THE BENEFITS OF STRETCHING DURING IMMOBILZATION

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Stretching may help maintain physiological functions during immobilization. We examined the effects of static stretching on calf girth, and dorsiflexion ROM, and plantarflexor strength after two weeks of immobilization. Thirty-six females aged (19.81±2.48) were randomly assigned to a control group (CG), experimental group (EG), or experimental stretching group (ESG). All groups completed pre-test and a post-test measures of muscle girth, dorsiflexion ROM, and plantarflexion strength. The EG and ESG wore an Aircast FP Walker for two weeks on the left leg, with the ESG participating in a stretching program two times each day. ANCOVA's and least significant differences procedures ($p<0.05$) were used to determine differences between groups. Significant differences were found between groups in the post-test measures for all three dependent variables.

KEY WORDS: ankle brace, stretching, muscle atrophy, joint range of motion

INTRODUCTION: The purpose of this study was to examine the effects of static stretching during immobilization. Most recent studies have found that stretching prior to a power or strength related activity decreases performance (Shrier, 2004). Conversely, long term stretching over weeks and months can improve performances in these activities as well as other performance related variables such as flexibility, gait economy, running speed, peak torque, and vertical jumping (Dintiman, 1964; Godges, MacRae, Longdon, Tinberg, & MacRae, 1989; Hunter & Marshall, 2002; Kokkonen, Nelson, Tarawhiti, Buckingham, & Winchester, 2010; Worrel, Smith, & Winegardner, 1994). Some of these effects have even been shown to occur during times of limited physical activity (Kokkonen, Nelson, Eldredge, & Winchester 2007). Improvements of over 30% in the 1RM of exercises such as leg extension have been found in as little as 10 weeks of stretching (Kokkonen, Nelson, Tarawhiti, et al., 2010).

Despite the positive effects on performance from long term stretching in healthy people, there is a lack of research in the positive effects of stretching during immobilization. There have been a number of animal based research studies examining the effects of stretching during immobilization. These studies have found cellular, hormonal, and structural changes resulting in protein synthesis and muscular hypertrophy (Goldspink, 1977; Goldspink, 1999; Holly, et al., 1980). One rat based study found that a group of rats that stretched daily had less muscle atrophy than another group that was immobilized but did not stretch (Coutinho, Gomes, Franca, Oishi, & Salvini, 2004).

Most animal research has found positive effects from stretching, even during immobilization. Although people often have injuries that result in immobilization of one or more joints, especially athletes, there is a lack of research with humans in this area. If the positive effects were found in humans, stretching could be a low intensity method to decrease the negative effects of immobilization. Therefore, this study investigated the effects of stretching on calf girth, dorsiflexion range of motion (ROM), and plantarflexion strength during two weeks of ankle immobilization.

METHODS: Thirty-six healthy females completed the study, however, four were removed during data analyses because they failed to adhere to the experimental protocol. The subjects were randomly assigned to one of three groups before the study started. The groups included a control group (CG) of 12 subjects (162.98 ± 4.94 cm, 64.11 ± 8.67 kg), an experimental group (EG) of 10 subjects (165.10 ± 5.49 cm, 62.73 ± 5.57 kg), and an experimental stretching group (ESG) of 10 subjects (164.59 ± 6.75 cm, 67.59 ± 18.81 kg).

On the first day all subjects completed a familiarization test on the Cybex II Isokinetic Dynamometer (Cybex, Division of Lumex Inc., Ronkonkoma, NY) followed by a five minute warm-up on a Monark 817 Stationary Exercise Bike. After the warm-up dorsiflexion ROM was assessed three times with a goniometer while the patients were lying prone as described by Starkey, Brown, & Jeff, (2010). Calf girth was measured using a Lufkin tape measure with a Gulick spring-loaded handle attachment (Lafayette Instruments, Laffayette, IN) as described by Ross & Worrell (1998). Lastly, a Cybex II Isokinetic Dynamometer was used as a strength measure at 30°/s.

After the testing on the first day the subjects in the EG and ESG were fitted for a Walker cast (Aircast FP Walker, DJO Inc, Vista, CA) on the left leg. The subjects starting wearing the Walker the following day and were only allowed to take it off when showering and sleeping. Any time the subjects had the Walker off they were required to log why and for how long. The EG returned to the facility and visited with the researcher two times during the next two weeks to confirm the Walker was being worn and see if the subjects were having any problems. The ESG returned to the facility nine separate days to make sure the stretching program was being completed two times per day and performed correctly. When the subjects came to the facility they used the pro-stretch (Prostretch original and wood, Medi-Dyne Health Care Productions, Colleyville, TX). When the subjects stretched at home they used the wall stretch. The stretching protocol involved stretching the calf with a straight leg for 30s followed by 30s of rest then stretching the calf with a bent knee for 30s followed by 30s of rest. This two minute protocol was repeated five times for a total of ten minutes.

