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Drop jumps improve repeated sprint ability performance in professional basketball players

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ABSTRACT: To verify the acute effect of drop jumps (DJ) on two repeated sprint ability tests (RSA), interspersed with a rest period simulating a basketball game break. Twelve first division basketball players (age: 24.8 ± 6.9 years; body mass: 97.0 ± 9.2 kg; height: 2.0 ± 0.1 m) performed, in a randomized crossover design, two RSA tests separated by 5 min after DJ or control conditions. The DJ condition comprised 5 DJs performed 4 min prior to the first RSA test, whereas 3 DJ were completed 30 s prior to a second RSA test. Surface electromyography was recorded from the lower body for root mean square (RMS) analyses during sprinting. Three countermovement jump (CMJ) tests were performed after warming up and immediately after the second RSA test. DJ improved RSA performance with a faster best time in the first RSA test ($p = 0.035$), and a shorter total time and mean time ($p = 0.030$) for the second RSA test. No significant differences were found in RMS between protocols. CMJ decreased in both conditions after the RSA tests ($p < 0.05$). This study revealed a post-DJ RSA potentiation in professional male basketball players. This simple and effective approach could be implemented at the end of the warm-up and before the end of game breaks to improve player preparedness to compete.

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INTRODUCTION

The basketball game imposes a high demand of brief high-intensity repeated sprints (< 10s) [1–3], which may impair neuromuscular function, thus decreasing physical performance capacity (e.g. decreased jump height) [4, 5]. For instance, a 14% decrease in distance covered at high intensity during the second half has been previously reported during basketball games [3]. To deal with this, players could benefit from frequent substitutions as they are not limited according to official FIBA rules. In this regard, it has been recently suggested that the ability to quickly recover from high-intensity phases should be considered a key component of basketball [6]. However, to the best of our knowledge, there are no studies analysing the potential benefits of manipulating breaks during games to benefit subsequent performance.

Post-activation potentiation (PAP) is an involuntary increase in muscle contraction capacity (measured by maximal twitch force evoked by an electrical stimulation), in response to prior maximal or submaximal voluntary stimuli [7, 8]. Post-activation potentiation has been traditionally proposed as a means for acutely increasing performance during high-intensity efforts [9–12]. The main physiological mechanisms proposed for PAP responses is the increase of myosin regulatory light chain phosphorylation [13, 14], but greater recruitment of higher order motor units [15] has also been proposed. More recently, the term post-activation performance enhancement (PAPE) has been proposed to refer to any performance enhancement without twitch verification as usually occurs in sport settings [16]. In this context, PAP/PAPE can be considered one of the main objectives of warm-up routines and priming exercises [17, 18].

The increase of acute muscular performance has been induced after different conditioning activities including heavy loads [9] and ballistic exercises [12, 19]. However, heavy loads may induce greater acute neuromuscular fatigue than other methods [20], which, in turn, may counteract the purported effects of PAPE. In addition, the application of heavy loads is not very practical in competitive settings as it involves the use of equipment which makes its implementation more difficult. A simple and valid alternative to promote performance improvements without the constraints associated with heavy loads could be ballistic exercises such as plyometric exercises (e.g. drop jump (DJ)). Plyometric exercises have been shown to promote larger effect sizes (ES) than heavy loads (ES – 0.47 vs. 0.41) on performance improvements via PAPE [21], without the need of complex equipment. Moreover, PAPE effects after DJs occur sooner (< 4 min) than after heavy loads. Thus, DJ protocols have been extensively used to increase muscle performance in power oriented activities such as jumping, throwing and sprinting [21, 22]. Further, we have recently demonstrated that a DJ protocol can induce both PAP (maximal force evoked by supramaximal stimulation) and PAPE (cycling performance) while also increasing the glycolytic contribution during a supramaximal cycling test [12]. Therefore, DJs emerge as a practical and efficient means to enhance high-intensity continuous exercise performances in athletes.

There are few studies specifically evaluating the effects of DJ protocols in team sports for performance enhancement via PAPE [11]. In this regard, only one study has reported improved performance in soccer players after performing a re-warm up [23]. This is an interesting approach for basketball players as player substitutions may be frequent during games [23]. Therefore, the main purpose of the present study was to verify the effect of DJ protocols on two repeated sprint ability (RSA) tests separated by a recovery period. This study design was used for simulating players' substitutions during a game to verify the effectiveness of this approach as a re-warm-up strategy. We hypothesized that the DJ protocol would induce an improvement in RSA performances when compared to a control condition.

