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Article

A Field Study of Low-Top *vs.* Mid-Top *vs.* High-Top American Football Cleats

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Abstract: Few studies have examined the role of shoe height in the context of American football cleats. Eighteen adult males (28.4 ± 1.9 years, 182.3 ± 0.6 cm, 75.7 ± 1.6 kg) performed four football drills (60-yd dash, 54-yd cutting drill, 5-10-5 drill [pro agility drill], and ladder jumping drill) in low-top, mid-top, and high-top American football cleats. Drill-specific performance outcomes were measured after each drill, and the subjects' ankle range-of-motion (dorsiflexion, plantarflexion, eversion, inversion) and perception of the footwear (comfort, heaviness, stability) were assessed before and after each drill sequence. Performance outcomes were not influenced by shoe height. The high-top cleat limited dorsiflexion and inversion, but not plantarflexion or eversion, compared to low-top and mid-top cleats. Athletes rated the high-top cleats as less comfortable and heavier than either the low-top or mid-top cleats, but perceived the mid-top and high-top cleats to be equally stable to each other, and both more stable than the low-top cleats. Range-of-motion and performance scores did not change as a result of acute exercise. These findings suggest that high-top cleats may limit ankle motions associated with injury without deleteriously influencing performance, though athletes may not perceive the high-top cleats as favorably as low- or mid-top cleats.

Keywords: agility; American football; cutting; drills; footwear; goniometry; range-of-motion; shoes; speed; sprinting

1. Introduction

Proper footwear is vital to optimal performance and injury prevention and should be based on individual athlete characteristics (such as stature and injury history), movements required by the sport, and playing environment [1–5]. Shoe height is one design element that impacts footwear properties. High-top shoes have been conventionally indicated for athletes who are convalescing from ankle injuries or may have increased ankle injury risk [6], or who play certain positions [7], given the footwear's presumed ability to limit ankle range-of-motion (ROM) [2,4]. Studies utilizing court footwear such as basketball shoes [6,8–10] or volleyball shoes [11] have explored the possible relationships between shoe height, ROM, and/or injury risk utilizing both laboratory and clinical models but have yielded conflicting results.

By contrast, far fewer studies have explored these relationships in the context of field sports such as soccer, lacrosse, or American football. Ankle sprains are one of the leading injuries in American football [12–14]. One laboratory study of American football shoes (hereafter referred to as cleats) demonstrated that a high-top cleat reduced both total inversion and maximal rates of inversion compared to a low-top cleat in 20 male physical education students tested on a drop platform that inverted the ankle to 35° [15]. In a separate laboratory study of low-top *vs.* high-top soccer boots in twelve male soccer athletes, high-top shoes conferred less stress to collateral ligaments when athletes' lower limbs were immobilized and their ankles progressively everted to 40° [16]. However, two retrospective studies examining American football cleat choice and ankle injury rates during the college season found either no association [17] or a negative association [18] between high-top cleats and ankle injuries; these studies were confounded by co-administration of ankle bracing or ankle taping, or the use of different cleat models across teams. Thus, the limited data on American football cleats are conflicting and do not address other questions important to athletes such as the effects of high-tops on other ankle motions (such as dorsiflexion or plantarflexion) or if high-tops maintain their effects on ROM during physical activity [19]. Many studies lacked necessary controls.

Less is known about the effects of high-top cleats on performance in American football contexts. A lone study conducted in the 1960s suggested that high-top cleats did not alter sprint or agility drill performance by 24 college-aged male physical education majors [20]. It is unclear if those results apply to modern American football cleats. Performance is also impacted by an athlete's perception of the footwear, including whether they find the footwear comfortable [21–26] or stable [27–29], though these are often intermingled in subjects' perception of overall shoe like or dislike [30]. The additional stability potentially provided by high-top shoes needs to be balanced by appropriate flexibility and weight [31] or it may negatively influence performance.

