Chronic Static Stretching Improves Exercise Performance

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ABSTRACT

KOKKONEN, J., A. G. NELSON, C. ELDREDGE, and J. B. WINCHESTER. Chronic Static Stretching Improves Exercise Performance. *Med. Sci. Sports Exerc.*, Vol. 39, No. 10, pp. 1825–1831, 2007. **Purpose:** This study investigated the influence of static stretching exercises on specific exercise performances. **Methods:** Thirty-eight volunteers participated in this study. The stretching group (STR) consisted of 8 males and 11 females whose activity was limited to a 10-wk, 40-min, 3-d·wk^{-1} static stretching routine designed to stretch all the major muscle groups in the lower extremity. The control group (CON) consisted of 8 males and 11 females who did not participate in any kind of regular exercise routine during the study. Each subject was measured before and after for flexibility, power (20-m sprint, standing long jump, vertical jump), strength (knee flexion and knee extension one-repetition maximum (1RM)), and strength endurance (number of repetitions at 60% of 1RM for both knee flexion and knee extension). **Results:** STR had significant average improvements ($P < 0.05$) for flexibility (18.1%), standing long jump (2.3%), vertical jump (6.7%), 20-m sprint (1.3%), knee flexion 1RM (15.3%), knee extension 1RM (32.4%), knee flexion endurance (30.4%) and knee extension endurance (28.5%). The control group showed no improvement. **Conclusion:** This study suggests that chronic static stretching exercises by themselves can improve specific exercise performances. It is possible that persons who are unable to participate in traditional strength training activities may be able to experience gains through stretching, which would allow them to transition into a more traditional exercise regimen.
Key Words: LONG JUMP, MUSCLE STRENGTH, MUSCLE ENDURANCE, SPRINTING, VERTICAL JUMP FLEXIBILITY

Flexibility (joint range of motion) is widely promoted as an important component of physical fitness (23). It is widely conjectured that increasing flexibility will promote better performances and reduce the incidence of injury (25,27). Consequently, stretching exercises designed to enhance flexibility are regularly included in both the training programs, and the preevent warm-up activities of many athletes (9,12,15).

Notwithstanding the widespread acceptance and use of stretching exercises as a major component of preevent activities, the purported benefits of stretching on performance and injury prevention have come into question in several review papers (9,12,15,29). In addition, recent research has established an adverse effect of acute static stretching on various different maximal performances. Preevent stretching has demonstrated an inhibitory effect on maximal force or torque production (16,21,26), vertical jump performance (3,4), running speed (19), and muscle endurance (20). In addition, a review by Hebert and Gabriel (12) concludes that there was little, if any, link between preactivity stretching and likelihood of injury. Thus, current research suggests that preevent stretching activities not only have minimal benefit for preventing injury, but also increase the chances for lowered maximal performance.

Even though preevent stretching may be contraindicated, the question concerning the benefits derived from doing regular (i.e., daily, or two to three times per week) stretching remains to be definitively answered. Unfortunately, there is limited research documenting performance benefits derived from doing regular stretching independently of any other training modality. In a recent review, Shrier (26) reports that only nine studies had examined the effects of regular stretching, with seven finding beneficial effects and two showing no effect. The no-effect studies dealt with tests of running economy, whereas the positive studies mainly dealt with improved joint range of motion. Of those factors related to performance (i.e., strength, speed, power, and endurance), the majority of studies have found improvements in strength. For example, Worrell et al. (32) and Handel et al. (11) found increases in hamstring isokinetic torque. Godges et al. (10) found increased trunk strength, and Wilson et al. (31) found improvements in the bench press. In addition, Dintiman (7) reports improved sprint performance, and Hunter and Marshall (14) saw increases in a countermovement vertical jump. Unfortunately, neither Dintiman (7) nor Hunter and Marshall (14) report strength changes. Finally, Hortobagyi et al. (13)

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Submitted for publication November 2006.
Accepted for publication May 2007.

