



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

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3 **Acute and chronic effects of competition on ankle dorsiflexion ROM in professional**
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5 **football players.**
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For Peer Review Only

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 hours 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 >2cm 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%) 48h 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 48h post-match.**

Keywords: soccer, injuries, performance, fatigue, sport

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 hours 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, Kristenson, Magnusson, & Walden, 2013; Ekstrand, Hagglund, & Walden, 2011). The great number of injuries could have a significant impact on team performance and results (Eirale, Tol, Farooq, Smiley, & Chalab, 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 >2cm 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

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3 activation during squat movements that could affect athletes' performance (Macrum,
4 Bell, Boling, Lewek, & Padua). Dorsiflexion ROM has a crucial influence on landing
5 and CODS performance in multidirectional sports movements (Gonzalo-Skok, Serna,
6 Rhea, & Marin, 2015; Lockie et al., 2014). However, many practitioners examine ankle
7 dorsiflexion before starting the season or during the off-season period. These procedures
8 limit the ability to acquire changes in ankle dorsiflexion ROM. On the other hand, the
9 regular control of this variable could facilitate the detection of possible functional
10 limitations (which may be associated with injuries) in football players. Moreover, it might
11 be possible to detect the chronic effects of the entire season as well (Wollin, Thorborg, &
12 Pizzari, 2017).

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27 One of the potential factors in injury causation is fatigue in the lower limbs due to match
28 play, since several studies have observed an increase in injury rates towards the end of
29 each half of a match (Rahnama, Reilly, Lees, & Graham-Smith, 2003; Woods, Hawkins,
30 Hulse, & Hodson, 2003). Fatigue is known to reduce sports performance through a
31 decrease in muscle strength (Phillips, 2015), neuromuscular control (Fort-
32 Vanmeerhaeghe et al., 2016), and balance and coordination (Paillard, 2012). Previous
33 studies have suggested that fatigue is a possible factor for an increased risk of knee and
34 ankle injuries (Ekstrand et al., 2011; Kofotolis, Kellis, & Vlachopoulos, 2007). Although
35 ankle sprains, ACL ruptures, Achilles and patellar tendinopathies have been attributed to
36 the biomechanical demands of a match, to our knowledge, only two previous studies has
37 analyzed the effects of a competitive match on ankle dorsiflexion ROM in football players
38 and reporting no significant differences (Wollin et al., 2017; Wollin Thorborg, & Pizzari,
39 2018). However, the results of the Wollin et al. (2017) study found a tendency to reduced
40 ankle dorsiflexion ROM post-match compared to pre-match, but these changes were not
41 statistically significant. Moreover, (Wollin et al., 2017; 2018) used a sample of youth elite

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3 football players who presented incomplete muscular development compared to
4 professional football players, and their match demands were lower than those of senior
5 professional athletes (Buchheit, Mendez-Villanueva, Simpson, & Bourdon, 2010). The
6 scarce evidence linking football practice and reduced ankle dorsiflexion encourages us to
7 broaden research in this aspect. Ankle dorsiflexion ROM can be related to muscle damage
8 shown in football players after a match (Ispirlidis et al., 2008), especially if we consider
9 the repeated high-force eccentric actions (decelerating and landing among other specific
10 skills), and the muscular impairment associated with them (Friden & Lieber, 2001).
11 Therefore, further research analyzing the relation between the acute and chronic effects
12 on ankle dorsiflexion ROM in professional football players is needed.

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The first aim of this study was to investigate the acute response of ankle dorsiflexion ROM immediately after a competitive match and 48 hours 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 players' 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 to 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

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3 dominance. The following exclusion criteria were adopted: a) history of pain or lower-
4 limb injury within the month of testing; b) no regular training (one month) prior to testing;
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6 c) less than 75 minutes play in a match. An injury was defined as: “*Any physical*
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8 *complaint sustained by a player that resulted from a soccer match or soccer training*”
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10 (Fuller et al., 2006) and led to an absence from the next training session or match. Nine
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12 football players were excluded from the study (6 field football players and 3 goalkeepers),
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14 either because they reported recent muscle strain injuries in the lower limb (3 hamstring
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16 strain injuries and 1 groin injury, all field players), or they played less than 75 min of the
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18 match (2 field players). The 3 goalkeepers were excluded from the study because of the
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20 different nature of their activity.
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27 Prior to the start of this investigation, all players were fully informed about the testing
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29 and training protocols and a written informed consent was obtained. The experimental
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31 procedure of this study is in accordance with the Declaration of Helsinki and was
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33 approved by the Ethics Committee of the University.
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41 **Data collection**

