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# Flexibility Augmented by Heat-applied Stretching Exercise Compared to Exercise Without Additional External Heat

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**Abstract:** Introduction: the goal of stretching can vary; such diversify aims as enhancing performance, preventing injury and recovering from following injury. Objective: The aim of study is to examine 80 male football project players to determine; if heat applied stretching would better improvement in flexibility or not. Method: To achieve the intended objective randomized experimental design was implemented. Players who have been volunteered and fulfilled the research inclusion criteria are recruited and randomly grouped in to four equal sections. The first group was control group and did not perform any treatment, whereas the rest 3 experimental groups followed six weeks intervention program (3 days per week). SEG (Stretching Exercise Group only) engaged in stretching exercises only, on the other hand the remaining groups HP=Heat Packs Group and CP=Cold Packs Group undertaking thermal interventions (hot and cold packs respectively) for 20 minutes before performing the stretching exercise. Cold exposure was examined to see if it would have the opposite effect. On the study sit and reach test used as a standard measuring tool. For instance to inspect actual changes in groups, and also paired t-test was used to compare mean value, to this end the difference between groups was tested dependent t-test. The analysis conducted by SPSS -V 25 and in commenting on the analysis results, significance and rated at  $p < .05$  level. Result: Except Control Group, all experimental groups produced significant improvement in flexibility; however interventions produced different results, the mean Pre/Post differences and ( $p < .05$ ) were .81 ( $p < .03$ ) for Group two, 2.2 ( $p < .01$ ) for Group three and .5.9 ( $p < .04$ ) for Group four. When compared with groups, the Group which received heat packs prior to stretching obtained the greatest improvement in flexibility, which resulted in applied heat. In line to the result the investigator noticed heat applied stretching exercise is the most effective for promoting flexibility and cold exposure may limit flexibility improvement, but it wasn't seen having the opposite effect. All in all these finding seem to support and endorse the use of heat as an adjunct with stretching techniques in improving flexibility.

**Keywords:** Flexibility, Stretching, Exercise, Heat

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## 1. Introduction

Stretching is widely used by football players, trainers, coaches, physicians and therapists as a means to maintain, or restore muscle flexibility [1]. Stretching also used as part of physical fitness programs, because it has thought to be positively influence on physical performance and also injury prevention. Numerous studies [1, 3-7] have been conducted to investigate the effectiveness of stretching. The goal of stretching can vary, including such diversify aims as enhancing sports performance, preventing injury, recovering from following injury, and preventing muscle soreness [8, 9]. Stretching can be categorized as active or passive, static or

dynamic, and acute or chronic [10].

The application of thermal agents such as heat or cold is popular in clinical and rehabilitative settings. Altering tissue temperature can have a range of therapeutic effects through changes in metabolism, nerve transmission, hemodynamics, and mechanical properties [11].

Heat applied to peripheral tissues also can be used to increase the flexibility in body [12, 13]. The application of heat reduces pain [14] and increase blood flow to tissue [15], Increasing soft tissue temperature prior to exercise is an accepted practice. [16] This can involve active warm-up or local heat application using warm water immersion or hot packs. Heat is thought to alter the viscoelastic properties of

muscles and other collagenous tissues in preparation for physical activity or rehabilitation [16]. Heat is also used as an adjunct to developmental stretching and is often employed to treat restrictions in range of movement (ROM) due to injury or prolonged immobilization. [16]

## 2. Selected Stretching Exercise Protocols

### A. Ballistic Stretching

Ballistic stretching is one of stretching exercise used by this article. Sometimes it is called low-load static stretching, and proprioceptive neuromuscular facilitation techniques [PNF] are all techniques that have been used to accomplish the goal of stretching [17-22]. Ballistic stretching refers to a technique that uses a repetitive bouncing motion that lengthens the muscle quickly and immediately returns it close to the starting point and it may be beneficial for clients who want to return to competitive sports [23]. These authors [23] further suggested that ballistic stretching should be performed in a controlled manner, thereby decreasing the possibility of injury to the tendon [5].