Many questions thus remain regarding the differing properties of low-top, mid-top, and high-top cleats in the context of field sports such as American football. The purpose of the present investigation was to investigate how shoe height influenced performance, perception, and ROM during American football field drills. Eighteen active adult males completed four field drills (60-yd sprint, 54-yd cutting drill, 5-10-5 [pro agility] drill, and 15-s ladder hopping drill) once each in low-top, mid-top, and high-top American football cleats. Drill-specific performance outcomes were assessed and subjects were asked to rate their perception of the cleats in terms of comfort, mass, and stability before and after each drill series. Dorsiflexion, plantarflexion, eversion, and inversion were measured before and after exercise. Based on the limited previous research discussed above, it was hypothesized that: (a) the high-top cleat would reduce inversion and dorsiflexion, but not plantarflexion or eversion, compared to the other cleats; (b) the high-top cleat would be able to maintain its restrictive effects on ROM throughout physical activity; (c) performance would be statistically similar for all three cleat models; and (d) subjects would rate the high-top cleat as less comfortable, heavier, and more stable than the other cleat models.

2. Method

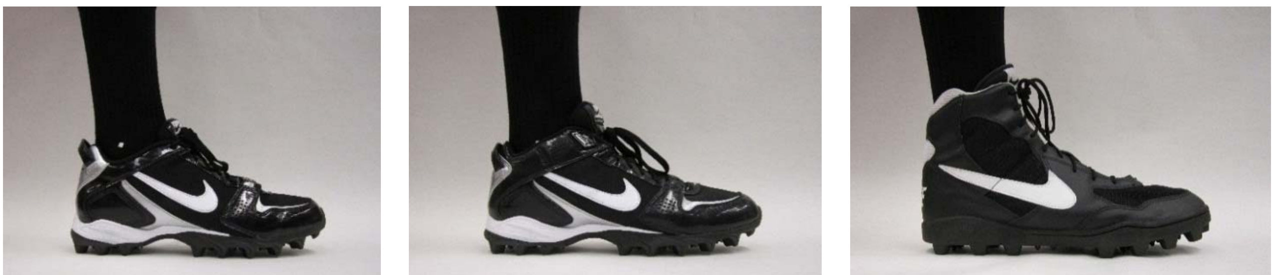
2.1. Subject Characteristics

All procedures were approved by the Drake University Institutional Review Board (ID 2009-10031) prior to the beginning of the study, and all subjects gave written consent prior to participation. Subjects were included if they were male, between the ages of 18 and 45 years old, were regularly recreationally active or were athletes, and wore approximately size 12 athletic shoes. In order to eliminate *a priori* biases, none of the subjects were American football players. Eighteen subjects participated, and their characteristics were as follows (expressed in means ± standard error): age = 28.4 ± 1.9 years, height = 182.3 ± 0.6 cm, mass = 75.7 ± 1.6 kg, mass of personal training shoes = 327.0 ± 14.8 g.

2.2. Shoes and Procedure

Three different models of Nike Land Shark football cleats (Figure 1; Nike. Inc.; Beaverton, OR, USA) were tested: high-top cleat (collar extended past the ankle malleolus; 546 g; malleolar notch height = 17.5 cm; maximum collar height = 19 cm), mid-top (collar at the level of the ankle malleolus; 502 g; malleolar notch height = 11.5 cm; maximum collar height = 14.5 cm), and low-top cleat (collar did not reach the ankle malleolus; 457 g; malleolar notch height = 10.5 cm; maximum collar height = 13 cm). All cleats were new when the study commenced. Subjects wore identical calf-height socks (BodyGlove Inc.; Rendondo Beach, CA, USA) to minimize possible perceptual differences due to sock variation. Subjects performed all four drills for a given cleat before switching cleats, and all three trials were completed in the same experimental session. Cleat presentation order was counterbalanced.

Figure 1. Cleats used in the study from left to right: low-top, mid-top, high-top. The white tape mark indicates the ankle malleolus.

