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Lengthening the Hamstring Muscles Without Stretching Using "Awareness Through Movement"

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Background and Purpose. Passive stretching is widely used to increase muscle flexibility, but it has been shown that this process does not produce long-term changes in the viscoelastic properties of muscle as originally thought. The authors tested a method of lengthening hamstring muscles called "Awareness Through Movement" (ATM) that does not use passive stretching. **Subjects.** Thirty-three subjects who were randomly assigned to ATM and control groups met the screening criteria and completed the intervention phase of the study. **Methods.** The ATM group went through a process of learning complex active movements designed to increase length in the hamstring muscles. Hamstring muscle length was measured before and after intervention using the Active Knee Extension Test. **Results.** The ATM group gained significantly more hamstring muscle length (+7.04°) compared with the control group (+1.15°). **Discussion and Conclusions.** The results suggest that muscle length can be increased through a process of active movement that does not involve stretching. Further research is needed to investigate this finding. [Stephens J, Davidson J, DeRosa J, et al. Lengthening the hamstring muscles without stretching using "Awareness Through Movement." *Phys Ther.* 2006;86:1641–1650.]

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Key Words: *Awareness Through Movement, Feldenkrais method, Hamstring, Muscle lengthening, Stretching.*

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The hamstring muscles are important contributors to the control of human movement and are involved in a wide range of activities from running and jumping to forward bending during sitting or standing and a range of postural control actions. Hamstring muscle strains are the most common muscle injuries in athletes.[1] The proposed etiology includes insufficient flexibility, strength (force-generating capacity) impairment or imbalance, and dyssynergic contraction that can place excessive strain on the hamstring muscles.[2] Static stretching of the hamstring muscles, to maintain flexibility and improve performance,[2–4] has been proposed as a proactive and preventive strategy and is now in common use. Studies with collegiate football players[5] and military basic trainees[2,6] document the success of this strategy in reducing the rates of lower-extremity injuries.

Reduced hamstring muscle flexibility has been implicated in lumbar spine dysfunction, with a number of studies[7–10] showing a strong positive correlation between decreased hamstring flexibility and low back pain. Other researchers[10–13] have suggested that hamstring muscle function in a variety of movements is part of a coordinated motor program and thus the appropriate periods of lengthening and shortening and perhaps even the degree of lengthening itself may be a learned part of the motor control process.

A variety of methods have been used to increase hamstring muscle flexibility, including static stretch,[14] proprioceptive neuromuscular facilitation,[15] dynamic range of motion,[16] and active motion in the neural slump position.[17] None of these methods, however, uses a process of active motion without pushing or holding at end-range to achieve its intended results.

"Awareness Through Movement" (ATM) is a process of verbally guiding a person through an activity during which movements usually are performed slowly and gently. It is thought that this process facilitates the learning of strategies for improving organization and coordination of body movement by developing spatial and kinesthetic awareness of body-segment relationships at rest and during motion, awareness of ease of movement, reducing effort in action, and learning the feeling of longer muscles in action.[18,19] This process has been shown to improve balance and coordination in people with multiple sclerosis[20] and balance and mobility in people with chronic cardiovascular accident.[21]

There has been limited study of this approach to hamstring muscle lengthening. Researchers in Australia found no effect of ATM on hamstring muscle length with a very brief intervention.[22,23] The purpose of our study was to test the hypothesis that ATM can be used effectively to increase the active length of the hamstring

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This study was approved by the Widener University Committee for the Protection of Human Subjects.

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muscles. We chose to look at active length because we believe that this measure is more meaningful than passive length in relation to normal functional movement and motor control.

Method and Materials

Subjects

Fifty-one subjects were recruited using posters and word of mouth from the population of graduate students and faculty at the Widener University, Chester, Pa, campus. The purpose of the study was explained, and volunteers signed an informed consent form approved by the Widener University Committee for the Protection of Human Subjects.