0195-9131/07/3910-1825/0
MEDICINE & SCIENCE IN SPORTS & EXERCISE®

DOI: 10.1249/mss.0b013e3181238a2b

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TABLE 1. Subjects' descriptive data.

Group	Age	Mass (kg)	Height (cm)
Stretch			
Female (*N* = 11)	22 ± 4	65 ± 11	167 ± 9
Male (*N* = 8)	23 ± 3	75 ± 8	179 ± 9
No stretch			
Female (*N* = 11)	22 ± 4	66 ± 16	166 ± 10
Male (*N* = 8)	25 ± 1	78 ± 13	176 ± 7

Values are means ± standard deviations.

report improvements in fast isometric force development as well as the speed of concentric contractions.

The limited information on how chronic stretching by itself alters muscle function is confounded by the lack of uniformity in the experimental methods between the aforementioned studies. Experimental differences include stretching regimens inconsistency (different stretches and stretch intensity), treatment duration (3–12 wk), and outcome measures (strength, speed, power). In addition, possible clinical applications for persons who are unable to participate in traditional resistance exercise activities (i.e., those persons who are nonambulatory or have poor balance) have been largely uninvestigated. Therefore, it was the purpose of this study to determine the capacity of a training program consisting exclusively of stretching exercises to alter muscle strength, endurance, and power. This study specifically investigated the influence of an intensive, chronic, lower-extremity stretching routine on strength, strength endurance, 20-m sprint, vertical jump, and standing long jump.

METHODS

Subjects. Forty students enrolled at Brigham Young University–Hawaii volunteered to participate in the study. Before participation in the study, the students were either physically inactive or recreationally active. During any given week, anyone who participated in multiple days of endurance or strength training was excluded. Also, recreationally active was defined as sporadic participation in sporting activities. In other words, each person had to engage in sporting activities no more than 60 $min \cdot d^{-1}$ and no more than three times per week. Moreover, a recreationally active person was defined as a person who participated in sporting activities no more than six times a month. Descriptive values are presented in Table 1. Anyone who was currently doing regular physical training or who initiated a regular program during the study was excluded from the study. The appropriate institutional review board approved the study, and each participant gave both written and oral consent before engaging in the experiment.

Experimental design. Initially, the volunteers' sit and reach, 20-m sprint time, vertical jump height, standing long jump length, knee extension and knee flexion strength (one-repetition maximum (1RM)), knee extension and knee flexion strength endurance, and $\dot{V}O_{2peak}$ were evaluated during 3 d. After the pretest, the participants were randomly assigned to either a stretching (STR) or no-stretching group (CON), with each group balanced with respect to gender. Both groups were instructed to maintain their current exercise habits; however, CON was asked to refrain from performing any stretching exercises, whereas the STR group added a stretching program to their usual activities. Each individual's diligence in maintaining a minimum activity program was monitored by weekly reports. In addition, all local recreational facilities were monitored by the research staff, and the presence of any subjects was noted and collaborated with their exercise logs. A pre and post $\dot{V}O_{2peak}$ test served as another back-up verification of limited activity. The STR and CON programs were performed for 10 wk. At the conclusion of the 10 wk, all of the aforementioned tests were performed again by the same testers, and in the exact same order and time of day as the pretest.

Testing protocols. The testing was performed during 3 d with a minimum of 48 h and a maximum of 72 h of rest between each testing session. On day 1, sit and reach, standing long jump, 20-m sprint, and the 1RM were obtained. The second-day tests were the vertical jump and muscle strength endurance. Finally on the third day, each person's $\dot{V}O_{2peak}$ was obtained. To eliminate the effect of an acute stretching bout on performance, the first day of posttesting started 72 h after the last stretching session had been completed. Also, as stated above, to obtain posttreatment values, this order of testing was repeated 10 wk later.

