The Effect of Compression Shorts on Pain and Performance in Male Football Players with Groin Pain – A Double Blinded Randomized Controlled Trial

Running title: The Effect of Compression Shorts on Groin Pain

Abstract

Objective: To investigate the effects of compression shorts on pain and performance in football players with groin pain.

Study Design: Double blinded randomized controlled trial.

Setting: Soccer pitch.

Participants: Thirty-four male football players with groin pain.

Main Outcome Measures: The effect of wearing zoned high compression shorts (ZHC-shorts), non-zoned low compression shorts (NZLC-shorts), and normal sports clothes on pain measured with the Numeric Pain Rating Scale (NPRS) and performance during the Copenhagen five-second squeeze test (CS), the Illinois Agility test (IAT), and maximum shooting (ST). The effects of wearing ZHC versus NZLC shorts on symptoms were measured using the Hip and groin outcome score (HAGOS) during actual football activities.

Results: Wearing ZHC-shorts reduced pain during the IAT (1.4, ES= 0.58, p= <0.01) and ST (1.2, ES= 0.47, p= <0.01) compared to wearing normal sports clothes, but did not negatively affect performance. Compared to the baseline HAGOS scores a clinically significant improvement in the symptoms (9.7, ES= 0.63, *p*= <0.01) and sport/recreation (13.2, ES= 0.68, *p*=0.01) subscales was found when wearing the ZHC-short during football activities.

Conclusion: Wearing zoned high compression shorts could be useful in reducing groin pain in football players during their football activities.

Key words: groin pain, athletes, compression, shorts, performance

INTRODUCTION

Athletes competing in sports that involve frequent direction changes and kicking often suffer from groin pain[22–24,38]. In male football players 4 to 19% develop groin pain that requires medical attention each season [40]. Even though groin pain in athletes is common, there is a paucity of high quality research available to guide treatment, with very few studies on conservative treatment[31].

Compression garments have proven their clinical value for the management of lymphatic oedema, wound care, deep vein thrombosis and other circulatory problems[1,2,4,7]. More recently compression garments have gained popularity in athletes[43], with claims of improved performance and reduction of symptoms and injury risk. A recent review [16] found contradictory results for their use, but found some evidence that wearing compression garments results in reduced muscle oscillations, improved joint awareness, reduced oxygen usage during sub-maximal exercise, altered local blood flow and protein or metabolite clearance, alleviated swelling and reduced muscle soreness during recovery. A recent review by Born et al.[6] concluded that wearing compression garments results in a significant improvement of performance with small positive effect sizes for sprint performance (10 to 60m), vertical jump height, time till exhaustion (during running at VO2max), and time-trial performance (3-60min trials).

Compression shorts are sometimes also used for the reduction and treatment of groin pain in athletes. Chaudhari et al.[8] found that compression shorts reduced ipsilateral adductor longus muscle electromyographic activation during a 45 degrees change of direction at full speed.

They hypothesized that wearing compression shorts may reduce pain in athletes with adductor muscle injury or reduce the risk of injury.

In a case-series of 11 athletes with pubic osteitis, McKim and Taunton[18] studied the differences in performance and perceived pain within subjects between wearing compression shorts and no compression shorts. Outcomes were recorded during several functional and physical tests. No effect on performance was found, but there was a significant reduction of pain on both the VAS and the NPRS. Subjective feedback from the participants revealed that the participants felt between "somewhat better" and "better" when wearing the compression shorts.

Despite these positive clinical observations reported for pain, no randomized control trials (RCT's) investigating the effects of compression shorts on pain and performance in athletes with groin pain have been performed so far.

Our study had two aims i) investigate the effects of zoned high compression shorts, non-zoned low compression shorts, and normal sports clothes on pain and performance in football players with groin pain. ii) compare the effect of zoned high compressions shorts to non-zoned low compression shorts during actual football activities on symptoms.

