AN ANALYTICAL STUDY ON THE EFFECTIVENESS OF WARM UP AND COOL DOWN ACTIVITIES IN REDUCING MUSCLE SORENESS AMONG SPORTS PERSON

Registration Number

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A DISSERTATION SUBMITTED TO

THE TAMIL NADU DR. M. G. R. MEDICAL UNIVERSITY, CHENNAI,

IN PARTIAL FULFILMENT OF THE REQUIREMENTS OF THE

DEGREE OF MASTER OF PHYSIOTHERAPY

APRIL 2011

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CERTIFICATE

This is to certify that the project entitled **AN ANALYTICAL STUDY ON THE EFFECTIVENESS OF WARM UP AND COOL DOWN ACTIVITIES IN REDUCING MUSCLE SORENESS AMONG SPORTS PERSON** and was work done by **Ms.L.GEETHA**, a bonafide student of Master of Physiotherapy (M.P.T.) Final Year student under The Tamil Nadu Dr. M.G.R Medical University, Chennai.

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COLLEGE OF PHYSIOTHERAPY
TRINITY MISSION AND MEDICAL FOUNDATION
ULTRA TRUST
MADURAI
TAMIL NADU

***Examiners:*_____**

_____

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I. INTRODUCTION

Delayed onset of muscle soreness (DOMS) is typically experienced by all individuals regardless of fitness level, and is a normal physiological response to increased exertion and the introduction of unfamiliar physical activities. Delayed onset of muscle soreness is thought to be a result of microscopic muscle fiber tears and is more common after eccentric exercise rather than concentric exercise.

Nevertheless it can lead to considerable suffering and handicaps athletes by temporarily impeding performance and preventing training. The pain and discomfort associated with DOMS typically peaks 24–48 hours after an exercise bout, and resolves within 96 hours.

Generally, an increased perception of soreness occurs with greater intensity and a higher degree of unfamiliar activities. Other factors that play a role in DOMS are muscle stiffness, contraction velocity, fatigue, and angle of contraction. Due to the sensation of pain and discomfort, which can impair the physical training and

performance, prevention and treatment of DOMS is of great concern to coaches, trainers and therapists.

Thus an effective treatment has been sought for many years. Among the treatments tried are transcutaneous electrical nerve stimulation, ultrasound, and the administration of aspirin and other anti – inflammatory drugs, steroids, and vitamin C and other antioxidants. To date, none of these approaches has been fully convincing. Warm-up is said to reduce muscle strain injuries by increasing muscle temperatures, and hence muscle compliance. Cool-down has been recommended because it has been observed that cool-down aids in the removal of lactic acid.

Many researchers have indicated that an effective warm – up may reduce the impact of the delayed-onset muscle soreness. An attempt is made in this project to assess the effectiveness of warm – up and cool down activities in reducing gastrocnemius muscle soreness in sports persons.

I.I STATEMENT OF THE STUDY

The statement of the study was **“An Analytical study on the effectiveness of warm-up and cool down activities in reducing muscle soreness among sports persons”.**

I.II AIM OF THE STUDY

The aim of this study was to analyze the effectiveness of warm-up and cool down activities in reducing muscle soreness in sport persons.

I.III OBJECTIVES OF THE STUDY

- To assess the effects of warm-up and cool down activities in reducing muscle soreness in sport persons.
- To compare the effects of warm-up and cool down activities in reducing muscle soreness in sport persons with the control group.

I.IV NEED OF THE STUDY

Prevention is better than cure. Since sports persons are more often affected with muscle soreness, an attempt is made in this project to assess the effectiveness of warm-up and cool down activities in reducing muscle soreness in sport persons.

If warm up and cool down activities were found to be effective in reducing muscle soreness, then they can be administered to all sports persons involved in novel sporting activities. Hence muscle soreness can be effectively reduced and even prevented.

I.V HYPOTHESIS

NULL HYPOTHESIS

There is no significant reduction in muscle soreness development if proper warm-up and cool down activities are included in the training regimen.

ALTERNATE HYPOTHESIS

There is significant reduction in muscle soreness development if proper warm-up and cool down activities are included in the training regimen.

I.VI OPERATIONAL DEFINITIONS

- **WARM-UP**

A warm-up is usually performed before participating in technical sports or exercising which should be specific to the exercise that will follow, which means that exercises (of warm up) should prepare the muscles to be used and to activate the energy systems that are required for that particular activity.

- **COOL DOWN**

Cooling down, also called warming down is the term used to describe an easy exercise that will allow the body to gradually transition from an exertion state to a resting or near-resting state.

- **DELAYED ONSET MUSCLE SORENESS**

Delayed-onset muscle soreness also called post-exercise muscle soreness is that distinctive muscle pain that everyone experiences after intense or unfamiliar exercise, sometimes so severe that it is sometimes mistaken for a pulled muscle.

