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Evaluation of warm-up for improvement in flexibility

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ABSTRACT

The purpose of this investigation was to evaluate the effects of warming the joints by jogging and then stretching on increases in joint flexibility. Subjects were 51 students enrolled in a physical conditioning class assigned to a jog and then stretch (JS), stretch and no jog (S), or a control group (C). Both the JS and S groups performed a series of stretching exercises 2 days a week for 9 weeks, with the JS group jogging for 5 minutes prior to stretching. Subjects were pretested and posttested for shoulder, hamstrings, trunk, and ankle flexibility with a Leighton flexometer. Results of *t*-tests indicated that significant increases in flexibility occurred for all of the joint angles evaluated for both the JS and S groups with the exception of trunk flexibility for the JS group. An analysis of variance (ANOVA) of gain scores indicated a significant gain in ankle flexibility for the JS group compared to S and C groups. The S group produced a significant gain in trunk flexibility compared to the JS group. Both JS and S groups were effective in improving flexibility, but when the gain scores were compared the results were variable. The data from this study again demonstrate that increases in flexibility can occur as a result of a static stretching training program. However, the results do not support the claim that warming the muscles prior to stretching by jogging will result in significant increases for all of the joint angles evaluated. Both methods offer possible advantages associated with improving joint flexibility.

Stretching exercises are often performed as a warm-up prior to participation in many exercise-related activities. Reasons for stretching relate to beliefs that stretching will increase flexibility, decrease the incidence of musculotendinous injuries, improve athletic performance, and/or prevent muscle soreness.[1-3,10]

While evidence indicates that stretching can increase flexibility, there is concern as to what stretching techniques or procedures should be used for optimal gains in flexibility.[1-4,10,13] Clinical studies conducted on laboratory animals have demonstrated that tissue temperature can significantly influence the extensibility of connective tissue and, therefore, affect joint flexibility.[5,9,11,12]

Suggestions have been made that at least 5 minutes of gradually progressive muscular exercises such as brisk walking, jogging, or cycling should precede the stretching routine in an effort to warm the muscles and connective tissue prior to stretching.[1,2] The suggestions were based upon the assumption that warming the muscles and connective tissue by jogging and then stretching would produce increased gains in flexibility and possibly prevent injury, since cold muscles and connective tissue may be more vulnerable to accidental injury through overstretching. While clinical evidence indicates that warming the connective tissue prior to stretching will increase flexibility, there is no empirical evidence to suggest that warming the joints by jogging and then stretching will significantly increase flexibility. The purpose of this investigation was to evaluate the effects of warming the joints by jogging and then stretching on increases in joint flexibility.

METHODS

Fifty-one students who were participants in a physical conditioning class agreed to participate in the study. After giving their informed consent, subjects were assigned to the JS, S, or C group. Subjects who missed more than two exercise sessions were eliminated from the study, leaving 16 in the JS group, 17 in the S group, and 11 in the C group. The

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mean age of the subjects was 23.18 years, the mean weight was 163.18 pounds, and the mean height was 68.35 inches.

Subjects were evaluated for joint range of motion using a Leighton flexometer. The reliability of the Leighton flexometer has been reported to be greater than 0.90.[6,7] For each subject, baseline data were determined by taking three trials and then repeating the three trials for each muscle group. All pretraining and posttraining measurements were taken at approximately the same time of day on the right side of the body. The flexibility of the shoulder, hamstrings, and trunk were measured as described by Sady et al.[8] Ankle flexibility was measured as described by Leighton.[7]

The flexibility training program was conducted for approximately 15 minutes per session, two times per week for 9 weeks. Stretching exercises that were specific to increasing shoulder, hamstrings, trunk, and ankle flexibility were selected. The range of motion exercises included the following:

Shoulder. The subject stood straight and raised the right arm up and back as far as possible (forward-upward elevation). The left arm was lowered and raised as far back as possible (backward elevation). Both arms were kept straight with no bend at the elbow. The back was kept straight with the head up. The stretched position was held for 30 seconds. At the end of 30 seconds the left arm assumed a position of forward-upward elevation and the right arm assumed a position of backward elevation. Each position was held for two 30 second periods.

