The Effect of Stretching Duration on Flexibility During Warming Up in Adolescent Soccer Players

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SUMMARY

The aim of the present study was to examine the effects of different duration static stretching and multiple stretching sessions on the passive joint range of motion (ROM) of the lower extremities of adolescent soccer players, using a general warming up procedure or stretching alone. Seventeen adolescent soccer players with a mean age of 15.8 ±0.6 years, height 174.0 ±4.3 cm, body mass 66.4 ±3.4 kg and 5.0 ±0.8 years of training participated in this study. The subjects performed, in nonconsecutive days, three static stretching protocols on the lower extremities muscle groups lasting for 30 seconds each. The first stretching protocol consisted of one 30 second stretch (1x30s). The second protocol consisted of two 15 second stretches (2x15s), whereas the third consisted of six 5 second stretches (6x5s). All three stretching protocols were performed twice, once after a general warming up session and once without prior warming up. ROM was determined during hip flexion, hip extension, hip abduction, knee flexion and ankle dorsiflexion for the right and left side of the body, using a flexometer and a goniometer. A mixed within- and between–subjects analysis of variance with repeated measures revealed similar ROM values between both two sides for all measured joints. No significant differences were observed among the stretching
protocols whether warming up preceded the experiment or not. Further statistical analysis of the data indicated significant improvements after all flexibility protocols. These findings suggest that one 30-seconds static stretch on the muscle of the lower extremities produced the same effect as two 15-seconds or six 5-seconds stretches over a flexibility training session and these effects are not affected by warming up procedures.

Key Words: Flexibility, Warming-up, Range of motion, Adolescent soccer players

INTRODUCTION

Muscle shortness and muscle contractures restrict the normal muscle action and are therefore considered as limiting factors for the range of motion. Performing stretching systematically could prevent such detrimental effects. Stretching can positively affect the everyday functional activities of an individual and narrow the risks for injury (Reid 1992).

It has been proposed (Garrett 1990) that stretching exercises may alter the viscoelastic behaviour of the muscle-tendon unit and thereby reduce the muscle-tendon injury risks. Muscle-tendon extensibility has been shown to increase during elevated temperatures, thus, it is commonly recommended that a warm-up session precede any stretching regimen (Garrett 1990; Smith 1994). Increased tissue temperature can be achieved relatively soon after the initiation of exercise and 10-min of warming-up exercise has been suggested as a sufficient preparation for muscle performance (Astrand and Rodahl 1986). According to Beaulieu (1981) a minimum of 5 minutes of gradually progressive muscular exercises such as brisk walking, jogging, or cycling should precede each stretching session in an attempt to warm the muscles and the connective tissue prior to stretching. Stretching after warming-up has been found to increase the ROM of the lower extremities (Wiktorsson-Moller et al. 1983; McNair and Stanley 1996), however, according to Wiktorsson-Moller and his associates (1983), warming-up on the cycle-ergometer for 15 minutes only increases the ankle range of motion and not the hamstring or the quadriceps ROM.

A short-term stretching program that lasted for 6-weeks (Knight et al. 2001) demonstrated improvements on the ankle dorsiflexion, using a stretching protocol and active warm-up exercises prior to the stretching. The Williford et al. (1986) study that lasted for 9 weeks investigated the effects of jogging prior to stretching compared to stretching alone on the shoulder, trunk, hamstring, and ankle flexibility. Researchers concluded that both methods were equally effective in increasing ROM and flexibility. Although connective tissue properties have been shown to change with increased temperature in animal models (Sapega 1981; Warren et al. 1976; Strickler et al. 1990), stretching alone appears to improve maximal joint ROM in humans (Taylor et al. 1995; Knight et al. 2001). However, it still remains unclear whether stretching alone can alter ROM in human subjects during acute conditions.

Improvements in flexibility have also been associated with the amount and the duration of the applied force during stretching (Sapega 1981). Several authors have made suggestions regarding the appropriate duration a stretch should be maintained, in order to be effective (Beaulieu 1981; Sady et al. 1982). Nevertheless, little scientific research exists on the duration and the number of repetitions of stretches needed to exert beneficial effects. Madding et al. (1987) examined hip abduction range of motion as a result of stretching for 15 seconds, 45 seconds, or 2 minutes. All those who underwent stretching exhibited significant improvements in flexibility over controls that did not stretch, but stretching for longer than 15 seconds did not continue to improve flexibility. Borms et al. (1987) compared the results of static stretch on hip flexibility for 10, 20 and 30 seconds. All three experimental groups increased hip flexibility but exhibited no significant between-group differences. Bandy and Irion (1994) recorded no
increments in flexibility when stretching lasted from 30 to 60 seconds.

