Effects of basketball match-play on ankle dorsiflexion range of motion and vertical jump performance in semi-professional players

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Title: Effects of basketball match-play on ankle dorsiflexion range of motion and vertical jump performance in semi-professional players

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ABSTRACT

BACKGROUND: The aim of this study was to investigate the effects of basketball match-play on ankle dorsiflexion range of motion (ROM) and countermovement (CMJ) performance, and their association with internal match load.

METHODS: Thirty semi-professional basketball players participated in this study. Ankle dorsiflexion ROM and bilateral CMJ performance were evaluated before (pre-match) and immediately after match-play (post-match). Also, ankle dorsiflexion ROM was measured 48h post-match. Furthermore, in each player, the ankle dorsiflexion ROM scores were categorized as normal or restricted according to the reference values previously reported (>2 cm of change from baseline pre-match to post-match and to 48h post-match).

RESULTS: Ankle dorsiflexion ROM was increased post-match from pre-match in dominant and non-dominant limbs and decreased 48h post-match compared with immediately post-match measures in both limbs. Approximately 20% of all players showed restricted ankle dorsiflexion ROM values 48h post-match. CMJ performance was higher post-match than pre-match.

CONCLUSIONS: Ankle dorsiflexion ROM is still reduced 48h after a competitive basketball match in semi-professional basketball players. The implementation of specific recovery strategies aiming at minimizing a decrease in ankle dorsiflexion after a match might be considered to reduce the likelihood of ankle injury.

Keywords: basketball; injury risk; fatigue; power performance.

INTRODUCTION

Basketball requires players to perform a very-high amount of repeated intermittent activities such as changes-of-direction, dribbles, shuffles, sprints, accelerations and decelerations, jumps and landings.[1] Due to these high-intensity movements and actions required during the course of matches, it would be advisable to quantify the training loads in order to know whether players are coping with the match demands.[2] In this sense, Gabbett[3] speculated that both inappropriate and excessive training loads would result in an increase of injury rates in athletes. In basketball, previous studies have showed an average injury rate of 7.0 to 19.1 injuries per 1000 hours played.[4, 5]

A restricted ankle dorsiflexion range of motion (ROM) is considered a risk factor for patellar tendon injury[6], ankle injury[7], anterior cruciate ligament (ACL) rupture[8], Achilles tendinopathy[9] and hamstring strain[10] in several sports. Specifically, the cut-off score of >2 cm has been previously suggested as the smallest worthwhile change to identify impairments in ankle dorsiflexion ROM.[11] This could be due to the fact that a meaningful reduction of ankle dorsiflexion ROM may restrict the ability to pass the leg forwards over the foot[12] and to lower the centre of mass during squat-type movements.[13] In addition, lower ankle dorsiflexion ROM might induce an overload of plantarflexor muscle-tendon units in a more lengthened and everted position during landing.[9] These alterations may lead to abnormal lower-limb biomechanics during closed chain strengthening exercises[14] and to increased landing forces and stiffness after a jump, significantly increasing the injury risk.[15] For example, reduced ankle dorsiflexion during a squat implies an increased knee valgus and medial knee displacement, decreased quadriceps activation, and increased soleus activation.[13]

In this sense, most authors have examined ankle dorsiflexion characteristics before the commencement of the season or in resting situations.[16] However, the ability of this assessment to capture fluctuations in ankle dorsiflexion ROM profile in-season, specifically in response to match-play, has not been studied yet.[16] Previous research has reported that team sports are characterized by intermittent activities in which the high-intensity actions are significantly reduced in the final stages of a competitive match-play[17], likely associated with match-induced fatigue.[18] In this sense, it has been demonstrated a decrement of lower limbs' power performance after match-play and subsequently this measure can be one of the potential factors in injury causation in sport.[19] Fatigue is known to reduce sports performance through the decrease of muscle strength, neuromuscular control, and ROM.[19] In this regard, recent studies have analyzed the impact of match-play on ankle dorsiflexion ROM in soccer[16] and in Australian football[11] but there is no information regarding this effect in basketball.

