Chapter 2
Review of Related Literature
Sincere efforts have been made by the researcher to locate literature related to this study. The relevant studies of specific importance are cited in this chapter. The literature review is divided into the following segments:

1. Stretch on flexibility
2. Massage on flexibility

**STRETCH ON FLEXIBILITY**

*Bugnet et al. (2011)* studied on the acute effects of static stretching of the gastronomies on limits of stability in young adults versus elderly adults to investigate the acute effects of stretching on dynamic balance of healthy young and elderly adults. The two groups were used to determine if stretching may discriminately affect balance at different ages. Thirty healthy adults between the ages of 18 and 35 (mean=25.8, SD=2.3) and 18 healthy elderly adults ages 65 and older (mean=72.0, SD=7.0) were included in the study. All subjects were recruited using email and word of mouth advertising. Each subject performed the limits of stability (LOS) test twice before a 30 second static stretching protocol of the gastronomies and once thereafter. The LOS test was performed on the Neuro-Com SMART Balance Master. There was a significant difference between the young and the elderly groups for all outcome measures on the LOS test at the first measurement (p<0.004). All the components of the LOS test, but endpoint excursion, showed no significant treatment effect for the stretching protocol used, ps>0.016. The results showed that short duration static stretching has little or no effect on dynamic balance regardless of age. This study also found a difference between young and elderly subjects' performance on the LOS test.
Mohr et al. (2011) did a research on effectiveness of foam rolling in combination with a static stretching protocol of the hamstrings to examine the effects of a foam rolling protocol in combination with a static stretching protocol. For this human subjects approved study, 46 healthy subjects were recruited with no history of lower or upper extremity injury in the 6 months prior to study participation. Forty subjects (male: n = 14, age = 21.29 ± 2.58 yrs, ht = 176.62 ± 5.28 cm, mass = 73.96 ± 16.9 kg; female: n = 26, age = 21.08 ± 2.91 yrs, ht = 167.05 ± 6.19 cm, mass = 73.62 ± 11.52 kg) completed all requirements of the study. Subjects were randomly assigned to 1 of 4 groups. Subjects received baseline hip range of motion (ROM) measurements before performing either a stretching only, foam rolling and stretching, foam rolling only, or control protocol. Immediately after completion post hip ROM values were obtained. Subjects visited the lab 6 times over a two week period. The results showed that regardless of group hip ROM increased over time (P < .003). Those subjects receiving the foam and stretch treatment had the greatest increase in hip ROM (P < .05). Those subjects receiving the stretch only, foam and stretch, and foam only had greater hip ROM values than controls (P < .05). Pre hip ROM measurements for subjects in the foam and stretch were greater than those in the stretch only group (P < .05).

Jones et al. (2010) did an experimental study on the effect of static stretching on recovery heart rate following the YMCA step test to determine the effects of static stretching on exercise and recovery heart rates, and aerobic fitness classification following the YMCA step test. Twenty participants, ten men and ten women, were involved in three testing sessions. The first visit involved familiarization with four different static stretching exercises and the YMCA step test. The two other visits involved a control condition (no static stretching) and an experimental condition (static stretching) prior to performance of the YMCA step test, with the order of visits randomly determined. The experimental condition involved performing a series of four static stretches for
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the quadriceps femoris muscle group on both limbs prior to performing the YMCA step test. Exercise heart rate was monitored and recorded each minute during the step test. Recovery heart rate was measured and recorded for one minute within five seconds after the last step. During the control visit the step test was preceded by a 5-minute warm-up only. The results indicated that recovery heart rate was not affected by stretching or sex of the participants. There was a significance difference between the stretches vs. no-stretch conditions for exercise heart rate, with the heart rate higher for the stretching condition. In addition, there was a difference in YMCA fitness classifications for eight out of twenty participants, with five of the eight having better fitness classifications for the no-stretch condition.

Sobolewski et al. (2010) studied on the effect of static stretching and order of warm-up on isokinetic peak torque of the knee extensors to determine if an acute static stretch influenced isokinetic peak torque (IPT), and to examine if the order in which the warm up routine was performed affected peak knee extension torque. Twenty trained college male students performed maximal isokinetic knee extensions under four conditions: a control consisting of no stretching, a stretch only trial, jog then stretch, and stretch then jog conditions. Each stretch was held for a total volume of 360 s. Measurements were taken on a Biodex System 3 isokinetic dynamometer at speeds of 60° s⁻¹ and 300° s⁻¹. Data were analyzed using t-tests to compare the stretch condition with the control. The results indicated that there was a significant difference between the stretch and the control at 300° s⁻¹ (p = 0.03 t = 2.42) but not at 60° s⁻¹ (p = 0.16). A 2 x 3 ANOVA (300° s⁻¹ x 60° s⁻¹, and control x stretch then jog x jog then stretch) yielded no significance at either speed (p > 0.05). Conclusions from this study indicate that stretching should not be the sole exercise in a warm-up routine as previous research confirms the decrease in IPT after stretching. Another finding of this study is that the negative effects of stretching
can be diminished when combined with an aerobic activity such as jogging prior to performance.

Workman et al. (2010) experimented effects of static stretching on foot velocity during the instep soccer kick to assess the acute effects of static stretching on foot velocity at impact with a soccer ball. Eighteen Division 1 female soccer athletes underwent two test conditions separated by 48 hr. Each condition was randomly assigned and began by placing four retro-reflective markers on bony landmarks of the ankle (total of eight markers, four on each ankle). One condition was the no-stretch condition, in which each participant performed a self-paced jog for 5 min as a warm-up, and then sat quietly for 6 min before performing three maximal instep kicks into a net. The second condition was the stretch condition, which was identical to the no-stretch condition, except the participants performed a series of six randomly ordered stretches instead of sitting quietly for 6 min. Three-dimensional motion analysis was used to quantify the resultant velocity of the head of the 5th metatarsal immediately prior to foot impact with a soccer ball. The results of a dependent t test indicated that there was no significant difference between the no-stretch (18.34 ± 1.29 m/s) and stretch conditions (17.96 ± 1.55 m/s; p = .102, d = .3).

Based on these findings, acute stretching performed one time for 30 s before maximal instep soccer kicking has no effect on the resultant foot velocity of Division 1A university female soccer players. Pre-event stretching performed in a like manner may best be prescribed at the discretion of the athlete.

Rapking and Covassin (2010) did a study on the effects of dynamic and static stretching on range of motion and performance to investigate which stretching protocol (static or dynamic) is more effective at the shoulder complex as measured by range of motion and peak torque. Static and dynamic shoulder stretches were performed by 30 NCAA Division 1 softball, baseball, and volleyball players. Range of motion and peak torque was measured pre and post stretching. The findings from the current study revealed an interaction between
the stretching protocols and time (i.e., pre to post stretch) for external rotation. Specifically, collegiate athletes demonstrated significantly greater range of motion on external rotation after performing a dynamic stretching protocol. All other results indicated that there were no significant differences between static and dynamic stretching on either range of motion or peak torque at the shoulder complex.

Kieran et al. (2009) studied on the effect of warm-up, static stretching and dynamic stretching on hamstring flexibility in previously injured subjects. The research design was a randomized crossover, over 2 separate days. Hamstring flexibility was assessed using passive knee extension range of motion (PKE ROM). 18 previously injured individuals and 18 uninjured controls participated. On both days, four measurements of PKE ROM were recorded: (1) at baseline; (2) after warm-up; (3) after stretch (static or dynamic) and (4) after a 15-minute rest. Participants carried out both static and dynamic stretches, but on different days. Data were analyzed using ANOVA. Across both groups, there was a significant main effect for time (p < 0.001). PKE ROM significantly increased with warm-up (p < 0.001). From warm-up, PKE ROM further increased with static stretching (p = 0.04) but significantly decreased after dynamic stretching (p = 0.013). The increased flexibility after warm-up and static stretching reduced significantly (p < 0.001) after 15 minutes of rest, but remained significantly greater than at baseline (p < 0.001). Between groups, there was no main effect for group (p = 0.462), with no difference in mean PKE ROM values at any individual stage of the protocol (p > 0.05). Using ANCOVA to adjust for the non-significant (p = 0.141) baseline difference between groups, the previously injured group demonstrated a greater response to warm-up and static stretching, however this was not statistically significant (p = 0.05). Warm-up significantly increased hamstring flexibility. Static stretching also increased hamstring flexibility, whereas dynamic did not, in agreement with previous findings on uninjured controls. The effect of warm-
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up and static stretching on flexibility was greater in those with reduced flexibility post-injury, but this did not reach statistical significance. Further prospective research is required to validate the hypothesis that increased flexibility improves outcomes.

Sady et al. (2009) did a research on the effects of stretching techniques on the flexibility of the shoulder, trunk, and hamstring muscles were compared in college men. The Subjects were randomly assigned to one of 4 groups: control (n=10), ballistic (n=11), static (n=10), or proprioceptive neuromuscular facilitation (PNF) (n=12). Baseline measurements (Leighton flexometer) were obtained on 2 separate days prior to and following a 3-day per week, 6-week flexibility training program. A 4x3 (subject group x muscle group) unweighted mean factorial analysis of variance for the difference scores revealed significant (p less than 0.05) main effects for the 4 subjects groups and the 3 muscle groups. Post hoc analysis showed that only the PNF group had flexibility increases (10.6 degrees) greater than the control (3.4 degrees), and that the hamstrings (9.4 degrees increase) improved more than the trunk (5.2 degree increase). Furthermore, reliability was generally higher for the post-training scores, and the variability between days was lower for the post-training scores of the shoulder and hamstrings (p less than 0.05). The significant (p less than 0.05) between-day changes in flexibility pre-training confirm the importance of establishing baseline data prior to any training study. The findings indicate that PNF may be the preferred technique for improving flexibility, and that flexibility training results in an increased consistency of flexibility scores.

Stephen et al. (2009) surveyed the impact of stretching on sports injury risk to assess the evidence for the effectiveness of stretching as a tool to prevent injuries in sports and to make recommendations for research and prevention. They found out that stretching was not significantly associated with a reduction in total injuries (OR 0.93, CI 0.78 –1.11) and similar findings were seen in the subgroup analyses. They concluded that there is not sufficient evidence to
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endorse or discontinue routine stretching before or after exercise to prevent injury among competitive or recreational athletes.