However, all the above scientists experimented with the duration of static stretching in one single effort and not in multiple ones. Taylor and his associates (1990) reported that maximal benefit on flexibility occurs when each muscle group was stretched for four times; further stretching did not result in significant increases in muscle length. In an attempt to determine the most effective method for improving joint flexibility, Wiktorsson-Moller et al. (1983) suggested that five to six repetitions are sufficient to increase hip, knee, and ankle ROM. Multiple repetitions were also used by Bandy et al. (1997) in adults aged 21-39 years old, as well as by Feland et al. (2001) in elders aged more than 65 years old, in a stretching protocol that lasted for 6 weeks. The first experiment revealed significant improvements in ROM whether stretching was repeated three times for 30 seconds each or three times for 60 seconds each. Feland et al. (2001) recorded significant improvements in ROM when stretching was performed four times for 60 seconds each, compared to four times for 15 or 30 seconds each. However, no effort was done in these studies to control the total stretching time, while manipulating stretch duration. This factor could have a different impact in the improvement of joint ROM during passive stretching.

Considering that many athletes and especially soccer players tend to perform stretching without prior warming up, and given that the time spent in each stretch is the minimum for most athletes, it would be interesting to examine the effects of passive stretching on the improvement of joint ROM, when multiple stretching efforts are performed in the same duration during active warming up procedures prior to stretching or when stretching is performed alone.

The aim of the present study was to investigate the effects of passive stretching duration, and multiple stretches in different duration, on the ROM during hip flexion, hip extension, hip abduction, knee flexion and ankle dorsiflexion while controlling the total amount of the time spent in a stretching session, in adolescent soccer players with stretching exercises being performed after and without a general warming-up session.

MATERIALS AND METHODS

Seventeen adolescent soccer players aged 15.8 ±0.6 (Mean ±SD) years old with 5.0 ±0.8 years of training volunteered to act as subjects for the present study. Subjects’ height was 174.0 ±4.3cm and their body mass was 66.4 ±3.4kg.

The experimental protocol consisted of three different passive stretching programs of the lower limbs, of total duration 30 seconds each. All three programs were performed twice, the first time without any warming up procedure and the second time after a general warming up session. The first stretching program consisted of one 30-second stretch (1x30s). The second stretching program consisted of two 15-second stretches (2x15s), whereas the third consisted of six stretches that lasted for 5-seconds each (6x5s). The stretching programs were performed solo as the control measurements and the stretching programs preceded by warming up sessions formed the experimental measurements. Between each set of the last two stretching programs there was a 10 second rest interval. All three programs were performed in exactly the same manner, whether warming-up preceeded stretching or not. The active warming-up session in the flexibility training programs lasted for 20 minutes and comprised of continuous jogging at a normal stride with a mean heart rate of 120-130 bpm. Intensity was estimated for all subjects via telemetry (Sport Tester, Finland). All the stretching groups performed the stretching exercises identically, under the direct supervision and guidance of the investigators.

The programs were performed in random order so as to eliminate the effects of familiarity on the results. The subjects agreed to maintain their normal exercise and activity levels for the duration of the study. All subjects were healthy with no history of musculoskeletal or
neurological disease. A sports medicine accredited doctor examined them physically before the beginning of the measurements. Before participating in the study, all subjects as well as their parents were informed of the nature, purpose and possible risks involved in the study before giving their informed written consent for participation.

All subjects performed the flexibility-training protocols in different training sessions. Each training session was separated by at least 1 week from the next, for each subject. The stretching exercises for all flexibility-training protocols consisted of passive lengthening of the muscles without causing pain maintained for 30, 15 or 5 sec at the position of maximum lengthening according to the flexibility program performed. The working muscle groups should be adductors, hip flexors, hamstrings, quadriceps and soleus of both body sides. Briefing sessions were co-ordinated in which visual demonstrations and individual assistance was provided to ensure all subjects felt confident with the experiment and competent in the execution of the stretches.