Subjects qualified for the study if they did not have a history of orthopedic problems, including surgery or injury to the back, pelvis, or lower extremities or neurologic dysfunction (eg, multiple sclerosis, cerebral palsy, or peripheral neuropathy) within 1 year from the beginning of the study. Subjects also were excluded from the study if they had an active knee extension angle greater than 165 degrees (full extension=180 degrees) measured using a quick-screen active knee extension test in which the subject lay supine with the hip flexed to 90 degrees and actively extended the knee.[17] If active knee extension was judged to fall outside of the desired range as marked on a plexiglass template, based on visual assessment, subjects were excluded.

Seven of the 51 subjects did not meet the screening criteria because their hamstring muscle length exceeded the maximum standard. Six subjects withdrew for personal reasons before group assignment. The remaining 38 subjects were randomly assigned to a group that received ATM intervention (ATM group [n=20]) or a group that received no intervention (control group [n=18]). Five subjects (2 in the ATM group and 3 in the control group) were dropped from the study after group assignment. Two of these subjects left the graduate program, 2 subjects missed the final data collection because of sickness or travel commitments, and 1 subject withdrew because of an acute ankle sprain sustained while running during the period of the study. Thirty-three subjects (18 in the ATM group and 15 in the control group) met the screening criteria and completed the intervention phase of the study.

All subjects were asked to refrain from beginning any new physical activity, including hamstring muscle stretching, that had not been part of their regular activity prior to the 3-week period of the intervention. Subjects in the ATM group were asked to perform a 15-minute ATM session 5 times per week guided by an audiotaped ATM lesson sequence. Subjects in the control group performed their regular daily activities. The ATM group was made up of 7 male and 11 female subjects who ranged in age from 22 to 36 years (25.9±3.8) ($\overline{X}$±SD) and had a pretest hamstring muscle length measurement of 141.96±7.89 degrees. The control group was made up of 6 male and 9 female subjects who ranged in age from 21 to 27 years (23.9±1.9) and had a pretest hamstring muscle length measurement of 140.66±8.19 degrees. There were no statistically significant differences between ATM and control groups based on age, sex, or pretest hamstring muscle length.

Instrumentation

Active knee extension hamstring muscle length was measured as the highest value in the range of knee extension using a PEAK Motus motion analysis system.* Accuracy of angle measurement for this system has been reported to be less than 0.1 degree, with an intraclass correlation coefficient (ICC) of .99.[24] An S-VHS Panasonic CL-700 digital video camera was placed 7.6 m (25 ft) from each subject and centered on a line perpendicular to the plane of motion of the subject's knee. Movement was recorded on a Sanyo editing S-VHS recorder at 60 frames per second and digitized using PEAK Motus software. An alignment apparatus similar to that described by Scholz and Millford[24] was constructed of 3.81-cm (1.5-in) diameter PVC pipes. Two vertical uprights 0.91 m (3 ft) in length were connected by a crossbar. The footings of each upright were secured to a standard plinth by 2 Stanley Quick Grips.† Reliability of knee angle measurements was determined using ICCs (2,3). A set of 3 repeated measurements from each subject was used for pretest and posttest calculations. The pretest ICC was .976, and the posttest ICC was .995.

Experimental Procedures

Measurement protocol. The hamstring muscle length of all subjects who met the screening requirements was measured using the Active Knee Extension Test (AKET)[25] 1 week prior to beginning the intervention. Hamstring muscle length was measured again 1 to 2 days after the end of the intervention period. Subjects were positioned supine on a standard 0.9-×1.8-m (3-×6-ft) plinth under the alignment apparatus. A 10.2-cm-wide (4-in-wide) Velcro strap‡ was placed around the subject at the level of the anterior superior iliac spine to stabilize the pelvis and lumbar spine. An additional 10.2-cm-wide Velcro strap was placed over the left thigh to stabilize the pelvis and left lower extremity. The subjects' right hip was flexed to 90 degrees until the anterior thigh was just touching the crossbar of the alignment apparatus.

