DOI: 10.7860/JCDR/2017/24766.9595

Original Article

Physiotherapy Section

Effect of Passive, Active and Combined Warm up on Lower Limb Muscle Performance and Dynamic Stability in Recreational Sports Players

KEDAR GOGTE[1], PRATEEK SRIVASTAV[2], GANESH BALTHILLAYA MIYARU[3]

ABSTRACT

Introduction: Warm up is an activity that is done before a sports activity. The warm up can be done actively and passively. The preferred mode is active warm up in athletes. There are inconclusive effects of passive warm up compared with an active warm up on short term muscle performance. The cumulative effect of passive and active warm up on muscle performance and dynamic stability is not known.

Aim: To find out the effects of passive, active and combined warm up on lower limb muscle performance and dynamic stability in recreational sports players.

Materials and Methods: A randomized crossover study was done on 19 recreational lower limb dominant sports players. Three different warm ups were included in the study passive, active and combined. Active warm up included series of activities like cycling, leg press, jump squats, squat jumps while passive warm up included application of moist heat for a period of 20 minutes on lower limb muscles. Combined warm up included both passive and active warm up. Six different sequences were made from these three warm ups. Subjects were screened and allotted into different groups based on the six warm up sequences after sequence randomization with 48 hours wash out period. After every warm up session Vertical Jump Test (VJT) and Star Excursion Balance Test (SEBT) was performed and results were recorded. Study duration was one year and six months.

Results: There was no difference noticed in both the outcome measures. Mean and SD values for passive, active and combined warm up are 47.62±9.64, 48.50±10.16 and 48.87±10.70 respectively in Vertical Jump Test (VJT) and 85.43±8.61, 85.17±8.60 and 85.17±8.38 respectively for SEBT. The p-value for mean difference between passive-active, active-combined, combined-passive are 0.67, 1.00, 0.51 respectively, for VJT and 1.00, 1.00, 1.00 respectively for SEBT.

Conclusion: All warm ups are equally effective in short term sports performance.

Keywords: Moist heat, Passive, Star excursion balance test, Vertical jump test

INTRODUCTION

Any activity which increases the body temperature by few degrees Celsius is called as warm up [1]. In attaining optimum performance warm up prior to exercise plays a vital role [2]. The effects of warm up are seen in the overall sports performance and reduction in sports injuries due to internal factors [3].

Warm up can be classified into active warm up and passive warm up [2]. In active warm up, temperature is raised from the energy released from contracting muscles [4]. External devices can be used to raise the tissue or body temperature in passive warm up [5]. Combination of both active and passive warm simultaneously at the same time can be called as combined warm up [6]. There are various effects of warm up on the body which can be related to thermal and non thermal effects [3].

Passive warm up helps in improving athletic performance by increasing flexibility [7], increase in oxygen release in the tissues [8], increase in metabolism of energy systems [9], increase in nerve conduction velocity [10], reduction in peak tension time in muscles [11], it can increase the temperature strain on the body and can help in increasing performance [12]. Active warm up helps increase in blood flow [13], increase in baseline Oxygen consumption [14], it leads to breaking of actin and myosin bonds which improves flexibility [11]. There is increase in post-activation potential [15]. There is increased preparedness for a sports activity after active warm up [16].

Short term muscle performance and dynamic stability are two parameters of athletic performance [17]. Increase in the muscle performance reduces injury and improves athletic performance [18]. There can be enhancement in motor skills from balance training resulting in increase in the rate of force development and thus, improving athletic performance [19].

However, there is a lack of literature on comparison of active and passive warm up on muscle performance, dynamic stability and effects of passive warm up on dynamic stability are not present. Therefore, aim of our study was to find out the effects of passive, active and combined warm up on lower limb muscle performance and dynamic stability in recreational sports players. If the muscle performance and dynamic stability of athletes is superior to any of the types of warm up, then it can be included in the athletic programs for improving performance.