**Murphy and Jeffrey (2008)** did a study on effect of acute dynamic and static stretching on maximal muscular power in a sample of college age recreational athletes to determine the effect of dynamic and static stretching on muscular peak power production and hip and knee range of motion in a sample of college age recreational males and Forty-two males (aged 18-24) healthy, physically active volunteers from a University of Pittsburgh physical education class participated as subjects in this investigation. The Subjects performed pre and post test measures of sit and reach, hip and knee goniometry measures, and vertical jump test. A one repetition maximum leg press was performed prior to pre-tests to determine group differences in strength. Subjects were randomly assigned to one of three stretch groups (dynamic, static, and control). All subjects began with a five minute warm-up on an upright cycle that elevated the heart rate to 110 beats per minute. Following the warm-up period, subjects immediately began their stretching program (dynamic or static), or remained seated for 12 minutes. A one-way ANOVA was conducted to detect group differences in strength levels conducted during pre-tests. A 3x2 factorial ANOVA was conducted to determine between and within group differences in treatment groups. Statistical significance was set at \( \alpha = 0.05 \). Results of the investigation showed significant time effects for all dependent measures \( (p < 0.05) \). Significant time x treatment interactions were found for maximum jump height, maximum peak power, and sit and reach in the DS and SS + DS groups, respectively \( (p < 0.05) \). However, there was no time x treatment interactions for mean jump height, mean peak power, knee range of motion, or hip range of motion. The results of the present study suggest that static and dynamic stretching for 20 seconds prior to a vertical jump can improve mean vertical jump height, mean peak power, and hip and knee range of motion in a sample of male college age recreational athletes.
Oakley and Reuter (2007) examined the effect of dynamic and static stretching on performance to examine the differences between three stretching protocols on the performance of the T-test for agility in Division III collegiate football players. Eighteen male subjects from a Division III football team volunteered for this study. Each subject was tested on six separate days. All subjects performed a 5 minute jog warm-up first. Subjects then rested for two minutes. Subjects then performed their randomly assigned protocol. They had another rest period of two minutes. They performed two trials of the T-test for agility with one minute rest in between trials. The best time was recorded. A significant effect was found (F (2, 34) = 5.518, p < .001). The study revealed that the type of stretching protocol has a significant effect on agility performance in Division III collegiate football players.

Nathan (2007) did an experimental study on effects of dynamic and static stretching on explosive agility activity to determine the effects of static and dynamic stretching protocols on performance time of the Illinois Agility Test. Nineteen Division II women soccer players from Humboldt State University were randomly assigned to three treatment groups; control, static, and dynamic. Each group ran a mile in ten minutes and performed the Illinois Agility Test. The static stretching group ran a mile in ten minutes, performed a static stretching protocol before running the Illinois Agility Test while the dynamic stretching group performed a dynamic stretching protocol before running the Illinois Agility Test. A one-way ANOVA revealed no significant differences among the three treatment groups on performance time to complete the Illinois Agility Test: control group (M = 14.24 s), static stretching group (M = 14.50 s), and dynamic stretching group (M = 14.15 s). Results suggested that dynamic stretching does not produce faster test times for explosive agility activity over static stretching.

Sawyer and Prentice (2006) did an experimental study on effects of forward head rounded shoulder posture on shoulder girdle flexibility, range of motion,
and strength to determine if clinical measures of flexibility, range of motion and strength were different between people with and without Forward Head Rounded Shoulder Posture (FHRSP). They measured the flexibility, range of motion, and strength of the right arm of twenty two FHRSP and fifteen ideal posture subjects. All measures of flexibility and range of motion were measured with a digital inclinometer. Mean and peak values (N) of strength were measured with a hand-held dynamometer. There were no significant differences (p < 0.05) seen in flexibility, range of motion, or strength between groups. The clinical assumptions of FHRSP were not supported in this study using common clinical tests. These findings introduce the idea that differences may be in the neuromuscular control of the shoulder girdle and not in the actual strength and flexibility of muscles and tissue.

Davis et al. (2005) studied on the effectiveness of 3 stretching techniques on hamstring flexibility using consistent stretching parameters; and they compared the effects of 3 common stretching techniques on the length of the hamstring muscle group during a 4-week training program. Subjects were 19 young adults between the ages of 21 and 35. The criterion for subject inclusion was tight hamstrings as defined by a knee extension angle greater than 208 while supine with the hip flexed 908. The participants were randomly assigned to 1 of 4 groups. Group 1 (n = 5) was self-stretching, group 2 (n = 5) was static stretching, group 3 (n = 5) was proprioceptive neuromuscular facilitation incorporating the theory of reciprocal inhibition (PNF-R), and group 4 (n = 4) was control. Each group received the same stretching dose of a single 30-second stretch 3 days per week for 4 weeks. Knee extension angle was measured before the start of the stretching program, at 2 weeks, and at 4 weeks. Statistical analysis (p <= 0.05) revealed a significant interaction of stretching technique and duration of stretch. Post hoc analysis showed that all 3 stretching techniques increase hamstring length from the baseline value during a 4-week training program; however, only group 2 (static stretching) was found to be
significantly greater than the control at 4 weeks. These data indicate that static stretching 1 repetition for 30 seconds 3 days per week increased hamstring length in young healthy subjects. These data also suggest that active self-stretching and PNF-R stretching 1 repetition for 30 seconds 3 days per week is not sufficient to significantly increase hamstring length in this population.

Odunaiya et al. (2005) did an experimental study on the effects of static stretch duration on the flexibility of hamstring muscles and they selected sixty purposively sampled subjects with unilateral hamstring tightness that had no history of low back and lower extremity dysfunctions that necessitated medical intervention participated in the study. They were randomly assigned into one of 5 intervention and one control groups. Groups a, b, c, d, e subjects had their hamstrings passively stretched for 120, 90, 60, 30, and 15 seconds respectively, while group f served as control. This intervention was carried out on alternate days for 6 consecutive weeks. Knee extension deficit (KED) was measured for all groups at baseline, weekly and 7 days post cessation of the intervention (carry-over). Data were analyzed using one-way ANOVA and paired t-test at 0.05 alpha. A significant reduction (P<0.05) was observed in the KED of subjects in all the intervention groups across the 6 intervention weeks. There was no significant difference between the immediate post intervention and carry-over KED values (p>0.05). The study shows that statically stretching tight hamstrings for any duration between 15 and 120 seconds on alternate days for 6 weeks would significantly increase its flexibility. The effect was also sustained for up to 7 days post intervention.

Bennell (2005) studied on “Isokinetic strength testing does not predict hamstring injury in Australian Rules footballers” They selected a total of 102 senior male Australian Rules footballers aged 22.2 (3.6) years that were tested at the start of a football season. Maximum voluntary concentric and eccentric torque of the hamstring and quadriceps muscles of both legs was assessed using a Kin-Com isokinetic dynamometer at angular velocities of 60 and 180
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degrees/second. Twelve (11.8%) players sustained clinically diagnosed hamstring strains which caused them to miss one or more matches over the ensuing season. There were no significant differences for any of the isokinetic variables comparing the injured and non-injured legs in players with unilateral hamstring strains (n=9). Neither the injured nor the non-injured leg of injured players differed from the mean of left and right legs in non-injured players for any isokinetic variable. The hamstring to opposite hamstring ratios also did not differ between injured and non-injured players. A hamstring to opposite hamstring ratio of less than 0.90 and a hamstring to quadriceps ratio of less than 0.60 were not associated with an increased risk of hamstring injury. A significantly greater percentage of players who sustained a hamstring strain reported a history of hamstring strain compared with non-injured players (p=0.02). However, this was not related to muscle weakness or imbalance. Isokinetic muscle strength testing was not able to directly discriminate Australian Rules football players at risk for a hamstring injury.

Wen and Biddington (2005) experimented the effect of proprioceptive neuromuscular facilitation vs. static stretching vs. control on the hamstring muscle group for flexibility, peak torque, and power to compare proprioceptive neuromuscular facilitation hold-relax stretching to passive static stretching and a control group to the hamstring muscle group examining aspects of flexibility, power, and peak torque. 23 physically active college students selected for this study, using three separate stretching protocols for the hamstring muscle group: proprioceptive neuromuscular facilitation hold-relax stretching, passive static stretching, and a control protocol. A modified sit and reach was used to test flexibility, single leg standing broad jump was used to test power of each leg, and a Biodex (TM) System 3 Multi-Joint Dynamometer was used to measure peak torque values of each leg at 60°/sec, 180°/sec, and 300°/sec. They concluded that there were no significant differences in flexibility, power, or
peak torque in the hamstring muscle groups between proprioceptive neuromuscular facilitation hold-relax stretching and passive static stretching.

**Jones and Greer (2004)** did a study on “Is sports massage a better alternative to static stretching in pre-competition warm-up?” To determine whether sports massage is more effective than static stretching in preparing an athlete for maximum performance, seventeen college students selected in three measurement sessions where baseline, static stretch, and sports massage scores were recorded for range of motion, time-to-peak torque, and peak torque. The static stretching treatment consisted of three quadriceps stretches held for 20 seconds, repeated three times each interspersed with a 10-second rest period. The same sports massage treatment was administered by a certified massage therapist and consisted of 5 minutes of various pre-competition techniques. Results of a one-way repeated measure ANOVA revealed a significant increase in range of motion after both the static stretch and sports massage treatments, but showed no main effect for time-to-peak torque and peak torque production. Static stretching and sports massage both increased muscle length, but failed to detrimentally impact maximum performance.