II. REVIEW OF LITERATURE

- **Arvie C. Vitente, in 2010,** in his study has quoted that **the major causes of DOMS** are the following, Lactic acid accumulation in muscles because of too much workout on muscle is the primary cause of DOMS. Tissue breakdown may also be the cause of DOMS. Biopsy studies of athletes especially runners were found to have more muscle destruction. The cell membrane or sarcolemma of muscle cells will be destroyed causing its cell content to leak out between each muscle fibre. Inflammatory process – after heavy exercise or strenuous activity, white blood cell count has been shown to increase. This led to the conclusion that DOMS is also caused by inflammatory processes.

- **Sharon Summers, in 2010,** Evidence-Based Practice Part 2: **Reliability and Validity of Selected Acute Pain Instruments** which states that Pain management is an important aspect of perianesthesia patient care? PACU nurses need to be familiar with pain measurement to judge effectiveness of pain management. In fact, the 1999-2000 Joint Commission on Accreditation of Healthcare Organizations' (JCAHO) guidelines have included the measurement of pain before and after pain treatment in their

standards of practice. This article reviews selected pain instruments including VAS, NRS, VDS and BRS that could be used to measure pain in perianesthesia patients and the available reliability and validity of the instruments.

- **Elizabeth Quinn, in 2008,** has conducted a study on **"Muscle Pain and Soreness after Exercise - What Is Delayed Onset Muscle Soreness?"** In her study she has mentioned a lot about preventing and treating DOMS - muscle pain and muscle soreness after exercise.

- **Roberta YW Law and Robert D Herbert, in 2007** (The University of Sydney, Australia) has conducted a study on "**Warm-up reduces delayed-onset muscle soreness but cool-down does not: a randomised controlled trial."** In their study they have found that warm-up and cool down were effective in reducing muscle soreness.

- **R. Law and R. Herbert, in 2007** conducted a study titled **"Delayed-Onset Muscle Soreness reduced by effective Warm-Up".** In their study the researchers hypothesised that the increase in

muscle temperature associated with warm-up could increase the compliance of structures in series with myofibrils which would reduce the degree of stretch experienced by the myofibrils. As DOMS is thought to be due to damage of stretched myofibrils then warm-up could decrease the myofibrillar damage that occurs with a new exercise.

- **Brad Walker, in 2006**, has conducted a study "**Two Important Factors: Warm Up AND Cool Down**". In his study he has explained the two important factors that results in soreness or pain after an unaccustomed activity. This soreness is caused by a number of things. Firstly, during exercise, tiny tears called micro tears develop within the muscle fibres. These micro tears cause swelling of the muscle tissues which in turn puts pressure on the nerve endings and results in pain. Secondly, when exercising, your heart is pumping large amount of blood to the working muscles. This blood is carrying both oxygen and nutrients that the working muscles need. When the blood reaches the muscles the oxygen and nutrients are used up. Then the force of the contracting (exercising) muscles pushes the blood back to the heart where it is re-oxygenated.

- **Rob D Herbert and Michael Gabriel, in 2002,** have conducted a study titled **"Effects of stretching before and after exercising on muscle soreness and risk of injury: systematic review".** They have concluded that the pooled estimate from two studies was that stretching decreased the risk of injury by 5%. This effect was statistically non-significant. Even if this effect was not simply a sampling error it would not be large enough to be of practical significance.

In army recruits, whose risk of injury in the control condition is high (approximately 20% over the training period of 12 weeks), a 5% reduction in relative risk implies a reduction in absolute risk of about 1%.

III. DESIGN AND METHODOLOGY

III.I RESEARCH DESIGN

The research design of this study was done by "**Experimental study**".

III.II SELECTION CRITERIA

INCLUSION CRITERIA

- Subjects with age group of 18-25 years
- Male amateur athletes
- Subjects who answered 'No' to all questions on the Physical Activity Readiness Questionnaire.
-

EXCLUSION CRITERIA

- Subjects with age group of below 18 or above 25 years.
- Female amateur athletes
- Subjects who answered 'Yes' to any one question on the Physical Activity Readiness Questionnaire.
- Subjects with muscle contractors or deformity.

III.III POPULATION

Male amateur athletes within the age group of 18-25 years were considered as the population.

III.IV SAMPLE AND SAMPLING TECHNIQUE

Thirty subjects satisfying the inclusion criteria were selected from the population by 'Convenient Sampling Technique'.

III.V VARIABLES OF THE STUDY

DEPENDANT VARIABLE

- Soreness

INDEPENDENT VARIABLE

- Warm-up and Cool down

III.VI SETTING OF THE STUDY

The study was conducted at

- Snap Fitness centre, Nungambakkam, chennai.

III.VII MATERIALS USED FOR THE STUDY

- Treadmill
- VAS Scale
- NRS scale
- Physical Activity Readiness questionnaire

PICTURE I

Treadmill

IV. METHODOLOGY

Thirty subjects satisfying the inclusion criteria were selected from the population by '**Convenient Sampling Technique**' and were divided in to two groups of fifteen subjects each.

