

## The Effects of Static and Dynamic Stretching Exercises on Ankle Muscle Strength and Balance

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### Abstract

Different types of stretching exercises are utilized prior to physical exercises as a part of warming-up. The purpose of this study is to investigate the effects of the dynamic and static stretching exercises on ankle muscle strength and single-leg balance. Twenty healthy male participants, who were between 25 and 30 years old and did not have a previous ankle injury, were included in the study. This study is a cross-over designed study. Isokinetic ankle muscle strength tests and single-leg balance tests were applied to the participants after different intervention protocols (two intervention protocols and one control protocol) on 6 different days. With isokinetic testing, peak torque and average power were measured at 60°/s and 120°/s angular velocities. The tests were performed to the participants after static stretching, dynamic stretching and for a resting period without stretching. The order of stretching intervention was determined randomly. The Peak Torque results of the 120°/s angular velocity isokinetic strength test after the dynamic stretching exercises were found significantly improved than those without stretching exercises ( $p<0.05$ ). A significant difference was not determined in Average Power and Peak Torque at 60°/s values ( $p>0.05$ ). It was also shown that the dynamic stretching significantly enhanced the balance scores ( $p<0.05$ ). In the current study, dynamic stretching exercises were found to have positive effects on isokinetic peak torque and balance scores.

**Keywords:** Muscle Strength, Postural Balance, Static Stretching, Dynamic Stretching.

### INTRODUCTION

As well as various external factors; some individual factors such as strength, balance, flexibility are associated with sports performance (Cronin and Sleivert, 2005; Hrysonmallis, 2011). The relationship between these factors is a matter of curiosity. There are various types of stretching exercises that are used before physical activity. Static stretching (SS) and dynamic stretching (DS) exercises are some of them. Static stretching is the type of stretching exercise often preferred by the athletes. Currently, many studies claim that both static and dynamic stretch affect athletic performance. Some researches, about the SS before physical activity, claimed that it caused a decrease in the vertical jump height (Bradley et al., 2007), sprint (Gelen, 2010) and isokinetic muscle strength (Cramer et al., 2006). The adverse effects of the SS are thought to be caused by mechanical (Herda et al., 2008) or neuromuscular factors (Hough et al., 2009). On the other hand, some studies reported that SS had no

significant effect (Beedle et al., 2008; Handrakis et al., 2010) or an enhancement effect on performance (Costa et al., 2009). It is thought that conflicting opinions are related to different factors such as duration and intensity of stretching and study populations (Behm & Chaouachi, 2011).

Dynamic stretching has become more popular due to contradictions in the literature about the effects of SS. The effects of dynamic stretching on joint mobility range of motion (ROM) and performance parameters were examined in some studies. It is stated that the DS improves ROM (Beedle and Mann, 2007), sprint (Fletcher and Anness, 2007), power (Manoel et al., 2008), isokinetic muscle strength (Sekir et al., 2010) and jump (Hough et al., 2009; Jaggars et al., 2008).

Besides, stretching exercises may affect the balance like as well as strength and power. Behm et al., (2004) reported that SS decreased the balance ability and adverse effects could be related to the changes in the length and stiffness of muscle tendons. However, there is a lack of knowledge in the literature about the effect of DS on balance. Furthermore, it is known that ankle plantar and dorsal flexor muscles are crucial to maintain the balance (Di Giulio et al., 2009; Jeon et al., 2013; Yaggie & McGregor, 2002).

To the authors' knowledge, there is not any study investigating the application of DS to the ankle plantar and dorsal flexor muscles on balance. The purpose of this study is to investigate the effects of different stretching exercises on the ankle plantar and dorsal flexor muscle strength and single-leg balance.

## **METHOD**

**Participants:** Twenty sedentary men ( $27.6 \pm 1.2$  years,  $179 \pm 5.6$  cm,  $81.8 \pm 10.3$  kg,  $25.3 \pm 2.4$  BMI) were participated in this study. Stretching exercises and tests were applied to the dominant leg of the participants. Patients with acute or chronic ankle injury and ankle ROM limitation were excluded from the study. This study was designed according to the Declaration of Helsinki, which printed in the British Medical Journal (18 July 1964). Ethical approval was obtained from the Ankara University Ethical Committee (26.08.2013/11-469-13). All participants were fully informed about the study and they all signed written informed consent form.

**Materials and Procedures:** This study is a cross-over designed study. Before the data gathering, each participant underwent in a physical examination and they received orientation training about the isokinetic tests and balance tests. Following the orientation, the participants implemented the tests on different days in the same order. Interventions before the tests are as follows: (a) the balance test after warm-up without stretching [control protocol], (b) balance test after warm-up and static stretching, (c) balance test after warm-up and dynamic stretching, (d) isokinetic muscle test after warm-up without stretching [control protocol], (e) isokinetic muscle test after warm-up and static stretching, (f) isokinetic muscle test after warm-up and dynamic stretching. In the current study, at least 48 hours interval was given between the tests to eliminate the learning effect. The tests were carried out on six different days and completed in a total of two weeks. All study procedures were performed between

16:00 and 20:00. The average duration of each static and dynamic stretching exercise took 5 minutes. Therefore, each participant was given a rest for 5 minutes in the control intervention before tests.