Additional to ankle dorsiflexion ROM, vertical jump performance has been demonstrated as a valid indicator to evaluate match-related fatigue during the course of basketball matches.[20] Specifically, countermovement jump (CMJ) performance has routinely been used in basketball players' performance to monitor neuromuscular readiness.[20] Although basketball is a demanding team sport which can induce fatigue and consequently a decline in players' power performance during the matches, previous studies with young players found that jumping performance was similar before and after matches.[21, 22] However, no research has investigated the effects of basketball match-play on semi-professional senior players' vertical jump performance. This fact can provide relevant information for strength and conditioning staff in order to design population-specific strategies during training sessions.

To implement specific training strategies aimed at maximizing on-field performance, it could be useful to understand the match-related fatigue in terms of ankle dorsiflexion ROM and vertical jump performances after official matches. Therefore, aim of this study was to investigate the effects of basketball match-play on ankle dorsiflexion range of motion (ROM) and countermovement (CMJ) performance, and their association with internal match load.

METHODS

Subjects

Thirty male semi-professional basketball players (age: 21.8 ± 4.7 years, height: 193.9 ± 8.4 cm, body mass: 90.4 ± 13.7 kg, training experience: 14.5 ± 4.7 years) volunteered to participate in this investigation. Players belonged to three different teams of the Spanish National Basketball League, and regularly took part in 5 training sessions (a total of 371 ± 10 min) per week, besides being involved in an official match on weekends during the 2017-2018 competitive season. Participants were classified into three individual playing positions: guards (n = 14), small forwards (n = 5) and centers (n = 11).[23] The inclusion criteria were: to be healthy and actively competing at the time of the study, to not have ankle pain nor have taken any type of medication for the treatment of pain or musculoskeletal injuries at the time of the study and to be involved in regular training during the last month prior to the investigation. Before the start of this investigation, all players were fully informed about the testing and the written informed consent was obtained. This investigation was performed in accordance with the Declaration of Helsinki 2013 and was approved by an institutional Ethics Review Committee (code: DPC.VMP.01.18).

Experimental approach to the problem

A cohort design was used to evaluate the acute effects of a basketball match-play on unilateral ankle dorsiflexion ROM and CMJ performance (Figure 1) from February to April in a total of 6 matches. Players underwent a 20 min warm-up consisting of 3-min of low to moderate-intensity running followed by 6–8 min of dynamic stretching that included 2 sets, from low- to high-intensity, with a 15 s rest period between each set (i.e., straight leg march, forward lunge with opposite arm reach, forward lunge with an elbow instep, lateral lunge, trunk rotations, multi-directional skipping). Before the match (pre-match), whitin 30 min immediately after the match (post-match) and 48h after the match (48h post-match), the unilateral ankle dorsiflexion was measured by the same investigator and using the same methodology. In addition, CMJ performance was also assessed pre- and post-match. The order of ROM and CMJ tests was randomized across the players but it was maintained constant for each player. The internal load imposed by the match was measured by the session rating of perceived exertion match load (sRPE ML) completed 30 min after the end of the competitive game while wellness scores were collected 48h post-match. A week before testing, basketball players were familiarized with all the tests, to reduce the influence of the learning effect. Based on Wollin et al.[16], player testing order and selection of tested leg were randomly selected prior to the pre-match test. To reduce the interference of uncontrolled variables, all the players were instructed to maintain their habitual lifestyle and training routines and normal dietary intake before and during the study.

Insert Figure 1 here please

Measurements

Ankle dorsiflexion measures

To measure unilateral ankle dorsiflexion for both sides we followed the methods previously described by Calatayud et al.[24] with the Lunge test using the Leg-Motion system test (LegMotion, Check your Motion, Spain) after standardized warm-up performed before pre-match, after match and 48h post-match. Participants were in a standing position on the Leg-Motion system with the tested foot on the measurement scale (Figure 2). 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 forward the knee to contact it to the metal stick. When the participant could maintain heel and knee contact achieving the maximal distance, the metal stick was progressed away from the knee, and the following achieved distance was recorded. The ankle dorsiflexion testing was performed by one experienced researcher in the clinical area of the basketball court. Dominant leg was defined as the participant's jump leg. Three repetitions were performed in each leg (i.e., dominant and non-dominant), with 10 seconds of passive recovery between trials. The best score among these measurements in each ankle was selected for subsequent analysis. The intraclass correlation coefficient (ICC) of the Leg-Motion system test was 0.96 to 0.98.[24]

