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Published online: 09 May 2019.

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## ORIGINAL ARTICLE

# Acute and chronic effects of competition on ankle dorsiflexion ROM in professional football players

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**ABSTRACT**

The aim of this study was to investigate the acute (a football match) and chronic (a whole season) effects of competition on ankle dorsiflexion ROM in professional football players. Forty football players participated in this study. Ankle dorsiflexion ROM was recorded to examine acute (pre-match, immediately post-match and 48 h post-match) and chronic (pre-season, mid-season and post-season) effects of competitive football. In addition, it was found that players had restricted mobility measures on ankle dorsiflexion as >2 cm change between baseline measures (pre-match and pre-season). The training load of all played matches was estimated using a global positioning system (GPS) and RPE. Pre-season ankle dorsiflexion ROM was greater compared to mid-season (8.1% in the dominant, and 9.6% in the non-dominant leg) and post-season (13.8% in the dominant, and 12.5% in the non-dominant leg). In addition, around 30% of all players showed restricted ankle dorsiflexion ROM values in post-season compared with pre-season. Related to acute effects, ankle dorsiflexion ROM increased after a match (5.8%) in the dominant ankle, and this value decreased (2.65%) 48 h post-match when post-match measurements in both dominant and non-dominant ankles were compared. The progressive decrease in ankle dorsiflexion ROM throughout a season can be an indicator of increased risk of injury and may be reinforce the need of prevention actions such as stretching exercises and eccentric strength training in professional football players. In addition, these findings suggest to implement specific recovery strategies aiming at minimizing alteration in ankle dorsiflexion ROM 48 h post-match.

**Keywords:** *Soccer, injuries, performance, fatigue, sport*

**Highlights**

- Several lower limb injuries, such as ankle injuries, ACL ruptures, Achilles, patellar tendon injuries, and hamstring strain injuries have been associated with restricted ankle dorsiflexion range of motion (ROM).
- Ankle dorsiflexion ROM was recorded to examine acute (pre-match, immediately post-match and 48 hours post-match) and chronic (pre-season, mid-season and post-season) effects of competitive football. The training load of all played matches was estimated using a global positioning system (GPS) and RPE.
- Pre-season ankle dorsiflexion ROM was greater compared to mid-season and post-season. In addition, around 30% of all players showed restricted ankle dorsiflexion ROM values in post-season compared with pre-season. Related to acute effects, ankle dorsiflexion ROM increased after a match in the dominant ankle, and this value decreased 48h post-match.
- The progressive decrease in ankle dorsiflexion ROM throughout a season can be an indicator of increased risk of injury and may be reinforce the need of prevention actions such as stretching exercises and eccentric strength training in professional football players.

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## Introduction

Football is an explosive sport, where players perform repeated high-intensity actions, such as sudden accelerations, decelerations, changes of direction (CODS), jumping and landing tasks (Bloomfield, Polman, & O'Donoghue, 2007). Due to the high physical demands of this practice, previous reports have shown an average injury rate of 8 injuries per 1000 h exposure, which corresponds to 50 injuries per season in a team of 25 players, causing an important loss of time from competitions for the players (Ekstrand, Hagglund, & Walden, 2011; Ekstrand, Hagglund, Kristenson, Magnusson, & Walden, 2013). The great number of injuries could have a significant impact on team performance and results (Eirale, Tol, Farooq, Smiley, & Chalabi, 2013), as well as long-term financial implications for football clubs (Ekstrand, 2013). Thus, functional tests and strategies have a critical importance for football players and clubs.