### B. Static Stretching

The second exercise included under the study was also static stretching protocol, which requires that the stretch be performed in a slow, gradual manner and held at end-range just before the point that causes discomfort to the players. [20, 23] stated that static stretching is preferred over ballistic stretching because it is energy efficient, thus requiring less energy to perform than the ballistic stretch, and because the probability of injury may be lower than with ballistic stretching.

### C. PNF Stretching

Proprioceptive neuromuscular facilitation [PNF] includes another stretching technique for this study, which used to aid the neuromuscular responses through proprioceptive stimulation [13]. These techniques utilize different combinations of alternating contraction and relaxation of the agonist and antagonist muscle groups to increase joint range of motion [20, 23-25]. In these techniques, the agonist, or prime mover which the muscle to be elongated is passively moved to end-range and isometrically contracted, which is followed by an eccentric contraction of the antagonist muscle [18, 23]. However PNF techniques may difficult for the subject to understand and typically require another person to perform. Lower-load, static stretching exercises are used in most settings because of their simplicity and the decreased potential for injury [23].

It is generally assumed that a warm up, by increasing tissue temperature, will increase tissue distensibility and reduce the chance of injury, [22, 26, 27] Williford et al [25] investigated the effects of jogging prior to stretching compared with stretching alone on shoulder, trunk, hamstring, and ankle flexibility. They concluded that both methods were effective at increasing ROM and flexibility. These warm-ups involve many modalities and can include stretching, heat, changes in tissue temperature by exercise, and even mental conditioning [22, 26, 27]. Moreover, Increasing hamstring

flexibility may decrease lower extremity overuse injuries [8].

### D. Heat-Applied Stretching

Active exercise warm up heat is commonly used before exercise; the advantage is that by enhancing muscle tissue metabolism the muscle is prepared for the metabolic challenge of training, these thermal agents also play a role in determining the amount of elongation obtained from a static stretch [13, 15, 19, 28]. It is no surprise then that heat is commonly used before exercise. Simplest way of heating the deep shell tissues is by light exercise. Light exercise raises the blood flow to muscle and the temperature of muscle rises toward that of the core [7, 10, 30]. However the other tissues like the knee and its ligaments (i.e. anterior and posterior cruciate ligaments), thigh can only be heated effectively externally; those part of tissue repeatedly associated with injury on football players [10, 31] This is also true for the ankle. Here, external heat may be of great benefit. However, it is not clearly stated in what extent heat is better to enhance flexibility and reduce injuries which result from low flexibility among study area.

As Mazumdar [32], suggested that Even though the six components of physical fitness affect the performance of a player to give good performance without being injured she/he must possess stretching exercise. Astrid J, Jiri Dvořák [31] Stated that Thigh strain is the common football injury, which linked with poor flexibility. In 2014 FIFA World Cup; a total of 104 injuries were reported; which is equivalent to an average of 1.68 injuries/match from this 15/17 (88.2%) of thigh strains occurred without contact due to poor muscle flexibility.

The present study population was 80 male football project players from Arba Minch town to examine if heat applied stretching exercise would increase flexibility. Therefore, the present study was undertaken with an innate objective of investigating the effect of 6 weeks heat applied stretching exercise on flexibility among Arba Minch U-17 male football project players. In addition to this to address the question:

Does flexibility performance augmented by applied heat stretching exercise and result in greater gains in flexibility compared with stretching exercise without extra external heat?

## 3. Materials and Methods

### 3.1. Study Area and Participant

The study was carried out in Arba Minch town, Found in Southern Nations, Nationalities, and Peoples Region, Ethiopia. Geographically it is located at 6°01'59" N, latitude and 37°32'59" E, longitudes and it is situated at elevation 1269 meters above sea level.

