Nat. Volatiles & Essent. Oils, 2021; 8(4): 12299-12314

NVEO
Natural Volatiles & Essential Oils

Walking Analysis Using TFI, PFI, TOA and Q1-Q4 Angles for Sciatic Nerve Function in Sciatic Rat Model Treated with Low-Intensity Aerobics

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Abstract

BACKGROUND: Peripheral nerve injury is one of the neurological diseases that occur in the productive age population. The perceived disturbance from the injury can be chronic and cause a person with peripheral nerve injury to have difficulty in daily activities. Currently, physical exercise such as aerobics is considered to have

benefits for reducing disorders caused by peripheral nerve injuries. But it is necessary to do research to find out how much influence low-intensity physical exercise has on peripheral nerve regeneration.

AIM: This study aims to determine the effect of low-intensity physical exercise therapy on peripheral nerve regeneration through walking analysis.

METHODS: The experimental study used male Sprague Dawley rats which were divided into three groups. Each group was treated with sham surgery (control), peripheral nerve injury with aerobic therapy (P1), and peripheral nerve injury without aerobic therapy (P2). Aerobics is given for 42 days with an intensity of 1 time every week. Furthermore, nerve regeneration was assessed by measuring the Tibial FunctionalIndex (TFI), Peroneal Functional Index (PFI), Toe Out Angle (TOA) and Q1-Q4 angles.

RESULTS: There was a significant change in the P1 group compared to the control on day 14 of the TFI examination, then on the examination of PFI, TOA, and Q1-Q4 angels there was a significant difference on certain days between the P1 and P2 groups with the control group.

CONCLUSION: Low-intensity aerobics can increase the regeneration of the peripheral nerves. Functional improvement due to the process of nerve regeneration appeared to be significant on TFI assessment, especially on day 14.

Funding Source : This work was supported by a grant from Indonesia Ministry of Research, Technology and Higher Education Grant, with contract number NKB-016/UN2.RST/HKP.05.00/2021

Keywords: sciatic nerve, peripheral nerve injury, nerve regeneration, low-intensity aerobics

Introduction

This experiment was done in order to analyzed the effect of low intensity aerobics on the repair of the peripheral nerve. Repair after aerobic administration is to determine the values of TFI, PFI, TOA, and Q1-Q4. The data from the TFI analysis are shown in the experimental animals used in this study were rats of the Sprague Dawley type. Making a peripheral nerve injury model by pinching the sciatic nerve originating from L4-L5.[1]The treatment made in this study is to provide peripheral nerve injury, namely the sciatic nerve in the left lower leg. Pinching causing lesions or damage to the sciatic nerve will result in walking difficulty for the rats. One of the characteristics of the damage to the sciatic nerve is the presence of foot drop on the sole and high stepping gait. When the healing characteristic of each

specimen is looked at in the experiment, the results found can determine the values of TFI, PFI, TOA, and Q1-Q4. in this experiment, we were able to use the Sprague daily type of rats to amicable conduct an experiment on how their recovery after experiencing a peripheral nerve injury. Aerobic methods did this healing. The results found were then tabulated into various categories that will be analyzed later in this particular report. All the analysis methods that were used including, TFI, PFI, TOA, and Q1-Q4. The report will also outline the various methods through which the data was collected in order to prove its integrity. Lastly, the report will discuss these findings in a bid to analyze the results and look at what methods used in the experiment provided the fastest and best recovery method. The data will show which rats could regain their normal mode of walking faster after injuring their peripheral nerve and which treatment model was used to achieve this.

Methods

The method used in this experiment was the observation method. The researchers were able to observe the test subjects over some time. During this period, they were able to watch the various changes that progressively took part in the rats, and they were able to record this data down. The experiment starts by injuring the lab rats, causing leg injuries that are bound to heal over time.

Fig.1 Castroviejo needle holder

The rats used in this study were male Sprague Dawley rats, weight ranged from 250-300g, and 2-3 months old. The rats were divided into 3 groups with details of the first group being the control group where only sham surgery was performed, the second group was the sciatica model rats, and the last group was the sciatica model rats and aerobic treatment. Prior to surgery, the rats was anesthetized using ketamine 100 mg/kg and 10 mg/kg Xylazine by intraperitoneal (ip) injection.[2] The experimental animals were made by making an incision on the inferior side of the os. femoris of the rat's left leg proximal to the knee joint. Then the identification of the sciatic nerve or sciatic nerve and the sural nerve or sural nerve. After that, the researcher separated the sciatic nerve from the surrounding muscle

tissue and then clamped the sciatic nerve for 4 minutes using a Castroviejo needle holder as shown at Fig.1. After clamping for 4 minutes, the skin of the mice was sutured using ethicon® coated vicryl sterile 8-0 suture with a simple interrupted suture technique.[3]