Several lower limb injuries, such as ankle injuries (Youdas, McLean, Krause, & Hollman, 2009), ACL ruptures (Wahlstedt & Rasmussen-Barr, 2015), Achilles (Whitting, Steele, McGhee, & Munro, 2011) and patellar tendon injuries (Bisseling, Hof, Bredeweg, Zwerver, & Mulder, 2008; Malliaras, Cook, & Kent, 2006; Whitting et al., 2011), and hamstring strain injuries (Gabbe, Bennell, Finch, Wajswelner, & Orchard, 2006; Gabbe, Finch, Bennell, & Wajswelner, 2005; van Dyk, Farooq, Bahr, & Witvrouw, 2018) have been associated with restricted ankle dorsiflexion range of motion (ROM). In particular, the cut off score of >2 cm has been previously suggested as the smallest worthwhile change to identify impairments in ankle dorsiflexion ROM (Charlton et al., 2018). According to previous reports, restricted ankle dorsiflexion ROM increases injury risk significantly by modifying lower-limb stiffness and landing forces after a vertical jump (Mason-Mackay, Whatman, & Reid, 2017). In addition, this parameter is also associated with increased knee valgus, decreased quadriceps activation and increased soleus activation during squat movements that could affect athletes' performance (Macrum, Bell, Boling, Lewek, & Padua, 2012). Dorsiflexion ROM has a crucial influence on landing and CODS performance in multidirectional sports movements (Gonzalo-Skok, Serna, Rhea, & Marin, 2015; Lockie et al., 2014). However, many practitioners examine ankle dorsiflexion before starting the season or during the off-season period. These procedures limit the ability to acquire changes in ankle dorsiflexion ROM. On the other hand, the regular control of this variable could facilitate the detection of possible functional limitations (which

may be associated with injuries) in football players. Moreover, it might be possible to detect the chronic effects of the entire season as well (Wollin, Thorborg, & Pizzari, 2017).

One of the potential factors in injury causation is fatigue in the lower limbs due to match play, since several studies have observed an increase in injury rates towards the end of each half of a match (Rahnama, Reilly, Lees, & Graham-Smith, 2003; Woods, Hawkins, Hulse, & Hodson, 2003). Fatigue is known to reduce sports performance through a decrease in muscle strength (Phillips, 2015), neuromuscular control (Fort-Vanmeerhaeghe et al., 2016), and balance and coordination (Paillard, 2012). Previous studies have suggested that fatigue is a possible factor for an increased risk of knee and ankle injuries (Ekstrand et al., 2011; Kofotolis, Kellis, & Vlachopoulos, 2007). Although ankle sprains, ACL ruptures, Achilles and patellar tendinopathies have been attributed to the biomechanical demands of a match, to our knowledge, only two previous studies has analyzed the effects of a competitive match on ankle dorsiflexion ROM in football players and reporting no significant differences (Wollin et al., 2017; Wollin, Thorborg, & Pizzari, 2018). However, the results of the Wollin et al. (2017) study found a tendency to reduced ankle dorsiflexion ROM post-match compared to pre-match, but these changes were not statistically significant. Moreover, (Wollin et al., 2017, 2018) used a sample of youth elite football players who presented incomplete muscular development compared to professional football players, and their match demands were lower than those of senior professional athletes (Buchheit, Mendez-Villanueva, Simpson, & Bourdon, 2010). The scarce evidence linking football practice and reduced ankle dorsiflexion encourages us to broaden research in this aspect. Ankle dorsiflexion ROM can be related to muscle damage shown in football players after a match (Ispirlidis et al., 2008), especially if we consider the repeated high-force eccentric actions (decelerating and landing among other specific skills), and the muscular impairment associated with them (Friden & Lieber, 2001). Therefore, further research analyzing the relation between the acute and chronic effects on ankle dorsiflexion ROM in professional football players is needed.

The first aim of this study was to investigate the acute response of ankle dorsiflexion ROM immediately after a competitive match and 48 h post-match. The second aim was to examine the chronic adaptations of ankle dorsiflexion ROM following a whole season. In addition, the current study was aimed at examining the relationship between external match play demands and player's age with acute and chronic changes in ankle dorsiflexion ROM.