MATERIALS AND METHODS

This was a double blinded randomized controlled trial, approved by the [redacted] Review Board under number [redacted]. The study was performed following the Declaration of Helsinki[42] and reporting was according to the

Consolidated Standards of Reporting Trials (CONSORT)[30]. Written informed consent was obtained prior to participation. This trial was registered at [redacted]

Participants

Participants were recruited through printed and electronic advertisements at local football clubs and on social media using Facebook, Twitter and Instagram. Those who were interested contacted the researchers ([redacted]) to discuss eligibility by phone. Participants were considered eligible for this trial when they were male football players with at least four weeks of groin pain, who had a minimum score of two out of ten on the Numeric Pain Rating Scale (NPRS) for their groin pain experienced during football, who compete at amateur levels, and who still played matches despite them suffering from groin pain. Potential participants were excluded from participation if they had previous surgery in de groin or hip area or suffered from a lower extremity injury in the last six months. If considered eligible they attended at the physiotherapy clinic for physical clinical examination. Their groin pain was classified, based on history and clinical examination, according the Doha consensus statement on terms and definitions on groin pain in athletes and at least one of the four clinical entities had to be found present (adductor-related groin pain, iliopsoas-related groin pain, inguinal-related groin pain, and/or pubic-related groin pain)[41]. Potential participants with a clinical suspicion of hip-related groin pain or other causes of groin pain[41] were excluded.

Procedures

After inclusion two experienced (>5 years) physiotherapists ([redacted]) performed all tests. Prior to testing the circumferences of the hip and the upper thigh were measured for each participant in order to establish the correct short size to be used during the physical testing procedure (see Table 1, also indicating the size table). The size table was used for both types of shorts.

Table 1. Compression short size table for both shorts used in the study.

Size:	XS	S	M	L	XL	XXL
Pelvis circumference (cm)	65-73	74-82	83-92	93-104	105-112	113-122
Mid-thigh circumference (cm)	< 40	40-50	50-60	60-70	70-75	>75

Pelvic circumference was measured at the height of the trochanter major. Mid-thigh circumference was measured at the height of 50% of the distance between the trochanter major and the lateral joint line of the knee (Knap‘man® Shapewear Europe B.V., Andijk, The Netherlands).

All physical tests were performed under three conditions: once wearing normal sports clothes (no compression), once wearing zoned high compression (ZHC) shorts (Knap'man Zoned Compression shorts 45%, Knap‘man® Shapewear Europe B.V., Andijk, The Netherlands), and once wearing non-zoned low compression (NZLC) shorts (Non Zoned Compression shorts 5% elastin, Knap‘man® Shapewear Europe B.V., Andijk, The Netherlands). The ZHC-shorts contain 3D-knitting technology and elastic yarns giving targeted compression (Figure 1A). The NZLC-shorts look similar to the ZHC-shorts, but with only low compression provided through 5% elastin and without targeted compression (Figure 1B).

Figure 1. The compression shorts used in the study.

A= Zoned high compression short (ZHC-short) with drawings depicting compression zones, B= Non-zoned low compression short (NZLC-short) alongside drawing. Both types of shorts look similar (Knap‘man® Shapewear Europe B.V., Andijk, The Netherlands).

Blinding, allocation concealment and randomization

Throughout the physical testing procedure the ZHC-shorts was referred to as short A and the NZLC-shorts as short B, so that the participants were unaware of thus not influenced by the possible properties of the shorts. The shorts looked similar regarding colour and material and no fabric or brand logos were present. The order of the test conditions was randomized in order to minimize the learning effect and the effect of fatigue. Block randomization with balanced permutations was done before data collection commenced using software (http://www.randomization.com). Each participant was given a piece of paper with the order of test conditions before his tests commenced. Then the participant would go to the changing room in order to change for the necessary test condition. Throughout the whole testing procedure, the participants wore long sports trousers and they were instructed not to tell the investigators about the current test condition in order to ensure investigator blinding. After completing all the test procedures the piece of paper was handed back to the investigator and blinding was broken for correct data entry.

Hip and groin outcome score (HAGOS)

Before any physical testing was performed, all participants completed the Dutch version of the Copenhagen Hip and Groin Outcome Score questionnaire (HAGOS)[33] in order to establish a baseline score. The HAGOS contains 6 subscales and is a valid (R=0.55 to 0.78) and reliable (ICC=0.63-0.86) patient reported outcome measure to assess levels of hip and groin related problems in young and active individuals[33]. Standard error of measurement (SEM) for the subscales range from 6.5–11.6[33].[32]

Physical testing protocol

Before the physical testing commenced participants performed a standardized warm-up procedure, starting with running two laps around the football pitch (approximately 500m) at a self-rated intensity of 60%. This was followed by commonly used warm up drills for football (skipping, butt kicks, side-steps (left and right), and shuffles (left and right)), each done three times over a distance of 16 meters. After this, participants performed four minutes of passing with one of the investigators over a distance of approximately 10 meters. The investigator passed the ball in different directions so that the participant was doing some light direction changing running in all directions. This was performed at a self-rated intensity of 70%. Performing each of the physical tests three times concluded the warm-up: once at 70%, once at 80%, and once at 90% of self-rated intensity.

