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Index

Serpetsoglou Lazaros

The effects of different types of stretching during an active warm-up on hip and ankle range of motion

Abstract

Active warm-up can bring about positive responses in the body such as increasing the range of motion of the joints (ROM). The purpose of this study was to examine the effects of the different types of stretching during the execution of an active warmup protocol on hip (flexion, external rotation) and ankle (dorsiflexion) ROM. The participants (n=17, age 24±4 yrs) were subjected to two experimental conditions, a) static stretching b) dynamic stretching, with a random order and an intervening interval of 48 hours. Warm-up protocol was consisted of track running, self-myofascial release with a foam roller, stretching and activation exercises. ROM measurements were performed before the start of the experiment on a different day (baseline) and after the end of each warm-up protocol. Kruskall-Wallis test indicated that there was a statistically significant difference ($p<0.05$) between the baseline and experimental measurements in the means of all ROM variables. Wilcoxon test for dependent samples indicated that there was a statistically significant difference in ROM during dorsiflexion of the right ankle ($Z=-2,179$, $p=0.029<0.05$) (Static Stretching 12.76±3.865 deg vs Dynamic Stretching 15.81±2.949 deg). Application of static and dynamic stretching while performing an active warm-up protocol is

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equally effective in increasing hip and ankle ROM with application of dynamic stretching showing a greater increase contralaterally.

Keywords: active warm-up, static stretching, dynamic stretching, ROM

Η επίδραση της διαφοροποίησης του είδους διατάσεων κατά την εκτέλεση ενεργητικής προθέρμανσης στο εύρος κίνησης του ισχίου και της ποδοκνημικής

Περίληψη

Η ενεργητική προθέρμανση μπορεί να επιφέρει θετικές αποκρίσεις στον οργανισμό όπως την αύξηση του εύρους κίνησης των αρθρώσεων. Σκοπός της παρούσας έρευνας ήταν να εξετάσει την επίδραση της διαφοροποίησης του είδους διατάσεων κατά την εκτέλεση ενός πρωτοκόλλου ενεργητικής προθέρμανσης στο εύρος κίνησης του ισχίου (κάμψη, έξω στροφή) και της ποδοκνημικής (ραχιαία κάμψη). Οι συμμετέχοντες (n=17 Μ.Ο. ηλικίας 24±4 έτη) υποβλήθηκαν σε δύο πειραματικές συνθήκες α) στατικές διατάσεις β) δυναμικές διατάσεις με τυχαία σειρά και ενδιάμεσο διάστημα 48 ωρών. Το πρωτόκολλο προθέρμανσης αποτελούταν από τρέξιμο στο στίβο, μυοπεριτονιακή αποσυμφόρηση με foam roller, διατάσεις και ασκήσεις ενεργοποίησης. Η μέτρηση του εύρους κίνησης των αρθρώσεων πραγματοποιήθηκε πριν από την έναρξη των πειραματικών συνθηκών σε διαφορετική ημέρα (baseline) και μετά το πέρας κάθε πρωτοκόλλου προθέρμανσης. Η δοκιμασία Kruskall Wallis υπέδειξε ότι υπήρξε στατιστικά σημαντική διαφορά ($p<0.05$) μεταξύ των αρχικών και πειραματικών μετρήσεων στους μέσους όρους όλων των μεταβλητών του εύρους κίνησης. Η δοκιμασία Wilcoxon για εξαρτημένα δείγματα υπέδειξε ότι παρουσιάστηκε στατιστικά σημαντική διαφορά στο εύρος κίνησης κατά την ραχιαία κάμψη της δεξιάς ποδοκνημικής ($Z=-2,179$, $p=0.029<0.05$) (Στατικές Διατάσεις 12.76±3.865 deg vs Δυναμικές διατάσεις 15.81±2.949 deg). Η εφαρμογή στατικών και δυναμικών διατάσεων κατά την εκτέλεση ενός πρωτοκόλλου ενεργητικής προθέρμανσης είναι εξίσου αποδοτική για την αύξηση του εύρους κίνησης της άρθρωσης του ισχίου και της ποδοκνημικής με την εφαρμογή δυναμικών διατάσεων να παρουσιάζει μεγαλύτερη αύξηση ετερόπλευρα.

Λέξεις κλειδιά: ενεργητική προθέρμανση, στατικές διατάσεις, δυναμικές διατάσεις, εύρος κίνησης αρθρώσεων

1. Introduction

Warm-up is now universally accepted as an integral part of training aimed at physically and psychologically preparing the athlete before exercise or competition[1]. A properly structured warm-up program can bring about many positive responses in the body that contribute to the optimization of athletic performance[2]. These responses are categorized into a) temperature-related and b) non-temperature-related. Temperature-related ones consist of hyperemia-induced increases in core and muscle temperature, neural tissue excitability, muscle fiber conduction rate, muscle metabolism, and connective tissue elasticity[3 4 5]. The non-temperature-related ones consist of increased tissue oxygen consumption at rest and enhanced performance due to post-activation potentiation [6].

