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ORIGINAL ARTICLE

EFFECTS OF PROPRIOCEPTIVE NEUROMUSCULAR FACILITATION (PNF) ON CARDIOVASCULAR RESPONSES ON YOUNG ADULTS.

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Abstract

Background: Proprioceptive neuromuscular facilitation (PNF) is being a preferred method as one of the treatment plans to improve patient's well-being by several physiotherapist in Malaysia. PNF is a stretching technique that has been practiced in improving the muscle elasticity, increasing the muscle thickness, dynamic balance and producing positive effects on active and passive range of motions.
Objective: The present study aimed to investigate the short-term effects of PNF stretching exercises on blood pressure & heart rate among young adults.
Methods: 50 subjects underwent the hold-relax PNF stretching exercise for upper limbs (biceps muscle) and lower limbs (hamstring muscle). All subjects were assigned to conduct 4 sets of a combination of passive movement, isometric contraction and passive stretching for both upper and lower limbs. Preliminary data (before exercise) and post-data (after exercise) for heart rate and blood pressure were measured and recorded.
Results: A paired samples t-test was performed to compare lower limb pre-testing (SBP_LL_pretest) and post-testing (SBP_LL_posttest). The results showed that, there was a significant difference in the scores for SBP_LL_pretest (M=114.98, SD=8.714) and SBP_LL_posttest (M=118.86, SD=9.94); t (49) =-2.28, p=0.027.
Conclusion: There was no significant difference for heart rate and diastolic blood pressure. However, significant changes present in systolic blood pressure of the participants/subjects.

Keywords: Proprioceptive Neuromuscular Facilitation (PNF), Cardiovascular, Heart Rate, Blood Pressure.

Introduction

Rehabilitation is one of the therapy forms for the chronic stroke patients who had suffered muscle tightness. Some researchers claimed that the exaggerated reflexes of spasticity in chronic stroke patients lead to muscle contracture.[1] [2] Several physiotherapists in Malaysia used proprioceptive neuromuscular facilitation (PNF) as one of their treatment plans to improve patient's well-being. There are many different rehabilitation approaches used to treat this condition such as proprioceptive neuromuscular facilitation (PNF) and strengthening exercises that have been developed to re-educate the muscles and spasticity especially for stroke patient.[3]

Proprioceptive neuromuscular facilitation (PNF) and strengthening exercises are the major therapeutic approaches that aimed at improving the important feature which is necessary for the functional ambulation of hemiplegic patient, such as muscular tone, strength, and flexibility.[4] PNF stretching exercise is widely believed may resulted in increased range of motion compared to static stretching acquired from increased inhibition of the targeted muscle. In a recent research in determining the effectiveness between proprioceptive neuromuscular facilitation and static stretching for increasing hamstring muscle extensibility in an active population, it was shown that there is no significant difference in regard to the effectiveness between PNF stretching exercises and static stretching exercises.[5]

Hold-relax technique is one of the PNF stretching exercises that is commonly used for the purpose of increasing muscular extensibility and range of motion. Unlike static stretching, hold-relax technique consists of passive movement to the specific position, isometric contraction of the target muscles and passive stretching technique performed in the specific time to complete one set of hold-relax exercise. The term isometric contraction has been used to describe the development of a pressure overload caused by pulsatile contraction resulting a significant increase in muscle blood flow on cardiovascular system.[6] A strong relationship between isometric contraction with heart rate, systolic blood pressure and diastolic blood pressure has been reported in this literature.

Proprioceptive Neuromuscular Facilitation (PNF) is a stretching technique that has been shown to improve muscle elasticity, muscle thickness, dynamic balance, and to have a positive effect on active and passive range of motion. This PNF method is effective for the rehabilitation of the upper limbs in stroke patients.[7] However, there are few studies that correlate between the PNF techniques in the stroke rehabilitation with the cardiovascular function. Therefore, the main objective of this study is to determine the effects of PNF stretching on cardiovascular responses among normal young adults.

Methodology

Participants

The sample population for this study is 50 Universiti Kuala Lumpur Royal College of Medicine Perak (UniKL RCMP) students aged between 18 - 25 years old. They agreed to be involved for this study based on their normal BMI and they had undergone PNF stretching exercises. The participants who have history of any injuries of upper and lower limbs, history of cardiovascular diseases, respiration pathology and Active smoker are excluded from this study.

