dorsiflexion Post	-3.498	9	0.003	0.007
Left Ankle Dorsiflexion Pre-Left Ankle Dorsiflexion Post	-2.300	9	0.023	0.047
Right Ankle Plantarflexion Pre-Right Ankle Plantarflexion Post	-5.622	9	<0,001	<0,001
Left Ankle Plantarflexion Pre-Left Ankle Plantarflexion Post	-3.592	9	0.003	0.006

Based on the results of statistical analysis using the Paired t-test on the Intervention group, it was found that there were significant changes between the ROM values before (pre-test) and after the intervention (posttest) in several joint range of motion variables. In the Intervention group, significant changes were observed in right hip flexion (t = -5.381; p < 0.001) and left hip flexion (t = -2.893; p = 0.018). In addition, significant increases in ROM also occurred in right knee flexion (t = -4.704; p = 0.001), left knee flexion (t = -2.578; p = 0.030), right ankle dorsiflexion (t = -3.498; p = 0.007), left ankle dorsiflexion (t = -2.300; p = 0.047), right ankle plantarflexion (t = -5.622; p < 0.001), and left ankle plantarflexion (t = -3.592; p = 0.006). The p-values for all variables were less than 0.05, indicating a change in joint range of motion in the intervention group before and after the intervention. In the intervention group, ROM improved, as noted in the mean.

Table 5. Pair t-test Control Group

Control Group	t	df	One-Sided p	Two-Sided p
Right Hip Flexion Pre-Right Hip Flexion Post	3.713	9	0.002	0.005
Left Hip Flexion Pre-Left Hip Flexion Post	2.883	9	0.009	0.018
Right Knee Flexion Pre-Right Knee Flexion Post	3.037	9	0.007	0.014
Left Knee Flexion Pre-Left Knee Flexion Post	2.866	9	0.009	0.019
Right Ankle Dorsiflexion Pre-Right Ankle Dorsiflexion Post	3.562	9	0.003	0.006
Left Ankle Dorsiflexion Pre-Left Ankle Dorsiflexion Post	6.485	9	<0,001	<0,001
Right Ankle Plantarflexion Pre-Right Ankle Plantarflexion Post	6.445	9	<0,001	<0,001
Left Ankle Plantarflexion Pre-Left Ankle Plantarflexion Post	3.117	9	0.006	0.012

Based on the results of statistical analysis using the Paired t-test on the control group, it was found that there were significant changes between the ROM values before (pre-test) and after the intervention (posttest) in several joint range of motion variables. In the control group, significant differences were seen in the right hip flexion variable (t = 3.713; p = 0.005), left hip flexion (t = 2.883; p = 0.018), right knee flexion (t = 3.037; p = 0.014), and left knee flexion (t = 2.866; p = 0.019). In addition, significant results were found for the right ankle dorsiflexion variable (t = 3.562; p = 0.006) and for left ankle dorsiflexion, which showed the most significant increase (t = 6.485; p < 0.001). Furthermore, a significant increase in range of motion was also seen in right ankle plantar flexion (t = 6.445; p < 0.001) and left ankle plantar flexion (t = 3.117; p = 0.012). The p-values for all variables were less than 0.05, indicating a change in joint range of motion from baseline to the post-baseline assessment in the control group. In the intervention group, ROM decreased, as noted in the mean values.

Table 6. Independent t-test

Variable		t	df	One-sided p	Two-sided p	Mean Difference
Right Hip Flexion Posttest	Equal variances assumed	-6.243	18	<,001	<,001	-32.400
	Equal variances not assumed	-6.243	16.599	<,001	<,001	-32.400
Left Hip Flexion Posttest	Equal variances assumed	-5.367	18	<,001	<,001	-25.300
	Equal variances not assumed	-5.367	17.450	<,001	<,001	-25.300
Right Knee Flexion Posttest	Equal variances assumed	-4.374	18	<,001	<,001	-20.100
	Equal variances not assumed	-4.374	17.994	<,001	<,001	-20.100
Left Knee Flexion Posttest	Equal variances assumed	-2.599	18	.009	.018	-17.000
	Equal variances not assumed	-2.599	15.150	.010	.020	-17.000
Right Ankle Dorsiflexion Posttest	Equal variances assumed	-3.295	18	.002	.004	-2.800
	Equal variances not assumed	-3.295	16.873	.002	.004	-2.800
Left Ankle Dorsiflexion Posttest	Equal variances assumed	-5.961	18	<,001	<,001	-8.300
	Equal variances not assumed	-5.961	15.669	<,001	<,001	-8.300
Right Ankle Plantarflexion Posttest	Equal variances assumed	-3.495	18	.001	.003	-10.100
	Equal variances not assumed	-3.495	17.856	.001	.003	-10.100

Variable		t	df	One-sided p	Two-sided p	Mean Difference
Left Ankle Plantarflexion Posttest	Equal variances assumed	-3.789	18	<,001	.001	-9.900
	Equal variances not assumed	-3.789	16.048	<,001	.002	-9.900

The results of the t-test analysis show significant differences in range of motion (ROM) after intervention across all measurement variables. In the right hip flexion measurement, a t-value of -6.243 with $p < 0.001$ indicates a significant increase in ROM with an average difference of -32.40 degrees. The same was observed in left hip flexion with a t-value of -5.367 and $p < 0.001$, with an average difference of -25.30 degrees.

