©Journal of Sports Science and Medicine (2008) **7**, 549-555
http://www.jssm.org

Research article

Acute effects of pre-event lower limb massage on explosive and high speed motor capacities and flexibility

Ramiz Arabaci
Department of Physical Education and Sport, Faculty of Education, University of Uludag, Bursa, Turkey

Abstract
The aim of this study was to examine the acute effects of pre-performance lower limb massage after warm-up on explosive and high-speed motor capacities and flexibility. Twenty-four physically active healthy Caucasian male subjects volunteered to participate in this study. All subjects were from a Physical Education and Sport Department in a large university in Turkey. The study had a counterbalanced crossover design. Each of the subjects applied the following intervention protocols in a randomised order; (a) massage, (b) stretching, and (c) rest. Before (pre) and after (post) each of the interventions, the 10 meter acceleration (AS), flying start 20 meter sprint (FS), 30 meter sprint from standing position (TS), leg reaction time (LR), vertical jump (VJ) and sit & reach (SR) tests were performed. A Wilcoxon's signed rank test was used to compare before and after test values within the three interventions (massage, stretching and rest). The data showed a significant worsening, after massage and stretching interventions, in the VJ, LR (only in stretching intervention), AS and TS tests ($p < 0.05$), and significant improvement in the SR test ($p < 0.05$). In contrast, the rest intervention led only to a significant decrement in TS performance ($p < 0.05$). In conclusion, the present findings suggest that performing 10 minute posterior and 5 minute anterior lower limb Swedish massage has an adverse effect on vertical jump, speed, and reaction time, and a positive effect on sit and reach test results.

Key words: Massage, warm-up, performance, stretching.

Introduction

Warm-up is practiced by athletes to increase their physiological and psychological capacities prior to training or competition, despite limited scientific evidence supporting one protocol over another (ACSM, 2006; Faigenbaum et al., 2005; O'Brien et al., 1997; Robergs et al., 1991). Different types, intensity and duration of warm-up ensure different physiological-biochemical and psychological changes in the body (Bishop, 2003a; 2003b; Mitchell and Huston, 1993; O'Brien et al., 1997). Traditionally, athletes perform static stretching after initial jogging during warm-up because it is easy, safe, and believed to be less likely to strain the muscles than other types of stretching (Alter, 1997; Hedrick, 2002; Koch et al., 2003; Young and Behm, 2002). However, recent research has shown that static stretching decreases acute explosive and high speed motor capacities such as power, strength, vertical jump, velocity and reaction time (Behm et al., 2001; 2004b; 2006; Behm and Kibele, 2007; Boyle, 2004; Church et al., 2001; Fletcher and Jones, 2004; Fowles et al, 2000; Little and Williams, 2006; McNeal and Sands, 2003; Nelson et al., 2005; Siatras et al., 2003).

Apart from stretching, pre-event massage can be used as an adjunct to physical warm-up (Tessier, 2005). Many claims are made about massage, but few are backed by any empirical data regarding either mechanisms or effects. Possible mechanisms of massage have been categorised into biomechanical, physiological, neurological and psychological (Weerapong et al, 2005). Some data have indicated that both massage and stretching causes a decline in motor unit activation (Dishman and Bulbulian, 2001; Goldberg et al., 1992; Goldberg et al. 1994; Morelli et al, 1991; Sullivan et al., 1991) and reduces muscle stiffness as evidenced by a lengthening of massaged muscle (Hernandez-Reif et al, 2001; Wiktorsson-Moller et al., 1983). However, existing data have been inadequate (Goodwin, 2002).

To date, very few studies have examined the effects of pre-event massage on performance. There are controversial claims in the sports literature that pre-event massage can increase or decrease performance (Weerapong et al, 2005). Wiktorsson-Moller et al. (2005) found that 6–15 minutes of petrissage, with the aim of promoting relaxation and comfort, reduced muscle strength. Goodwin et al. (2007) found that a controlled 15 minute lower limb massage administered prior to warm-up had no significant effect on sprint performance. Research conducted by Hunter et al. (2006) showed that lower limb massage appears to produce a reduction in force during the first contraction of muscles. Two studies found that massage of the hamstring muscle group increased the passive range of motion in hip and lower limb joints (Crosman et al., 1984; Wiktorsson-Moeller et al., 2005; McKechine et al., 2007). Moreover, there is no consensus on the type, style, application, duration, intensity, number of strokes applied, or the time of application prior to training or competition (Caldwell, 2001, King, 1993, Paine, 2000). Consequently, the effects of pre-event massage on performance are still inconclusive due to lack of well-controlled studies. To my knowledge, no previous studies have examined the acute effects of anterior and posterior lower limb pre-event massage on reaction time, vertical jump, speed and flexibility, and compared these with results of static stretch warm-up and warm-up without massage or stretch protocols. Therefore, the purpose of this study was to examine acute effects of pre-

Received: 15 September 2008 / Accepted: 14 November 2008 / Published (online): 01 December 2008

performance lower limb massage after warm-up on explosive and high speed motor capacities and flexibility.