Procedure

All participants' blood pressure and heart rates are recorded once as pre-data prior to the study. The participants took part in hold-relax PNF stretching exercises in the first session of the study, and the post data for blood pressure and heart rate are recorded immediately after 4 sets of PNF stretching exercises are completed. Then the participants were rested for 2 weeks (14 days) to make sure their muscles are fully recovered and relaxed. After 14 days of rest interval, they were asked to put through the PNF stretching exercises for the lower limbs and the post data for blood pressure and heart rate are recorded immediately after 4 sets of PNF stretching exercises are completed.

Hold-relax PNF stretching protocol for upper limb

The hold-relax PNF stretching exercise for left biceps muscle was performed in sitting position with the left arm fully supported on the plinth. The therapist then instructed the participants to perform elbow flexion against the therapist's resistance. For one set of hold relax procedure, the technique requires the participants to hold in 90° elbow flexion with 15 seconds isometric contraction and later, the therapist asked the participants to relax (no contraction for the biceps muscle). Afterward, the therapist performed the gentle passive stretching for full elbow flexion for 15 seconds. The participants will be given 5 seconds rest interval between the sets of exercises. The participants went through 4 sets of these exercises per limb.

Hold-relax PNF stretching protocol for lower limb

The hold-relax PNF stretching exercise for left hamstring muscle was performed in supine area with the participant's leg in 90° hip flexion and 0° knee extension, supported on the therapist's shoulder. The therapist instructed the participant to perform hip extension and knee flexion against the therapist's resistance. For one set of hold relax procedure, the technique requires the participants to hold in 90° hip extension and 0° knee extension with 15 seconds isometric contraction and later, the therapist asked the participants to relax (no contraction for the hamstring muscle). Afterward, the therapist performed the gentle passive stretching for full hip extension and knee extension for 15 seconds. The participant will be given 5 seconds rest interval between the sets of exercises. The participants went through 4 sets of the exercise per limb.

Heart rate and blood pressure measurements

The sphygmomanometer was used to measure blood pressure. The measurements of SBP and DBP were performed at rest, and at the end of the exercise series. In the exercises, the values were measured in the left arm, and after the fourth repetitions, the device was turned on for the parameters immediately at the end of the series. In data collection tool, ECQ machine (Kenz 108 single channel) is used to identify heart rate (RR interval) and ECG data.

Statistical analysis

After test of normality analysis was conducted, the data were statistically evaluated by Paired-samples t test and Non-parametric Sign test at ($p<0.05$) level of confidence by using SPSS 23.0 tool.

Results

Heart rate

These graphs illustrate the differences in heart rate responses before and after PNF stretching exercises for upper limb (Figure 1) and lower limb (Figure 2). It records the changes in heart rate for 50 respondents with negative correlation. A paired samples t-test was conducted to compare upper limb pre-testing (HR_UL_pretest), post-testing (HR_UL_posttest), and lower limb pre-testing (HR_LL_pretest) and post-testing (HR_LL_posttest). There is no significant difference in the scores for HR_UL_pretest (M=76.64, SD=13.189) and HR_UL_posttest (M=75.36, SD=12.262); t (49) =1.00, p=0.322. There is no significant difference in the scores for HR_LL_pretest (M=76.76, SD=12.923) and HR_LL_posttest (M=76.58, SD=12.12); t (49) =0.146, p=0.885. These results suggest that a lower limb PNF stretching exercises really does not have any effect to the heart rate.

Systolic blood pressure

These graphs illustrate the differences in systolic blood pressure (SBP) responses before and after PNF stretching exercises for upper limb (Figure 3) and lower limb (Figure 4). It records the changes in systolic blood pressure for 50 respondents with negative correlation. A paired samples t-test was conducted to compare upper limb pre-testing (SBP_UL_pretest) and post-testing (SBP_UL_posttest) and lower limb pre-testing (SBP_LL_pretest) and post-testing (SBP_LL_posttest). There is a significant difference in the scores for SBP_UL_pretest (M=155.12, SD=8.698) and SBP_UL_posttest (M=119.30, SD=13.686); t (49) =-2.174, p=0.035. There is a significant difference in the scores for SBP_LL_pretest (M=114.98, SD=8.714) and SBP_LL_posttest (M=118.86, SD=9.94); t (49) =-2.28, p=0.027. These results suggest that a lower limb PNF stretching exercises really does have an effect to systolic blood pressure.