MATERIALS AND METHODS

To investigate the application of DJ protocols after warming up and between RSA tests, thus simulating a substitution during a basketball game, a randomized crossover trial was conducted with players completing a DJ protocol or a control condition before two RSA tests interspersed with 5 min of recovery simulating a brief recovery of players. The dependent variables were performance in RSA tests (i.e. best time, total time, mean time, worst time and% decrement), root mean square (RMS) of surface electromyography signal of lower limb muscles (i.e. rectus femoris, vastus lateralis, vastus medialis, biceps femoris, semitendinosus, medial gastrocnemius and tibialis anterior), and countermovement jump (CMJ) performance (i.e. jump height, peak power and peak force).

A professional basketball team composed of twelve male players (age: 24.8 ± 6.9 years; weight. 97.0 ± 9.2 kg; height: 2.0 ± 0.1 m) who were the Champions of the National Brazilian Championship during the 2016/2017 season was recruited for participation in this study. All participants were informed about the risks and benefits and signed an informed consent form. All procedures were conducted according to the Declaration of Helsinki and were approved by the Ethics Committee of the São Paulo State University (process number: 3.115.036).

This randomized crossover trial consisted of 3 testing sessions and was completed during the first month of the 2017/2018 preseason (two weeks after the start of the season). All procedures were performed on the regular court of training, at the same time of day (9:00–12:00 a.m.), with controlled temperature and relative humidity of 25 ± 3ºC and 48 ± 10%, respectively. Before testing, a familiarization session was performed to identify the optimal height for DJ, and to familiarize players with RSA testing. All sessions were separated with a minimum of 48 hours, with the professional players performing only low intensity technical training.

During the 2nd and 3rd sessions, participants were allocated to the DJ protocol or the control conditions following simple randomization. Players performed a standardized 5 min warm-up for all conditions, which consisted of 1 min 30 s of running at moderate intensity, 1 min 30 s of ball shooting, and 2 min of submaximal jumps and sprints (~5 m) as performed during training sessions and games. After 5 min of passive rest, players performed three maximal countermovement jumps (CMJ) with 1 min of recovery between trials. After 5 min, the DJ protocol or the control condition was carried out. After this, a recovery of 4 min was included before the first RSA test (RSA_1). After the RSA_1, a recovery time lasting 5 min was included to mimic the time of a typical break or player substitution during games. Thereafter, a 2nd DJ protocol was performed and the second RSA test (RSA_2) was conducted after 30 s of rest. Immediately after RSA_2, the CMJ test was repeated. During DJ protocols, participants were instructed to perform the jumps as high and as fast as possible, keeping the hands on the hip. During CMJ performances they were instructed to jump as high as possible. For the control condition, additional recovery times were added instead of the DJ protocols (80 s before RSA_1 and 50 s before RSA_2) for equating the time between conditions.

Surface electromyography (EMGs) signal measurement

During all RSA tests, surface electromyography (EMGs) signals of the rectus femoris, vastus lateralis, vastus medialis, biceps femoris, semitendinosus, medial gastrocnemius and tibialis anterior were recorded from the supporting leg.

Drop jump (DJ) protocol

The optimal height for DJ was identified during the first familiarization session. Based on a preliminary pilot testing, every player was instructed to perform three DJs from two different heights (90 and 110 cm) with 1 min between attempts. The greatest jump height/contact time ratio (reactive strength index; RSI) was considered as the optimal height [24].

The first DJ protocol during experimental sessions involved the completion of 5 DJs interspersed with 15 s of rest [19]. The second DJ protocol included 3 DJs interspersed with 15 s of rest. The number of DJs was selected based on previous studies [12, 25] and on pilot testing. All DJs were performed on a force plate (Cefise, Nova Odessa, SP, Brazil) with data acquisition at 600 Hz.

Repeated sprint ability

The repeated sprint ability test (RSA) consisted of 10 × 30 m shuttle sprints (10 m + 10 m + 10 m) with two 180° changes of direction (COD) separated by 30 s of passive recovery [26]. The players were instructed to run as fast as possible and received strong verbal encouragement during all tests.