Insert Figure 2 here please

Countermovement Jump (CMJ)

Bilateral CMJ tests were used to assess the explosive strength of the lower limb muscles. During the jump, hands were held at the hips as described by Núñez et al.[25] From a standing position with straight knees, the player squatted down to ~90º before jumping as high as possible. They were instructed to jump and land in exactly the same place, with the body in an erect position during the jump until landing. Jump tests were performed on a contact mat connected to the Ergo tester (Ergo Jump Bosco System, Italia) unit. The ICC for these tests ranged from 0.94 to 0.96.

Internal match load

The internal match load was measured by the session sRPE ML. The 10-point scale proposed by Foster et al.[26] was administered 30 min after the end of the basketball matches in order to quantify the self-reported rates of exertion. Players answered the question: how hard was the match? The same person was responsible for asking the question to all players. Then, the RPE score was multiplied by the effective playing time of each player, thus reporting the internal match load (ML) in arbitrary units (AU).[27] Participants became fully accustomed and familiarized to the RPE evaluation during the previous month.

Wellness

Basketball players completed a well-being questionnaire following the protocol of McLean et al.[28] This questionnaire was filled out 48h after the end of the official match-play. The questionnaire assessed players' fatigue, sleep quality, general muscle soreness, stress levels and mood on a five-point scale. Overall, well-being was then determined by summing up the score of each item. The well-being questionnaire was administered by the same examiner and in an individual and private manner to each player.

Statistical analysis

Results are presented as means ± standard deviation (SD). We used a magnitude-based inference approach to identify changes induced by the basketball match-play. The effect size (ES) with the uncertainty of the estimates shown as 90% confidence intervals (CI) were used quantify the magnitude of the differences between pre-match, post-match and 48h post-match concerning unilateral ankle dorsiflexion and CMJ performance. The same procedure was used to compare playing positions (i.e., guards, small forwards and centers). 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).[11] The ES were classified as follows: trivial (<0.2), small (0.2–0.6), moderate (0.6–1.2), large (1.2–2.0), very large (2.0–4.0) and extremely large (>4.0).[29] The percentage chances were then qualified via probabilistic terms and assigned using the following scale: 25–75%, possibly; 75–95%, likely; 95–99.5%, very likely; >99.5%, most likely.[29] If the chance of having beneficial/better or detrimental/poorer was >75%, the true difference was considered clear (substantial). Inference was classified as unclear if the 90% CI overlapped the thresholds for the smallest worthwhile positive and negative effects.[29] The relationships between the relative change (Δ% = ((post-match or 48 h post-match - pre-match / pre-match) * 100)) of the players' unilateral ankle dorsiflexion and CMJ performance and the sRPE ML were examined using Pearson's correlation coefficients, with 90% CL. The following scale of magnitudes was used to interpret the magnitude of the correlation coefficients: <0.1, *trivial*; 0.1– 0.3, *small*; 0.3–0.5, *moderate*; 0.5–0.7, *large*; 0.7–0.9, *very large*; >0.9, *nearly perfect*.[29]

RESULTS

Basketball players' internal match load and wellness perception are presented in Table 1. For all players, the internal load measured by sRPE ML score was 107.70±69.14 AU and the wellness value was 18.33±1.63 AU. Unclear differences among playing positions (i.e., guard, small forward and center) were found in the sRPE ML. On the other hand, while unclear differences in wellness were reported between guards and centers, lower wellness values was observed in guards (*likely; small*) and centers (*likely; moderate*) in comparison to small forwards.

Insert Table 1 here please

Table 2 shows the pre-match, post-match and 48h post-match values of the ankle dorsiflexion ROM. An increase in dominant and non-dominant ankle dorsiflexion ROM was found from pre-match to post-match. In contrast, lower values were observed from post-match to 48h post-match in all basketball players (*most likely; small* and *most likely; moderate*), guards (*very likely; moderate* and *most likely; large-moderate*), small forwards (*likely-most likely; moderate* and *very likely-most likely; moderate*) and centers (*likely; small* and *most likely; small*). However, no substantial changes were observed in dominant and non-dominant ankle dorsiflexion ROM from pre-match to 48h post-match.