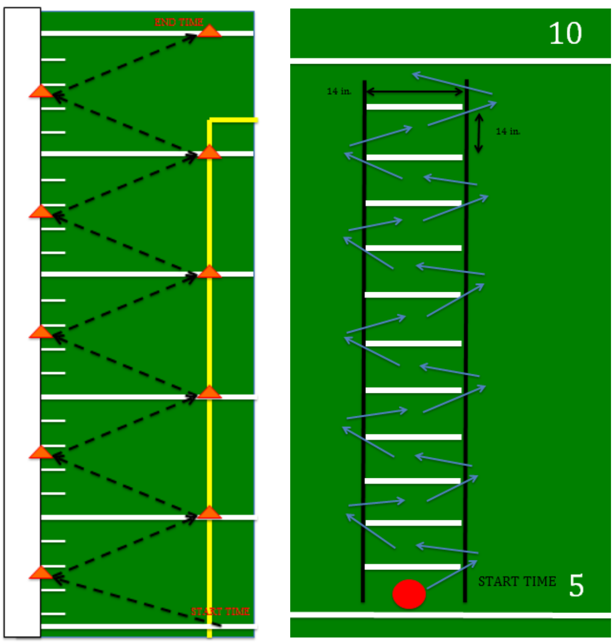


Before and after each trial, the subjects' dorsiflexion, plantarflexion, talar eversion, and talar inversion were measured manually with a goniometer (HPMS Inc.; Windham, NH, USA) and subjects were asked to rate perceived comfort, heaviness, and stability of the cleats on a 10-cm line (visual analogue scale, or VAS) with the left side labeled as "The least (comfortable, heavy, stable) possible" and the right side labeled as "The most (comfortable, heavy, stable) possible." VAS were used instead of Likert scales based on previous comparative research [24]. During data entry it was discovered that seven of the subjects received inappropriate instructions on how to complete the VAS; therefore, those subjects' data for perception (but not other measures) were removed, leaving $n = 11$ for the perceptual scales.

2.3. Field Drills

The four field drills were performed outdoors on artificial turf ("Field Turf", 2nd generation; Tarkett Sports Co.; Calhoun, GA, USA). The first drill was the 60-yd sprint. Subjects lined up at the goal line of the football field and performed an all-out sprint until they reached the 60-yd mark. Time (in s) was recorded. The second drill was the 10-cone cutting drill, in which subjects were told to run as quickly and accurately as possible diagonally between a set of ten cones for a total of 10 cuts spaced over 54-yd (Figure 2). Time, number of cones missed, and number of missteps (left foot contacting right-side cone or *vice versa*) were recorded. The third drill was the 5-10-5 or "Pro Agility" drill, in which subjects started on the 20-yard line and were asked to run to their right until they reached the 25-yard line, touch the line and make a cut, then immediately run to the opposite 15-yard line, again touch the line and make a cut, and sprint across the 20-yard line as quickly as possible. Time was recorded. The fourth and final drill was the ladder-hopping drill. Subjects were asked to stand on their right foot only and hop in and out of the exercise ladder in a weaving fashion for 15 seconds (Figure 2). If they reached the end of the ladder before the 15 s were over, subjects turned around and continued the drill in the opposite direction. Number of total steps and number of missteps (foot out of sequence or on the rope) were counted and recorded.

Figure 2. Field drills including cone weave (**left**) and ladder drill (**right**).



2.4. Statistics

Univariate ANOVA tests were conducted in PASW 22.0 (SPSS, Inc.; Armonk, NY, USA) with a *p*-value of 0.05 for significance. If a significant main effect was found, *post hoc* tests using LSD were performed. For the performance outcomes, shoe and presentation order were the independent factors. For the goniometry and perception scales, shoe, presentation order, and pre/post were the independent factors.