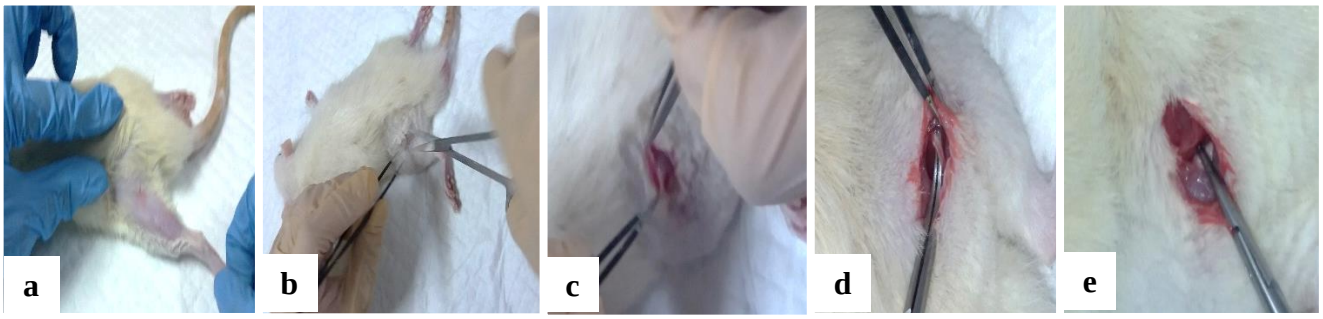
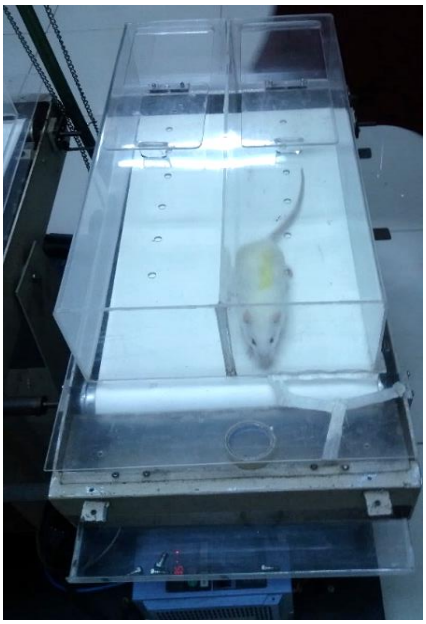


Fig.2. Process make sciatic injury (a. identification os.femoris and os.patella, b.incision in skin rat c.blunt dissection d.identification nerve sciatic e.pinch nerve sciatic)

In group 3, namely the aerobic treatment group, rats were given aerobic exercise, namely walking on a treadmill for 60 minutes with a 5-minute warm-up using a specially modified treadmill for rats with a speed of 10 meters/minute at shown at fig.3.Aerobic treatment is done 5 times a week for 4 weeks.

After this happens, it will ultimately result in the Rats having difficulties walking around. This new difficulty is caused by a foot drop or a high stepping gait in how the Rat moves around. Analyzes of the effects of peripheral nerve repair after aerobic administration determine the values of TFI, PFI, TOA, and Q1-Q4. in the next couple of weeks, this analysis is done. The rats are subjected to various conditions through which they are monitored, and the results on their healing progress are taken down, over as long as 14 weeks. This observable data is taken down. We get to see that the data provided was consistent and the healing processes of the Rats were correctly determined, with each rat's milestone being adequately documented in a manner that made sure the experiment had integrity and that the data found provided the correct analysis outcomes.