The two warm-up methods applied are passive and active. For passive warm-up, hot water, sauna and heated pads are used to increase core and muscle temperature without extensive energy expenditure. However, the practical application of passive methods is not always feasible for practitioners and positive warm-up responses are only achieved using active methods[7 8]. Active warm-up consists of two periods, the general and the specific warm-up[9]. The general warm-up begins with 5 minutes of low-intensity physical activity (cycling, running, swimming) and aims to increase heart and respiratory rate[10]. Then, self-myofascial release is applied using a foam roller to achieve tissue hydration and increase muscle blood flow[11 12]. Afterwards, the application of stretching helps to increase the range of motion of the joints (ROM) to properly perform the movements of the main activity or competition. Lastly, after the end of the general warm-up, the specific warm-up follows, which includes low-intensity exercises to activate all the

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4 McGowan, C. J., Pyne, D. B., Thompson, K. G., & Rattray, B. (2015). Warm-Up Strategies for Sport and Exercise: Mechanisms and Applications. *Sports Medicine*, *45*(11), 1523–1546.

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12 Sullivan, K. M., Silvey, D. B. J., Button, D. C., & Behm, D. G. (2013). Roller-massager application to the hamstrings increases sit-and-reach range of motion within five to ten seconds without performance impairments. *International Journal of Sports Physical Therapy*, *8*(3), 228–236.

muscle groups that produce or stabilize the movements of the body during the main part of training and exercise drills to learn or practise the technique of the sport [13 14].

The active warm-up program should progress smoothly and be performed with a correct quantification of the intensity in order to achieve the necessary adaptations without fatigue and a dramatic decrease in the energy reserves of the practitioner. Thus, the ideal warm-up duration is defined between 10 and 20 min, while at the same time it is suggested to be completed no later than 15 min before the start of the upcoming activity [15].

1.1. Types of Stretching

Stretching is performed actively or passively and is divided into static, ballistic, dynamic and the PNF method. Static stretching is performed with the exerciser holding the final position firmly for 15 to 30sec resulting in autogenic relaxation of the muscle being stretched [16 17]. Due to the slow manner of execution, there is no activation of the myotatic reflex resulting in less potential for injury compared to other methods[18]. Furthermore, according to the existing literature, it appears to be an effective method for increasing ROM[19 20 21]. Ballistic stretching requires muscle activation to perform explosive movements without pausing in the final position and quickly returning to the initial position[22]. This method is usually used during the warm-up before the start of the main activity. In cases where the exerciser cannot achieve proper control of the movement, there is a potential for muscle or connective tissue injury. Dynamic stretching or mobility exercises are the execution of controlled movements throughout the ROM according to the characteristics and

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requirements of the main activity or sport[23]. When designing warm-up programs, the application of this method is recommended because it is effective for improving dynamic flexibility, increasing core and muscle temperature, and activating the nervous system[24 25]. The PNF method (Proprioceptive Neuromuscular Facilitation) was originally developed as part of neurological rehabilitation programs for the relaxation of hypertonic muscles[26]. To perform this method, assistance from another person is usually required as the techniques include passive and active movements. The application of PNF seems to produce better results in increasing ROM compared to other stretching methods because it facilitates the activation of the inhibitory mechanisms of the neuromuscular system[27 28 29]. However, this method is usually not applied during the warm-up because it can be a painful experience for the practitioner and at the same time requires the intervention of a specialized person[30].

1.2. Myofascial Release

Fascia is a three-dimensional formation of fibrous connective tissue that covers the entire surface of the body surrounding muscles, bones, organs, blood vessels and other structures[31]. In cases of injury, inflammation or immobility, the fascia loses its elasticity leading to reduced joint functionality, pain, dysfunction of the venous and lymphatic system, and the formation of trigger points[32]. In recent years, the use of the foam roller as a tool for myofascial release has been widespread, as the intervention of a health professional is not necessary for the application of this method. The exerciser uses his body weight to move on the roller exerting pressure on all the muscle groups of the body. According to literature findings, the use of this method appears to have a positive effect on increasing ROM and

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flexibility, reducing delayed onset muscle soreness and optimizing warm-up[33 34 35].

1.3. Purpose of the Study

The purpose of this study was to examine the effects of different types of stretching during the execution of an active warm-up on hip and ankle ROM. We hypothesize that:

1. performing static stretches will increase ROM
2. performing dynamic stretches will increase ROM
3. performing dynamic stretches will result in a greater increase in ROM compared to static stretches.

