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Comparison of two different warm-up protocols on functional performance in athletes

Moazzam H Khan[1], Shibili Nuhmani[2], Gagan Kapoor[3]
[1]*Central Reserve Police Force, New Delhi, India*
[2]*Department of Rehabilitation Sciences Jamia Hamdard, India*
[3]*Manav Rachna International University, Faridabad, India*

Abstract. Study objective was to know that which warm-up protocol will be more effective in improving athletics performance. *Material and method*. Study design: post test same subject group design. Settings: central reserve police force, Okhla, New Delhi. Subjects: 30 healthy athlete volunteers, male, hockey player of age 18-24 years, participated in the study. Measurement: a total number of 30 homogenous subjects were randomly assigned into two groups, group A and B, each group consisted of 15 subjects. The two warm-up protocols were used, ice pack with active warm-up and hot pack with active warm-up. Initially treatment was randomized between groups following which it was conveniently switched over to the subjects. Each warm-up protocol was given at least 48 hours after the previous protocol. After all the warm-up protocols three maximal performance tests, single leg vertical jump height, forty yard sprint and agility shuttle run was done for each subjects. *Results*. Repeated measure ANOVA with post hoc analysis Bonferroni was used to compare all the three performance tests after all the warm-up protocol. The result indicates that there is highly significant difference after hot pack with active warm-up then the ice pack with active warm-up protocol in single leg vertical jump height, forty yard sprint and agility shuttle run ($P < 0.05$). Conclusion. The study result showed that hot pack with Active warm-up was more effective then ice pack with active warm-up in improving athletics performance

Key words: *performance, warm-up, vertical jump, sprint, agility*.

Introduction

It is important to be properly warmed up prior to training and competition.

A warm up involves low intensity exercise (<60% VO_2max, 65% maximum heart rate) of relatively short duration (<15 minutes). It is a period of preparatory exercise to enhance subsequent competition or training performance (1).

There are a number of studies which show the effects of warming up (2-4). Most of the studies have found that warm up is having positive effects on performance

According to Fradkin A, approximately 60% of these studies found some type of warm up to be superior to no warm-up, approximately 11% found no warm up to be superior and approximately 29% found no significant differences between types of warm up and no warm- up (5). Maximal force developed by muscle and their rates of force generation, contraction, relaxation, and power output all gets altered when body temperature varies (6, 7).

According to Davies et al. (1983), the effects of heating on contractile properties of skeletal muscle have been studied extensively. It is clear from the research that increasing muscle temperature increases the speed of muscle contraction, thereby decreasing both time to peak tension and half relaxation time (8). Davies et al (1982) findings are consistent irrespective of whether muscle temperature is elevated as a consequence of exercise or passive heating (9). Depending on the duration of treatment and timing of measurement cryotherapy has been associated with both increased and decreased in muscle strength. Isometric muscle strength has been found to increase directly after application of ice massage for 5 minutes or less, the proposed mechanism for this response to nerve excitability and increased psychological motivation to perform (10). Despite limited scientific evidence supporting the effectiveness, warm-up routines prior to exercise are well accepted in practice.

The majority of the effects of warm-up have been attributed to temperature related mechanisms e.g. decrease stiffness, increased nerve conduction rate, altered force velocity relationship, increased anaerobic energy provision and increased thermoregulatory strain, although non-temperature related mechanisms have been also proposed like elevation of baseline oxygen consumption.

One study observed that the strength of an eccentric contraction was improved with the application of ice, whereas another indicated the ice helped to facilitate concentric but not eccentric strength (11, 12). This may be due to an increase in the ability to recruit additional motor neurons during and after cooling (13).

It also appears that higher torque values can be produced following the application of cold packs than hot packs (14).

The use of cryotherapy does not seem to affect peak torque but may increase endurance (15). Cold appears to have some effect on muscular power also, it has been shown that performance in vertical jumping is decreased following the application of cold (16, 17).

Material and Method

A total 30 healthy athletes volunteers (male), aged 18-24 years, participated in the study. Mean values of their age, height, weight, mid thigh girth, and standing vertical reach height were 22.46 ± 1.43, 168 ± 7.38, 66.36 ± 8.44, 54.46 ± 6.06, and 210.83±11.48, respectively. Subjects: were included male subjects from athletic team or had participate in physical activity (cardio vascular and/or weight training 3 times per week) and excluded those were injury at lower extremity within 6 month, cardiac condition (e.g. hyper tension, coronary disease), hypersensitivity to cold and hot, diabetic condition.

All the subjects were informed about the nature, purpose, and possible risk involved in the study and an informed written consent was taken from them prior to participation. Subjects were randomly assigned into 2 experimental groups A and B on the basis of inclusion and exclusion criteria.

Study Design. Post-test same subject group experimental design. Three functional performances (single-leg vertical jump, 40-yard sprint, agility shuttle run) were dependent variables and independent variables by type of cold application, type of heat application and active warm-up.

