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THE EFFECT OF UPPER LEG COMPRESSION AND HIP JOINT STIFFNESS ON SPRINTING AND JUMPING PERFORMANCE

John W. Wannop, Jay T. Worobets and Darren J. Stefanyshyn
Human Performance Laboratory, Faculty of Kinesiology, University of Calgary, Alberta, Canada
bwannop@kin.ucalgary.ca

INTRODUCTION

Performance apparel is used by many athletes in a variety of sports, yet studies investigating their effects on performance show mixed results [1,2,3,4,5]. Typically, studies that have failed to show performance benefits state that the amount of compression applied by the apparel may have been insufficient. Thus, the amount of compression needed to elicit a performance benefit is not currently known. However, not only does performance apparel compress the soft tissues, it also has the ability to alter joint stiffness of the athlete [6], although this component has never been studied in regards to performance. This raises the question of which component, compression or stiffness, is actually responsible for potential performance benefits, and how much compression and/or stiffness is optimal. Currently, no study has examined the effects of both compression apparel and increasing joint stiffness on performance. Therefore the purpose of this study was to determine how systematically increasing upper leg compression and hip joint stiffness independently from one another affects sprinting and jumping performance.

METHODS

Ten male athletes participated in the study, including 5 jumping athletes (volleyball and basketball players) and 5 sprint athletes. Eight concept apparel conditions and one control condition were tested on two separate testing sessions for both a sprint and countermovement jump. The control condition was adidas Climalite shorts. Of the eight concepts, four specifically altered the amount of compression exerted on the thigh. This was done by using compression shorts of different sizes (from smallest to largest, size 42, 44, 48 and 50).

The remaining four apparel concepts specifically altered hip stiffness, by incorporating elastic thermoplastic polyurethane (TPU) bands. This was done by using a harness that was anchored to a waist belt as well as by leg straps attached to the distal thigh of each leg, just above the knee. The belt and leg straps were attached by adjustable TPU bands that originated at the posterior midline of the waist belt and inserted on the posterior midline of each leg strap. In order to alter the hip stiffness each harness had a different number of TPU bands. The 1X harness had one band, 2X had two bands, the 3X had three bands and the 6X had six bands, all attached to each leg strap.

Sprint performance testing (5 sprint athletes) was broken into two testing sessions, each consisting of maximum effort 30m sprints starting from rest on an indoor running track. During session one, the subjects performed sprints in the control condition and all compression apparel while in session two the subjects performed in the control and all the stiffness conditions. Flying 20m sprint times were collected with timing lights placed at the 10 and 30m marks on the track.

Similar to sprint testing, jump testing (5 jumping athletes) was conducted over two sessions, with the compression and control tested in session one and the stiffness and control tested in session two. Jump testing was conducted in lab with a Vertec jump meter. The subjects executed a countermovement squat jump, with the goal of reaching as high on the Vertec as possible. After a warm-up of practice jumps, two trials in each condition were recorded.

During all testing sessions, athletes were given a minimum of one minute rest between trials and the order that the conditions were tested was randomly assigned. Testing sessions were separated by at least two days to reduce the effect of fatigue. Kinematic data of the hip joint were collected with a the high speed camera (Casio EX-FH25) collecting at 480Hz. Markers were placed on the lateral aspect of the knee joint, the greater trochanter and the upper body in order to define the thigh and trunk segments, and to determine the hip joint angle using Dartfish software (Dartfish, Switzerland). During the sprint, data were collected during the stance phase at the 25m mark, while during the jump, data were collected during the entire jump. For the sprint and jump testing, the average of two trials in each condition was calculated and comparisons were made between each compression and stiffness condition and the control using repeated measures ANOVA ($\alpha=0.05$).

RESULTS AND DISCUSSION

The sprint performance results can be seen in Figure 1. On average, the control condition produced a faster sprint time than all of the compression conditions, although only significantly faster than the size 44. However, when individual subject-specific results were examined, none of the subjects had their best performance in the control. No differences in hip angle were seen at touchdown, however, the compression apparel caused the sprinters to have more hip flexion at takeoff (Table 1). The results indicate that

compression apparel can have an effect on sprinting, but the optimal amount of compression to elicit a positive effect remains unknown and appears to be very subject specific. This subject specific effect may explain why previous studies found no difference between compression and a loose fitting control during sprint performance [2,4,7].

All stiffness conditions led to a statistically significant decrease in sprint performance compared to the control. No differences in hip kinematics were seen (Table 1). A previous study has shown differences in kinematics during the early acceleration phase of sprinting, relating to a decrease in range of motion of the hip joint [6]. This was not seen in the current study and may be due to the fact that kinematic measurements were taken at the 25m mark of the 30m sprint, while the previous study collected kinematics of the initial few strides of a sprint start in the lab.

