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Original Research Article

Effectiveness of Nordic Hamstring Exercise in Improving Hamstring Muscle Flexibility, Strength and Endurance among Young Adults

Seethal K Babu[1], Anila Paul[2]

[1]MPT, [2]Professor & HOD,
Medical Trust Institute of Medical Sciences, College of Physiotherapy, Irumpanam, Kochi, Kerala. 682309.

Corresponding Author: Anila Paul

ABSTRACT

Background: Hamstring injuries are common in activities of daily living and sports. Nordic hamstring exercise (NHE) is an eccentric training of the hamstrings which can both lower the risk of hamstring strain and improve muscle performance. Fitness parameters like, muscle flexibility, strength and endurance are important for injury prevention. Therefore, this study was designed to investigate effect of Nordic Hamstring Exercise (NHE) in improving Hamstring muscle flexibility, strength and endurance among young adults.
Methodology: Forty subjects were recruited for the study through purposive sampling based on inclusion criteria. Participants were allocated to two groups, experimental group (females= 15, males= 5) and control group (females=15, males=5) randomly. Pre test analysis was conducted for both groups for Hamstring muscle flexibility using sit and reach test, strength with Modified Sphygmomanometer Test (MST) and endurance with Sit to stand test. Experimental group received NHE in addition to conventional exercise whereas; control group received conventional exercise for 5 weeks. Immediate post test analysis was conducted. Student's 't' test was used for statistical analysis.
Results: There was a significant difference in flexibility (t=4.20), strength right side (t=3.54), strength left side (t=3.48) and endurance (t=4.41) between the control and experimental group with level of significance $p \leq 0.05$.
Conclusion: This study revealed significant improvement in Hamstring muscle flexibility, strength, and endurance after 5 weeks of Nordic Hamstring Exercise training.

Keywords: Nordic Hamstring Exercise, Eccentric training, Flexibility, Strength, Endurance.

INTRODUCTION

Hamstring is a group of muscle on the posterior aspect of the thigh consists of Biceps femoris, Semitendinosus and Semimembranosus. [1] Being an antigravity muscle, Hamstring muscle aid in maintaining body posture, holding position of pelvis and performing trunk movements in relation to lower extremity. Direct or assisted participation of Hamstring is inevitable in activities like running, jumping and changing speed. [1]

Activities of Daily Living (ADLs) like, descending the stairs, transition from sitting to standing, walking, running etc. require eccentric contractions of Hamstring muscle. Lack of physical activity as well as sedentary life style can increase the risk of

chronic diseases and reduce motor firing there by inducing muscle wasting especially, muscles of lower extremity. Eventually, prolonged sitting can also lead to Hamstring muscle shortening. [2] Reduced activation of motor units has been reported in sedentary individuals. According to literature, Hamstring is one of the muscles expected to be affected by prolonged sitting in terms of flexibility, strength and endurance. [3]

Eccentric muscle contraction has got reduced oxygen requirement and thus lower metabolic demand. Muscle contractions occur during our ADLs like descending the stairs, transition from sitting to standing, walking, running etc. Studies show that muscles are at risk of injury during eccentric activities. [3] Some of the benefits of eccentric contractions of the muscles are: more nervous adaptation to eccentric than concentric training, the greater force production due to greater use of external load, maximal eccentric contractions activates fast twitch fibers, each motor unit gets more stimulation, and most of micro-trauma of muscle cells is induced by eccentric training. It serves as a signal to begin the process of adaptation of muscle. During an eccentric contraction the muscles behave like springs in the musculoskeletal system. [3,4]

Eccentric exercise produces more muscle tension compared to concentric exercise. It produces a lengthening contraction. Total number of sarcomeres, which are arranged in series and parallel, increases with eccentric training. This form of exercise induces more rapid adaptations, by addition of sarcomeres. This induces sub-cellular damage or micro-lesions in the muscle, thereby it aids in impressive adaptations. [4]

A length-tension relationship curve of a muscle fiber gives the information about the length at which, maximum or least amount of force is produced. Greater number of cross bridge formation is achieved through optimum length of muscle fiber. While considering the whole muscle, both active and passive components of the muscle contribute in producing maximum force. At longer lengths, maximum force is produced by passive components. But at shorter lengths maximum force is produced by active components. [5]

During eccentric contraction, myosin cross bridges of active elements of muscle is broken. Myosin head is detached from actin without the release of ADP and subsequent rebinding of ATP. Thus force production from active elements of muscle during lengthening requires less energy. This contributes to an efficient eccentric phase. All these factors result in increase in muscular endurance. [6]

Hamstring muscles are vulnerable to injuries due to its impact on two major joints of human body while performing multiple activities. They act on the hip joints and knee joints, which are very important in basic movements of gait. Stabilizing role during movement requires very good coordination among these muscles with the synchronized activity of other muscles. Concentric and especially eccentric movements are very prominent during functioning of hamstring muscles. During eccentric movements, there occurs sudden lengthening contraction of the muscle. Thus it requires much greater force to withstand that strain which otherwise may contribute to an injury. [6]

The Hamstrings are susceptible to injury during terminal swing before initial heel strike. Hamstrings appear to be the most biomechanically exposed during terminal swing. Most of the inertial force acting about knee joint at this time is potentially imparted onto hamstrings and they are working to decelerate knee extension and also becoming an active extensor of hip joint. [7]