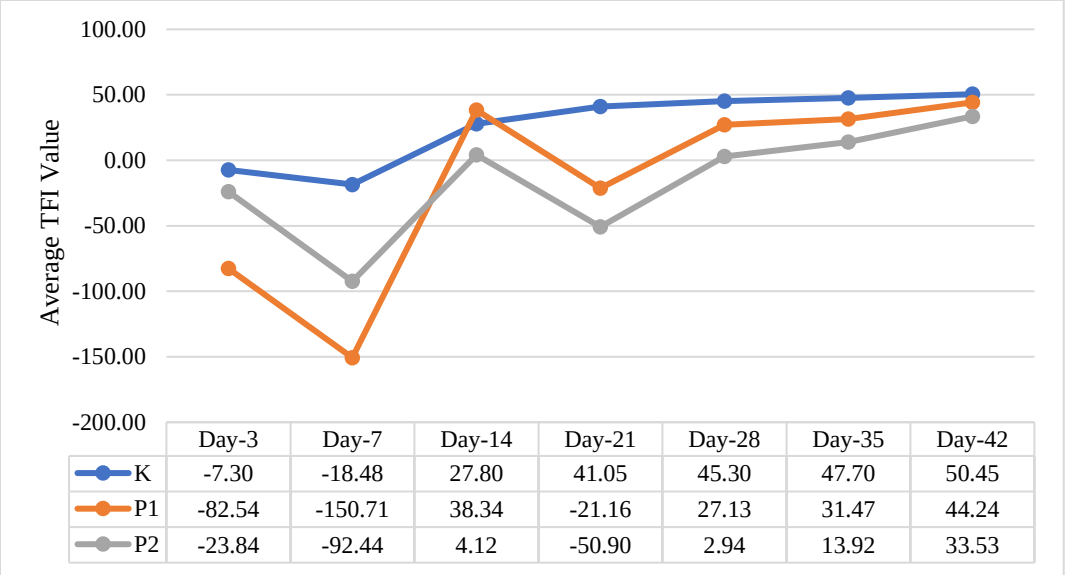
Fig.3 Treadmill for rat



Results

TFI Data Results

Experimental animals in this study were rats of Sprague Dawley type. Making a peripheral nerve injury model by pinching the sciatic nerve originating from L4-L5.[1]The treatment made in this study is to provide peripheral nerve injury, namely the sciatic nerve in the left lower leg. Pinching causing lesions or damage to the sciatic nerve will result in walking difficulty for the rats. One of the characteristics of the damage to the sciatic nerve is the presence of foot drop on the sole and high stepping gait.[4]High-stepping gait is the inability to lift the foot when walking due to muscle weakness.[5]Besides, peripheral nerve injury results in walking difficulty on the heel. This is caused by weak muscles in dorsiflexion so that the rat will drag the injured leg on the floor. Analyzes of the effects of peripheral nerve repair after aerobic administration are to determine the values of TFI, PFI, TOA, and Q1-Q4. The data from the TFI analysis are shown in Figure 4.



	Day-3	Day-7	Day-14	Day-21	Day-28	Day-35	Day-42
K	-7.30	-18.48	27.80	41.05	45.30	47.70	50.45
P1	-82.54	-150.71	38.34	-21.16	27.13	31.47	44.24
P2	-23.84	-92.44	4.12	-50.90	2.94	13.92	33.53

Figure 4: TFI values for each treatment on Day 3 to Day 42. K, control group; P1, injury treatment group with aerobics; P2, non-aerobic injury treatment group

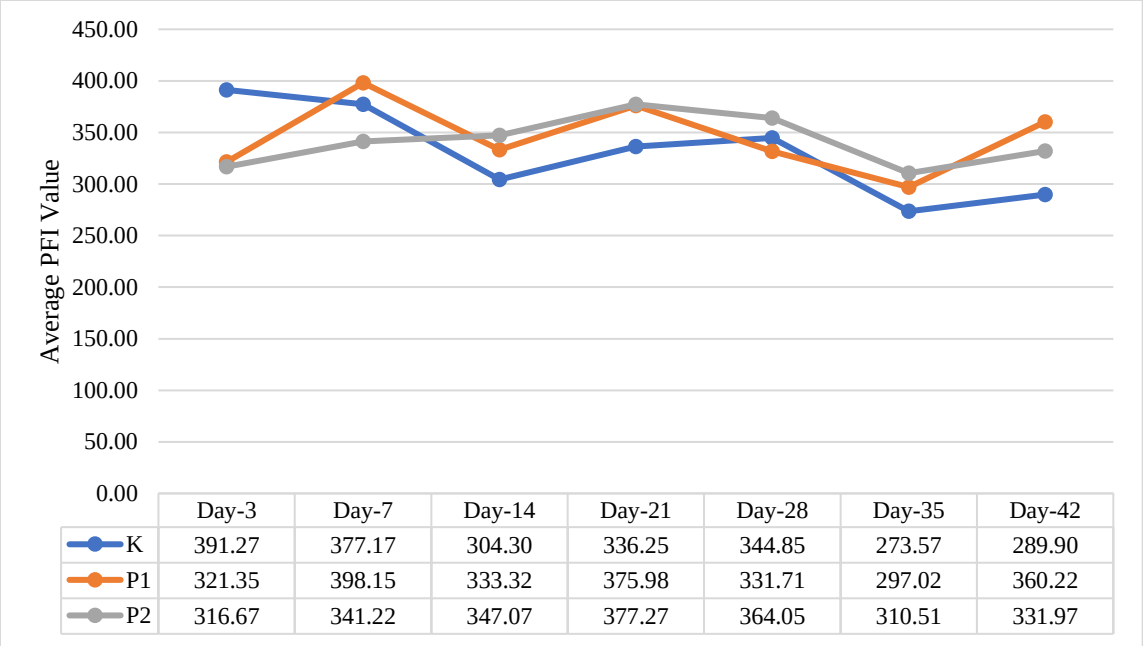
The normal value on TFI is indicated by a number close to -10. This shows that this value is close to the normal function of the rat's gait. Meanwhile, -100 indicates a complete function loss of the rat's gait. TFI data for each treatment on day 3 to day 42 are shown in Table 1.

Table 1: Results analysis of TFI values for each treatment on Day 3 to Day 42

Days	Research Group		
	K	P1	P2
3	Normal	Abnormal	Abnormal
7	Normal	Abnormal	Abnormal
14	Normal	Normal	Normal
21	Normal	Normal	Normal
28	Normal	Normal	Normal
35	Normal	Normal	Normal
42	Normal	Normal	Normal

PFI Data Results

PFI data for each treatment on Day 3 to Day 42 are shown in Table 2. The table data from the analysis of TFI values for each treatment on Day 3 to Day 42 are shown in Table 2.