Day 1 testing protocol. First, each person warmed up for 5 min by slowly jogging 400 m, followed by general range-of-motion movements (i.e., leg swings, toe touches, and ankle rotations) of the lower limbs for 2–3 min. After warming up, sit and reach was assessed with an Acuflex I sit-and-reach flexibility tester using a previously reported protocol (21). Next, the standing long jump was measured. It began with each person standing upright with the feet hip-width apart. The jump was initiated by bending at the knees and hips and dipping to roughly a quarter squat position, (subjects were allowed to self-select their depth), with the arms extended behind the body. From this position, the person jumped horizontally with both feet as far as possible while simultaneously swinging his or her arms forward. For the jump to count, the person had to land on both legs without taking either a forward or backward step. Five submaximal warm-up/practice jumps were first performed, followed by three maximum-effort jumps. Each jump was separated by a 1-min rest interval, and the longest of the three jumps was used as the score. After jumping, each person rested for 5 min and then performed the 20-m sprint test. The sprints were initiated from a standing start and were timed with an automated timer (Speedtrap II, Brower Timing Systems, 12660 South Fort Street, Suite 102, Draper, UT). The timing device started when a single laser light beam, which was placed directly in front of the person and projected across the track, was broken. The timer stopped when the sprinter broke a single laser light beam projected across the track 20 m from the starting line. The laser beam was positioned so that the height above the ground approximated the height of the runners' waist. Each person did five submaximal sprints as a warm-up/practice, and then three maximal sprints. A 3-min rest period separated each maximal sprint, and the best time was recorded. After the last sprint, a 10-min rest period was given, and this was followed by a 1RM test for knee flexion strength. A 10-min rest period followed the knee flexion test, and, finally, a knee extension 1RM test was performed. The knee flexion and knee extension 1RM tests used the protocol of Kokkonen et al. (16).

Day 2 testing protocol. Day 2 began with each person warming up for 5 min by slowly jogging 400 m, followed by lightly stretching the lower limbs for 2–3 min. This warm-up was followed by vertical jump measures. Vertical jump performance was measured via a Vertec testing device (Questtek Corp., Northridge, CA) using commonly reported methods. Reach height was established by having the subject stand flat-footed and reach up to displace the marker on the Vertec. The subject then performed a two-leg standing vertical jump. To perform this measure the subject would dip to a self-selected depth and then jump and reach the preferred hand to displace the marker on the Vertec. Five submaximal warm-up jumps were allowed. After the warm-up jumps, three all-out-effort jumps were performed with a 1-min rest between each jump. The best of the three maximum jumps was used as the score. After jumping, each subject rested for 5 min, and then performed a local muscular endurance test. Local muscular endurance was defined as the number of repetitions completed lifting 60% of the previous day's 1RM. The endurance of both knee flexion and knee extension were measured and followed the protocol of Nelson et al. (20).

Day 3 testing protocol. On day 3, the subjects reported to the laboratory at least 2 h postprandially, and body mass was recorded. Next, each person's $\dot{V}O_{2peak}$ was measured using a running graded exercise test protocol, detailed below. The test started with a 3-min walk at approximately 80 $m \cdot min^{-1}$ (3 mph). Then, the initial grade was set at 0% with a speed of either approximately 161 $m \cdot min^{-1}$ (6 mph) for the males or approximately 134 $m \cdot min^{-1}$ (5 mph) for the females. The grade was then increased by 2% every 2 min until the subject reached volitional fatigue (i.e., no longer desired to keep pace with the treadmill). Expired gases and minute ventilation were monitored continuously with a SensorMedics series 2500 analyzer. Oxygen consumption was measured breath-by-breath then averaged and outputted at 20-s intervals. $\dot{V}O_{2peak}$ was defined as the highest 20-s average obtained during the last 4 min of the test.

Stretching protocol. The 10-wk STR stretching program consisted of 15 different static stretches designed to stretch all of the major lower-extremity muscle groups (i.e., hamstrings, quadriceps, adductors, abductors, external and internal rotators, plantar flexors, and dorsiflexors). 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. Each stretching session lasted approximately 40 min and was performed 3 $d \cdot wk^{-1}$ for 10 wk.

Four of the 15 exercises were variations of the sit and reach. These were performed both actively and passively by sitting on the floor with the legs in one of four different positions: legs parallel, legs in the lotus position, legs abducted 45° apart, or legs abducted as far as possible. Once in position, the subject would bend forward at the waist as far as possible.