Eccentric muscle training is gaining importance nowadays due to its effects in reducing injury by adapting the muscle for the particular activity through sarcomerogenesis. Nordic hamstring exercise (NHE) is the eccentric training of the hamstrings which can both lower the

risk of hamstring strain and improve muscle performance. The Nordic hamstring exercise was described by Brockett in 2001 as Nordic Hamstring Lowers. [4] Later in 2004, Mjolsnes et al restructured Nordic Hamstring Lowers and it was termed as Nordic Hamstring Exercise. The Nordic Hamstring Exercise is performed with the subject standing on his knees, hips and back straight and arms along sides. One should sit behind the subject holding on to the subject's ankles. And he is instructed to slowly descend to the ground. [8] In this position, the hamstrings are activated as soon as the player starts his descend, working eccentrically. The gluteus maximus, lower back extensors as well as gastrocnemius also assist in holding the subject back from falling on his chest. [9]

Need of study: Literature reported that Nordic Hamstring Exercise (NHE) reduced number of injury rates after pre season training among athletes. But, there are controversies on improvement in Hamstring muscle strength. Several studies reported neither an improvement in muscle strength nor a reduction in injury rates. [10] Therefore, this study was designed to investigate the effect of NHE in improving the parameters like hamstring flexibility, strength, and endurance among the young adult population.

Objectives: The objectives of this study were to explore the effectiveness of Nordic Hamstring Exercise in improving hamstring muscle flexibility, muscle strength and endurance.

Relevance of study: Several investigations have been performed in professional & semi professional athletes regarding the effect of Nordic Hamstring Exercise. Few studies reported reduced injury rates on implementation of Nordic Hamstring Exercise among athletes. Controversies exist regarding the effectiveness of the exercise since some studies reported that implementing NHE in pre season training reduced the performance rate of the athletes. [10] There is a scarcity of literature regarding the effects of Nordic hamstring exercise among young adults specifically in improving Hamstring muscle flexibility, strength and endurance. The present study attempts to fill up this void in literature.

MATERIALS AND METHODS

Ethical approval was obtained from the Ethics Committee of the institution and the study was conducted among college students. Two group pre test - post test design was used with purposive sampling. Selected subjects were randomly allocated to two groups using computer generated random table. Forty subjects (30 females & 10 males, within the age group of 18-35 years) who fulfilled inclusion and exclusion criteria were recruited for the study. The independent variables were Nordic Hamstring Exercise and Conventional exercise where as the dependent variables were Hamstring muscle flexibility, strength and endurance.

Sample selection: One hundred and fourteen subjects, who volunteered, underwent initial screening. During initial screening, Hamstring muscle flexibility was measured using sit and reach box. Females who got a score less than or equal to 24 cm and males with score less than or equal to 21 cm on sit and reach box test were selected. It was followed by a secondary screening for any known cardiovascular, neurological and/or musculoskeletal disorders. Those who reported with such disorders were excluded from the study. From the remaining forty six subjects, 40 subjects were recruited randomly into conventional and experimental group by using computer generated random table.

One week before the intervention commenced, participants underwent pre tests: sit and reach test, modified sphygmomanometer test and 30 sec sit to stand test. After the completion of pre test, interventions were given for 5 weeks. Both groups were re assessed after the 5 weeks training.