Methods

Experimental approach to the problem

Prior to the test trials, each subject visited our indoor sports facility to receive instructions and to participate in a familiarization trial to practice all the tests that were to be performed in the study. Two days after the familiarization trial, all subjects completed three different interventions on three nonconsecutive test days within one week. During this period subjects carried out no other physical activity or training. The study had a counterbalanced crossover design. Each of the subjects applied the following intervention protocols in a randomised order; (a) massage, (b) stretching, and (c) rest. Before (pre) and after (post) each intervention, the 10 meter acceleration, flying start 20 meter sprint, 30 meter sprint from standing position, leg reaction time (audio), vertical jump and sit & reach tests were performed. All these performance tests were carried out on a synthetic floor in an indoor sport facility. The temperature of the indoor sport facility was between 20-24ºC during the week of testing. Subjects were encouraged to achieve maximal performance during the tests. Forty eight hours before the familiarization trial, subjects did not engage in heavy physical activity or exercise. They recorded their normal dietary intake during the study and took no food or fluid (except water) 3 hours before each intervention. Subjects conducted the same warm-up protocol before each intervention. The warm-up protocol lasted for 15 minutes, and consisted of the following;

- Jogging (400 m): 4 minutes
- 60% maximal pace running: two repetitions each of 5 m back, 5 m sidestepping and 5 m forward: 3 minutes
- 70% maximal pace 30 m forward, repeated three times: 2 minutes
- 100% maximal speed for 5 m and 20 m, each repeated two times: 2 minutes
- Active rest: 2 minutes

Immediately after rest, subjects carried out a vertical jump, a 30 m sprint (within the 30 m sprint time, the leg reaction time (first pace), 10 m acceleration, and flying 20 m sprint time were also recorded individually) and sit & reach tests. All subjects always performed the vertical jump test the first, the 30 m sprint second and the sit & reach test last. After subjects had performed the pre-intervention performance tests, they received a 15 minute massage, performed a 15 minute static stretching exercise for lower limbs, or had 15 minutes of passive rest in random crossover fashion for three visits. Immediately following the intervention, subjects completed the same performance tests. Figure 1 shows the complete experimental design.

Subjects

Twenty-four physically active healthy Caucasian male subjects volunteered to participate in this study. All subjects were students from a Physical Education and Sport Department in a large university in Turkey. Their mean ± SD age, weight, height, BMI and body fat were 22.2 ± 1.41 years (range 19–26), 70.7 ± 9.40 kg (range 55–92), 1.76 ± 0.07 m (range 1.65–1.90), 22.7 ± 1.8 (range 19–26) and % fat 12.6 ± 3.2 (range 8.3–21.1), respectively. Subjects were informed of the test procedures and interventions of the study, completed questionnaires for the health screening, and their written informed consent to participate was obtained in accordance with the Helsinki Declaration (WMADH, 2000).

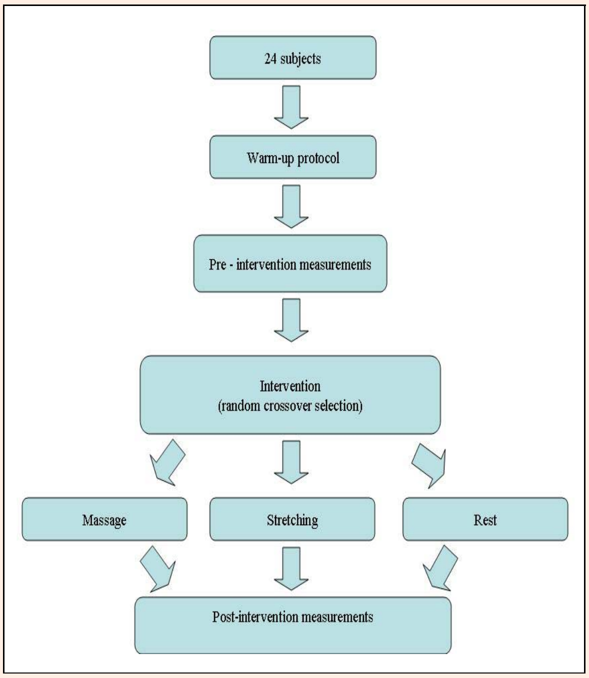

Figure 1. Experimental design.