**Roberts and Wilson (2004)** did an experimental study on the effect of stretching duration on active and passive range of motion in the lower extremity and Twenty four university sport club members (19 men, five women), with a mean (SD) age of 20.5 (1.35) years, were randomly assigned to one of three groups (two treatment and one control). The two treatment groups participated in a static active stretching program three times a week for a five week period, holding each stretch for duration of either five or 15 seconds. The total amount of time spent in a stretched position was controlled. The five second group performed each stretch nine times and the 15 second group three times resulting in a total stretching time of 45 seconds for both groups for each exercise. The control group did not stretch. Active and passive ROM were determined during left hip flexion, left knee flexion, and left knee extension.
before and after the training program using an inclinometer. Two factors within subject analysis of variance indicated no significant difference in ROM before and after the training program for the control group. However, significant improvements in active and passive ROM ($p < 0.05$) were shown in both treatment groups after the five week training program. Two factor analysis of variance with repeated measures and post hoc analysis showed significant differences between the treatment groups and the control group for the improvements observed in active ($p < 0.05$) and passive ($p < 0.05$) ROM. The five and 15 second treatment groups did not differ from one another when ROM was assessed passively, but significant differences were apparent for active ROM, with the 15 second group showing significantly greater improvements ($p < 0.05$) than the five second group. These findings suggest that holding stretches for 15 seconds, as opposed to five seconds, may result in greater improvements in active ROM. However, sustaining a stretch may not significantly affect the improvements gained in passive ROM.

Gajdosik (2004) experimented effects of static stretching on the maximal length and resistance to passive stretch of short hamstring muscles. The study examined the effects of three weeks of daily static stretching of short hamstrings on passive straight leg raising (SLR), maximal hamstring length (MHL), and their maximal resistance to passive stretch (MRPS). Twenty-four healthy men (18-37 yrs) with SLR $\leq 70^\circ$ were assigned randomly to a stretching group ($N = 12$) or a control group ($N = 12$). All subjects were positioned on their left sides with the pelvis stabilized and the right thigh fixed at $90^\circ$ on a horizontal platform. The right knee was then passively extended until amplified EMG activity ($>50 \mu V$) from the hamstrings was observed. The knee angle represented MHL, and MRPS (torque in nm) was calculated. Subjects in the stretching group completed daily static stretching of the hamstrings for three weeks. After three weeks, SLR increased for the stretching group, but not for the control group ($<0.001$). The knee angle for the stretching
group was less than the control group (p < 0.001), and the MRPS for the stretching group exceeded the control group (p < 0.05). The results indicated that static stretching increased SLR with concomitant increases in the MHL and the MRPS. The results also support using SLR as a valid clinical test for measuring hamstring length changes resulting from therapeutic interventions.

Snyder and Armstrong (2004) studied on the acute influence of static and ballistic stretching on the biomechanics and muscle activity associated with the hamstring stretch to examine the biomechanics and muscle activity associated with static and ballistic stretching of the hamstring muscles in order to compare the assets and liabilities of each technique. In a randomized cross-over design, 16 men and 13 women (22.5 ± 4.5 yrs) participated in both static (STA) and ballistic (BAL) conditions. Each condition required the subject to perform a pre-maximum stretch, a series of three 30-second static or ballistic stretches, and a post-maximum stretch. Electromyography (EMG) of the gluteus maximus, hamstrings, gastrocnemius, and rectus femoris muscles as well as joint kinematics were measured during all procedures. Data regarding maximum stretch distance and hip angle were recorded. Measurements of perceived soreness were made before and after the stretching exercise as well as at 24, 48 and 72 hours after stretching. A two-way repeated measures ANOVA was used for statistical analysis of perceived soreness, maximum stretched distance, and hip angle and t-tests were used for analysis of muscle activity. Significance was determined at the p < 0.05 level. Stretching exercise significantly increased maximum distance stretched and hip flexion (p < 0.05), however there was no difference between the stretching techniques. No significant effects for muscle activity or soreness were found between the static and ballistic conditions. In conclusion, static and ballistic stretching influence range of motion, hip angle, muscle activity, and soreness similarly and, thus, contraindications towards ballistic stretching may be unwarranted.
**Kelleher and Amanda (2003)** did a research on the delayed effect of proprioceptive neuromuscular facilitation and static stretching on hamstring flexibility to determine the delayed effects of stretching, both static and PNF, on hamstring flexibility following exercise. Subjects were randomly assigned to one of three groups: PNF on left leg, static stretch on right leg; PNF on right leg, static stretch on left leg; and no stretch. Testing limbs were also randomly assigned. A total of 30 college aged students, 19 males and 11 females, who were healthy and free of current and prior knee, hip, and low back injuries, volunteered for the study. The research design was analyzed with two 3 x 3 mixed factorial ANOVA (treatment groups x testing session). A significant interaction was found for treatment groups x testing sessions for PNF and static stretch from the pretest to the mid-test and the pretest to the posttest, as well as for the control group from the pretest to the posttest and the mid-test to the posttest. No significant interaction was found for treatment groups x testing sessions in the sit and reach. However, a main effect difference was found between the testing sessions between pretest to posttest, mid-test to posttest, and between pretest and mid-test.

**Dadebol et al. (2003)** did a study on flexibility training protocols and hamstring strains in professional football clubs in England and they concluded that Flexibility training protocols were characterized by wide variability, with static stretching the most popular stretching technique used. Hamstring strains represented 11% of all injuries and one third of all muscle strains. About 14% of hamstring strains were re-injuries. Hamstring strain rate (HSRs) were highest in the Premiership (13.3 (9.4) 1000 hours) with the lowest rates in Division 2 (7.8 (2.9)/1000 hours); values are mean (SD). Most (97%) hamstring strains were grade I and II, two thirds of which occurred late during training/matches. Forwards were injured most often. Use of the standard stretching protocol (SSP) was the only factor significantly related to HSR ($r = -0.45$, $p = 0.031$) in the correlation analysis, suggesting that the more SSP is used, the lower the
HSR. About 80% of HSR variability was accounted for by stretching holding time (SHT), SSP, and stretching technique (STE) in the multiple regression equation: 

$$HSR = 37.79 - (0.33SHT - 10.05SSP + 2.24STE) \pm 2.34$$

SHT (negatively correlated with HSR) was the single highest predictor, and accounted for 30% of HSR variability, and an additional 40% in combination with SSP. They concluded that Flexibility training protocols in the professional clubs were variable and appeared to depend on staffing expertise. Hamstring stretching was the most important training factor associated with HSR. The use of SSP, STE, and SHT are probably involved in a complex synergism which may reduce hamstring strains. Modification of current training patterns, especially stretching protocols, may reduce HSRs in professional footballers.

Chan et al. (2001) did a research on flexibility and passive resistance of the hamstring of young adults using two different static stretching protocols; and for this research forty healthy subjects (24 males and 16 females) aged 18 to 30 years were randomly assigned to one of four groups. The two training groups underwent static stretch training of the hamstrings either with a four-week protocol or an eight-week protocol. The other two groups acted as control groups. A significant increase in flexibility of hamstrings was found in both of the two training groups ($P<0.05$). No difference was found in the range of motion gained between the two training groups. An increase in passive resistance at the corresponding maximal joint angle was only demonstrated in the four-week training group ($P<0.05$). Both protocols are effective in terms of improving flexibility of hamstrings. However, if injury is reduced when there is relatively lower passive resistance at the end-of-range, then the eight-week training regimen would be recommended.

Perry et al. (2001) experimented the acute effects of various types of stretching (static, dynamic, ballistic, and no stretch) of the iliopsoas on 40-yard sprint times in non-athletes to determine the effect of static, ballistic, dynamic, and no stretching immediately prior to a 40-yard sprint in college students. 35 healthy
subjects (22 male and 13 female) between the ages of 24 and 37 (Mean = 26.46 yrs, SD = 2.99 yrs) were sampled. The experiment consisted of running 4, 40-yard sprint trials immediately following 1 of 4 different stretching protocols. Prior to each 40-yard sprint trial, a 5-minute warm up was performed at 3.5 mph on a treadmill. Each subject received each of the four techniques in a randomized order and ran a baseline sprint prior to each stretching protocol. In each protocol, subjects received one of four stretching techniques: ballistic, dynamic, static, no stretch and immediately ran a timed 40-yard sprint post stretch. The trials were completed within a 2 week time period allowing 48-72 hours between each trial. In the no stretch condition, subjects improved significantly from pre to post sprint times (p<0.0005). There were no statistically significant differences in pre and post stretch condition times among the static (p=0.804), ballistic (p=0.217), and dynamic (p=0.022) stretching conditions. These results could be due to the benefits of a dynamic warm up and also the negative impact of mechanical and neural effects of stretching. Sprint performance may show greatest improvement without stretching and through the use of a dynamic warm up.

Scott et al. (2001) experimented duration of maintained hamstring flexibility after a one-time, modified hold-relax stretching protocol. The study had a 1 x 1 mixed-model, repeated-measures design. The independent variables were group (control and experimental) and time (0, 2, 4, 6, 8, 16, and 32 minutes). The dependent variable was hamstring flexibility as measured in degrees of active knee extension with the hip flexed to 90 degrees. Measurements were taken in a preparatory military academy athletic training room and thirty male subjects (age, 18.8 +/- 0.63 years; height, 185.2 +/- 14.2 cm; weight, 106.8 +/- 15.7 kg) with limited hamstring flexibility in the right lower extremity were randomly assigned to a control (no-stretch) group or an experimental (stretch) group. All subjects performed 6 warm-up active knee extensions, with the last repetition serving as the pre-stretch measurement. The experimental group received 5
modified (no-rotation) hold-relax stretches, whereas the control group rested quietly supine on a table for 5 minutes. Posttest measurements were recorded for both groups at 0, 2, 4, 6, 8, 16, and 32 minutes. The repeated-measures analysis of variance revealed a significant group-by-time interaction, a significant main effect for group, and a significant main effect for time. Dennett post hoc analysis revealed a significant improvement in knee-extension range of motion in the experimental group that lasted 6 minutes after the stretching protocol ended. The findings suggest that a sequence of 5 modified hold-relax stretches produced significantly increased hamstring flexibility that lasted 6 minutes after the stretching protocol ended.

