

Influence of Compression Garments on Vertical Jump Performance in NCAA Division I Volleyball Players

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Reference Data

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ABSTRACT

The purpose of this study was to determine whether compression shorts affected vertical jump performance. Subjects, 18 men and 18 women varsity volleyball players, were thoroughly familiarized with the jump tests and experimental techniques. Testing utilized compression shorts of normal fit (CS), undersized compression shorts (UCS), and loose fitting gym shorts as the control garment (CT). All tests were conducted on the same day using a balanced, randomized block design to remove day-to-day variation. Jumps were performed on an AMTI force plate interfaced to a computer with customized software to determine jump force and power. Ten consecutive maximal countermovement jumps with hands held at waist level were evaluated. The garments had no effect on maximal force or power of the highest jump. However, mean force and power production over the 10 jumps when wearing the CS were significantly ($p \leq 0.05$) higher than CT for both men and women. In men the UCS mean power production was also higher than the CT. The data indicate that compression shorts, while not improving single maximal jump power, have a significant effect on repetitive vertical jumps by helping to maintain higher mean jumping power.

Key Words: power, force, anaerobic performance

Introduction

Over the past 5 years compressive garments (e.g., elastic shorts, tights) have become popular among athletes and fitness enthusiasts. Factors such as style, garment fit, less chaffing between the legs when exercising, and anecdotal reports of enhanced performance effects have all contributed to their popularity. Yet the data are limited as to whether such garments have any influence on physical performance.

Initial studies on the use of compressive garments were based in part on the prophylactic effect of elastic compression on the formation of venous thrombosis in postoperative patients. Such studies demonstrated that compression stockings resulted in increased venous blood flow and decreased venous stasis in the lower limbs (6, 9, 10, 13). From this it was thought that any positive effects with exercise were probably due to enhanced circulation. Berry and McMurray (5) had hypothesized that the use of elastic compression stockings would result in lower lactate concentrations due to the increased blood flow observed while wearing the stockings. Their results revealed lower blood lactate concentrations following maximal exercise when the stockings were worn during the exercise. In a subsequent study on the influence of such garments worn during the recovery period after exhaustive exercise, Berry et al. (4) found no significant differences in oxygen consumption, heart rate, or venous blood lactate between the control and compressive garment condition and thus concluded that elastic tights would not significantly affect postexercise responses.

We have observed that the sports which have popularized compressive garments tend to be power sports (basketball, track and field, volleyball) and are dependent on vertical jump ability. But there were no data as to the effects of compression garments on power production. Harman and Frykman (7) demonstrated that the wearing of compressive wraps around the knee joints increased force production and may be one reason why such wraps are worn by competitive lifters for enhanced one-repetition maximum (RM) performance in the squat. However, such high amounts of compression would not be comfortable for long-term use such as during an entire game. Thus the question arises as to whether compression garments not limited by a comfort factor could have any observable benefits for strength or power production. Therefore, the primary purpose of this investigation was to determine the influence of compressive shorts on power production during maximal effort vertical jumping.

Methods

Subjects

Eighteen men and 18 women members of the Penn State varsity volleyball teams were informed of the benefits and risks of the study. Subsequently each signed informed consent in accordance with the guidelines of Pennsylvania State University's Institutional Review Board for use of human subjects. The subjects were medically screened and had no medical or orthopedic problems that would compromise their participation and performance in the study. Each team had been ranked among the top 4 NCAA Div. I teams in its respective seasons of competition. Subject characteristics were as follows:

- Men: age 21.0 ± 3.1 yrs; height 187.3 ± 6.8 cm; body mass 80.6 ± 11.35 kg.
- Women: age 20.4 ± 3.09 yrs; height 172.72 ± 8.6 cm; body mass 68.7 ± 8.1 kg.

Each subject was carefully familiarized with jump test procedures, jumping techniques, and the 10-jump endurance test. All familiarization took place without the use of compressive shorts. Although many players had worn various types of compressive shorts in the past, covariate analyses revealed that prior experience with the use of compressive shorts did not influence the results. It was vital that adequate time be given to the practice phase so that variations in jump technique, learning effects, or pattern of effort would not add extraneous error to the measurements. Thus, unlimited practice was allowed until each subject could achieve a repeatable measure of maximal power and pattern (descending curve) of power changes. If individuals could not produce repeatable fatigue curves, they were not used as subjects. Test-retest reliabilities demonstrated intraclass correlations of ≥ 0.94 for all dependent variables.