As equipment, were used in this study hydrocollator pack, ice bag, inch tape, electronic stopwatch and ink pad.

Protocol. A total number of 30 homogenous subjects were randomly assigned into two groups, group A and B, both group consisted of 15 subjects. The two warm-up protocols (18) were hot pack with active warm-up and ice pack with active warm-up. Initially treatment was randomized between groups following which it was conveniently switched over to the subjects. Each warm-up protocol was given at least 48 hours after the previous protocol.

Ice pack with active warm-up: the subjects were given Ice bag for 10 minutes 20 on anterior thigh followed by 6.5 minutes of Active warm-up which consisted of 3 minutes jogging, 3 minutes stretching and ten 2-legged vertical jumps (19).

Hot pack with active warm-up: the subjects were given hot pack for 10 minutes on anterior thigh, followed by 6.5 minutes of active warm-up which consisted of 3 minutes jogging, 3 minutes stretching and ten 2-legged vertical jumps (19).

After the two warm-up protocols three maximal performance tests, single leg vertical jump height, forty yard sprint and agility shuttle run was done for each subjects.

Procedure. Participants attended a total of 4 data collection sessions. On the first visit a complete physical fitness was evaluated. Subjects who were suitable for participation in the study were requested to sign consent forms on the first day each participant attended an orientation session to become familiar with the testing procedures and warm up technique. Measurements of height, weight, mid thigh girth, and standing vertical reach were taken during the orientation session. The subjects performed 3 practice trials of each of the 3 functional tests to ensure proper technique. Each individual self-selected (19) his preferred leg and this extremity were cooled, heated and tested in the single-leg vertical jump. All the measurements were taken while the participants were wearing T-shirt, short pants, socks, and athletic shoes, the same shoes and clothing were worn for each testing session. Subject were given warm up protocol and after each warm up protocol 3 trials of all the functional performance test were performed and in that the best functional performance was taken for data analysis.

Active warm up. The active warm-up consisted of 3 minutes of light jogging (65 % maximum heart rate by using heart rate monitor) followed by 3 minutes of stretching. Two minutes were allowed for general active stretching, which consisted of the butterfly stretch for the inner thigh and groin, seated hamstring stretch, seated spinal twist for lower back and gluteal muscles, and standing calf stretch for gastrocnemius and soleus muscle groups. One minute was given for quadriceps stretching, which consisted of both side- lying and standing quadriceps stretches lasting 30 seconds each. All other stretches were performed bilaterally, with 15 seconds allotted for each side. Stretching was followed by ten times 2-legged vertical jumps. The 2-legged vertical jumps were performed with a counterforce movement using both arms, and participants were instructed to jump as high as possible. The total time for the entire warm-up routine was approximately 6.5 minutes (19).

Ice bag application with active warm-up. Each ice bag comprised 3 lb (1.36 kg) of crushed ice in a 1-gal (3.79-L) plastic bag [19] Subject was in high sitting position and the ice bag was applied on anterior thigh for 10 minutes with a compression wrap followed by 6.5 minutes of active warm up.

Hydrocollator pack (hot pack) with active warm-up. Hydrocollator pack consists of a silicate gel enclosed in a cotton fabric container. They were heated by being placed for 2 hours in a special tank of water warmed to 75- 80^0C by an electric heater controlled by thermostat (18). Subject was in high sitting position the hot pack was wrapped in towel with four layers and applied to the anterior thigh for 10 minutes.

Functional Tests. Three tests of functional performance, single-leg vertical jump, agility shuttle run, and 40-yd sprint, were performed after each warm up protocol for each subject. A total of 48 hours rest period was given to each subject between each warm up protocol for the recovery of previous warm up and functional performance test. A 1-minute rest period was allowed between each functional performance tests.

Three trials of each functional performance test were performed, with a 30-second rest period between each trial. The best score from the 3 trials for each functional performance test was used for data analysis (19).

1. Single-leg vertical jump. The single-leg vertical jump was performed by the treated extremity. Each participant, with blue ink on his fingers, stood with the treated-extremity side of his body next to the wall marked in increments by inch tape. Each subject was instructed to place the opposite arm behind his back while raising the arm nearest to the wall vertically over his head and to stand only on the leg closest to the wall. Using a countermovement, the participant jumped vertically as high as possible and touched the wall with his fingertips at the apex of his jump. The difference between the heights of the subjects' jumped and their standing reach height was recorded in centimeters as the trail score. Before each trail, we encouraged subjects to give maximal effort and jump when ready. No encouragement or knowledge of results during or after test trails was given to participant (19).