* Peak Performance Technologies Inc, 7388 S Revere Pkwy, Suite 901, Centennial, CO 80112. The Panasonic camera and Sanyo VCR were obtained as part of the PEAK Motus system.

† Stanley Tools Group, 480 Myrtle St, New Britain, CT 06053.

‡ Velcro USA Inc, 406 Brown Ave, PO Box 5218, Manchester, NH 03103.

Figure 1.
Setup for measuring hamstring muscle length using PEAK Motus motion analysis system.

Reflecting markers 2.54 cm (1 in) in diameter were placed on the subjects' right lower extremity over the greater trochanter, the middle of the lateral joint line of the knee, and the lateral malleolus. Proper alignment of the right thigh parallel to the vertical post of the alignment apparatus and perpendicular to the horizontal surface of the plinth was verified using the video monitor (Fig. 1).

Subjects were told to maintain the position of the anterior thigh in light contact with the crossbar of the alignment apparatus. They were permitted to use a towel wrapped around the posterior right thigh just proximal to the knee throughout the test procedure to maintain anterior thigh contact with the crossbar. The starting position for the test was with the anterior thigh touching the crossbar of the alignment apparatus and the right knee in a relaxed and fully flexed position. One repetition of a knee extension movement consisted of moving the knee into extension until a feeling of resistance from the stiffness of the hamstring muscle stopped the movement and then returning to the starting position. Subjects were told to begin a series of extension movements when one of the researchers gave a "go" signal and to continue until a "stop" signal was given. Movements were paced at one per 2 seconds using a watch and giving verbal cues of "up" during the extension phase and "down" during the flexion phase of the movement. The timer gave a "ready" signal 3 seconds before the beginning of the procedure. The researcher responsible for data collection began recording with the PEAK system just before the beginning of the first repetition and continued for the collection of 6 full repetitions for the pretest and posttest for each subject. Repetitions 4 through 6 only were used as measures of hamstring muscle length to allow all subjects the same amount of practice and warm-up time before the measured trials. Subject data were identified by number only, and the researcher responsible for determining knee angle from the PEAK data was not aware of the group to which each subject was assigned.

Intervention. The ATM intervention was given over a 3-week period and consisted of an initial group training lesson and a home practice program. All subjects in the ATM group participated in the initial 30-minute classroom lesson targeting movements of the right lower extremity. The lesson consisted of an introduction plus 3 movement segments, with each segment covering variations of movements requiring lengthening of the hamstring muscle in different postural configurations. This lesson was recorded on audiotape, and a copy was given to each subject in the ATM group for independent home practice during the course of the study. The Appendix gives a description of the audiotaped ATM lessons.

Each segment of the lesson began and ended with a body scan in the supine position. This scan was designed to make subjects aware of their quality of neuromuscular control, including the rate and depth of breathing, the level of neuromuscular system tension throughout the body from the jaw to the feet, and the effort involved in simple movements such as rolling the leg left and right. The first movement segment began with the subjects lying on their left side. In the second movement segment, subjects sat in a long-sitting position. The third movement segment was done in the standing position, beginning with the hips and knees flexed and the pelvis posteriorly tilted. In each segment, movements were suggested in which subjects flexed and extended the right knee, tilted the pelvis forward and back, and rotated the right hip with the head and upper extremities in various positions. The goal was for subjects to learn to extend the knee, medially (internally) rotate the extending leg, and anteriorly tilt the pelvis at the same time, an organization of movements designed to lengthen the hamstring muscle from both ends.