In the right knee flexion joint, a t-value of -4.374 ($p < 0.001$) was obtained, indicating a significant change with a mean difference of -20.10 degrees. Meanwhile, left knee flexion also showed a considerable increase, with a t-value of -2.599 and $p = 0.018$, and an average difference of -17.00 degrees.

At the ankle, the correct dorsiflexion variable showed a t-value of -3.295 ($p = 0.004$). In contrast, the left dorsiflexion variable showed a t-value of -5.961 ($p < 0.001$), indicating a significant increase with a mean difference of -2.80 degrees. The plantar flexion measurements also showed significant results, where right plantar flexion had a t-value of -3.495 with $p = 0.003$ (mean difference -10.10 degrees), and left plantar flexion showed a t-value of -3.789 with $p = 0.001$ (mean difference -9.90 degrees).

Overall, these results indicate that the intervention significantly improved ROM across all joint groups tested, as evidenced by p-values < 0.05 for all variables. The intervention had a strong positive effect on lower extremity flexibility and motor function.

DISCUSSION

Strenuous physical activity will result in significant fatigue. Disorders that arise after strenuous physical activity can reduce muscle strength due to increased muscle stiffness, thereby affecting flexibility and joint range of motion (Armstrong et al., 2021; Ibrahim et al., 2015). Intense exercise forces the muscles to contract continuously, including eccentric contractions, which can cause muscle disorders and movement dysfunction (Baumert et al., 2016). Thus, strenuous physical activity can affect joint flexibility.

This study aims to determine the effect of massage on improving joint mobility after strenuous physical activity. Parametric statistical analysis of the data shows that massage improves joint mobility (ROM) after strenuous physical activity. Based on the results of data analysis, the Sig. The value before and after the intervention group was <0.05, indicating a significant positive change in the intervention group. The study showed that combining effleurage massage and tapotement increased joint mobility after heavy physical activity. At the same time, the control group also showed a significant difference ($p < 0,05$) but experienced negative changes.

Additionally, based on the comparison results between the intervention and control groups, the Sig. The value was also <0.05, indicating a difference in ROM changes between the two groups. Thus, the intervention group showed a strong positive effect on improving flexibility and lower extremity movement function.

These findings indicate that massage-based recovery techniques are effective in reducing muscle tension and improving soft-tissue flexibility, thereby contributing to an optimal increase in joint range of motion after physical activity-induced muscle fatigue (Kholis et al., 2023). The improvement in ROM demonstrated through parametric statistical analysis supports the physiological concept that massage can increase local blood flow, accelerate the removal of exercise metabolites, and reduce muscle spasms. Therefore, these results are consistent with previous studies stating that massage is a safe and effective non-pharmacological recovery method for accelerating musculoskeletal function recovery (Field et al., 2015).

In this study, massage treatment combining effleurage and tapotement had the effect that rhythmic stroking and tapping improved blood and lymph circulation, thereby increasing oxygen supply and providing a relaxing and comfortable effect on the subjects, which triggered the release of endorphins (Darni et al., 2023). The effleurage technique has a positive effect on overcoming DOMS in sore muscles across various parts of the body. It helps eliminate edema or fluid buildup that can exert pressure on tissues and stimulate pain receptors, thereby increasing joint movement limitations The tapotement technique helps loosen connective tissue and fascia that restrict joint movement. At the same time, improved circulation increases the supply of oxygen and nutrients to tissues and accelerates muscle relaxation, thereby enhancing overall joint flexibility (Kurniawan & Kurniawan, 2021). Therefore, the results of this study reinforce previous research findings that massage is one of the recovery methods that can improve ROM after strenuous physical activity.

CONCLUSION

Based on the research and statistical analysis, it can be concluded that massage combining effleurage and tapotement techniques is effective in increasing joint range of motion (ROM) after strenuous physical activity. This intervention provides relaxation effects, improves blood circulation, reduces muscle spasms, and accelerates the elimination of exercise metabolites, thereby reducing muscle tension and stiffness that cause decreased ROM. The significant improvement in the intervention group compared to the control group shows that massage is a safe, non-pharmacological recovery method that can be used as an effective strategy to restore musculoskeletal function after intense exercise. These findings reinforce the evidence that proper recovery management after strenuous physical activity is important for maintaining flexibility, preventing injury, and supporting optimal physical performance.

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