Depino et al. (2000) did a research on duration of maintained hamstring flexibility after cessation of an acute static stretching protocol and subjects performed 6 active warm-up knee extensions, with the last repetition serving as the baseline comparison measurement. After warm-up, the experimental group performed 4 30-second static stretches separated by 15-second rests. They selected thirty male subjects (age = 19.8 ± 5.1 years, ht = 179.4 ± 18.7 cm, wt = 78.5 ± 26.9 kg) with limited hamstring flexibility of the right lower extremity were randomly assigned to control and experimental groups. Tukey post hoc analysis indicated significant improvement of knee-extension range of motion in the experimental group that lasted 3 minutes after cessation of the static stretching protocol. Subsequent measurements after 3 minutes were not statistically different from baseline. A dependent t test revealed a significant increase in knee-extension range of motion when comparing the first to the sixth active warm-up repetition. And the results indicates that 4 consecutive 30-second static stretches enhanced hamstring flexibility (as determined by increased knee-extension range of motion), but this effect lasted only 3 minutes after cessation of the stretching protocol. Future research should examine the effect of other stretching techniques in maintaining same-day flexibility gains.
William and Jean (2000) did a research on the effect of time on static stretch on the flexibility of the hamstring muscles and fifty-seven subjects (40 men, 17 women), ranging in age from 21 to 37 years and with limited hamstring muscle flexibility (i.e., 30° loss of knee extension measured with femur held at 90° of hip flexion), were randomly assigned to one of four groups. Three groups stretched 5 days per week for 15, 30, and 60 seconds, respectively. The fourth group, which served as a control group, did not stretch. Before and after 6 weeks of stretching, flexibility of the hamstring muscles was determined by measuring knee extension ROM with the femur maintained in 90 degrees of hip flexion. Data were analyzed with a 4×2 analysis of variance (group test) for repeated measures on one variable. The data analysis revealed a significant group test interaction, indicating that the change in flexibility was dependent on the duration of stretching. Further post hoc analysis revealed that 30 and 60 seconds of stretching were more effective at increasing flexibility of the hamstring muscles (as determined by increased ROM of knee extension) than stretching for 15 seconds or no stretching. No significant difference existed between stretching for 30 seconds and for 1 minute, indicating that 30 seconds of stretching the hamstring muscles was as effective as the longer duration of 1 minute. The results of this study suggest that duration of 30 seconds is an effective time of stretching for enhancing the flexibility of the hamstring muscles. Given the information that no increase in flexibility of the hamstring muscles occurred by increasing the duration of stretching from 30 to 60 seconds.

Duddy and Michel (1999) did a research on the effect of an exercise program on low back pain, muscle strength, flexibility and golf performance in the amateur golfer. It assessed the effects of an education, flexibility and lumbar stabilization program on three amateur golfers with complaints of low back pain. Subjects were placed on an exercise program and educated about the basics of proper body mechanics both on and off the golf course. After a two-
week baseline, each subject was begun on a different intervention lasting two weeks, and the order of each varied by subject. Flexibility measures were obtained for forward bending using the Modified fingertip-to-floor method, and for functional axial rotation (FAR) using a FAR device. Strength measures of the trunk extensors were obtained using the Biering-Sorensen method. Performance was measured by overall golf score for 9 holes. Pain measures were recorded via the Visual Analog Scale and the Dallas Pain Questionnaire.

All subjects demonstrated an improvement in strength, flexibility and pain. Two subjects reported subjective improvements in their golf game. No changes in golf score were reported.

O'Rourke and Karnes (1999) did a research on the effect and the duration of the effect of a static hamstring stretch on active knee range of motion to determine the effect and the duration of the effect of a static hamstring stretch on knee range of motion. Sixteen healthy male and female college students participated. Measurements were taken of each subject's right lower extremity using the active knee extension test. Subjects in the experimental group were treated daily for ten days. Each treatment consisted of four 30-second repetitions of a static stretch. Measurements were taken before and after each treatment. A t-test was used to determine if significant changes in measurements occurred between day 1 and day 10. The resulting level of significance was $p = .285$. Additional t-tests were used to determine significance between daily measurements. Only day 5 showed significance ($p = .049$). Even though the directional hypothesis was rejected, results suggest, based on the experimental group mean change, that this stretch may cause an increase in hamstring muscle length.

Gribble et al. (1999) experimented effects of static and hold-relax stretching on hamstring range of motion using the flex ability LEI000 to determine the effects of static and hold-relax stretching on hamstring range of motion and to examine the reliability of the flex ability LEI000 compared with the
goniometrically measured active knee-extension test. Forty-two participants (18-25 years old) were assigned to either a control, static, or hold-relax training group. Participants were stretched four times a week over a 6-week period, with four 30-s stretches per session using a straight-leg-raise method on the Flex Ability LE1000. It was determined that both static and hold-relax techniques significantly improved hamstring flexibility (ISLR: +33.08 ± 9.08; and +35.17 ± 10.39, respectively). Participants of both techniques reached a plateau in flexibility improvement between Weeks 4 and 5. Thus, static and hold-relax stretching are equally effective in improving hamstring ROM. The Flex Ability LE1000 and the goniometer were both found to be highly reliable. Therefore, either measurement technique could be used successfully to measure hip-flexion ROM.

Feland and Myrer (1999) did an experimental study on a comparison of different durations of static stretch of the hamstring muscle group in an elderly population to determine which of three durations of stretches would produce and maintain the greatest flexibility gains in the hamstring muscle group in an elderly population. Sixty-two subjects, with a mean age of 84.7 years and exhibiting tight hamstrings, were randomly assigned to one of four groups and completed a physical activity questionnaire. Group 1: control group, performed no stretching. Groups 2 through 4 were passively stretched using a straight-leg-raise technique, five times per week for six weeks for 15, 30, and 60 seconds, respectively. All stretches were repeated four times with a 10-second rest between stretches. All subjects were measured once a week for six weeks for knee extension restriction with the femur held at 90 degrees of hip flexion in order to determine hamstring flexibility. All subjects were then measured for knee extension restriction once a week for four more weeks to determine the lasting effect of the stretching treatment. Data were analyzed using a growth curve model in SAS proc mixed to appropriately account for within subject repeated measures. Data analysis revealed that activity levels were significantly
related to flexibility, and that a 60-second stretch was significantly better than a 15- or 30-second stretch. However, both 15- and 30-second stretches were significantly better than no stretching. Post hoc analysis revealed that the 15- and 30-second treatment groups had returned to pretest measurement values after four weeks of not stretching, but the 60-second treatment group was still significantly more flexible than at pretest. The results of this study suggest that a static stretch held for 60-seconds will improve flexibility significantly better than 15 or 30 seconds in an elderly population. Due to age-related physiological changes that take place in muscle and connective tissue, longer duration stretches may be more beneficial in the elderly.

Bloomquist (1996) did a study on effect of thirty second static stretch on hamstring muscle flexibility in subjects over age 65 to determine the effect of a thirty second static stretch on hamstring muscle length in a sample of healthy people over age sixty-five. Twelve individuals between the ages of 65 and 89 were randomly assigned to two groups: a treatment group which performed one repetition of a thirty second static stretch of the hamstrings, one time per day for four weeks, and a control group which did not perform a hamstring stretch. ANCOVA results were calculated as p = .046, implying a significant treatment effect. Overall power was calculated as .541. The results suggest that in the healthy elderly, thirty seconds is an adequate duration to apply a static stretch and achieve therapeutic effects.

Halbertsma and Joeken (1996) experimented Sport stretching effect on passive muscle stiffness of short hamstring and they sampled sixteen students from the Department of Human Movement Sciences who participated with informed consent in the experiment. Subjects were limited to men and women without a history of neurological and orthopedic disorders. To select subjects with short hamstrings, the finger-ground distance had to be greater than 0cm (unable to touch the floor when bending forward) and the manual leg lifting was not to exceed 80°. One group of 10 subjects performed static stretching
exercises during 10 minutes interspersed with relaxing, whereas the untreated group of 6 subjects was used as a control. The instrumental straight-leg-raising set-up enables the measurement of the force needed to lift the leg, range of motion (ROM), pelvic-femoral angle, and the electromyogram of the hamstrings. These variables provide information about the stiffness, elongation, and state of activity of the hamstring muscles. One 10-minute sport stretch resulted in a significant increase in passive muscle moment, ROM, and elongation of the hamstrings. There was no significant change in the course of the passive muscle stiffness curve with respect to the pre-stretch stiffness curve. One session of static stretching does not influence the course of the passive muscle stiffness curve. The increased ROM, i.e., the extensibility of the hamstrings, results from an increase in the stretch tolerance.

Bandy et al. (1994) experimented the effect of time and frequency of static stretching on flexibility of the hamstring muscles and ninety-three subjects (61 men, 32 women) ranging in age from 21 to 39 years who had limited hamstring muscle flexibility were randomly assigned to one of five groups. The four stretching groups stretched 5 days per week for 6 weeks. The fifth group, which served as a control, did not stretch. Data were analyzed with a 5 x 2 (group x test) two-way analysis of variance for repeated measures on one variable (test). The change in flexibility appeared to be dependent on the duration and frequency of stretching. Further statistical analysis of the data indicated that the groups that stretched had more ROM than did the control group, but no differences were found among the stretching groups. The results of this study suggest that 30-second duration is an effective amount of time to sustain a hamstring muscle stretch in order to increase ROM. No increase in flexibility occurred when the duration of stretching was increased from 30 to 60 seconds or when the frequency of stretching was increased from one to three times per day.
Heise and Jacobson (1993) studied on the effect of static stretching on hamstring and lower back flexibility in elementary school children. A total of 156 boys and 161 girls were randomly assigned to a treatment or control group. The treatment group participated in an eight-week, two days a week static stretch exercise program. The control group did not perform stretching exercise. Pretest and posttest measurements were taken by using the Sit and Reach Box as the measurement tool. Analysis of Covariance was computed to determine significance in the comparison of gender and in the comparison of groups. In the comparison of gender, significant differences were observed in the adjusted posttest means of boys and girls. In the comparison of groups, there was a significant difference in the adjusted posttest means of the treatment and control groups. It was concluded that boys and girls, six through eleven years of age can increase flexibility of the hamstring muscles and lower back by participating in an eight-week, two days a week static stretch exercise program.