For this study, source of population was Arba Minch U-17 male football project players. 80 healthy, under 17 years of age, volunteered to participate and free from injury and drug abuse after signing an informed consent statement. For instance, to be eligible for this study, all 80 players were met the pre-requisites, inclusion criteria and completed the study. The subjects had a mean age of 16.46 years (SD=1.48, range=15-17) were selected as study sample by employing

comprehensive sampling technique. To this end, samples were randomly assigned in to four equal groups.

### 3.2. Study Design

The Complete randomized experimental design was employed; it is best suited for the notion that two or more groups are equal on relevant characteristics before and treatment is applied to one of the groups. Also, in order to judge whether the training program has been in effect, the groups may usually be compared before and after the treatment. The study was four groups. To this end, the effect of exercise was evaluated by pre and post Sit and Reach Test [33]. In order to instruct each subject on how to correctly perform stretching exercises, sit and reach test and to adapt hot and cold packs, familiarization session was conducted prior to initiating the study and stretching exercise protocol.

### 3.3. Experimental Treatments

All experimental group subjects performed suggested stretching exercises protocol in a controlled environment, throughout the researcher observing and administering the sessions. The first group was control group and did not perform any treatment, whereas the rest 3 experimental groups followed six weeks intervention program (3 days per week). SEG (Stretching Exercise Group only) engaged in stretching exercises only, on the other hand the remaining groups HPG=Heat Packs Group and CPG=Cold Packs Group undertaking thermal interventions (hot and cold packs respectively) for 20 minutes before performing the stretching exercise. Cold exposure was examined to see if it would have the opposite effect Superficial heat applied in the form of hot packs, paraffin, Fluid therapy, and infrared radiation. [19] Some physical therapists commonly use hot packs because they are easy to apply and economical. Studies [34, 35] have shown that applying superficial heat simultaneously with a low-load static stretch improves the flexibility of shoulder and hip muscles compared with stretching alone.

### 3.4. Stretching Exercise Protocol

After clear orientation has been giving to the participant, the experimental groups were engage designed training given from 4:00 PM to 4:30, in average temperature 30 °c. The subjects were instructed to stretch 3 times per week every other day at approximately the same time of day for 6 weeks. The duration of the whole exercises session was 30 minutes with a 10 second rest period between sets. Apart from this warm up session consists activity like incremental, synchronized movement of hands and legs, arm circles different types of stretching exercise, buttock kicks, stepping, buttock kicks, walking, high knees and with steeping the knees in four direction, main session consists Dynamic, Static, Ballistic and PNF stretching and lasting with cooling down. The stretching dose was standardized across groups, in terms of its mode, duration, and frequency.

### 3.5. Data Management and Analysis

Before further statistical analysis, the normal distribution was checked. Paired t-test used to compare mean value of pre and post training result, whereas the difference between groups was tested dependent t-test. The analysis conducted by SPSS -V 25 and in commenting on the analysis results significance rated through  $p < .05$  level.

### 3.6. Screening and Pretest

As indicated below in Table 1, Prior to the collection of data, all subjects completed a demographic and general health screening survey, and flexibility measured with sit and reach test using the standard protocol described by [33] about its validity.

## 4. Results

*Descriptive Statistics and T-test Result of Sit and Reach Test in cm*

**Table 1.** Demographics and characteristics of the groups.

Group	n	Age	Weight (Kg)	Height (M)	BMI
		Mean + SD	Mean + SD	Mean + SD	Mean + SD
Control	20	19.2 ± 2.4	19.3 ± 2.5	0.006	0.98
Exercise only	20	20.9 ± 4.0	21.8 ± 4.1	0.81	0.03
Hot Pack	20	18.0 ± 4.4	20.2 ± 2.8	2.23	0.01
Cold Pack	20	18.2 ± 3.4	18.8 ± 3.2	0.59	0.04

