Comparison between the effects of a resistance training combined with massage, PNF and static stretching on performance in non-athlete male students

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Abstract

The purpose of this study was to compare between the effects of a resistance training combined with massage, PNF and static stretching on performance during an 8-week training protocol in non-athlete male students. Forty healthy non-athlete male students (age 21.6 ± 3.2 years, height 173.8 ± 5.2 cm, weight 73.43 ± 2.4 kg; means ± S.D.) were randomly divided into a resistance training (RT) group (n=10), resistance training combined with a massage (RT+MAS) group (n=10), resistance training combined with a static stretching (RT+ST) group (n=10), and resistance training combined with proprioceptive neuromuscular facilitation (PNF) stretching (RT+PNF) group (n=10). The resistance training program was performed 3 days, each week for 8 weeks. The resistance training consisted of 3 sets of 8 repetitions with 80% of the 1RM for triceps pushdown; bench press and lateral pull down. Also, the 8 week’s stretching program consisted of 15 different PNF and static stretches designed to stretch all of the major upper-extremity muscle. Also deep friction massage technique is used for this study. Subjects were tested for performance before and after the 8-week period. The correlated T-test was used for evaluation of programs in pretest and posttest, and the ANOVA test and the Turkey’s post hoc test were used for determining a significant distance between groups in a level of p<0.05. The results of this study showed significantly (P< 0.05) improvements in strength, muscle volume, explosive power and flexibility from Post test occurred for all groups when compared to Pre test. There were also no significant differences (P> 0.05) between groups. However, findings showed the RT+PNF group had slightly more improvements when compared the RT, RT+MAS and RT+ST groups.In sum, it can be concluded 8 weeks resistance training combined with massage and stretching (PNF and static) was found to improved muscle volume, strength, explosive power and flexibility, but no difference was found between RT, RT+ST, RT+MAS and RT+PNF groups.

Key words: explosive power, resistance training, massage, pnf, stretching

Introduction

Often the exercise programs consist of strength and flexibility training. The role of strength and flexibility in exercise performance is a widely debated topic in the exercise science field. Both components are considered fundamental for those who wish to attain improved performance and a healthy physical fitness level (Ercole et al., 2007). Resistance training, also known as strength or weight training, has become one of the most popular forms of exercise for enhancing and individual's physical fitness as well as for conditioning athletes (Arazi and Asadi, 2011).

Also stretching is commonly promoted as a method to improve flexibility, power and performance in various sports and recreational activities (Surburg and Schrader, 1997; Shrier, 1999). In practice, there are 4 different protocols for stretching training–static, ballistic, dynamic and proprioceptive neuromuscular facilitation (PNF),
(Marzilli et al., 2004). Static stretching, or slow movements that gradually lengthen muscles to an elongated position, hold for 15 to 60 s, is the most widely used protocol (Torres et al., 2009). Pre-event stretching has demonstrated an inhibitory effect on maximal force or torque production (Nelson et al., 2005c; Shrier, 2004), vertical jump performance (Church et al., 2001), running speed (Nelson et al., 2005a), and muscle endurance (Nelson et al., 2005b). For example (Worrell et al., 1994; Handel et al., 1997) found increases in hamstring isokinetic torque. Godges et al., (1989) found increased trunk strength, whereas (Wilson et al., 1992) found improvements in the bench press. In addition, (Hunter and Marshall, 2002) saw increases in a counter movement vertical jump. Kokkonen et al., (2007) have reported that 10 weeks of static stretching alone improved jumping. Also (Kokkonen et al., 2010) have reported that 8 weeks of static stretching combined with resistance training improved lower body strength.