Mills and Roberts (1991) did a study on the effect of low intensity aerobic exercise on muscle strength, flexibility, and balance among sedentary elderly persons. The purpose of this study was to determine the effects of a low intensity aerobic exercise program on muscle strength and flexibility of the lower extremities and balance among sedentary elderly persons. Proprioception, vibratory sensation, and visual acuity were assessed and statistically controlled for when they were significantly related to the dependent variables. Using Birren and Renner's (1977) use/disuse theory, the low aerobic exercise program was expected to increase balance and perception of balance and increase flexibility and muscle strength of the knees and ankles. This pretest-posttest quasi-experimental study consisted of 47 sedentary subjects not engaged in regular exercise and living in metropolitan housing in southwestern Ohio. Convenience sampling was used with two apartment complexes randomly assigned to the experimental or comparison groups. To prevent diffusion of
treatment, subjects were assigned to these groups depending on their place of residence. The 20 experimental subjects, with a mean age of 75.3, participated in eight weeks of low intensity exercise while the comparison group (n = 20), with a mean age of 74.8, maintained their usual level of activity for eight weeks. The low intensity aerobic exercise program was three times a week for eight weeks. Experimental subjects also did the exercises on their own between classes. The program consisted of stretching and strengthening exercises for the lower extremities, and, except for two exercises, they were done while sitting in a chair. The exercise group had significantly greater flexibility of the ankles and the right knee than the comparison group. No significant differences were found between the groups for muscle strength. Although balance and perception of balance were not significantly different between the groups, the experimental group improved their balance by 22.4% from pretest. This study demonstrated that sedentary elders can safely perform these exercises, find them easy to do, and are able to fit them into their daily routine. Replication of this study should be done with different populations of sedentary elders and with longer duration for the exercise program. These may increase the effect of the program.

Godges et al. (1989) studied on the effects of two stretch procedures on hip range of motion and gait economy and they chose seven asymptomatic males, 18-22 years of age, served as subjects. Goniometric measurements of hip range of motion (ROM) and gait economy, as measured by sub-maximal oxygen consumption of walking and running on a treadmill, were taken before and after each of the two stretching procedures, (a) static stretching, and (b) soft tissue mobilization with proprioceptive neuromuscular facilitation (STM/PNF). Static stretching procedures resulted in significant improvements in ROM for hip extension (p < 0.01) and hip flexion (p < 0.01). The STM/PNF also resulted in significant improvements in hip extension ROM (p < 0.01) and hip flexion ROM (p < 0.05). There was a significant improvement in gait economy at 40%
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VO2max (p < 0.05), at 60% VO2max (p < 0.05), and at 80% VO2max (p < 0.01) following the static stretching procedure. The STM/PNF procedure improved gait economy only at one workload, 60% of VO2max (p < 0.05). These results suggest that a single bout of static stretching or STM/PNF was effective for improving hip ROM but static stretching was more effective for improving gait economy in young, asymptomatic males.

Egon et al. (1989) did an experimental study on passive tension of the ankle before and after stretching. The passive tension resulting from dorsi-flexion of the ankle was measured in relation to stretching in six handball players and six soccer players. Corresponding values of ankle angle and passive tension were measured by a strain gauge and a potentiometer connected to a pedal system. The passive tension versus ankle angle was measured before and 90 minutes after a single contract-relax stretching program of the plantar flexors. Stretching lowered the passive tension by up to 18%. Contract-relax stretching performed twice a day for 3 weeks lowered the passive tension in the plantar flexors by up to 36%. Before the last measurements, no stretching was performed for 20 hours or more. Stretching thus had both a short-term effect, matching the length of a training session, and a long-term effect, shown in a reduction of passive tension after 3 weeks. The relative decrease in passive tension after stretching exercises was constant from a neutral position of the ankle to maximal dorsi-flexion. There was no correlation between 1) flexibility and the short-term effect of stretching, 2) flexibility and the long-term effect of stretching, or 3) the short-term and long-term effects of stretching. This indicates that passive tension was decreased in all subjects irrespective of their flexibility, and that subjects who had short-term effects after stretching did not necessarily demonstrate a long-term effect.

Etnyre and Lee (1988) did an experimental study on chronic and acute flexibility of men and women using three different stretching techniques. They compared chronic and acute.
range of motion (ROM) changes of hip flexion and shoulder extension between men and women and a control group during a 12-week program. Comparative increases in flexibility in women were not significantly different from those in men.

Borms et al. (1987) did an experimental study on optimal duration of static stretching exercises for improvement of coxo-femoral flexibility and the experimental group was 20 sedentary women (20-30 years of age), participated in an exercise program of static stretching exercises with emphasis on the hamstring muscles. The program lasted for 10 weeks and consisted of two 50-min sessions per week. A control group of 15 sedentary women did not participate in the program. Hip flexibility was determined before, during and at the end of the program by means of a goniometric measuring technique developed by us and described elsewhere. Three sub-groups were formed, each following the same program except that the duration of the static stretch differed (group 1, 10 s; group 2, 20 s; group 3, 30 s). The ANOVA tests showed that for all groups - the control group accepted - the hip flexibility had improved significantly after 10 weeks (P less than 0.05). No significant differences in hip flexibility were noted between the three subgroups at the end of the program. This finding suggests that duration of 10 s static stretching is sufficient for improving coxo-femoral flexibility.

Medeiros et al. (1977) did an experimental study on the influence of isometric exercise and passive stretch on hip joint motion. The method was designed to compare the effects of isometric contractions and passive stretch on modifying joint range of motion in 30 normal men. Subjects were randomly assigned into a control group, a passive stretch group, or an isometric contraction group. Each subject assumed a left side lying position on the force table. Stabilization was applied to the pelvis and left lower extremity. The cuff, to which the force cable was attached, was applied to the right lower extremity. Force measurements produced by the isometric contractions or passive stretch
procedures were stored on computer tape. The results of the mean differences in pelvi-femoral angle measurements indicated that both treatment groups significantly increased their range of passive hip flexion with the knee extended when compared to the control group. Comparisons between the two treatment groups indicated that the isometric contraction and passive stretch procedures had significant and similar effects.

**MASSAGE ON FLEXIBILITY**

*Luo and Chang (2011)* did a research on electromyographic evaluation of therapeutic massage effect using multi-finger robot hand. The multi-finger robot hand (IRA-Hand I) is specially designed for massage applications. Surface electromyographic (SEMG) evaluation of therapeutic massage effects using multi-finger robot hand are presented in this paper. After an isometric 50% MVC (maximum voluntary contraction) of human back muscles is performed for 90 seconds, SEMG signals of the subject show a muscular fatigue. A grasp-kneading massage by the robot hand is applied on the subject's shoulder for recovering from muscular fatigue. To evaluate the therapeutic-effects of massage, the SEMG signals measured from the trapezius muscles before and after the massage therapy are analyzed. Electrical activity (EA) and median frequency (MF) of the SEMG signals are calculated as indexes of the muscle physiological states. The experimental results show that EA increases from the occurrence of fatigue, while MF shifts towards lower frequency in the spectral distribution. After massage, a decrease in EA and an increase in MF are observed which demonstrate the effectiveness of recovery through the grasp-kneading massage by the robot hand. In addition, the joint analysis of EMG spectrum and amplitude, which considers the changes in time domain and in frequency domain simultaneously, verifies that the therapeutic massage recovers the trapezius muscle from fatigue effectively.

For comparison, the experiments with a massage specialist performing the massage therapy are conducted with the same procedures. It is evidenced
that the robot hand massage has even better effectiveness than the human hand in most cases.

**Sharpe et al. (2010)** did a research on a randomized study of the effects of massage therapy compared to guide relaxation on well-being and stress perception among older adults to assess the effects of massage compared to guided relaxation on stress perception and well-being among older adults. A randomized pilot study enrolled adults ages 60 and older to receive 50 min, twice weekly massage therapy or guided relaxation sessions. Questionnaires were administered at pre-test (1 week before the first session) and post-test (after the last session). Participants (n=54) received 50 min massage or guided relaxation sessions twice weekly for 4 weeks. The massage included Swedish, neuromuscular, and myo-fascial techniques. For the relaxation group, an appropriately trained assistant read a script to guide the participant in using visualization and muscle relaxation. Significant improvements were found for the anxiety, depression, vitality, general health, and positive well-being subscales of the General Well-being Schedule and for Perceived Stress among the massage participants compared to guided relaxation. Findings indicate that massage therapy enhances positive well-being and reduces stress perception among community-dwelling older adults.

**Lynch and Axtell (2010)** did an experimental study on the effect of massage on creatine kinase and delayed onset muscle soreness in female distance runners. They investigated the effect of a 20-minute leg massage on DOMS and CK after a ten-mile run. Creatine kinase levels and DOMS were assessed in ten female runners 31.1 ± 8.68 years of age. Two hours post-run, the experimental group received a 2-hour massage while the control group rested. Blood samples were taken and perceived muscle soreness was assessed immediately pre-run, immediately post-run, immediately post-treatment, and 24 hours post-treatment. There was no significant difference in CK levels between the control group and massage group. The control group experienced a significantly higher
mean DOMS perception (2.65) than the massage group (0.965) (P<0.05). A 2-hour massage, 2 hours post-10-mile run does not reduce CK levels but may have an effect on perceived musclesoreness.

Grant et al. (2010) experimented acute effects of two massage techniques on ankle joint flexibility and power of the plantar flexors to determine if three minutes of petrissage and tapotement forms of massage would influence plantar flexors’ flexibility, and muscle power. Nineteen participants were randomly subjected to three conditions (control and two massages) before performing two power tests. Prior to the intervention, subjects completed ankle joint flexibility assessments. The conditions were; (1) control, where subjects lay prone and had a therapist’s hands resting, (2) vigorous petrissage, and (3) tapotement applied at a rate of 4Hz; all on the triceps surae. Following completion of the intervention, subjects immediately completed a post-ankle joint flexibility test, followed by a drop-jump and concentric calf raise. The power measures were; concentric peak force, rate of force development, and drop-jump height / contact time. The data showed a significant increase (p < 0.05) in ankle joint angle on the right leg and a corresponding tendency on the left. No significant change was seen with the power measures. Results suggest that massage can increase plantar flexors’ flexibility without a change in power and thus may be an alternative to static stretching during an athletic warm-up.