2. 40-yard sprints. The 40-yd (36.5m) sprint began with the subjects in a forward lunge position with the treated leg forward. Again for the test, time was started when we said, "go" and stopped when the subject's foot touched the end line. We measured elapsed time by hand, using a stopwatch accurate to 0.1 second. Here also we instructed subjects to perform each test as fast as possible and no encouragement or knowledge of results during or after test trails was given to participant. During each testing session, they performed three trials of the test (19).

3. Agility shuttle run. The shuttle run (19) consisted of four 6.1-m sprints (24.4 m total). Subjects sprinted 6.1 m, stopped, turned around, immediately sprinted back to the starting line, and then repeated the process. They changed the direction three times. The shuttle run reproduced the acceleration and deceleration forces experienced during high-intensity athletics. For test, time was started when we said, "go" and stopped when the subject's foot touched the end line. We measured elapsed time by hand, using a stopwatch accurate to 0.1 second and instructed subjects to perform each test as fast as possible and no encouragement or knowledge of results during or after test trails was given to participant. During each testing session, they performed three trials of the test (19).

Result

The data analysis was done by using SPSS-15 software system. Demographic data of subjects including age, height, weight, mid thigh girth and standing vertical reach height were descriptively summarized. The dependent variables were analyzed using repeated measure ANOVA for within group comparison. Post Hoc paired comparison was done using Bonferroni correction.

A prior alpha level p = <0.05 was set as significance for all comparison. Mean values of their age, height, weight, mid thigh girth, and standing vertical reach height were 22.46±1.43, 168±7.38, 66.36± 8.44, 54.46 ± 6.06, and 210.83±11.48, respectively.

Single leg vertical jump height. Repeated measure ANOVA showed that there was highly significant differences between two warm-up protocols for single leg vertical jump height with f = 12.21, p = 0.00, Hot pack with active warm-up showed better performance than Ice pack with active warm-up in two warm-up protocols. The post hoc analysis with Bonferroni correction showed that there was significant difference in the single leg vertical jump height performance. Comparison between Ice pack with active warm-up and Hot pack with Active warm-up showed that Hot pack with active warm performance was better than ice pack with active warm-up, p=0.001 < 0.05.

Forty yard sprint. Repeated measure ANOVA showed that there was highly significant differences between two warm-up protocols for forty yard sprint with f = 20.14, p = 0.00 Hot pack with active warm-up showed better performance than ice pack with active warm-up in two warm-up protocols. The post hoc analysis with Bonferroni correction showed that there was significant difference in the forty yard sprint performance. Comparison between Ice pack with active warm-up and Hot pack with Active warm-up showed that Hot pack with active warm performance was better than ice pack with active warm-up, p=0.000 < 0.05

Agility shuttle run. Repeated measure ANOVA showed that there was highly significant differences between two warm-up protocols for Agility shuttle run with f = 19.92, p = 0.00, Hot pack with active warm-up showed better performance than ice pack with active warm-up in two warm-up protocols.

The post hoc analysis with Bonferroni correction showed that there was significant difference in the agility shuttle run performance. Comparison between Ice pack with active warm-up and Hot pack with active warm-up showed that Hot pack with active warm performance was better than ice pack with active warm-up, p=< 0.05.

Table I. Comparison between Ice pack with active warm-up and Hot pack with active warm-up

Variables	Ice+Active warm up Means ±S.D (N=30)	Hot+Active warm up Means ±S.D (N=30)	Repeated ANOVA		Post hoc analysis Bonferroni
			f	p	IC+AW vs. HP+AW
VJH(cm)	27.06±3.87	28.63±3.24	12.21	0.00	0.001
40YdSP(S)	5.41±0.20	5.30±0.21	20.14	0.00	0.000
AGSR(S)	6.98±0.17	6.87±0.19	19.92	0.00	0.000

SLVJH (cm) = single leg vertical jump height (cm), 40 Yd SP (s) = forty yard sprint (s), AGSR(s) = agility shuttle run (s), AW= active warm up, IC+AW= Ice pack with active warm up, HP+AW= Hot pack with active warm up.

Discussion

A total number of 30 homogenous subjects were randomly assigned into two groups, group A and B, each group consisted of 15 subjects. The two warm-up protocols was Ice pack with active warm-up and Hot pack with Active warm-up. Purpose of the study was to compare the effects of two warm-up protocols on three maximal performance test: single leg vertical jump height, forty yard sprint and agility shuttle run.