- Experimental Group
- Control Group

The exercise was designed to induce muscle soreness in gastrocnemius muscle by unaccustomed eccentric loading of the right leg. The participants were instructed to walk large backwards step with the right knee extended on downhill treadmill which inclined at 13 degrees, for 30 minutes at 35 steps per minute, leading with the right leg and strike with the toe.

The experimental group received a 10 minute proper warm-up before the activity and a proper cool down for 10 minutes after the activity. The control group did not receive any warm-up or cool down regimens. They engaged in the activity directly.

Muscle soreness of the subjects was measured using Visual Analogue Scale (VAS) and Numerical Rating Scale (NRS) after the activity in 24 Hours, 48 Hours and 72 Hours.

IV.I MEASUREMENT TOOLS

VISUAL ANALOGUE SCALE (VAS)

The visual analogue scale is the patient's psychological measurement of pain. It consists of an unmarked straight line having two ends. One end indicating no pain and the other with maximum pain. The subjects were instructed to make a mark on the 100mm Non - segmental horizontal line which represents the level of pain at the time of test. Then the distance from the left end to the subjects mark was measured in millimetres and recorded.

NUMERICAL RATING SCALE (NRS)

Perhaps one of the most commonly used pain scales in healthcare; the numerical rating scale offers the individual in pain to rate their pain score. It is designed to be used by those over the age of 9. In the numerical scale, the user has the option to verbally rate their scale from 0 to 10 or to place a mark on a line indicating

their level of pain. The Numerical Rating Pain Scale allows the healthcare provider to rate pain 0 as no pain, 1-3 as mild, 4-6 moderate and 7-10 represents the most intense pain, which can indicate a potential disability level.

IV.II INTERVENTION PROCEDURE

Experimental group subjects were instructed to do both warm up and cool down exercise consisted of walking forward uphill on a gently inclined treadmill of 3 degree inclination for 10 minutes at 4.5 to 5 kph. Walking at this speed and on this inclination consumes energy at an estimated average rate of approximately 3.1 to 3.4 METS (Whaley et al 2000). Walking was used to warm up and cool down because, like the activities used to warm up and cool down protocols, this activity involves similar though not identical muscle groups and muscle actions to those involved in the activity which subsequently induced muscle soreness.

IV.III OUTCOME MEASURES

The outcome measures on muscle soreness were taken for the subjects using Visual Analogue Scale and Numerical Rating Scale after the activity in 24 Hours, 48 Hours and 72 Hours. The data calculated and analyzed by statistics to find significance.

PICTURE II

Control Group – Walking Backwards on downhill Treadmill with Right knee extended

PICTURE III

Control group – Treadmill inclined at 13 degrees, for 30 minutes at 35 steps per minute

PICTURE IV

Control Group Treadmill Display

PICTURE V

Experimental Group – Warm - up and Warm down Treadmill inclined at 3 degrees, for 10 min

PICTURE VI

Experimental Group - Treadmill Display

V. OBSERVATION AND ANALYSIS

A separate Performa was used to record the post intervention scores at different time periods for each subject.

The data collected were analysed using these formulas.

PAIRED'T' TEST

$$\text{Mean } d = \frac{\overline{\sum d}}{n}$$

$$\text{Standard Deviation (SD)} = \sqrt{\frac{\sum (d - \overline{d})^2}{(n-1)}}$$

$$\text{Standard Error (SE)} = \frac{SD}{\sqrt{n}}$$

$$\text{Paired 't' test} = \frac{d - \overline{O}}{SE}$$

INDEPENDENT 't' TEST

$$\text{Standard Deviation (SD)} = \sqrt{\frac{(n_1-1)\,S_1^2 + (n_2-1)\,S_2^2}{n_1 + n_2 - 2}}$$

$$\text{Standard error (SE)} = SD \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}$$

$$\text{"t" critical value} = \frac{(\overline{X_1} - \overline{X_2})}{SE}$$

ANALYSIS OF VARIACE (ANOVA) IN TWO – WAY

Source of Variation	Sum of Squares	Degrees of Freedom	Mean sum of Squares	Ratio of F
Between Samples Between Rows Residual or Error	SSC SSR SSE	(c-1) (r-1) (c-1) (r-1)	MSC=SSC/(c-1) MSR=SSR/(r-1) MSE=SSE/(r-1(c-1)	MSC/MSE MSR/MSE
Total	SST	n-1		

SSC = Sum of squares between columns

SSR = Sum of squares between rows

SSE = Sum of squares due to error

SST = Total sum of squares

SSE = SST – (SSC + SSR)

n-1 or cr-1 = The total number of degrees of freedom

c = Number of columns

r = Number of rows

(c-1) = Number of degrees of freedom between columns

(r-1) = Number of degrees of freedom between rows

(c-1) (r-1) = Number of degrees of freedom for residual

VI. RESULTS AND DISCUSSION

VI.I RESULTS

The present study was designed to examine the effectiveness of warm-up and cool-down activities before and after an exercise, in reducing muscle soreness among sports person.