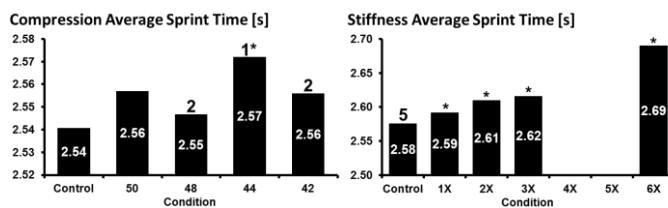


Figure 1: Performance results of the sprinters in the compression apparel (left) and stiffness conditions (right). Asterisks represent a significant difference from the control condition. The number of athletes who performed best in each condition is labeled above the condition.

Jump performance results are shown in Figure 2. For the compression apparel, the size 48 condition resulted in a statistically significant increase in jump height compared to the control, with 4 of the 5 subjects having their best jump in this condition. The effect of compression on vertical jump performance has been shown to have conflicting results in the literature with some studies showing performance increases [1,2,3] while other studies have reported no differences between compression apparel and loose fitting shorts [4,5]. The conflicting results of these studies may be due to the difference in the location and type of compression used as well as due to individual responses of the subjects to the compression used. Compression apparel resulted in greater peak hip flexion, which has been shown previously [7], with the size 48 significantly increasing hip flexion compared to the control. It is currently not known why the size 48 led to greater hip flexion than the other conditions.

For the stiffness conditions, the stiffest condition (6X) resulted in the trend of increasing jump height ($p=0.07$), with 4 of the 5 subjects attaining their highest jump in this condition. Each stiffness condition resulted in a systematic decrease in the peak hip flexion angle (Table 1). This is in

direct contradiction of the results seen for the compression vertical jumps. While wearing the compression, increases in jump performance were seen with increases in hip flexion angle. This suggests that increased stiffness results in increased jump height despite the fact that the peak flexion was decreased which warrants further investigation.

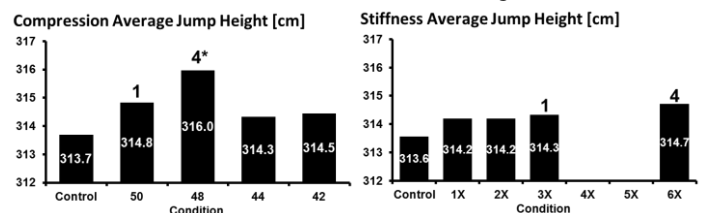


Figure 2: Performance results of the jumping subjects in the compression apparel (left) and harness conditions (right). Asterisks represent a significant difference from the control condition. The number of athletes who performed best in each condition is labeled above the condition.

CONCLUSIONS

During sprinting, on average, the compression conditions were slower than the control. However, compression can enhance performance, as each individual subject had his best performance with one of the compression conditions. Thus, optimal compression seems to be subject specific and it is currently not known how to identify the optimal compression for maximal performance of individual athletes. Until this question is solved, it may be beneficial to limit the amount of compression to avoid potential negative effects on performance. Increasing hip joint stiffness had a negative effect on sprint performance.

During jumping, on average, the size 48 apparel (mid-range compression) resulted in the highest jump height. This apparel condition led to increased hip flexion, however, hip flexion was not systematically changed with increasing compression and it is unknown why a mid-range compression (size 48) led to greater hip flexion than either more or less compression. Increasing stiffness systematically decreased hip flexion. Despite this, jump height was systematically increased with increasing stiffness, which could be related to the corresponding increases in passive joint moments with stiffer apparel.

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Table 1: Average kinematic values during the sprint and jumping movements. Bold values represent a significant difference between the experimental condition and the control.

		Compression					Harness				
		Control	50	48	44	42	Control	1X	2X	3X	6X
Sprint	Hip Flexion Angle at Touchdown [°]	31.3	33.8	39.1	30.6	37.7	28.1	35.1	31.5	28.2	24.3
	Hip Flexion Angle at Takeoff [°]	-1.5	5.5	10.6	8.4	9.6	-8.9	-3	-7.8	-5.6	-6.2
	Hip Range of Motion [°]	32.9	28.2	28.4	22.2	28.1	37	38.1	39.4	33.7	30.5
Jump	Peak Hip Flexion Angle [°]	82.2	85.8	89.2	85.6	85.5	83.1	81.2	77.2	74.7	69.6