PNF is a stretching technique utilized to improve muscle elasticity and has been shown to have a positive effect on active and passive range of motions (Funk et al., 2003). PNF is similar to static stretching, but it is more effective at increasing flexibility as a partner resists an active muscle and assists a passive muscle to achieve greater range of motion (Tanigawa, 1972). A study conducted by (Feland and Marin, 2004) showed significant improvements in hamstring flexibility via sub maximal contractions using PNF stretching. A study conducted by (Giordano et al., 2005) concluded that one session of PNF stretching prior to participating in a 40-yard dash and vertical jump test showed no significant improvement in performance. In correlation, information from a study done by (Mayer et al., 2005) indicated that PNF stretching was an effective way of increasing flexibility. Church et al., (2001); Bradley et al., (2007) noted a significant reduction in the vertical jump performance after PNF. However, other authors did not report significant PNF-induced decreases in muscle performance in activities involving maximal muscular contraction, explosive strength and jumping (Miyahara et al., 2005; Young and Elliot, 2001). In addition, the PNF was combined with resistive training making the attribution of the slight gains in strength indistinguishable between the resistance and the PNF (Arazi et al., 2012).

Apart from stretching, pre-event massage can be used as an adjunct to improve performance (Tessier, 2005). Massage is also thought to relax, and could therefore help to enhance joint flexibility by reducing the passive tension of antagonistic muscles (Barlow et al., 2004). Athletes use massage in an attempt to aid recovery as well as warm-up for training or competition (Caldwell, 2001). There are controversial claims in the sports literature that pre-event massage can increase or decrease performance (Weerapong et al., 2005). Goodwin et al., (2007) found that a controlled 15 minute lower limb massage administered prior to warm up had no significant effect on sprint performance. In contrast, (Crosman et al., 1984) found that a single massage of the hamstring muscle group increased the passive range of motion in hip joints.

Given that resistance training, massage and stretching can be improved performance, it is possible that if resistance training, massage and stretching (static and PNF) are included in a training program, their effects could be additive. However it is not clear what type of stretching (static or PNF) or massage is better used in combination with resistance training and to our knowledge, no previous studies have examined these methods against each other. Therefore, the purpose of this study was to determine the comparison between the effects of a resistance training combined with massage, PNF and static stretching on some physical fitness factors (flexibility, muscle strength, muscle volume and explosive power) in non-athlete male students.

Material & Methods

Subjects

Forty healthy nonathlete male students of Guilan University volunteered to participate in this study. Subjects were randomly divided into four groups; resistance training (RT) group (n=10), resistance training combined with static stretching exercises (RT + ST) group (n=10), resistance training combined with proprioceptive neuromuscular facilitation (PNF) stretching (RT + PNF) group (n=10), and resistance training combined with massage (RT+MAS) group (n=10). Demographic data are presented in table 1. Before undergoing the tests, the subjects were given explanations about the assessment procedures, study objectives, and the possible benefits and risks and all participants completed a written informed consent and were allowed to discontinue the study at any time. The Institutional Review Board of the University approved the research protocol. All subjects based on medical information questionnaire were healthy and had no specific disease, also did not follow a specific diet and had to be physical inactive at least six months before the study.
To ensure compliance and consistency among sessions, members of the research team did the assigned position (beyond the expected position) at approximately 70% of estimated 1 repetition maximum (1RM) values were obtained on the following exercises: bench press, triceps pushdown and lateral pull down. The resistance training program consisted of 3 lifts: triceps pushdown, bench press and lateral pull down. The training consisted of 3 sets of 8 repetitions, and the initial weight was 80% of the pre-1RM. Rest times between sets were 2–3 minutes, and 3–5 minutes elapsed between the 3 different lifts. The resistance training program was performed 3 days (Sunday, Tuesday and Thursday) each week for 8 weeks. After the 8-week training program, post-testing for 1RM were repeated in the same manner in which they were performed during pre-testing. Also, the 8 week’s static stretching program consisted of 15 different static stretches designed to stretch all of the major upper-extremity muscle groups (pectoralis major, triceps, biceps, teres minor & major and deltoitus). Each of subjects actively performed (i.e., unassisted stretching) the 15 exercises, and 12 of the 15 exercises were also performed passively (i.e., assisted stretching). To ensure compliance and consistency among sessions, members of the research team did the passive stretching. For each stretch, the muscle was held in the stretched position for 15 s, and this was repeated three times. A 15-s rest period was implemented between trials, and a minimum period of 1 min separated the different exercises. Also, the PNF stretching program consisted of four series of exertions in which the muscles were contracted isometrically for 5 s and sustained, motionless, for 30 s in the movement position (beyond the discomfort threshold), the series were spaced by 20-s intervals. Also deep friction massage technique is used to massage all of the major upper-extremity muscle groups (pectoralis major, triceps, biceps, teres minor & major and deltoitus). Each stretching and massage session lasted approximately 30 min and was performed 3 days (Saturday, Monday, Wednesday) each week for 8 weeks.