MATERIALS AND METHODS

The study was a randomized crossover trial carried out from October 2015 to March 2016. Institutional ethical clearance was obtained for the study. Twenty seven recreational sports players of both genders aged between 18-30 years playing lower limb dominant sports like basketball, volleyball, athletics and football were included in the study. Sample size was calculated using the formula

$n = (Z1-\alpha/2 + Z1-\beta)\ 2\sigma 2 / d2,$

where n= sample size, $Z1-\alpha/2$= 2.395 at 5% level of significance, $Z1-\beta$ =1.64 at 90% power, σ+ anticipated standard deviation -4.28, d= minimum significant difference -4 cm.

Sample size was calculated based on VJT as primary outcome measure. Subjects having a recent history of the upper quarter,

lower quarter injuries and impaired sensations were excluded from the study. All subjects were screened for inclusion, exclusion criteria and were selected in the study. Allocation of the subjects has been explained in [Table/Fig-1]. Participation information sheet was given to the subjects and informed consent was obtained. Subjects who were included in the study went through three different warm up sessions, namely passive, active and combined warm up explained in [Table/Fig-2] and were required not to be involved in vigorous physical activity as it could hinder their performance in the study. Passive warm up was given using moist heat heating device that included eight Chattanooga original hydrocollator moist heat hot packs, standard-size (10" W x 12" L). Leg press exercise and stationary bicycle were used for active warm up. BOSU® ball exercises were used to give balance training. Sargent VJT and SEBT were used to access muscle performance and dynamic stability respectively.

Sargent VJT: VJT was the primary outcome measure that was used for assessing the muscle performance in the study. The participant stood facing a smooth dark wall with feet on the ground and toes touching the wall. The participant then reached as high as possible and marked the point with the chalk powder on the wall (taken as P1). The athlete then jumped as high as possible and marked another point at the peak of the jump (taken as P2). This was repeated thrice. The difference between P1 and P2 was measured and the best of three was considered [20].

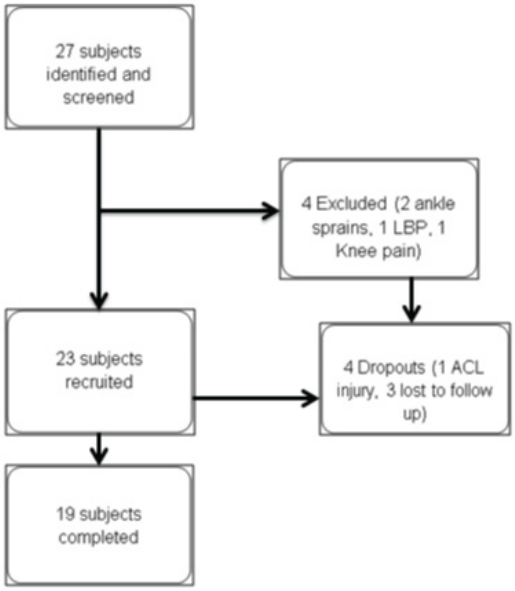
Star Excursion Balance Test: SEBT was used as a secondary outcome measure used for assessing dynamic balance. The standard SEBT procedure was used where the participant stood on the ground. The participant was asked to use the non-stance limb to reach maximally to touch a point along one to eight designated lines on the ground. The test was performed first with non-dominant leg and the dominant leg. Best of three readings were recorded [21].