The sprinting time for every attempt was recorded using a digital camera (GoPro Black3 Hero, San Mateo, CA, USA) positioned in parallel, 6 m far from the running pad. Subsequently, video data were analysed using free-access kinematic analyses software (Kinovea, version 0.8.15, Kinovea Open Source Project, http://www.kinovea.org) to determine best time (B_T), total time (T_T), mean time (M_T), worst time (W_T), and the decrement percentage (%Dec) according to Fitzsimons et al. [27]:

$$\text{Decrement percentage} = (100 \times (T_T/B_T*10) - 100)$$

Where T_T corresponds to total time, and B_T is the best sprint time multiplied by 10 (number of sprints).

The coefficients of variation for B_T, T_T, M_T, W_T and%Dec were previously reported to be 2.1 ± 1.9%, 1.5 ± 2.3%, 1.5 ± 2.3%, 1.7 ± 1.2% and 24.3 ± 18.1%, respectively [26].

Countermovement jump (CMJ)

The countermovement jump (CMJ) test was assessed on a calibrated force plate (Cefise, Nova Odessa, SP, Brazil) with data acquisition at 600 Hz. Every player completed 3 CMJs interspersed with 1 min of passive recovery. The force-time curve of the highest CMJ was analysed using custom designed LabChart Pro v8software (Ad Instruments, Colorado Spring, CO, USA) to determine jump height (CMJ_{height}), and peak force (F_{max}) before and after RSA testing.

EMG signal

The EMG signal was acquired using a Wave Wireless EMG (MiniWave, Cometa System, Milan, Italy) device, with a sampling rate of 2000 Hz, and an amplifier gain of 1000 Hz. Skin preparation of each muscle belly was performed for positioning the electrodes on the rectus femoris, vastus lateralis, vastus medialis, biceps femoris, semitendinosus, lateral gastrocnemius and tibialis anterior according to SENIAM recommendations [28]. The signal was subsequently band-pass filtered at 20–500 Hz and the mean root mean square (RMS) of the EMG signal in every sprint was calculated using custom designed MATLAB software (R2015a MATLAB, MathWorks, Natick, MA, USA). RMS data were normalized by the mean RMS of the 1st sprint during the control condition.

Statistical analysis

Statistical analysis was performed using SPSS v. 15.0 (SPSS Inc., Chicago, Illinois, USA). Data are presented as mean ± standard deviation (SD). Data normality was verified with the Shapiro-Wilk test. A two-way repeated measures ANOVA was used to compare all outcomes between conditions (DJ vs. control) and within-conditions (pre- and post-). A paired t-test was used to compare differences in performance outcomes between every condition. In all cases, a 5% significance level was considered. The Cohen's *d* effect size (ES) of the RSA outcomes was also calculated between conditions.

RESULTS

The RSA test results are presented in Table 1. The DJ condition improved the B_T significantly ($p = 0.035$) compared to the control condition during RSA_1, whereas the T_T ($p = 0.030$) and M_T ($p = 0.030$) improved significantly in RSA_2. However, T_T ($p = 0.035$), M_T ($p = 0.038$) and B_T ($p = 0.014$) presented significant differences between conditions in the ANOVA with no significant interactions identified. One player did not complete RSA_2 because of muscular discomfort during efforts.

TABLE 1. Outcomes of Repeated sprint ability (RSA) tests.

		DJ condition	Control Condition	P-value	Cohen's d ES ± 90% confidence limits
RSA_1 (n = 12)	B_T (s)	6.80 ± 0.35	6.85 ± 0.30	0.035	-0.18 ± 0.13
	T_T (s)	69.64 ± 3.45	70.15 ± 3.07	0.215	-0.16 ± 0.22
	M_T (s)	6.96 ± 0.35	7.01 ± 0.31	0.215	-0.16 ± 0.22
	W_T (s)	7.19 ± 0.40	7.21 ± 0.35	0.767	-0.08 ± 0.42
	%Dec.	2.50 ± 1.07	2.43 ± 1.54	0.857	0.14 ± 0.41
RSA_2 (n = 11)	B_T (s)	6.81 ± 0.34	6.88 ± 0.32	0.105	-0.23 ± 0.23
	T_T (s)	70.38 ± 3.69	71.31 ± 3.59	0.030	-0.25 ± 0.18
	M_T (s)	7.04 ± 0.37	7.13 ± 0.36	0.030	-0.25 ± 0.18
	W_T (s)	7.30 ± 0.47	7.48 ± 0.42	0.054	-0.43 ± 0.36
	%Dec.	3.41 ± 1.52	3.60 ± 1.58	0.677	-0.15 ± 0.38

Outcomes are presented as mean ± SD. B_T – best time. T_T – total time. M_T – mean time. W_T – worst time.%Dec. - decrement percentage.