Procedures

Massage Condition: Many coaches, athletes and sports therapists have applied Swedish type massage (Hemmings, 2001; Tessier, 2005; Weerapong et al, 2005). In the present study Swedish massage techniques were applied in the massage protocol. This massage included five manipulations: effleurage, friction, petrissage, vibration and tapotment. The massage was applied; a) on the posterior lower limbs for 10 minutes and b) on the anterior lower limbs (thighs) for 5 minutes. Posterior lower limb massage was performed on muscle groups of the gluteal region, posterior thigh and leg. In contrast, the anterior lower limb massage was performed only on the anterior thigh. Posterior lower limb massage was performed between the ankle and the hip, but anterior lower limb massage was performed between the knee and the hip. Therefore, the duration of the posterior lower limb massage was greater than the duration of the anterior lower limb massage. Eighteen and 12 different massage techniques were applied to the posterior and anterior lower limbs, respectively. Manipulations were generally applied in the direction from inferior to superior. The massage techniques are shown in Tables 1 and 2. Massage was performed on both left and right lower limbs simultaneously by two

Table 1. Posterior lower limb massage protocol.

Massage Technique	Rate	Time (duration) In seconds
1. Effleurage	30-40 strokes/min	45
2. Friction on trochanter major	90-100 circle/min	10
3. Friction (circular) performed with the thumb (left hand, right hand, two hands together)	60-70 circles/min	50
4. Friction (circular) performed with the other four fingers (left hand, right hand, two hands together)	60-70 circles/min	50
5. Friction (circular) performed with the palm (left hand, right hand, two hands together)	60-70 circles/min	50
6. Deep friction	40-50 circles/min	20
7. Friction on achilles tendon	50-60 circles/min	20
8. Stroking on achilles tendon	40-50 strokes/min	20
9. Comb friction	30-40 strokes/min	50
10. Octave friction (medial, intermediate, lateral)	60-70 circles/min	50
11. Petrrissage (circular kneading with palm)	60-70 strokes/min	20
12. Petrissage with two hands (kneading medial thigh)	60-70 strokes/min	20
13. Cutting petrissage with two hands (medial thigh)	60-70 strokes/min	45
14. Petrissage on twisted leg	60-70 strokes/min	20
15. Stroking on twisted leg	45-50 strokes/min	20
16. Tapotment – hacking	240-260 contacts/min	45
17. Vibration - shaking	60-70 shakes/min	20
18. Effleurage	40-50 strokes/min	45

masseurs using baby oil. Prior to the study initiation, masseurs performed the massage protocols on themselves for familiarization with the stroke order and rate. Subjects received posterior lower limb massages while lying in the prone position and received anterior leg massages while lying in the supine position.

Stretching: The target muscles of static stretching were six muscle groups in the lower limbs: plantar flexors, hip extensors, hamstrings, hip flexors, adductor and quadriceps femoris. Static stretching exercises that were performed are shown in Figure 2A-F. Subjects first positioned their left lower limb into each of the stretch positions slowly and attentively. When their joint reached the limit of the range of motion and pain threshold, they held this position for 20 seconds. After a 10 second rest period, the same stretch was performed on the right lower limb for 20 seconds. Therefore, a single stretching exercise lasted a total of 40 seconds for both left and right lower limbs. A rest period (10 sec) was provided in order to prepare the subject for the next stretch. These stretching exercises were performed for sets (three sets x six static stretching exercises x 40 seconds stretch and 10 seconds rest). The entire stretching intervention lasted approximately 15 minutes.

Performance tests

Vertical Jump: Laser operated optoelectronic jump height measurement equipment (EMZ-10) was used to measure stationary vertical jump height (Musayev, 2006). The equipment recorded values with 1 cm precision. The vertical jump test involved a 2-footed vertical jump from a stationary position with the intention of attaining maximum height. Subjects were instructed to maintain their hands on the hips and keep the legs straight once they had left the ground. Before each jump, subjects were verbally encouraged to jump as high and as straight up as possible. Shuffling of feet or steps was not allowed. Consequently, each jump was closely observed to ensure that subjects

Table 2. Anterior lower limb (thigh) massage protocol.

Massage Technique	Rate	Time (duration) In seconds
1. Effleurage	30-40 strokes/min	30
2. Friction (circular) performed with the thumb (left hand, right hand, two hands together)	60-70 circles/min	30
3. Friction (circular) performed with the other four fingers (left hand, right hand, two hands together)	60-70 circles/min	30
4. Friction (circular) performed with the palm (left hand, right hand, two hands together)	60-70 circles/min	30
5. Deep friction	40-50 circles/min	15
6. Comb friction	30-40 strokes/min	25
7. Octave friction (medial, intermediate, lateral)	60-70 circles/min	30
8. Petrrissage (circular kneading with palm)	60-70 strokes/min	20
9. Cutting petrissage with two hand (medial thigh)	60-70 strokes/min	20
10. Tapotment – hacking	240-260 contacts/min	30
11. Vibration	60-70 shakes/min	10
12. Effleurage	40-50 strokes/min	