2. Material & Methods

2.1. Participants

17 trained healthy men with an average age of 24±4 years took part in the present study. Before conducting the experimental conditions, the participants were informed in detail about the purpose and methodology of the research and signed the consent form that was given to them after the approval of the Clinical Research and Ethics Committee of the Metropolitan College. The evaluation and measurement procedures took place at the Sports Center of Thessaloniki, Greece.

2.2. Procedures

Participants were subjected to two experimental conditions:

A. 5min running with an intensity of 50-60% of the maximum heart rate (HRmax), 10 slow repetitions with the Grid Foam Roller of the company Trigger Point© on the muscle groups of the lower limb contralaterally, static stretching performed for 30sec, and two sets of 15 repetitions of "hip thrusts" using medium resistance mini bands from the company Blackroll© and "squats" without external resistance.

B. 5min running with an intensity of 50-60% of HRmax, 10 slow repetitions with the Grid Foam Roller of the company Trigger Point© on the muscle groups of the lower limb contralaterally, dynamic stretching performed for 10 repetitions, and two sets of 15 repetitions of "hip thrusts" using a medium resistance mini

33 Aboodarda, S. J., Spence, A. J., & Button, D. C. (2015). Pain pressure threshold of a muscle tender spot increases following local and non-local rolling massage. *BMC Musculoskeletal Disorders*, *16*, 265.

34 Cafarelli, E., & Flint, F. (1992). The role of massage in preparation for and recovery from exercise. An overview. *Sports Medicine (Auckland, N.Z.)*, *14*(1), 1–9.

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band from the company Blackroll© and "squats" without external resistance.

The calculation of the heart rate during the performance of the physical activity was carried out with the equation (220 – age) X intensity % [36] and its recording using the Band 6 activity tracker of the company Huawei©. In Table 1, the active warm-up protocols of the two experimental conditions are presented in detail.

Table 1. Active warm-up protocols.

General Warm-up	5min track running 50-60% HRmax	
Self-myofascial Release with Foam Roller	10 slow repetitions on each leg: gastrocnemius, hamstrings, quadriceps, adductors (knee bent), glutes (legs crossed	
Stretching	**Static Stretching**	**Dynamic Stretching**
	30sec each leg gastrocnemius/soleus standing stretch (hands against the wall) iliopsoas/rectus femoris stretch box stretch (rear knee touches the floor) hamstrings box stretch (leg straight parallel to the ground) adductors box stretch (knee bent, torso points forward)	*10 reps each leg* half kneeling position hip-knee-ankle flexion kneeling position hip external -internal rotation (hands against the wall) Hip Hinge Lateral Squats
Specific Warm-up	*2x15 (3-1-X)* Hip Thrusts with mini band Squats *30sec rest between sets* *1min rest between exercises*	

Prior to performing the experimental protocols, participants underwent a baseline measurement of passive ROM of the hip during flexion in the transverse axis and external rotation in the longitudinal axis, and of the ankle during dorsiflexion in the transverse axis in both legs using an analog goniometer from the company Gima©. This procedure was performed on a different day at the beginning of the measurement period with the participants abstaining from intense physical exercise for 48 hours. Then, they took part in the two experimental conditions where 5min after the end of the warm-up protocol the passive ROM of the joints was also measured in the same way. The execution of the experimental conditions was carried out in a random order on different days and an intervening interval of 48 hours.

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2.3. Statistical Analysis

The IBM SPSS Statistics version 26 program was used for the statistical analysis of the data on a computer with Microsoft Windows 10 software. Kruskal-Wallis test was performed in order to investigate the differences between the baseline measurements and the two experimental conditions. Wilcoxon test for dependent samples was performed to determine the differences between the two experimental conditions. The level of significance was defined as p<0.05.

3. Results

The results of the study are presented as means of ROM values ± their standard deviation as recorded during the baseline measurements and after the end of the two experimental conditions.

Table 2. Means & standard deviations of range of motion variables.

	Baseline	**Static Stretching**	**Dynamic Stretching**
Right Ankle Dorsiflexion	8.59±7.168 deg	12.76±3.865 deg	15.81±2.949 deg
Left Ankle Dorsiflexion	5.18±7.780 deg	8.47±3.085 deg	11±4.2430 deg
Right Hip Flexion	112±14.756 deg	121.29±5.599 deg	121.88±7.606 deg
Left Hip Flexion	111.82±7.544 deg	120.18±6.803 deg	122.69±6.819 deg
Right Hip External Rotation	23.12±4.820 deg	31.71±7.346 deg	31.94±5.744 deg
Left Hip External Rotation	23.82±4.953 deg	32.59±9.125 deg	32.25±6.330 deg

Kruskal-Wallis test showed a statistically significant difference between the baseline measurements and the experimental conditions in the means of the variables Right Ankle Dorsiflexion (H=15.431, p=0<0.05), Left Ankle Dorsiflexion (H=8.374, p=0.015<0.05), Right Hip Flexion (H=7.386, p=0.025<0.05), Left Hip Flexion (H=16.775, p=0<0.05), Right Hip External Rotation (H=17.831, p=0<0.05) and Left Hip External Rotation (H=15.633, p=0<0.05).