As with all other movements in the lesson, these movements were done slowly and continuously, with the subjects resting when tired, and within a comfortable range of movement, noticing when effort in other areas of the body interfered with these specific movement intentions and trying to reduce those efforts and breathe easily through the entire process. Subjects were told explicitly not to push into the end-range of knee extension as they might if they were doing active or passive end-range stretching. Variations of the options of rotating the hip medially and laterally (externally), extending and flexing the knee, and tilting the pelvis were suggested. Subjects in the ATM group were asked to use the guidance of the audiotaped ATM lesson sequence until they were comfortable with the process of exploring the movements suggested, at which time they could proceed without the guidance of the audiotape. All subjects were asked to keep an activity log that included leisure and exercise activities and for the ATM group also included the frequency and duration of their ATM practice.

Data Analysis

The dependent variable of interest was hamstring muscle length as measured by the maximum active knee extension angle. Three trials per subject from each measurement session were recorded, and the mean was used for data analysis. A 2-factor repeated analysis of variance (ANOVA) (group × time) was used with time as the single repeated measure.[26] An alpha level of .05 was used as the criterion for significance of difference.

Subjects in the ATM group practiced independently over a period of 3 weeks and differed widely from each other in their number of practice sessions and total minutes practiced. Furthermore, because all subjects in the ATM group did not follow the same practice schedule, their postintervention hamstring muscle length measurements were done with different periods of delay following the time of their final practice session. To assess the possible effects of these practice and delay variables on the outcome measure of hamstring muscle length, a *post hoc* multiple regression analysis was done.[26] The number of practice sessions, total minutes of practice, and delay (in days) were used as independent variables with the dependent variable of hamstring muscle length change within the ATM group. In this analysis, a significance level of <.05 would indicate that the independent variable made a significant contribution to the prediction of the outcome measure of hamstring muscle length change. All statistical analyses were done using SPSS version 11.0.4 for Macintosh.[§]

At the end of the intervention period, subjects in the ATM group were asked the question: "From your experience of ATM, would you say that this process is different from stretching, as you understand it?" After the hamstring muscle length change analysis was completed, subjects in the ATM group were divided into 3 levels based on the amount of muscle length change. Five subjects achieved no change in muscle length ($\overline{X}$=0.1°, range= −3.4°–2.6°). Six subjects achieved a moderate amount of change ($\overline{X}$=6.1°, range=4.6°–6.8°). Seven subjects achieved a large amount of change ($\overline{X}$=12.9°, range=9.1°–17.5°). One person representing each of these levels was interviewed using open-ended questions to assess their understanding of and experience and strategies in practicing the ATM lessons. These qualitative data were used to help interpret the quantitative data collected.

Table 1.
Change in Hamstring Muscle Length Measured in Degrees[a]

Group	Time	$\overline{X}$	SD
ATM (n=18)	Pretest	141.96	7.89
	Posttest	149.00	7.40
Control (n=15)	Pretest	140.66	8.19
	Posttest	141.81	7.61

[a] Full extension=180 degrees. ATM=Awareness Through Movement.

Table 2.
Two-Factor Analysis of Variance With One Repeated Measure (Time) and Hamstring Muscle Length as the Dependent Variable

	df	F	*P*
Group	1	2.807	.104
Time	1	17.779	<.001[a]
Group × time	1	9.177	.005[a]

[a] Significant difference.

Results

The mean change in hamstring muscle length in the ATM group was +7.04 degrees compared with the control group change of +1.15 degrees (Tab. 1). There was a significant increase in hamstring muscle length over time and an interaction of group × time, indicating an increase in hamstring muscle length in the ATM group compared with the control group (*P*=.005) (Tab. 2, Fig. 2).

Table 3 shows the number of practice sessions, total minutes of practice, and change in hamstring muscle length for each subject in the ATM group. There was wide variation in the amount of practice among subjects. The range for number of sessions was 7 to 18, and total minutes of practice ranged from 80 to 300 over the 3-week period of the intervention. The delay between the last practice session and the final hamstring muscle length measurement ranged from 1 to 10 days. The regression analysis (Tab. 4) showed that there was no significant effect on hamstring muscle length change in the ATM group as a result of number of practice sessions, the total number of minutes of practice, or amount of delay between the last practice session and the final hamstring muscle length measurement.