**Table 2.** Descriptive statistics and T-test result of sit and reach test in cm.

Group	n	PT	PoT	MD	Sig (p<.05)
		Mean + SD	Mean + SD		
Control	20	19.2 ± 2.4	19.3 ± 2.5	0.006	0.98
Stretching Exercise only	20	20.9 ± 4.0	21.8 ± 4.1	0.81	0.03
Hot Pack	20	18.0 ± 4.4	20.2 ± 2.8	2.23	0.01
Cold Pack	20	18.2 ± 3.4	18.8 ± 3.2	0.59	0.04

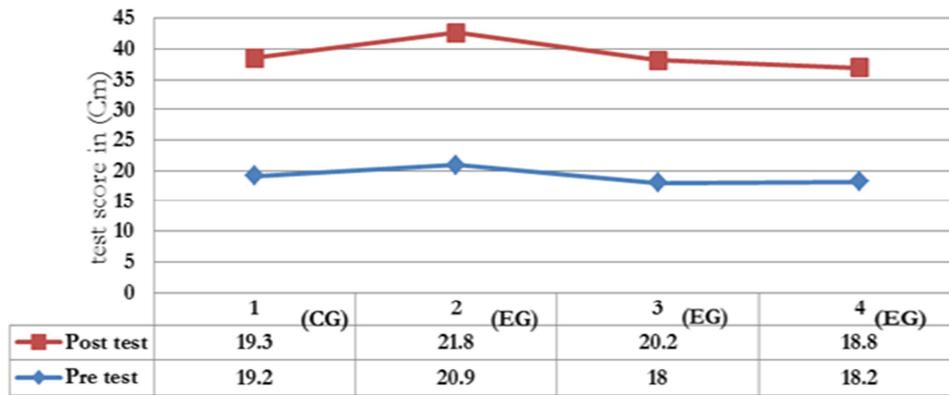
As table 2, illustrates the descriptive statistics and T-test result of sit and reach test; the first Control Group were control group and did not perform the stretching exercise, the rest three experimental groups (i.e. groups 2–4) followed six

week intervention program (3 days per week) for 6 weeks. Stretching Exercise Group only (SEG) engaged in stretching exercises protocol only, whereas Heat Packs Group (HPG) and Cold Packs Group (CPG) undertaking thermal

interventions (hot and cold packs respectively) Heat Packs Group (HPG) taken superficial, moist heat packs for 20 minutes before performing the stretching exercise, whereas the other section Cold Packs Group (CPG) performed

superficial, moist cold packs before performing stretching exercise, Cold exposure examined to see if it would have the opposite effect.

A. Experimental Groups Vs Control Group



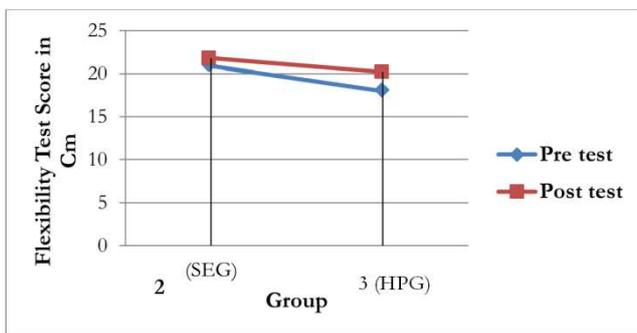
(CG)=Control Group, and Groups (2-4) EG=Experimental Groups.

Figure 1. Flexibility test score between Control and Experimental Group.

The first group were control group and did not perform the stretching exercise, Among subjects tested, the significance differences were not found in the measurements over time from pre to post-test in this group, however significant increment was noted in all 3 experimental groups (EG) (groups 2-4) between pre and post-measurements, the mean Pre/Post differences were .81 (p<.03) for Exercise only, 2.2 (p<.01) for heat pack group and .5.9 (p<.04) for Cold pack group, this is due to the effect of stretching exercise protocol they were engaged in.