Insert Table 2 here please

The basketball players' vertical jump performances pre- and post-match-play are presented in Table 3. An increase in CMJ jump height was found for all players (*very* *likely; small*), guards (*likely; small*) and centers (*likely; small*). However, no substantial differences in CMJ performance were observed in small forwards (*possibly; small*).

Insert Table 3 here please

The relationships between sRPE ML and wellness with the Δ% match change in unilateral ankle dorsiflexion ROM and CMJ performance for all basketball players and for each playing position are presented in Table 4. Regarding to sRPE ML, *unclear* relationships were found with Δ% match changes measures. With respect to wellness, *unclear* relationships were observed with Δ% match changes measures for all players.

Insert Table 4 here please

DISCUSSION

The aim of the present study was to investigate the effects of basketball match-play on ankle dorsiflexion ROM and CMJ performance measures. In addition, we attempted to quantify the internal basketball match load and the wellness perception 48h after match-play for each playing position and to analyze the association between sRPE ML and wellness (48h post-match), and changes in post-match ROM and CMJ. This is the first study that analyzes the acute effects of basketball match-play on ankle dorsiflexion ROM measures. The main results showed that basketball match-play acutely produced an increase on ankle dorsiflexion ROM and CMJ performance in all players. In addition, ankle dorsiflexion ROM decreased 48h post-match in both limbs compared to the values obtained just after the end of the game in all players and in some specific positions (i.e., guards and small forwards). Specifically, by calculating the number of players with greater restrictions than the cut-off score of 2 cm in ankle dorsiflexion ROM measures between pre-match vs 48h post-match, 20% of the players were identified as restricted. The sRPE ML has been considered a useful tool to quantify the internal basketball match load, mainly due to its low cost, user-friendly nature and associated high-speed data processing (13).[26] It has been implemented not only during training sessions[30] but also in official matches.[31] This tool has become a very relevant strategy to assess physical load imposed by basketball competition/training not only in investigation but also in the applied field. The sRPE ML showed in our study were lower than those reported by previous studies with young and senior basketball players.[31-33] While in the current study basketball players reported sRPE ML values of 108 ± 69 AU, other studies showed higher values of sRPE (≈ 450-500 AU).[34] These differences can be explained because Manzi et al.[34] used the complete duration of the match, including all stops from the start to the end of the game while in our analysis, the perceived exertion of each player was multiplied by the individual minutes played, which better reflects the involvement of the player during the game. In addition, we observed no substantial differences in sRPE ML among playing positions (i.e., guard, small forward and centers). Considering that few studies has analyzed the internal load imposed to basketball players[34, 35], these data could provide insightful information to coaches in order to design training sessions that replicate competition conditions. On the other hand, regarding wellness, higher values were observed in small forwards in comparison to guards and centers. This better recovery state is probably caused by the their playing style as small forwards display less contact with opponents and lower number of acceleration and deceleration compared to the players acting in the other positions.[35] Nevertheless, further research is warranted to investigate the relationship between physical demands imposed on basketball players and post-match exertion and wellness, especially because in this study there was only one time point (48h post-match) to quantify the latter.

Ankle dorsiflexion ROM seems to be important in several sport-specific tasks in order to facilitate ground clearance and preparation for foot impact.[9, 13, 14] However, restricted ankle dorsiflexion ROM could alter movement mechanics in these actions[36] and consequently increase the injury risk of the athletes.[15] For example, Wollin et al.[16] found a reduced dorsiflexion ankle ROM of 6.7% after match-play compared to pre-match in elite football players. However, the results obtained in the present study showed that a basketball match-play induced an increase of ankle dorsiflexion ROM immediately post-match compared to pre-match values in all players, guards, centers and small forwards in both lower limbs. Increases in ankle dorsiflexion ROM immediately post-match are likely due to the increase in tissue extensibility caused by temperature increment which leads to a reduction of the viscous resistance of muscle tissues and joints.[37] These findings suggest that the physiological effect caused by a basketball match-play on the ankle dorsiflexion ROM did not induce higher injury risk. In this regard, although several injuries is attributed to the restriction of ankle dorsiflexion ROM, it can be produced by different structural damages and caused by or related to many other factors, such as a poor conditioning, repetitive loading, and/or abrupt increase in training load.[3]