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43 All testing was conducted at the players’ home ground. Players’ body mass, height,
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45 medical history, and training frequency (number of hours of practice per day and week)
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47 were collected before the beginning of the study. Ankle dorsiflexion testing was
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49 performed by two experienced members of the team’s medical staff. For the study of
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51 chronic adaptations, data collection was conducted at three different times throughout the
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53 competitive season: pre-season (second week), mid-season (fifth month) and post-season
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55 (tenth month). All testing measurements were taken at the same time at the first regular
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57 training session after a rest day. One week before data collection began, all the football
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3 players performed two familiarization trials to reduce the influence of a possible learning
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5 effect. For the study of acute effects, measurements were performed at three different
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7 moments: pre-match (within two hours of the start of the competition), immediately post-
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9 match, and 48 hours after pre-match testing (following a day of complete rest). During
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11 the competitive season, standard warm-up was maintained throughout all sessions, and
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13 only a few variations were introduced depending on the day of the weekly microcycle.
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15 This warm up consisted of running at progressive intensity, static and dynamic stretching,
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17 mobility exercises, core stability work and technical exercises. In the cool down, players
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19 carried out 2 repetitions of 5 different unassisted static stretching exercises, holding the
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21 stretched position for 20-30s. Participants did not receive any kind of myofascial release
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23 or similar intervention to treat tight muscles on testing days. Other physical therapy
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25 interventions provided by the staff during the season, **specifically aimed at the triceps**
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27 **surae**, were considered as normal procedures (17.5%). Hence, this kind of activity was
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29 recorded, but not considered for the study. Prior to the testing session, participants
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31 performed a warm up consisting of 3 min of low to moderate-intensity (self-perceived)
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33 running followed by 6–8 min of dynamic stretching (i.e., straight leg march, forward
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35 lunge with opposite arm reach, forward lunge with an elbow instep, lateral lunge, trunk
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37 rotations, multi-directional skipping) performing 2 sets, from low to high intensity, with
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39 a 15 s rest period between each set. The intensity of each exercise was performed at
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41 approximately 70-90 % of the point of discomfort, where 0 = “no stretch discomfort at
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43 all” and 100 % = “the maximum imaginable stretch discomfort”, while the velocity of
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45 movement progressively increased from 50 to 90%. ROM assessment was carried out 1-
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47 3 min after the dynamic warm up. Immediately post-match, the players’ only ingestion
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49 was 250mL of electrolyte drink, and water as a recovery measure just prior to the
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51 completion of the post-match test.
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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, 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 seconds 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 to 0.98 (Calatayud et al., 2015).

****Insert Figure 1 near here****

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 minutes of

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3 completing each training and match, which was previously validated (Foster et al., 2001).
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5 Each player was familiarized with the scale before starting the study. The obtained value
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7 was multiplied by the time played during the match to register a game load in arbitrary
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9 units (AU) (Foster et al., 2001).
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16 *External Match Load*

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20 The intensity of all played matches was estimated using GPS (Global Positioning System,
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22 Catapult Optimeye S5, Melbourne, Australia), at a sample rate of 10Hz and an
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24 accelerometer sampling of 100Hz, with reliability measured by a coefficient of variation
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26 (CV) of 0.7% and accuracy measured by standard error of measurement (SEM) of 5.1%
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28 (Castellano, Casamichana, Calleja-Gonzalez, Roman, & Ostojic, 2011) The GPS units
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30 were placed between the scapulae of the players in bespoke vests (PlayerTek vest,
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32 Catapult, Melbourne, Australia). Following each match, data was downloaded using a
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34 specialized analysis software (Catapult #39598). The studied parameters selected were:
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36 distance covered, high-speed-running (distance covered $>23 \text{ km}\cdot\text{h}^{-1}$), accelerations and
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38 decelerations (acceleration and deceleration $<2\text{m/s}$).
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44 **Statistical Analysis**