TABLE 2. Outcomes of countermovement jump tests.

	Control Condition			DJ Condition		
	Pre- RSA	**Post- RSA**	**% change**	**Pre- RSA**	**Post- RSA**	**% change**
Jump Height (cm)	43.2 ± 9.7	37.6 ± 4.0	-9.4 ± 18.0	42.7 ± 7.3	36.1 ± 4.9	-12.1 ± 18.5
Peak Force (N)	1432.2 ± 304.2	1482.0 ± 225.6	7.2 ± 32.6	1362.7 ± 245.0	1405.8 ± 296.2	3.4 ± 13.3

Table 2 shows the outcomes from CMJ tests. A main effect was only verified for moment ($p = 0.002$) in jump height, but with no significant differences between conditions ($p = 0.684$), and no interaction ($p = 0.883$). A similar result was observed for peak force ($p = 0.292$ for moment, $p = 0.226$ for condition, and $p = 0.937$ for interaction).

The RMS results are presented in Fig. 1. There was no significant interaction between conditions for the rectus femoris ($p \leq .169$), vastus lateralis ($p \geq .182$), vastus medialis ($p \geq .154$), biceps femoris ($p \geq .173$), semitendinosus ($p \geq .076$) or medial gastrocnemius ($p \geq .131$). However, DJ condition led to greater RMS values for the tibialis anterior in RSA_2 ($p = .032$) compared with the control condition.