*Static Stretching Protocol:* Before the static stretching session, each participant performed a warm-up exercise with a bicycle ergometer at 60 RPM and 50 Watt for 5 minutes. For stretching the ankle plantar and dorsal flexor muscles of the dominant leg, two static stretching exercises were applied to both muscle groups. The participants repeatedly practiced both exercises for 20 seconds in the point that accepted as their moderate discomfort level. Between each stretching repetition, it was asked to keep the ankle in the neutral position for 15 seconds. In total, the static stretching exercise lasted 5 minutes (Sekir et al., 2010).

*Dynamic Stretching Protocol:* Before the dynamic stretching session, each participant performed the warm-up exercise with a bicycle ergometer at 60 RPM and 50 Watt for 5 minutes. As dynamic stretching, two stretching exercises were performed in both on standing and sitting poses for plantar and dorsal flexor muscle groups. Dynamic stretching exercises were performed with the contraction of antagonist muscle groups of target muscles. Before each stretching exercise, the antagonist muscles were kept contracted for 2 seconds to stretch the target muscle. Then, the participants were asked to contract antagonist of the target muscles 5 times slowly and 10 times as strongly and quickly as possible. Between each stretching repetition, it was asked to keep the ankle in the neutral position for 15 seconds of resting period. In total, the dynamic stretching exercise lasted about 5 minutes (Sekir et al., 2010).

### **Data Collection:**

*Isokinetic Test Protocol:* Biodex Isokinetic System Pro was used for isokinetic concentric peak torque (PT) and average power (AP) measurements of plantar and dorsal flexor muscles in the ankle. The participant's ankle to be tested was placed on the device's plantar flexor and dorsal flexor plate. Afterward, the participants performed five ankle flexion and extension exercises at 60°/s angular velocity and ten ankle flexion and extension exercises at 120°/s angular velocity. A 1-minute rest was given between each angular velocity. The PT and AP values of each test were used in the data analysis.

*Balance Test Protocol:* The balance test was carried out with the Biodex Balance Systems SD device. This device consists of a moving circular platform and a pivot shaft under the platform. The platform that measures the center of gravity changes is connected to a computer. The changes are determined as "balance score" according to their distance from the starting point. The changes are calculated as anteroposterior (A-P), mediolateral (M-L) and total (T) score. The decrease in the balance scores indicates a better balance ability. "Athletic Single-Leg Test" procedure was conducted to the participants. The participants were asked to stand on the platform three times for 20 seconds with their dominant leg on the standing platform of the device. A 1-minute rest was given between each test. Anteroposterior (A-P), mediolateral (M-L) and total (T) balance scores were used for data analysis.

**Data Analysis:** The sample size was determined to be 0.80 power, 0.05 alpha and 0.25 effect size (R 3.0.1 open source program). The Friedman test was used to investigate the differences between the three protocols. Post-Hoc Tests were performed for paired comparison. All statistical analysis was performed with the arrangement of importance to  $p < 0.05$  by SPSS in Windows 11.5 operating system.

## RESULTS

When the dynamic stretching protocol and the control protocol were compared, there was a significant increase in plantar flexion peak torque values at  $120^\circ/\text{s}$  angular velocity after dynamic stretching ( $p < 0.05$ ). There was not any significant difference in other isokinetic strength measurements (Table 1-2).

**Table 1.** Isokinetic test Peak Torque (PT) values of three protocols. Values are median (min-max)

	Static	Dynamic	Non-Stretch	<i>p</i> value
60°/sec PF-PT (Nm)	40.5(21.9-68.3)	47(23.5-76.5)	39.8(17-77.8)	0.157
60°/sec DF-PT (Nm)	33.9(25.4-55.5)	38.75(26.1-59.5)	32.4(28.4-54.1)	0.247
120°/sec PF-PT (Nm)	30.9(20.7-48.6)	36.5(21-68.8)	31.5(19.6-52)	0.022*
120°/sec DF-PT (Nm)	24.7(15.7-52.4)	29.85(19.5-49.8)	27.4(19.9-45.5)	0.705

\* Significant difference between dynamic stretching and non-stretching protocols ( $p < 0.05$ ) (Friedman test and post-hoc tests)  
 \*\* PF= Plantar Flexor, DF= Dorsal Flexor, PT= Peak Torque

**Table 2.** Isokinetic test Average Power (AP) values of three protocols. Values are median (min-max)

	Static	Dynamic	Non-Stretch	<i>p</i> value
60°/sec PF-AP (W)	16.6(6.9-34.8)	20.45(6.8-42.9)	17.65(3-39.9)	0.387
60°/sec DF-AP (W)	20.5(11.3-29.4)	19.7(13.8-33.9)	19.6(16.1-28.2)	0.359
120°/sec PF-AP (W)	18(7.2-34)	20(3.2-43.9)	14.8(3.8-45.1)	0.074
120°/sec DF-AP (W)	19.3(11.6-34.5)	19.55(11.9-37.4)	19.1(17.1-27.3)	0.287

\* PF= Plantar Flexor, DF= Dorsal Flexor, AP= Average Power

When the dynamic stretching protocol and the control protocol were compared it was seen to cause a significant change in the balance scores after dynamic stretching ( $p < 0.05$ ). When the control protocol was compared with the static stretching protocol, no significant difference was found in the balance scores ( $p > 0.05$ ) (Table 3).