Experimental Design and Procedures

This study employed a 10-maximal jump test using a countermovement jump with hands on the waist to isolate the lower body and remove the influence of the arm movements. Subjects were told not to perform strenuous exercise for 12 hrs prior to testing, get a normal night's sleep, and not eat for 2 hrs prior to testing. Tests were conducted with all garment conditions on the same day using a balanced, randomized block design to eliminate day-to-day variation. Ten maximal jumps were performed, one every 3 sec as cued by an auditory signal. Subjects were instructed not to pace themselves but to exert maximum effort with each jump. After familiarization, this resulted in a typical descending power output fatigue curve.

No target was set for the subjects. A 10-min rest period between conditions was allowed for recovery and garment changing. The subjects took part in low intensity jumping warm-up and stretching prior to maximal jump testing. Then they performed 30 maxi-

mal jumps, 3 sets of 10 with different garment conditions. The highest power output for a single jump was used for comparing maximal jump performances. This occurred in the first 1 or 2 jumps of the 10-jump protocol.

The compression shorts (CS) covered the area from the waist to just above the knee and were individually fitted by waist and hip size according to manufacturer guidelines. The garment consisted of an 88% 70-denier Antron® nylon and 12% 40-denier Lycra® spandex warp knit tricot weighing 8.2 oz per sq yd and having approximately $165\% \times 125\%$ total stretch. The undersized compression shorts (UCS) acted as a placebo and were fitted one size smaller than the CS, which was considered a normal fit. The control garment (CT) was a pair of regular gym shorts with no tight fitting undergarments worn underneath.

Compression was measured by strain gauge measurements under the front and sides of each garment while the individual was standing. UCS > CS, while CT (regular gym shorts) had a 0 compression factor since no force was exerted on the thigh. All jumps were performed on an AMTI (Advanced Medical Technology, Inc., Newton, MA) force plate interfaced with a computer, and customized software was used to calculate maximal force and power from each vertical jump tracing.

A multivariate ANOVA was used to analyze the data, and Tukey post hoc tests were used to determine pairwise differences when appropriate. Significance in this study was set at $p \leq 0.05$.

Results

The results demonstrated that compressive shorts are of benefit in helping competitive volleyball players maintain power production over repeated jumps. The compressive shorts did not influence maximal jump power, as shown in Table 1. Yet, in men the force production was higher for the CS and UCS conditions. Figures 1 and 2 overview the mean power output over 10

Table 1
Force and Power Outputs for Highest Vertical Jump

	Force (N)		Power (W)	
	M	± SD	M	± SD
Men				
CS	2,208	651*	4,641	757
CT	1,987	1,358	4,311	845
UCS	2,623	1,264*	4,415	593
Women				
CS	1,553	233	2,774	566
CT	1,484	211	2,856	489
UCS	1,515	233	2,891	480

CS = compression shorts, CT = control shorts; UCS = undersized compression shorts.

* $p \leq 0.05$ from corresponding CT value.

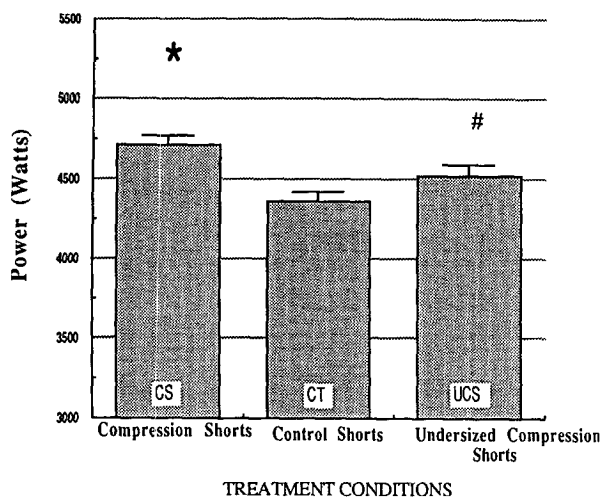


Figure 1. Mean power output for 10 vertical jumps in 18 NCAA Div. I male volleyball players under different garment treatment conditions. * $p \leq 0.05$ from corresponding CT condition; # $p \leq 0.05$ from corresponding CT and CS conditions.