The study was conducted among 30 male amateur athletes aged between 18 to 25 years, divided into experimental (N=15) and control (N=15) groups. Both the experimental and control group were given an unaccustomed eccentric exercise (walking backwards downhill on a treadmill, inclined at 13 degrees, for 30 minutes at 35 steps per minute). The experimental group were made to do warm-up before and cool-down after the exercise. Control group did not receive any warm-up or cool-down regimen. Muscle soreness of all the subjects was measured using Visual Analog Scale (VAS) and Numerical Rating Scale (NRS) at 24hr, 48hr and 72hr of completing the exercise.

All the 30 participants completed the study. There were no dropouts or withdrawals during the course of the study, and there were no missing data. Group data for the two groups at the three different time periods are presented in Table 1 and the individual data of the 2 groups for all the three time periods are given in Appendix.

Statistical analysis was done using student's 't' test and ANOVA. Dependent 't' test was used to compare mean muscle soreness values of each group during different time periods. Independent 't' test was used to compare mean muscle soreness values at different time intervals between the experimental and control group. ANOVA was used to compare mean VAS and NRS scores.

TABLE - I

Mean values for VAS score of the experimental and control group

Time Period	Experimental Group	Control Group
24hr	16.20±5.49	24.07±6.84
48hr	20.60±6.42	33.80±8.78
72h	12.53±3.60	28.93±7.14

TABLE - II

Mean values of NRS score of the experimental and control group

Time Period	Experimental Group	Control Group
24hr	3.20±1.21	4.20±0.77
48hr	4.73±0.80	5.20±0.68
72hr	1.33±0.82	3.73±1.16

TABLE - III

Dependent 't' values for testing significant difference in mean VAS score for muscle soreness within the Experimental group during different time periods

Time Period	't' value	P value
Between 24hr and 48hr	6.97	<0.01*
Between 48hr and 72hr	7.94	<0.01*
Between 24hr and 72hr	5.69	<0.01*

*Significant at 1% level

From the above table, it can be deciphered that there is a significant difference at 1% level in the VAS scores for muscle soreness within the experimental group during the different time periods as P values are less than 0.01.

TABLE - IV

Dependent 't' values for testing significant difference in mean VAS score for muscle soreness within the Control group during different time periods

Time Period	't' value	P value
Between 24hr and 48hr	8.13	<0.01*
Between 48hr and 72hr	5.32	<0.01*
Between 24hr and 72hr	4.54	<0.01*

*Significant at 1% level

The above table shows that there is a significant difference at 1% level in the VAS scores for muscle soreness within the control group during the different time periods as P values are less than 0.01.

TABLE – V

Dependent 't' values for testing significant difference in mean NRS score for muscle soreness within the Experimental group during different time periods

Time Period	't' value	P value
Between 24hr and 48hr	5.60	<0.01*
Between 48hr and 72hr	17.87	<0.01*
Between 24hr and 72hr	6.09	<0.01*

*Significant at 1% level

From the above table, it can be deciphered that there is a significant difference at 1% level in the NRS scores for muscle soreness within the experimental group during the different time periods as P values are less than 0.01.

TABLE – VI

Dependent 't' values for testing significant difference in mean NRS score for muscle soreness within the Control group during different time periods

Time Period	't' value	P value
Between 24hr and 48hr	4.18	<0.01*
Between 48hr and 72hr	5.73	<0.01*
Between 24hr and 72hr	1.82	>0.05 NS

*Significant at 1% level

NS Not significant

From the above table, it can be deciphered that there is a significant difference at 1% level in between the time periods of 24hr – 48hr, 48hr – 72 hr in the NRS scores for muscle soreness within the control group during the different time periods as P values are less than 0.01. In 24hr – 72hr the p value is more than 0.05 and it is not giving a significant difference.

TABLE - VII

Independent 't' values for testing significant difference in mean VAS score for muscle soreness between the Experimental and Control group during different time periods

Time Period	Experimental Group	Control Group	't' value	P value
24hr	16.20±5.49	24.07±6.84	3.47	<0.01*
48hr	20.60±6.42	33.80±8.78	4.70	<0.01*
72h	12.53±3.60	28.93±7.14	7.95	<0.01*