Table 1: Baseline physical characteristics. Data are means (±SD)

<table>
<thead>
<tr>
<th></th>
<th>RT (n=10)</th>
<th>RT + ST (n=10)</th>
<th>RT + PNF (n=10)</th>
<th>RT + MAS (n=10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yrs)</td>
<td>20.6±3.1</td>
<td>23.1±1.4</td>
<td>22.2±1.2</td>
<td>20.5±2.1</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>176.3±3.2</td>
<td>174.3±2.8</td>
<td>173.2±2.6</td>
<td>171.2±2.8</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>70.7±1.3</td>
<td>75.6±3.3</td>
<td>71.3±2.5</td>
<td>70.7±1.3</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>22.74±3.43</td>
<td>24.88±4.36</td>
<td>23.76±2.54</td>
<td>24.22±3.18</td>
</tr>
</tbody>
</table>

RT= Resistance training group. RT + ST= Resistance training combined with static stretching exercises group. RT + PNF= Resistance training combined with proprioceptive neuromuscular facilitation (PNF) stretching group. RT + MAS= Resistance training combined with massage group.

Experimental design

Before starting the training, pre-1 repetition maximum (1RM) values were obtained on the following exercises: bench press, triceps pushdown and lateral pull down. The resistance training program consisted of 3 lifts: triceps pushdown, bench press and lateral pull down. The training consisted of 3 sets of 8 repetitions, and the initial weight was 80% of the pre-1RM. Rest times between sets were 2–3 minutes, and 3–5 minutes elapsed between the 3 different lifts. The resistance training program was performed 3 days (Sunday, Tuesday and Thursday) each week for 8 weeks. After the 8-week training program, post-testing for 1RM were repeated in the same manner in which they were performed during pre-testing. Also, the 8 week’s static stretching program consisted of 15 different static stretches designed to stretch all of the major upper-extremity muscle groups (pectoralis major, triceps, biceps, teres minor & major and deltoitus). Each of subjects actively performed (i.e., unassisted stretching) the 15 exercises, and 12 of the 15 exercises were also performed passively (i.e., assisted stretching). To ensure compliance and consistency among sessions, members of the research team did the passive stretching. For each stretch, the muscle was held in the stretched position for 15 s, and this was repeated three times. A 15-s rest period was implemented between trials, and a minimum period of 1 min separated the different exercises. Also, the PNF stretching program consisted of four series of exertions in which the muscles were contracted isometrically for 5 s and sustained, motionless, for 30 s in the movement position (beyond the discomfort threshold), the series were spaced by 20-s intervals. Also deep friction massage technique is used to massage all of the major upper-extremity muscle groups (pectoralis major, triceps, biceps, teres minor & major and deltoitus). Each stretching and massage session lasted approximately 30 min and was performed 3 days (Saturday, Monday, Wednesday) each week for 8 weeks.

Strength measures

Upper body maximal strength was assessed by using one repetition maximum (1RM) actions. The bench press is a measure of dynamic strength of the upper body. Bench press testing was performed in the standard supine position: each participant lowered the bar until contact with the chest was achieved and subsequently lifted the bar back to the fully extended elbow position.

Each subject performed a warm-up set using a resistance (5-10 repetitions of bench press exercises) that was approximately 40-60% of his perceived maximum. After a 2 minute rest, the participants attempted to complete 10 repetitions at approximately 70% of estimated 1-RM. If the participant was successful at performing 10 repetitions at this weight increment, the weight was increased conservatively. After a 3-5 minute rest the participant was required to attempt to complete 10 repetitions at the new resistance increment. This procedure was continued until each participant completed no more than 10 repetitions. This value was then recorded as the weight lifted for the amount of repetitions and each participant’s 1-RM value was then calculated using the following formula (Brzycki, 1993):

\[
1RM = \frac{Weight(kg)}{1.0278 - (0.0278 \times \text{number of repetitions})}
\]

All 1RM measurements were reported in kilograms for subsequent data analysis.