Susanne et al. (2009) did an experimental study on effect of massage therapy on pain, anxiety, and tension in cardiac surgical patients to assess the role of massage therapy in the cardiac surgery postoperative period. Specific aims included determining the difference in pain, anxiety, tension, and satisfaction scores of patients before and after massage compared with patients who received standard care. A randomized controlled trial comparing outcomes before and after intervention in and across groups was carried. The subjects were the patients undergoing cardiovascular surgical procedures (coronary artery bypass grafting and/or valvular repair or replacement) (N = 58). Patients
in the intervention group received a 20-minute session of massage therapy intervention between postoperative days 2 and 5. Patients in the control group received standard care and a 20-minute quiet time between postoperative days 2 and 5. Statistically and clinically significant decreases in pain, anxiety, and tension scores were observed for patients who received a 20-minute massage compared with those who received standard care. Patient feedback was markedly positive. The study showed that massage can be successfully incorporated into a busy cardiac surgical practice. These results suggest that massage may be an important therapy to consider for inclusion in the management of postoperative recovery of cardiovascular surgical patients.

**Willison and Kevin (2009)** experimented massage therapy visits by the aged: Testing a modified Andersen model to help ascertain if it is useful towards understanding factors associated with massage therapy (MT) utilization. Respondents represented an elderly sample (aged 60+) that resided within a large urban city in Ontario Canada (Toronto). Eligible respondents at the time of the study were non-institutionalized and self-reported having one or more current chronic illness conditions which they have had for six months or more, and had been diagnosed by a medical doctor. Using a quantitative method, retrospective data were gathered using a pre-tested English-only mail questionnaire, developed specifically for the study. Data were gathered over a period of 6 months, between late 2000 to mid 2001. Bivariate analysis suggests that inequity exists whereby the ability to access massage-therapy varies according to one’s socioeconomic status. This is further supported using backwards step-wise regression analysis, whereby one’s total annual household income was a strong predictor of MT use status. One’s CAM-related health and social network as well as having back problems also emerged as strong predictors of MT use. Overall findings suggest that a modified Andersen model as used in this study does have utility in relation to helping to identify potential factors associated with the utilization of massage therapy. Based on regression
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Analysis, findings here suggest, for example, that those with higher incomes are 1.5 times more likely to use MT. This provides support that there are existing inequities regarding access to rehabilitation-oriented health care services. With population aging and rising numbers of people needing restorative and rehabilitation services, study findings will increasingly have important public health as well as health care policy related implications.

Perkins et al. (2009) did an experimental study of accreditation and massage therapy licensure in the state of Ohio to explore if there was a proportional difference between massage therapy programs licensure success based on the presence or absence of institutional accreditation. It was a quantitative, descriptive study using a two proportion z-test. This descriptive study allowed the researcher to gain more information about the massage therapy field of study, specifically the state average pass rate of 63% on the licensure exam in Ohio. This study also provided research that identifies possible areas of needed improvement in the current curricular requirements, while also justifying the current curricular requirements of the State Medical Board.

The research supported these results by rejecting the null hypothesis that the accredited and non-accredited institutions were proportionally equal. The findings suggest that institutional accreditation may have a significant effect on the massage therapy licensure pass rates in Ohio when proportionally explored. But although the research rejected the null hypothesis, the data results failed to prove that the State Medical Board curriculum insufficiently prepares students to sit for the licensure exam based on the maintenance of greater successes rather than failures in passage of these licensure exams for both institutional classes.

Snyder and Taylor (2007) studied on the effects of therapeutic massage on stress and quality of life of female faculty to investigate the immediate and cumulative effects of massage on stress, relaxation, and comfort. explore effects of massage on anxiety, pain, and QoL outcomes, and identify the
benefits of and barriers to patient acceptance of massage during phases of the ASCT process in individuals undergoing ASCT for cancer. The project used mixed methods, unmasked, prospective, randomized experimental design. Baseline demographics and history, health-related QoL, state anxiety, perceived stress, comfort, and relaxation levels, pain, and social support were assessed. Descriptive statistics and graphing techniques were used to analyze the data. An immediate effect in stress reduction, increased relaxation, and increased comfort were identified post massage. Cumulative effects of massage over transplant phases were not seen in the massage group. Participants in the massage group also reported lower anxiety scores across the transplant phases and lower affective and sensory pain scores during hospitalization following transplant than those in the SMC alone group. Perceived benefits of massage for the participants included improvement in symptoms that they had been experiencing prior to undergoing ASCT as well as their current treatment-related symptoms. They concluded that supportive care massage can have immediate effects on stress, comfort, and relaxation and improve treatment-related symptoms for patients undergoing ASCT.

Sven et al. (2007) did a study on sports massage after eccentric exercise. They used prospective randomized clinical trial. Sixteen subjects performed 300 maximal eccentric contractions of the quadriceps muscle bilaterally. Massage was given to 1 leg, whereas the other leg served as a control. Subjects were treated once daily for 3 days. Maximal strength was tested on a Kin-Corn dynamometer, and functional tests were based on 1-leg long jumps. Pain was evaluated using a visual analog scale. There was a marked loss of strength and function of the quadriceps directly after exercise and on the third day after exercise. The massage treatment did not affect the level or duration of pain or the loss of strength or function following exercise. They concluded that sports massage could not improve the recovery after eccentric exercise.
Corrie et al. (2005) did an experimental study on the effects of massage on delayed onset muscle soreness and physical performance in female collegiate athletes to determine if post-exercise massage has an effect on delayed-onset muscle soreness (DOMS) and physical performance in women collegiate athletes. The study used a randomized pre-test post-test control group design. Twenty-two NCAA Division I women basketball and volleyball players participated. On the day of predicted peak soreness, the treatment group (n=11) received a thigh massage using effleurage, petrissage and vibration while the control group (n=11) rested. Paired t-tests were used to assess differences between pre and post massage measures (alpha=0.05) for vertical jump displacement, timed shuttle run, quadriceps length and pressure-pain threshold in the thigh. A significant increase (slowing) was found in shuttle run times for the control group (p=0.0354). There were significant changes in vertical jump displacement (p=0.0033), perceived soreness (p=0.0011) and algometer readings (p=0.0461) for the massage group. The study supports the use of massage in women collegiate athletes for decreasing soreness and improving vertical jump.

A M Hunter et al. (2005) studied on effect of lower limb massage on electromyography and force production of the knee extensors to evaluate the effect of massage on force production and neuromuscular recruitment. Ten healthy male subjects performed isokinetic concentric contractions on the knee extensors at speeds of 60, 120, 180, and 240°/s. These contractions were performed before and after a 30 minute intervention of either rest in the supine position or lower limb massage. Electromyography (EMG) and force data were captured during the contractions. The change in isokinetic mean force due to the intervention showed a significant decrease (p<0.05) at 60°/s and a trend for a decrease (p=0.08) at 120°/s as a result of massage compared with passive rest. However, there were no corresponding differences in any of the EMG data. A reduction in force production was shown at 60°/s with no
corresponding alteration in neuromuscular activity. The results suggest that motor unit recruitment and muscle fibre conduction velocity are not responsible for the observed reductions in force. Although experimental confirmation is necessary, a possible explanation is that massage induced force loss by influencing “muscle architecture”. However, it is possible that the differences were only found at 60°/s because it was the first contraction after massage. Therefore muscle tension and architecture after massage and the duration of any massage effect need to be examined.

**Galloway and Watt (2005)** did a study on experimented massage provision by physiotherapists at major athletics events between 1987 and 1998 to quantify the amount of their time that physiotherapists devote to massage treatment at major athletics events in an attempt to determine the importance of this treatment modality, and to examine whether the use of massage at athletics events is changing over time. Data recorded by the head team physiotherapist from 12 major athletics events (national and international events) between 1987 and 1998 were examined. For each event, the data included: total number of treatments administered by the physiotherapist, the treatment modalities used, and the number of attendances for treatment. The amount of massage provided was expressed as a percentage of the total number of treatments for each athletic event, and the pattern of change in use of massage treatment over time was evaluated. The percentage of time spent providing massage treatment ranged from 24.0% to 52.2% of the total number of treatments made. The overall median percentage of total treatments in the form of massage was 45.2%. No significant increase or decrease in the use of massage as a treatment modality was observed between 1987 and 1998 in the athletics events examined (p = 0.95). A significant proportion of physiotherapists’ time is devoted to the delivery of massage treatment at athletics events. The demand for massage treatment has been steady over the time period, in the events for which data are available, indicating a consistent use of this treatment modality.
Cowen and Burkett (2005) did a research on a comparative study of Thai massage and Swedish massage to compare and contrast a single general massage treatment, using one of two different styles of massage, on physiological and psychological outcomes. Fifty-three participants enrolled in the study and were randomly assigned to receive one TM or SM treatment. Dependent variables included blood pressure, heart rate, range-of-motion, perceived anxiety, and mood. Physiological assessments (blood pressure, heart rate, range of motion) were conducted immediately before (T1) and after the massage (T2). Psychological assessments (anxiety and mood) were conducted at T1, T2, and at 48-hour follow-up (T3). A multivariate analysis of variance (MANOVA) revealed overall significant differences for the massage. However, there were no differences between the treatment groups. Repeated measures analysis of variance (ANOVA) for individual dependent variables found significant improvement between T1 and T2 in resting heart rate, ankle plantar flexion, ankle dorsiflexion, and shoulder abduction/rotation. Significant overall improvement was noted in mood at T2, and in tension-anxiety as well as confusion-bewilderment at T2 and T3 compared to T1. The findings suggest that a single treatment of TM is as effective as SM on general physiological and psychological outcomes.