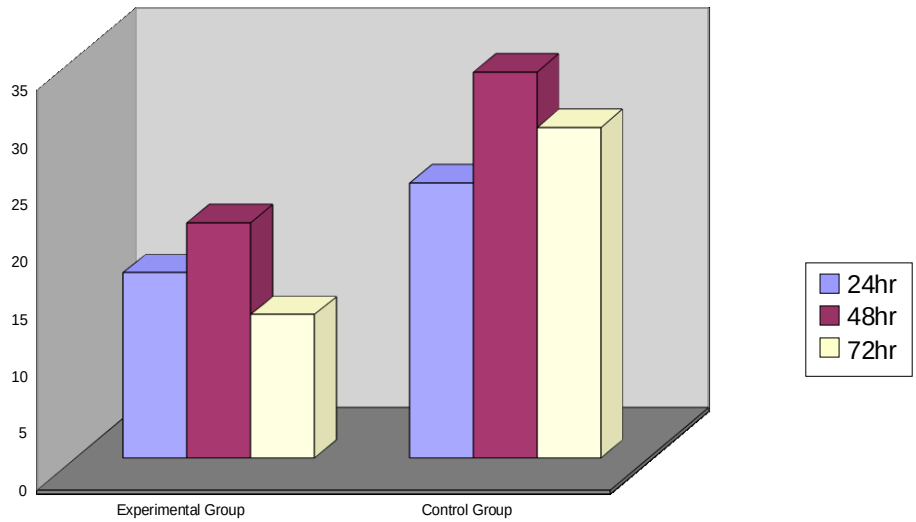
*Significant at 1% level

The above table shows that there is a significant difference at 1% level ($P<0.05$) in the VAS scores of the experimental and control group at 24hr, 48hr and 72 hours.

The mean values shows that at 24hrs, the experimental group experienced less muscle soreness (VAS score 16.20±5.49) compared to the control group (VAS score 24.07±6.84) and at 48hrs, the experimental group experienced less muscle soreness (VAS score 20.60±6.42) compared to the control group (VAS score 33.80±8.78) and at 72hrs, the experimental group experienced less muscle soreness (VAS score 12.53±3.60) compared to the control group (VAS score 28.93±7.14).

GRAPH – I

VAS Score of the Experimental and the Control Group



The above graph clearly shows that the muscle soreness of the experimental group increased from 24hr to 48hr, but reduced lesser than 24hr value at 72hr. But muscle soreness in control group increased from 24 hr to 48 hr, but only reduced lesser than 48 hr value at 72hr. So the mean value of the experimental and control group clearly shows the initial muscle soreness was less for the experimental group, when compared with the control group and that there is also a greater reduction of muscle soreness in the experimental group than the control group.

TABLE – VIII

Independent 't' values for testing significant difference in mean NRS score for muscle soreness between the Experimental and Control group during different time periods

Time Period	Experimental Group	Control Group	't' value	P value
24hr	3.20±1.21	4.20±0.77	2.70	<0.01*
48hr	4.73±0.80	5.20±0.68	1.72	>0.05NS
72h	1.33±0.82	3.73±1.16	6.54	<0.01*

*Significant at 1% level

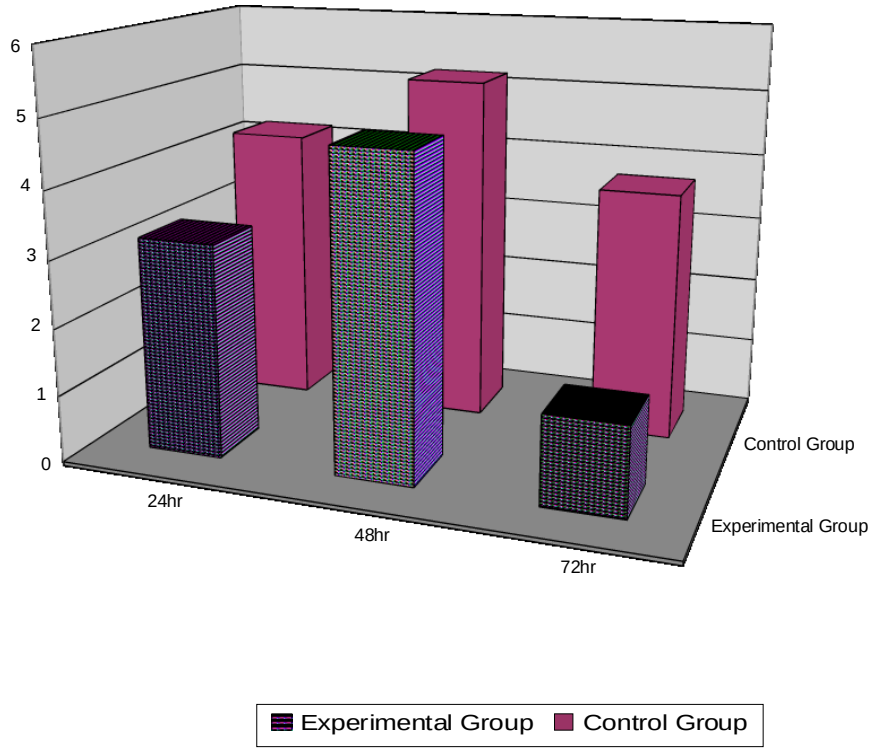
NS Not significant

The above table shows that there is a significant difference at 1% level ($P<0.01$) in the NRS scores of the experimental and control group at 24hr, 72 hours and there is no significant difference in 48hr.