STATISTICAL ANALYSIS

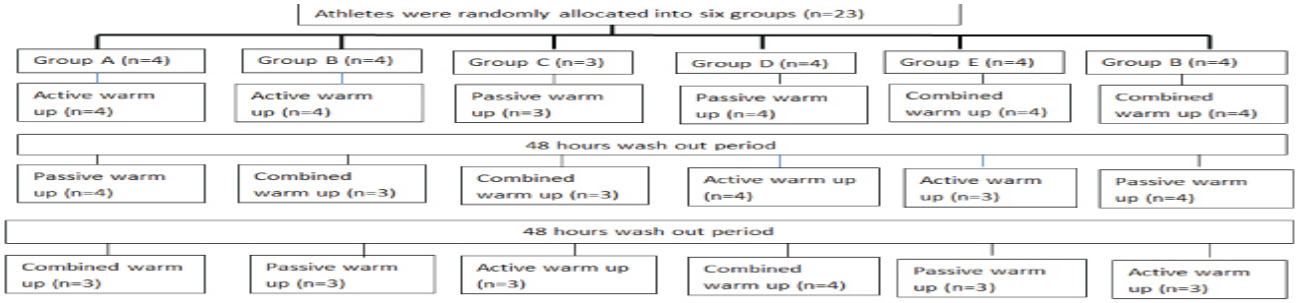
Data was analysed using Statistical Package for Social Sciences (SPSS) version 15.0. Descriptive statistics were used for demographic variables. Data followed a normal distribution since standard deviation was less than twice the mean. Both the outcomes were assessed using repeated measures ANOVA.

RESULTS

The descriptive statistics for the demographic characteristics demonstrated in [Table/Fig-3]. Test outcomes were assessed



[Table/Fig-1]: Identification to completion of study participants (LBP-Low back pain, ACL-Anterior Cruciate Ligament).



[Table/Fig-2]: Allocation and procedure for six groups.

Passive Warm Up: Passive warm up group received moist heat as intervention. Moist heat packs were applied over hamstrings, quadriceps, gastro-soleus complex and over the gluteus muscles at the same time for a period of 20 minutes. The subjects rested in the prone position during the application. Subjects were asked not to sleep and were asked from time to time about the intensity of heat. Following passive warm up, self-stretching of the lower limb muscles was done by the subject. Hamstrings, quadriceps, gastro-soleus and gluteus muscles were stretched.

Active Warm Up: Active warm up session included exercises as the intervention. It started with five minutes of cycling on static cycle at 40 rpm followed by five leg presses with half the body weight, five squat jumps, five jump squats, five heel raises and one minute BOSU® ball balancing exercise with eyes closed and externally given perturbations. Stretching followed after active warm up exercises as explained earlier.

Combined Warm Up: Combined warm up included both passive warm up and active warm up exercises. Only difference in active warm up exercises and combined warm up was that the total duration of cycling and BOSU® ball exercise was reduced to half and other activities were reduced to three repetitions instead of five. Self-stretching of lower limb muscle followed combined warm up.

Parameters	Minimum	Maximum	Mean±SD
Age (years)	18.00	24.00	21.12±1.97
Height (cm)	153.50	188.50	171.79±8.63
Weight (Kg)	48.00	82.00	65.58±11.16

[Table/Fig-3]: Demographic characteristics of participants.

Warm ups	Mean±SD (VJT)	Mean±SD (SEBT)
Passive	47.62±9.64	85.43±8.61
Active	48.50±10.16	85.17±8.60
Combined	48.87±10.70	85.17±8.38

[Table/Fig-4]: Mean and SD for warm up trials in VJT and SEBT.

Warm ups	VJT: mean difference, p-value*	SEBT: mean difference, p-value*
Passive-Active	-0.88 (0.67)	0.262 (1.00)
Active-Combined	-0.37 (1.00)	-0.002 (1.00)
Combined-Passive	1.25 (0.51)	-0.260 (1.00)

[Table/Fig-5]: Mean difference and p-value between warm up trials in VJT and SEBT.
*Using repeated measure ANOVA

using repeated measures ANOVA. Mean and standard deviation for VJT for passive, active and combined warm up is 47.62±9.64, 48.50±10.16 and 48.87±10.70 respectively, demonstrated in [Table/Fig-4]. There was no significant difference present between warm up trials as the mean difference between passive-active, active-combined and combined-passive is -0.88, -0.37 and 1.25 respectively demonstrated in [Table/Fig-5].

The mean and standard deviation for passive, active and combined warm up [Table/Fig-4] are 85.43±8.61, 85.17±8.60 and 85.17±8.38. There is no significant difference between warm up trials as mean difference [Table/Fig-4] is 0.262, -0.002 and -0.260 for passive-active, active-combined and combined-passive warm up respectively and also.

