

Effects of External Compression on Isokinetic Muscular Endurance of the Quadriceps and Hamstring Muscle Groups

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*****Note: Figures may be missing from this format of the document**

Abstract:

The purpose of this study was to determine whether external compression would cause a decrease in the isokinetic muscular endurance of the quadriceps and hamstring muscle groups. Subjects were tested on the Cybex II dynamometer (Cybex, Ronkonkoma, NY) under two conditions: with external compression applied to the thigh and without external compression applied to the thigh. External compression was applied with a lower extremity blood pressure cuff inflated to a predetermined clinically standardized pressure. The subjects performed an isokinetic endurance test consisting of 30 maximal repetitions at 180 deg/sec under both conditions. A paired *t* test showed no statistical differences ($p > 0.05$) between the mean total work, work over the first five repetitions, and work over the last five repetitions between the two conditions for the quadriceps and the hamstring muscle groups. Results indicated that external compression applied to the thigh at 30 mm Hg caused no significant decrease in the isokinetic muscular endurance of the quadriceps or hamstrings. Further research is indicated to determine whether external compression could influence other aspects of muscular performance.

Article:

INTRODUCTION

Athletic trainers often use compression wraps to provide support for injured thigh muscles during athletic activity. There are few clinical data to suggest whether a compression wrap is an enhancement or detriment to athletic performance.

Research has shown a high rate of variability of pressure when athletic trainers apply compression wraps.^{5, 14} Other studies have shown that different wrapping pressures can inhibit blood flow to muscles.^{3, 12, 13} There is no established optimal pressure range concerning the application of compression wraps.^{5, 14} Based on the variability of application and the lack of standards to follow when applying wraps, some compression wraps may have a detrimental effect on muscular performance. Specifically, muscular endurance may be significantly affected.

There appears to be no published research justifying or contraindicating the use of compression on working musculature during athletic activity. The purpose of this study was to examine the

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effects of external thigh compression on quadriceps and hamstring muscular endurance using a Cybex II isokinetic dynamometer (Cybex, Ronkonkoma, NY).

METHODOLOGY

Subjects

Subjects in this study were 15 college-age men (mean age 21.6 ± 2.82 years, mean weight 78.5 ± 8.0 kg, mean height 179.6 ± 4.92 cm). Each subject was informed of the low risk of participating in a concentric isokinetic testing and was informed of the testing protocol. The subjects were given a detailed description of the study and voluntarily signed a consent form. Each subject was screened for previous injury to the knee or thigh musculature. Only subjects with no history of knee joint, quadriceps, or hamstring injury were included in this study.

Compression

To determine a clinically relevant pressure, 10 certified athletic trainers were asked to apply an elastic wrap to the thigh. Each athletic trainer performed three trials, and pressure applied was measured by a manometer (AirCast Inc., Summit, NJ) attached to an air-filled bladder. Pressure (mm Hg) was recorded for each trial. The mean pressure applied for 30 trials was 30.67 ± 6.46 mm Hg.

To standardize pressure during isokinetic testing, external compression was applied with a lower extremity blood pressure cuff. The cuff was applied to the mid-thigh at a pressure of 30 mm Hg and remained on the subject throughout the testing procedure.

Test Protocol

Each subject underwent two randomly ordered tests in two sessions. One session consisted of assessing the isokinetic muscular endurance of the dominant leg without external thigh compression. The other session followed the same protocol, but with the use of external compression applied to the thigh.

Muscular endurance was measured using a Cybex II isokinetic dynamometer with a dual-channel recorder and Cybex data reduction computer. Test protocol and verbal cues were standardized for all subjects. The testing protocol consisted of measuring total work performed during reciprocal concentric contractions of the quadriceps and hamstrings over 30 maximal repetitions at 180 deg/sec. The isokinetic warm-up protocol consisted of three sub-maximal concentric contractions followed by three maximal concentric contractions. This warm-up was followed by a 1-minute rest period, then the 30-repetition test.

Subjects were stabilized with hip and thigh straps during testing. The subjects were tested with the hip flexed at approximately 90°. The knee range of motion tested was from 90° of flexion to 0° of extension. The axis of rotation of the dynamometer was visually aligned with the joint line of each subject's knee. No flexion or extension stops were used. All data collected were gravity corrected for the weight of the subject's leg and input arm of the dynamometer. Subjects were retested with at least 72 hours of rest between test sessions and were excluded until any residual symptoms from the first test had subsided.