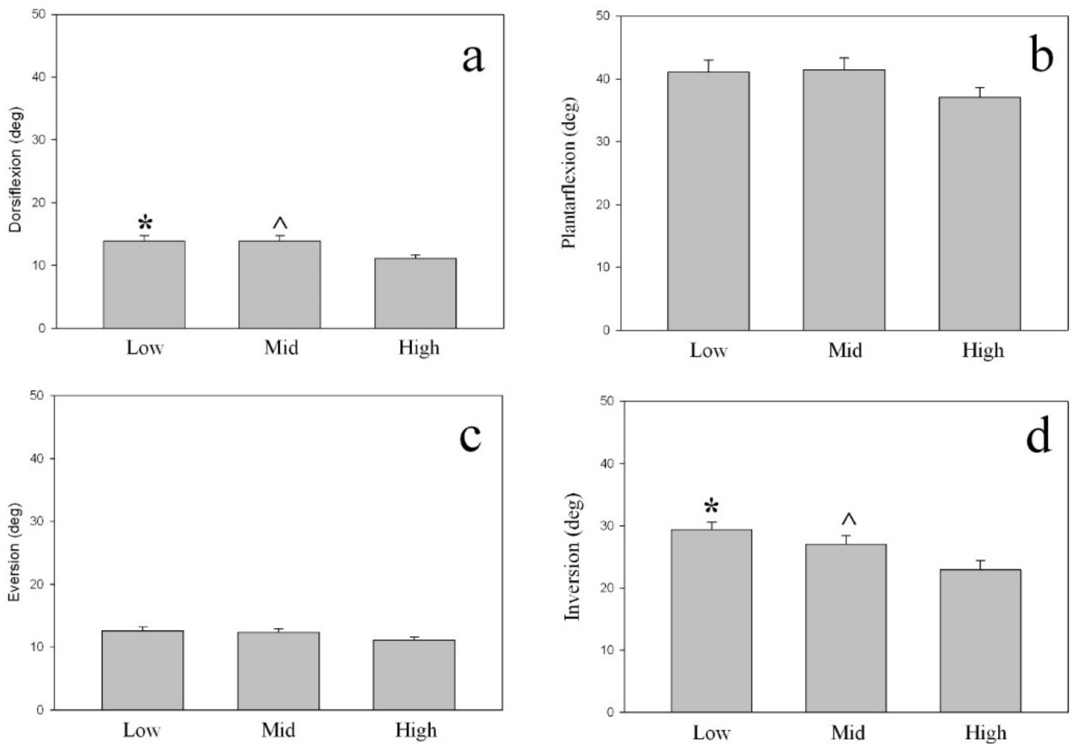
3. Results

There were never any main effects for cleat presentation order nor for differences between pre- and post-exercise measurements; therefore, the pre- and post-exercise data were combined for analysis.

3.1. Goniometry

There was a significant effect of shoe type on dorsiflexion ($p = 0.027$; Figure 3a). *Post hoc* tests found significant differences between low-tops and high-tops ($p = 0.02$), and between mid-tops and high-tops ($p = 0.02$), but not between low-tops and mid-tops. There was a significant effect of shoe type on talar inversion ($p = 0.035$; Figure 3d). *Post hoc* tests revealed significant differences between low-tops and high-tops ($p = 0.001$), as well as between mid-tops and high-tops ($p = 0.034$), but not between low-tops and mid-tops. No significant differences were found by shoe type for either plantarflexion or talar eversion (Figure 3b,c).

Figure 3. Range-of-motion (ROM) as determined by manual goniometry. Values are degrees and given as averages ± standard error. Asterisks (*****) indicate a significant difference between low-top and high-top. Carats (^) indicate a significant difference between mid-top and high-top.



3.2. Performance

Across all performance tests, no significant difference was found between any of the shoes. Performance data are presented in Table 1.