In another five exercises, the head was lowered towards the knee (both passive and active) while at least one leg was straight, but placed in different positions relative to the body. The first position was sitting on the floor with the legs abducted as far as possible. From here, the head was lowered to each knee three times, alternating between knees. The second position was sitting on the floor with one leg placed straight out in front (0° abduction) and the other leg in the lotus position. While in this position, the head was lowered to the knee of the straight leg three times before leg positions were swapped. The third and fourth positions were performed while standing erect with one leg resting on a table (90° hip flexion). From this position, the participants' heads were lowered three times to the knee of the supported leg (third position), and then the participants would externally rotate the erect leg 90° and bend down three times to the knee of the erect leg (fourth position). After performing these exercises, the erect leg and supporting leg were switched, and the exercises were repeated. The fifth position was standing erect with one hip flexed (> 120° hip flexion) as much as possible with the corresponding foot resting on a beam at eye level or above. Once in position, the participants' heads were lowered three times to the knee of the supported leg, and then the position of the legs was swapped.

The next group of exercises used the standing half-lotus position. Two exercises were performed, and both were done actively and passively. While standing with one foot flat on the floor, the participants placed the opposite leg in a lotus position on a table (90° hip flexion). The participants would then alternate lowering their head toward either the foot (first exercise) or the knee (second exercise) of the leg resting on the table. Each exercise was performed three times before the leg positions were changed.

Two other activities consisted of quadriceps stretching, with one of the activities being done only actively. The active-only stretch required the participants to stand up straight and balance on one leg. The non–weight-bearing leg was flexed at the knee, and, using the corresponding

TABLE 2. The effects of chronic stretching on selected variables.

	STR pre	STR post	CON pre	CON post
Mass (kg)	67.5 ± 10.8	68.8 ± 11.4	71.3 ± 15.4	72.0 ± 15.8
$\dot{V}O_{2peak}$ ($mL \cdot kg^{-1} \cdot min^{-1}$)	47.2 ± 11.4	47.6 ± 12.1	47.1 ± 7.0	47.8 ± 6.6
Sit and reach (cm)	36.2 ± 5.5	42.6 ± 5.6*	39.8 ± 6.4	38.9 ± 6.4
Standing long jump (cm)	211.2 ± 42.3	215.8 ± 42.1*	222.1 ± 31.3	218.5 ± 32.5
Vertical jump (cm)	43.1 ± 12.4	44.8 ± 12.5*	45.4 ± 11.5	45.4 ± 11.5
20-m sprint (s)	3.80 ± 0.51	3.75 ± 0.48*	3.63 ± 0.33	3.68 ± 0.31
Knee flexion 1RM (kg)	44.7 ± 14.5	51.0 ± 14.1*	46.1 ± 15.1	47.0 ± 14.4
Knee extension 1RM (kg)	63.8 ± 24.5	82.0 ± 25.8*	69.7 ± 21.5	71.0 ± 20.8
Knee flexion endurance (no.)	17.2 ± 3.4	22.3 ± 4.7*	19.5 ± 4.1	19.3 ± 4.4
Knee extension endurance (no.)	18.5 ± 3.1	23.7 ± 4.7*	18.6 ± 2.7	18.6 ± 3.6

Values are means ± standard deviations.
* Significant improvement over the pre score.

hand, the heel was held as close as possible to the buttocks. For the other quadriceps stretch (done both actively and passively), the participants stood with their back to a pommel horse and then placed the dorsal side of one foot on the pommel horse by flexing at the knee joint. From this position, the participants would lean (or, when assisted, the corresponding knee and shoulder were pushed) backwards. The other two active-only stretches involved the calf muscles. To do one of the calf stretches, the participants first stood with one foot flat on the floor and the other foot placed on a block so that the ball of the foot was approximately 10 cm above the heel. The participants would then lean forward until maximum dorsiflexion was achieved and noticeable tension was felt in the calf. The other calf stretch was the classic Awall push. Here, the participants stood with one leg 15–30 cm away from a wall with the other foot placed even further away from the wall so that the ankle was dorsiflexed. The participants would then lean towards the wall, keeping the heel of the dorsiflexed foot in contact with the floor. Both the height of the block and the distance from the wall were increased over the duration of the program to compensate for increases in flexibility.