**Table 3.** Balance values of three protocols. Values are median (min- max)

	Static	Dynamic	Non-Stretch	<i>p</i> value
Balance Total	1.1(0.7-1.6)	1(0.5-1.5)	1.2(0.8-1.7)	0.008*
Balance A-P	0.8(0.5-1.3)	0.75(0.2-1.3)	1(0.6-1.5)	0.003*
Balance M-L	0.5(0.4-1.2)	0.5(0.1-0.9)	0.6(0.2-0.9)	0.506

\* Significant difference between dynamic stretching and non-stretching protocols ( $p < 0.05$ ) (Friedman test and post-hoc tests). \*\* A-P= Anteroposterior, M-L= Mediolateral.

## DISCUSSION

Some studies in the literature have investigated the effects of stretching types on balance and performance parameters. According to our literature review, this study is the first to investigate the isokinetic parameters on the plantar and dorsal flexor muscles of the dynamic stretching ankle and to focus on the single-leg balance skill scores after applying dynamic stretching exercises at the muscles. In the present study, it was detected that dynamic stretching exercises significantly increased the values of PF-PT at 120°/s, and this data is consistent with previous studies. However, in some studies, it was observed that there was no significant effect the dynamic stretching on the performance such as vertical jump height and isometric peak torque (Christiensen and Nordstrom, 2008; Herda et al., 2008). The intensity (e.g. frequency, range of motion) and duration of dynamic stretching may have affected the results of previous investigations. In the literature, there is no evidence that dynamic stretching deteriorated the performance. Our results also showed that the dynamic stretching does not have any adverse effect on muscle strength. Furthermore, Beedle and Mann reported that dynamic stretching contributed to flexibility (2007).

It was reported that static stretching caused a decrease in performance (Gelen, 2010; Herda et al., 2010; Sekir et al., 2010). Nevertheless, in some studies static stretching was shown to have no significant effect (Beedle et al., 2008; Winke et al., 2010). In our study, static stretching was found to have no significant effect on peak torque and average power and is consistent with some of the literature.

It is suggested that short-term stretching times do not affect performance. In some studies, with short-term static stretching (30-120 seconds), no significant change in power or torque was shown (Molacek et al., 2010; Torres et al., 2008). In our study, static stretching for a short-term (20 sec) was applied to each muscle group. It is reported that a 40-second static stretching caused more deterioration in muscle performance than a 20-second static stretching exercise (Franco et al., 2008). However, there are also studies which show that deteriorations in isokinetic muscle parameters occur after 20 seconds of static stretching exercise is repeated 2 times (Sekir et al., 2010). Thus, it is understood that the reasons for the conflicting literature cannot be explained only by different stretching times. The types of contractions, stretching intensity and population are also stated as considerable effects (Behm & Chaouachi, 2011).

In the present study, a significant improvement was found in the A / P and Total Balance scores after dynamic stretching exercises. Similar results were reported by Chatzopoulos et al. (2014). It is suggested that the dynamic stretching increases muscle temperature (Fletcher and Jones, 2004), increases neural conduction (Herda et al., 2008; Jagers et al., 2008) and it can be an explanation of the balance increase.

Although the balance scores improved after the static stretching exercise, this difference was not statistically significant. In some of the previous studies, it was determined that the static stretching had a negative effect on the balance (Behm et al., 2004; Nagano et al., 2006), and in some cases, it had a positive effect (Costa et al., 2009; Handrakis et al., 2010). In one of the previous studies 3 repetitive static stretching for 15 seconds (Costa et al., 2009) and in the other a total of 3 minutes of static stretching to the gastrocnemius were applied (Nagano et al., 2006). Stretching duration may be the explanation of this conflict. Moreover, to avoid the learning effect, it was thought that the duration between two balance tests should be at least 48 hours (Gribble et al., 2007). In the present study, at least 48 hours interval was given between the tests to eliminate the learning effect. The differences in the duration of static stretching exercises, the effect of muscle fatigue on balance, and the learning effect are accepted as the possible reasons for different outcomes.

## CONCLUSIONS

According to these results, we concluded that dynamic stretching exercises improved balance ability and made an increase in 120°/s in ankle plantarflexion concentric muscle strength. Since there is no harmful effect on the isokinetic parameters and it improves the balance skill, dynamic stretching exercises can be recommended to improve performance before the exercises that require balance and strength.

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