Diastolic blood pressure

These graphs illustrate the differences in diastolic blood pressure (DBP) responses before and after PNF stretching exercises for upper limb (Figure 1) and lower limb (Figure 2). It records the changes in diastolic blood pressure for 50 respondents with negative correlation. A paired samples t-test was conducted to compare upper limb pre-testing (DBP_UL_pretest) and post-testing (DBP_UL_posttest) and compare lower limb pre-testing (DBP_LL_pretest) and post-testing (DBP_LL_posttest). There is no significant difference in the scores for DBP_UL_pretest (M=76.12, SD=7.88) and DBP_UL_posttest (M=77.56, SD=11.14); t (49) =-0.876, p=0.385. There is no significant difference in the scores for DBP_LL_pretest (M=76.64, SD=7.564) and DBP_LL_posttest (M=74.22, SD=8.125); t (49) =1.887, p=0.065. These results suggest that a lower limb PNF stretching exercises does not have any effect to diastolic blood pressure.

Discussion

The present study did not find evidence of increased heart rate immediately after hold-relax PNF stretching exercise for both upper and lower limb. Based on our findings, the heart rate for upper limb and lower limb are p=0.322 and p=0.885 respectively. Since the value of p>0.05, hence, there is no significant difference on the effects of proprioceptive neuromuscular facilitation on heart rate. This implies that after several sets of hold-relax PNF stretching exercises, the heart rate remains unchanged drastically and the exercises are safe for the young adult patient.

All articles that were reviewed address the effects of PNF stretching exercises on heart rate. The reviewed literature demonstrates that the PNF stretching exercises does not significantly change the heart rate after several sets. The researcher evaluated heart rate during and after passive stretching for ischio-tibialis muscles and gastrocnemius muscles of 22 healthy male subjects.[7] Based on their study, it was found that there is no significant changes occurred on the subjects' heart rate (p>0.05). They suggested that the heart rate remained stable throughout the sets even though it was significantly greater than the resting (pre-test) measurement.

When comparing the studies in this critically appraised topic, there is some literature which suggested significant increase of heart rate in their study. The study recent researcher stated that, there is an increase of the heart rate and peripheral vascular resistance with a consequent increase in mean arterial pressure caused by isometric exercise.[6] The mechanical activity of the muscle increases the intramuscular pressure that compresses the blood vessels and inhibits the production of metabolites released during isometric exercises. The accumulation of mechanical action activates metaboreceptors of the muscle, contributing to an increase in the heart rate.

The primary finding of this study was the systolic blood pressure (SBP) that showed a significant difference with p<0.05 after the participants underwent 4 sets of hold-relax PNF stretching exercise. But for diastolic blood pressure, with p>0.05 no significant changes were recorded between the pre and post measurement. The finding was consistent with some previous studies. In 1995, some researchers investigated the acute systolic (SBP) and diastolic (DBP) blood pressure responses within passive and modified PNF stretching techniques in three trials. By using arterial blood pressure which is taken from the contralateral third finger with a Finapres finger cuff, it was found there were no increase blood pressure values above baseline levels for first and second trial. However, in the third trial there were no significant differences even though the blood pressure is increased.[8]

Mounting prospective evidence suggests that isometric exercise training in normotensive and hypertensive (medicated and non-medicated) cohorts of young and old participants may produce similar, if not greater, reductions in BP, with meta-analyses reporting mean reductions of between 10 and 13 mmHg systolic, and 6 and 8 mmHg diastolic. Although the mechanisms responsible for these adaptations remain to be fully clarified, improvements in conduit and resistance vessel endothelium-dependent dilation, oxidative stress, and autonomic regulation of heart rate and BP have been reported. [9] However, one study found that static exercise causes a greater increase in arterial blood pressure than dynamic exercise. This is due to the combination of an increase in cardiac output and in total systemic vascular resistance because of increase sympathetic outflow and mechanical compression of the vessels in the active muscles. During exercise, increases in cardiac stroke volume and heart rate raise cardiac output, which coupled with a transient increase in systemic vascular resistance, elevate mean arterial blood pressure. [10]