The mean values shows that at 24hrs, the experimental group experienced less muscle soreness (NRS score 3.20±1.21) compared to the control group (NRS score 4.20±0.77) and at 48hrs, the muscle soreness of the experimental group (NRS score 4.73±0.80) was lesser than the control group (NRS score 5.20±0.68) and at 72hrs, the experimental group experienced less muscle soreness (NRS score 1.33±0.82) compared to the control group (NRS score 3.73±1.16).

GRAPH – II

NRS Score of the Experimental and the Control Group



The above graph shows that the muscle soreness of the experimental group and the control group increased from 24hr to 48hr, but reduced lesser than the 24hr value at 72hr. So the mean value of the experimental and control group clearly shows there is reduction of muscle soreness more in the experimental group than the control group.

TABLE - IX

ANOVA values for testing significant difference in VAS score between the groups and during different time periods

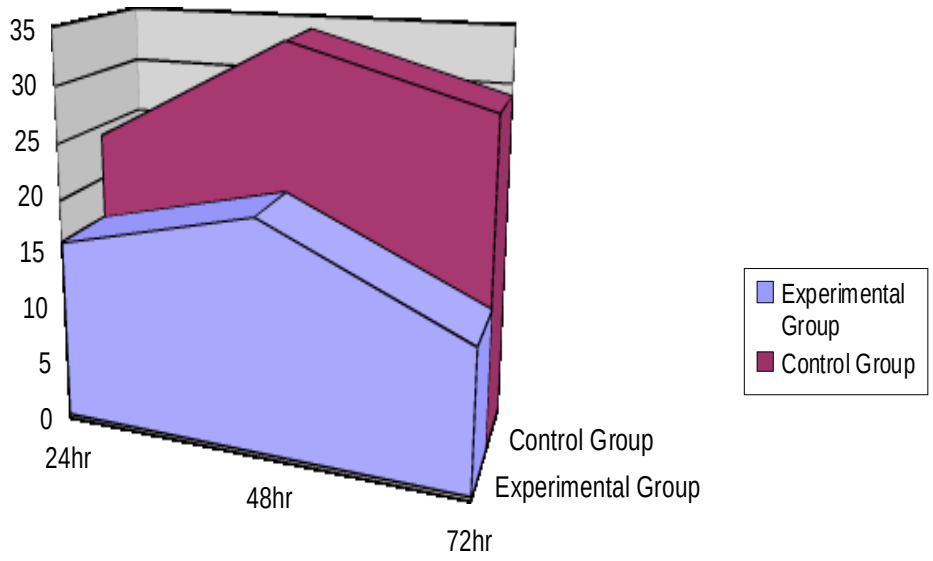
Time Period	Experimental Group	Control Group	Source of Variation	't' value	P value
24hr	16.20±5.49	24.07±6.84	Between Columns	69.9	<0.05*
48hr	20.60±6.42	33.80±8.78			
72h	12.53±3.60	28.93±7.14	Between Rows	30.1	<0.05*

*Significant at 5% level

Using two-way ANOVA, the VAS score values obtained from the experimental and control groups were statistically analyzed. The results (table 7) shows that P value is <0.05, therefore it is statistically significant at 5% level. We conclude that, VAS scores between the groups during the different time periods differs significantly.

GRAPH – III

VAS Score of the Experimental and the Control Group between the groups and during different time periods



The above graph shows that the mean muscle soreness measured using VAS scale of the experimental group is lesser than the mean muscle soreness of the control group during the 24hr, 48hr and 72hr time period.

TABLE – X

ANOVA values for testing significant difference in NRS score between the groups and during different time periods

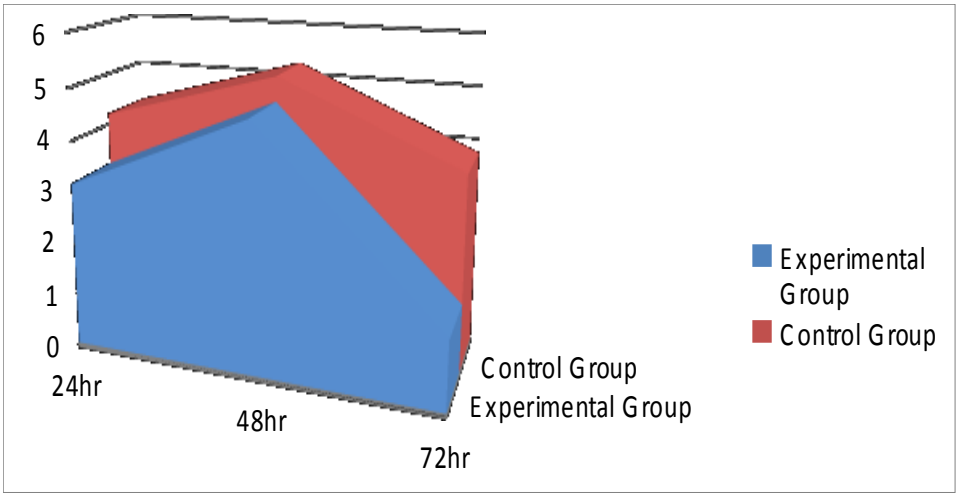
Time Period	Experimental Group	Control Group	Source of Variation	't' value	P value
24hr	3.20±1.21	4.20±0.77	Between Columns	23.39	<0.05*
48hr	4.73±0.80	5.20±0.68			
72h	1.33±0.82	3.73±1.16	Between Rows	90.4	<0.05*