[§] SPSS Inc, 233 S Wacker Dr, Chicago, IL 60606.

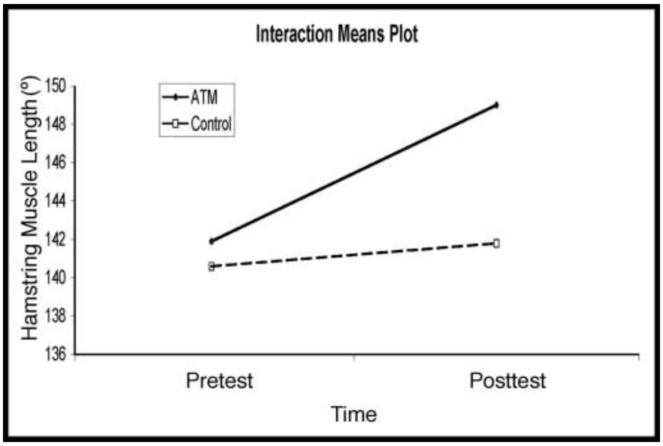

Figure 2.
Interaction plot for means test. ATM="Awareness Through Movement."

Table 3.
Data for Number of Practice Sessions, Total Minutes of Practice, Posttest Measurement Delay, and Muscle Length Change for Subjects in the "Awareness Through Movement" Group

Subject No.	No. of Practice Sessions	Total Minutes of Practice	Posttest Measurement Delay (d)	Muscle Length Change (°)
32	12	275	1	17.5
19	11	165	1	15.1
50	8	125	2	13.6
4	12	120	1	13.1
11	12	180	1	11.3
1	7	105	2	10.3
33	11	180	2	9.1
16	13	210	1	6.8
45	14	210	1	6.6
49	11	135	8	6.6
9	13	195	2	6.2
24	10	230	1	5.6
38	8	80	2	4.6
35	7	105	10	2.6
26	NA[a]	NA	2	1.3
23	18	300	1	0.0
41	7	135	1	0.0
51	18	260	1	−3.4
Mean	11.3	177.1	2.2	7.0

[a] "NA" indicates subject did not turn in activity report.

Discussion

Outcome and Stretching Literature

The data suggest that selected ATM lessons are an effective method of increasing active hamstring muscle length and flexibility. This is the first time that a method that does not involve stretching has been shown to increase muscle length.

The only previously published research on the effect of ATM on hamstring muscle lengthening showed that the effects of ATM were no different from the effects seen in a wait-list control group or a relaxation training control group over the study period.[22,23] James et al[22] suggested

Table 4.
Within-Group Multiple Regression Analysis of Effects of Practice (Number of Practice Sessions and Minutes of Practice) and Posttest Measurement Delay With Hamstring Muscle Length as the Dependent Variable for Subjects in the "Awareness Through Movement" Group

Variable	B	SE	Beta	*t*	*P*
No. of practice sessions	0.1910	0.7620	0.2496	0.2507	.8054
No. of minutes of practice	0.0202	0.0462	0.4207	0.4367	.6685
Posttest measurement delay (d)	0.2276	0.6060	0.0841	0.3756	.7125

3 possible problems with their study that might explain their observation of no change in hamstring muscle length. First, the subjects may not have had enough opportunity within their intervention process to perform ATM lessons directed toward lengthening the hamstring muscles. Their intervention included 4 ATM lessons, but only 1 ATM lesson was directed toward lengthening hamstring muscles. The specificity of training concept[27] suggests that it is unlikely that lessons directed only toward other muscle groups, movements, or areas of the body would contribute in any significant way to lengthening the hamstring muscles. Although some practitioners of Feldenkrais method claim that significant changes can be observed from a single lesson,[28] there is no published literature documenting that such changes are stable over any length of time greater than a few hours. We agree with James and colleagues' suggestion that a single session may not have been sufficient to produce stable change.[22] Therefore, we designed our intervention to be carried out over a 3-week period with the number of intervention sessions similar to what has been used in published studies using other approaches (Tab. 5).