Hamstrings. The subject started in the supine position on the floor. Both legs remained straight and extended throughout the exercise. The right leg was raised upward as far as possible and held for a 30 second period. The left leg remained in contact with the floor. At the end of 30 seconds, the right leg was lowered to the floor and the left leg was raised and stretched. Each leg was stretched for two 30 second periods.

Trunk. The subject lay on the floor with the arms positioned above the head. Both legs remained straight and in contact with the floor. The subject raised the trunk and stretched as far forward as possible toward the feet with both arms. The position was held for 30 seconds. The subject relaxed and repeated the exercise for 30 seconds.

Ankle. A jogger's wall stretch was used to stretch the ankle and Achilles tendon. The subject stood approximately 2 to 3 feet away from a solid wall. The hands were placed against the wall. One leg was kept straight with the foot flat against the floor. The other leg was bent with the foot placed closer to the wall. Slowly the hips were moved forward causing a stretch of the ankle. The position was held for two 30 second periods for both the right and left ankles. For all of the stretching exercises the stretched positions were assumed gently and slowly until tightness, not pain, was felt.

The JS group warmed the muscles and connective tissue by jogging prior to stretching. The jogging consisted of 5 minutes of light but gradually progressive jogging. At the end of 5 minutes of jogging, the JS group joined the S group and both groups started their stretching routines. Both the JS and S groups performed identical stretching routines, at the same time, under the direction of the investigators. All jogging and stretching took place in the gymnasium of the Department of Physical Education.

Statistical analysis

The reliability of the pretest and posttest measures was determined by computing correlation coefficients. The first three pretest measures were averaged and the second three pretest measures, obtained on a separate occasion, were averaged and correlation coefficients were computed to determine the reliability of the pretest measures. The same procedure was used to determine the reliability of the posttest measures.

One-way ANOVAs with the three stretching groups were conducted to determine if there were significant differences on the pretests for each of the following variables: height, weight, age, and each of the joint angles evaluated. A 3 × 4 (treatment group × muscle group) factorial ANOVA of the gain scores nested within subjects (post and pre) was used to determine differences between the treatment groups and muscle groups. The gain scores were obtained by first averaging the six trials on two separate occasions for pretesting and posttesting. Then each individual's average pretraining score was subtracted from the average posttesting score. Post hoc tests were performed according to Tukey "a" procedure.

Multiple t-tests at an experiment-wise alpha of 0.05 were computed to determine if there was a significant gain in flexibility from pretest to posttest for each treatment group and muscle group.

RESULTS AND DISCUSSION

Table 1 shows that the correlation coefficients for pretesting and posttesting were high ranging from $r = 0.91$ for shoulder flexibility on the pretests to $r = 0.99$ for hamstring flexibility on the posttests. The correlation coefficients for the posttests were generally higher than pretests. Sady et al.[8] also found higher reliability for posttraining when compared to pretraining and suggested that the training effect of increased consistency of flexibility scores was brought about by a learning process that takes place within the neural circuits.

Table 2 shows the mean pretest flexibility scores. One-way ANOVAs of the pretest with the three stretching groups yielded nonsignificant results for the following variables: height, weight, age, shoulder flexibility, hamstrings flexibility, trunk flexibility, and ankle flexibility.

A 3 × 4 (treatment group × muscle group) ANOVA (Table

TABLE 1
Correlation coefficients of pretest and posttest measures

	Shoulder	Hamstrings	Trunk	Ankle
Pretest	0.91	0.94	0.94	0.94
P-value	0.0001	0.0001	0.0001	0.0001
Posttest	0.95	0.99	0.97	0.97
P-Value	0.0001	0.0001	0.0001	0.0001

TABLE 2
Pretest mean flexibility scores

Group	Shoulder		Hamstrings		Trunk		Ankle	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
C	200.00	17.34	97.59	18.20	163.73	16.35	75.77	8.32
S	193.74	12.00	91.03	13.13	160.82	12.67	69.56	8.31
JS	193.97	18.13	90.00	11.02	163.06	12.19	69.84	7.36