Similar suggestion was made some colleagues that the reduction in BP was significant regardless of the participant's initial BP level, gender, physical activity level, antihypertensive drug intake, type of BP measurement, time of day in which the BP was measured, type of exercise performed, and exercise training program (p < 0.05 for all). ANOVA tests revealed that BP reductions were greater if participants were males, not receiving antihypertensive medication, physically active, and if the exercise performed was jogging. A significant inverse correlation was found between age and BP, body mass index (BMI) and SBP, duration of the exercise's session and SBP, and between the number of sets performed in the resistance exercise program and SBP (p < 0.05). Regardless of the characteristics of the participants and exercise, there was a reduction in BP in the hours following an exercise session. However, the hypotensive effect was greater when the exercise was performed as a preventive strategy in those physically active and without antihypertensive medication.[11]

The previous study by some researcher found that the PNF protocol used in this study did not statistically change the HR, SBP and DBP values among 12 normotensive female swimmers. In this study, the subjects in the PNF group rested for 10 min before having the HR, SBP and DBP and SPO2 measured two times. During data collection process, they conducted two sets of PNF hold relax procedure for the pectorals and biceps muscles. It starts with 6 seconds isometric contraction and followed by 24 sec of sustained stretching. There is 15 seconds rest interval between sets. Immediately after two sets, the HR, SBP and DBP values were measured and recorded two times. The researchers identified that there is no evidence found of increased HR immediately after PNF stretching exercises and there are not significant increases in BP even though there is slight elevation in the mean values of SBP and DBP were observed after PNF stretching. They conjecture that the short duration (2 sets with 30 seconds) of the sustained stretching technique was inadequate to cause an acute increase in the involvement of sympathetic branch from the autonomic nervous system. They suggested the involvement different samples, use another muscle group (upper limb and lower limb), measurement techniques and stretching methods for further studies. [12]

On the question of the effects of PNF on heart rate, systolic blood pressure and diastolic blood pressure, a study was conducted on 40 young healthy adults; found that there was significant increase in heart rate, systolic blood pressure and diastolic blood pressure with Valsalva Maneuver (VM) immediately after the exercise session. The researcher also observed notable increase in responses between hamstring stretching group (lower extremity) and pectorals stretching group (upper extremity). [13] This study performed three sets of PNF stretching exercises, with 6 seconds of isometric contraction each and followed by 24 seconds of sustained stretching, unlike the previous study conducted two sets of PNF stretching. [12] However, this study has its limitation such as, the researcher measured heart rate manually and the force applied during isometric contraction in the PNF stretching technique was not measured. They also suggested that future study need to increase the number of sample size and can be conducted among cardiac patient to see the effects.

Prior to this study, it was found that there is a hemodynamic relationship between the increase of heart rate and blood pressure with cardiac outputs that affects the finding for upper extremity and lower extremity exercises. The increased of cardiac output resulted from the vasodilatation occurs in the active muscles because of the accumulation of metabolites produced by the contracting muscles. This study shown that the upper extremity exercise has greater heart rate and blood pressure compared to lower extremity at the similar exercises.[14]

In 2015, some researcher in their study of hemodynamic responses during and after multiple sets of stretching exercises, assigned 15 subjects performed stretching protocols comprising 10 sets of maximal passive unilateral hip flexion with 30 seconds hold for each set. The result of this study shown multiple sets of the passive stretching of unilateral hip flexion exercise performed for 30 seconds significantly increased the heart rate, blood pressure and rate pressure product. However, the paper fails to offer an adequate explanation on how the muscular activity is controlled by means of electromyography monitoring, which is used to detect involuntary muscle contraction. [15]

In a previous study, the researchers question the extent to which the effect of passive muscle stretches of heart rate responses at the onset of muscle contraction. The researcher conducted two studies in their article; 1) the time course of heart rate and blood pressure changes were tested for various intensities of voluntary isometric triceps muscle contraction and 2) the cardiovascular changes in response to the passive muscle stretch of the triceps muscle. From their finding, a significant increase in heart rate but no significant changes in blood pressure was caused by a sustained passive stretch of the triceps for one minute. They suggested that there is an increase for the mean arterial blood pressure at the onset of stretch and then it decrease to a similar value during rest for the remainder stretch duration. The findings strongly suggest that the effect on heart rate is mediated by muscle mechanoreceptors as activation of these receptors by prolonged passive muscle stretch decreases parasympathetic activity and increases heart rate. [16]