Explosive power

Explosive power measured by overhead medicine ball throw (forwards) test. For implement of this test, the subject stands at a line with the feet side by side and slightly apart, and facing the direction to which the ball is to be thrown. The ball is held with the hands on the side and slightly behind the center. The throwing action is similar to that used for a soccer/football sideline throw-in. The ball is brought back behind the head, then thrown
vigorously forward as far as possible. The subject is permitted to step forward over the line after the ball is released, and is in fact encouraged to do so in maximizing the distance (meter) of the throw. Three attempts are allowed. The distance from the starting position to where the ball lands is recorded. The best result of three throws is used. The weight of the medicine ball was 2 kilograms (Duncan et al., 2005).

**Muscle volume**

Upper body muscle volume was assessed by using upper arm muscle size. Upper arm circumference (millimeters) was measured to the nearest millimeter with a steel tape with the right arm hanging relaxed. The measurement was taken midway between the point of the acromion and olecranon process. Triceps skin fold (millimeters) was measured to the nearest millimeter with a Lange skin caliper having a pressure 10 g/mm2 of contact surface area. The measurement was taken on the back of the arm and midway between the point of the acromion and olecranon process while the arm was hanging relaxed (Frisancho, 1974). Estimates of muscle size were derived: 1) Arm muscle diameter (millimeters) = arm circumference (mm)/ π - triceps skin fold (mm), 2) Arm muscle circumference (mm) = arm circumference (mm) - π (triceps skin fold, 3) Arm muscle area (mm²) = π/4(arm diameter²).

**Flexibility**

Upper body flexibility measured by Two-armed "back scratch" Test. This test is done in the standing position. Place one hand behind the head and back over the shoulder, and reach as far as possible down the middle of body back, your palm touching body and the fingers directed downwards. Place the other arm behind body back, palm facing outward and fingers upward and reach up as far as possible attempting to touch or overlap the middle fingers of both hands. An assistant is required to direct the subject so that the fingers are aligned, and to measure the distance between the tips of the middle fingers. If the fingertips touch then the score is zero. If they do not touch, measure the distance between the fingertips (a negative score), if they overlap, measure by how much (a positive score). Practice two times, and then test two times (Marzilli et al., 2004).

**Statistical Analysis**

All statistical analyses were performed using SPSS software (version 18.0; SPSS Inc.). All data are presented as mean ± SD. A one-way analysis of variance (ANOVA) and tukey’s test were applied for examining the difference in the means of the four groups. Changes from baseline were assessed using the paired sample t-test. A criterion α level of P ≤ 0.05 was used to determine statistical significance.

**Results**

The results of this study are presented in table 2. There were significant changes in the flexibility, muscle strength, muscle volume and explosive power for all training groups (P < 0.05).

<table>
<thead>
<tr>
<th>Variables</th>
<th>Pre</th>
<th>RT+ST</th>
<th>RT+PNF</th>
<th>RT+MAS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper body strength</td>
<td>79.25±2.73</td>
<td>83.56±5.58</td>
<td>82.75±5.58</td>
<td>80.25±7.49</td>
</tr>
<tr>
<td>(kg)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Muscle volume (mm²)</td>
<td>302.2±21.3</td>
<td>298.3±24.1</td>
<td>298.2±17.5</td>
<td>277.1±30.5</td>
</tr>
<tr>
<td>Explosive power (m)</td>
<td>8.03±0.56</td>
<td>7.94±0.84</td>
<td>8.05±0.58</td>
<td>8.01±1.10</td>
</tr>
<tr>
<td>Flexibility (cm)</td>
<td>1.6±0.5</td>
<td>1.4±0.2</td>
<td>1.3±0.4</td>
<td>1.5±0.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
| RT: Resistance training group, RT+ST: Resistance training combined with static stretching group, RT+PNF: Resistance training combined with PNF stretching group and RT+MAS: Resistance training combined with massage group. * Significantly different from corresponding to pre training value.