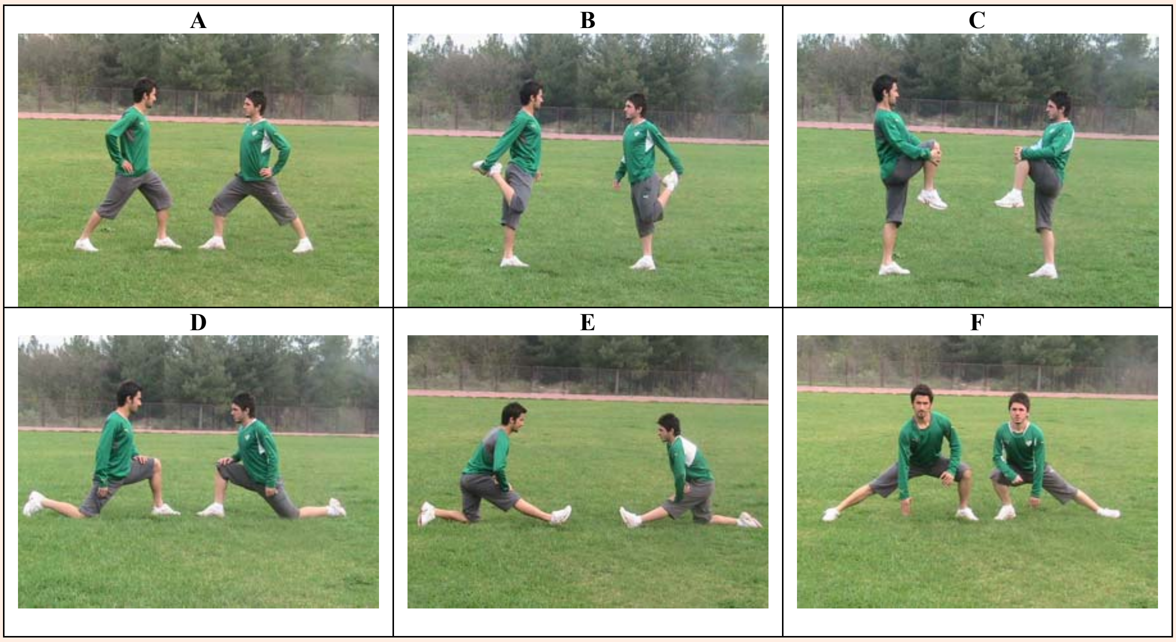

Figure 2. A) Plantar flexor stretch, B) Quadriceps stretch, C) Hip extensors stretch, D) Hip flexors stretch, E) Hamstring stretch, F) Adductors stretch.

did not alter their jumping technique to manipulate the time spent in the air.

30 m sprint: This test involves sprinting for 30 meters as fast as possible from a stationary standing start position, with no swinging movements**.** Since this is a very short distance to cover, subjects were expected to work at 100% maximum efficiency. Sprint time was measured with an optoelectronic photocell (split time 10 meter). In addition to the 30 meter sprint time, this test also measured leg reaction time (first step), 10 meter acceleration and flying 20 meter sprint time. Previous studies have shown very good reliability of these sprint distances and this starting position for high speed performance assessment (Duthie et al., 2006; Moir et al., 2004)

Reaction time: Audio reaction and movement times of the dominant lower limb were measured in this study. The reaction time equipment was designed in a U shape and consisted of two sensors and one main apparatus. The main apparatus consisted of four digital counters. This equipment does not require calibration. Subjects first assumed a stationary standing position. After the toes of their dominant leg were fixed in the U sensor system, a research assistant pressed a button for an audible signal. When the subject heard the signal, he was instructed to take a forward step as quickly as possible.

Sit & reach test: Subjects sat with the soles of their feet against the box, with their hips flexed to about 90˚ to assume an upright sitting position. Subjects were instructed to flex their hip joints and vertebral column (with possible contributions from shoulder joint flexion and scapular elevation) to reach forward as far as possible. A centimetre scale was printed on the top surface of the box.

Statistical analyses

All statistical analyses were performed using SPSS version 16.0 (SPSS, SPSS Inc, Chicago, IL, USA) software. All values of variables were expressed as mean and standard deviation (M ± SD) and percent changes (%). Since the test parameters showed skewness according to Shapiro-Wilk's test and did not provide the homogeneity of variance according to Levene statistic, non-parametric statistical testing was chosen.

A Wilcoxon's signed rank test was used to compare before and after test values within the three interventions (massage, stretching and rest). All tests were matched pairwise (before - after intervention) and statistical significance was accepted at $p < 0.05$. The results were presented in tables.

Results

The mean scores (± SD) and percent changes (%) for the performance measures before and after the three different interventions are presented in Table 3. The data showed a significant decrease in performance after massage and stretching interventions for VJ, LR (only in stretching intervention), AS and TS ($p < 0.05$), and a significant improvement in the SR test ($p < 0.05$). In contrast, the rest intervention lead only to a significant decrement in TS performance ($p < 0.05$).

