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A Study to Compare the Immediate Effect of PNF Stretching and Dynamic Stretching during Warm - up on 12 Minute Cooper Run Test Performance and Modified Sit and Reach Test among Young Individual: A Comparative Study

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Abstract: ***Background and objectives: Warming - up prior to a competitive exercise bout and physical activity is a widely accepted practice in the modern day sporting environment. Measurement of physical fitness is a common and appropriate practice in preventive and rehabilitative exercises programs. Extensive research has been conducted over the past decade to determine the key warm - up elements for specific exercise tasks on various field test like 12minute cooper run test. But there are limited evidence where PNF stretching warm up and Dynamic stretching warm - up are compared. Methods: The study was conducted on 150 young individuals who were selected according to selection criteria. Each group consisted of 75 subjects Group A was given PNF stretching warm - up and Group B was given Dynamic stretching warm - up. Result: Intra - group comparison for 12minute cooper run test and modified sit and reach test was done by Wilcoxon sign rank test and inter - group comparison for 12minute cooper run test and modified sit and reach test was done by Mann Whitney U test. The results revealed that the both Group showed significant improvement in 12 minute cooper run test and modified sit and reach test. Also, between group comparison revealed significant difference between the two techniques in 12 minute cooper run test (z value= - 7.599, p value<0.05) modified sit and reach test (z value= - 3.621, p value <0.05) for young individual. Conclusion: It can be concluded that both PNF stretching warm - up and Dynamic stretching warm - up are effective for improving performance and flexibility. But PNF stretching warm up group seems to have more effect on improving performance and flexibility as compare to Dynamic stretching warm - up group.***

Keywords: PNF Stretching, Dynamic stretching, 12minute Cooper run test performance, Modified Sit and Reach test, warm – up

1. Introduction

The term warm - up is defined as a period of preparatory exercise in order to enhance subsequent competition or training performance. [1] Warming - up prior to a competitive exercise bout or any physical activity is a widely accepted practice in the modern sporting environment. [2]As evidence continues to evolve regarding the numerous health benefits of physical activity and exercise, the focus on health - related physical fitness and physiological fitness appears to have superseded to that of skill - related physical fitness. [3]Measurement of physical fitness is a common and appropriate practice for preventive and rehabilitative exercise programs. [3]

Commonly used modes for exercise testing are field tests, treadmill tests, cycle ergometry tests, and step tests. Field tests consist of either walking or running a certain distance in a given time (i.e., 12 - minute and 1.5 - mile [2.4 - km] run tests, and the 1 - and 6 - minute walk test) [3].

Warm - up prior to an athletic event or physical activity is considered essential to improve performance. [4]According to the general procedure of submaximal exercise testing, the exercise test should begin with a two - to three - minute warm - up to acquaint the client and prepare him or her for the exercise intensity in the first stage of the test. [3] Extensive research has been done over the past decade to determine the key warm - up elements for specific exercise tasks. [2] Several minutes of low - intensity aerobic exercise followed by stretching is generally recommended for young fitness participants. [5]

Stretching can be defined as the act of applying a tensile force to lengthen muscle and connective tissue. [6] Warm - ups are typically composed of a submaximal aerobic activity, stretching and an activity which is specific to particular sport. [7] Flexibility has been defined as the ability of a muscle to lengthen and allow one joint to move through a range of motion. [8] Loss of flexibility is defined as a decrease in the ability of a muscle to deform. [8]

Over the past few years, long - held beliefs regarding the value of pre - event static stretching have been in question, and increased attention has centred on the performance of higher - intensity movements during the warm - up period. [5]

Stretching

Stretching is a general term used to describe any therapeutic manoeuver designed to increase the extensibility of soft tissues, thereby improving flexibility and ROM by elongating (lengthening) structures that have adaptively

shortened and have become hypomobile over time. [6]Numerous stretching techniques have been developed, reported and applied by physical therapists, coaches and athletic trainers for improving ROM as well as for warm - up purposes.