Diana et al. (2005) did an experimental study on “Evaluation of the effect of two massage techniques on hamstring muscle length in competitive female hockey players” to evaluate the effect of dynamic soft tissue mobilization (DSTM) in comparison with classic massage on hamstring muscle length in competitive female field hockey players. A randomized, self-controlled comparative clinical trial, with a blinded measurer. Thirty-nine players were recruited and randomly allocated into two groups. One group received classic massage and the other DSTM. Passive straight leg raise (PSLR) and passive knee extension (PKE) were used to measure indirect hamstring length, before, following and 24 h post-intervention. The PKE test demonstrated a significant
improvement in hamstring length immediately following massage in both groups (F=7.66, p=0.01). This increase was comparable between the two massage groups (F=0.164, p=0.69). Post-hoc linear contrast showed no maintenance over 24 h in either group, (classic F(1,18)=2.106, p=0.164, DSTM F (1,15)=0.599, p=0.451). Passive KE showed that both classic massage and DSTM had an immediate, significant effect on hamstring length in competitive female field hockey players.

**Hilbert et al. (2003)** did a study on the effects of massage on delayed onset muscle soreness to investigate the physiological and psychological effects of massage on delayed onset muscle soreness (DOMS). Eighteen volunteers were randomly assigned to either a massage or control group. DOMS was induced with six sets of eight maximal eccentric contractions of the right hamstring, which were followed 2h later by 20 min of massage or sham massage (control). Peak torque and mood were assessed at 2, 6, 24, and 48h post exercise. Range of motion (ROM) and intensity and unpleasantness of soreness were assessed at 6, 24, and 48h post exercise. Neutrophil count was assessed at 6 and 24 h post exercise. A two factor ANOVA (treatment v time) with repeated measures on the second factor showed no significant treatment differences for peak torque, ROM, neutrophils, unpleasantness of soreness, and mood (p > 0.05). The intensity of soreness, however, was significantly lower in the massage group relative to the control group at 48h post exercise (p < 0.05). Massage administered 2 h after exercise induced muscle injury did not improve hamstring function but did reduce the intensity of soreness 48 h after muscle insult.

**Robertson et al. (2003)** studied on effects of leg massage on recovery from high intensity cycling exercise to examine the effects of leg massage compared with passive recovery on lactate clearance, muscular power output, and fatigue characteristics after repeated high intensity cycling exercise, with the conditions before the intervention controlled and standardized. Nine male
games players participated. They attended the laboratory on two occasions one week apart and at the same time of day. Dietary intake and activity were replicated for the two preceding days on each occasion. After baseline measurement of heart rate and blood lactate concentration, subjects performed a standardized warm up on the cycle ergometer. This was followed by six standardized 30 second high intensity exercise bouts, interspersed with 30 seconds of active recovery. After five minutes of active recovery and either 20 minutes of leg massage or supine passive rest, subjects performed a second standardized warm up and a 30 second Wingate test. Capillary blood samples were drawn at intervals, and heart rate, peak power, mean power and fatigue index were recorded. There were no significant differences in mean power during the initial high intensity exercise bouts (p = 0.92). No main effect of massage was observed on blood lactate concentration between trials (p = 0.82) or heart rate (p = 0.81). There was no difference in the maximum power (p = 0.75) or mean power (p = 0.66) in the subsequent Wingate test, but a significantly lower fatigue index was observed in the massage trial (p = 0.04; mean (SD) fatigue index 30.2 (4.1) % vs 34.2 (3.3) %). No measurable physiological effects of leg massage compared with passive recovery were observed on recovery from high intensity exercise, but the subsequent effect on fatigue index warrants further investigation.

Barlow et al. (2003) studied on effect of massage of the hamstring muscle group on performance of the sit and reach test to investigate if a single massage of the hamstring muscle group would alter the performance of the sit and reach test. Before treatment, each of 11 male subjects performed the sit and reach test. The treatment consisted of either massage of the hamstring muscle group (both legs, total time about 15 minutes) or supine rest with no massage. Performance of the sit and reach test was repeated after treatment. Each subject returned the subsequent week to perform the tests again, receiving the alternative treatment relative to their initial visit. Mean percentage changes in
sit and reach scores after treatment were calculated for the massage and no massage treatments, and analyzed using Student’s $t$ tests. Mean (SD) percentage changes in sit and reach scores after massage and no massage were small (6.0 (4.3) % and 4.6 (4.8) % respectively) and not significantly different for subjects with relatively high (15 cm and above) values before treatment. Mean percentage changes in sit and reach scores for subjects with relatively low values before treatment (below 15 cm) were large (18.2 (8.2) % and 15.5 (16.2) % respectively), but no significant differences were found between the massage and no massage groups. 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.

Hernandez et al. (2001) studied on lower back pain is reduced and range of motion increased after massage therapy to evaluate reducing pain, depression, anxiety and stress hormones, and sleeplessness and for improving trunk range of motion associated with chronic low back pain. Twenty-four adults (M age = 39.6 years) with low back pain of nociceptive origin with a duration of at least 6 months participated in the study. The groups did not differ on age, socioeconomic status, ethnicity or gender. Twenty-four adults (12 women) with lower back pain were randomly assigned to a massage therapy or a progressive muscle relaxation group. Sessions were 30 minutes long twice a week for five weeks. On the first and last day of the 5-week study participants completed questionnaires, provided a urine sample and were assessed for range of motion. By the end of the study, the massage therapy group, as compared to the relaxation group, reported experiencing less pain, depression, anxiety and improved sleep. They also showed improved trunk and pain flexion performance, and their serotonin and dopamine levels were higher. They concluded that massage therapy is effective in reducing pain, stress hormones and symptoms associated with chronic low back pain.
Brewer and Sherry (2001) did a study on “massage of feet: A pain control option” to examine responses of surgical patients experiencing acute surgical pain to determine if simple massage of feet decreases the patient's perception of pain intensity or pain affect. Simple massage involved light to medium touch and is similar to that used by nurses to provide back rubs. Prior to initiation of the massage, the investigator obtained patient responses on two pain scales, a 0-10 numeric descriptor of pain severity and a 0-5 verbal descriptor rating scale of pain distress. The massage intervention was initiated for five minutes to each foot for a total of 10 minutes. A convenience sample of 32 volunteers, age 18 or greater, who spoke English and had a total joint replacement surgery during the hospital stay agreed to participate in the study. The majority was female and Caucasian. Foot massage significantly decreased pain severity and pain affect. No significance was found among subject responses when compared by demographics or surgery characteristics. This study holds promise that simple message to the feet may provide a cost effective, easily administered, non-pharmacological intervention for nurses and others to use in decreasing a patient's pain perception.

Chin and Good (1999) studied on the effects of back massage on surgical stress responses and postoperative pain to examine the effects of back massage on stress responses and postoperative pain among gynecological surgical patients. With a pretest-posttest experimental design, 112 Taiwanese subjects were assigned to either the massage or the control group using permuted block randomization controlling for direction of incision (horizontal or vertical). On the day of surgery and the first postoperative day, patients in both groups were turned to a side-lying position, and then the massage group received a 10-minute back massage without conversation, while the control group rested. On each day, at each time point (baseline, post-turning, pretreatment, post treatment I and post treatment II), stress responses and postoperative pain were measured. The indicators of stress responses included
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serum cortisol and beta-endorphin concentrations, electromyography (EMG) of frontalis and trapezius muscles, and self-reported physical and psychological tension measured with 0-100 scales and visual analogue scales (VAS). The sensation and distress of postoperative incisional and muscle pain were both measured with 0-100 scales and VAS. Controlling for pretreatment scores, repeated measures ANCOVA showed no significant differences between the massage and control group in surgical stress responses, incisional pain, and distress of muscle pain across post-treatment I and II on either the day of surgery or the first postoperative day. However, massage significantly reduced the VAS (and not 0-100) sensation of muscle pain on the first postoperative day, $F(1, 93) = 10.67, p = .002$, but not on the day of surgery. It is recommended that future researchers looking for massage effects take EMG measurement at the site of pain rather than frontalis and trapezius muscles, use a 0-100 scale on the day of surgery, increase the number of times massage is given, and use a crossover design to reduce error variance. Distress of incisional pain was significantly and positively related to psychological tension at most time points and to physical tensions at post-treatment I and II. Having the patients turn to the side did not increase sensation and distress of incisional pain, but did significantly reduce sensation of muscle pain on both days and distress of muscle pain on the day of surgery. The research findings suggest that nurses should assist surgical patients with position changes and provide back massage to relieve muscle pain when patients are on bed rest the first postoperative day.

Brian et al. (1999) did a research on effects of massage on physiological restoration, perceived recovery, and repeated sports performance to investigate the effect of massage on perceived recovery and blood lactate removal, and also to examine massage effects on repeated boxing performance. Eight amateur boxers completed two performances on a boxing ergo-meter on two occasions in a counterbalanced design. Boxers initially completed performance 1, after
which they received a massage or passive rest intervention. Each boxer then
gave perceived recovery ratings before completing a second performance,
which was a repeated simulation of the first. Heart rates and blood lactate and
glucose levels were also assessed before, during, and after all performances. A
repeated measures analysis of variance showed no significant group differences
for either performance, although a main effect was found showing a decrement
in punching force from performance 1 to performance 2 (p<0.05). A Wilcoxon
matched pairs test showed that the massage intervention significantly increased
perceptions of recovery (p<0.01) compared with the passive rest intervention.
A doubly multivariate multiple analysis of variance showed no differences in
blood lactate or glucose following massage or passive rest interventions,
although the blood lactate concentration after the second performance was
significantly higher following massage (p<0.05). The findings provide some
support for the psychological benefits of massage, but raise questions about the
benefit of massage for physiological restoration and repeated sports
performance.

Corrigan, and Lamberth (1997) studied on effects of massage therapy on
concentric and eccentric peak torque generation of the quadriceps muscle
complex to determine concentric and eccentric quadriceps muscle peak torque,
average power, and total work utilizing a BIODEX isokinetic dynamometer
after implementing sports massage to enhance recovery between exercise
sessions. Twenty-one males served as subjects. Subjects reported to Oktibbeha
County Hospital Physical Therapy for two sessions. The first session subjects
had an exercise work bout of 10 maximal open chain knee extensions and
flexions at a preset speed of 60 deg/s, and 25 maximal open chain knee
extensions and flexions at a preset speed of 240 deg/s. Both speeds were
concentric. After these performances an eccentric passive test of 5 maximal
open chain knee resistances, from extension to flexion, were performed at 60
deg/s. The work bout was followed by 8 minutes of passive rest, then a repeat
of the earlier work bout. The second sessions were identical to the first session except that an 8-minute quadriceps sports massage replaced the passive rest portion of the test protocol. Statistical analysis indicated a non significant difference in speed concentric contractions of 240 deg/s and significant difference in speed contractions of 60 deg/s concentric and eccentric.