Physical tests

Participants performed each of the following three physical tests three times under each test condition: the Copenhagen Five-second Squeeze (CS) with hand held dynamometry, the Illinois Agility Test (IAT), and a maximum ball shooting test (ST).

Copenhagen Five-second squeeze (CS) with hand held dynamometry

The CS is a valid test to quantify the amount of groin pain in athletes (concordance correlation coefficient= 0.90)[36]. This test is performed with the participant lying supine. The hips and knees are in a neutral position. The investigator places the hand held dynamometer (HHD) (Chattillon DFX2-200, AMETEK, Inc., Largo, FL, USA) between the ankles of the participant just above the medial malleolus (MDC% = 6.6[15]) (Figure 2). The participant is then asked to slowly start squeezing until the first onset of groin pain occurs. This moment is referred to as P1. The amount of force in Newtons is recorded. Then the participant is then asked to squeeze as hard as possible against the HHD for five seconds. This score on the

HHD is referred to as the Pmax (pain at the point of maximum force production). The amount of force in Newtons was recorded as well as the amount of pain the participant experienced on the NPRS (0-10). Between each test participants were allowed 30 seconds of rest.

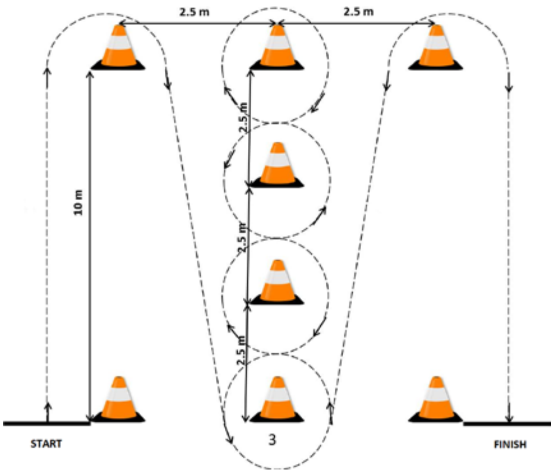
Figure 2. Copenhagen Five-second squeeze (CS) with hand held dynamometry test setup.

The test is performed with the participant lying supine. The hips and knees are in a neutral position. The investigator places the hand held dynamometer between the ankles of the participant just above the medial malleolus.

Illinois Agility Test (IAT)

The IAT is a performance test in which the participant performs different direction changes, that mimic football specific tasks[12]. The IAT has a high test-retest reliability (ICC= 0.95)[11] and a Minimal Detectable Change (MDC) of 1.80 seconds[25]. The test starts with the participant lying prone with their head behind the starting line and the hands placed alongside the shoulders, similar to a push-up position. When the starting signal sounds, the participant stands up as quickly as possible and sprints at 100% intensity through the test set-up as depicted in Figure 3. The time was recorded using timing gates (SmartGoals Timing System, SmartGoals, Eindhoven, The Netherlands). After each attempt the participant was asked to rate the amount of pain during the test on the NPRS (0-10). Between runs there was a one-minute rest-interval.

Figure 3. Illinois Agility test[26].



Maximum ball shooting test (ST)

In order to mimic shooting activities, the participant was asked to perform three maximum effort shots on goal[14]. Between shots there was a 30 second rest interval. The shots were performed five meters from the goal. The speed detector was placed directly behind the goal, 150 cm above the ground. The participant was asked to shoot the ball (official UEFA Euro 2016 size-5 match ball, Adidas, Herzogenaurach, Germany) towards the speed detector. In order to minimize the influence of the direction of the ball on the results, only attempts that were shot within one meter of the speed detector were accepted. Participants performed the shots with the preferred leg and were free to decide what kind of pre-shooting run up they performed. The speed of the ball was measured with a speed detector (WG 54, D&L, Utrecht, The Netherlands) in km/h. Data of the manufacturer showed this is accurate to within 1 km/h[10]. The participants were asked to rate their pain during kicking directly after every kick on a NPRS (0-10).

Wearing shorts during football activities

After completing the physical tests under each of the three conditions, the participants were instructed to take both the ZHC-short and the NZLC-short home and wear them both for two weeks each during their football training sessions and matches. The order in which the shorts were to be worn was noted on a form that was provided to the participants, and determined using block randomization generated with randomizing software (http://www.randomization.com).