DISCUSSION

Our study shows that the type of warm up does not influence muscle performance and dynamic stability. There is no significant difference in either of the warm up trials that was assessed using VJT and SEBT [20,21].

Passive warm up when compared with active warm up shows no significant change with respect to muscle performance and dynamic stability. These results are similar to the study results of Demura T et al., [22]. They had used gentle gripping exercises over a sponge as an active warm up and passive heating of flexors of forearm using polarized radiation [22].

These similar results can be because of the temperature related effects of passive warm up while temperature and non temperature related effects in active warm up [23]. There can be formation of metabolities like lactate in muscles as well as reduction in enegry substrates which can be one of the reaseon for equal performance [24]. Active warm up has positive effect of increasing flexibility by breakdown of actin and myosin [25]. Whereas, there could have been preservation of energy substrates and the positive temperature related effects in case of passive warm up that might have led to similar performance with respect to active warm up [26].

Our study results are different from the study results found by Yaicharoen P et al., who found passive warm up better over active warm up with respect to power and work done during intermittent sports performance [23]. This can be because of the difference in the method of passive warm up and the outcome measure used. They had used hot water immersion for 45 minutes as a passive warm up because of which there would have been more heating of the body that led to better performance and they had used intermittent sprint as outcome measure which uses anaerobic system as a source of energy [23]. ATP-PCr and muscle glycogen may be preserved during passive warm up [27]. As these are anaerobic system substrates, it may have resulted in muscle performance difference resulting in passive group muscle performance to be superior.

A study was done to compare the effects of different types of warm ups on swimming performance, they found there was no influence of type of warm up on the performance of swimmers. However, in this study passive warm seemed to be appropriate, but they recorded a lower self-confidence [28].

In this study, there was no significant differences found in SEBT measures between the two warm up techniques. This can be because of reduction of muscle and fascia viscosity due to thermal effect of passive warm up [29]. This might have led to improved flexibility in the muscles and fascia and thus, similar reach distance on SEBT in passive warm up group compared to active warm up group [30].

Combined warm up didn't show any significant change with respect to VJT and SEBT compared with active and passive warm up. One reason can be that the effects of passive warm up are nullified by active warm up. The preservation of energy substrates during passive warm up may have got utilized to more extent during active warm up session [2].

Though the time and activities in active warm up which is a part of combined warm up was less as compared to active warm up alone, passive warm up prior to active warm up could have led to faster utilization of energy substrates [31]. This may have resulted in reduction in energy substrates that led to non-significant differences in between the warm up trials in VJT and SEBT.

Though combined warm up was not statistically significant different from passive and active warm up, we found VJT outcome measures better in combined warm up trial than after passive and active warm up trial. Even this small increment in performance might benefit the players during sports events.

Passive warm, active and combined warm up can be used in short term high intensity muscle activities like high jumps, long jumps, sprinting, gymnastics, but the selection of warm up will be based on athletes and the requirement of a particular sports event. Like in case of short duration, high intensity activities which require mainly anaerobic energy substrates, passive warm up would be better as there is preservation of energy substrates that can be utilized during sports activity. No activity during passive warm up results in non-formation and collection of metabolites in the blood which can also improve sports activity.

LIMITATION

This study had a few limitations like the extent of rise in muscle temperature between the warm up trials was not considered. Thus, we can't say that the thermal effects were equal in all the three groups. Also, the effects of warm up trials were not tested on high intensity short duration muscle performances. So the extent of utilization of the anaerobic energy substrates was less during VJT and SEBT would have been less. So this can be the reason for not getting any difference in muscle performance. May be a larger sample size would have also shown change in performance of each group.

Still further research is needed in the same area using other passive methods like hot water immersions. Also, other tests to check vigorous sports performances like high intensity sprinting can be used. The extent of rise in the core and muscle temperature can also be monitored. The effects of passive, active and combined can also be tested on intermediate sports performances and similar studies can be done on professional sports players.