## Methods

### Participants

A total of 49 professional football players volunteered to participate in this prospective observational study. Among these, only 40 players (age: 24.5 ± 5.3 years [19–38 years]; body mass: 76.4 ± 6.6 kg; height: 180.6 ± 6.4 cm) completed this study. The participants were recruited from two different teams playing in the top Spanish football league. Fifteen of these player were defenders, 17 midfielders and 8 attackers. Twenty-nine (72.5%) players presented right lower-limb dominance and eleven (27.5%) had left leg dominance. The following exclusion criteria were adopted: (a) history of pain or lower-limb injury within the month of testing; (b) no regular training (one month) prior to testing; (c) less than 75 min play in a match. An injury was defined as: "*Any physical complaint sustained by a player that resulted from a soccer match or soccer training*" (Fuller et al., 2006) and led to an absence from the next training session or match. Nine football players were excluded from the study (6 field football players and 3 goalkeepers), either because they reported recent muscle strain injuries in the lower limb (3 hamstring strain injuries and 1 groin injury, all field players), or they played less than 75 min of the match (2 field players). The 3 goalkeepers were excluded from the study because of the different nature of their activity.

Prior to the start of this investigation, all players were fully informed about the testing and training protocols and a written informed consent was obtained. The experimental procedure of this study is in accordance with the Declaration of Helsinki and was approved by the Ethics Committee of the University.

### Data collection

All testing was conducted at the players' home ground. Players' body mass, height, medical history, and training frequency (number of hours of practice per day and week) were collected before the beginning of the study. Ankle dorsiflexion testing was performed by two experienced members of the team's medical staff. For the study of chronic adaptations, data collection was conducted at three different times throughout the competitive season: pre-season (second week), mid-season (fifth month) and post-season (tenth month). All testing measurements were taken at the same time at the first regular training session after a rest day. One week before data collection began, all the football players performed two familiarization trials to reduce the influence of a possible learning effect. For the study of acute effects, measurements were performed at three different moments: pre-match (within two hours of the start of the competition), immediately post-match, and 48 h after pre-match testing (following a day of complete rest). During the competitive season, standard warm-up was maintained throughout all sessions, and only a few variations were introduced depending on the day of the weekly microcycle. This warm up consisted of running at progressive intensity, static and dynamic stretching, mobility exercises, core stability work and technical exercises. In the cool down, players carried out 2 repetitions of 5 different unassisted static stretching exercises, holding the stretched position for 20–30s. Participants did not receive any kind of myofascial release or similar intervention to treat tight muscles on testing days. Other physical therapy interventions provided by the staff during the season, specifically aimed at the triceps surae, were considered as normal procedures (17.5%). Hence, this kind of activity was recorded, but not considered for the study. Prior to the testing session, participants performed a warm up consisting of 3 min of low to moderate-intensity (self-perceived) running followed by 6–8 min of dynamic stretching (i.e. straight leg march, forward lunge with opposite arm reach, forward lunge with an elbow instep, lateral lunge, trunk rotations, multi-directional skipping) performing 2 sets, from low to high intensity, with a 15 s rest period between each set. The intensity of each exercise was performed at approximately 70–90% of the point of discomfort, where 0 = "no stretch discomfort at all" and 100% = "the maximum imaginable stretch discomfort", while the velocity of movement progressively increased from 50 to 90%. ROM assessment was carried out 1–3 min after the dynamic warm up. Immediately post-match, the players' only ingestion was 250 mL of electrolyte drink, and water as a recovery measure just prior to the completion of the post-match test.

### Measurements

*Ankle dorsiflexion measures.* Unilateral ankle dorsiflexion ROM was tested using the LegMotion System test (LegMotion, Check your Motion, Albacete, Spain) (Calatayud et al., 2015). Test procedures were assessed following the methodology previously described by Calatayud et al. (2015). Subjects were in a standing position in the LegMotion System with the tested foot on the measurement scale (Figure 1). The contralateral foot was positioned out of the platform with toes at the edge of it. Each player performed the test with their hands on their hips, with the assigned foot on the middle of the longitudinal line, and just behind the transversal line of the platform. While maintaining this position,

Figure 1. Ankle dorsiflexion ROM test.

subjects were instructed to flex the knee forward placing it in contact with the metal stick. When the subject was able to maintain heel and knee contact achieving the maximal distance, the metal stick was progressively moved away from the knee, and the following achieved distance was recorded. Three trials were allowed for each leg (i.e. left and right), with 10 s of passive recovery between trials. The best score for each ankle among these trials was selected for subsequent analysis. The intraclass correlation coefficient (ICC) of the LegMotion System test was 0.96–0.98 (Calatayud et al., 2015).