After each training and match the participants were instructed to report the following on the form that was provided to them; the duration of the football session in minutes, the intensity of the football session on the Borg-scale (range 6-20)[5], the average pain of the session on the NPRS (0-10), and the comfort of the shorts on a numeric rating scale (NRS) (0-10). After each period of wearing one of two shorts for two weeks the participants were instructed to complete the HAGOS again. Return envelopes were provided to each participant.

Statistical analysis

A priori a statistical power analysis was performed for sample size estimation. It was expected that the primary outcome, pain reduction during physical tests, would be at least medium in size. We therefor planned for a study requiring at least 33 participants (alpha= 0.05 and power= 0.80) to detect an effect of *d*= 0.5.

Results of the squeeze test were normalized to bodyweight (kg), after which mean pain and performance scores were collected for each test and each testing condition. Statistical analysis was performed using statistical software (SPSS version 23, IBM, Armonk, NY, USA). The data of the physical tests and the data of the HAGOS questionnaires were compared to each other using repeated measures analysis of variance (ANOVA). The

Mauchly's test of sphericity[17] was employed and post-hoc pairwise comparison was applied using the Bonferroni adjustment. The amount of training sessions, matches, the amount of minutes per training and per match, the Borg-scale scores, and the effects of the shorts on pain and comfort during football activities were analysed using intention-to-treat analysis using a standard paired t-test. The alpha level for statistical significance was set at $p \leq .05$. Effect sizes were calculated using Cohen's *d* [9] to determine the practical relevance of significant findings.

RESULTS

Forty-four male football players contacted the investigators ([redacted]) between March 2018 and August 2018. Eight participants were excluded by phone because they were currently unavailable to play due to the amount of pain. Two participants were excluded after clinical examination because their groin pain was clinically diagnosed as possible hip-related groin pain[41]. After exclusion 34 participants were included; their characteristics are presented in Table 2.

Table 2. Characteristics of included players.

	n = 34
Age, years (mean ±SD, range)	25 ±5, 18-37
Height, cm (mean ±SD, range)	180 ±6, 169-195
Weight, kg (mean ±SD, range)	77 ±8, 64-95
BMI, kg/m2 (mean ±SD, range)	23.7±2.0, 20.5-29.7
Preferred shooting leg	30 Right / 4 Left
Side of pain	23 preferred shooting leg / 11 other leg
Clinical diagnosed entities:	
Adductor-RGP	16 (47%)
Iliopsoas-RGP	2 (6%)
Inguinal-RGP	1 (3%)
Adductor + iliopsoas-RGP	4 (12%)
Adductor + inguinal-RGP	1 (3%)
Adductor + pubic-RGP	4 (12%)
Iliopsoas + pubic-RGP	2 (6%)
Adductor + iliopsoas + pubic-RGP	3 (9%)
Adductor + inguinal + pubic-RGP	1 (3%)

Average pain during sports preceding 4 weeks (NPRS)	6.1 ±1.7
Baseline HAGOS subscale scores:	
Symptoms	61 ±15
Pain	70 ±14
ADL	74 ± 17
Sports/Recreation	50 ±19
PA	49 ± 24
QOL	57 ±14

Values shown are mean ± standard deviation. Abbreviations: BMI= Body Mass Index; NPRS= Numeric Pain Rating Scale; ADL= Activities of Daily Living; PA= Participation in Physical Activity; QOL, Quality of Life; RGP= related groin pain

All 34 participants completed all physical tests. The mean results for each test and the different testing conditions are presented in Table 3. For each test Maucly's test of sphericity was assumed.

Table 3. Repeated measures ANOVA test results of the different testing conditions (n=34).

	No Compression	**ZHC-shorts**	**NZLC-shorts**	***P*-value**
CS P1 (N/kg)	1.6 ±0.7	1.7 ±0.7	1.6 ±0.8	0.40
CS PMax (N/kg)	2.7 ±0.6	2.8 ±0.7	2.7 ±0.7	0.30
CS NPRS (0-10)	5.4 ±2.2	4.6 ±2.6	5.1 ±2.4	0.01*
IAT time (seconds)	15:84 ±0:81	15:59 ±0:64	15:78 ±0:70	<0.01*
IAT NPRS (0-10)	4.2 ±2.5	2.7 ±2.4	3.5 ±2.4	<0.01*
Shooting speed (km/h)	88.9 ±10.2	89.8 ±10.1	90.1 ±9.5	0.24
Shooting NPRS (0-10)	3.0 ±2.6	1.8 ±2.5	2.4 ±2.2	<0.01*

Values shown are mean ± standard deviation. Abbreviations: ZHC= Zoned High Compression; NZLC= Non Zoned Low Compression; CS= Copenhagen Adduction Squeeze test; P1= Moment of first onset of pain; Pmax= Moment of maximum pain; NPRS= Numeric Pain Rating Scale; IAT= Illinois Agility Test.