The result illustrated that current stretching exercise protocol had have positive significant result and the investigator noticed that suggested stretching exercise protocol be positive effect on developing and promoting the flexibility performance of football players.

B. Stretching Exercise only (SEG) versus Heat Packs and Stretching Exercise (HPG)



(SEG)=Stretching Exercise Group and (HPG)=Hot Packs Group.

Figure 2. Flexibility test score (Cm) between Stretching training group & Hot pack group.

(SEG) engaged in stretching exercises protocol only, while heat pack group taken superficial, moist heat from hot packs for 20 minutes before performing the stretching exercise protocol.

Even though significant improvement was noted in all 3 experimental groups (groups 2-4) between pre and post-

measurements, however, interventions produced different results, the group that taken superficial, moist heat from hot packs for 20 minutes before performing the stretching exercise protocol, (HPG) displayed the greater improvement in flexibility test with mean difference 2.2 (p<.01) than Stretching Exercise only (SEG) engaged in stretching exercises protocol only, which have mean difference .81 (p<.03).

Ten studies [1, 2, 6, 8, 14-16, 28, 31, 37] examined the effects of interventions undertaken over periods of up to 5 weeks. Four studies [2, 8, 14, 28] found little differences in ROM between groups, at the end of the intervention package. The remaining 6 studies [1, 6, 14, 31, 37, 15, 16] found effects in favor of stretching and heat, with 4 studies 19, 30, 31, 38 reaching statistical significance. The largest effect in favor of heating and stretching was reported by Draper et al [14] based on an MD of 10.9 degrees (95% CI, 4.76e17.04 versus stretching alone).

C. Stretching Exercise only (SEG) versus Cold and Stretching Exercise (CPG)

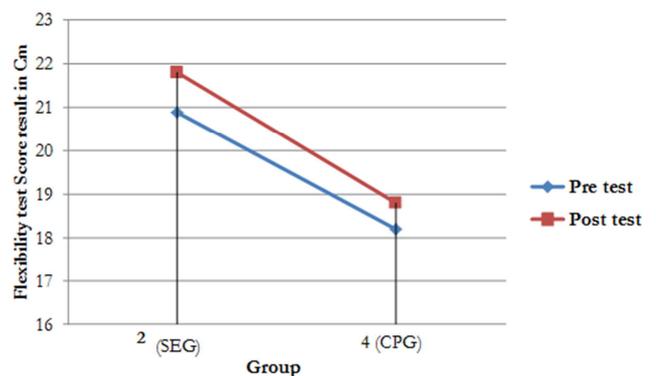


Figure 3. Flexibility test score (Cm) in Stretching training group & Cold pack group.

Stretching training group engaged in stretching exercises protocol only, whereas the other section Cold pack group performed superficial, moist cold packs before performing stretching exercise,

As Figure 3 reveals, within same stretching exercise protocol, and stretching dose in terms of its mode, duration, and frequency, the mean Pre/Post differences at 6 weeks were different in SEG and CPG, which resulting in superficial, moist cold packs before performing stretching exercise, The result illustrated cold exposure may limit flexibility development, but it had shown significant mean difference, with mean difference .81 ( $p < .03$ ) for SEG, and .5.9 ( $p < .04$ ) for CPG it wasn't having the opposite effect on stretching exercise rather it limits improvement.