Our results indicated that 10 minutes of hot pack application on anterior thigh with 6.5 minutes of active warm-up is better than the other warm-up protocols on immediate performance of athletes. Single leg vertical jump height performance was

better in hot pack with active warm-up than the ice pack with active warm-up protocols.
Forty yard sprint and agility shuttle run test is time dependent variables.
The subjects who will take less time to cover the target are considered best performance. The subjects who were given hot pack with active warm-up took less time to complete the target, so the hot pack with active warm-up protocol was better than the ice pack with active warm-up protocols. The majority of the effects of warm up have been attributed to temperature-related and non-temperature-related physiological mechanisms. However psychological mechanisms have also been proposed (e.g. increased preparedness). Non temperature-related and psychological mechanism is common for both the groups but temperature related mechanism varies from group to group due to different warm-up protocols. Proposed temperature related mechanisms include decreased stiffness, increased nerve-conduction rate, altered force-velocity relationship, increased anaerobic energy provision and increased thermoregulatory strain.
Our result is consistent with Asmussen and Boje (1945) (20) concluded that "…a higher temperature in the working organism facilitates the performance of work". Since then, the effects of warm up have largely been attributed to temperature-related mechanisms. Decreases in muscle and joint stiffness (18) and increases in nerve conduction rate (19) following an increase in temperature have the potential to improve performance especially strength and power tasks. There was more increase in anterior thigh muscle temperature after hot pack with active warm-up then ice pack with active warm-up, so an increase in muscle temperature may affect performance via decrease in the viscous resistance of muscle. Mild warming has been reported to reduce the passive resistance of the human metacarpal joint by 20% (21).
It has also been suggested that performance changes following warm up may result from increased oxygen delivery to the muscles via a right ward shift in the oxyhaemoglobin dissociation curve and vasodilation of muscle blood vessels (22) .Furthermore, an elevated temperature also stimulates vasodilation of blood vessels and increases muscle blood flow. (23). An increase in muscle temperature may also contribute to improved performance by augmenting the function of the nervous system. Karvonen (24) has demonstrated that increased Tm improves central nervous system function and increases the transmission speed of nervous impulses. Single leg vertical jump height was less in Ice pack with Active warm-up protocol than the other warm up protocols which are consistent with the finding of the Bergh and Ekbon (25).
There is a positive relationship between the muscle temperature and the height of vertical jump. Bergh and Ekbon (1979) (25) best demonstrated this relationship finding the height of the jump decreased with a decrease in muscle temperature at a rate of 4.2% x ^{0}C decreases in CMJ height can be attributed to changes in dynamic strength following the application of cold. Ruiz et al. (1993) contended ice caused a significant decrease in both concentric and eccentric quadriceps strength immediately following a 25 minute ice application (12). Ruiz et al. (12) and Howard et al. (26) investigated the use of ice immersion and strength and concluded that strength is impaired at higher movement velocities which are required during athletic activity.
The results of our study were also consistent with Greicar's (1996) examination of agility using a carioca test and found immediately following the treatment that time was increased to complete agility shuttle run (27). The more functional, T-test for agility demonstrated an increase of 10.8% immediately following treatment Cross et al. (1996) also found a significant increase in shuttle run times from 6.54s to 6.71s immediately following a 20 minute 13°C treatment leading to concluded cold applied to the lower leg and ankle does, indeed have a detrimental effect on agility performance immediately following treatment. Therefore, it appeared that agility was affected immediately following cold application. (28).
Speed, a component of agility, has not been studied in great detail. Bergh & Ekblom (1979) are the pioneer researchers who attempted to quantify the effects of muscle temperature on speed. They found sprint performance measured on a bicycle ergometer was significantly reduced with a decreased muscle temperature (25).
Along with changes in strength, the decreased agility and speed performance in our study can be attributed to increased joint and tissue stiffness. Cold application to connective tissue results in increased stiffness and decreased extensibility as temperatures decrease (29), functional performance decrements may also be related to the stretch-reflex phenomenon. As noted by Davies & Young (8) the impaired ability of the muscle spindle to trigger the stretch-reflex may have decreased the amount of elastic potential

which could be produced during the eccentric loading phase of muscular contraction.

It was evident by the work of Bergh & Ekblom (25) that muscular contraction speed and the capacity to generate force are reduced by cold.

Future research may be by increasing number of subjects can be included, Since passive warm up involves raising muscle or core temperature by some external means and active warm-up utilizes exercise, comparison between the two can be done to check athletes' performance. Thigh skin fold thickness measurement can be taken because the skin fold thickness varies among individuals. The temperature of the treated part can be monitored so that we can find out how changes in temperature are proportional to changes in performance. Further the effects of temperature on physical performance of the whole lower limb could be studied. Delayed effects of these three warm up protocols can also be checked.

Relevance to clinical practice from this study it is evident that the hot pack with active warm-up can be used to enhance the immediate performance of the athletes. Moreover, the research findings do add to the knowledge base of athletic trainers and others sports medicine professionals who should be aware of three different types of warm-up on maximum physical performance.

The study result showed that hot pack with Active warm-up is more effective then ice pack with Active warm-up for the improvement of athletes performance.

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Corresponding author
Shibili Nuhmani
Department of Rehabilitation Sciences
Faculty of Applied Health Science, Jamia Hamdard
New Delhi, India
Email: *vakeri@gmail.com*

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