The post-hoc pairwise comparisons between the different testing conditions for each test are displayed in Table 4.

Table 4. Post-hoc pairwise comparisons of the different testing conditions (n=34).

			Mean Difference	***P*-value**	**ES (Cohen's *d*)**	
CS P1 (N/kg)	No compression	ZHC-short	-0.1	0.90	0.13	trivial effect
	No compression	NZLC-short	< 0.1	1.0	0.02	trivial effect
	ZHC-short	NZLC-short	0.1	0.42	0.13	trivial effect

CS PMax (N/kg)	No compression	ZHC-short	< -0.1	0.98	0.09	trivial effect
	No compression	NZLC-short	< 0.1	1.0	0.06	trivial effect
	ZHC-short	NZLC-short	0.1	0.44	0.15	trivial effect
CS NPRS (0-10)	No compression	ZHC-short	0.8	0.03*	0.34	small effect
	No compression	NZLC-short	0.4	0.53	0.16	trivial effect
	ZHC-short	NZLC-short	-0.5	0.17	0.18	trivial effect
IAT time (seconds)	No compression	ZHC-short	0.3	0.02*	0.03	trivial effect
	No compression	NZLC-short	0.1	1.0	0.01	trivial effect
	ZHC-short	NZLC-short	-0.2	0.04*	0.03	trivial effect
IAT NPRS (0-10)	No compression	ZHC-short	1.4	<0.01*	0.58	medium effect
	No compression	NZLC-short	0.7	0.15	0.27	small effect
	ZHC-short	NZLC-short	-0.8	0.02*	0.31	small effect
Shooting speed (km/h)	No compression	ZHC-short	-0.9	0.56	0.09	trivial effect
	No compression	NZLC-short	-1.2	0.29	0.02	trivial effect
	ZHC-short	NZLC-short	-0.3	1.0	0.01	trivial effect
Shooting NPRS (0-10)	No compression	ZHC-short	1.2	<0.01*	0.47	small effect
	No compression	NZLC-short	0.7	0.08	0.28	small effect
	ZHC-short	NZLC-short	-0.5	0.18	0.22	small effect

Abbreviations: ZHC= Zoned High Compression; NZLC= Non Zoned Low Compression; CS= Copenhagen Adduction Squeeze test; P1= Moment of first onset of pain; Pmax= Moment of maximum pain; NPRS= Numeric Pain Rating Scale; IAT= Illinois Agility Test; ES= Effect size. *Statistical significant $P \leq 0.05$