Discussion

Traditionally, athletes perform a warm-up session prior to physical activity or competition. The aim of the warm-up is to improve the physiological, biomechanical and psychological performance of the athlete. However, coaches, athletic trainers, athletes, and sport scientists have not yet determined which warm-up protocol is the best. Generally, coaches and athletes apply jogging and static stretching during the warm-up session. Recently, studies have shown that pre-event static stretching (particularly increasing the stretching duration) decreases the

Table 3. Results of performance tests before and after massage, stretching and rest interventions. Data are Means (±SD).

	Massage			Stretching			Rest		
	Before	After	Change (%)	Before	After	Change (%)	Before	After	Change (%)
10 m Acc (s)	1.84 (.09)	1.91 (.08) *	4.0 (3.3)	1.78 (.09)	1.85 (.09) *	4.2 (.7)	1.82 (.09)	1.83 (.09)	.5 (2.1)
FS 20 m SP (s)	2.42 (.10)	2.45 (.40)	1.4 (3.1)	2.44 (.10)	2.44 (.11)	0.0 (.4)	2.45 (.10)	2.47 (.11)	.9 (2.3)
30 m SP (s)	4.27 (.16)	4.37 (.18) *	2.5 (2.5)	4.22 (.17)	4.29 (.17) *	1.8 (.3)	4.27 (.16)	4.30 (.15) *	.8 (1.3)
LRT (ms)	454 (91)	506 (102)	16.8 (37.7)	438 (85)	505 (85) *	16.3 (6.2)	425 (76)	429 (76)	1.0 (4.2)
VJ (cm)	46.3 (5.6)	44.5 (5.3) *	-3.6 (5.8)	45.6 (6.1)	44.3 (5.8) *	-3.0 (1.3)	45.3 (6.4)	45.1 (6.4)	-.4 3 (.5)
S&R (cm)	11.8 (6.2)	12.7 (6.2) *	15.1 (35.9)	11.5 (5.9)	13.4 (6.1) *	22.8 (31.6)	11.9 (6.2)	11.6 (6.2)	-4.8 (15.5)

* $p<0.05$ (between pre and post measurement). Acc = Acceleration, FS = Flying start, SP = Sprint, LRT = Leg reaction time, VJ = Vertical jump, SR = Sit & reach.

performance of acute explosive speed and power exercises (Church et al, 2001; Fowles et al, 2000; Young and Behm, 2002; 2003; Kokkonen et al., 1998). In an attempt to further elucidate the optimal pre-participation protocols for explosive type activities, the novel approach in this study was to examine acute effects of pre-performance lower limb massage after warm-up on explosive and high speed motor capacities and flexibility. The findings of the present study showed that 10 min posterior and 5 min anterior lower limb Swedish massage after a warm-up session significantly degrades the performance of VJ, SR, AS and TS tests. In contrast, massage significantly increased flexibility of the hip joint (sit & reach test). In addition to massage intervention, the current study also employed stretching and rest interventions.

The results of stretching intervention were similar to those of the massage intervention. Engaging in 15 minutes of static stretching significantly worsened performance of the VJ, SR, AS, TS and LR tests. Moreover, like massage, static stretching significantly increased the flexibility of the hip joint (sit & reach test). The results of the rest intervention differed from those of the other two. There were no significant differences between the pre- and post-rest intervention performance of the VJ, SR, FS, AS, and LR tests.

The results of the present study are partially consistent with previous studies that examined the use of massage in pre-event warm-up. For example, Hunter at al. (2006) found a decline in mean force from pre- to post-intervention for the massage condition. Wiktorsson-Moller et al. (1983) found that 6–15 minutes of petrissage, with the aim of promoting relaxation and comfort, reduced muscle strength. In contrast, Goodwin et al. (2007) found that a controlled 15 minute lower limb massage administered prior to warm-up had no significant effect on subsequent 30 meter sprint performance. Harmer (1991) examined the effects of 30 minutes of pre-exercise whole body Swedish massage in sprinters. Their results showed that the mean stride frequencies were not significantly different between the massage and control groups. Moreover, McKechine et al. (2007) found no significant change in the power measures following massage. Crosman et al. (1984) found that a single massage of the hamstring muscle group increases the passive range of motion in the hip joint. Similarly, McKechine et al. (2007) suggested that pre-event massage can increase the plantar flexors' flexibility. However, Barlow et al. (2004) suggested that a single massage of the hamstring muscle group was not associated with any significant increase in sit and reach performance immediately after treatment in physically active young men. Wiktorsson-Moeller et al. (1983) found that stretching is more effective than massage as a way to increase the range of motion in lower limb joints.