*Internal match load.* Subjective internal load was estimated using rate of perceived exertion by the perceived exertion method, with ratings obtained from each individual player within 30 min of completing each training and match, which was previously validated (Foster et al., 2001). Each player was familiarized with the scale before starting the study. The obtained value was multiplied by the time played during the match to register a game load in arbitrary units (AU) (Foster et al., 2001).

*External match load.* The intensity of all played matches was estimated using GPS (Global Positioning System, Catapult Optimeye S5, Melbourne, Australia), at a sample rate of 10 Hz and an accelerometer sampling of 100 Hz, with reliability measured by a coefficient of variation (CV) of 0.7% and accuracy measured by standard error of measurement (SEM) of 5.1% (Castellano, Casamichana, Calleja-Gonzalez, Roman, & Ostojic, 2011) The GPS units were placed between the scapulae of the players in bespoke vests (PlayerTek vest, Catapult, Melbourne, Australia). Following each match, data was downloaded using a specialized analysis software (Catapult #39598). The studied parameters selected were:

distance covered, high-speed-running (distance covered >23 km·h$^{-1}$), accelerations and decelerations (acceleration and deceleration <2 m/s).

*Statistical analysis*

All analyses were performed using the SPSS package (version 25, SPSS Inc., Chicago, IL, USA). Descriptive statistics including means and standard deviations were calculated for ankle dorsiflexion ROM tests separately by limb (dominant and non-dominant). Furthermore, ankle dorsiflexion ROM scores for each participant were categorized as normal or restricted according to the reference values previously reported as clinically meaningful (difference >2 cm) (Charlton et al., 2018). Such as previously reported changes of 1 cm represents 1.39° change in terms of degrees (Calatayud et al., 2015). The normality of the data was verified using the Kolmogorov–Smirnov test. One-way repeated measures ANOVA were conducted to identify differences in unilateral ankle dorsiflexion (dominant and non-dominant) and limbs (dominant *versus* non-dominant) between time points. Statistical significance was set at $p <$ 0.05. In addition, to determine the magnitude of differences between the ankle dorsiflexion in dominant, non-dominant and between limbs at different time points, the effect size (ES; Cohen's *d)* and the 95% confidence intervals (CI) were calculated and interpreted as: <0.2 trivial; 0.2–0.6 small; 0.6–1.2 moderate; and >1.2 large (Hopkins, 2015). Pearson's correlation coefficients were calculated to determine the relationship between ankle dorsiflexion ROM and player's age, position in the field, number of matches and minutes played during the season. Likewise, the same correlation coefficients were obtained from acute changes on ankle dorsiflexion after match play and external match play demands (total distance covered, high-speed-running, accelerations and decelerations), as well as player's age and match load.

## Results

*Chronic effects throughout the season*

The forty professional players performed 30.8 ± 9.9 matches per season and 2222 ± 844 min per season. The descriptive ROM values (mean ± SD) and results of the ankle dorsiflexion ROM throughout the pre-season, mid-season and post-season are presented in Table I. This parameter showed a significant decrease from pre-season to mid-season (dominant leg decreased 8.1%, ES = 0.25 [−0.07, 0.57], $p =$ <0.001, and non-dominant 9.6%, ES = 0.25 [−0.07, 0.57], $p =$ <0.001), and post-season

Table I. Average ± standard deviation for ankle dorsiflexion ROM in the football players, comparing pre-season, mid-season and post-season (chronic effect)

| Range of motion (cm) | Pre-season | Mid-season | Post-season | Pre-season vs Mid-season | Pre-season vs Post-season | Mid-season vs Post-season |
|---|---|---|---|---|---|---|
| | Mean ROM | Mean ROM | Mean ROM | $p$ ES [95% CI] | $p$ ES [95% CI] | $p$ ES [95% CI] |
| ADF (DOMINANT) | 7.78 ± 2.51 | 7.15 ± 2.72 | 6.7 ± 2.77 | .001, 0.25 [−0.07, 0.57] | .001, 0.43 [0.09, 0.75] | .039, 0.16 [−0.15, 0.48] |
| Qualitative outcome* | | | | Normal (2) | Normal (11) | Normal (8) |
| ADF (NON-DOMINANT) | 7.49 ± 2.78 | 6.77 ± 2.79 | 6.55 ± 2.94 | .001, 0.25 [−0.07, 0.57] | .001, 0.33 [0.00, 0.66] | .328, 0.08 [−0.23 0.39] |
| Qualitative outcome* | | | | Normal (5) | Normal (13) | Normal (4) |