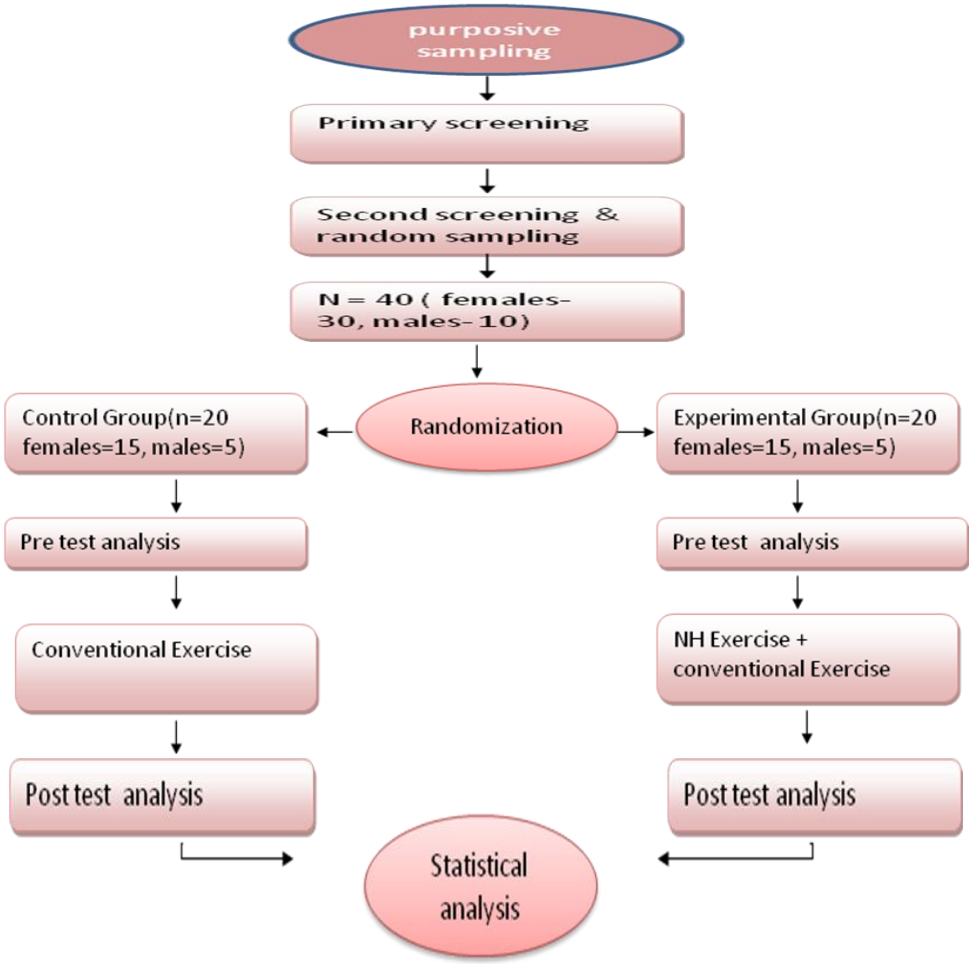


Figure I: Flow chart representing methodology

Materials used for data collection were, Sit and reach box, Modified sphygmomanometer, Chair, Timer, Goniometer and Inch tape. The inclusion criteria were, age between 18 to 35 years, both genders and pre-diagnosed hamstring tightness with sit and reach test - females having less than 24 cm & males having value less than 21cm were included. Exclusion criteria were, subjects sustained recent fractures, ligament injuries, muscles cramps, recent surgeries, balance disorders, any deformities & pathological conditions affecting musculoskeletal system, non co-operative subjects and subjects with any known cardiovascular, neurological musculoskeletal disorders.

Outcome Measures:

Hamstring flexibility was assessed with sit and reach box. Participants performed short warm up stretch prior to test. Participant was instructed to remove their shoes. The subject was instructed to sit with the soles of the feet flat against the Flexometer at the 23cm mark. Inner edges of the soles were placed within 2 cm of the measuring scale. By keeping the knees extended, client was instructed to place both hands superimposed with tips of middle finger at 23cm mark. Command "reach forward with both hands as far as possible" was given. He/she was asked to hold this position for approximately 2 Sec. The subject was instructed to keep both hands superimposed and in contact with measuring scale. Best of 2 trials were recorded. [11]

Hamstring strength was assessed with modified sphygmomanometer test. Participants were asked to do short warm up prior to strength testing. They were made to sit on the couch with legs on side of the couch. Knees were in 90 degrees of flexion

at edge of the couch. Cuff was inflated to 40 mmHg and kept between the posterior aspects of the distal end of leg. He was asked to press on to the cuff with maximal effort and hold for 5 seconds. Maximum values attained were noted and best of 2 trials were recorded. Same procedure was performed for opposite leg. [12,13]

Figure II: Sit and Reach Test

Endurance was assessed with 30 seconds sit to stand test. A chair without arm rest and seat height of 17 inches from the floor was placed with back rest against the wall. The participant was asked to perform a short warm up prior to the test. He was instructed to: sit on to the middle of the chair, keep his feet flat on the floor, keep his back straight, place his arms against his chest and hands on the opposite shoulder. On the command; "Go" he was instructed to rise on to full standing position and then sit back again as fast as possible. Repeat it for 30 seconds in the timer. Numbers of repetitions the subject came to a full standing position were counted and documented. If the subject was in half way to standing position when 30 sec was elapsed, it was counted as a stand. If the subject must use his/her arms to stand, test should be stopped and the score should be recorded as "zero". [14]

Figure III: Modified sphygmomanometer test

Figure V: Ending position for Sit to Stand test

Figure IV: starting position for Sit to Stand test

Method: All students and faculties of the college within the age group 18 to 35 years were invited to participate in the study. Out of which, one subject disagreed to participate. Response rate was 99.12%. All the participants were informed about entire procedure & a written consent was taken from all participants who were willing to participate. Those who fulfilled the inclusion criteria were recruited for the study after scrutiny (N=40). Outcome measures like sit and reach test, modified sphygmomanometer test & sit to stand test were demonstrated and explained to them. Two trials were performed and scores were documented.

Using the computer generated random table participants were assigned to two groups, group A & B with each group having 20 subjects. Group A was experimental group who received NHE and conventional exercises whereas, group B was control group who received conventional exercises only.

Intervention: All training sessions were preceded by a general warm up of 10 minutes for both control and experimental group. Warm up included whole body self stretches, spot jogging, neck rotation, arm rotation, dynamic chest, hip rotation and pushups. A cool down period of 10 minutes were provided after the exercise training. Cool down phase included whole body self stretches and gentle walking. Experimental group (group A) received Nordic Hamstring Exercise & conventional exercise. Control group received only conventional exercise.

Nordic Hamstring Exercise: Subjects were informed about the role of hamstring muscle, the possible injuries that may be caused by tightness as well as insufficient strength and endurance, importance of boosting the hamstring strength etc. NHE was demonstrated and its expected effect on the hamstring muscle was explained.