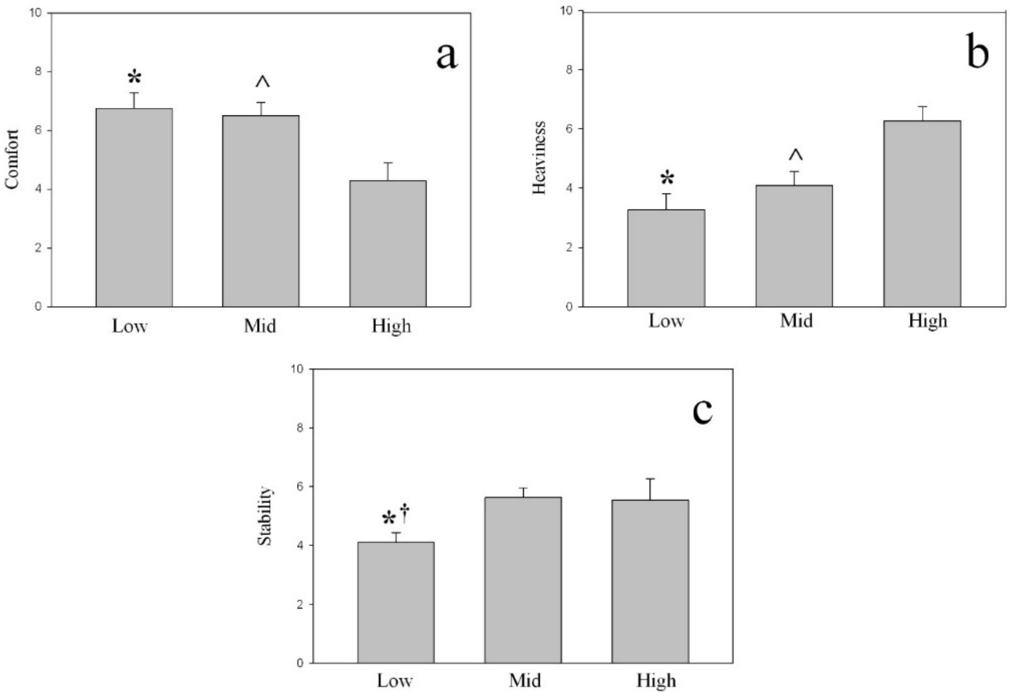
Table 1. Football drill performance data. There were no significant differences between cleats for any outcome.

		Low-Top	Mid-Top	High-Top
60-yd Sprint	**Time (s)**	7.64 ± 0.1	7.69 ± 0.2	7.76 ± 0.2
Cutting Drill	**Time (s)**	13.8 ± 0.3	13.7 ± 0.3	13.7 ± 0.3
	Missed cones (#)	0.3 ± 0.2	0.4 ± 0.2	0.5 ± 0.2
	Bad contacts (#)	0.1 ± 0.1	0.2 ± 0.1	0.1 ± 0.1
5-10-5 Drill	**Time (s)**	4.86 ± 0.1	4.94 ± 0.1	4.91 ± 0.1
Agility Ladder	**Total Steps (#)**	42.1 ± 1.0	41.6 ± 1.0	41.2 ± 1.0
	Missteps (#)	4.6 ± 1.0	3.1 ± 0.6	3.8 ± 0.8

3.3. Perception

There was a significant effect of shoe type on perception of comfort ($p = 0.005$; Figure 4a). *Post hoc* tests indicated that subjects perceived low-tops and mid-tops both to be more comfortable than the high-tops ($p = 0.003$ and 0.007, respectively). There was a significant effect of shoe type on perception of heaviness ($p = 0.001$; Figure 4b). *Post hoc* tests indicated that subjects perceived low-tops and mid-tops both to be less heavy than the high-tops ($p = 0.005$ and <0.001, respectively). There was a borderline significant effect of shoe type on perception of stability ($p = 0.065$; Figure 4c). *Post hoc* tests indicated that subjects perceived the low-tops to be less stable than both the mid-tops and the high-tops ($p = 0.037$; and 0.049, respectively).

Figure 4. Athletes' perceptions of the cleats as determined by 10-cm visual analogue scales (VAS). Values are centimeters and given as averages ± standard error. Asterisks (*****) indicate a significant difference between low-top and high-top. Carats (^) indicate a significant difference between mid-top and low-top. Daggers (†) indicated a significant difference between low-top and mid-top.



4. Discussion

4.1. Range-of-motion

Hypothesis A was that the high-top cleat would limit dorsiflexion and inversion (but not plantarflexion or eversion) compared to both the low-top and mid-top cleat. Most ankle sprains occur through inappropriate eversion which strains the ATFL (anterior talofibular ligament) and not eversion movements because the deltoid ligament is relatively stronger [2,19], so inversion was of particular concern given the high incidence of ankle sprains in American football [12–14]. The results support the hypothesis because the high-top cleat limited both dorsiflexion and inversion over the low-top and mid-top cleats (Figure 2a,d) but did not affect plantarflexion or eversion (Figure 2b,c).