In addition, the current results showed decreased ankle dorsiflexion ROM 48h post-match compared with after post-match values in all basketball players (and clinically relevant changes compared to pre-match in 20% of players) and in each playing position in dominant and non-dominant limbs. These findings are partially supported by Wollin et al.[16], who did not report significant results but a trend towards reduced dorsiflexion ankle ROM 48h post-match (1.9% compared to post-match). Related to these results, Souglis et al.[38] described the inflammatory, muscle damage and metabolic indices response in basketball players after playing a match, lasting from 13 to 37h post-game, and researchers concluded that competition provoked muscle damage shown by different blood markers (creatine kinase, and lactate dehydrogenase). Therefore, this ROM reduction may be related to muscle damage generated during the match, which might be attributed to induced impairments in the mechanical and neural properties of the muscle-tendon unit[39], that could lead to a reduction in players' ankle dorsiflexion flexibility 48h post-match. Based on these results, there is a greater risk of injury at 48h post-match; therefore, preventive stretching exercises focused on soleus, gastrocnemius and hamstring muscles should be implemented during the specific recovery program within 48h after match-play, with the aim to avoid future injuries.

An assessment of power performance pre- and post-match-play on basketball players can be relevant due to continuous high-intensity actions such as jumps, accelerations/decelerations and changes of directions performed during match-play.[1] Our results, in contrast to previous studies which revealed no changes pre- to post-match-play on vertical jump performance[21, 22], showed an enhancement in CMJ performance immediately post-match in all players, guards and centers. However, no substantial differences in CMJ performance were observed in small forwards. These differences could be explained, because the basketball's specific actions can elicit the post-activation potentiation effect on players.[40] However, given that no associations have been found between sRPE ML and Δ% post-match change in CMJ performance, it would be appropriate to quantify the match load providing other load indicators (especially the external ones) in order to better understand the changes on vertical jump performance.

Although the present study is believed to be the first to analyze the acute effect of competitive basketball match-play demands on ankle dorsiflexion ROM, some limitations exist as to the interpretation of data. First, the sample was composed of high performance and well-trained basketball players but the size can be considered as small. For this reason, the effect size was calculated to determine the magnitude of the effect, independent of the sample size, and confidence intervals were provided to account for inter-individual variability in the variables under investigation. A second limitation of this study was the analysis of only one competitive match, and future studies investigating ankle dorsiflexion ROM responses to match-play after multiple matches or in a multiday competition is needed to fully establish the changes in ROM that occur in the related muscle group after competition. Finally, this study did not investigate the CMJ 48h post-match due the coach did not allow this evaluation; hence, future studies should investigate CMJ 48h post-match.

CONCLUSIONS

The present study showed that immediately after basketball match-play the players' ankle dorsiflexion ROM and CMJ increased; however, after 48h post-match the ankle dorsiflexion ROM was reduced in comparison to pre-match (>2 cm in 20% of players) and post-match (group average). These findings suggest that a basketball match-play did not reduce ankle dorsiflexion and thus a higher risk of injury cannot be associated to deteriorated ankle ROM during the game. However, during the 48h following the match, players require specific recovery strategies (i.e., stretching) in ankle joint before returning to strong training or match-play. In addition, our findings showed that basketball match-play induced lower wellness value in guards and centers in comparison to small forwards; however, no differences were found between playing positions with regards to sRPE ML. So, further research could investigate the relationship between these physical demands imposed to basketball players and wellness post-match values.