Second, James et al[22] thought that their subjects may have had some negative preconceived ideas about the usefulness of ATM, and therefore may have not cooperated fully with the intention of the intervention. We cannot rule out this possibility in our subjects. Although most of our subjects were physical therapist students, as were James and colleagues' subjects, some of them had heard of the Feldenkrais method but had no prior experience or other specific knowledge.

Third, James et al[22] suggested that, because the motor pattern of the hamstring muscle lesson used during the intervention was not the same as that used in measuring the outcome of training, a pattern was learned in the lesson that did not transfer to the test measure. This possibility is refuted by our results. Our intervention offered 3 different forms of hamstring muscle lengthening activity, none of which was the same as the test measure. In our training audiotape, we suggested that

Table 5.
Hamstring Muscle Stretch Literature Results[a]

Article, Year of Publication	N	Groups and Time	Results	Rate of Gain (°/wk)
Worrell et al,[3] 1994	19	2 groups (SS, PNF) 4 × 20 s/d 5 d/wk 15 sessions in 3 wk	SS=8.0° PNF=9.5°	SS=2.7° PNF=3.2°
Webright et al,[17] 1997	40	2 groups (SS, NBS) 2/d × 7 d/wk 84 sessions in 6 wk	SS=8.9° NBS=10.2°	SS=1.5° NBS=1.7°
Bandy et al,[16] 1998	58	3 groups (CON, SS, DROM) CON: no stretch SS: 1 × 30 s/d, 5 d/wk DROM: 6 × 5 s/d, 5 d/wk	CON=0.7° SS=11.4° DROM=4.3°	SS=1.9° DROM=0.7°
Decoster et al,[29] 2004	28	2 groups (standing SS, supine SS) 3/d × 3 wk	Stand=9.1° Supine=8.4°	Stand=3.1° Supine=2.7°
Current study	33	2 groups (CON, ATM) CON: no stretch ATM: 15 min/d, 5 d/wk 15 sessions in 3 wk	CON=1.1° ATM=7.0°	CON=0.4° ATM=2.4°

[a] All studies used the Active Knee Extension Test (AKET) to measure hamstring muscle length and did intervention 5 days per week over some period of weeks. SS=static stretch, PNF=proprioceptive neuromuscular facilitation, NBS=nonballistic stretch, DROM=dynamic range of motion, CON=control, ATM="Awareness Through Movement."

subjects learn all 3 forms and choose for themselves which forms they would practice. We made this choice based on pilot data that suggested that the 3 different forms of practice might produce equivalent results. This idea is supported by recent data showing that 2 methods of static hamstring muscle stretching—1 standing and 1 supine—had equivalent outcomes.[29] Thus, we did not control this variable and do not know exactly what subjects did in this regard. Subjects may have selected any 1 form or some combination of the 3 forms over the training period.

The results reported here compare favorably with accepted methods of stretching that have been reported in the literature. Table 5 shows a representative sample of studies published between 1994 and 2004 all of which used the same method of measuring outcome, the AKET. These data indicate that ATM is comparable to commonly used stretching methods in the rate and amount of hamstring muscle length gain that is produced over similar periods of time.

Limitations and Future Research

One of the limitations of our study is that we did not use a stretching control group. We made this choice based on the fact that there is a large amount of literature on various methods of hamstring muscle stretching that would serve as a valid comparison. This allowed us to maximize our sample size for experimental subjects.