Statistics. A two-way (treatment vs pre–post) repeated-measures ANOVA was used for analysis. *Post hoc* ANOVA analysis involved, where appropriate, the use of Tukey's protected *t*-test. The level of significance was set at $P < 0.05$ and was adjusted to cover for multiple comparisons using a Bonferroni adjustment (i.e., P value divided by number of comparisons). For the purpose of the Bonferroni adjustment, the data were analyzed as four separate experiments (#1: flexibility, consisting of the sit and reach; #2: power, consisting of the standing long jump, vertical jump, and 20-m sprint; #3: strength, consisting of the knee flexion and knee extension 1RM; and #4: endurance, consisting of the knee flexion and knee extension endurance tests). Hence, for significance at the 0.05 level to occur, the *t*-score needed to exceed the required *t*-score for $P < 0.05$ for the flexibility tests, $P < 0.017$ for the power tests, and $P < 0.025$ for both the strength and endurance tests. In addition, effect size was expressed via the generalized omega squared (ω_G^2) statistic, using the formula recommended for repeated-measure designs (22). Olejnik and Algina (22), however, point out that ω_G^2 by itself has little meaning, and is best used when comparing results between differing experiments with similar experimental designs.

RESULTS

The influences of the stretching program on all measures are shown in Table 2. Thirty-eight subjects successfully completed the study. The reason the two subjects (one from STR and one from CON) gave for dropping out of the study was the desire to initiate a more strenuous exercise program. None of the STR group missed more than 2 of the 30 training sessions, and none of the missed 2 d were consecutive. For both the STR and CON subjects, no one participated in sporting activities for more than 18 d during the whole 10 wk. Moreover, for any given week, no one participated in more than 3 d of sporting activities. Finally, there were no group differences in the total number of activity days, but CON had the top three most active individuals (≥ 15 activity days). Pre to post body mass and $\dot{V}O_{2peak}$ were analyzed for both STR and CON. Neither the difference in body mass nor $\dot{V}O_{2peak}$ changed significantly during the study.

Flexibility. For STR, the number of centimeters traveled during the sit and reach increased on average 18.1%, whereas the CON distance changed, on average, −2.4%. A 95% confidence interval for the difference between the STR and CON changes was 20.5% ± 5.5%. The interaction between treatment and pre–post ($F(1, 18) = 60.9$, $P < 0.0001$, $\omega_G^2 = 0.088$) was significant. *Post hoc* analysis showed that this significance was attributable to the STR gain.

Power. For the standing long jump, STR averaged a 2.3% increase, whereas CON had a 1.7% decrease. A 95% confidence interval for the difference between the STR and CON changes was 4.0 ± 1.7%. The interaction between treatment and pre–post ($F(1, 18) = 20.3$, $P = 0.0003$, $\omega_G^2 = 0.003$) was significant, and the *post hoc* analysis showed that this significance was attributable to the STR gain. The vertical jump results varied from the standing long jump results. In this case, STR averaged an increase of 6.7%, whereas CON remained virtually unchanged (0.1% increase). A 95% confidence interval for the difference between the STR and CON changes was 6.6 ± 4.5%. Like the standing long jump, the interaction between treatment and pre–post ($F(1, 18) = 7.4$, $P = 0.0138$, $\omega_G^2 = 0.002$) for the vertical jump was significant, whereas the *post hoc* analysis showed that this significance was attributable to only the STR gain. Finally, the STR 20-m sprint time averaged a decrease of 1.3%, and CON averaged an increase of 1.4%. For this measure, a 95% confidence interval for the difference between the STR and CON changes was −2.8 ± 1.4%. In addition, the interaction between treatment and pre–post ($F(1, 18) = 11.6$, $P = 0.0032$, $\omega_G^2 = 0.004$) was significant, and the *post hoc* analysis showed that this significance was attributable to the STR improvement.