REFERENCES

1. Stojanović E, Stojiljković N, Scanlan AT, Dalbo VJ, Berkelmans DM, Milanović Z. The Activity Demands and Physiological Responses Encountered During Basketball Match-Play: A Systematic Review. Sports Medicine. 2018;48(1):111-35.
2. Torres-Ronda L, Ric A, Llabres-Torres I, De Las Heras B, Schelling X. Position-dependent cardiovascular response and time-motion analysis during training drills and friendly matches in elite male basketball players. Journal of Strength and Conditioning Research. 2016;30:60-70.
3. Gabbett TJ. The training-injury prevention paradox: should athletes be training smarter and harder?. British Journal of Sports Medicine. 2016;50(5):273-80. http://bjsm.bmj.com/lookup/doi/10.1136/bjsports-2015-095788
4. Drakos MC, Domb B, Starkey C, Callahan L, Allen AA. Injury in the national basketball association: a 17-year overview. Sports Health. 2010;2(4):284-90.
5. Taylor JB, Ford KR, Nguyen AD, Terry LN, Hegedus EJ. Prevention of Lower Extremity Injuries in Basketball: A Systematic Review and Meta-Analysis. Sports Health. 2015;7(5):392-98.
6. Backman LJ, Danielson P. Low range of ankle dorsiflexion predisposes for patellar tendinopathy in junior elite basketball players: a 1-year prospective study. American Journal of Sports Medicine. 2011;39(12):2626-33.
7. Youdas JW, McLean TJ, Krause DA, Hollman, JH. Changes in active ankle dorsiflexion range of motion after acute inversion ankle sprain. Journal of sport rehabilitation. 2009;18(3):358-74.
8. Wahlstedt C, Rasmussen-Barr E. Anterior cruciate ligament injury and ankle dorsiflexion. Knee Surgery, Sports Traumatology, Arthroscopy. 2015;23(11):3202-7.
9. Whitting JW, Steele JR, McGhee DE, Munro BJ. Dorsiflexion capacity affects achilles tendon loading during drop landings. Medicine and Science in Sports and Exercise. 2011;43(4):706-13.
10. van Dyk N, Farooq A, Bahr R, Witvrouw E. Hamstring and ankle flexibility deficits are weak risk factors for hamstring injury in professional soccer players:

a prospective cohort study of 438 players including 78 injuries. American Journal of Sports Medicine. 2018;46(9):2203-10.

11. Charlton PC, Raysmith B, Wollin M, Rice S, Purdam C, Clark RA, et al. Knee flexion strength is significantly reduced following competition in semi-professional Australian Rules football athletes: Implications for injury prevention programs. Physical Therapy in Sport. 2018;31:9-14. https://doi.org/10.1016/j.ptsp.2018.01.001
12. Mauntel TC, Begalle RL, Cram TR, Frank BS, Hirth CJ, Blackburn T, et al. The effects of lower extremity muscle activation and passive range of motion on single leg squat performance. Journal of Strength and Conditioning Research. 2013;27(7):1813-23.
13. Macrum E, Bell DR, Boling M, Lewek M, Padua D. Effect of limiting ankle-dorsiflexion range of motion on lower extremity kinematics and muscle-activation patterns during a squat. Journal of Sport Rehabilitation. 2012;21(2):144-50. http://www.ncbi.nlm.nih.gov/pubmed/22100617
14. Bell DR, Padua DA, Clark MA. Muscle strength and flexibility characteristics of people displaying excessive medial knee displacement. Archives of Physical Medicine and Rehabilitation. 2008;89(7):1323-8.
15. Mason-Mackay AR, Whatman C, Reid D. The effect of reduced ankle dorsiflexion on lower extremity mechanics during landing: A systematic review. Journal of Science and Medicine in Sport. 2017;20(5):451-8. http://dx.doi.org/10.1016/j.jsams.2015.06.006
16. Wollin M, Thorborg K, Pizzari T. The acute effect of match play on hamstring strength and lower limb flexibility in elite youth football players. Scandinavian Journal of Medicine and Science in Sports. 2017;27(3):282-8.
17. Sykes D, Twist C, Nicholas C, Lam, K. Changes in locomotive rates during senior elite rugby league matches. Journal of Sports Sciences. 2011;29(12):1263-71.
18. Black GM, Gabbett TJ, Naughton GA, McLean BD. The effect of intense exercise periods on physical and technical performance during elite Australian Football match-play: A comparison of experienced and less experienced players. Journal of Science and Medicine in Sport. 2016;19(7):596-602. http://dx.doi.org/10.1016/j.jsams.2015.07.007

19. Small K, McNaughton LR, Greig M, Lohkamp M, Lovell R. Soccer fatigue, sprinting and hamstring injury risk. International Journal of Sports Medicine. 2009;30(8):573–8.