We did not monitor the practice of our subjects. Thus, there was a concern that they may have slipped into a familiar pattern of doing stretching rather than ATM as taught. There are 2 reasons why we think that our subjects did ATM and not stretching. First, we instructed all subjects in the ATM group during the training session to be sure that they understood the difference between ATM and stretching and that movements in the ATM lessons were to be done slowly, not held at the end-range and with no strain at the end-range. We audiotaped this instruction session and gave subjects a copy of the audiotape to guide their practice sessions at home.

Second, we asked subjects on an exit survey: "From your experience of Awareness Through Movement, would you say that this process is different from stretching as you understand it? If yes, please briefly describe the differences." Ninety-four percent (17/18) of the subjects in the ATM group stated that ATM was different from stretching. Representative comments describing the difference were: "slower and more repetitive"; "I concentrated more on the movements"; "when I stretch, I just go through the motions"; "didn't stress my back, felt fluid"; "moving rather than static"; "did not hold as in a stretch"; "more difficult because using muscle groups together that do not normally seem related"; "didn't experience the customary burn associated with stretching"; "didn't feel as if I had exercised at all"; "more sensing where the muscle was and whether it was lengthening from my awareness"; "not prolonged as in stretching . . . more of a movement pattern"; and "lots of movement involved." Subject 32, who had the largest muscle length gain at 17.5 degrees, said that the movements were difficult at first and that he strained, causing discomfort that persisted into the next day. After the first week, he stopped pushing the limits, did fewer and smaller movements, and began to notice changes such as the back pain that he usually experienced in class was eliminated. Subject 38, who had a low intermediate gain at 4.6 degrees, said that he never was able to master the side-lying movements and that coordinating difficult movements caused a strain. He also said that ATM felt like stretching except that it also incorporated the anterior pelvic tilt, which was difficult. Subject 51, who had the lowest length gain at −3.4 degrees, also had the longest hamstring muscles at the outset. She stated that she mastered the movements but was surprised that she qualified for the study because she was not aware that her hamstring muscles were short. From these procedures and comments, we conclude that the subjects were adherent to the process in which we instructed them and did not do stretching, with one possible exception (subject 38).

Another limitation may be the practical aspect of the amount of practice time that was required to produce an outcome. In our study, subjects practiced an average of 15 minutes per session-day compared with 30 seconds per session-day in the study by Bandy et al[16] or 80 seconds per session-day in the study by Worrell et al,[3] as described in the procedures noted in the studies cited in Table 5. Why would anyone want to spend 15 minutes when equivalent results could be obtained more quickly? We have shown here that, within the ranges of duration (7–18 sessions) and number of minutes (80–300) that our subjects practiced (Tab. 3), these variables did not have an effect on the amount of hamstring muscle length change that occurred (Tab. 4). In an unpublished pilot study exploring whether ATM practice time could be reduced, we have found that equivalent results may be achieved with as little as 15 seconds to 2 minutes per session-day, which is well within the time range of the stretching protocols. Further research is needs to be done to investigate this possibility.

There has been an interest in describing ATM as a process of motor learning.[30,31] Unfortunately, our study was not done using a formal motor learning design, which would have included a number of muscle length measurements during the acquisition period followed by post-acquisition retention or transfer tests after some delay.[27] Because of this design difference, we cannot assess our result in terms of motor learning as some practitioners of ATM would like. This is also an area for future research.