Evidence from previous studies suggests that massage results in the lengthening of the muscle (Hemmings, 2001; Wiktorsson-Moeller et al., 1983). Two hypotheses have been proposed for the stretching-induced decrease in force production. First, mechanical factors involving the viscoelastic properties of the muscle may affect the muscle's length-tension relationship. The second involves neural factors, such as decreased muscle activation or altered reflex sensitivity. Recent studies have proposed that the primary mechanism underlying the muscle lengthening that induces decreases in force may be related to increased muscle compliance that could alter the muscle-tension relationship, increase sarcomere shortening distance and velocity, and decrease force production due to the force-velocity relationship. In other words, when skeletal muscle is lengthened, the number of prospective actin / myosin cross-bridges declines (Kokkonen et el, 1998; Nelson et al, 1996; 2001a; 2001b). Although this explanation was not investigated in the present study, in view of this relationship between muscle viscoelastic properties or muscle stiffness and high speed motor capacities or flexibility, it is plausible to say that a massage-induced reduction in muscle stiffness accounted for the decreases in high speed motor capacities and increased flexibility observed here. In addition, it is possible that neural mechanisms also significantly contributed to the decreases in high speed motor capacities and increased flexibility.

The findings obtained in the present study were unique in that, to our knowledge, no other studies have examined the effects of both anterior and posterior lower limb pre-event massage on vertical jump, sprint, reaction time and flexibility. Previous studies used either posterior (more frequent) or anterior lower limb massage. Our choice of methodology was motivated by fact that both anterior and posterior lower limb muscle groups, such as hamstring, triceps surae, plantar flexors and quadriceps femoris are flexed during multiple motions such as vertical jump and sprint.

There were several limitations of this study. Subjects were not controlled for dietary intake, sleep amount, or previous day's activity. Another concern is that we used two intervention masseurs. Although the masseurs were familiarised with the intensity and frequency of massage manipulations, intensity and frequency may have been applied differently. Also, the subjects of the investigation were students in a physical education and sport department. Thus, the results of this study should not be generalised to competitive athletes. Because an individual's training level may affect the response to postatctivation potentiation (Chiu et al., 2003), future studies should evaluate athletes from different sport disciplines, age and gender populations.

Conclusion

In conclusion, the present findings indicate that performing 10 minute posterior and 5 minute anterior lower limb Swedish massages has an adverse affect on vertical jump, speed, and reaction time and a positive effect on sit and reach test results. Because of the limited number of subjects (n = 24) in the study, these results should not be generalised. Larger subject pools are needed to verify these events. It can be said that massage increases muscle compliance and this may limit more crossbridge coupling, vertical jump, speed and reaction time. According to the present results, long duration massage should not be recommended for warm-ups. Further studies should examine the effectiveness of shorter duration and various types and frequencies of massage manipulations for their utility immediately prior to explosive and high speed motor activities. In addition, more investigations are required in order to determine the best warm-up program.

References

Alter, M.J. (1997) *Sports Stretch*. Champaign, IL: Human Kinetics Publ. Windsor Ontario, Canada.

ACSM. (2006) *General principles of exercise prescription.* In: ACSM's Guidelines for Exercise Testing and Prescription 17th edition. M.H. Whaley. Ed. Baltimore Lippincott Williams & Wilkins, 133-165.

Barlow, A., Clarke, R., Johnson, N., Seabourne, B., Thomas, D. and Gal, J. (2004) Effects of massage of the hamstring muscle group on performance of the sit and reach test. *British Journal of Sports Medicine* **38,** 349-351.

Behm, D., Button, D. and Butt, J. (2001) Factors affecting force loss with prolonged stretching. *Canadian Journal of Applied Physiology* **26,** 261-272.

Behm, D., Bambury, A., Cahill, F. and Power, K. (2004) The Effect of Acute static stretching on force, balance, reaction time and movement time. *Medicine and Science in Sports and Exercise* **36(8),** 1397-1402.

Behm, D.G., Bradbury, E.E., Haynes, A.T., Hodder, J.N., Leonard, A.M. and Paddock, N.R. (2006) Flexibility is not related to stretch-induced deficits in force or power. *Journal of Sports Science and Medicine* **5,** 33-42.

Behm, D.G. and Kibele, A. (2007) Effects of differing intensities of static stretching on jump performance. *European Journal of Applied Physiology* **101(5),** 587-594.

Bishop, D. (2003a) Warm up I: Potential mechanisms and the effects of passive warm up on exercise performance. *Sports Medicine* **33**, 439-454.

Bishop, D. (2003b) Warm up II: Performance changes following warm up and how to structure the warm up. *Sports Medicine* **33**, 483-498.

Boyle, P.M. (2004) The effect of static and dynamic stretching on muscle force production. (Part IV: Physiology). *Journal of Sports Science* and Medicine **22,** 273-274.