Subject was in kneeling position on the mat, head and neck in neutral position, arms by the side or in front of the chest, back and hip straight, knees in 90^0 flexion, and ankles well stabilized by the therapist. Therapist positioned behind the subject by stabilizing the ankles. Subject's legs were held stable by the therapist or the other partner. Subject was asked to lean forward slowly with a steady speed while trying to resist the forward fall by using the hamstring muscles as long as possible. When the balance to resist the forward fall is lost he/she falls on their arms & let the chest touch the ground. Push backward immediately to reduce the contraction of hamstring. In the first week use 2 sets with 5 repetitions, and then increase the number of sets to 3 and repetitions gradually every week according to the protocol. [10]

Dosimetry:

Week 1: 1 session, 2 sets, 5 repetitions per set

Week 2: 2 session, 2 sets, 6 repetitions per set

Week 3: 3 sessions, 3 sets, 6 repetitions per set in the 1st session, 7 repetitions per set in the 2nd session and 8 repetitions per set in the 3rd session

Week 4: 3 sessions, 3 sets per set, 8 repetition per set in 1st session, 9 repetition per set in 2nd session and 10 repetitions per set in 3rd session

Week 5: 3 sessions, 3 sets per session, 12 repetition per set in 1st session, 10 repetition per set in 2nd session and 8 repetitions per set in 3rd session

Figure VI: Initial position for NHE

Figure VII: Subject performing NHE

Figure VIII: Final position of NHE

Conventional Exercise: Participants were informed about the importance of training their hamstring and its crucial role in different activities of daily life. Exercises were demonstrated and they were made to perform trials. In standing position, subjects were asked to kick their right and left heels alternatively to touch buttocks for 20 times. It was followed by lifting their right and left knees alternatively close to chest for ten times. Both set of exercises were repeated for 3 times.

Hamstring self stretches using contract relax method. Subjects were instructed to be in half kneeling position. Knee kept in front was slightly flexed at the start and ankle was relaxed. Subjects were instructed to press their heel on to the ground and hold it for 5-10 sec. Then they were instructed relax and use their hands to extend their knees. Stretch was held for 20 sec. Stretch was repeated for 3 times. A partner stretch of the hamstring in supine lying was performed. Subject was instructed to be in supine lying. Subject's hip was flexed while keeping his/her knee in flexion. The stretch was held till he could feel the stretch on back of his thighs. Then he was asked to press his heel to extend the knee. This stretch was carried out for 15 seconds and 3 times. [10,15]

For prone leg hangs, subjects were instructed to be in prone lying with their knees flexed at 90 degrees. From this position they were instructed to drop their legs by extending knees. While performing that extension, they were asked to catch/stop extension just prior to the terminal extension (drop & catch). Speed was increased and progressively weight was added. [10] Immediately after the completion of 5 weeks training post test was done on hamstring strength, flexibility and endurance.

Figure IX: Heel to Buttocks kick

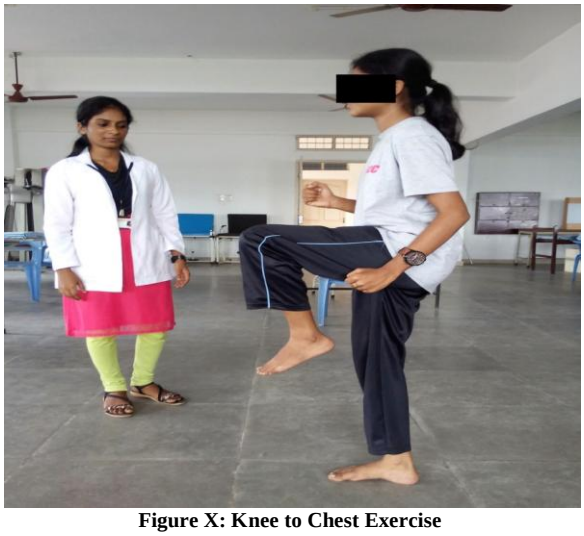


Figure X: Knee to Chest Exercise

Figure XI: Hamstring self stretch

All the statistical analysis and graph preparations were performed using SPSS and Microsoft excel. Student's unpaired t test was used to determine the training effect between experimental and control group and paired t test was used for intra group comparison of pre - post test. The independent variables were Nordic hamstring exercise as well as conventional exercise and the dependent variables were Hamstring muscle flexibility, strength and endurance. Significance level was kept at $p<0.05$ with 95 % confidence interval. All the tests were two – tailed.

RESULTS

The study was a pre test – post test experimental design to explore the effectiveness of Nordic Hamstring Exercise among young adults. The mean age was 20.7 ± 0.80 years in experimental group & 21.2 ± 0.61 years in control group. The mean BMI was 21.55± 3.3 kg/m^2 in experimental group & 20.92 ± 3.34 kg/m^2 in control group. Both groups had 15 females and 5 males each. All participants were adherent to the study throughout the protocol. Forty subjects (male = 10 and female = 30) within age group of 18-35 years were recruited for the study.