Three studies are in consistent with current study used

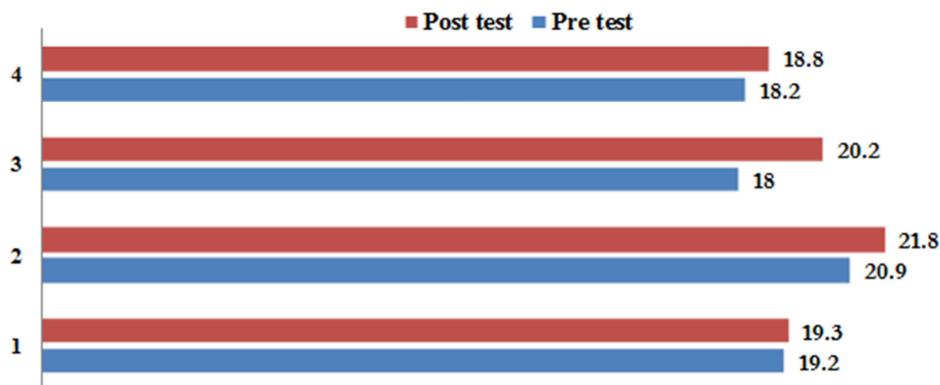


Figure 4. Sit and reach test result of all study groups.

The study demonstrates that the application of heat potentiates the effect of stretching exercise on improving flexibility among football project players. Heating provided beneficial influence on flexibility after multiple treatments in healthy football project players. Among the subjects tested, the use of heat packs for 20 minutes prior to stretching exercise may have the most effective for increasing flexibility. Heat applied stretching exercise group have had shown a greatest positive significant change in improving the flexibility than non-heat applied equivalent group players of the same project. On the other hand, as showed in (CPG) even if there was showed significant increment, cold exposure may limit degree of increment on flexibility, but it couldn't conclude the opposite effect on stretching exercise.

## 5. Discussion

Studies [30, 48, 49] are in line with this study the above scholars have shown that an elevated tissue temperature increases the amount of elongation obtained from a stretch. The result of this study finding is also consistent with the finding of [23-25] heat increasing flexibility and thus reducing the chance of injury, and reducing energy cost of muscle contraction by reducing internal friction. These results also agree with those [44] stated that heat increases range of motion and flexibility by enabling glycogen re-synthesis and help muscle recovery from injury.

Four studies found that hamstring heating increased knee extension [12, 17, 43] the largest increase from baseline was an MD of 8.8 degrees (95% CI, 4.77e12.83).27 this study [12] also reported significant increases in ROM compared with an

over periods of 5 days [8, 31] or 4 weeks [39] there were no significant differences in ROM at the end of each study; the largest between-group differences were in favor of stretching only MD, 2.4 deg [95% CI, 1.7 to 6.5]. (8), Variables to be considered include the magnitude, duration and timing of stretching [16]. even if the above variables were not stated on the above studies, in the current study subjects taken in equal magnitude, duration and timing of stretching (from 4:00 PM to 4:30), in average temperature 30 °c, due to this higher temperature of study area the cold packs exposure group (CPG) result may be altered in this study.

untreated control (MD, 7.8deg [95% CI, 5.42e10.18]). Others found small but statistically insignificant effects in favor of heating when compared with icing [MD, 2.3deg [95% CI, 8.65 to 13.25], (43) stretching (MD, 2.6deg [95% CI, 3.12 to 8.12]), [17] or untreated controls (MD, .36deg [95% CI, 4.87 to 5.59]). [43]

These study results also agree with Chris M. and Joseph T, 2013 [9] It was concluded and there was clear evidence that combined heat and stretching is more effective than stretching alone. These findings seem to support the use of heat as an adjunct to developmental and therapeutic stretching techniques.

## 6. Conclusion

At the conclusion of the study, Among subjects tested, the significance differences were not found in Control Group (CG) over time from pre to post-test, however significant improvement was noted in all 3 Experimental Groups (EG) (Groups 2–4), however, Even though significant improvement was noted interventions produced different results. When compared with in Experimental Groups, the Group receiving heat pack for 20 minute prior to stretching exercise obtained the largest overall mean difference over a 6-week period, which resulted applied heat before stretching exercise. In line to study result, there was clear evidence that combined heat and stretching is more effective than stretching alone. These findings seem to support the use of heat as an adjunct to developmental stretching techniques. Cold and heat may alter flexibility, Heat have beneficial and better role in stretching exercise by increasing flexibility and may help to reduce athletic injuries, but cold treatment may

have the opposite effect.

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