Table 1 Quadriceps total work, work over the first five repetitions, and work over the last five repetitions at 180 deg/sec (n = 15).

Condition	Total work	First 5	Last 5
With pressure	2,142.0 ± 211.3	448.4 ± 84.4	251.0 ± 15.4
No pressure	2,194.5 ± 246.9	461.0 ± 80.1	260.1 ± 30.2

Values are mean joules ± SD.

Statistical Analysis

Paired *t* tests were used to compare total work, first five repetitions, and last five repetitions for the quadriceps and hamstring muscle groups with and without the cuff applied to the thigh. Alpha level was preset at ($p < 0.05$).

RESULTS

Group means and standard deviations for total work, work over the first five repetitions, and work over the last five repetitions for the quadriceps and hamstring muscle groups are shown in Tables 1 and 2, respectively. There were no statistically significant differences ($p > 0.05$) between the two test conditions in either muscle group.

Total work ranged from 1,808.6 to 2,675.8 J and 652.7 to 1856.7 J for the quadriceps and hamstring muscle groups, respectively. Work over the first five repetitions ranged from 272.3 to 635.6 J and 66.6 to 407.7 J for the quadriceps and hamstring muscle groups, respectively. Work over the last five repetitions ranged from 189.4 to 293.8 J for the quadriceps and ranged from 136.2 to 205.0 J for the hamstrings.

DISCUSSION

This study showed that external pressure applied to the thigh with a lower extremity blood pressure cuff inflated to 30 mm Hg caused no significant decrease in the isokinetic muscular endurance of the quadriceps or hamstring muscle groups. There are some issues concerning the design and methodologies that may have influenced results.

Table 2 Hamstring total work, work over the first five repetitions, and work over the last five repetitions at 180 deg/sec (n = 15).

Condition	Total work	First 5	Last 5
With pressure	1,389.0 ± 199.0	292.0 ± 79.3	162.1 ± 13.1
No pressure	1,411.8 ± 259.7	302.7 ± 73.4	164.0 ± 20.7

Values are mean joules ± SD.

This study used a lower extremity blood pressure cuff to apply the external pressure. A concern was that the pressure exerted by the cuff on the leg during testing did not equate to the clinically applicable pressure exerted by an elastic wrap. Future studies should use an elastic wrap with an air bladder and manometer or multiple air bladders and manometers during the test rather than a blood pressure cuff to more closely replicate the athletic setting.

It was also noted during testing that the pressure reading on the cuff dial would increase with knee extension and return to the original setting during knee flexion. This appeared to be caused by the increased thigh girth associated with contraction of the quadriceps. At the end of the test, it was noted that the baseline pressure setting also decreased slightly. This was thought to be caused by slight migration of the cuff during the test session. Although not thought to be a significant factor, these changes also may have had an influence on data collection.

Another issue was whether the pressure applied to the thigh was an accurate assessment of the clinical standard. Suggestions to remedy this would be to include more than 10 athletic trainers in the establishment of a clinically standard wrapping pressure. The results of Duffley and Knight⁵ demonstrated a mean wrapping pressure of 55.2 mm Hg over the ankle by four experienced athletic trainers. Another study had a mean wrapping pressure over the thigh with an elastic wrap of 46.8 mm Hg by advanced student athletic trainers.¹⁴ Yamaguchi *et al.*¹⁵ also reported no significant effects on blood flow when bandage pressures were at 30 mm Hg. Considering these results, a more in-depth study of a standard pressure is needed before investigating its effect on muscular performance. Furthermore, a study using similar methodologies but with different pressures applied (i.e., 20, 40, 50 mm Hg) also may be indicated.

Several studies have examined the effect of externally applied pressure on blood flow, although discrepancy in findings may be found. Decreases in vascular flow have been reported at pressures lower than the cuff pressure used in this study. Neilsen⁹ demonstrated decreases in blood flow in pressure ranges of 12-30 mm Hg in four patients. Husni *et al.*⁶ showed decreases in blood flow with simulated venous occlusion at pressures of 25-30 mm Hg.