*Significant at 5% level

Using two-way ANOVA, the NRS score values obtained from the experimental and control groups were statistically analyzed. The results (table 8) shows that P value is <0.05, therefore it is statistically significant at 5% level. We conclude that, NRS scores between the groups during the different time periods differs significantly.

GRAPH – IV

NRS Score of the Experimental and the Control Group between the groups and during different time periods



The above graph shows that the mean muscle soreness measured using NRS scale of the experimental group is lesser than the mean muscle soreness of the control group during the 24hr, 48hr and 72hr time period.

The above results clearly show that the inclusion of a warm up and cool down session before and after the workout definitely has an effect in reducing DOMS in the subjects. Therefore the null hypothesis is rejected and alternate hypothesis is accepted.

VI.II DISCUSSION

This study was started with the aim of analyzing the effectiveness of warm-up activity and cool down activity in reducing DOMS in 24 hr, 48 hr and 72 hr after the exercise. The warm-up and cool-down protocol given in the present study involved an exercise that was specific to the subsequent activity and muscles utilized.

Down-hill treadmill running was used as the eccentric exercise in both groups. From the statistical analysis, it is concluded that significant reduction of soreness was obtained in the experimental group incorporated with warm-up and cool down training before and after an activity.

The present study demonstrates that warm-up and cool-down has an appreciable effect on muscle soreness. This can also clearly be noted from the mean soreness values for VAS and NRS of the two groups.

Delayed-onset muscle soreness is thought to be due to damage of stretched myofibrils (Friden and Lieber 2001, Morgan

1990, Morgan and Allen 1999, Proske and Morgan 2001). The increase in muscle temperature associated with warm-up (of the order of 3 degrees C) (Gray and Nimmo 2001) could increase the compliance of structures in series with myofibrils. This would reduce the degree of stretch experienced by myofibrils, which could decrease the myofibrillar damage that occurs with unaccustomed exercise and the resulting muscle soreness. This suggests a mechanism by which warm-up could reduce delayed-onset muscle soreness.

Cooling-down performed after the exercise interferes with the cascade of events that follow the initial damage initiated by eccentric exercise-induced muscle damage, thereby reducing muscle soreness.

The above stated details may be the reason why the experimental group, who had a warm up and cool down session experienced lesser muscle soreness compared to the control group who weren't given any warm up or cool down session.

VI.III LIMITATIONS OF THE STUDY

- The age groups of the samples were between 18-25 years. So the result of this study cannot be generalized over all the age groups.
- The size of the sample is too small to generalize the findings.
- A potential threat to the validity of the findings is that participants could not be blinded.

VI.IV SCOPE FOR FURTHER STUDY

- The study was conducted among a small population. It can be done with more subjects.
- This study was done only in male athletes. It can be done with female athletes also.
- This study was done in the younger age group 18-25 years of age. It can be done in the middle and older age group as well.
- Further studies can be done among elite professionals as this study was done only among with amateur athletes.
- The present study was conducted with a 10 minute warm-up and cool-down session. Further studies can be conducted with different duration of warm-up and cool-down.
- The study can be done concentrating on different large muscle groups.

VI.V CLINICAL IMPLICATION

This study shows that warm-up and cool down regimen can reduce delayed-onset muscle soreness. As warm-up and cool-down exercises can be easily performed, athletes can make a worthy use of this activity in improving performance.

VII. CONCLUSION

Warm-up immediately prior to and cool-down immediately after an unaccustomed eccentric exercise reduces delayed-onset muscle soreness compared to the group which had no warm-up or cool-down. Athletes can take advantage of this data and incorporate a few minutes of warm-up and cool-down before and after their training session, so that with reduced muscle soreness, they will be able to train and perform better, thereby improving performance.

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APPENDIX

PAR-Q & YOU (A Questionnaire for People Aged 15 to 69)

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. However, some people should check with their doctor before they start becoming much more physically active.

If you are planning to become much more physically active than you are now, start by answering the seven questions below. If you are between the ages of 15 and 69, the PAR-Q will tell you if you should check with your doctor before you start. If you are over 69 years of age, and you are not used to being very active, check with your doctor.

Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly: check YES or NO.

QUESTIONS	Remarks YES NO
Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?	
Do you feel pain in your chest when you do physical activity?	
In the past month, have you had chest pain when you were not doing physical activity?	
Do you lose your balance because of dizziness or do you ever lose consciousness? Do you have a bone or joint problem (for example, back, knee, or hip) that could be made worse by a change in your physical activity?	
Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?	
Do you know of any other reason why you should not do physical activity?	