We propose that the benefits of an ATM approach to flexibility might be valuable in 3 areas. First, Agre[2] suggested that dyssynergic control, which he defined as exertion of too much force at the wrong time or poor transition in functional role (eg, eccentric knee extension control to concentric hip extension in gait), is a common etiology for hamstring muscle injury. Research is needed to compare ATM with static stretching as a means of preventing hamstring muscle injury or, more generally, muscle injury. Second, static stretching traditionally has been included in warm-ups preceding athletic performance, especially where recruitment of explosive power is involved. However, there has been very little study of the efficacy of this practice. The findings of recent studies suggest that running or jumping performance either is not enhanced by[32,33] or is negatively affected by[34,35] stretching prior to performance. Research comparing the results of ATM with stretching prior to running or jumping types of power performance would be a useful addition to our knowledge. A third area is adherence to exercise programs among people who have low pain tolerance. In our pilot work and in this study, subjects reported that the ATM process is more gentle, less of a strain, and generally less painful than stretching. These reports suggest that there may be better adherence with the use of ATM in elderly people and people who have chronic pain or low pain and stress tolerance. Some support for this idea comes from Phipps et al,[36] who conducted a retrospective study of a group of people between 20 and 77 years of age with a history of treatment for chronic pain that included components of ATM or yoga. Eighty-five percent of these people reported reduction of pain problems, and more than 75% reported continuing to use ATM and yoga techniques on their own 2 years after the end of their inpatient programs. More research in this area is suggested.

Finally, the ATM process is different from stretching. It is important to understand what its mechanism might be. Because mechanical explanations seem unlikely here, neural mechanisms should be considered. It has been shown that the stretch reflex can be regulated by operant conditioning,[37–39] patterned sensory stimulation,[40] and skill training.[41–44] Further research into the possible effects of ATM on the stretch reflex or other neural mechanisms would be enlightening.

Conclusions

We have shown that hamstring muscles can be lengthened by a method that does not involve stretching. Further research is needed to describe this process, to identify people who might benefit from it, and to understand the mechanisms through which it may work.

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Appendix.

Summary of "Awareness Through Movement" Lessons

Introduction

- Pay attention to whole-body patterns of movement involving multiple body segments.
- Do movements with the idea of exploring the possibilities about how they might be done.
- Become aware of efforts made in all areas of the body and try to reduce effort.
- Do 5 to 10 repetitions of a movement, then rest.
- Movements should be done slowly and easily without pushing or holding at end-range.
- At regular intervals, do a process of scanning by lying in a supine position and noticing any changes in body-segment relationships, muscle tone, breathing, or ease of small movements.
- Do an equal amount of movement with each leg.
- Demonstrate an anterior tilt of the pelvis by placing forearm or towel roll under the lumbar spine.

Initial Lengthening Concept

- Practice pelvic tilting without anything under the back.
- Add movements of knee flexion and extension to the pelvic tilting.
- Do knee flexion, hip lateral (external) rotation, and posterior pelvic tilting together and knee extension, hip medial (internal) rotation, and anterior pelvic tilting together.

Side-lying Lesson:

- Lie on the left side with the head in the hand or otherwise resting comfortably.
- Abduct the right leg and flex the hip and knee to a 90°/90° position.
- Reach the right hand to the right knee.
- From this starting position, learn the coordination of combining knee extension, hip medial rotation, and anterior pelvic tilting and of combining knee flexion, hip lateral rotation, and posterior pelvic tilting.
- Slide the hand farther down the leg as reaching becomes easier.
- Repeat lying on the right side. Rest as needed. Scan at regular intervals.

Sitting Lesson:

- Sit in a long-sitting position with legs a comfortable distance apart and lean back on hands, if needed.
- Place a towel roll under the knees as needed.
- From this starting position, learn the coordination of combining knee extension, hip medial rotation, and anterior pelvic tilting and of combining knee flexion, hip lateral rotation, and posterior pelvic tilting.
- As possible, slide the hands forward down the legs with the knee extension component of the movement.
- Rest as needed. Scan at regular intervals.

Standing Lesson:

- Stand with feet a comfortable distance apart.
- Flex the hips and knees and bend forward reaching the hands to touch somewhere comfortably below the knees.
- From this starting position, learn the coordination of combining knee extension, hip medial rotation, and anterior pelvic tilting and of combining knee flexion, hip lateral rotation, and posterior pelvic tilting.
- As possible, slide the hands farther down the legs with the knee extension component of the movement.
- Rest as needed. Scan at regular intervals.

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