Proprioceptive Neuromuscular Facilitation (PNF) –
When muscle fibres are reflexively inhibited through autogenic or reciprocal inhibition, there is less resistance to elongation by the contractile elements of the muscle. [6]

Dynamic stretching –
Low - intensity active stretching, using repeated, short - duration, end range active muscle contractions of the muscle opposite the shortened muscle is a form of self - stretching exercise. [6]

PNF Stretching –
In the early 1900s, Sherrington defined the concepts of neuromuscular facilitation and inhibition, and that subsequently led to the development clinical PNF stretching by Kabat. [9]PNF stretching is thought to target Golgi Tendon Organs (GTOs) and muscle spindles specifically; inhibiting muscle spindles and increasing GTO activity allowing a muscle to stretch further. [10]Several Theories exist that attempt to explain the mechanisms by how PNF stretching can increase ROM and therefore improve performance.

The main theories are – [6]
1) Autogenic Inhibition and
2) Reciprocal Inhibition

1) Autogenic Inhibition
When a muscle contracts, the tension in muscle increases. The Golgi tendon organ detects the muscle tension and sends impulses through afferent (group Ib) fibres, which enter the spinal cord through dorsal root. In the spinal cord, the group Ib afferents stimulate the inhibitory interneurons. And the inhibitory interneurons in turn release inhibitory mediator glycine, which inhibits α - motor neurons and cause relaxation of the muscle that was originally contracted [11]

2) Reciprocal inhibition
Contraction of muscles is accompanied by simultaneous inhibition of their antagonists. Reciprocal innervation is a necessary part of coordinated motion. Relaxation techniques make use of this property. [12]

Dynamic Stretching
The dynamic stretch involves similar leg positioning as the other stretching interventions, but the stretch will be achieved through muscular activation and rhythmic movement. [13]

Static stretching (SS) has been recently criticized for impairing muscular performance reflected, for example, in maximal voluntary strength, muscle power, sprint time, and jump height. Because of this there is a shift from SS back to dynamic stretching (DS), recommending that DS may be included in the stretching component of warm-ups to increase task-specific range of motion (ROM), and facilitate stretch-shortening cycle soon before an activity, and/or when a full pre-activity routine is not completed. [14]

The mechanisms that seek to explain the advantage of dynamic stretching are only suggestive that include increased heart rate, elevation of core and muscle temperature, and increased transmission rate and increased metabolism, therefore increasing tissue compliance and range of motion. [14]Specific rehearsal of movement patterns that may enhance proprioception and an increase in neuromuscular activity that is possibly linked to post-activation potentiation (PAP) also may lead to strength and power enhancement. [14]

Cooper 12minute Run test
Two of the most widely used running tests for assessing fitness are the Cooper 12 - minute test and the 1.5 - mile (2.4 - km) test for time. [3]The objective in the 12 - minute test is to cover the greatest distance in the allotted time period. [3] The objective in the 12 - minute test is to cover the greatest distance in the allotted time period. [3] The advantages of field tests are that they are easy to administer to large numbers of individuals at one time and little equipment (e. g., a stopwatch) is needed. [3]

Modified Sit and Reach test
The American college of sports medicine (1992) describes a modified sit and reach test which is used in the sports environment to assess non - specific flexibility. [15]

2. Review of Literature

- George M. Pamboris et. al, (2019) conducted a study on dynamic stretching is not detrimental to neuromechanical and sensorimotor performance of ankle plantarflexors and concluded that slow dynamic stretching (SDS) showed greater improvement than fast dynamic stretching in both neuromechanical and sensorimotor performance, and hence, SDS can be recommended as part of warm-up in sporting contexts [14]
- Laura Deguzman et. al, (2018) conducted a study for the immediate effects of self - administered dynamic warm - up, proprioceptive neuromuscular facilitation, and foam rolling on hamstring tightness and concluded that all interventions investigated appeared to be viable methods for increasing hamstring flexibility. Practitioners have their choice of the technique that most closely matches the athlete's needs and abilities [16]
- Courtney J. McGowan et. al conducted a study on warm - up strategies for sport and exercise: mechanisms and applications: review article, and concluded that The majority of the recent research supports the notion that a well - structured active warm - up elicits improvements in performance across a wide range of sports. [2]

Muscular injury is one of the major problems and cause for reducing performance. Warm - up has proved to have effect in increasing performance and reducing muscle injuries during any physical activity. Also warm - up consist of submaximal aerobic activity and different kind of stretching [7]. But there are little studies where comparison is done between these techniques and their effect on submaximal aerobic exercise test like 12 minute cooper test performance

is observed. So the purpose of this study is to see the immediate effect of PNF stretching and Dynamic stretching on 12 minute cooper test performance and modified sit and reach test among young individual. And also to compare the effect of both these techniques on 12 minute cooper test performance and modified sit and reach test among young individual.