20. Heishman AD, Daub BD, Miller RM, Freitas EDS, Frantz BA, Bemben MG. Countermovement Jump Reliability Performed With and Without an Arm Swing in NCAA Division 1 Intercollegiate Basketball Players. Journal of Strength and Conditioning Research. 2018 doi: 10.1519/JSC.0000000000002812

21. Chen WH, Yang WW, Lee YH, Wu HJ, Huang CF, Liu C. Acute Effects of Battle Rope Exercise on Performance, Blood Lactate Levels, Perceived Exertion, and Muscle Soreness in Collegiate Basketball Players. Journal of Strength and Conditioning Research. 2018 https://doi.org/10.1519/JSC.0000000000002661

22. Cortis C, Tessitore A, Lupo C, Pesce C, Fossile E, Figura F, et al. Inter-limb coordination, strength, jump, and sprint performances following a youth men's basketball game. Journal of Strength and Conditioning Research. 2011;25(1):135-42.

23. Alejandro V, Santiago S, Gerardo VJ, Carlos MJ, Vicente GT. Anthropometric Characteristics of Spanish Professional Basketball Players. Journal of Human Kinetics. 2015;46:99-106. doi:10.1515/hukin-2015-0038.

24. Calatayud J, Martin F, Gargallo P, Garcia-Redondo J, Colado JC, Marin PJ. The validity and reliability of a new instrumented device for measuring ankle dorsiflexion range of motion. International Journal of Sports Physical Therapy. 2015;10(2):197-202

25. Núñez FJ, Santalla A, Carrasquila I, Asian JA, Reina JI, Suarez-Arrones LJ. The effects of unilateral and bilateral eccentric overload training on hypertrophy, muscle power and COD performance, and its determinants, in team sport players. PLoS One. 2018:13(3):e0193841. doi:10.1371/journal.pone.0193841. eCollection 2018.

26. Foster C, Florhaug J A, Franklin J, Gottschall L, Hrovatin LA, Parker S, et al. A new approach to monitoring exercise training. Journal of Strength and Conditioning Research. 2001;15(1):109-115.

27. Los Arcos A, Yanci J, Mendiguchia J, Gorostiaga EM. Rating of muscular and respiratory perceived exertion in professional soccer players. Journal of Strength and Conditioning Research. 2014;28:3280-8.

28. McLean BD, Coutts AJ, Kelly V, McGuigan MR, Cormack SJ. Neuromuscular, endocrine, and perceptual fatigue responses during different length between-match microcycles in professional rugby league players. International journal of sports physiology and performance. 2010;5(3):367-83.

29. Hopkins WG, Marshall SW, Batterham AM, Hanin J. Progressive statistics for studies in sports medicine and exercise science. Medicine and Science in Sports and Exercise. 2009;41(1):3–13.

30. Paulauskas H, Kreivyte R, Scanlan AT, Moreira A, Siupsinskas L, Conte D. Monitoring Workload in Elite Female Basketball Players During the In-Season Phase: Weekly Fluctuations and Effect of Playing Time. International journal of sports physiology and performance. 2019:1–22. https://doi.org/10.1123/ijspp.2018-0741

31. De Arruda AFS, Aoki MS, Drago G, Moreira A. Salivary testosterone concentration, anxiety, perceived performance and ratings of perceived exertion in basketball players during semi-final and final matches. Physiology and Behavior. 2019:198:102-7. https://doi.org/10.1016/j.physbeh.2018.10.008

32. Moreira A, Crewther B, Freitas CG, Arruda AFS, Costa EC, Aoki MS. Session RPE and salivary immune-endocrine responses to simulated and official basketball matches in elite young male athletes. Journal of sport medicine and physical fitness. 2012a;52(6):682–7.