Chiu, L.Z., Fry, A.C., Weiss, L.W., Schilling, B.K., Brown, L.E. and Smıth, S.L. (2003) Postactivation potentiation response in athletic and recreationally trained individuals. *Journal of Strength and Conditioning Research* **17(4),** 671-677.

Caldwell, E. (2001) *Remedial massage therapy.* Corpus Publishing Ltd. Fishbourne, Chichester. 35-41.

Church, J.B., Wigcins, M.S., Moode, F.M. and Crist, R. (2001) Effect, of warm up and flexibility treatments on vertical jump performance. *Journal of Strength and Conditioning Research* **15**, 332-336.

Crosman, L., Chateauvert, S. and Weisberg, J. (1984) The effects of massage to the hamstring muscle group on range of motion. *Journal of Orthopaedic & Sports Physical Therapy* **6**, 168-72.

Dishman, J.D. and Bulbulian, R. (2001) Comparison of effects of spinal manipulation and massage on motoneuron excitability. *Electromyography and Clinical Neurophysiology* **41**, 97-106.

Duthie, G.M., Pyne, D.B., Ross, A.A., Livingstone, S.G. and Hooper S.L. (2006) The reliability of ten-meter sprint time using different starting techniques. *Journal of Strength and Conditioning Research* **20**, 246–251.

Faigenbaum, A.D., Bellucci, M., Bernieri A, Bakker, B. and Hoorens, K. (2005) Acute effects of different warm-up protocols on fitness performance in children. *Journal of Strength and Conditioning Research* **19 (2),** 376-381

Fletcher, I.M. and Jones, B. (2004) The effect of different warm up stretch protocols on 20 meter sprint performance in trained rugby union players. *Journal of Strength and Conditioning Research* **18**, 885-888.

Fowles, J.R., Sale D.G. and MacDougall, J.D. (2000) Reduced strength after passive stretch of the human plantar flexors. *Journal of Applied Physiology* **89**, 1179-1188.

Goodwin, J.E. (2002) A comparison of massage and sub-maximal exercise as warmup protocols combined with a stretch for vertical jump performance. *Journal of Sports Sciences* **20,** 48–49.

Goodwin, J.E., Glaister, M., Howatson, G., Lockey, R.A. and McInnes, G. (2007) Effect of pre-performance lower-limb massage on thirty-meter sprint running. *Journal of Strength and Conditioning Research* **21(4)**, 1028-1031.

Goldberg, J., Seaborne, D.E., Sullivan, S.J. and Leduc, B.E. (1994) The effect of therapeutic massage on H-reflex amplitude in persons with a spinal cord injury. *Physical Therapy* **74,** 728-737.

Goldberg, J., Sullivan, S.J. and Seaborne, D.E. (1992) The effect of two intensities of massage on H-reflex amplitude. *Physical Therapy* **72**, 449-457.

Harmer, P. (1991) The effect of pre-performance massage on stride frequency in sprinters. *Journal of Athletic Training* **26,** 55-58.

Hedrick, A. (2002) Flexibility training for range of motion. *Performance Training Journal* **1,** 13-20.

Hemmings, BJ. (2001). Physiological, psychological and performance effects of massage therapy in sport: a review of the literature. *Physical Therapy in Sport* **2**, 165-170.

Hernandez-Reif, M., Field, T., Krasnegor, J. and Theakston, H. (2001) Lower back pain is reduced and range of motion increased after massage therapy. *International Journal of Neuroscience* **106,** 131–145.

Hunter, A. M., Watt, J.M., Watt, V. and Galloway, S.D.R. (2006) Effect of lower limb massage on electromyography and force production of the knee extensors. *British Journal of Sports Medicine* **40,** 114-118.

King, R. (1993) *Performance massage.* Human Kinetics Publishers, Champaign, Illinois. 8-72.

Koch, A.J., O'Bryant, H.S., Stone M.E., Sanborn, K., Proulx, C., Hruby, J., Shannonhouse, E., Boros, R. and Stone M.H. (2003) Effect of warm up on the standing broad jump in trained and untrained men and women. *Journal of Strength and Conditioning Research* **17**, 710-714.

Kokkonen, J, Nelson, A.G., Cornwell, A. (1998) Acute muscle stretching inhibits maximal strength performance. *Journal of Strength and Conditioning Research* **69**, 411-415.

Little, T. and Williams A. (2006) Effects of differential stretching protocols during warm-ups on high-speed motor capacities in professional soccer players. *Journal of Strength and Conditioning Research* **20(1)**, 203–207.

McNeal, J. and Sands W. (2003) Acute static stretching reduces lower extremity power in trained children. *Pediatric Exercise Science* **15,** 139-145.

McKechnie, G.J.B., Young, W.B. and Behm, D.G. (2007) Acute effects of two massage techniques on ankle joint flexibility and power of the plantar flexors. *Journal of Sports Science and Medicine* **6**, 498-504.