In a more current study was concluded that there was a significant change in heart rate, diastolic blood pressure and mean arterial pressure (MAP) except for systolic blood pressure due to sustained isometric contraction and a positive significant correlation of body mass index (BMI) with DBP and MAP. They believed that during isometric contraction, as in any muscular work, the active muscle increased the metabolic demands. Due to the mechanical constriction of blood vessels caused by a high intramuscular tension during static contraction, blood flow to the target muscles is restricted. Static exercise causes a build-up of local metabolic by-products due to the reduction in muscle blood supply. These metabolic by-products excite sensory nerve endings, resulting in a pressure reflex that raises diastolic and mean arterial pressure. [17]

There are several limitations that have impacted the current findings. The first limitation is the data just focused on pre and post data measurement of heart rate, blood pressure and ECG reading. It would provide more meaningful data if this study included the data during the hold-relax PNF stretching exercises especially during isometric contraction, so that the muscle forces can be examined. During PNF stretching exercises, no muscle activity is recorded. It is recommended that an electromyography test be performed on the target muscle during PNF stretching so that the researcher can determine when the highest intramuscular tension occurs. Next, the subjects are healthy young adult who does not have any flexibility problem such as muscle tightness.

Conclusion

The present study is the post-test measurement performed immediately after the hold-relax PNF stretching exercises protocols, therefore, our study only focused on the immediate physiological responses to PNF stretching, which is of great scientific importance. There is significant difference for SBP but there are no significant differences for HR and DBP. Even without consistent evidence to support the use of hold-relax PNF stretching exercise, there appears to be little to no risks for physiotherapist to make their own personal decision on the PNF stretching exercise application. Future researchers are recommended to perform data collection before (pre-test), during and after (post-test) hold-relax PNF stretching exercises especially during isometric exercises. Other than that, future researchers can use electromyography (EMG) to investigate effects of PNF stretching exercise on muscle activities together with cardiovascular responses.

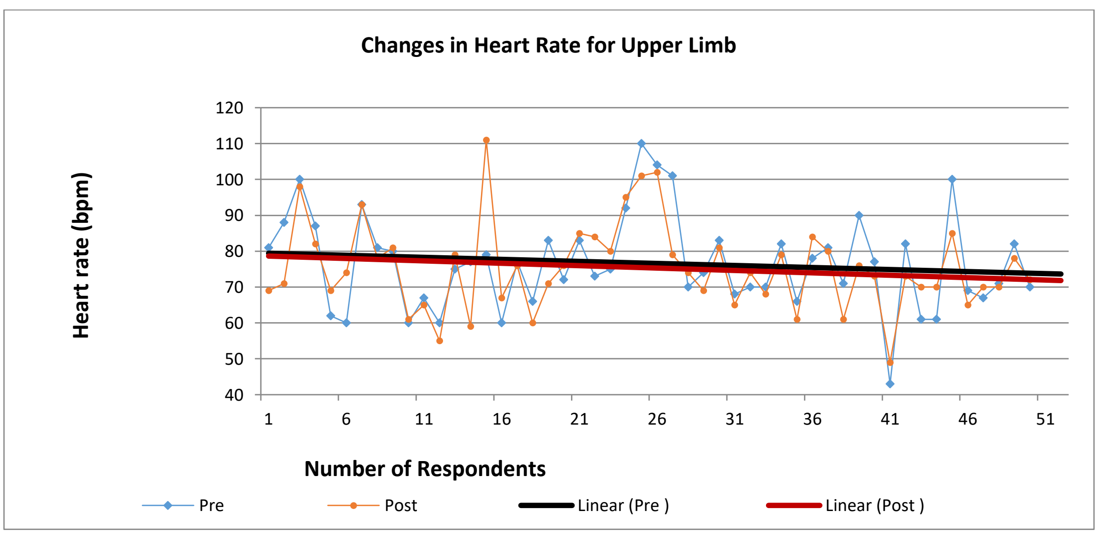

Figure 1: The difference in heart rate before and after PNF stretching exercises for upper limb.