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47 All analyses were performed using the SPSS package (version 25, SPSS Inc., Chicago,
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49 IL, USA). Descriptive statistics including means and standard deviations were calculated
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51 for ankle dorsiflexion ROM tests separately by limb (dominant and non-dominant).
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53 Furthermore, ankle dorsiflexion ROM scores for each participant were categorized as
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55 normal or restricted according to the reference values previously reported as clinically
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57 meaningful (difference $>2\text{cm}$) (Charlton et al., 2018). **Such as previously reported**
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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 minutes per season. The descriptive ROM values (mean \pm SD) and results of the ankle dorsiflexion ROM throughout the pre-season, mid-season and post-season are presented in Table 1. 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

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3 9.6%, ES = 0.25 [-0.07, 0.57], $p = <0.001$), and post-season (dominant leg decreased
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5 13.8%, ES = 0.43 [0.09, 0.75], $p = <0.001$, and non-dominant 12.5%, ES = 0.33 [0.00,
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7 0.66], $p = <0.001$) (Table 1). Comparing mid-season to post-season (Table 1), ankle
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9 dorsiflexion was reduced significantly in the dominant ankle (a decrease of 6.29%, ES =
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11 0.16 [-0.15, 0.48], $p = 0.039$), while non-significant differences were observed in the non-
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13 dominant ankle (ES = 0.08 [-0.23, 0.39], $p = 0.328$).
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24 Statistical analysis reported no significant differences ($p > 0.05$) between dominant and
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26 non-dominant limbs for ankle dorsiflexion ROM throughout the pre-season, mid-season
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28 and post-season (Table 2).
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32 *****Insert Table 2 near here*****
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39 Pearson's analysis showed a trivial correlation between the chronic changes in the ankle
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41 dorsiflexion values and player's age ($r = -0.170$ to 0.238 , $p > 0.05$), position in the field (r
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43 $= -0.226$ to 0.202 , $p = 0.16$ to $p = 0.21$), number of matches ($r = -0.183$ to 0.45 , $p = 0.25$
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45 to $p = 0.78$) and minutes played during season ($r = -0.083$ to 0.163 , $p = -0.61$ to $p = 0.31$).
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49 **Acute effects of match play**

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52 For data regarding acute effects, the average football match length was 87 ± 10 minutes
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54 in a total of 12 matches, with a mean RPE load of 712.48 ± 159.11 AU per match. The
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56 average of the total distance covered by the players and the amount of high-speed-running
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58 were 8549 ± 1879 m and 398 ± 155 m, respectively, during competitive matches. In
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3 addition, the mean distance covered in accelerating and decelerating were 313 ± 105 m
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5 and 273 ± 87 m, respectively.
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9 The descriptive ROM values (mean \pm SD) and the comparison of ankle dorsiflexion ROM
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11 among pre-match, immediately post-match and 48 hours post-match in the dominant and
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13 non-dominant limbs, respectively, are reported in Table 3. Ankle dorsiflexion ROM
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15 increased post-match by 5.8% from pre-match values in the dominant ankle (ES = -0.16
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17 [-0.48, 0.15], $p = 0.002$), and decreased 2.65% 48 hours post-match compared to post-
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19 match results in the dominant (ES = 0.21 [-0.11, 0.52], $p = 0.001$) and non-dominant (ES
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21 = 0.16 [-0.16, 0.47], $p = 0.04$) ankle (Table 3). No significant differences were detected
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23 in the other variables (Table 3).
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34 **There were no significant differences ($p > 0.05$) between dominant and non-dominant**
35 **limbs ankle dorsiflexion ROM with regard to pre-match, immediately post-match and**
36 **48 hours post-match.**
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43 Pearson's correlation showed a small relationship between the decrease in ankle
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45 dorsiflexion ROM in the dominant ankle (from pre-match to 48 hours post-match) and
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47 player's age ($r = 0.327$, $p = 0.040$). However, possible relationships between the variation
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49 of ankle dorsiflexion and the rest of parameters under analysis (distance covered, high-
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51 speed-running, accelerations and decelerations and the internal match load) were non-
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53 significant ($p > 0.05$).
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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 hours 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 2cm (according to the reference values previously reported by Charlton et al. (2018) in ankle dorsiflexion ROM measures between post-match and 48 hours 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, Burns, Buchbinder, Landorf, & Cook, 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

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3 of 6.7% after match play compared to pre-match, while Wollin et al. (2018) no significant
4 differences reported in 15 youth players. This lack of agreement between studies may be
5 due to the characteristics of the samples used and/or demands of the participants' match
6 play in the studies (i.e., young versus professional players). For instance, while the
7 previous studies does not provide information regarding external match demands of the
8 match play in young players with an average age of 16.7 ± 0.3 years (Wollin et al., 2017)
9 and an average age of 15.81 ± 0.65 years (Wollin et al., 2018), our study found an average
10 distance covered of 8549 ± 1879 m, with 398 ± 155 m of high-speed-running in 40
11 professional players with an average age of 24.5 ± 5.3 years. Previous studies, conducted
12 in sports have shown that match running performance is affected by age, specifically older
13 players cover greater distances at high intensities (Al Haddad, Simpson, Buchheit, Di
14 Salvo, & Mendez-Villanueva, 2015).