	Day-3	Day-7	Day-14	Day-21	Day-28	Day-35	Day-42
K	391.27	377.17	304.30	336.25	344.85	273.57	289.90
P1	321.35	398.15	333.32	375.98	331.71	297.02	360.22
P2	316.67	341.22	347.07	377.27	364.05	310.51	331.97

Figure 5: PFI values for each treatment on Day 3 to Day 42. K, control group; P1, injury treatment group with aerobics; P2, non-aerobic injury treatment group

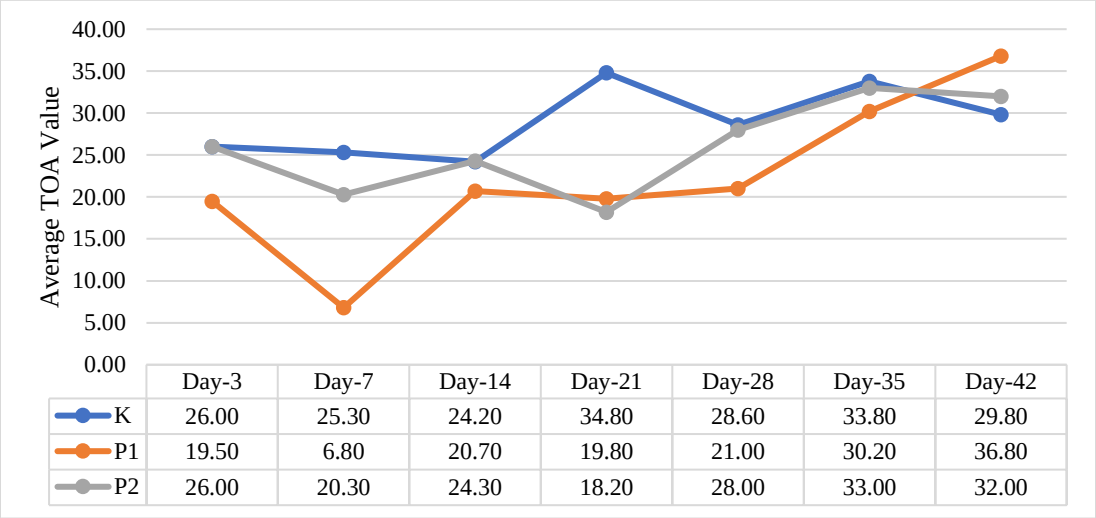
Table 2: Results analysis of TFI values for each treatment on Day 3 to Day 42

Days	Each treatment average		
	K	P1	P2
3	391,27	321,35	316,67
7	377,17	398,15	341,22
14	304,30	333,32	347,07
21	336,25	375,98	377,27
28	344,85	331,71	364,05
35	273,57	297,02	310,51
42	289,90	360,22	331,97

TOA Data Results

TOA data for each treatment on Day 3 to Day 42 are shown in Table 3. The table data from the TOA values for each treatment from Day 3 to Day 42 are shown in Table 3. TOA data results show no significant difference on Days 3, 14, 28, k2-35, and 42 ($p>0.05$; one-way ANOVA). However, on Day 7, there are significantly different results in the P1 group compared to the control group ($p=0.00001$; one-

way ANOVA). On Day 21, there is a significant difference between the control group and P1 group (p=0.014; one-way ANOVA), and P2 (p=0.019; one-way ANOVA). This shows that TOA values in the control group are higher than P1 and P2 groups.



	Day-3	Day-7	Day-14	Day-21	Day-28	Day-35	Day-42
K	26.00	25.30	24.20	34.80	28.60	33.80	29.80
P1	19.50	6.80	20.70	19.80	21.00	30.20	36.80
P2	26.00	20.30	24.30	18.20	28.00	33.00	32.00

Figure 6: TOA values for each treatment on Day 3 to Day 42. K, control group; P1, injury treatment group with aerobics; P2, non-aerobic injury treatment group

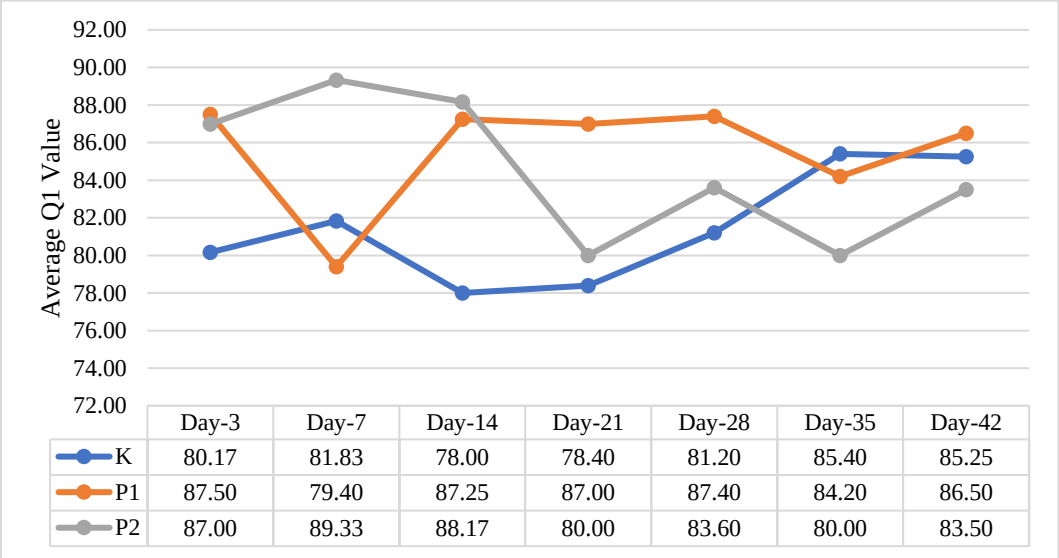
Table 3: Results analysis of TOA values for each treatment on Day 3 to Day 42