If you answered YES to one or more questions:

Talk with your doctor by phone or in person BEFORE you start becoming much more physically active or BEFORE you have a fitness appraisal. Tell your doctor about the PAR-Q and which questions you answered YES.

You may be able to do any activity you want—as long as you start slowly and build up gradually. Or, you may need to restrict your activities to those that are safe for you. Talk with your doctor about the kinds of activities you wish to participate in and follow his/her advice.

Find out which community programs are safe and helpful for you.

If you answered NO honestly to all PAR-Q questions, you can be reasonably

sure that you can:

Start becoming much more physically active—begin slowly and build up gradually. This is the safest and easiest way to go.

Take part in a fitness appraisal—this is an excellent way to determine your basic fitness so that you can plan the best way for you to live actively. It is also highly recommended that you have your blood pressure evaluated. If your reading is over 144/94, talk with your doctor before you start becoming much more physically active.

CONSENT FORM

I have been informed about the procedure and purpose of the study. I have understood that I have the right to refuse my consent or withdraw it any time during the study without adversely affecting my treatment.

I am aware that being subjected to this study I will have to give my time for assessment and treatment and these assessments do not interfere with the benefit.

I ----------, the undersigned give my consent to be a participant of this investigation / study program / clinical trail.

Signature of the Guide

Signature of subject

(Name & Address)

ASSESSMENT PERFORMA

NAME :

AGE :

SEX :

SUBJECT NUMBER :

SIDE :

PSYCHOLOGICAL STATUS : GOOD / BAD

ANY CONTRAINDICATIONS : YES / NO

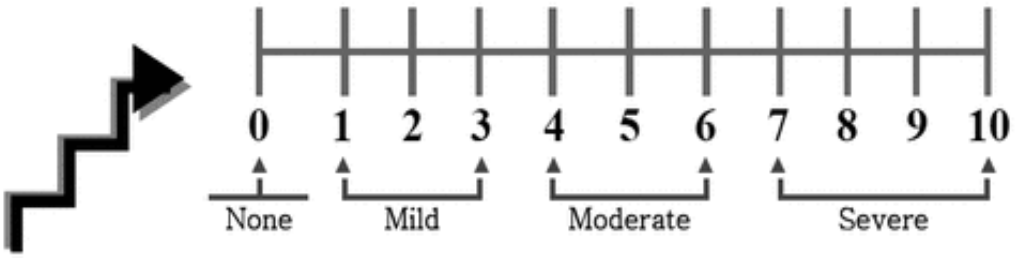
GROUP : Experimental / Control

DATA COLLECTION SCORE OF SORENESS - VAS and NRS

VARIABLE	**Score after 24 Hours**	**Score after 48 Hours**	**Score after 72 Hours**
Soreness using VAS			
Soreness using NRS			

Guide Signature **Student Signature** **Subject Signature**

NUMERICAL PAIN RATING SCALE



VISUAL ANALOGUE SCALE

No pain

Worst pain ever

100 mm

MASTER CHART

EXPERIMENTAL GROUP

SORENESS SCORE USING VAS in mm

S.No.	Score after 24 Hours	Score after 48 Hours	Score after 72 Hours
1	15	20	12
2	23	26	18
3	30	38	21
4	10	17	8
5	15	25	12
6	12	14	10
7	17	19	14
8	15	18	10
9	11	15	8
10	18	24	12
11	22	26	14
12	10	15	10
13	15	17	12
14	18	21	16
15	12	14	11

EXPERIMENTAL GROUP

SORENESS SCORE USING NRS in mm

S.No.	Score after 24 Hours	Score after 48 Hours	Score after 72 Hours
1	4	6	2
2	3	5	0
3	5	5	1
4	2	5	2
5	4	6	3
6	4	4	2
7	4	4	1
8	3	4	1
9	5	6	2
10	4	5	2
11	2	4	1
12	2	5	1
13	3	4	0
14	1	4	1
15	2	4	1

CONTROL GROUP

SORENESS SCORE USING VAS in mm

S.No.	Score after 24 Hours	Score after 48 Hours	Score after 72 Hours
1	19	25	20
2	27	32	24
3	35	44	38
4	21	28	25
5	25	32	29
6	14	26	25
7	17	30	24
8	36	52	44
9	28	43	29
10	31	47	41
11	27	33	32
12	19	29	28
13	16	32	26
14	19	21	20
15	27	33	29

CONTROL GROUP

SORENESS SCORE USING NRS in mm

S.No.	Score after 24 Hours	Score after 48 Hours	Score after 72 Hours
1	5	6	5
2	5	5	4
3	4	5	2
4	3	5	4
5	4	6	4
6	4	5	4
7	4	4	2
8	5	6	5
9	5	6	5
10	5	5	5
11	4	5	4
12	3	5	4
13	4	4	2
14	3	6	2
15	5	5	4