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32 Another possible explanation for the discrepancies found could be the differences in the
33 recording methods. Although the referred studies (Wollin et al., 2017; 2018) used the
34 knee-to-wall test to measure ankle dorsiflexion ROM (similar to the Leg Motion System
35 test assessment), the players did not perform a warm up prior to the testing sessions. In
36 contrast, in the present study, all participants performed a standardized warm up. Despite
37 this discrepancy between studies, it is feasible to support the improvements in ROM
38 reported in the current study by considering the acute temperature-related mechanisms
39 (e.g. decreased muscle stiffness) observed during a match (Bishop, 2003). It is also
40 possible to support this finding if we consider that muscle damage after exercising is not
41 presented immediately after finishing the exercise (Friden & Lieber, 2001). However, our
42 results should be further investigated in future studies.

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58 In contrast to results immediately post-match, our results related to the variations of
59 dorsiflexion ROM 48h post-match are partially supported by Wollin et al. (2017), who
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3 did not report significant results but a trend towards reduced dorsiflexion ankle ROM 48
4 hours post-match (1.9% compared to post-match). The results of the current study support
5 such findings, which are significant ($p < 0.05$) in this case. Related to this finding,
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10 Ispirlidis et al. (2008) described the inflammatory response of soccer players after playing
11 a match, lasting from 1 to 4 days post-game, and they concluded that competition
12 provoked muscle damage shown by different blood markers (creatine kinase, lactate
13 dehydrogenase and C-reactive protein). In this sense, the review carried out by Friden &
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did not report significant results but a trend towards reduced dorsiflexion ankle ROM 48 hours 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 & 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 hours 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 hours 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

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3 decelerations). Therefore, such variables do not influence acute and chronic variation in
4 ankle dorsiflexion ROM. Further research and analysis need to be developed in this field.
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11 **Chronic effects during the season**

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15 Ankle dorsiflexion ROM showed a significant reduction from pre-season in dominant (-
16 8.1%; -9.6%, mid- and post-season, respectively) and non-dominant (-12.5%; -13.8%,
17 mid- and post-season, respectively) ankles. A decrease in this parameter was also found
18 in the dominant limb when comparing post-season to mid-season (-6.3%). In addition,
19 the current data indicates that a large number of players showed restricted ankle
20 dorsiflexion ROM values in the post-season compared to pre-season in the dominant
21 (27.5%) and non-dominant limb (32.5%) and between dominant and non-dominant sides
22 (15%).
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35 The authors of this study are not aware of similar studies addressing this issue in football
36 players; thus comparisons cannot be made. A possible reason for the decrease in ankle
37 dorsiflexion ROM throughout the season could be associated with chronic muscle
38 adaptations due to the high demands of training and matches that players to perform such
39 as sudden accelerations and decelerations, COD and jumping and landing tasks. In this
40 sense, it is well known that continuous exposure to high-intensity eccentric actions
41 increases the stiffness of muscles and tendons (Seymore, Domire, DeVita, Rider, &
42 Kulas, 2017) and decreases joint ROM (Mizrahi, Verbitsky, & Isakov, 2000). The reasons
43 mentioned above could explain the decrease in ankle dorsiflexion ROM values during the
44 competition year. Another factor influencing the chronic restriction of dorsiflexion ROM
45 could be related to repetitive muscle damage induced during match (indicated in the acute
46 effects) and the lack of recovery between matches, with a highly demanding competitive
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3 calendar at professional levels, focusing on competition and thus compromising the right
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5 planning of training loads (Lopez-Valenciano et al., 2019b). The players enrolled in this
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7 study participated in over 30 matches/season (30.8), playing a mean of >2000
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9 minutes/season, with 3 to 6 training sessions every week throughout the competitive year.
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11 Such findings could have important implications for the decrease in ankle dorsiflexion
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13 ROM, which has been posited as a predisposing factor for increasing the risk of hamstring
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15 strain injuries (Gabbe et al., 2006; Gabbe et al., 2005; van Dyk et al., 2018) in football,
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17 and of several of the most prevalent injuries in other sports (e.g. basketball, volleyball)
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19 such as, ankle injuries (Youdas et al., 2009), ACL ruptures (Wahlstedt & Rasmussen-
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21 Barr, 2015), Achilles (Whitting et al., 2011) and patellar tendinopathies (Backman &
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23 Danielson, 2011; Bisseling et al., 2008; Malliaras et al., 2006).