Days	Each treatment average		
	K	P1	P2
Day-3	26,00	19,50	26,00
Day-7	25,30	6,80	20,30
Day-14	24,20	20,70	24,30
Day-21	34,80	19,80	18,20
Day-28	28,60	21,00	28,00
Day-35	33,80	30,20	33,00
Day-42	29,80	36,80	32,00

Q1-Q4 Angles Data Results

Q1 data for each treatment on Day 3 to Day 42 are shown in Table 4. The table data from analysis results of Q1 values for each treatment on Day 3 to Day 42 are shown in Table 4. Calculation of values of Q1, Q2, Q3, and Q4 are conducted by measuring the angle on the sole treated with peripheral nerve injury.

The results on the measurement of Q1 values in P1 and P2 groups on Days 3, 7, 21, 28, 35, and 42 show results that are not significantly different from the control group. However, on Day 14, there is a significant difference between the control group and P1 group (p=0.04; one-way ANOVA) and P2 (p=0.02; one-way ANOVA). This indicates a change in the values of Q1 in the P1 and P2 groups (p>0.05; one-way ANOVA).



	Day-3	Day-7	Day-14	Day-21	Day-28	Day-35	Day-42
K	80.17	81.83	78.00	78.40	81.20	85.40	85.25
P1	87.50	79.40	87.25	87.00	87.40	84.20	86.50
P2	87.00	89.33	88.17	80.00	83.60	80.00	83.50

Figure 4: Q1 values for each treatment on Day 3 to Day 42. K, control group; P1, injury treatment group with aerobics; P2, non-aerobic injury treatment group

Table 4: Results analysis of Q1 values for each treatment on Day 3 to Day 42

Days	Each treatment average		
	K	P1	P2
Day-3	80,17	87,50	87,00
Day-7	81,83	79,40	89,33
Day-14	78,00	87,25	88,17
Day-21	78,40	87,00	80,00
Day-28	81,20	87,40	83,60
Day-35	85,40	84,20	80,00
Day-42	85,25	86,50	83,50

Q2 data for each treatment on Day 3 to Day 42 are shown in Table 5. Table data from the analysis of Q2 values for each treatment on Day 3 to Day 42 are shown in table 5. Table data from results analysis of

Q2 values for each treatment on Day 3 to Day 42 are shown in Table 4. Results data of Q2 values on Day 14 indicate there are significant differences between the control group and P1 group (p=0.04; one-way ANOVA) and the P2 group (p =0.02; one-way ANOVA). This indicates a change in Q1 values of the P1 and P2 groups. However, the results of the measurement of Q1 values in P1 and P2 groups on Days 3, 7, 21, 28, 35, and 42 show results that are not significantly different from the control group (p >0.05; one-way ANOVA).