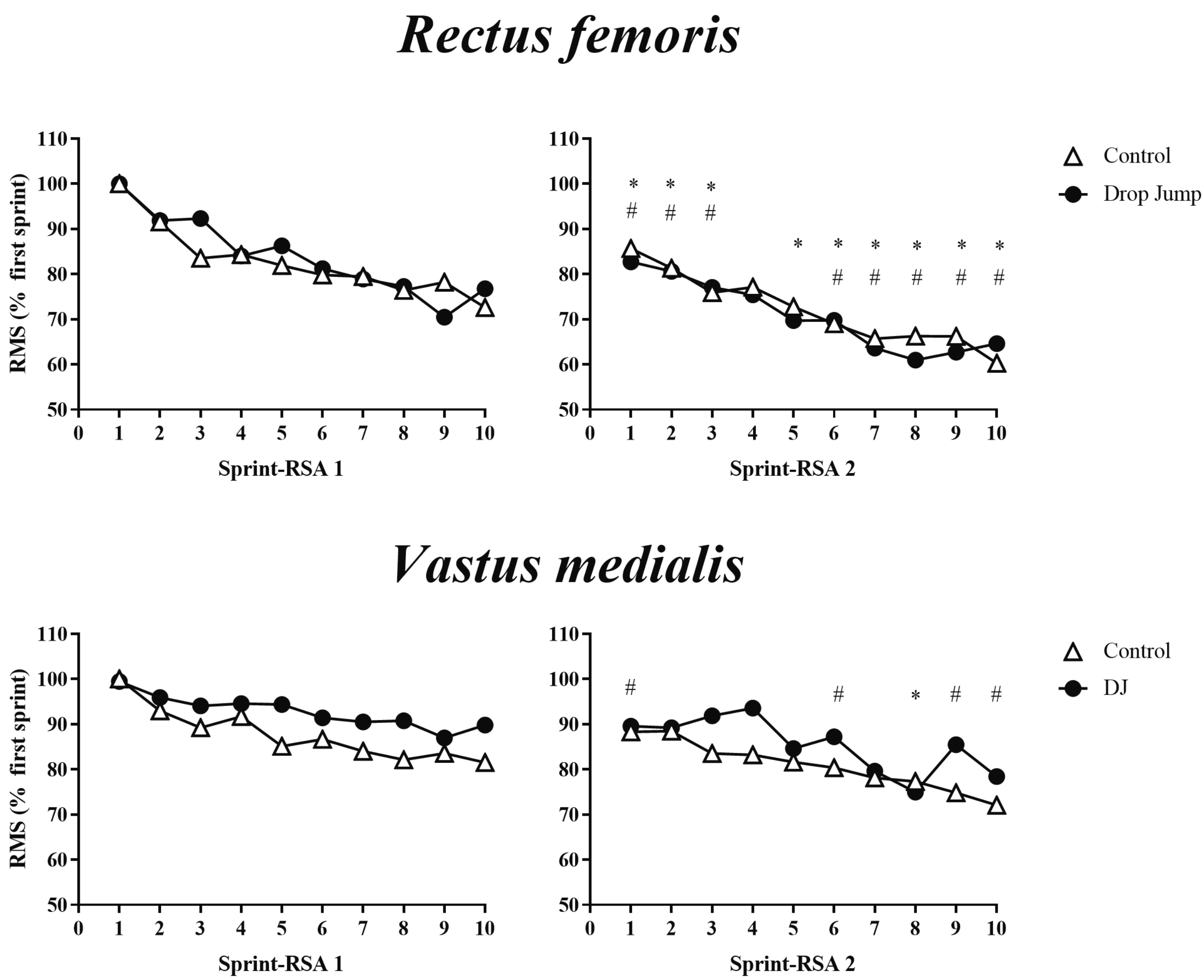
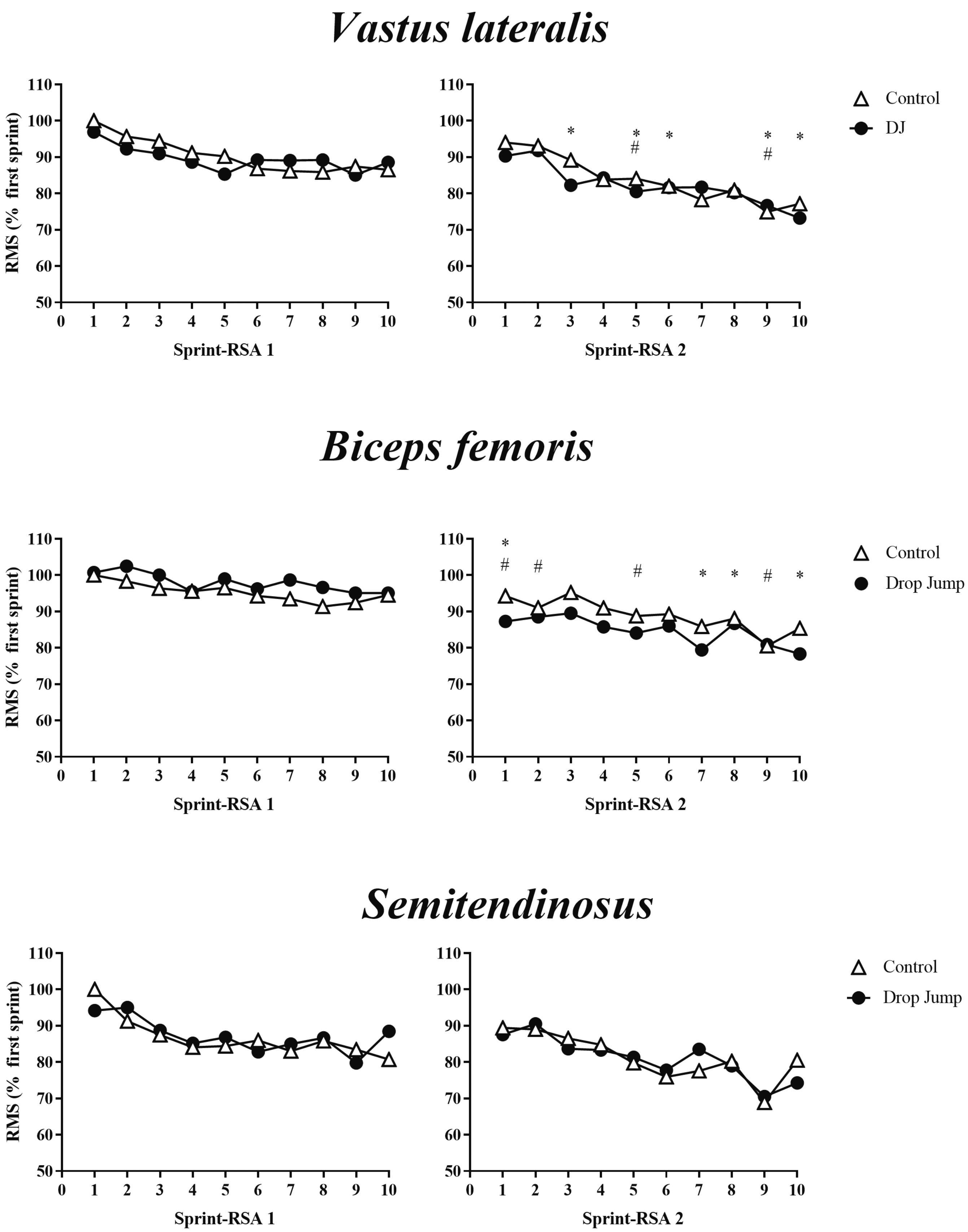