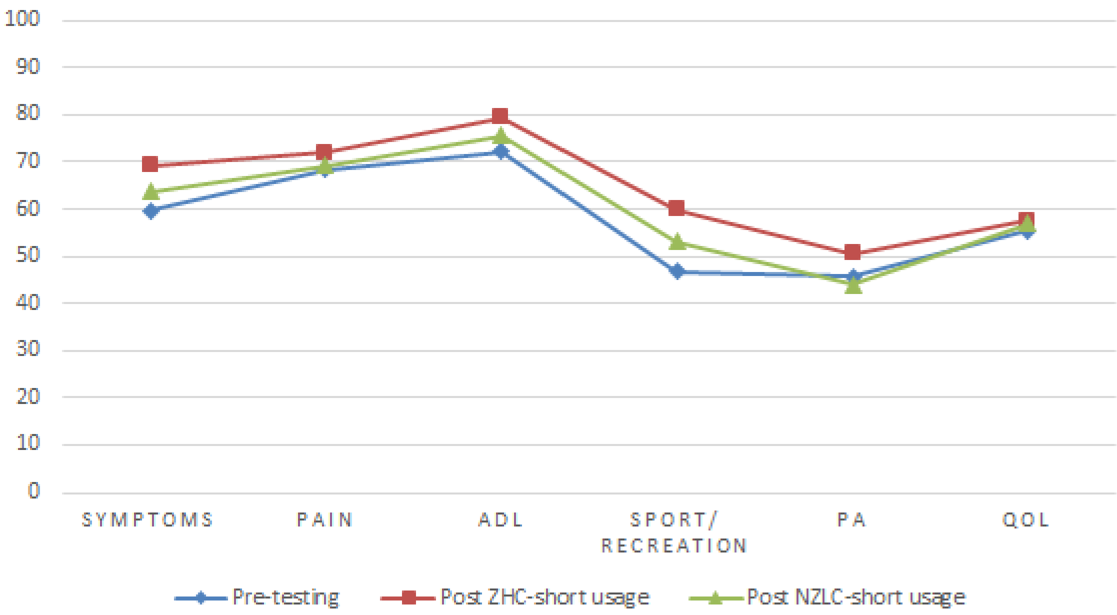
Of the 34 participants that were recruited for the study, 27 participants returned the envelope and provided feedback of using the compression shorts during their football activities. Seven participants did not return their return envelopes for several reasons (1 participant lost to follow up, 2 participants reported having sent their envelope but these were not received, 3 participants got injured at a different body location, and 1 participant did not want to continue because of aggravated pain after performing the physical tests). Of the 27 of whom data were collected, 16 started using the ZHC-shorts the first two weeks and 11 started using the NZLC-shorts the first two weeks. No significant differences were found between respectively wearing the ZHC-shorts and the NZLC-shorts for the amount of training sessions (3.8 ±0.6 vs. 3.7 ±0.7, p=0.33) or matches (1.8 ±0.5 vs. 1.8 ±0.6, p=0.3) between wearing the two different shorts. No significant differences were found for the average amount of minutes spent per training (79.0 ±13.6 vs. 78.8 ±10.6, p=0.96) or per match (75.6 ±26.4 vs. 73.5 ±22.1, p= 0.59). A small, but significant difference was found on the average Borg-scale score during matches (14.9 ±3.1 vs. 13.7 ±3.7, p=0.01), but not during training sessions (12.8 ±2.7 vs. 12.4 ±2.4, p=0.39). The average pain and comfort ratings for the training sessions and matches for each condition are presented in Table 5. The average HAGOS subscale scores and the results of the repeated measures ANOVA are presented in Figure 4. For each subscale Maucly’s test of sphericity was assumed. The post-hoc pairwise comparisons for each HAGOS subscale are displayed in Table 6.

Table 5. Pain and comfort ratings for the training sessions and matches for each condition (n=27).

	ZHC-shorts	**NZLC-shorts**	***P*-value**	**ES (Cohen's *d*)**	
NPRS-score training	4.1 ±1.9	5.0 ±2.4	0.05*	0.41	small effect
Compression short comfort training	6.4 ±1.9	6.5 ±2.3	0.90	0.05	trivial effect
NPRS-score match	4.0 ±2.2	5.1 ±2.5	0.03*	0.47	small effect
Compression short comfort match	6.4 ±1.9	6.5 ±2.3	0.90	0.05	trivial effect

Values shown are mean ± standard deviation. Abbreviations: ZHC= Zoned High Compression; NZLC= Non Zoned Low Compression; NPRS= Numeric Pain Rating Scale; ES= Effect size. Statistical significant *P ≤0.05*

Figure 4. Average HAGOS subscale scores and the results of the repeated measures ANOVA (n=27).



HAGOS Subscale	Pre-testing	Post ZHC-short usage	Post NZLC-short usage	*P* -value
Symptoms	59.7 ±15.7	69.3 ±14.9	63.8 ±16.1	<0.01*
Pain	68.3 ±14.2	71.9 ±16.0	69.3 ±15.5	0.24
ADL	72.2 ±18.4	79.3 ±18.6	75.6 ±17.3	0.03*
Sport/ Recreation	46.8 ±18.5	60.0 ±20.1	53.2 ±19.4	<0.01*
PA	45.8 ±25.7	50.5 ±25.4	44.0 ±27.8	0.32
QOL	55.4 ±12.5	57.6 ±19.7	57.0 ±18.6	0.74

Values shown are mean ± standard deviation. Abbreviations: ZHC= Zoned High Compression; NZLC= Non Zoned Low Compression; ADL= Activities of Daily Living; PA= Participation in Physical Activity; QOL, Quality of Life.
* P ≤0.05.

Table 6. Pairwise comparisons of the results of the HAGOS subscales (n=27).