Abbreviations: ADF = Ankle dorsiflexion; ES = Effect size [95% confidence limits]; *Qualitative score of the mean range of motion, in parentheses the number of players with a restricted range of motion score according to previously published cut-off scores (see Statistical analysis section).

(dominant leg decreased 13.8%, ES = 0.43 [0.09, 0.75], $p$ = <0.001, and non-dominant 12.5%, ES = 0.33 [0.00, 0.66], $p$ = <0.001) (Table I). Comparing mid-season to post-season (Table I), ankle dorsiflexion was reduced significantly in the dominant ankle (a decrease of 6.29%, ES = 0.16 [−0.15, 0.48], $p$ = 0.039), while non-significant differences were observed in the non-dominant ankle (ES = 0.08 [−0.23, 0.39], $p$ = 0.328).

Statistical analysis reported no significant differences ($p$ > 0.05) between dominant and non-dominant limbs for ankle dorsiflexion ROM throughout the pre-season, mid-season and post-season (Table II).

Pearson's analysis showed a trivial correlation between the chronic changes in the ankle dorsiflexion values and player's age ($r$ = −0.170–0.238, $p$ > 0.05), position in the field ($r$ = −0.226–0.202, $p$ = 0.16 to $p$ = 0.21), number of matches ($r$ = −0.183–0.45, $p$ = 0.25 to $p$ = 0.78) and minutes played during season ($r$ = −0.083–0.163, $p$ = −0.61 to $p$ = 0.31).

### Acute effects of match play

For data regarding acute effects, the average football match length was 87 ± 10 min in a total of 12 matches, with a mean RPE load of 712.48 ± 159.11 AU per match. The average of the total distance covered by the players and the amount of high-speed-running were 8549 ± 1879 m and 398 ± 155 m, respectively, during competitive matches. In addition, the mean distance covered in accelerating and decelerating were 313 ± 105 m and 273 ± 87 m, respectively.

The descriptive ROM values (mean ± SD) and the comparison of ankle dorsiflexion ROM among pre-match, immediately post-match and 48 h post-match in the dominant and non-dominant limbs, respectively, are reported in Table III. Ankle dorsiflexion ROM increased post-match by 5.8% from pre-match values in the dominant ankle (ES = −0.16 [−0.48, 0.15], $p$ = 0.002), and decreased 2.65% 48 h post-match compared to post-match results in the dominant (ES = 0.21 [−0.11, 0.52], $p$ = 0.001) and non-dominant (ES = 0.16 [−0.16, 0.47], $p$ = 0.04) ankle (Table III). No significant differences were detected in the other variables (Table III).

There were no significant differences ($p$ > 0.05) between dominant and non-dominant limbs ankle dorsiflexion ROM with regard to pre-match, immediately post-match and 48 h post-match.

Table II. Average ± standard deviation for bilateral differences in ankle dorsiflexion ROM in the football players, comparing pre-season, mid-season and post-season.

| Range of motion (cm) | Pre-season | Mid-season | Post-season | Pre-season vs Mid-season | Pre-season vs Post-season | Mid-season vs Post-season |
|---|---|---|---|---|---|---|
| | Mean ROM | Mean ROM | Mean ROM | $p$ ES [95% CI] | $p$ ES [95% CI] | $p$ ES [95% CI] |
| ADF Bilateral differences | 0.29 ± 1.74 | 0.37 ± 1.76 | 0.15 ± 1.65 | 1.000, 0.03 [−0.27, 0.35] | 1.000, 0.09 [−0.22, 0.41] | .788, 0.05 [−0.26, 0.36] |
| Qualitative outcome* | | | | Normal (0) | Normal (6) | Normal (3) |

Abbreviations: ADF = Ankle dorsiflexion; ES = Effect size [95% confidence limits]; *Qualitative score of the mean range of motion, in parentheses the number of players with a side to side restricted range of motion score according to previously published cut-off scores (see Statistical analysis section).