CONCLUSION

All three types of warm ups had similar effects on muscle performance and dynamic stability in recreational athletes. Any of these warm up techniques can be used by a recreational athlete to improve their performance in the sports. However, more research is needed in this field to understand the efficacy of these warm up trials in different sports scenarios.

REFERENCES

[1] Andrade DC, Henriquez-Olguin C, Beltran AR, Ramirez MA, Labarca C, Cornejo M, et al. Effects of general, specific and combined warm-up on explosive muscular performance. Biol Sport. 2015;32(2):123-28.
[2] McGowan CJ, Pyne DB, Thompson KG, Rattray B. Warm-up strategies for sport and exercise: mechanisms and applications. Sports Med. 2015;45(11):1523-46.
[3] Bishop D. Warm up I: potential mechanisms and the effects of passive warm up on exercise performance. Sports Med. 2003;33(6):439-54.
[4] Gray SC, Devito G, Nimmo MA. Effect of active warm-up on metabolism prior to and during intense dynamic exercise. Med Sci Sports Exerc. 2002;34(12):2091-96.
[5] Wahl P, Zinner C, Yue Z, Bloch W, Mester J. Warming-up affects performance and lactate distribution between plasma and red blood cells. J Sports Sci Med. 2010;9(3):499-507.
[6] Neiva HP, Marques MC, Barbosa TM, Izquierdo M, Viana JL, Marinho DA. Effects of 10min vs. 20min passive rest after warm-up on 100m freestyle time-trial performance: A randomized crossover study. J Sci Med Sport. 2017;20(1):81-86.
[7] Bizzini M, Impellizzeri FM, Dvorak J, Bortolan L, Schena F, Modena R, et al. Physiological and performance responses to the "FIFA 11+" (part 1): is it an appropriate warm-up? J Sports Sci. 2013;31(13):1481-90.