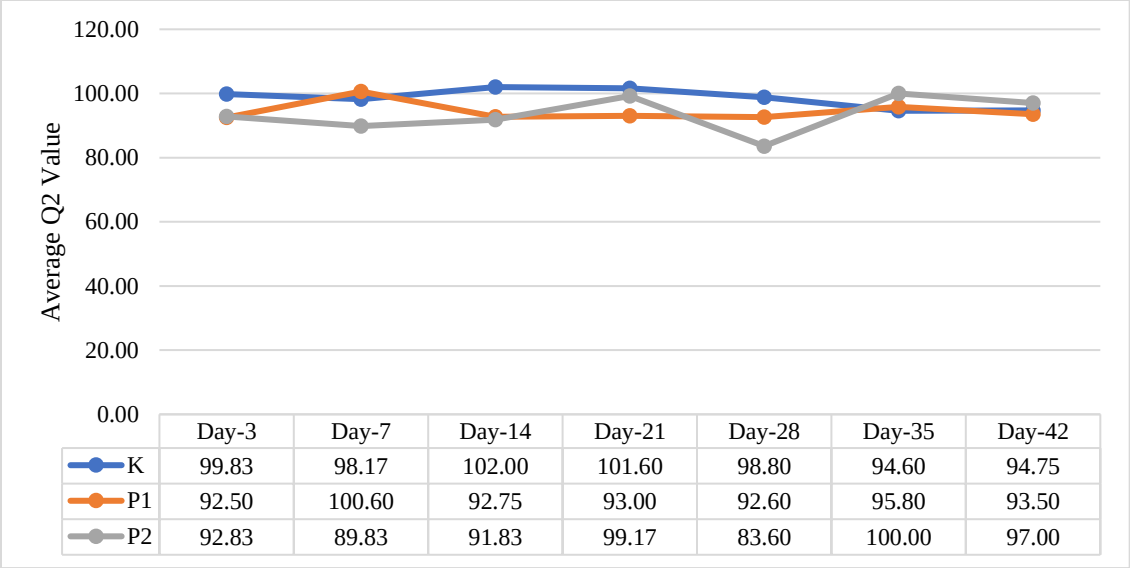


Figure 5: Q2 values for each treatment on Day 3 to Day 42. K, control group; P1, injury treatment group with aerobics; P2, non-aerobic injury treatment group

Table 5: Results analysis of Q2 values for each treatment on Day 3 to Day 42

Days	Each treatment average		
	K	P1	P2
Day-3	99,83	92,50	92,83
Day-7	98,17	100,60	89,83
Day-14	102	92,75	91,83
Day-21	101,60	93	99,17
Day-28	98,80	92,60	83,60
Day-35	94,60	95,80	100
Day-42	94,75	93,50	97

Q3 data for each treatment on Day 3 to Day 42 are shown in Table 6. Table data on the analysis of the result of Q3 values for each treatment on Day 3 to Day 42 are shown in Table 6. Results of treatment to the model rat with peripheral nerve injury give a significant difference in Q3 values of the P1 group (p=0.02; one-way ANOVA) and P2 group (p=0.02; one-way ANOVA) against the control group on Day 14. However, on Days 3, 7, 21, 28, 35, and 42, the results are not significantly different from the control group (p>0.05; one-way ANOVA).

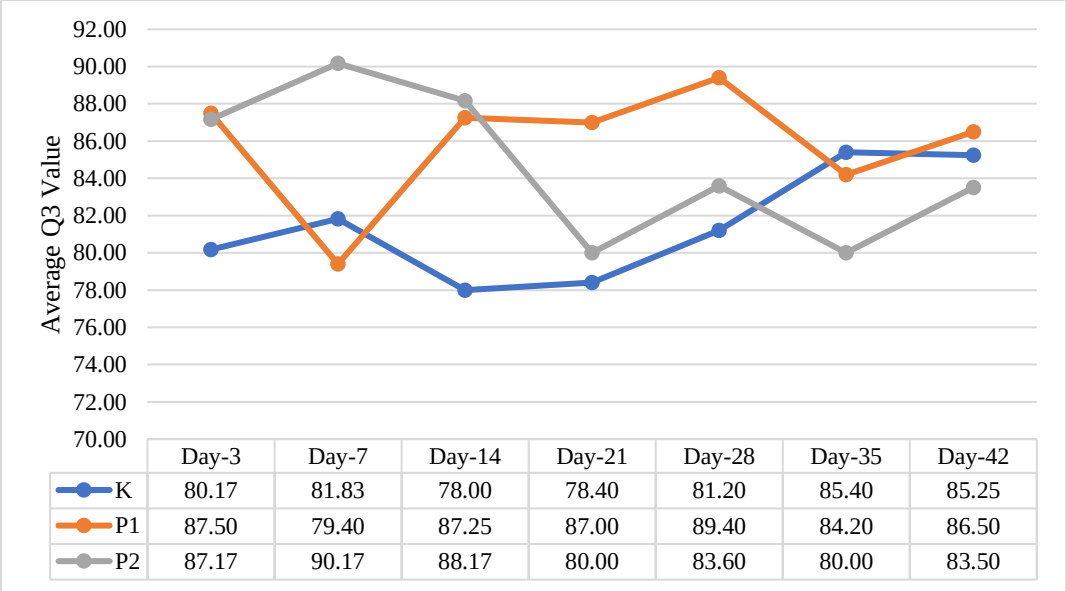
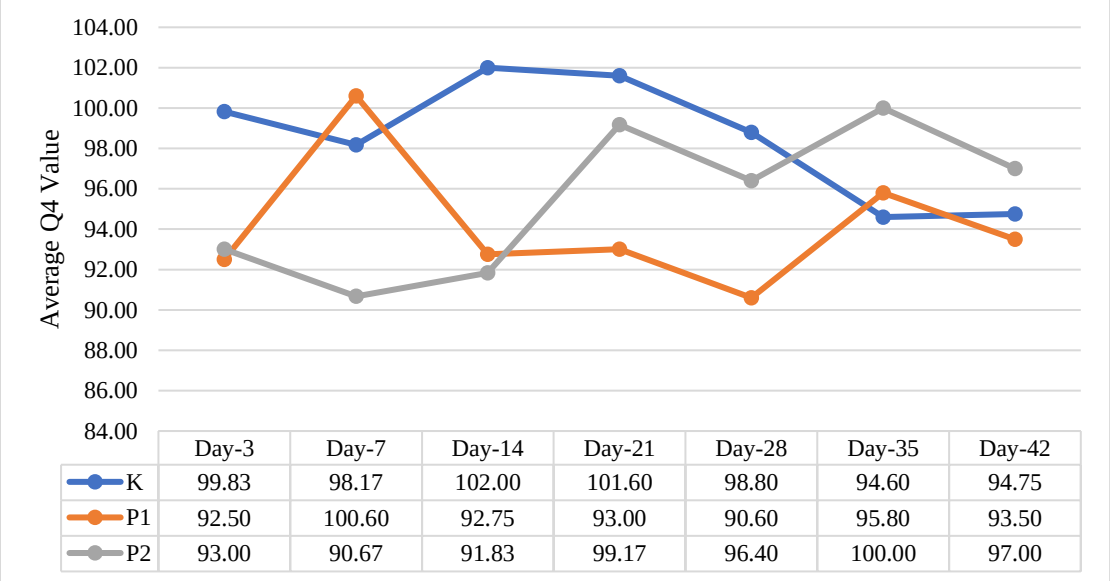