Table III. Average ± standard deviation for ankle dorsiflexion ROM in the football players, comparing pre-match, post-match and 48 h post-match (acute effect).

| Range of motion (cm) | Pre-match | Post-match | 48 h post-match | Pre-match vs Post-match | Pre-match vs 48 h post-match | Post-match vs 48 h post-match |
|---|---|---|---|---|---|---|
| | Mean ROM | Mean ROM | Mean ROM | *p* ES [95% CI] | *p* ES [95% CI] | *p* ES [95% CI] |
| ADF (DOMINANT) | 7.93 ± 2.95 | 8.42 ± 3.34 | 7.71 ± 3.09 | .002, −0.16 [−0.48, 0.15] | .133, 0.07 [−0.24, 0.39] | .001, 0.21 [−0.11, 0.52] |
| Qualitative outcome* | | | | Normal (1) | Normal (1) | Normal (4) |
| ADF (NON-DOMINANT) | 7.92 ± 3.13 | 8.2 ± 2.99 | 7.71 ± 3.02 | .066, −0.08 [−0.40, 0.23] | .182, 0.06 [−0.25, 0.38] | .004, 0.16 [−0.16, 0.47] |
| Qualitative outcome* | | | | Normal (1) | Normal (0) | Normal (4) |

Abbreviations: ADF = Ankle dorsiflexion; ES = Effect size [95% confidence limits]; *Qualitative score of the mean range of motion, in parentheses the number of players with a restricted range of motion score according to previously published cut-off scores (see Statistical analysis section).

Pearson's correlation showed a small relationship between the decrease in ankle dorsiflexion ROM in the dominant ankle (from pre-match to 48 h post-match) and player's age ($r = 0.327$, $p = 0.040$). However, possible relationships between the variation of ankle dorsiflexion and the rest of parameters under analysis (distance covered, high-speed-running, accelerations and decelerations and the internal match load) were non-significant ($p > 0.05$).

## Discussion

The aim of the present study was to analyze the acute (post-match) and chronic (throughout the season) effects of competition on ankle dorsiflexion ROM in professional football players. Moreover, this study was aimed at examining the relationship between external match play demands and players' age with acute and chronic changes in ankle dorsiflexion ROM.

### Acute effects of a match play

The present study has shown a significant increase of 5.8% in ankle dorsiflexion ROM immediately post-match compared to pre-match values in the dominant limb, while the same parameter was reduced by 2.65% 48 h post-match compared to post-match values in both lower limbs. Furthermore, by calculating the number of players with greater restrictions than the cut-off score of 2 cm (according to the reference values previously reported by Charlton et al. (2018) in ankle dorsiflexion ROM measures between post-match and 48 h post-match), more than 10% of the players were identified as restricted. No significant differences were detected in the other variables.

Related to post-match variations, it is known that activity, even the application of stretching exercises, can lead to an increase in ankle ROM (Radford et al., 2006). From a physiological point of view, enhancement in temperature plays a key role in the acute increase in ROM which leads to a reduction in the viscous resistance of muscle tissues and joints (Bishop, 2003). Thus, the trivial augmented dorsiflexion ankle ROM reported in this study could be attributed to increased tissue extensibility (Opplert & Babault, 2018). However, the results of this study differ with previous studies conducted in youth football players (Wollin et al., 2017; 2018). In a cohort of 14 youth players, Wollin et al. (2017) found a reduced dorsiflexion ankle ROM of 6.7% after match play compared to pre-match, while Wollin et al. (2018) no significant differences reported in 15 youth players. This lack of agreement between studies may be due to the characteristics of the samples used and/or demands of the participants' match play in the studies (i.e. young versus professional players). For instance, while the previous studies does not provide information regarding external match demands of the match play in young players with an average age of 16.7 ± 0.3 years (Wollin et al., 2017) and an average age of 15.81 ± 0.65 years (Wollin et al., 2018), our study found an average distance covered of 8549 ± 1879 m, with 398 ± 155 m of high-speed-running in 40 professional players with an average age of 24.5 ± 5.3 years. Previous studies, conducted in sports have shown that match running performance is affected by age, specifically older players cover greater distances at high intensities (Al Haddad, Simpson, Buchheit, Di Salvo, & Mendez-Villanueva, 2015).