Other studies have obtained data to the contrary. Lawrence and Kakkar⁷ reported a significant increase in deep venous velocity with no changes in muscular blood flow or subcutaneous tissue flow at pressures ranging from 8 to 18 mm Hg. At pressures of 12-30 mm Hg, deep venous velocity also increased but caused a significant decrease in subcutaneous tissue flow. Yamaguchi *et al.*¹⁵ demonstrated a decrease in pulsatile blood flow at 70 mm Hg. No significant decrease was reported at 30 mm Hg. Neilsen⁹ showed no significant reduction in blood flow at 10-20 mm Hg and a decrease in flow as external pressure approached diastolic blood pressures.

Dahn *et al.*⁴ found results similar to those in the studies cited above in muscular blood flow. They reported significant decrease or stoppage in muscular blood flow when external pressure approached diastolic pressure. Thorsson *et al.*¹³ showed that at rest a 57% decrease in mean relative blood flow was recorded when mean external pressure was 39.5 mm Hg. After exercise, a mean pressure of 40.5 mm Hg caused a decrease in mean relative blood flow of 32%. Styf¹² showed a decrease in blood flow during exercise when the intramuscular pressure was 30-40 mm Hg. The external pressure applied ranged from 30 to 60 mm Hg. Perhaps it is not the external pressure applied that influences blood flow, but the intravenous or intramuscular pressure that is the key factor. If this is the case, body

composition and location of the muscle being compressed and exercised could have had a great influence on our results.

Subjects included in this study may also have been an influencing factor on our results. All 15 subjects were moderately to highly active healthy college-age men. Often it is injured athletes returning to competition who have wraps applied to the proximal aspect of the lower extremity. The results obtained using such a homogeneous group cannot be used to make generalizations about a more heterogeneous population or about the athletic population at large.

The period between tests may have influenced the data as well. The only stipulation for time between tests was that each subject had to have 72 hours of rest between test sessions. Some subjects were retested on the 4th day after the first test, and some subjects were retested on the 5th day after the first test. Other subjects were retested with a full week between test sessions. Although all subjects had the minimum rest period between bouts, the differences in time between retests may have caused inconsistencies in the data.

The reliability of using isokinetics to measure endurance has also been questioned. In the past endurance has been measured isokinetically by calculating an endurance ratio, i.e., comparing the work completed during the first five repetitions to the work done in the last five repetitions. Some studies have questioned the reliability of this measure.^{2,10} It has been suggested that total work performed over a fixed number of contractions may be a better indicator of endurance.^{8,11} This study used total work over all contractions, the first five contractions, and the last five contractions. Data analysis showed no significant differences in endurance using these measurement parameters. It remains to be proven conclusively, however, whether isokinetic endurance is an accurate indicator of true muscular endurance.

Perhaps a more accurate way to assess endurance in a study such as this one would be to have subjects perform an exercise bout with compression applied to the working musculature and then perform the test on the isokinetic dynamometer. In this study, the isokinetic test only lasted 30 seconds and was performed at a maximal level. This would indicate that the energy system used by the working muscles was fast glycolysis.¹ In this system oxygen is not used in energy production. This would suggest that oxygen supply, and as a result blood flow, would be inconsequential for the muscular performance. Endurance activities incorporate the energy-producing pathways of slow glycolysis and oxidative phosphorylation.¹ Oxygen supply and blood flow play a much greater role in this type of exercise and energy production. By incorporating a submaximal exercise bout before an isokinetic endurance test, external compression may produce a more clinically applicable effect on the muscles and on the blood and oxygen supply. This would more closely simulate athletic performance and still allow for quantification of changes in performance of the working musculature.

CONCLUSION

As a result of this study, it can be concluded that external compression applied to the thigh at 30 mm Hg does not cause a statistically significant decrease in the isokinetic muscular endurance of the quadriceps or hamstring muscle groups. As such, the application of an elastic wrap to the proximal thigh is probably not a detriment to physical performance. Further investigation is needed to determine whether external compression influences other aspects of muscular performance. Research is also indicated to investigate whether higher applied external pressure

influences muscular performance. Changes in protocol also may be indicated to develop a more clinically applicable study.

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