Sunshine et al. (1996) did a study on fibromyalgia benefits from massage therapy and transcutaneous electrical stimulation. Thirty adult fibromyalgia syndrome subjects were randomly assigned to a massage therapy, a transcutaneous electrical stimulation (TENS), or a transcutaneous electrical stimulation no-current group (Sham TENS) for 30-minute treatment sessions two times per week for 5 weeks. The massage therapy subjects reported lower anxiety and depression, and their cortisol levels were lower immediately after the therapy sessions on the first and last days of the study. The TENS group showed similar changes, but only after therapy on the last day of the study. The massage therapy group improved on the dolorimeter measure of pain. They also reported less pain the last week, less stiffness and fatigue, and fewer nights of difficult sleeping. Thus, massage therapy was the most effective therapy with these fibromyalgia patients.

Menard (1995) did an experimental study on the effect of therapeutic massage on post surgical outcomes. It evaluated the effectiveness of therapeutic massage as an adjunct to standard medical care in improving surgical outcomes for 30 gynecologic oncology patients, who received an abdominal hysterectomy. Prior to surgery, patients were randomly assigned to receive either standard postsurgical care alone or standard care plus therapeutic massage. The treatment group of 15 patients who received a daily 45 minute massage in addition to standard care was compared to the control group of 15 patients who received only standard care. Outcomes evaluated include scores on the Profile of Mood States and the State/Trait Anxiety Inventory, self-reported levels of pain, amount of pain medication, systolic blood pressure, urinary free cortisol.
levels, length of hospital stay, and amount and kind of follow-up medical services used over a four-week postoperative period. Results were generally supportive of the hypothesis that therapeutic massage promoted recovery from surgery through reducing autonomic arousal. By postoperative day five, mean systolic blood pressure was lower, and mean cortisol level was lower, with a higher percentage of massaged patients within reference range. Mean scores for anxiety and depression, pain ratings, and patient-controlled analgesia use were lower during hospital stay in the massage treatment group but did not reach statistical significance. No additional medical services were used by the massage treatment group during the four-week follow-up period; five out of 15 standard care patients utilized additional physician visits.

Richards et al. (1993) examined the effect of a muscle relaxation, imagery, and relaxing music intervention and a back massage on the sleep and physiological arousal of elderly males hospitalized in the critical care environment. They aimed to test the effect of (1) a combination of muscle relaxation, mental imagery, and relaxing music (MRMIM), and (2) slow stroke back massage (SSBM) on the sleep and physiological arousal of elderly males with a cardiovascular illness hospitalized in a critical care unit. The 69 subjects were randomly assigned to a control group that received the usual nursing care (N = 17), a MRMIM group that received a brief teaching session on relaxation and listened to a 7.5-minute MRMIM audiotape (N = 28), and a SSBM group that received a back massage given by the investigator (N = 24). The variables measuring psycho physiological arousal were anxiety, frontalis muscle tension (FMT), heart rate (HR), and respiratory rate (RR). Sleep variables were sleep efficiency index (SEI), percent stage 2 NREM, percent stages 3 and 4 NREM, and percent stage REM. Because there were significant pretest differences in anxiety scores between the MRMIM and the SSBM groups, ANCOVA was used to test for differences in anxiety among the three groups. Pretest anxiety measures served as covariates. The ANCOVA revealed...
that both the MRMIM and the SSBM groups had significantly less posttest anxiety than the control group. A MANOVA comparing the three groups on HR, RR, and FMT did not reveal differences. Independent two-tailed t-tests tested the effectiveness of the interventions on sleep. There were significant differences between the SSBM and the control group in SEI, percent stage 2, and percent stage REM. There were no significant differences between the MRMIM and the control group in sleep. A stepwise multiple regression to predict the SEI was performed. Two variables, SSBM and receiving theophylline, entered the model and accounted for 16% of the variance. Additional findings were that 37 (54%) subjects experienced sleep disordered breathing, and 73% of the 37 experienced oxygen desaturation to less than 90% during apneic episodes. Subjects accurately estimated total sleep time (r = .61), and the Richards Campbell Sleep Questionnaire was significantly correlated with SEI (r = .57). Manifest content analysis was performed to analyze qualitative data. Thirty subjects, ten from each of the three groups, comprised the sample. Effects of the SSBM were relaxing, comforting, soothing, helped backache, made feeling a lot better, and helped going to sleep. Essential elements of a therapeutic backrub as perceived by subjects were a willingness to give the patient a backrub, feeling comfortable touching the patient, having a rapport between the patient and the nurse, and a gentle touch.

Margareta et al. (1993) experimented effects of warming up, massage, and stretching on range of motion and muscle strength in the lower extremity in eight male volunteers. Thigh muscle strength was not influenced by the experimental procedures. Stretching resulted in a significantly increased range of hip flexion, extension, hip abduction, knee flexion, and ankle dorsi-flexion; the effect was significantly greater than that obtained by massage and warming up separately or combined. Only ankle dorsi-flexion was influenced by massage or warming up, whereas stretching affected all muscle groups tested.
Stretching was, therefore, superior to the other methods tested for increasing flexibility in the lower extremity.

**Finkelstein and Lopez (1992)** examined the effects of massage therapy on delayed-onset muscle soreness after unaccustomed exercise for healthy, sedentary adults. Fifteen volunteers between the ages of 23 and 63 performed 100 calf raises followed by 15 minutes of rest. After the rest period, one leg was randomly assigned to receive a 5-minute massage while the other leg received a 5-minute placebo ultrasound treatment. A questionnaire was administered to evaluate DOMS at 24, 48, and 72 hour post-treatment intervals when DOMS reportedly is at its peak. A double blind control was employed so that the examiner was unaware as to which treatments were performed on each leg. A t-test for non-independent samples was used with significance set at the 0.05 level. There was less DOMS reported in the massaged leg at each interval, however, only a significant reduction in DOMS was reported at the 24 hour post-treatment interval.

**Maguire and Bennett (1992)** did a study on the effects of short duration ice massage on isokinetic, concentric and eccentric muscle contractions. Forty-eight healthy adults, (ages 18-32), participated in a study to determine the effects of a 5-minute ice massage to the right quadriceps muscle on maximal isokinetic concentric and eccentric contractions. The muscle contractions consisted of knee extensions of 60 degrees range of motion. An isokinetic dynamometer was used to measure the peak torque and average torque involved at a velocity of 60 degrees per second for concentric and 90 degrees per second eccentrically. The study consisted of a pretest and 3 repeated post measurements over time (immediate post treatment, 15 minutes, and 30 minutes). Analysis of the study did not statistically support the hypothesis. The findings did indicate a trend for concentric peak torque group differences ($F (1, 47) = 3.439, p =.07$). The trend indicated in this study is also supported by similar studies.
Stoll et al. (1990) did a study on effects of therapeutic massage on the psychosocial adjustment of persons with brain injury. Prior to initiation of the study, all possible participants signed a written consent form and were administered the Reading subtest of the Kaufman Functional Academic Skills Test (K-FAST). Participants who achieved a score falling at or above the 75th percentile for their age group then completed the State-Trait Anxiety Inventory (STAI), Beck Depression Inventory - II (BDI-II), and Symptom Checklist - 90-Revised (SCL-90-R). Participants were randomly assigned to one of two groups: TM (n = 24) or control (n = 26). Participants in the TM group received a 20-minute chair massage from a Certified Massage Therapist once per week for six consecutive weeks. Immediately after the third massage, participants completed the STAI, BDI-II, and SCL-90-R a second time to evaluate the immediate effects of TM on psychosocial functioning. Control participants completed the measures a second time during the same week of the study. All participants completed the measures a third time within two weeks following the last of the six massages to determine whether there were any sustaining effects of TM on psychosocial functioning. Data were analyzed through a total of eight ANCOVAs, which examined both the immediate and sustained effects of TM on state anxiety, trait anxiety, depression, and psychological disturbance. Results suggested that TM may be an effective treatment intervention for reducing both state anxiety and depression immediately after treatment is provided; however, the effect is apparently temporary.

Lynch (1989) did a research on effect of therapeutic massage after competition on concentrations of muscle enzymes in the blood of triathletes. They examined the effects of a therapeutic massage on the muscle recovery process following a triathlon, in 18 subjects, (mean age--32 years). Ten subjects received a therapeutic massage immediately post exercise, 24 and 48 hours post exercise and eight control subjects did not receive a therapeutic massage. Lactate dehydrogenase (LDH), creatine phosphokinase (CPK), myoglobin (MYO), and
serum glutamic oxaloacetic transaminase (SGOT) were measured 24 hours pre-race, 10 minutes, 24, 48, and 72 hours-post race to determine muscle damage. An analysis of variance with repeated measures was performed to determine statistical significance at the 0.05 level of confidence. The results demonstrated no significant differences in serum LDH, CPK, MYO, and SGOT levels between the groups. Therefore, it was concluded that therapeutic massage does not have a significant effect on reducing muscle recovery time.

Crosman et al. (1984) did a research on the effects of massage to the hamstring muscle group on range of motion to measure the effect on range of motion of a single massage treatment to the hamstring muscle group. Thirty-four normal female subjects between 18 and 35 years of age were given a 9-12 minute massage treatment to the posterior aspect of one randomly assigned lower extremity. Passive range of motion of both lower extremities was measured by taking the perpendicular distance from the lateral malleolus to the table surface in a straight leg raise and by conventional goniometry for hip flexion and knee extension. Measurements were taken pre-, and post-, and 7-days post massage treatment. Immediate post massage increases in range of motion were noted in the test group (massaged) legs with significance at the 0.05 level. The possible use of this treatment in athletics and pathological conditions are discussed.