Another possible explanation for the discrepancies found could be the differences in the recording methods. Although the referred studies (Wollin et al., 2017, 2018) used the knee-to-wall test to measure ankle dorsiflexion ROM (similar to the Leg Motion System test assessment), the players

did not perform a warm up prior to the testing sessions. In contrast, in the present study, all participants performed a standardized warm up. Despite this discrepancy between studies, it is feasible to support the improvements in ROM reported in the current study by considering the acute temperature-related mechanisms (e.g. decreased muscle stiffness) observed during a match (Bishop, 2003). It is also possible to support this finding if we consider that muscle damage after exercising is not presented immediately after finishing the exercise (Friden & Lieber, 2001). However, our results should be further investigated in future studies.

In contrast to results immediately post-match, our results related to the variations of dorsiflexion ROM 48 h post-match are partially supported by Wollin et al. (2017), who did not report significant results but a trend towards reduced dorsiflexion ankle ROM 48 h post-match (1.9% compared to post-match). The results of the current study support such findings, which are significant ($p < 0.05$) in this case. Related to this finding, Ispirlidis et al. (2008) described the inflammatory response of soccer players after playing a match, lasting from 1 to 4 days post-game, and they concluded that competition provoked muscle damage shown by different blood markers (creatine kinase, lactate dehydrogenase and C-reactive protein). In this sense, the review carried out by Friden and Liebe (2001) described muscle impairment provoked by eccentric exercise. To understand why all these events are produced in a soccer match, it is necessary to consider the many high-intensity multidirectional movements existing in this kind of competition (e.g. accelerations, decelerations, CODS, jumping, tackling and sprinting), involving continuous stretch – shortening cycles (Reilly & Ekblom, 2005) and provoking repeated high intensity eccentric actions. It is feasible to relate all these muscular events to the reduced ankle range of dorsiflexion found in the present study, especially if range of motion has been identified as one of the parameters for studying muscle damage (Nedelec et al., 2012). Therefore, this ROM reduction could be related to muscle damage generated during the match, which might be ascribable to induced impairments in the mechanical and neural properties of the muscle-tendon unit (Friden & Lieber, 2001), which could lead to a reduction in ankle dorsiflexion flexibility 48 h post-match.

This study has analyzed the relationship between external match play demands and players' age with the acute and chronic changes in ankle dorsiflexion ROM. A low relationship has been found between the decrease in ankle dorsiflexion ROM in the dominant ankle after 48 h post-match and player's age ($r = 0.327$). However, no other relationships have been found between the variation of ankle dorsiflexion and the rest of parameters under analysis (distance covered, high-speed-running, accelerations and decelerations). Therefore, such variables do not influence acute and chronic variation in ankle dorsiflexion ROM. Further research and analysis need to be developed in this field.

*Chronic effects during the season*

Ankle dorsiflexion ROM showed a significant reduction from pre-season in dominant (−8.1%; −9.6%, mid- and post-season, respectively) and non-dominant (−12.5%; −13.8%, mid- and post-season, respectively) ankles. A decrease in this parameter was also found in the dominant limb when comparing post-season to mid-season (−6.3%). In addition, the current data indicates that a large number of players showed restricted ankle dorsiflexion ROM values in the post-season compared to pre-season in the dominant (27.5%) and non-dominant limb (32.5%) and between dominant and non-dominant sides (15%).