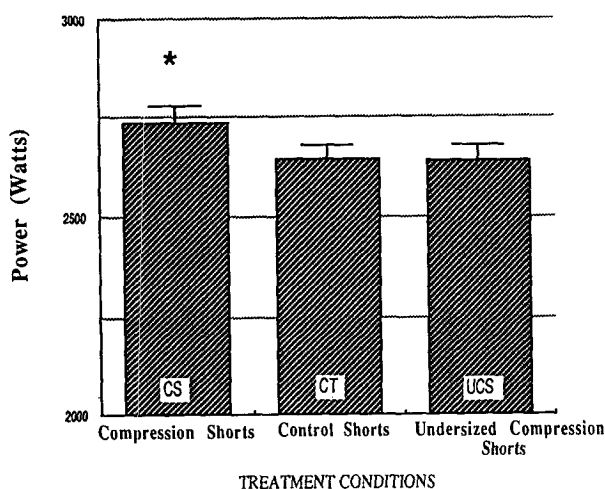


Figure 2. Mean power output for 10 vertical jumps in 18 NCAA Div. I female volleyball players under different garment treatment conditions. * $p \leq 0.05$ from corresponding CT and UCS conditions.

vertical jumps for men and women, respectively. Mean force (N) was also significantly greater for CS ($2,047 \pm 50$) and UCS ($2,036 \pm 56$) when compared to CT ($1,951 \pm 45$).

Discussion

The primary finding was that NCAA Div. I volleyball players were better able to maintain power output during repeated jumping when wearing normally fitted compression shorts. However, the influence of comfortable compression levels found in commercial garments does not appear to augment the highest maximal vertical jump power output. This indicates there may be a

more subtle ergonomic interplay between the garment and natural biological mechanisms. Such a finding also suggests that the popular use of these garments may extend beyond simply the fashion aspects.

Compression has been shown to be beneficial in that it helps the muscle pumping action of the cardiovascular system remove lactate from exercising muscle (5). In addition, power lifters have found benefits in wearing tightly bound wraps around various joints of the body (e.g., knees) to enhance force production. Harman and Frykman (7) were the first to document that knee wraps produce an increase in vertical force at the feet (mean 11.4 ± 2.7 kg) and thus contribute to a greater 1-RM squat. Anecdotally, the use of "super suits" (considered extreme compression, as lifters can only tolerate them for short periods) in power lifting appears to enhance high force development for 1-RM lifts.

The garments used in this study did not have such extreme levels of compression since they are commercially designed for long-term wear. Yet, despite the lack of high levels of compression, there still appears to be a benefit for the CS. Interestingly, no negative effects were observed with the use of this level of compression in the shorts, even with the UCS garments. Subject reports did reveal that the UCS were not comfortable due to the tight fit in the gonadal area and at a stretch band area anchoring the garment around the lower thigh.

The mechanisms for such improvement remain speculative and require further study. Yet it could be that lower levels of compression interact with biological cueing systems to enhance performance under conditions of fatigue. Joint proprioception, or the ability to perceive joint movement and position in space, is a highly developed physiological function involving a variety of neural pathways coming from receptors in the skin, muscle, ligament, and joint capsule (1, 2, 3).

There are data on patient populations, and in some cases healthy knee joints, to demonstrate enhanced proprioception with the use of elastic bandages or sleeves over the knees. The enhanced proprioception in open chain movement is thought to be related to increased proprioceptive "cues" coming from the skin and joint receptors that are not damaged or surgically removed (e.g., anterior cruciate ligament) (3, 11). Although speculative, one might hypothesize that increased proprioception at the hip joint in this study could contribute to more effective jumping technique, especially under conditions of fatigue.

Harman et al. (8) demonstrated power outputs of $3,767 \pm 686$ W in non-elite male jumpers. The higher power outputs in our elite male volleyball players are consistent with the increases expected of players at a higher level of competition. Few data exist on power outputs in elite women volleyball players. While it may appear that changes in the magnitude of power production and maximum force generation should increase or decrease together, the time over which the power vari-

able is calculated may actually cause power to decrease under maximum force generation. Power, impulse, and force are all integral measures and predictors of motion. Power and impulse rely on temporal information to determine their associated magnitudes; force, however, is temporally independent.

Every individual has his or her own optimized relationship for force generation when trying to create enough of an impulse to maximize vertical jump performance. Usually the individual attempts to generate great force over a short time. Small changes in the duration of time may allow higher forces to be attained, but if the increased time of force application interferes with the intersegmental transfer of forces through the kinetic chain, then jump performance may be hindered. Maximum power for this study was determined by the combination of force and velocity that produced the highest instantaneous power output during the vertical jump.

Practical Applications

The vertical jump is an important skill for many positions on a volleyball team, therefore improvement in this skill has been a primary training goal (12). The style and use of various types of uniform garments has changed over the years. The data from this investigation indicate that the use of compressive shorts in highly skilled jumpers may have value for enhancing power output over a repeated number of jumps. This may be due to enhanced proprioceptive cues, but further work is needed to understand the mechanisms of this ergonomic interface.

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