HAGOS Subscale			**Mean Difference**	***p*-value**	**ES (Cohen's *d*)**	
Symptoms	Pre-testing	Post ZHC-short	-9.7	<0.01*	0.63	medium effect
	Pre-testing	Post NZLC-short	-4.1	0.67	0.26	small effect
	Post ZHC-short	Post NZLC-short	5.6	0.13	0.36	small effect
Pain	Pre-testing	Post ZHC-short	-3.6	0.49	0.02	trivial effect
	Pre-testing	Post NZLC-short	-0.9	1.0	<0.01	trivial effect
	Post ZHC-short	Post NZLC-short	2.7	0.59	0.02	trivial effect
ADL	Pre-testing	Post ZHC-short	-7.0	0.05*	0.04	trivial effect
	Pre-testing	Post NZLC-short	-3.3	0.51	0.02	trivial effect

	Post ZHC-short	Post NZLC-short	3.7	0.40	0.02	trivial effect
Sport/ Recreation	Pre-testing	Post ZHC-short	-13.2	0.01*	0.68	medium effect
	Pre-testing	Post NZLC-short	-6.5	0.16	0.34	small effect
	Post ZHC-short	Post NZLC-short	6.7	0.17	0.34	small effect
PA	Pre-testing	Post ZHC-short	-4.6	1.0	0.02	trivial effect
	Pre-testing	Post NZLC-short	1.9	1.0	<0.01	trivial effect
	Post ZHC-short	Post NZLC-short	6.5	0.40	0.02	trivial effect
QOL	Pre-testing	Post ZHC-short	-2.2	1.0	0.01	trivial effect
	Pre-testing	Post NZLC-short	-1.7	1.0	0.01	trivial effect
	Post ZHC-short	Post NZLC-short	0.6	1.0	0.01	trivial effect

Abbreviations: ZHC= Zoned High Compression; NZLC= Non Zoned Low Compression; ADL= Activities of Daily Living; PA= Participation in Physical Activity; QOL, Quality of Life; ES=Effect Size.
* P ≤0.05.

DISCUSSION

This study investigated the effects of compression shorts on pain and performance in male football players with groin pain. The use of the ZHC-short reduced pain during the physical test and during actual football activities, but did not negatively affect performance.

Small effects on the reduction of pain were found during CS (-0.8 (-14.8%)) and ST (-1.4 (-40.0%)) and medium effects were found for the IAT (-1.2 (-35.7%)) when wearing the ZHC-short compared to wearing normal sports clothes. With the exception of CS, these results are clinically significant as they exceed the minimal clinical important difference (-15%)[27], and are even associated with the concept of “much better” as the reduction of pain is greater than 33.0%[27]. When the effects of the ZHC-shorts are compared to NZLC-shorts the results indicate a significant small clinical important effect on the amount of reduction of pain during the IAT (-0.8 (-22.9%)). On the other tests no significant differences were found (Table 3 and 4).

Using the ZHC-short also showed a statistical significant improvement of time to complete the IAT compared to wearing normal sports clothes (-0.3 seconds (-1.6%)). The size of the effect was trivial and did not exceed the minimal detectable change (MDC) of 0.52 seconds[11]. The effect of the ZHC-short on performance during the IAT compared to the NZLC-short was trivial (-0.2 seconds (-1.2%)), but statistical significant. Compared to wearing normal sports clothes the NZLC-shorts did not show any effect (neither better nor worse) on performance during the tests.

During both the training sessions (-0.9 (-18%)) and the matches (-1.1 (-21.6%)) wearing the ZHC-short resulted in a small but statistical and clinically significant reduction in pain compared to wearing the NZLC-short. No differences were found in the comfort ratings between de shorts (Table 5).

Compared to the baseline HAGOS scores wearing the ZHC-shorts during football activities significantly improved the scores on the ADL, symptoms and sport/recreation subscales (Figure 4 and Table 6). The improvements on the symptoms and sport/recreation subscales are clinically relevant as the minimal important change (MIC) for these HAGOS subscales, respectively 9.3 and 10.8 were exceeded[35].

The results of wearing ZHC-shorts in this RCT are partly in line with that of the case series by McKim and Taunton[18] in which medium reduction of pain was observed (ES= 0.52-0.62). McKim and Taunton did not find any effect though on performance during the changing direction test that was used in their study. This is contrary to the results of this study in which we found a trivial but statistical significant improvement on performance during the IAT wearing the ZHC-short compared to wearing normal sports clothes. The difference in the results could be explained through the difference in the changing direction test used. Where this study used the IAT, McKim and Taunton used a figure eight running drill and a twenty meter cutting drill with five turns of 60˚.