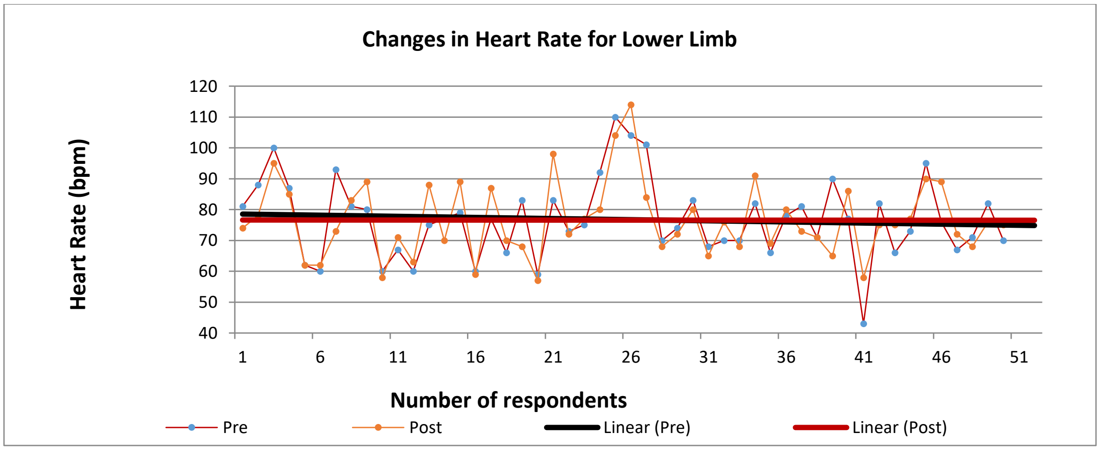

Figure 2: The difference in heart rate before and after PNF stretching exercises for lower limb.

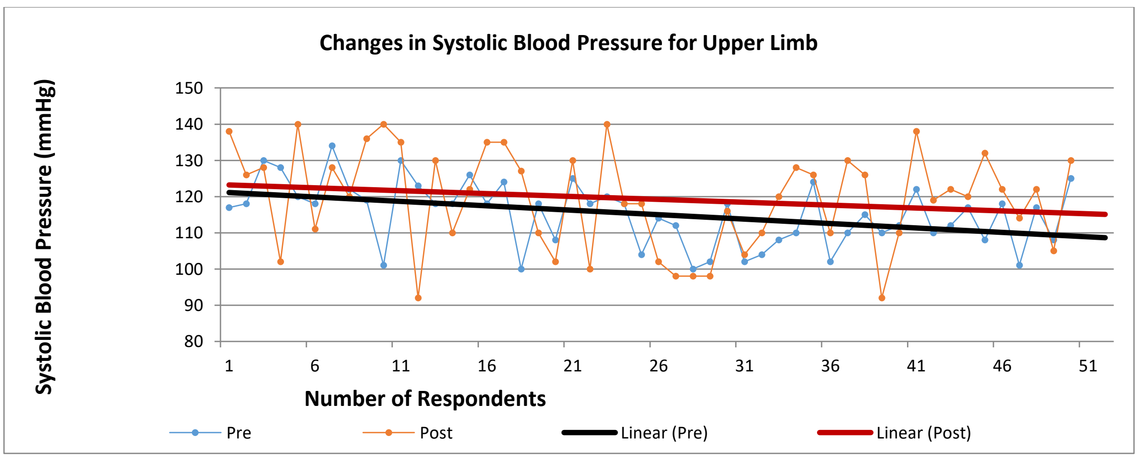

Figure 3: The difference in systolic blood pressure before and after PNF stretching exercises for upper limb.

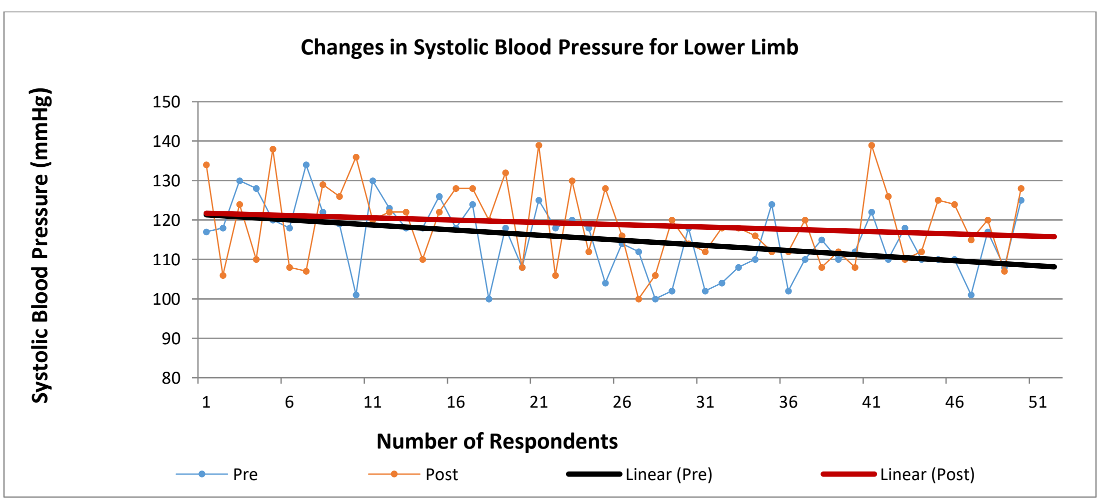

Figure 4: The difference in systolic blood pressure before and after PNF stretching exercises for lower limb.