The authors of this study are not aware of similar studies addressing this issue in football players; thus comparisons cannot be made. A possible reason for the decrease in ankle dorsiflexion ROM throughout the season could be associated with chronic muscle adaptations due to the high demands of training and matches that players to perform such as sudden accelerations and decelerations, COD and jumping and landing tasks. In this sense, it is well known that continuous exposure to high-intensity eccentric actions increases the stiffness of muscles and tendons (Seymore, Domire, DeVita, Rider, & Kulas, 2017) and decreases joint ROM (Mizrahi, Verbitsky, & Isakov, 2000). The reasons mentioned above could explain the decrease in ankle dorsiflexion ROM values during the competition year. Another factor influencing the chronic restriction of dorsiflexion ROM could be related to repetitive muscle damage induced during match (indicated in the acute effects) and the lack of recovery between matches, with a highly demanding competitive calendar at professional levels, focusing on competition and thus compromising the right planning of training loads (Lopez-Valenciano et al., 2019b). The players enrolled in this study participated in over 30 matches/season (30.8), playing a mean of >2000 min/season, with 3–6 training sessions every week throughout the competitive year. Such findings could have important implications for the decrease in ankle dorsiflexion ROM, which has been posited as a predisposing factor for increasing the risk of hamstring strain injuries (Gabbe et al., 2005; Gabbe et al., 2006; van Dyk et al., 2018) in football, and

of several of the most prevalent injuries in other sports (e.g. basketball, volleyball) such as, ankle injuries (Youdas et al., 2009), ACL ruptures (Wahlstedt & Rasmussen-Barr, 2015), Achilles (Whitting et al., 2011) and patellar tendinopathies (Backman & Danielson, 2011; Bisseling et al., 2008; Malliaras et al., 2006).

Not only does dorsiflexion ROM have implications for injury prevention but also for sports performance. Previous studies have stated that such a parameter has critical importance in multi-directional running tasks to facilitate ground clearance and preparation for foot impact (Jonhagen, Ericson, Nemeth, & Eriksson, 1996; Lockie et al., 2014), and in unilateral dynamic balance, considered a fundamental component of performance in the game of football, where players are required to perform repetitive and explosive unilateral movements, such as jumping and landing (Lopez-Valenciano, Ayala, De Ste Croix, Barbado, & Vera-Garcia, 2019a). Therefore, Gonzalo-Skok et al. (2015) observed that elite basketball players with a limitation of ankle dorsiflexion ROM reported decreased COD capability, which is a key skill in professional basketball performance. In a similar way, COD actions are crucial for football (Kim et al., 2014), and the limitation of these actions could also be detrimental for performance. Based on the relevance of this knowledge, the present study has reported information regarding the acute and chronic effects on ankle dorsiflexion ROM in professional football players for the first time. However, some limitations to the study must be acknowledged. Firstly, as the current study was conducted with a specific sample of male professional field football players, these findings cannot be extended to goalkeepers, female athletes or to the general population. A further limitation of the present investigation was the analysis of only one competitive match when studying acute effects. In this sense, future studies investigating ankle dorsiflexion ROM responses to match play are needed, increasing the number of analyzed matches to fully establish changes in dorsiflexion after competition.

## Conclusion

The current study provides important information for clinicians, sports therapy practitioners and physical training coaches regarding the effects of ankle dorsiflexion ROM during a competitive season and following a football match. The present study showed significant reductions in ankle dorsiflexion ROM during the competitive year and 48 h after match play in both limbs compared to post-match values. For this reason, restoring the football player's baseline ankle dorsiflexion ROM before playing the next match would appear to be necessary during the competitive year. This can be done by educating players to use specific eccentric exercises, stretching routines, joint mobilization, and other recovery strategies such as self-myofascial release using a foam roller, to avoid injuries and maintain performance levels. Moreover, considering that limited ankle dorsiflexion ROM might suggest a potential impairment of specific skills needed in team sports, the authors suggest that practitioners develop regular preventive stretching (Lopez-Valenciano et al., 2019b) and eccentric strength training strategies during the season, with a focus on enhancing dorsiflexion ROM and strength improvements.

## Disclosure Statement

No conflict of interest was reported by the authors.

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