Five ROMs of the lower extremities (hip flexion, hip extension, hip abduction, knee flexion and ankle dorsiflexion with knee flexed) were measured. The measurements were performed prior to and immediately after each stretching protocol. Hip abduction was measured with a specially constructed double protractor goniometer, and the rest of the movements were measured with a Myrin flexometer (Lic Rehab. 17183 Solna, Sweden). This flexometer is a modification of the Leighton flexometer, and consists of a circular scale with a weighed pointer controlled by gravity attached to the centre. All flexibility measurements were performed according to the Ekstrand et al. (1982) method. The coefficient of variation for the method of goniometric measurements was high (1.9 ±0.7%).

All measurements except for ankle dorsiflexion were held on an adjustable bench. The initial and final positions of each movement were passively measured starting from a 0 point, as defined by the American Academy of Orthopaedic Surgeons (1965). Maximal flexibility was defined as the point where the joint attained to end-range. Two examiners performed the measurements; a tester, who was responsible for the maximal passive movement of the examined joint and an observer, who was responsible for the actual ROM measurement. Throughout the experiment the same experimenter was assigned the same task. Both tester and observer were experienced and familiarized with the measurement of joint ROM. Ranges were passively measured in the lower extremity joints first on the right-side and then on the left-side of the body. All pretest and posttest measurements were taken at approximately the same time of day. No warning-up exercises were performed prior to the initial flexibility measurements, and none of the subjects undertook any training program or other type of exercise during the 48 hours prior to the measurements. The reliability coefficient of each measurement was high and has been reported elsewhere (Zakas et al., 2003).

Statistical analysis

A mixed within and between subjects 3x2x2x5 ANOVA model with repeated measurements over tests was applied for each depended variable. The first repeated factor was the joint and this had 5 levels (hip flexion, hip extension, hip abduction, knee flexion and ankle dorsiflexion). The second repeated factor was the leg and this had 2 levels (right and left leg). The third repeated factor was the warm-up and this had 2 levels (stretching alone and stretching preceded by warm-up). The between subjects factor was the treatment protocols and this had 3 levels (1x30s, 2x15s, and 6x5s). When significant differences were found, a Scheffe post hoc analysis was applied to determine the significance of the relationship of the means. In addition, when significant interactions were noted, these were broken down further by using analysis of simple main effects. Statistical significance was accepted at the 95% level (p<.05).

RESULTS
The analysis of the main effects revealed no significant differences between the two legs, for either control or experimental measurements (p>0.05), indicating that the range of motion did not differ between the two body sides in the three testing programs. Additionally, no significant interactions were noted for joint x treatment protocol group, for leg x treatment protocol group, for joint x leg or for joint x leg x treatment protocol group.

A further analysis by paired t-test that used for each treatment, protocol group in each flexibility joint movement, showed no significant differences in the joint ROM between the two body sides of the players. Thus, only the results of the right side will be presented.

A significant increase was observed in all joint ROMs (p<0.01 to p<0.001) immediately after flexibility training protocol in all three-flexibility treatment protocols, when warming up preceded stretching (Table 1) and without warming up (Table 2). The increments in degrees were similar with or without warming up. During hip flexion the increments varied from 8.4 to 10.1 degrees, during hip extension from 5.9 to 6.6 degrees, during hip abduction from 4.9 to 5.4 degrees, during knee flexion from 4.0 to 4.2 degrees and during ankle dorsiflexion the increments varied from 2.8 to 4.0 degrees.

Table 1. Five ranges of motion in adolescent team soccer players initially and immediately after the flexibility training sessions of different duration with warming-up procedures preceded. Mean values are given in degrees±SD.