Mitchell, J. B. and Huston J. S. (1993) The effect of high- and low-intensity warm-up on the physiological responses to a standardized swim and tethered swimming performance. *Journal of Sports Sciences*, **11,** 159-165.

Moir, G., Button, C., Glaister, M. and Stonr, M.H. (2004) Influence of familiarization on the reliability of vertical jump and acceleration sprinting performance in physically active men. *Journal of Strength and Conditioning Research* **18,** 276-280.

Morelli, M., Seaborne, D.E. and Sullivan, S.J. (1991) H-reflex modulation during manual muscle massage of human triceps surae. *Archives of Physical Medicine and Rehabilitation* **72,** 915-919.

Musayev, E. (2006) Optoelectronic vertical jump height measuring method and device. *Measurement* **39,** 312–319.

Nelson, A.G., Allen, J.D., Cornwell, A. and Kokkonen, J. (2001) Inhibition of maximal voluntary isometric torque production by acute stretching is joint-angle specific. *Research Quarterly for Exercise and Sport* **72,** 68-70.

Nelson, A.G., Cornwell, A. and Heise, G.D. (1996) Acute stretching exercises and vertical jump stored elastic energy [Abstract]. *Medicine & Science in Sports & Exercise* **28,** S156.

Nelson, A.G., Guillory, I.K., Cornwell, C. and Kokkonen, J. (2001b) Inhibition of maximal voluntary isokinetic torque production following stretching is velocity-specific. *Journal of Strength and Conditioning Research* **15,** 241-246.

Nelson, A.G., Kokkonen, J. and Eldredoe, G. (2005) Strength inhibition following an acute stretch is not limited to novice stretchers. *Research Quarterly for Exercise and Sport* **76,** 500-506.

O'Brıen, B., Payne, W., Gastın, P. and Burge, C. (1997) A comparision of active and passive warm-ups on energy system contribution and performance in moderate heat. *Journal of Science and Medicine in Sport* **29,** 106-109.

Paine, T. (2000) *The complete guide to sports massage*. A & C Black Publishing Ltd. London. Chapter 9. 79-114.

Robergs, R.A., Pascoe, D.D., Costıll, D.L., Fınk, W.J., Chwalbınska-Moneta, J., Davis, J.A. and Hickner, R. (1991) Effects of warm-up on muscle glycogenolysis during intense exercise. *Medicine & Science in Sports & Exercise* **23,** 37-43.

Siatras, T., Papadopoulos, G., Mameletzi, D., Gerodimos, V. and Kellis, S. (2003) Static and dynamic acute stretching effect on gymnasts' speed in vaulting. *Pediatric Exercise Science* **15,** 383-391.

Sullivan, S.J., Williams, L.R., Seaborne, D.E. and Morelli, M. (1991) Effects of massage on alpha motor neuron excitability. *Physical Therapy* **71,** 555-560.

Tessier, D.G. (2005) Sports Massage: An Overview. *Athletic Therapy Today* **10(5),** 67-69.

Weerapong, P., Hume, P.A. and Kolt, G.S. (2005) The Mechanisms of massage and effects on performance, muscle recovery and injury prevention, *Sports Medicine* **35(3)**, 235-256.

Wiktorsson-Moller, M., Oberg, B., Ekstrand, J. and Gillquist, J. (1983) Effects of warming up, massage, and stretching on range of motion and muscle strength in the lower extremity. *American Journal of Sports Medicine* **11,** 249–252.

WMADH. (2000) World Medical Association Declaration of Helsinki: Ethical principles for medical research involving human subjects. *Journal of the American Medical Association* **284,** 3043-3045.

Young, W.B. and Behm, D.G. (2002) Should static stretching be used during a warm-up for strength and power activities? *Strength and Conditioning Journal* **24 (6),** 33-37.

Young, W.B. and Behm D.G. (2003) Effects of running, static stretching and practice jumps on explosive force production and jumping performance. *Journal of Sports Medicine and Physical Fitness* **43,** 21-27.

Key points

- Performing 10 minute posterior and 5 minute anterior lower limb Swedish massages has an adverse affect on vertical jump, speed, and reaction time and a positive effect on sit and reach test results.
- According to the present results, long duration massage should not be recommended for warm-ups.
- Larger subject pools are needed to verify these events.

AUTHOR BIOGRAPHY

Ramiz ARABACI

Employment

Lecturer, Department of Physical Education and Sport, Faculty of Education, University of Uludag, Bursa, Turkey

Degree

PhD

Research interests: Evaluation of physical performance, training, kinesiology, massage.

E-mail: ramizar@uludag.edu.tr

✉ **Ramiz Arabaci**

Department of Physical Education and Sport, Faculty of Education, University of Uludag, 16059 Bursa, Turkey