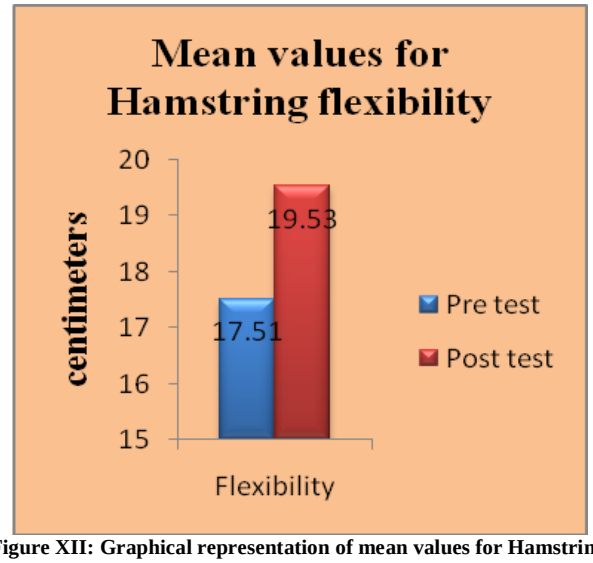
Comparison of pre and post test data within control group: Analysis among the control group showed that, mean pre test values for Hamstring muscle flexibility was 17.51, and mean post test value was 19.53 with standard deviation of 3.94 and 4.21 respectively. t value for flexibility was found to be greater than the table value at 95 % of confidence interval ($p<0.05$).

Mean pre test value for right Hamstring muscle strength was 133.0 and mean post test value was 148.0. Standard deviation was 1.42 and 2.82 respectively. t value for was found to be greater than the table value at level of significance less than 0.05. Mean pre test value for left Hamstring muscle strength was 131.3 and mean post test score was 148.0. Standard deviation was 1.64 and 2.91 respectively. t value for was found to be greater than the table value with level of significance less than 0.05.

Mean pre test value for muscle endurance was 19.65 and mean post test value was 21.90 with standard deviation 3.45 and 2.73 respectively. t value was found to be greater than table value with level of significance less than 0.05.

Table 1: Paired t test of control group

parameter		Mean	SD	t	Significance
Flexibility	Pre	17.51	3.94		
	Post	19.53	4.21	3.72	*p<0.05***
Strength right	Pre	133.0	14.22		
	Post	148.7	28.24	4.36	*p<0.05***
	Pre	131.3	16.40		
Strength left	Post	148.0	29.08	4.80	*p<0.05**
Endurance	Pre	19.65	3.45		
	Post	21.90	2.73	5.18	*p<0.05**



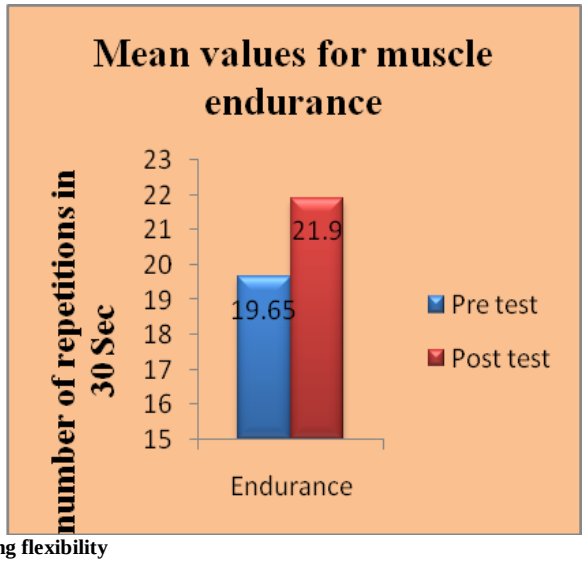


Figure XII: Graphical representation of mean values for Hamstring flexibility
Figure XIII: Graphical representation of mean values for Hamstring Endurance

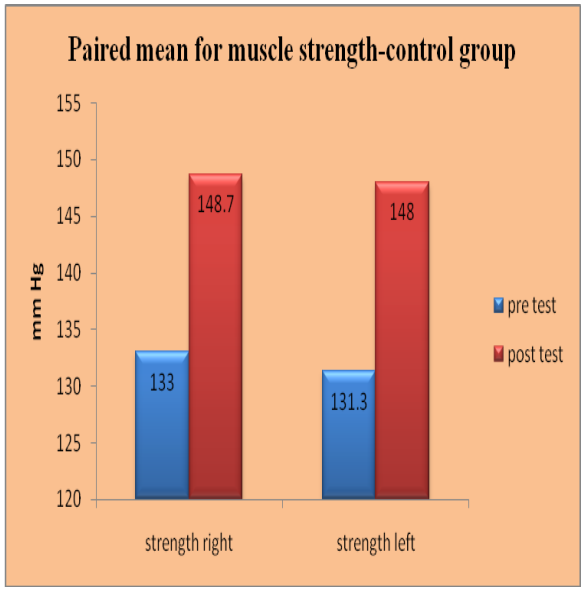


Figure XIV: Graphical representation of mean values right and left Hamstring strength in control group

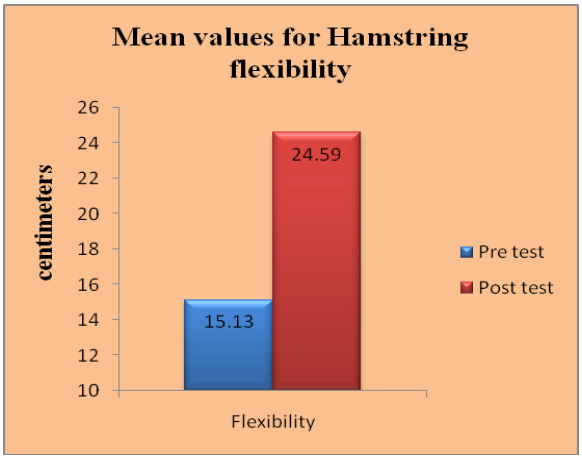
Comparison of pre and post test data within experimental group: Analysis among the experimental group showed that, mean pre test values for Hamstring muscle flexibility was15.13, and mean post test value was 24.59 with standard deviation of 4.39 and 3.37 respectively. t value for flexibility was found to be greater than the table value at 95 % of confidence interval ($p<0.05$).