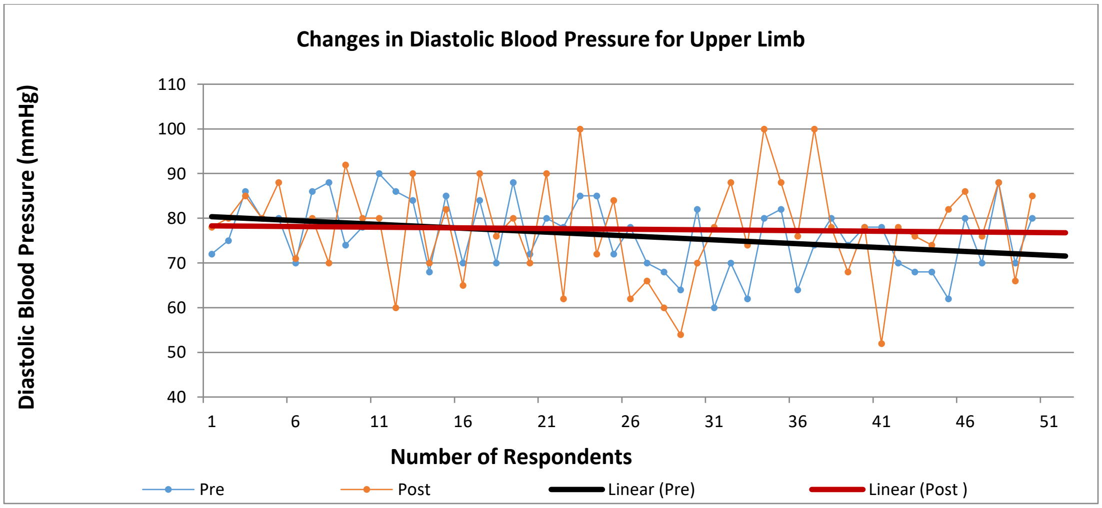

Figure 5: The difference in diastolic blood pressure before and after PNF stretching exercises for upper limb.

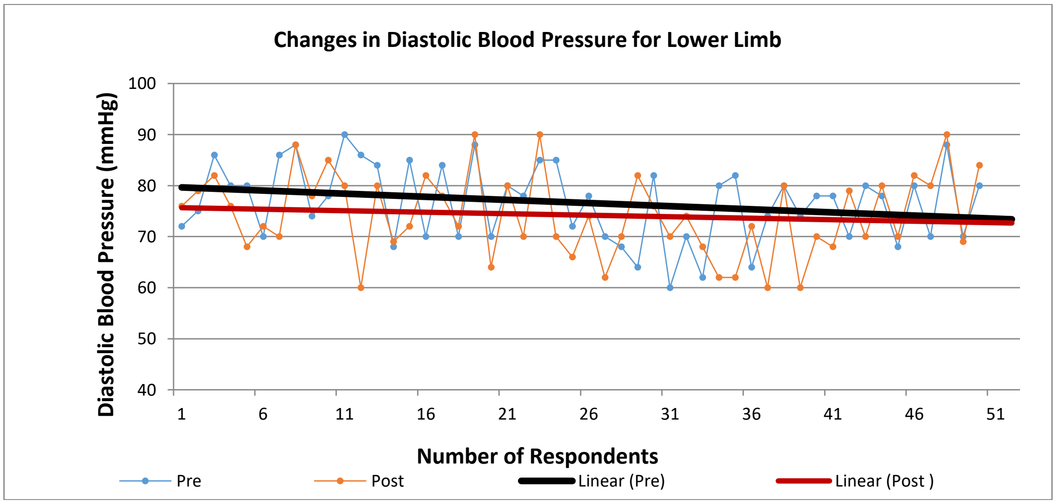

Figure 6: The difference in diastolic blood pressure before and after PNF stretching exercises for lower limb.

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