Figure 6: Q3 values for each treatment on Day 3 to Day 42. K, control group; P1, injury treatment group with aerobics; P2, non-aerobic injury treatment group

Table 6: Results analysis of Q3 values for each treatment on Day 3 to Day 42

Days	Each treatment average		
	K	P1	P2
Day-3	80,17	87,50	87,17
Day-7	81,83	79,40	90,17
Day-14	78,00	87,25	88,17
Day-21	78,48	87,00	80,00
Day-28	81,20	89,40	83,60
Day-35	85,40	84,20	80,00
Day-42	85,25	86,50	83,50

Q4 data for each treatment on Day 3 to Day 42 are shown in Table 7. Table data on the analysis of the result of Q4 values for each treatment on Day 3 to Day 42 are shown in Table 7. The same results are shown in Q4 values. On Day 14, there is a significant difference between the P1 group (p=0.02; one-way ANOVA) and the P2 group (p=0.02; one-way ANOVA) against the control group. However, on Days 3, 7, 21, 28, 35, and 42, the results are not significantly different from the control group (p>0.05; one-way ANOVA).



	Day-3	Day-7	Day-14	Day-21	Day-28	Day-35	Day-42
K	99.83	98.17	102.00	101.60	98.80	94.60	94.75
P1	92.50	100.60	92.75	93.00	90.60	95.80	93.50
P2	93.00	90.67	91.83	99.17	96.40	100.00	97.00

Figure 7: Q4 values for each treatment on Day 3 to Day 42. K, control group; P1, injury treatment group with aerobics; P2, non-aerobic injury treatment group

Table 7: Results analysis of Q4 values for each treatment on Day 3 to Day 42

Days	Each treatment average		
	K	P1	P2
Day-3	99,83	92,50	93,00
Day-7	98,17	100,60	90,67
Day-14	102,00	92,75	91,83
Day-21	101,60	93,00	99,17
Day-28	98,80	90,60	96,40
Day-35	94,60	95,80	100,00
Day-42	94,75	93,50	97,00

The results of the values of Q1 to Q4 in the P1 and P2 groups, which show insignificant results against the control group, indicate that the tibial nervous function recovers faster than the peroneal.

Discussion

The normal value on TFI is indicated by a number close to -10.[6] This shows that this value is close to the normal function of the rat's gait. Meanwhile, -100 indicates a complete function loss of the rat's gait. TFI data for each treatment on day 3 to day 42 are shown in Table. With this data, we can see the TFI values for each treatment on Day 3 to Day 42. K, control group; P1, injury treatment group with aerobics; P2, non-aerobic injury treatment group show that after day 14, the P1 group taking part in the experiment became healed faster when compared to the other groups. this is turn, is a major milestone in relation to aerobic treatment as it shows the nature of its abilities and the numerous applications that the treatment can be put to in real-life situations.

In the second experiment, TOA, data for each treatment on Day 3 to Day 42 are shown in Table 3. TOA data results show no significant difference on Days 3, 14, 28, k2-35, and 42 ($p>0.05$; one-way ANOVA). However, on Day 7, there are significantly different results in the P1 group compared to the control group ($p=0.00001$; one-way ANOVA). On Day 21, there is a significant difference between the control group and P1 group ($p=0.014$; one-way ANOVA) and P2 ($p=0.019$; one-way ANOVA). This shows that TOA values in the control group are higher than P1 and P2 groups. This, in turn, tries to show the manner through which the Rats are healing by the use of the TOA method.[7] As per the data, we see that there was no significant difference between the Rats on certain dates of the experiment as compared to other dates when there was a noted difference between the three test groups, which are the control group, test injury group with aerobics, and the non-aerobic injury treatment group. When we look at the days where there were noted changes, such as on the 3,14 and 28 days, it shows that TOA as a treatment method works in stages, and on certain days, the Rats may not experience any significant changes in the healing of their injuries. But over time, the rats show changes, with the Rats in test group P1 where their injuries were being treated via aerobics, showing the fastest healing rate amongst all other test groups.