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29 Not only does dorsiflexion ROM have implications for injury prevention but also for
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31 sports performance. Previous studies have stated that such a parameter has critical
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33 importance in multi-directional running tasks to facilitate ground clearance and
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35 preparation for foot impact (Jonhagen, Ericson, Nemeth, & Eriksson, 1996; Lockie et al.,
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37 2014), and in unilateral dynamic balance, considered a fundamental component of
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39 performance in the game of football, where players are required to perform repetitive and
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41 explosive unilateral movements, such as jumping and landing (Lopez-Valenciano, Ayala,
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43 De Ste Croix, Barbado, & Vera-Garcia, 2019a). Therefore, Gonzalo-Skok et al. (2015)
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45 observed that elite basketball players with a limitation of ankle dorsiflexion ROM
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47 reported decreased COD capability, which is a key skill in professional basketball
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49 performance. In a similar way, COD actions are crucial for football (Kim et al., 2014),
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51 and the limitation of these actions could also be detrimental for performance. Based on
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53 the relevance of this knowledge, the present study has reported information regarding the
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55 acute and chronic effects on ankle dorsiflexion ROM in professional football players for
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3 the first time. However, some limitations to the study must be acknowledged. Firstly, as
4 the current study was conducted with a specific sample of male professional field football
5 players, these findings cannot be extended to goalkeepers, female athletes or to the
6 general population. A further limitation of the present investigation was the analysis of
7 only one competitive match when studying acute effects. In this sense, future studies
8 investigating ankle dorsiflexion ROM responses to match play are needed, increasing the
9 number of analyzed matches to fully establish changes in dorsiflexion after competition.
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23 **Conclusion**

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26 The current study provides important information for clinicians, sports therapy
27 practitioners and physical training coaches regarding the effects of ankle dorsiflexion
28 ROM during a competitive season and following a football match. The present study
29 showed significant reductions in ankle dorsiflexion ROM during the competitive year and
30 48 hours after match play in both limbs compared to post-match values. For this reason,
31 restoring the football player's baseline ankle dorsiflexion ROM before playing the next
32 match would appear to be necessary during the competitive year. This can be done by
33 educating players to use specific eccentric exercises, stretching routines, joint
34 mobilization, and other recovery strategies such as self-myofascial release using a foam
35 roller, to avoid injuries and maintain performance levels. Moreover, considering that
36 limited ankle dorsiflexion ROM might suggest a potential impairment of specific skills
37 needed in team sports, the authors suggest that practitioners develop regular preventive
38 stretching (Lopez-Valenciano et al., 2019b) and eccentric strength training strategies
39 during the season, with a focus on enhancing dorsiflexion ROM and strength
40 improvements.
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Figure 1. Ankle dorsiflexion ROM test.

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Figure 1. Ankle dorsiflexion ROM test

99x74mm (220 x 220 DPI)

Table 1. 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	<i>p</i>	ES [95% CI]	<i>p</i>	ES [95% CI]	<i>p</i>	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).

Table 2. Average \pm 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	<i>p</i>	ES [95% CI]	<i>p</i>	ES [95% CI]	<i>p</i>	ES [95% CI]
ADF									
Bilateral differences	0.29 \pm 1.74	0.37 \pm 1.76	0.15 \pm 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 3. Average ± standard deviation for ankle dorsiflexion ROM in the football players, comparing pre-match, post-match and 48 hours post-match (acute effect).

Range of motion (cm)	Pre-match	Post-match	48 hours post-match	Pre-match vs Post-match		Pre-match vs 48 hours post-match		Post-match vs 48 hours post-match	
	Mean ROM	Mean ROM	Mean ROM	<i>p</i>	ES [95% CI]	<i>p</i>	ES [95% CI]	<i>p</i>	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).

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