33. Moreira A, McGuigan MR, Arruda AFS, Freitas CG, Aoki MS. Monitoring internal load parameters during simulated and official basketball matches. Journal of Strength and Conditioning Research. 2012b;26(3):861-6.

34. Manzi V, D'Ottavio S, Impellizzeri FM, Chaouachi A, Chamari K, Castagna C. Profile of weekly training load in elite male professional basketball players. Journal of Strength and Conditioning Research. 2010;24:1399-406.

35. Puente C, Abián-Vicén J, Areces F, López R, Del Coso J. Physical and Physiological Demands of Experienced Male Basketball Players During a Competitive Game. Journal of Strength and Conditioning Research. 2017;31(4):956-62.

36. Gonzalo-Skok O, Serna J, Rhea MR, Marín PJ. Relationships between functional movement tests and performance tests in Young elite male basketball players. International journal of sports physical therapy. 2015;10(5):628-38.

37. Bishop D. Warm up I: potential mechanisms and the effects of passive warm up on exercise performance. Sports Medicine. 2003;33(6):439-54.
38. Souglis A, Bogdanis GC, Giannopoulou I, Papadopoulos Ch, Apostolidis N. Comparison of inflammatory responses and muscle damage indices following a soccer, basketball, volleyball and handball game at an elite competitive level. Research in Sports Medicine. 2015;23(1):59-72.
39. Friden J, Lieber RL Eccentric exercise-induced injuries to contractile and cytoskeletal muscle fibre components. Acta Physiologica Scandinavica. 2001;171(3):321-6.
40. Boullosa DA, Tuimil JL. Postactivation potentiation in distance runners after two different field running protocols. Journal of Strength and Conditioning Research. 2009,23(5):1560-5.

Competing interests.

The authors report no conflicts of interests with contents of this paper.

Authors' contributions.

VM conceived the research idea and collected the sample data. DC analyzed the data and statistically interpreted the findings. VM prepared the manuscript and FN, JDC, JR and DC critically revised the article, read and approved the final manuscript.

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TABLE LEGENDS:

TABLE 1. Practical difference in session rating of perceived exertion match load (sRPE ML) and wellness values between-playing positions in basketball players.

TABLE 2. Descriptive statistics and mean differences across match-play in unilateral ankle dorsiflexion ROM in all basketball players and each playing position (i.e., guard, small forward and center), along with effect sizes and qualitative inferences.

TABLE 3. Descriptive statistics and mean differences across match-play in countermovement jump (CMJ) performance on all basketball players and each playing position, along with effect sizes and qualitative inferences.

TABLE 4. Relationships (±90% CL) for session rating of perceived exertion match load (sRPE ML) and for wellness with the Δ% match change (((post-match or 48 h post-match - pre-match / pre-match) * 100)) in unilateral ankle dorsiflexion range of motion (ROM) and countermovement jump (CMJ) performance on all basketball players.

FIGURE LEGENDS:

FIGURE 1. Study design of the measures obtained during each basketball match.

FIGURE 2. Ankle dorsiflexion ROM test.

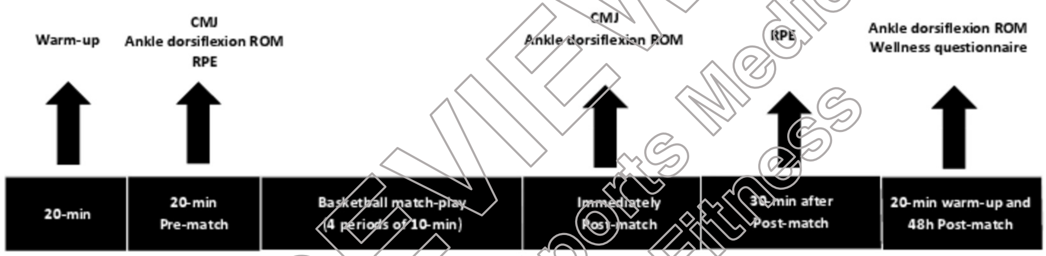

Figure 1. Study design of the measures obtained during each basketball-match.

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