<table>
<thead>
<tr>
<th>Treatment groups</th>
<th>Hip flexion (degrees)</th>
<th>Hip extension (degrees)</th>
<th>Hip abduction (degrees)</th>
<th>Knee flexion (degrees)</th>
<th>Ankle dor/flexion (degrees)</th>
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<td>pre #</td>
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<td>pre</td>
<td>post</td>
<td>pre</td>
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<tr>
<td>treatment 1</td>
<td>62.4</td>
<td>±6.2</td>
<td>91.8***</td>
<td>±9.1</td>
<td>76.3</td>
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<tr>
<td>(1x30 sec)</td>
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<tr>
<td>treatment 2</td>
<td>83.0</td>
<td>±9.3</td>
<td>91.4***</td>
<td>±9.6</td>
<td>75.0</td>
</tr>
<tr>
<td>(2x15 sec)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>treatment 3</td>
<td>82.6</td>
<td>±8.6</td>
<td>92.7***</td>
<td>±9.9</td>
<td>75.0</td>
</tr>
<tr>
<td>(6x5sec)</td>
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@: ankle dorsiflexion, #: initial values, $: after flexibility training session values. ***p<0.01, ****p<0.001.
Our study was designed in order to obtain a more thorough understanding of whether elongation of a warmed-up muscle improves ROM, when the passive stretching lasts for half a minute or when the stretches are repeated more times in the same total duration, as well as how joint ROM is affected when stretching is performed with and without warming up. According to the data, in the treatment that lasted for 30 seconds or less, active warm-up prior to stretching or stretching alone achieved similar results in increasing ROM in all measured joints of the lower extremities.

In unpublished findings we found similar results during acute flexibility training conditions in adolescent soccer players when after a general warming up subjects performed static stretching for 30 seconds one time, 15 seconds for two times and 5 seconds for six times. Regarding the 30 second stretch that was performed once, the results of our study are in conjunction with previous results obtained in short-term flexibility training programs. Borms and his colleagues (1987) demonstrated significant increases in hip flexibility ROM when subjects performed 30, 20 and 10 seconds single static stretching for 10 weeks, twice per week. Bandy and Irion (1994) as well as Bandy et al. (1997) found significant improvements in the ROM, when static stretching of the femoral lasted for 30 seconds.

Scientific data is conflicting regarding the ideal number of stretches needed in order to obtain the maximum gains in joint ROM. The present study demonstrated similar increments in joint ROM when the stretches were performed once, twice or six times in a total duration of 30 seconds. Similar results have been published elsewhere (Bandy et al. 1997) in the hamstring muscles ROM, irrespectively of whether the stretches were performed once, or three times for 30 or 60 seconds. Other studies (Roberts and Wilson 1999) also demonstrated similar increments in passive ROM during hip and knee flexion and extension, irrespectively of whether the static stretches were performed three times for 15 seconds or nine times for 5 seconds each, in a 5 week static stretching program. Taylor and his associates (1990) recorded the greatest gains in ROM of animal subjects with 4 repetitions of the stretches, whereas Wiktorsson-Moller et al. (1983) suggested that five to six repetitions are sufficient to increase hip, knee, and ankle ROM. On the contrary, a study on elderly subjects (Feland et al. 2001) concluded that a 60 seconds stretch was more effective in increasing knee extension ROM than a 15 or 30 second stretch of the same total duration. This might be due to the fact that elderly people need longer duration stretches in order to improve ROM, since joint mobility declines with increasing age, acknowledging that the results should be applied only to a

### TABLE 2

<table>
<thead>
<tr>
<th>Treatment groups</th>
<th>Hip flexion (degrees)</th>
<th>Hip extension (degrees)</th>
<th>Hip abduction (degrees)</th>
<th>Knee flexion (degrees)</th>
<th>Ankle dorsiflexion (degrees)</th>
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<td></td>
<td>pre #</td>
<td>post $</td>
<td>pre</td>
<td>post</td>
<td>pre</td>
</tr>
<tr>
<td>treatment 1</td>
<td>82.8 ± 8.8</td>
<td>92.3*** ± 6.0</td>
<td>76.0 ± 7.4</td>
<td>82.6*** ± 6.4</td>
<td>45.0 ± 6.4</td>
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<tr>
<td>1x30 sec</td>
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<tr>
<td>treatment 2</td>
<td>83.2 ± 9.3</td>
<td>90.6*** ± 6.0</td>
<td>75.0 ± 6.3</td>
<td>81.8*** ± 6.3</td>
<td>44.5 ± 6.7</td>
</tr>
<tr>
<td>2x15 sec</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>treatment 3</td>
<td>82.5 ± 8.4</td>
<td>92.5*** ± 6.0</td>
<td>76.2 ± 8.3</td>
<td>82.5*** ± 6.3</td>
<td>45.1 ± 6.1</td>
</tr>
<tr>
<td>6x5 sec</td>
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</table>

@ ankle dorsiflexion, # initial values, $ after flexibility training session values, ***p < 0.01, **p < 0.001.