[8] Chen QF, Cai LC, Zhang Y, Gu YJ. The dissociation and equation of state of dense fluid oxygen at high pressures and high temperatures. J Chem Phys. 2008;128(10):104512.
[9] Neiva HP, Marques MC, Barbosa TM, Izquierdo M, Marinho DA. Warm-up and performance in competitive swimming. Sports Med. 2014;44(3):319-30.
[10] Ross A, Leveritt M. Long-term metabolic and skeletal muscle adaptations to short-sprint training: implications for sprint training and tapering. Sports Med. 2001;31(15):1063-82.
[11] Marshall PW, Cross R, Lovell R. Passive heating following the prematch warm-up in soccer: examining the time-course of changes in muscle temperature and contractile function. Physiol Rep [Internet]. 2015 Dec 4760448]; 3(12).
[12] Gregson WA, Drust B, Batterham A, Cable NT. The effects of pre-warming on the metabolic and thermoregulatory responses to prolonged submaximal exercise in moderate ambient temperatures. Eur J Appl Physiol. 2002;86(6):526-33.
[13] Raccuglia M, Lloyd A, Filingeri D, Faulkner SH, Hodder S, Havenith G. Post-warm-up muscle temperature maintenance: blood flow contribution and external heating optimisation. Eur J Appl Physiol. 2016;116(2):395-404.
[14] Atkinson G, Todd C, Reilly T, Waterhouse J. Diurnal variation in cycling performance: influence of warm-up. J Sports Sci. 2005;23(3):321-29.
[15] Hancock AP, Sparks KE, Kullman EL. Postactivation potentiation enhances swim performance in collegiate swimmers. J Strength Cond Res. 2015;29(4):912-17.
[16] Knicker AJ, Renshaw I, Oldham AR, Cairns SP. Interactive processes link the multiple symptoms of fatigue in sport competition. Sports Med. 2011;41(4):307-28.
[17] Edouard P, Arnal P, Gimenez P, Samozino P, Jimenez-Reyes P, Brughelli M, et al. Athletic injury prevention: Determinants of sprint performance. Ann Phys Rehabil Med. 2016;59S:e22-e3.
[18] Opar DA, Serpell BG. Is there a potential relationship between prior hamstring strain injury and increased risk for future anterior cruciate ligament injury? Arch Phys Med Rehabil. 2014;95(2):401-05.
[19] Hrysomallis C. Balance ability and athletic performance. Sports Medicine. 2011;41(3):221-32.
[20] Cochrane DJ, Stannard SR. Acute whole body vibration training increases vertical jump and flexibility performance in elite female field hockey players. Br J Sports Med. 2005;39(11):860-65.
[21] Dobija L, Coudeyre E, Pereira B. Measurement properties of the star excursion balance test in the anterior crucial ligament-deficient subjects - preliminary analysis. Ann Phys Rehabil Med. 2016;59S:e18.
[22] Demura T, Demura S, Aoki H, Uchida Y, Yamaji S. Effect of linear polarized near-infrared light irradiation and light exercise on muscle performance. Journal of Physiological Anthropology. 2011;30(3):91-96.
[23] Yaicharoen P, Wallman K, Morton A, Bishop D, Grove RJ. The effects of warm-up on intermittent sprint performance in a hot and humid environment. Journal of Sports Sciences. 2012;30(10):967-74.
[24] Overmyer KA, Evans CR, Qi NR, Minogue CE, Carson JJ, Chermside-Scabbo CJ, et al. Maximal oxidative capacity during exercise is associated with skeletal muscle fuel selection and dynamic changes in mitochondrial protein acetylation. Cell Metab. 2015;21(3):468-78.
[25] Billington N, Revill DJ, Burgess SA, Chantler PD, Knight PJ. Flexibility within the heads of muscle myosin-2 molecules. J Mol Biol. 2014;426(4):894-907.
[26] West DJ, Dietzig BM, Bracken RM, Cunningham DJ, Crewther BT, Cook CJ, et al. Influence of post-warm-up recovery time on swim performance in international swimmers. J Sci Med Sport. 2013;16(2):172-76.
[27] Balilionis G, Nepocatych S, Ellis CM, Richardson MT, Neggers YH, Bishop PA. Effects of different types of warm-up on swimming performance, reaction time, and dive distance. J Strength Cond Res. 2012;26(12):3297-303.
[28] Adams S, Psycharakis SG. Comparison of the effects of active, passive and mixed warm ups on swimming performance. J Sports Med Phys Fitness. 2014;54(5):559-65.
[29] Markovic G. Acute effects of instrument assisted soft tissue mobilization vs. foam rolling on knee and hip range of motion in soccer players. J Bodyw Mov Ther. 2015;19(4):690-96.
[30] Donato AJ, Lesniewski LA, Delp MD. The effects of aging and exercise training on endothelin-1 vasoconstrictor responses in rat skeletal muscle arterioles. Cardiovasc Res. 2005;66(2):393-401.
[31] Tyler CJ, Sunderland C, Cheung SS. The effect of cooling prior to and during exercise on exercise performance and capacity in the heat: a meta-analysis. Br J Sports Med. 2015;49(1):07-13.

PARTICULARS OF CONTRIBUTORS:
1. Postgraduate Student, Department of Physiotherapy, School of Allied Health Science, Manipal, Karnataka, India.
2. Assistant Professor, Department of Physiotherapy, School of Allied Health Science, Manipal, Karnataka, India.
3. Assistant Professor, Department of Physiotherapy, School of Allied Health Science, Manipal, Karnataka, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Dr. Prateek Srivastav,
Assistant Professor, Department of Physiotherapy, School of Allied Health Science, Manipal University,
Manipal-576104, Karnataka, India.
E-mail: prateek.srivastav@manipal.edu

FINANCIAL OR OTHER COMPETING INTERESTS: None.

Date of Submission: **Oct 13, 2016**
Date of Peer Review: **Nov 25, 2016**
Date of Acceptance: **Jan 20, 2017**
Date of Publishing: **Mar 01, 2017**