Strength and endurance. The 1RM for the STR group increased, on average, for both knee flexion (15.3%) and knee extension (32.4%). Likewise, the CON group had on average increases of 3.3% for knee flexion and 2.8% for knee extension. For knee flexion, a 95% confidence interval for the difference between the STR and CON changes was 12.4 ± 5.8%. Also, a 95% confidence interval for the difference between the STR and CON changes for knee extension was 29.6 ± 13.2%. In addition, the interactions between treatment and pre–post for both knee flexion 1RM ($F(1, 18) = 7.4$, $P < 0.0001$, $\omega_G^2 = 0.009$) and knee extension 1RM ($F(1, 18) = 53.4$, $P < 0.0001$, $\omega_G^2 = 0.034$) were significant, whereas the *post hoc* analysis showed that this significance was attributable only to the STR gain.

The endurance changes were slightly different from the strength changes. STR endurance increased, on average, for both knee flexion (30.4%) and knee extension (28.5%). On the other hand, CON endurance was nearly unchanged for both knee flexion (−0.9%) and knee extension (−0.1%). The 95% confidence intervals for the difference between the STR and CON knee flexion and knee extension endurance changes were 31.3 ± 10.8 and 28.6 ± 10.3%, respectively. Again, the interactions between treatment and pre–post for both knee flexion endurance ($F(1, 18) = 38.4$, $P < 0.0001$, $\omega_G^2 = 0.095$) and knee extension endurance ($F(1, 18) = 34.4$, $P < 0.0001$, $\omega_G^2 = 0.114$) were significant, whereas the *post hoc* analysis showed that the STR changes were responsible for the significance.

DISCUSSION

Notwithstanding the widespread acceptance and use of stretching exercises as a component of exercise training, there is limited research documenting the benefits derived from including regular (i.e., daily, or two or three times per week) stretching into a training program. This is especially true concerning any benefits derived from performing stretching exercises exclusive of any other training modality. As mentioned above, previous research indicates that the primary benefit derived from regular stretching, exclusive from increased range of motion, is increased strength. Unfortunately, although strength gains are correlated with performance gains, this correlation does not imply a direct cause and effect. Moreover, the stretching activities typically recommended (23) to be included in training programs are of a lower magnitude than those used to achieve the reported strength gains in the aforementioned studies. Hence, this study was designed to ascertain whether an intensive regular stretching program could improve several of the aspects of physical performance. The results of this study suggest that 40 min of static stretching three times per week for 10 wk increases flexibility, strength, endurance, and power in the lower extremity. Thus, the results of this study support the inclusion of stretching activities in training programs for untrained or recreationally trained subjects.

Although this study was not designed to investigate the responsible mechanism(s), it is most probable that the improved power and endurance are strongly related to the strength improvements. Our finding that several days of static stretching have the capacity to improve strength is not novel. After 15 d of static stretching hamstrings, Worrell et al. (32) reported increases in maximal voluntary isokinetic torque. Eccentric torque increased 8.5% at 1.05 $rad{\cdot}s^{-1}$ and 13.5% at 2.1 $rad{\cdot}s^{-1}$, whereas concentric isokinetic torque increased 11.2% at 2.1 $rad{\cdot}s^{-1}$. How the stretching programs caused strength gains is up to speculation; however, passive stretching is related to muscle hypertrophy. For instance, a continually applied stretch for 10 d can trigger myoblast proliferation (6). In addition, Stauber et al. (28) stretched rat soleus muscles three times a week for 4 wk, and they found muscle mass to be increased by 13% and fiber area by 30%. Similar results have been reported by Coutinho et al. (5), who report a 16% increase in rat soleus fiber area by stretching the muscle for 40 min every 3 d for 3 wk.