Mean pre test value for right Hamstring muscle strength was 124.5 and mean post test value was 182.4. Standard deviation was 1.66 and 3.19 respectively. t value for was found to be greater than the table value at level of significance less than 0.05. Mean pre test value for left Hamstring muscle strength was 121.5 and mean post test score was 182.2. Standard deviation was 1.72 and 3.29 respectively. t value for was found to be greater than the table value with level of significance less than 0.05.

Mean pre test value for muscle endurance was 18.35 and mean post test value was 26.35 with standard deviation 2.48 and 3.59 respectively. t value was found to be greater than table value with level of significance less than 0.05.

Table 2: Paired t test for experimental group

Parameter		Mean	Sd	t	Significance
Flexibility	Pre	15.13	4.39	13.01	*p< 0.05**
	Post	24.59	3.37		
Strength right	Pre	124.5	1.66	10.66	*p< 0.05**
	Post	182.4	3.19		
Strength left	Pre	121.5	1.72	10.88	*p<0.05**
	Post	182.2	3.29		
Endurance	Pre	18.35	2.48	5.18	*p<0.05**
	Post	26.35	3.59		



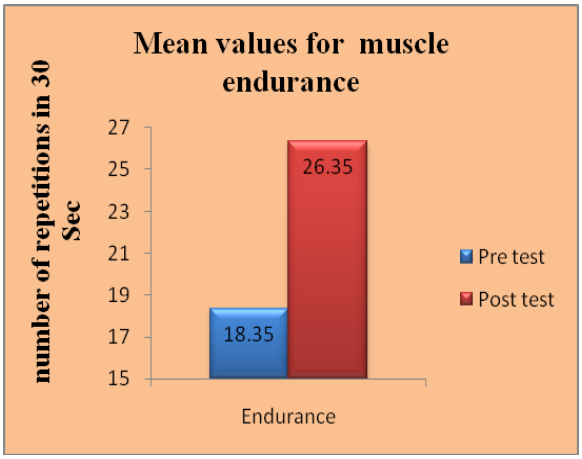


Figure XV: Graphical representation for mean values of flexibility in experimental group
Figure XVI: Graphical representation for mean values of endurance in experimental group

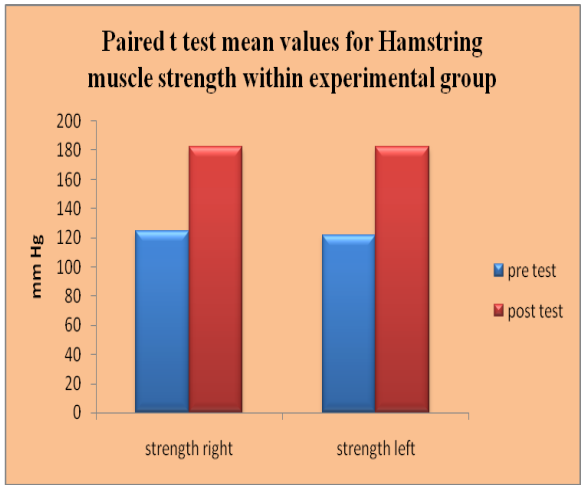


Figure XVII: Graphical representation for mean values of right & left side Hamstring strength in experimental group

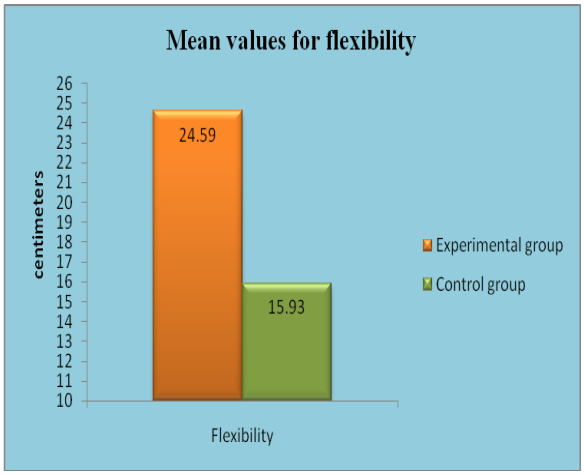


Figure XVIII: Graphical representation for comparison of flexibility between control & experimental group

Comparison of Hamstring muscle flexibility between experimental & control group: Analysis between control and experimental group showed that mean value for Hamstring muscle flexibility among experimental group was 24.59 and among control group was 19.53. Standard deviation for experimental group was 3.37 and for control group was 4.21. t value for flexibility was found to be greater than the table value and level of significance (p value) was less than 0.05. So we can conclude that the experimental group shows a highly significant score for Hamstring muscle flexibility compared to control group.