When we look at the third set of results. From Q1 to Q4. Data for each treatment on Day 3 to Day 42 are shown in Table 4. The table data from analysis results of Q1 values for each treatment on Day 3 to Day 42 are shown in Table 4. Calculation of values of Q1, Q2, Q3, and Q4 are conducted by measuring the angle on the sole treated with peripheral nerve injury.[8] The results on the measurement

of Q1 values in P1 and P2 groups on Days 3, 7, 21, 28, 35, and 42 show results that are not significantly different from the control group. However, on Day 14, there is a significant difference between the control group and P1 group (p=0.04; one-way ANOVA) and P2 (p=0.02; one-way ANOVA). This indicates a change in the values of Q1 in the P1 and P2 groups (p>0.05; one-way ANOVA).Q2 data for each treatment on Day 3 to Day 42 are shown in Table 5. Table data from the analysis of Q2 values for each treatment on Day 3 to Day 42 are shown in table 5. Table data from results analysis of Q2 values for each treatment on Day 3 to Day 42 are shown in Table 4. Results data of Q2 values on Day 14 indicate there are significant differences between the control group and P1 group (p=0.04; one-way ANOVA) and the P2 group (p =0.02; one-way ANOVA). This indicates a change in Q1 values of the P1 and P2 groups. However, the results of the measurement of Q1 values in P1 and P2 groups on Days 3, 7, 21, 28, 35, and 42 show results that are not significantly different from the control group (p >0.05; one-way ANOVA). Q3 data for each treatment on Day 3 to Day 42 are shown in Table 6. Table data on the analysis of the result of Q3 values for each treatment on Day 3 to Day 42 are shown in Table 6. Results of treatment to the model rat with peripheral nerve injury give a significant difference in Q3 values of the P1 group (p=0.02; one-way ANOVA) and P2 group (p=0.02; one-way ANOVA) against the control group on Day 14. However, on Days 3, 7, 21, 28, 35, and 42, the results are not significantly different from the control group (p>0.05; one-way ANOVA). Q4 data for each treatment on Day 3 to Day 42 are shown in Table 7. Table data on the analysis of the result of Q4 values for each treatment on Day 3 to Day 42 are shown in Table 7. The same results are shown in Q4 values. On Day 14, there is a significant difference between the P1 group (p=0.02; one-way ANOVA) and the P2 group (p=0.02; one-way ANOVA) against the control group. However, on Days 3, 7, 21, 28, 35, and 42, the results are not significantly different from the control group (p>0.05; one-way ANOVA).

When all four sets of data are analyzed, it is evident that only Q4 could display a significant amount of data change in the experiment. For instance, we see that in the first set of data Q1, the test group and the injury groups were able to show little results through the whole 42-day period. the injured rats in group P1 and P2 also showed no significant and outright betterment in their injuries, with as much as the 42 days going by in order for the rats to show a significant increase in their health, thus losing the gait caused by peripheral nerve damage. The resultsare the sameboth, test group Q2 and Q3, with significant changes between the control group and the injured rats being witnessed in Q4. this showed that the treatment process used in Q4 was way better compared to the other processes. here we see that on day 14, there is significant change between the control group and the injured rats in P1

and P2. the aerobic healed rats are also able to show faster healing when compared to the other rats in P2.

Conclusion and Recommendation

In conclusion we see that Researchers did the experiment to determine the effect of low-intensity aerobics on the repair of the peripheral nerve. The test subjects for the experiment were rats. The researchers experimented to determine the values of TFI, PFI, TOA, and Q1-Q4. Here we see that the rats got separated into various categories. One category had normal rats with no injuries, another type had injured rats treated using low-intensity aerobics, and the last variety had rats that were to heal naturally by themselves. By studying the various healing processes, the rats were subjected to and comparing them to the control group, looking to see the periods through which certain changes will occur. The injured rats will regain their correct walking gait, thus signifying that the healing method completely healed the rat's peripheral nerve. From the experiment, we have concluded that the TFI method provided the fastest healing to both the P1 and P2 groups. In this category, the rats were able to quickly heal from their injuries in a period of less than two weeks. This is in sharp contrast with the other treatment methods. In the other three treatment methods, PFI, TOA, Q1-Q4. The healing process was significantly slower, with many rats not showing complete healing even after seven weeks of being treated. In all the four-part experiment series, we noted that low-intensity aerobic treatment worked well in all the circumstances compared to natural healing. The rats treated with the low aerobic treatment healed faster when compared to the other rats that did not get the same treatment but had similar injuries. This, in essence, shows that researchers can use low-intensity aerobics to treat damaged nerve function when it is carefully done to patients, just like it happened in the lab-controlled experiment.

Acknowledgements

We would like to thank Penelitian Dasar from the Indonesia Ministry of Research, Technology, and Higher Education for funding this research under contract number NKB-016/UN2.RST/HKP.05.00/2021

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