The gains in power could also be attributed to increases in muscle length. Increases in length lead to increases in both contractile velocities and the forces generated at a given shortening velocity (17). *In situ* lengthening has been reported through the application of continuous stretch through diverse mechanisms such as casting a muscle in a stretched position, increasing bone length, or relocating tendon insertions (for a review, see Lieber (17)). Also, muscle-lengthening results from programs of intermittent stretching performed for several days. For example, Williams report that 30 min of daily stretching was sufficient to cause an increase in the number of sarcomeres in series (30). Likewise, Coutinho et al. (5) have reported a 5% increase in length and a 4% increase in serial sarcomere number after stretching for 40 min every 3 d for 3 wk.

Conversely, the improvement seen in this study may not be related to the stretching exercises. It is possible that the strength gains in each leg were the result of muscle contractions in the nonstretched leg when it was used to stabilize the body during the stretches. Although in some cases standing on one leg can lead to a stabilization or proprioceptive stimulus, it is unlikely that this phenomenon is a major factor in this current study. First, studies have shown that it is the lower-leg muscles rather than the thigh muscles that are the most active during exercises requiring postural stability maintenance (2). More importantly, those studies (1,2,24) that found improved strength from proprioceptive training typically placed the subjects in unstable conditions (i.e., some kind of wobble board).

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This type of stimulus would not seem to be consistent with the demands of this current study, where, during the stretch, the subjects had at least two points of balance resting on a stable object.

Although the improvements in muscle strength, endurance, and power are a desired training modification for the athletic population, the results of this study do not suggest that stretching exercises alone could either supplant or enhance existing training programs. Although the stretching improved the performance of sporadically active individuals, it is not known whether people with more trained muscles will respond similarly to the stretching stimulus. Also, because the stretching program was performed singularly, it is inadvisable to assume that combining stretching with strength training would produce additive benefits. Clearly, there is a need to further research the influence repetitive stretching has on athletic performance. This study could serve as a springboard for further investigation, such as whether trained individuals respond the same as the recreationally active person, or whether the stretching regimens are additive to usual strength training gains.

On the other hand, improvements in muscle strength, endurance, and power can also be important to the nonathletic population. Several studies have established a link between muscular fitness and overall health or the likelihood of early death (8,13,18). Unfortunately, most persons who are at the lowest end of the muscular fitness continuum also have difficulty performing the usual activities found to generate improvements in muscular fitness. Thus, these people are likely to experience a continual spiraling decline in both muscular performance and overall health. It is possible that a chronic stretching program could be used in rehabilitation settings as a mode of exercise for those unable to participate in more traditional exercise regimens. Considering that our results in this current study indicate an average of a 23.9% increase in muscular strength and a 29.5% increase in muscular endurance, it is certainly possible that a similar stretching program could benefit the aforementioned individuals. Granted, this study did not exam severely challenged individuals, so one can not assume that the magnitude of change would be similar. Moreover, the stretching program would most likely need to be modified, because a physically challenged person may not be able to perform the exact same stretching regimen. Thus, key exercises needed to stimulate the desired gains might not be done. Nevertheless, the possibility of a benefit exists and is worthy of further study. Particularly, research into the use of stretching during the initial stages of rehabilitation, when patients may not be able to participate in more traditional resistance exercise programs, is warranted.

This study provides more information concerning the benefits of incorporating an intensive stretching program into a person's weekly activities. A healthy, active person can expect the stretching program to at least not hinder other training activities being used to improve muscle strength, endurance, and power. In addition, it is possible that incorporating an intensive stretching program into a person's weekly activities may act as a magnifier of any other training modalities. On the other hand, an intensive stretching program alone may greatly benefit individuals on the lower end of the physical capacity spectrum. Regardless of physical capacity, anyone can submit to a program of passive stretching. Moreover, if the less capable can similarly respond to the stretches used in this study, then one would expect to see an increase in functional capacity and, hopefully, improve enough to be able to engage in more intensive types of exercise. Clearly, regularly performing stretching exercises provides more physical benefits than just an increased joint range of motion, and more research into all the possible uses, benefits, and proper timing of regular stretching is needed.

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