Hypothesis B was that the high-top cleat would be able to maintain its restrictive effects on ROM throughout physical activity. There were no differences in ankle ROM (or perceptions) pre- to post-exercise, supporting the hypothesis. Work from other teams has shown that the effectiveness of ankle taping or spatting wanes with increasing physical activity, even in as little as 15 min [32–34]. The present results suggest that high-top shoes may be a substitute for ankle taping or spatting as the shoe may hold its effects over time. Others state that high-top shoes are expected to lose their rigidity with wear, and that the benefits of high-top shoes in studies cited here may come from the newness of their materials *vs.* their height [35]. Because professional players may have the luxury of playing each game in new shoes whereas the casual or amateur player may not, findings from such studies may not be applicable to the everyday athlete [9].

Previous studies have also examined the effects of shoe height on ROM; shoe makes and models are reported when known. In a study of 20 college athletes wearing American football cleats and standing on a drop-platform that simulated sudden ankle forces, scientists reported reduced inversion in the high-top cleat (Reebok Turf Rat High; Reebok International Ltd.; Canton, MA, USA) compared to the low-top cleat (Reebok Turf Rat Low) [15], similar to present findings. Only one other study used volitional athlete movement with manual goniometry as performed here and showed that for 16 female and 14 male recreationally active young adults tested in both low-top and mid-top Asics Gel Airier volleyball shoes (Asics, Inc.; Kobe, HYG, Japan), dorsiflexion (but not plantarflexion) was reduced when wearing the mid-top shoe compared to the low-top [11].

Other researchers have studied the effects of high-top shoes on ankle ROM in the context of performance or simulated performance, such as by coupling cutting drill movements with real-time ankle motion analysis via camera arrays (Appendix A), by coupling jumping movements with real-time motion or force analysis via force platforms (Appendix B), or by using various mechanical apparatuses that manipulate athletes' ankles in controlled manners (Appendix C). Discrepancies between studies are expected given the variability inherent in such techniques [1,36], the use of shoes from different sports and manufacturers, and the use of athletes of different builds, so results may not be directly comparable. The cutting maneuvers from the studies in Appendix A are similar to the cutting drill employed in the present study whereas the jumping maneuvers from the studies in Appendix B are similar to the ladder drill employed in the present study. Although performance and ankle ROM measurement were uncoupled in the present study *vs.* those in Appendices A–C, results of the present study are generally in agreement with previous research. Notably, the sample size in the present study (n = 18) was larger than the average sample size

($n = 12.2 \pm 5.4$) from the studies in Appendices A–C. The present study is also novel in that it examined four ankle movements concomitantly, whereas most studies have reported one or two.

4.2. Performance

Hypothesis C was that performance would be statistically similar for all three cleat models, and was borne out by the present study (Table 1). Only one other study has examined the effects of high-top American football cleats on performance [20]. Coaches tested 24 college-aged male physical education majors in speed and agility drills (30-yd forward sprint, 15-yd backward sprint, and agility run) in both low-top and high-top football cleats that differed by 0.15 ounces (4.3 g) in mass and 2.5 inches (6.4 cm) in collar height. Differences in performance times were 0.05, 0.02, and 0.03 seconds favoring the low-top cleats, which the coaches deemed to be insignificant and offset by the presumed injury prevention benefits of the high-top cleat. The present study confirmed and extended those findings by showing that performance differences may be insignificant for low-top, mid-top, and high-top football cleats collectively. Between the low-top and high-top cleats used in the present study, the mass difference was 89 g and the height difference was 6 or 7 cm (if considering maximum collar height or malleolar notch height differences, respectively); thus the mass differences between high-top shoes and low-top shoes in the present study was much greater than in [20] but the height differences were similar. Taken with the previous data [20], the present findings suggest that these mass differences do not influence performance outcomes in agility- or sprint-type American football drills.