DISCUSSION

Our study was designed in order to obtain a more thorough understanding of whether elongation of a warmed-up muscle improves ROM, when the passive stretching lasts for half a minute or when the stretches are repeated more times in the same total duration, as well as how joint ROM is affected when stretching is performed with and without warming up. According to the data, in the treatment that lasted for 30 seconds or less, active warm-up prior to stretching or stretching alone achieved similar results in increasing ROM in all measured joints of the lower extremities.

In unpublished findings we found similar results during acute flexibility training conditions in adolescent soccer players when after a general warming up subjects performed static stretching for 30 seconds one time, 15 seconds for two times and 5 seconds for six times. Regarding the 30 second stretch that was performed once, the results of our study are in conjunction with previous results obtained in short-term flexibility training programs. Borms and his colleagues (1987) demonstrated significant increases in hip flexibility ROM when subjects performed 30, 20 and 10 seconds single static stretching for 10 weeks, twice per week. Bandy and Irion (1994) as well as Bandy et al. (1997) found significant improvements in the ROM, when static stretching of the femoral lasted for 30 seconds.

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similar age group. Hence, it appears that the increments in joint ROM is irrespective to the
frequency of the elongation performed by the muscles during static stretching, however, further
research is needed in order to clarify the issue.

The results of the present study demonstrated similar increases on the flexibility when static
stretching was performed after or without a general active warming-up session. Similar results
have been published in previous studies conducted either in acute stretching conditions or
after a short-term stretching program. Taylor et al. (1995) reported increments on hamstring
ROM when the stretching protocol was performed without prior stretching but with passive
warm compresses on the hamstring muscles. McNair and Stanley (1996) also demonstrated
increases on the dorsiflexion ROM using a stretching protocol without warming up and a
stretching protocol that included running prior to the stretches. Increases in hip flexion, hip
extension, hip abduction, knee flexion and ankle dorsiflexion ROM were demonstrated by
Wiktorsson-Moller et al. (1983) after a stretching protocol that was preceded by a 15-min
warming-up session on the cycling ergometer. In a short-term-stretching program, Knight et al.
(2001) demonstrated increases on ankle dorsiflexion ROM when a 6-weeks program was
performed with stretching alone and with active exercise warming-up prior to the stretching.
Similar results were also published by Williford et al. (1986) concerning shoulder, trunk,
hamstring and ankle flexibility, when a 9-week stretching program was performed with and
without stretching.

The increased muscle temperature during warming-up does not appear to improve flexibility
when it is not associated with stretching exercises or when it does not include active muscle
elongation (Zakas et al. 2003) hence, passive heat alone cannot cause any increase in hip
range of motion (Henricson et al. 1984). Shrier and Gossal (2000) reported that contrary to
popular belief, warming-up performed without stretching does not increase range of motion.
Most of the research in this area has been performed on animals using passive warming
devices such as heat lamps, whereas in human studies, physical activity is the most popular
means for warming the muscles. The belief that warming-up is associated with improvements
in flexibility derives from animal experiments in vitro. These studies have demonstrated that
tissue temperature can significantly alter the extensibility of connective tissue and, therefore,
affect joint flexibility (Saepa et al. 1981; Warren et al. 1976). The impact of connective tissue
as a stimulus for stretching seems however overestimated, whereas the myogenic constraints
in determining ROM appears to be underestimated (Hutton 1992). It has been suggested (Hill
1968; Magid and Law 1985) that in still sartorius muscles of the frog a proportion of the cross-
bridges are connected and during the muscle's elongation these are detached.

The improved joint flexibility of the soccer players performing the stretching exercises only,
could be attributed to the myogenic constraints instead of the connective tissue lengthening,
since similar improvements in the ROM have occurred when warming up preceded the
stretches. These improvements appear to be the results of static muscle lengthening.
According to Van der Poel (1998) muscle length is completely dependent on how the muscle is
used during movement. However, further research is needed in this area in order to further
identify the mechanisms involved in improving flexibility, since the role of connective tissue in
affecting flexibility appears to be over-rated.

CONCLUSION

The results of the present study suggest that the improvements in joint ROM of the lower
extremities appear to be irrelevant to the frequency of muscle elongation via passive stretching.
Warming-up the muscles prior to stretching does not necessarily improve flexibility in
adolescent soccer players. These findings could be helpful to players who desire to increase
their flexibility, as well as to the coaches who incorporate static stretching activities in their
training programs.
REFERENCES