2. Method

A Comparative study was conducted at Shri K. K. Sheth physiotherapy college, Rajkot on 150 individuals according to the selection criteria. Inclusion criteria were: Age: 18 - 25 years, Gender: Both Male and Female. And Exclusion criteria were: Individual with any recent lower limb injury in past one year. Individual with any cardiac or respiratory condition in past one year. Individual with any history of muscle injury in past one year. Individuals with any neurological condition. Individual not satisfying PARQ questionnaire.

After the approval for the study from the ethical committee, 150 young individual from in and around Rajkot city, who fulfilled the selection criteria were taken for the study purpose. After proper explanation about the purpose and procedure of the study, individuals who participate in this study were requested to sign a written consent form.

The selection of participants was done by convenient sampling and then randomly divided into either of the two group, Group – A PNF stretching warm - up and Group – B Dynamic stretching warm - up.

A pre - participation evaluation form consisting of basic assessment chart which was to be filled, which included name, age, gender, occupation, address, and ROM.

After that explanation of Modified sit and reach test and 12 minute cooper test was given to the subjects and pre - evaluation was carried out for the same. The pre - data measured were recorded in the data collection sheet.

Procedure –
For 12 minute cooper test

For 12 minute cooper test, a flat course with measured distances (30m) was selected so that the number of laps completed can be easily counted and multiplied by the course distance. Markers were placed to divide the course of a distance of 3meter each so that quick determination of the exact distance covered in 12 min can be done. Individual were instructed to run or walk as fast as possible. Walking was allowed, but the objective of these tests was to cover as much distance as possible in 12 min. [17]

At the end of the test distance covered in meters was calculated and documented.

For modified sit and reach test
Individual was asked to sit with back support at wall and a measuring tape was placed on the floor and tape was placed across it at a right angle to the 15 - inch mark. The participant sits with the measuring tape between the legs, with legs extended at right angles to the taped line on the floor. Heels of the feet should touch the edge of the taped line and be about 10 to 12 inches apart. [3]

After evaluation for pre–data, on the next day post data was taken after warm up. In warm - up individual was asked to perform on spot marching for about 3 minutes followed by either PNF stretching or Dynamic stretchingfor bilateral hamstring, calf, and Quadriceps muscles was given according to prescribed group, after that rest was given for about 2 minute [18, 19]. This was included in warm–up.

Warm - up protocol for both groups were –
For **Group–A PNF stretching** (Hold - Relax technique) –
For **Hamstring** [figure 1**]** group of muscle individual was asked to lie in supine lying position, then therapist flexes the leg at hip joint up to the end range, individual was then asked to perform isometric contraction of hamstring muscle by asking them to press on shoulder of therapist or to perform hip extension movement. Maximal isometric contraction was to be elicited which was hold for 10sec and then 20sec stretch was given before initiating second contraction. [12, 17]

Figure 1

For **calf muscle** [figure 2], individual was asked to lie in supine lying position therapist grasp the individuals' ankle and perform passive dorsiflexion movement up to the end range, individual was then asked to perform isometric contraction of calf muscles by plantar flexing the foot. This contraction was also held for 10 sec followed by 20 sec stretch. [12, 7]

For **Quadriceps** group of muscle [figure 3] individual was asked to lie in the prone lying position with knee flexed and therapist grasp the thigh of the individual. Then individual was asked to perform hip flexion along with knee extension isometric contraction which was hold for about 10sec and followed by 20 sec stretch. [12, 17]

Figure 2

Figure 3

For each group of muscle 3 repetition of stretching was given and was given to bilateral lower limb. After warm – up 2 minute rest was given then evaluation for post data was taken for Modified sit and reach test and 12 minute cooper test.