All other studies exploring the effects of high-top shoes on performance have been basketball shoe studies. In a study of eight male physical education majors completing a basketball-inspired "obstacle course" and performing maximum vertical jumps in prototype high-top and low-top basketball shoes, high-top shoes increased time to complete the obstacle course by 1% and decreased maximum vertical jump height by 3%, which the authors felt were significant declines [6]. Studying 20 male athletes, a different team of researchers similarly showed that as they increased resistance of the high-top basketball shoe upper (by inserting different numbers of plastic rods into the padding), time to complete an obstacle course decreased [37]. Differences between the basketball studies [6,37], *vs.* the lone football study [20] plus Table 1, suggest that impacts of high-top shoes on performance may be sport-specific, varying because of differences in the sport's movements and/or sport-specific footwear design differences.

4.3. Perception

Hypothesis D was that subjects would rate the high-top cleat as less comfortable, heavier, and more stable than the other cleat models. The data for comfort (Figure 3a) and heaviness (Figure 3b) directly supported the hypothesis, but the data for stability (Figure 3c) was more complex and indicated that subjects in the present study perceived the mid-top and the high-top cleat both to be more stable than the low-top cleat, with no differences in stability perceived between the mid-top and high-top.

Literature exists regarding perceptual and proprioceptive effects of ankle appliances such as taping jobs and braces [38–44]. No references were located that scientifically evaluated athlete perception of differing shoe heights, though some [2,31,45] have intuited that the high-top shoe, by din of its higher collar making increased surface contact with the ankle, improves proprioceptive feedback which may be augmented or diminished by the amount of padding. Thus, the findings in Figure 3 are particularly novel and illumine our understanding of shoe height and athlete proprioception.

4.4. Limitations and Future Directions

Several limitations exist in the present study. First, this experiment examined only one American football cleat series (the Nike Land Shark) in a limited set of drills utilizing subjects anthropometrically analogous to running backs and receivers; consequently, findings may not apply to all makes and models of football cleats, to American football players of different positions or builds, or to other practice and game scenarios. Second, to eliminate *a priori* biases such as a preference for one height of shoe *vs.* another based on previous experience (which might subjectively influence performance or perceptual outcomes), none of the subjects were professional American football players. It is possible that the subjects selected for this study did not perform the drills with the same speed and power as professional American football players might have. Third, because it was an acute study, this experiment cannot speak directly towards the potential injury reduction benefits of high-top field cleats. Ankle ROM restriction may not necessarily translate directly to injury prevention [19]. Fourth, the present study was a field study and consequently did not have access to some technologies that would be available in a more controlled biomechanics laboratory-like setting, which could have improved precision and allowed for the coupling of measurements (such as joint angles) with movements in real-time.

There are several avenues for future investigation. Further experiments involving different types of American football cleats, athletes representing different field positions, different drills that simulate other field conditions (e.g., route trees) or longitudinal studies examining the effects over repeated practices or games are obvious extensions. Orthoses, prophylactic taping or spatting, and prophylactic bracing are often used in conjunction with cleats, particularly in the context of American football, yet conflicting evidence exists regarding the effects of combining appliances [18,23,31,36,46]. Other shoe factors that deserve research because they may modify the effects of shoe height include: the material the upper is constructed from [16]; outer sole properties, such as traction [26] or height and configuration the studs [47]; midsole properties including cushioning [26,48]; heel characteristics such as flares and height in relation to the forefoot [48]; shoe features such as straps or inner boots [31]; and lacing configurations such as eyelet numbers, lacing patterns, tautness, and notched eyestay systems [1,10,28,49]. Another question that remains to be addressed is “how much” additional shoe height provides stability benefits, though some studies [50] have laid the foundation for such a quest.

5. Conclusions

Findings from the present study add generally to our understanding of high-top footwear, but most specifically to American football cleats which have been poorly studied; thus, they make help athletes, coaches, and athletic trainers in footwear selection. The primary findings were that high-top American football cleats may: (1) reduce ankle ROM (particularly movements associated with ankle sprains such as inversion) and that these effects persist after acute physical activity; and (2) enhance athletes’ sense of ankle stability without disrupting performance, though they may concomitantly decrease athletes’ sense of comfort or feel more bulky. Stated another way, the findings suggest that high-top American football cleats may yield ankle prophylaxis benefits without reducing performance.