The average (±SD) 1RM values are presented in table 3. There was no significant difference between RT, RT+PNF, RT+ST and RT+MAS for upper body strength 1RM (p = 0.18), muscle volume (p = 0.54), flexibility...
(p = 0.86) or explosive power (p = 0.63). However, results showed the RT + PNF group; slightly greater improved their strength, explosive power, flexibility and muscle volume when compared to other groups.

<table>
<thead>
<tr>
<th>Variables</th>
<th>F</th>
<th>P</th>
<th>Mean difference</th>
<th>t</th>
<th>df</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper body Strength(kg)</td>
<td>1.28</td>
<td>0.17</td>
<td>4.75</td>
<td>1.39</td>
<td>36</td>
<td>0.18</td>
</tr>
<tr>
<td>Muscle Volume (mm³)</td>
<td>0.84</td>
<td>0.04</td>
<td>6.96</td>
<td>0.76</td>
<td>36</td>
<td>0.54</td>
</tr>
<tr>
<td>Explosive power(m)</td>
<td>6.98</td>
<td>0.01</td>
<td>0.15</td>
<td>0.48</td>
<td>36</td>
<td>0.63</td>
</tr>
<tr>
<td>Flexibility(cm)</td>
<td>5.51</td>
<td>0.30</td>
<td>0.03</td>
<td>0.17</td>
<td>36</td>
<td>0.86</td>
</tr>
</tbody>
</table>

RT: Resistance training group, RT+ST: Resistance training combined with static stretching group, RT+PNF: Resistance training combined with PNF stretching group and RT+MAS: Resistance training combined with massage group.

**Discussion and Conclusion**

The primary purpose of this study was to compare between the effects of a resistance training combined with massage, PNF and static stretching on performance (flexibility, muscle strength, muscle volume and explosive power) during an 8-week training protocol in non-athlete male students. The results of this study suggest that for all groups (RT, RT+ST, RT+PNF and RT+MAS) significantly improved in the flexibility, muscle strength (1RM bench press), muscle volume and explosive power during an 8-week training protocol. Also, these results showed no significant difference (P > 0.05) between groups (RT, RT+ST, RT+PNF and RT+MAS) but results showed the RT+PNF group slightly greater improved their strength, flexibility, explosive power and muscle volume when compared to RT, RT+ST and RT+MAS groups.

Resistance training combined with stretching is more effective in the RT+PNF, RT+ST and RT+MAS group is of great interest. Likely that small non-significant difference was observed related to the effects of stretching (PNF and static) and massage. Because the responses to stretching and resistance training are similar, it is possible that if both resistance training and stretching are included in a training program, their effects could be additive. Some data have indicated that both massage and stretching causes a decline in motor unit activation (Dishman and Bulbulian, 2001) and reduces muscle stiffness as evidenced by a lengthening of massaged muscle (Hernandez-Reif et al., 2001). Also some of the common effects stated in the majority of current literature for massage include increased blood flow, increased lymphatic drainage, and neural stimulation, encouragement of venous return, relief of pain, injury rehabilitation and relaxation. Many claims are made about massage, but few are backed by any empirical data regarding either mechanisms or effects. Possible mechanisms of massage have been categorized into biomechanical, physiological, neurological and psychological (Goldspink and Harridge, 2003).

These findings were consistent to the some studies by Arazi et al., (2012) Kokkonen et al., (2010), Marzilli et al., (2004), Hunter and Marshall (2002), Church et al., (2001), and Crosman et al., (1984). However, other studies reports significant reduction in the performance after stretching and massage (Church et al., 2001; Bradley et al., 2007; Hunter et al., 2006).