For **Dynamic stretching –**
The dynamic stretch involved similar leg positioning as the other stretching interventions, but the stretch was to be achieved through muscular activation and rhythmic movement. [13]Dynamic Stretching were given in standing position.

For **Hamstrings** muscle [figure 4]: The subject contracted the hip flexors with knee extended and flexed the hip joint so that the leg swung forwards to the anterior aspect of his body i. e. front kick through the active ROM of the hip joint. [16]

For **calf muscle** [figure 5] – Step forward with one leg and keep back heel flat on the ground while knee was flexed. Contraction of quadriceps and tibialis anterior muscles to extend back knee. At the same time, move forward to the point of mild stretch on the back calf muscle and then immediately release i. e., forward lunge. [16, 20]

Figure 5

Figure 4

For **Quadriceps muscles** [figure 6] – The subject was asked to flex knee to buttocks and maintain the trunk in erect position until the point of mild stretch and then release the ankle. [20]

Figure 6

15 - 18 repetitions of each exercise were performed in an order. [16] After warm up 2minute rest was given then subject was asked to perform modified sit and reach test followed by 12 minute cooper test for post data.

3. Statistical test and Result:

12 minute cooper test performance data and data of modified sit and reach test are of interval/ratio type, [44] but normality was not followed according to Shapiro - willk test. So non - parametric test was applied. Intra - group comparison was done by applying Wilcoxon Signed - Rank Test. And inter group comparison between both the group was done by Mann - Whitney U test. **Level of significance (p value)** was set to 0.05 level i. e. at 95% confidence limit.

Table 1: Mean value, Standard Deviation, Wilcoxon signed rank test value of 12 minute cooper test performance for **Group A** before and after warm - up.

12 minute Cooper Test Performance (Group A)	Mean Standard deviation	Wilcoxon Test Z value	P value
Pre - data	1051.03+178.30	- 7.526	.000
Post - data	1125.16 +181.35		

Table 2: Mean value and Standard Deviation, Wilcoxon signed rank test of 12 minute cooper test performance for **Group B** before and after the warm - up.

12 minute Cooper Test Performance (Group B)	Mean Standard deviation	Wilcoxon Test Z value	P value
Pre - data	1061.75 +168.64	- 7.297	.000
Post - data	1104.99+171.99		

Table 3: Mean value and Standard Deviation, Wilcoxon signed rank test of Modified sit and reach test for **Group A** before and after the warm - up

Modified Sit and Reach Test (Group - A)	Mean Standard deviation	Wilcoxon Test Z value	P value
Pre - data	33.31+9.90	- 7.424	.000
Post - data	40.43+9.59		

Table 4: Mean value and Standard Deviation, Wilcoxon signed rank test of Modified sit and reach test for **Group B** before and after the warm - up.

Modified Sit and Reach Test (Group - B)	Mean Standard deviation	Wilcoxon Test Z value	P value
Pre - data	33.51+10.98	- 7.234	.000
Post - data	38.31+10.98		

Table 5: Mean value and Standard Deviation of12 minute cooper run test comparison between Group A PNF warm - up and Group B Dynamic warm - up

12 minute Cooper Test Performance	Group – A	Group – B	Mann – Whitney Test Z Value	P value
Mean	74.13	42.81	- 7.599	.000
Standard deviation	+20.58	+20.56		

Table 6: Mean value and Standard Deviation of Modified Sit and Reach Test comparison between Group A PNF warm - up and Group – B Dynamic warm - up

Modified Sit and Reach Test	Group – A	Group – B	Mann – Whitney Test Z Value	P value
Mean	7.1733	4.68	- 3.621	.000
Standard deviation	+4.10462	+3.17		

4. Discussion

The purpose of this study was to compare the effect of PNF stretching during warm - up and Dynamic stretching during warm - up on 12 minute cooper test performance and modified sit and reach test among young individual.