FIG. 1. Root mean square (RMS) results of repeated sprint. * = $p < 0.05$ significant within-subject factor for DJ condition; # = $p < 0.05$ significant within-subject factor for control; † = $p < 0.05$ significant between-subjects factor (DJ vs. control). Note: Error bars not included for clarity.



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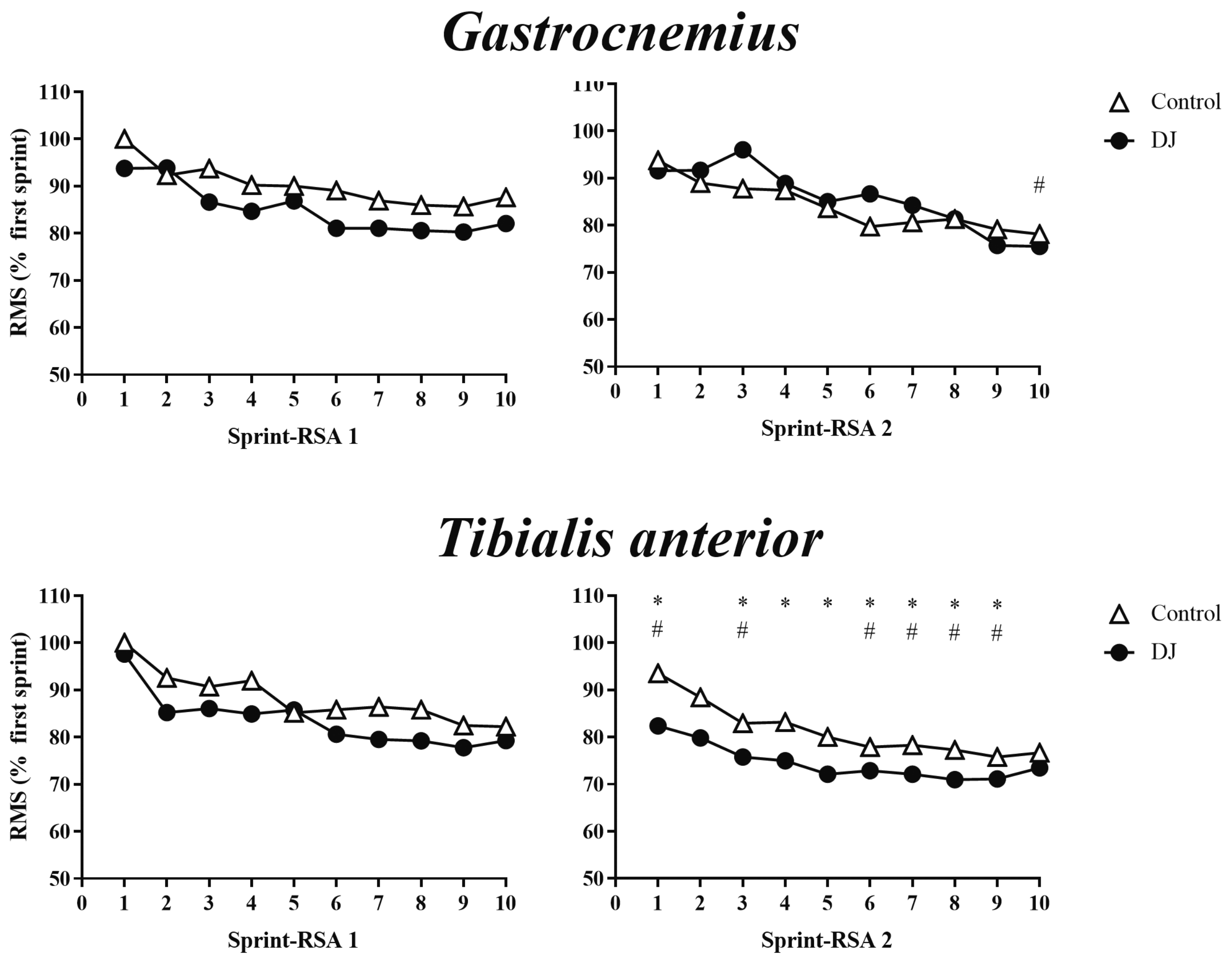