TABLE 3
Summary of ANOVA of gain scores

Source	df	MS	F	*P*-value
Treatment group	2	175.0	4.40	0.0143
Muscle group	3	1268.3	14.88	0.0001
Subject (within treatment group)	41	167.4	1.96	0.0025
Treatment group × muscle group	6	313.9	3.68	0.0021
Error	123	85.2		

TABLE 4
Mean flexibility gains in degrees

Group	Shoulder	Hamstrings	Trunk	Ankle
C	10.0	7.1	3.5	2.4
S	15.2*	8.2*	8.9*	4.6*
JS	24.6*	8.2*	0.8	10.9*

* Significant flexibility gain at experiment-wise alpha of $P < 0.05$.

3) of the gain scores nested within subjects revealed significant main effects for the three treatment groups, the subjects within the treatment groups, the four muscle groups, and the interaction of the treatment group with the muscle group. Tukey "a" post hoc procedure indicated that the following significant differences occurred between groups: (1) the JS group showed significant improvement in ankle flexibility when compared to the S and C groups, (2) the S group showed significant improvement in trunk flexibility when compared to the JS group, and (3) for an average gain in flexibility (average of gains for shoulder, hamstrings, trunk, and ankle) the JS group showed significant improvement when compared to the C group.

Table 4 shows the mean gains for each treatment group and muscle group. Multiple *t*-tests at an experiment-wise alpha of 0.05 indicated that significant improvement in flexibility scores occurred in 7 of the 12 cases. Significant improvement occurred for each of the joint angles measured for the S group and for each joint angle with the exception of trunk flexibility for the JS group. The C group increased in flexibility, but the increases were not significant at an experiment-wise alpha of 0.05. One reason for the improvements in the C group may be related to the fact that the C group was composed of fairly inactive individuals who were participating in a physical activity course consisting of weight training and jogging. Physical activity other than stretching may have been responsible for the gains in flexibility.

The JS group showed significant improvement for the shoulder, hamstrings, and ankle (and its sample gains were at least as large as for the other two groups). However, the JS group did not show significant improvement for trunk flexibility; it is not clear why. Other investigators have suggested that flexibility may be specific to various joints throughout the body, and lack of improvement in some measures may be related to initial levels of flexibility for those joint movements.[8,13] Also, it has been suggested that various body movements allow for greater range of motion of the trunk, while movements requiring complete stretch of the hamstrings are minimal and the hamstrings have greater room for improvement.[8,13]

The data from this study again demonstrate that increases in flexibility can occur as a result of a static stretching training program. However, the results do not support the claim that warming the muscles prior to stretching by jogging will result in significant increases in all of the joint angles evaluated. The JS group demonstrated significant gains in shoulder, hamstrings, and ankle flexibility but not trunk flexibility. The S group demonstrated significant improvement in all of the joint angles evaluated. When the gains were compared, the JS group showed improvement in ankle flexibility when compared to the S and C groups. The S group produced significant improvement in trunk flexibility when compared to the JS group. The JS group produced an overall significant mean gain in flexibility when compared to the S and C groups.

In the absence of evidence indicating clear superiority of one method over the other, there are certain possible advantages associated with both the JS and S methods. The warm-up and then stretch method may protect against injury by warming the cold muscles and tendons prior to stretching. A significant increase in ankle flexibility occurred as a result of warming the ankle joint prior to stretching. Running injuries have often been associated with tight Achilles tendons and poor ankle flexibility. Warming the Achilles tendon prior to stretching could possibly aid in the treatment of or prevention of tight Achilles tendons, but caution should be used in attempting to jog or exercise with a tight Achilles tendon. Jogging on a tight Achilles tendon could possibly cause further injury.

Significant increases in flexibility occurred as a result of the static stretching program with no prior warm-up. The S method requires very little energy expenditure and involves very little danger to the participant. Slow static stretching without warm-up could possibly produce sufficient warming of the muscles to aid in increases in flexibility. Further research is needed to investigate the relationships between warming the muscle and connective tissue and increases in flexibility. Future efforts should be directed toward determining what type and intensity of exercise will warm the individual joint sufficiently to produce optimal gains in flexibility.

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