The ZHC-short did not affect CS performance. This finding is different to the results of the pilot RCT-study by Sawle et al.[28], which reported a large positive effect size of targeted compression shorts on squeeze test performance, which was similar to the CS test used in this study. The different study populations may explain this difference as Sawle et al. used a mixed gender athletic population including to the relative homogenous group of male amateur football players in our study. The exact characteristics of the shorts used in the study by Sawle et al. are not known, but the results of the studies might also indicate that there are differences between the shorts that were used. Future research investigating the characteristics of compression shorts is necessary.

The reduction of pain during the physical tests can be explained in several ways. First, compression shorts reduce the activation of the adductor longus muscle, reducing the loading levels of this muscle[8] and its attachment on the pubic bone and symphysis[20]. This may in turn lead to a reduction of pain[32]. Secondly, compression shorts contribute to increased pelvic stability[29]. A cadaver study showed that a pelvic belt increased pelvic stability by reducing movement in the sacroiliac joints[39], and in athletes with adductor-related groin pain the use of a pelvic belt significantly reduced pain during forceful isometric hip adduction in 68% [19]. It is unclear though whether the effects of the fairly rigid tensioned belt can be achieved with compression shorts in vivo during sports. A final explanation could be the placebo effect, being caused by the beliefs and/or expectations of the participants[21,37]. The participants were aware that this study was designed to investigate the effects of shorts that were intended to have an effect on groin pain. It is plausible that the participants expected that the investigated shorts had this kind of effect on their pain. This study aimed to reduce the placebo effect on the results as much as possible by not providing the participants any information on the properties of the shorts and providing two sorts.

The fact that the ZHC-shorts had a greater effect on pain reduction during the physical test compared to NZLC-shorts can likely be explained through the specific characteristics of the short such as the zoned compression, but could also be influenced by the high compressive forces of the ZHC-short, which are likely to give more proprioceptive “cues” [13] causing the participant to be more aware of the shorts [16] and making them think the short with the higher compression has better effects on pain compared to the NZLC-short.

The effects found on the HAGOS subscales ADL, symptoms, and sport/recreation but not the other subscales, can be explained by the fact that these subscales are most related to more strenuous activities. The participants only wore the ZHC-short during their sport activities (football). It would maybe be expected that an effect would be found on the PA (physical activity) subscale, but as these questions are related to the level of participation, the significant changes were found as one of the inclusion criteria for the study was that the participant should still be participating in their football activities even though they were experiencing groin pain. Further research could investigate the effects of compression on the other HAGOS subscales i.e. when worn during recovery after exercise. Both Beliard et al.[3]

and MacRae et al.[16] found some evidence for the use of compression garments on performance recovery in their reviews.

It is unknown if similar effects of ZHC-shorts are found in other populations and sports. Positive effects of ZHC-shorts would also be expected in female football players with groin pain, but should be subject of future research. Applying these shorts in other sports that have different movement characteristics than football should also be studied, but it can be expected that other athletes involved in field sports could benefit. Testing regimes should then preferably mimic the sporting demands of that specific sport. More research is also needed to investigate if compression shorts with different characteristics, such as even higher compression, zoned compression in different areas or with specific straps, have different effects on pain and performance in football players with groin pain. Whether or not compression shorts assist in the primary prevention of groin pain in football players remains unclear from the study design and should be subject of future studies.

This study has its limitations. The a priori power calculation indicated at least 33 participants to be included in this study. Although we studied the effects of compression shorts during performance tests in 34 participants in first part of this study, there were 7 dropouts for the second part. This resulted in lower power in the second part of the study in which the effects of the shorts during football activities were evaluated. Despite the lower power the two domains of the HAGOS pertaining to sports activities showed a significant medium effect. Eventual presence of a carryover effect of the results in the second part of the study, which can be the case in studies that use a crossover design, is another limitation.

CONCLUSION

This study found clinically relevant reductions on groin pain wearing zoned high compression shorts compared to wearing normal sports clothes, in a population of amateur football players with ongoing groin complaints, without negatively affecting performance. Non-zoned low compression shorts had little or no effect on pain. Our findings suggest that wearing zoned high compression shorts might prove useful in reducing groin pain in football players during their football activities.

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