After two weeks of wearing the Walker, a post-test was completed using the same measures as the pre-test. Following the post-test, each subject handed in their respective completed written logs. All subjects in the ESG were found to have completed the required stretching protocol. The subjects in the ESG and EG were found to have the Walker off approximately 30 minutes per day. The pre and post means of girth, dorsiflexion, and strength are reported in Table 1.

Differences between groups were analysed using an analysis of covariance (ANCOVA) with the pre-test scores used as the covariant. Pairwise t-test of adjusted means with Tukey-Kramer adjustments were used as post hoc tests. An alpha level of $P<0.05$ was used for all analyses. Intraclass correlation coefficients for the pre-post was found to be .992 for calf girth, .803 for calf strength, and .812 for dorsiflexion ROM.

Table 1
Mean of Girth, Dorsiflexion ROM, and Strength

Group	Girth (cm)		ROM (deg)		Strength (%BW)	
	Pre	Post	Pre	Post	Pre	Post
CG	35.36±2.67	35.45±2.72	15.00±5.14	14.10±5.28	34.83±6.66	32.92±7.68
EG	34.52±1.81	33.94±1.63	15.22±3.74	10.88±1.90	37.10±11.00	31.20±6.66
ESG	35.35±4.30	35.01±4.09	14.28±5.25	17.88±5.48	32.70±7.20	36.30±8.50

RESULTS: The assumptions of the ANCOVA were examined and found to be meet for each variable. The ANCOVA results showed that there were significant differences between the three groups for the post girth measure ($F_{2,31}=6.50$, $P=0.0048$), the post dorsiflexion ROM measure ($F_{2,31}=29.06$, $P<0.0001$), and the post strength measure ($F_{2,31}=6.74$, $P=0.0041$). Post hoc analysis showed that there was a significant difference ($t=3.55$, $P=0.0039$) in calf girth between CG and EG. The CG maintained calf girth while EG lost calf girth. Although it was non-significant, EG was found to lose more calf girth than the ESG. The dorsiflexion ROM were found to be significant for all group comparisons, CG and EG ($t=3.47$, $P=0.0048$), CG and ESG ($t=-4.49$, $P=0.0003$), and EG and ESG ($t=-7.60$, $P<.0001$). The CG maintained dorsiflexion ROM, the EG decreased in dorsiflexion ROM, and the ESG actually increased in dorsiflexion ROM. Finally, there were significant differences between the ES and ESG (t=-

6.64, P=0.0030) in strength. The ES lost strength and the ESG increased strength. No significant differences were found between the CG and EG and the CG and ESG in strength.

DISCUSSION: We had hypothesized that stretching would reduce the negative effects of immobilization. Although the ESG still experienced some loss in muscle girth it was less than the EG experienced. Amazingly, the ESG actually increased in ROM and strength, despite having their ankle immobilized for two weeks.

Significant muscle atrophy can occur in injured people with-in two weeks of immobilization (Stevens, Walter, Okereke, et al., 2004). Although we did find some loss of muscle girth, especially in the EG, the losses were not to the degree found in other studies (Leterme, Cordonnier, Mounier & Maurice, 1994; Coutinho, et al., 2004; Stevens, Walter, Okereke, et al., 2004). This could be due to the use of rats in some studies, a slightly longer immobilization period, or differences the methodology of the studies. Regardless, we found that stretching did result in less muscle loss, which has important applications for people who are immobilized.

Generally, ROM will be improved as a result of stretching and decreased during immoblization.19 In our study dorsiflexion ROM increased 25% in the ESG and decreased 28% in the EG. These results are similar to Kokkonen et al. (2007) who found a 18.1% increase in the sit and reach as a result of a stretching program and Guissard and Duchateau (2005) who found a 30.8% increase in ankle dorsiflexion.

Strength is usually reduced during immobilization. However, just stretching has been found to increase strength (Kokkonen, et al., 2007). We found strength increased 11% in the ESG despite the ankle being immobilized for two weeks. Contrast that to the EG which had a 16% decrease in strength. Kokkonen, et al. (2007) found similar results in a study were inactive subjects were on a stretching program for 10 weeks. They found an increase of 15.3% in 1RM for knee flexion and 32.2% for knee extension.

We did not examine why the changes in muscle girth, ROM, and strength happened. The changes could be due to changes in protein synthesis, growth factor production, or neutrophil elevation. Protein synthesis in rats was found to increase 7% per day during stretching, leading to muscular hypertrophy (Goldspink, 1994). Goldspink (1977) found IGF-1 was the main growth factor in repairing and remodelling tissue when chronic stretching was implemented. Pizza, et al. (2002) found an increase in neutrophil and macrophage concentrations after a stretching program.

CONCLUSION: In conclusion, stretching during immobilization showed a decrease in the loss of strength, girth, and ROM. Chronic stretching should be considered in an athlete's everyday training after practice or on days of no practice. An important implication of this study is that injured athletes, who might have to reduce or stop training for a period of time, could reduce the negative effects of immobilization and help maintain their physiological function and performance by just stretching. Thus possibly allowing them to return to play in less time and at a level of performance that is closer to where they were before the injury.

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