Table 3: Results of comparison mean values for flexibility

Group	Mean	S.D.	Difference between means	t	Significance (*p*-value)
Experimental group	24.59	3.37	5.06	4.20	*p < 0.05**
Control Group	19.53	4.21			

Comparison of Hamstring muscle strength (right) between experimental & control group: Analysis between control and experimental group showed that mean value for right Hamstring muscle strength among experimental group was 182.0 and among control group were 149.0. Standard deviation for experimental group was 3.19 and for control group was2.82. t value for flexibility was found to be greater than the table value and level of significance (p value) was less than 0.05. So we can conclude that the experimental group shows a highly significant score for right Hamstring muscle strength compared to control group.

Table 4: Independent t test for hamstring strength (right)

Group	Mean	S.D.	Difference between means	t	Significance (*p*-value)
Experimental group	182.0	3.19	33.0	3.54	*p < 0.05**
Control Group	149.0	2.82			

Comparison of Hamstring muscle strength (left) between experimental & control group: Analysis between control and experimental group showed that mean value for right Hamstring muscle strength among experimental group was 182.0 and among control group were 148.0. Standard deviation for experimental group was 3.29 and for control group was2.91. t value for flexibility was found to be greater than the table value and level of significance (p value) was less than 0.05. So we can conclude that the experimental group shows a highly significant score for left Hamstring muscle strength compared to control group.

Table 5: Independent t test for hamstring strength (left)

Group	Mean	S.D.	Difference between means	t	Significance (*p*-value)
Experimental group	182.0	3.29	34.0	3.48	*p < 0.05***
Control Group	148.0	2.91			

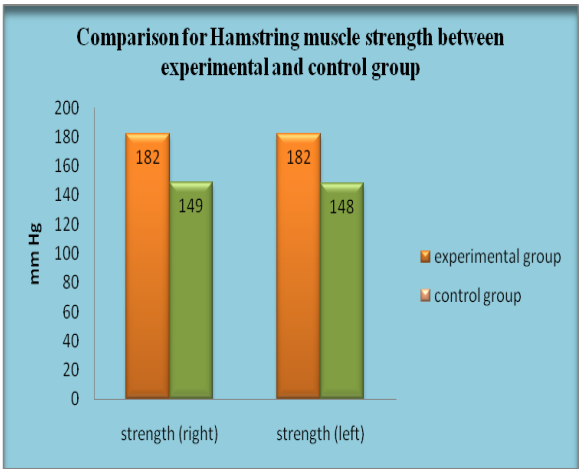


Figure XIX: Graphical representation for comparison of Hamstring strength between control & experimental group

Comparison of endurance between experimental & control group: Analysis between control and experimental group showed that mean value for muscle endurance among experimental group was 26.35 and among control group were 21.90. Standard deviation for experimental group was 3.59 and for control group was2.73. t value for flexibility was found to be greater than the table value and level of significance (p value) was less than 0.05. So we can conclude that the experimental group shows a highly significant score for muscle endurance compared to control group.

Table 6: Independent t test for endurance

Group	Mean	S.D.	Difference between means	t	Significance (*p*-value)
Experimental group	26.35	3.59	4.45	4.41	*p < 0.05***
Control Group	21.90	2.73			

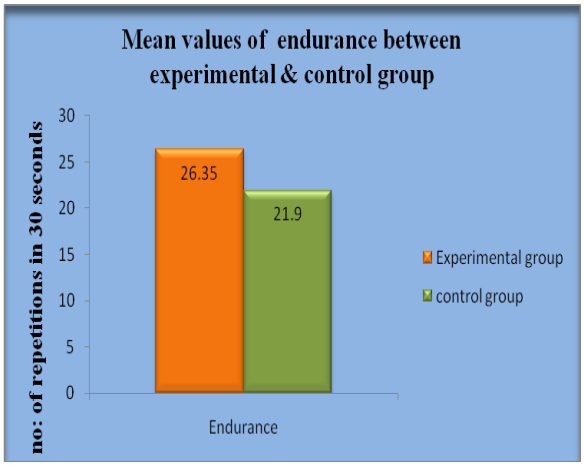


Figure XX: Graphical representation for comparison of lower limb mucsle endurance between control & experimental group

Thus it can be concluded that Nordic Hamstring Exercise is effective in improving Hamstring muscle flexibility, strength and endurance.

DISCUSSION

Results demonstrated that, there is improvement in Hamstring flexibility, strength and endurance among both the groups but experimental group showed a significant improvement compared to control group. Within group comparison of pre and post test data for Hamstring muscle flexibility among the experimental group, showed a highly significant difference in the paired t test with a mean difference of 9.46 at level of significance less than 0.05. Right Hamstring muscle strength showed a significant difference in paired t test with mean difference of 5.80 with level of significance <0.05. Left Hamstring strength showed a mean difference of 6.07 at p value 0.05 <0.05. Lower limb endurance showed a mean difference of 8.0 with level of significance less than 0.05