Acknowledgments

Thank you to all the subjects who volunteered their time for the study. Students in Bio 134 L in 2011 (“Biology of Exercise & Sport Lab”) and 2013 (“Exercise Physiology Lab”) participated in some study design and data collection elements of the study.

Author Contributions

DSS oversaw the initial study design and troubleshooting, and performed the early stages of data collection and analysis. CWD was responsible for latter stages of data collection and analysis. CWD and DSS jointly wrote the paper.

Appendices

Appendix A. Prior studies of high-top athletic shoes and ankle ROM in the context of cutting drills.

Study	Subjects	Shoes	Movement	Findings
Avramakis *et al.* 2000 [51]	12 male floorball players	High-top *vs.* low-top Adidas Handball Worldteam shoes	Sideward or combined forward-sideward cutting	High-top shoes reduced supination (e.g., improved lateral stability) compared to low-top shoes
Stacoff *et al.* 1996, 1998 [52,53]	12 male floorball players	High-top basketball shoes *vs.* low-top handball, cross-training, and prototype shoes	Diagonal and sideward cutting	High-top shoes reduced inversion, β-angles, and foot slippage more than the low-top shoes
Stussi *et al.* 1989 [50]	15 male athletes (various sports)	Shoes with shaft heights of 10.5, 14.5 and 23 cm (analogous to running, basketball, and boxing shoes, respectively)	Lateral cutting	Higher-top shoes had reduced supination

Appendix B. Prior studies of high-top athletic shoes and ankle ROM in the context of jumping or jump-simulating drills.

Study	Subjects	Shoes	Movement	Findings
Brizuela *et al.* 1997 [6]	8 male recreational basketball players	High-top *vs.* low-top prototype basketball shoes	Vertical jumps	High-top shoe limited both eversion and plantarflexion (but not inversion), attributed to confining effects of the heel counter and taller upper jointly
Petrov *et al.* 1988 [31]	4 cadaver legs	High-top (Nike Air Jordan V SE) *vs.* low-top (Nike Dart IV)	Controlled impacts	High-top shoe limited dorsiflexion and Achilles tendon tension moreso than low-top shoe; effects were greater when shoes were tied *vs.* untied
Sussmann *et al.* 1988 [54]	8 female athletes	High-top *vs.* low-top shoe	Two-legged landings on a force platform after a rebound	High-top shoe had better ankle movement prophylaxis
Vanwanseele *et al.* 2012 [55]	11 netball players	High-top Nike Jordan *vs.* low-top Asics Ignite 3	Single-legged landings on a force platform while receiving a chest pass	High-top shoe had lower maximal eversion angles than the low-top shoe, though the effect was not statistically significant

Appendix C. Prior studies of ankle ROM in the context of sudden ankle manipulations.

Study	Subjects	Shoes	Movement	Findings
Ashton-Miller *et al.* 1996 [8] and Ottaviani *et al.* 1995 [10]	20 male athletes	¾-top Nike Air Force Max basketball shoe *vs.* low-top Nike Air Force I basketball shoe	"Wobble board"-like testing apparatus	High-top shoe reduced inversion (but not eversion) forces better than the low-top shoe when the foot was in various degrees of plantarflexion
Johnson *et al.* [16]	12 male soccer players	High-top *vs.* low-top soccer boots	Athletes' lower limbs were immobilized and ankles everted to 40°	High-top soccer boots confer less stress to collateral ligaments
Robinson *et al.* 1986 [37]	20 male athletes	High-top basketball shoes with space for plastic rods to be inserted in the shaft	Ankle-manipulating apparatus	Dorsiflexion, eversion, and inversion are negatively correlated to the stiffness of the high-top shoe's shaft
Shapiro *et al.* [45]	5 cadaver ankles	High-top *vs.* low-top athletic shoes	Ankle-manipulating apparatus	High-top shoe augmented inversion resistance compared to a low-top shoe

Conflicts of Interest

The authors declare no conflict of interest.

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