Wilcoxon test for dependent samples showed a statistically significant difference between the two experimental conditions in the means of the variable Right Ankle Dorsiflexion (Z=-2,179, p=0.029<0.05) (Static Stretching 12.76±3.865 deg vs Dynamic Stretching 15.81±2.949 deg), while there was no statistically significant difference in the means of the variables Right Ankle Dorsiflexion (Z=-1.830, p=0.067>0.05) (Static Stretching 8.47±3.085 deg vs Dynamic Stretching 11±4.2430 deg), Right Hip Flexion (Z=-0.971, p=0.331>0.05)

(Static Stretching 121.29±5.599 deg vs Dynamic Stretching 121.88±7.606 deg), Left Hip Flexion (Z=-1.751, $p=0.08>0.05$) (Static Stretching 120.18±6.803 deg vs Dynamic Stretching 122.69±6.819 deg), Right Hip External Rotation (Z=-0.463, $p=0.643>0.05$) (Static Stretching 31.71±7.346 deg vs Dynamic Stretching 31.94±5.744 deg) and Left Hip External Rotation (Z=-0.473, $p= 0.636>0.05$) (Static Stretching 32.59±9.125 deg vs Dynamic Stretching 32.25±6.330 deg).

4. Discussion

According to the existing literature, the application of stretching while performing an active warm-up protocol can result in increased ROM[37 38 39]. In particular, static and dynamic stretching bring about an improvement in flexibility[40 41 42]. Furthermore, performing a general warm-up at the start of the protocol consisting of 5 min of low-intensity physical activity and self-myofascial release is deemed necessary to increase core and muscle temperature[43 44 45 46] as well as performing a specific warm-up consisting of activation exercises to smoothly transition into the main part of the training or match[47 48].

The purpose of the present study was to examine the effect of different types of stretching during the execution of an active warm-up protocol on hip ROM during flexion in the transverse axis and external rotation in the longitudinal axis, and ankle ROM during dorsiflexion in the transverse axis. During data analysis, a statistically significant difference was presented between the baseline measurements and the

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37 Gray, S. R., Soderlund, K., Watson, M., & Ferguson, R. A. (2011). Skeletal muscle ATP turnover and single fibre ATP and PCr content during intense exercise at different muscle temperatures in humans. *Pflugers Archiv : European Journal of Physiology*, *462*(6), 885–893.

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43 Beardsley, C., & Škarabot, J. (2015). Effects of self-myofascial release: A systematic review. *Journal of Bodywork and Movement Therapies*, *19*(4), 747–758.

44 DeVries Housh, Terry J., H. A. (1994). *Physiology of exercise for physical education, athletics, and exercise science*. WCB Brown & Benchmark.

45 Schleip, R., & Müller, D. G. (2013). Training principles for fascial connective tissues: scientific foundation and suggested practical applications. *Journal of Bodywork and Movement Therapies*, *17*(1), 103–115.

46 Sullivan, K. M., Silvey, D. B. J., Button, D. C., & Behm, D. G. (2013). Roller-massager application to the hamstrings increases sit-and-reach range of motion within five to ten seconds without performance impairments. *International Journal of Sports Physical Therapy*, *8*(3), 228–236.

47 Jeffreys, I. (2007). *Warm up revisited the ramp method of optimising performance preparation.*

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two experimental conditions, verifying the first and second research hypotheses as the application of static and dynamic stretching resulted in increased ROM.

The mean values of ROM after the application of the warm-up protocol were greater during the experimental condition of dynamic stretching, verifying the third research hypothesis. However, the results of the statistical analysis showed that there was a statistically significant difference in ROM during dorsiflexion of the right ankle. Therefore, both active warm-up protocols are equally effective in increasing ROM, with the application of dynamic stretching showing a greater increase contralaterally.

5. Research Suggestions

Applying an active warm-up protocol that includes a combination of static and dynamic stretching is likely to have a greater effect on increasing ROM, as is applying a long-term warm-up program. However, it should be examined whether the above intervention can affect the athletic performance of the participants by measuring the rate of force development and the maximum force production during the execution of the main part of training. Finally, the selection of a larger sample is considered necessary for the generalization of the results.

6. Conclusions

An active warm-up can bring about positive responses in the body such as increasing ROM. According to the findings of the present study, the application of static and dynamic stretches while performing an active warm-up protocol is equally effective in increasing hip ROM during flexion and external rotation and ankle ROM during dorsiflexion as the application of dynamic stretching shows a greater increase contralaterally.

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