Although this study was not designed to investigate the responsible mechanism(s), it is most probable that the massage and stretching-based flexibility, muscle strength, muscle volume and explosive power improvements are related to morphological changes. Stretching programs might cause strength gains is up to speculation; however, in a manner similar to resistance training, passive stretching is related to increases in muscle hypertrophy (Folland and Wikkiams, 2007; Goldspink and Harridge, 2003). For instance, placing a muscle on stretch can induce Z-line ruptures (Goldspink and Harridge, 2003); increase protein synthesis (Goldspink and Harridge, 2003) and growth factor production, and trigger myoblast proliferation (Day et al., 1997). The synergistic influence of the stretching program on flexibility and strength gains might also be related to increases in muscle length. Increases in length lead to increases in both contractile velocities and the forces generated at a given shortening velocity (Lieber, 2002). In situ lengthening has been reported through the application of diverse mechanisms of continuous stretch such as casting a muscle in a stretched position, increasing bone length, or relocating tendon insertions (Lieber, 2002). Also, muscle lengthening results from programs of intermittent stretching performed for several days. For example, (Williams, 1994) reported that 30
minutes of daily stretching was sufficient to cause an increase in the number of sarcomeres in series. Also, the mechanism of flexibility action is that static stretching exercise causes plastic stretching which results in irreversible tissue elongation (Turner et al., 1988).

Finally, RT+PNF group showed better results when compared the RT, RT+ST and RT+MAS groups. Likely that small non-significant difference was observed related to the effect of PNF stretching. The basis for PNF stretching is theorized to be through neural inhibition of the muscle group being stretched. The proposed neural inhibition reduces reflex activity, which then promotes greater relaxation and decreased resistance to stretch, and hence greater range of movement (Hutton, 1993).

The success of PNF stretches has largely been attributed to neurophysiologic mechanisms (Sady et al., 1982). Most of them are credited to the muscle spindle and the Golgi tendon organs and their reflex activity: Activation of the muscle spindle elicits contraction of the agonist and inhibition of the antagonist, sometimes referred to as the myotatic reflex or stretch reflex (Mayer et al., 2005). Activation of Golgi tendon organs elicits inhibition of the agonist (autogenic inhibition, or inverse myotatic reflex (Miyahara et al., 2005) while facilitating the antagonist (Enoka, 2002). The mechanism by which autogenic inhibition is purported to contribute to PNF efficacy. Increased inhibition from Ib-inhibitory interneurones, a result of the amplified Golgi tendon organs input, results in a reduced level of excitability of the homonymous target muscle, thereby facilitating additional stretch (Mitchell et al., 2009).

Autogenic inhibition (historically known as the inverse myotatic reflex or autogenetic inhibition) refers to a reduction in excitability of a contracting or stretched muscle, that in the past has been solely attributed to the increased inhibitory input arising from Golgi tendon organs within the same muscle (Laporte and Lloyd, 1952). The reduced efferent (motor) drive to the muscle by way of autogenic inhibition is a factor believed to assist TM elongation (Tanigawa, 1972).

PNF stretching is designed to maximize improvements in flexibility which aid in preventing or recovering from these issues. Finally, muscle volume, explosive power, strength and flexibility pertain to assisting the vast majority of the population regardless of age, gender, or athletic skill level. Furthermore, variables such as the participants’ comfort levels, muscle soreness or fatigue from PNF exercises, diet, and rest were not controlled, which may have slightly affected the results. Another disadvantage of PNF stretching is that a partner is required to assist with the stretch (Prentice and William, 1999). According to the results of this study, there was no significant difference between groups. Therefore, we cannot necessarily suggest that PNF, static and massage stretching exercises combined with resistance training is effective.

Yet the, greater improvement (small non-significant difference) was observed in performance of the RT+PNF group when compared to RT, RT+ST and RT+MAS groups. This observation is important because, nowadays the high level of muscular fitness can aid to achieve best performance. On this basis, Athletes are searching for ways to improve their performance to provide them with an advantage over their opponent. However, these results have need to further study at future.

In conclusion, the results of this investigation suggested that 8-week resistance training combined with the PNF, static stretching and massage increase muscle volume, explosive power, flexibility and upper body strength in non-athlete male students. But given that there was no significant difference between the applied methods. Thus, the PNF, static stretching and massage combined with resistance training can not necessarily be effective on muscle volume, strength, explosive power and flexibility.

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References