Muscular injury is one of the major problems faced by today's individuals who are engage in physical activity, both recreationally and professionally. Injuries that are related to skeletal muscle represent more than 30% of the injuries seen in sports medicine clinics [21]. Warm - up activities are necessary in order to prepare the body for vigorous physical activity because they enhance performance and decrease the risk of muscular injury. [22]Several clinical studies, also including a recent high quality randomized trial, suggest that structured warm - up programs designed to prevent injuries can reduce injury risk by 50% or more. [23]

For current study, after taking approval from ethical committee the comparative study was conducted on 150 young individuals 75 in each group. The pre data and post data for 12 minute cooper run test and modified sit and reach test was taken before and after giving the warm - up. When the values of pre - treatment and post treatment for 12 minute Cooper Test and Modified Sit and Reach test were analyzed, it shows statistically significant difference in both the groups. Also, when comparison was done between Group A and Group B, both the techniques were showing statistical significant difference for 12 minute Cooper Test and Modified Sit and Reach Test values.

The improvement in both flexibility and performance may be due to the beneficial effect of the warm - up given prior to tests. When the warm - up is given, the muscles become less viscous, which results in smoother contractions. In addition, the warm - up produces increase in muscle temperature, which leads to increased blood flow through active tissue and also facilitates the dissociation of oxygen from haemoglobin. [19] Also, increase in speed of nerve transmission is achieved. It has been shown that a warm - up provides a protective mechanism to muscle by requiring greater length of stretch and force to produce a tear in the warmed muscle. Thus how warm - up is beneficial in injury prevention. [21]

According to study by Cem Kurt et. alstatic and/or dynamic stretching exercises can be applied in addition to aerobic running to enhance flexibility, the author also suggest giving 2minute rest between the warm - up and test performed [19], which is supported by a previous study performed by Zachary D. Molacek concluding that sufficient rest given after acute stretching may mitigate potential negative effects on performance. [18]

The current study demonstrates that there is Statistical significant improvement in modified sit and reach test before and after giving warm - up techniques supporting the previous study. Possible explanation for the improved flexibility for the PNF technique could be because of viscoelastic nature of the muscle, also Knott. M. and Voss. D. (1968) proposed that during PNF stretching (hold - relax) autogenic inhibition of the target muscle is achieved. [24] This inhibitory effect has been suggested to increase muscle compliance, allowing for increased length during a stretch without stimulation of the stretch reflex. [24] The golgi tendon organ is a nerve receptor found in tendons, this receptors fires when tension increases in the tendon and this tension can be due to stretch or contracting muscle when the golgi tendon organ fires a signal is sent to the spinal cord causing the agonist muscle to relax. [24]

The possible mechanism by which dynamic stretching increased the flexibility and performance was explained by George M. Pamboris et. al, in his study on "dynamic stretching is not detrimental to neuromechanical and sensorimotor performance of ankle plantarflexors" and suggested that the change in the end ROM after acute bouts of Dynamic Stretching was because of a relatively larger increase in the strain of the tendon than the muscle. [14] Also Kieran O'Sullivan et al. has suggested that there is consistent evidence that dynamic stretching improves performance measures such as, agility, speed, and strength. Also it was mentioned that it appears that flexibility improves most with static stretching, while immediate physical performance improves with dynamic stretching. [25] This is in support with the analysis of the present study which shows the improvement in individuals' immediate performance after application of Dynamic warm - up.

So, for the current study the alternate hypothesis was verified as there was Statistical significant difference found when statistical analysis was done, hence the null hypothesis for the current study does not hold true.

Clinical Implication:
The current study demonstrates the effect of warm - up on test performance and flexibility. It is known that in order to prevent any muscular injury during any exercise or athletic competition warm - up is beneficial. The current study suggests that both dynamic warm - up and PNF warm - up can be used to improve the physical activity performance of the individual and it also improves the flexibility of the muscles among young individual. So either of these warm - up can be practiced before performing any physical activity to prevent any muscular injury.

5. Conclusion

The results of the present study conclude that there is significant difference among data recorded before and after giving warm - up for 12 minute cooper test and modified sit and reach test for both the Group A and Group B, showing effectiveness of warm - up on performance and flexibility. Also when intergroup comparison was done, significant difference was found between both the groups. Hence warm - up can significantly improve the performance of the individual and can be incorporated in daily recreational or sports specific activity.

6. Limitations of the study and further recommendation

Limitation are Gender inequality among subjects, only one age group was considered. Further recommendation could be similar study can be conducted for individual gender, other age group can be taken into consideration for the study, other muscles can also can be included for the study.

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