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DISCUSSION

The main finding of the present study was that sprint performance improved after DJ protocols in both RSA tests (i.e. B_T in RSA_1, and T_T and M_T in RSA_2). Thus, our initial hypothesis was accepted. Further, the RSA test used in the current study represents a physical effort associated with game-related performance in basketball, with the current study design mimicking a player's substitution, therefore providing great ecological validity for our findings.

Previous studies have also observed positive effects of different conditioning exercises on sprint performance in team sports [9–11, 29]. For instance, Dello Iacono et al. [11] investigated the effects of loaded hip-thrust with two different loads (50 and 85% of 1 RM) on 15 m sprint performance and observed an improvement of 2.4 and 4.4%, respectively. The different percentage improvement between the Dello Iacono et al. study [11] and the current study (0.81% to best time during the first RSA) may be attributed to the change of direction component during RSA testing. Meanwhile, Okuno et al. [10] reported significant improvements (~1%) in best time and mean time after a conditioning activity based on heavy half squats, during an RSA test with changes of direction, which agrees with the current findings. Future studies should consider these aspects in further comparisons between studies.

The improvement in RSA performance after the DJ protocol may be associated with PAP mechanisms, as supported by de Poli et al. [12]. One of the previously suggested mechanisms associated with PAP effects is the enhanced recruitment of higher order motor units [15]. However, the findings of the present study do not support the influence of this mechanism as a significant interaction was only observed for the RMS response of the tibialis anterior during the first sprint. In another recent study, we found that repeated drop jumps improved cycling supramaximal performance (7–10%) via PAP with an increased glycolic pathway contribution, but no changes were observed in the EMG data [12]. Therefore, based on these and previous findings, it may be suggested that performing DJs as conditioning activities can improve best time during RSA testing and that this performance improvement may be related to PAP, and enhanced anaerobic contribution, but not to changes in recruitment of higher order motor units. Further studies are needed to appropriately confirm the existence of PAP and greater anaerobic contribution during RSA testing with this approach.

In a recent study, it was found that a re-warm up could be very useful for enhancement of neuromuscular performance in soccer players [23]. Likewise, the current study aimed to investigate the positive effect of including DJ as a strategy to improve RSA performance after a brief pause simulating a game break. We adopted a recovery interval of 5 min that enabled satisfactory recovery for players before returning to game playing with an enhanced RSA performance after inclusion of DJ protocols.

Despite the observed post-DJ RSA potentiation in professional male basketball players [30], the CMJ height and peak force were not significantly different between conditions. The main effect of moment for jump height can therefore be attributed to the effect of fatigue during RSA testing. Further studies are warranted to assess the changes in selected kinetic parameters [31] during jumping under similar conditions, which was not possible with the methods used in the current study.

A limitation of the current study was that we did not use peripheral neuromuscular stimulation to verify that the DJ protocol effectively induced PAP as in a previous study from our group [12]. In addition, further studies should control muscle or skin temperature to verify the partial influence of muscle temperature on muscle power production and subsequent performance [8]. However, we would expect that the short DJ protocol would not raise muscle temperature more than the standardized warm-up protocol.

CONCLUSIONS

A DJ protocol improved best time RSA performance in professional basketball players and inclusion of a similar stimulus after a brief recovery break enabled improvement of mean time and total time in a second RSA test.

Practical applications

Our results suggest that a DJ protocol like that used in the current study could be included in priming routines of basketball players, before starting the game and after players' substitutions, as an easy and efficient strategy for improving RSA performance with changes of direction, which is a key ability for basketball players.

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Conflict of Interest Declaration

None of the authors have conflicts of interest to declare

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