While considering the comparison between means of Hamstring muscle

flexibility among experimental and control group, Experimental group showed improvement with mean difference of 5.06. Level of significance was less than 0.05. Significant difference in flexibility might be due to change in the optimum length of the Hamstring muscle fibers following repeated eccentric contractions. Based on the existing literature, eccentric contractions result in change in length of the sarcomere and a shift in the optimum angle. It is proposed that there will be an acute shift in length immediately after the eccentric exercise and a second shift in length after repeated training sessions. Acute shift is thought to occur from increased compliance and disrupted sarcomeres. [12] Morgan D et al proposed that during active lengthening, myofilaments are stretched and some sarcomeres will be overstretched. They will become progressively weaker until the myofilaments no longer overlap. But when these eccentric contractions are repeated, over time more sarcomeres will be converted from weaker to stronger and they will not re integrate at the end of each contraction. Another theory suggests that eccentric contraction can cause increase in passive tension of the muscle which might be the reason for improvement in flexibility after the NHE. [10]

In comparison between means of Hamstring muscle strength among experimental and control group, Experimental group showed improvement with mean difference of 33.0 in right Hamstring strength and 34.0 in left Hamstring and level of significance was less than 0.05. Significant difference in the Hamstring muscle strength can be explained with the literature support from Newton R et al (1994). When there is dynamic explosive movements, type 2 muscle fibres are recruited and as the velocity of contraction increases, muscle's ability to produce strength will be increased. [15]

It is possible that the gain in strength must be due to increased neural activities like increased motor unit recruitment, increased rate and synchronization of firing, and motor learning. These changes are caused by decrease in the inhibitory function of CNS and GTO. These strength improvements most probably occur at muscle as well as at the musculotendinous junction. The connective tissues around the muscle fibres thicken, giving more support to the fibres. It is proposed that the non contractile soft tissues of the muscle may develop strength more rapidly with eccentric training than with other types of exercises. [15] This might be the reason for the significant improvement in Hamstring strength among experimental group.

Another point is that, NHE can be considered as a closed chain exercise according to the conditions of closed chain motion described by Steindler. There is proposition that closed chain exercise provide greater proprioception and kinesthesia because axial loading provides joint approximation which is believed to stimulate mechanoreceptors in muscles and joint. [16] These factors might have a positive effect on the muscular strength and endurance.

While considering comparison between means of lower limb endurance among experimental and control group, Experimental group showed improvement with mean difference of 4.45 and level of significance was less than 0.05. Healthy individuals with below average STS test performance could be associated with decreased lower body muscular strength and endurance. Since experimental group showed a improvement in STS, it indicates that NHE being an eccentric exercise with several repetitions aid in improving both lower body endurance as well as strength in healthy young adults. It is said that, there is an improvement in number of sarcomeres and cross sectional area of type 2 muscle fibers in the eccentrically trained muscle. [17] This might be the reason for improvement in Hamstring muscle endurance in eccentrically trained experimental group compared to control group.

Maximal motor unit firing increases in response to dynamic resistance training.

This can be correlated with improvement in Hamstring muscle strength and endurance in control group. He also suggests that, stretch combined with loading that is nothing but an eccentric training is the most effective stimulus for enhancing motor unit firing rate in the muscle. [18] This can be the reason behind a highly significant improvement in endurance in the Experimental group.

Pre test- post test analysis using paired t test in both experimental and control group showed that both groups had significant changes in the parameters. Prone leg hangs performed in the conventional exercise and NHE performed in experimental group is different patterns of eccentric training of Hamstring muscle. This might be the reason for improving the parameters in both groups. But significant improvement is observed in experimental group. It can be explained by the concept of lever system.

During prone leg hangs, the lever is the lower leg, fulcrum is knee joint, effort is supplied by contraction of Hamstring muscle at its insertion and weight is the weight of the lower leg and pull force of gravity or weight of the resistance added. This can be considered as a third order lever. During this eccentric contraction only small amount of muscular contraction is required to achieve a much more rapid and extensive movement compared to NHE. While performing NHE, hip joint is stabilized by muscular contraction to form a lever. The fulcrum is knee joint; weight of the body is transmitted to tibia. The effort is applied at the origin of Hamstring muscle. [19] These factors would have contributed to the significant change in experimental group compared to control group. In current scenario, people spend more time in sitting and standing postures. Thus implementing NHE with daily exercise program will have an added advantage.

Strength of the study was compliance of the subjects with study and use of reliable objective outcome measures. Limitations of the study were lack of follow up for long term effects of NHE on Hamstring muscle.

Future studies could examine the relation between core muscle strength and NHE and its effect on hamstring injury as well as performance. In addition, studies incorporating control group with sham training could be conducted to explore the other variances that might have contributed to the result.

CONCLUSION

The results of the study showed that Nordic Hamstring Exercise demonstrated a significant improvement in Hamstring muscle flexibility, strength, and endurance as measured by sit and reach test, modified sphygmomanometer test and 30 sec sit to stand test respectively after 5 weeks of training. Thus it can be concluded that, Nordic Hamstring Exercise is effective in improving Hamstring flexibility, strength, and endurance among young adults. Since, improvement in physical fitness parameters like muscle flexibility, strength and endurance can prevent easy fatigue of the muscles thereby enhancing the efficiency of activities of daily living, it can be concluded that Nordic Hamstring exercise is an effective training program that can be incorporated in routine exercise program. Nordic Hamstring Exercise is easy to perform, is not a big time consumer, and can be done without the use of any additional equipment.

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