Effects of Eccentric Overload Bout on Change of Direction and Performance in Soccer Players

Authors

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Key words

- eccentric overload training
- crossover cutting
- side-step cutting
- muscle performance
- maximal power output

Abstract

The aims of this study were to analyse the effects of eccentric overload training (EOT) on kinetic parameters during change of direction (COD) and performance related to sprinting and jumping abilities. 20 male soccer players performed 2 different protocols: 1) 5-min cycling warm-up and 2) 5-min cycling warm-up + YoYo half-squat exercise. The outcome measured included vertical ground reaction force (vGRF) and propulsive force (PvGRF), time to vGRF (T_vGRF) and propulsive force (T_PvGRF), contact time (CT), eccentric (ECC_IMP), concentric (CONC_IMP) and total (TOT_IMP) impulses and moments (Mx, My and Mz) during 2 COD tasks. Additionally, subjects performed a counter-movement jump (CMJ) and 20 m sprint tests. Results showed a substantial better improvement (*likely to almost certainly*) in vGRF (ES: 0.84), vAGRF (ES: 0.72), CT (ES: 0.48), My (ES: 0.35), Mz (ES: 0.44) and ECC_IMP (ES: 0.45) during crossover cutting maneuver, whereas during side-step cutting maneuver Time_ECC (ES: 0.68), CT (ES: 0.64), vGRF (ES: 0.48) and My (ES: 0.47) were substantially enhanced (*likely*). Furthermore, substantial better performance was found in CMJ (ES: 0.47; *very likely*) and 20 m (ES: 0.20; *possibly*). In conclusion, EOT produced a better muscle activation during 2 different COD tasks and greater sprinting and jumping performance.

Introduction

Different warm-up strategies are used to prompt a potential phenomenon that is called post-activation potentiation (PAP) [51]. This phenomenon is induced by a voluntary muscle contraction, performed typically at maximal or near-maximal intensity, and it has been shown to increase explosive activities [6,51]. In this regard, the proposed mechanisms underlying PAP are primarily associated with phosphorylation of myosin regulatory light chains during muscle contraction [3], which makes protein filaments (i.e., actin and myosin) more sensitive to the release of calcium (Ca^{2+}). Consequently, this mechanism triggers a cascade of events to enhance the muscle response [28]. Furthermore, an increase in the recruitment of higher order motor units has also been reported [51]. Nevertheless, the "real" physiological mechanisms involved during PAP remain unclear [51].

Several factors (i.e., volume, intensity, recovery and muscle action type) determine the PAP response and, in fact, their combination might lead to either potentiation or fatigue [25,55], although both mechanisms can coexist [43]. For example, the effect of different muscle actions (i.e., isometric, concentric [CONC], eccentric [ECC]) has been previously analyzed [17,26,34,44,53,54,57]. In this sense, studies that have used isometric contractions to examine PAP reported performance enhancement [2,19] and no change in performance [20,45]. Using dynamic exercises (both CONC and ECC movement phases), Young et al. [57] and Kilduff et al. [34] showed an acute enhancement of counter-movement jump (CMJ) after a half squat training at 5 repetition maximum (RM) or 3 RM respectively. In contrast, Esformes et al. [19] showed no changes after a 3 RM barbell bench press. However, the influence of ECC overload exercises (EOE) in the PAP response remains unknown. These protocols (i.e., ECC overload) are usually performed in sport rehabilitation and injury prevention programs given their specific physiological and mechanical properties [16,31]. Nevertheless, it has been reported that ECC training induces short-term muscle fatigue [21,24].

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Interestingly, this response is more significant at high loads [35], when performing ECC actions at high velocities [10] and when the range of motion is shortened [41]. In addition, significant physiological changes such as local inflammatory response, nociceptors sensitization [42], and proprioceptive perturbations [8, 46, 55] are also exhibited following an ECC bout. Therefore, it would be of interest to ascertain the best combinations (i.e., intensity, recovery…) for producing potentiation instead of fatigue.
In most team sports, players are required to repeatedly perform short, explosive efforts such as accelerations and decelerations during change of direction (COD). These actions are frequently linked to non-contact anterior cruciate ligament (ACL) injuries [11] and, in fact, the acute fatigue and proprioceptive alteration may have a substantial influence on the probability of suffering an ACL injury. As such, a change in kinematic, kinetic and electromyography activity during a COD task following a fatiguing strength-training exercise has been taken into account [12]. Furthermore, acute changes in biomechanical fatigue, such as an increment in anterior tibial translation [56], a decrease in ground reaction forces (GRF) and moments in the vertical, antero-posterior and medio-lateral directions, a greater knee abduction angle or a decrease in knee flexion angle following different fatiguing protocols have been reported [13]. Collectively, these results suggest that the optimal knee joint stabilization is compromised and, thereby increasing the acute risk of injury. Thus, the appropriate stimulus for avoiding a possible fatigue must be ascertained.
It can be speculated that an effective warm-up strategy (e.g., ECC overload training [EOT]) may acutely enhance physical performance and reduce the likelihood of suffering an injury. In this regard, it has been observed that light loads may cause smaller muscle changes than heavy loads during ECC exercises [39, 40]. Furthermore, a performance improvement and a muscle injury decrement have been shown following an EOT program with submaximal loads in junior elite soccer players [15]. Interestingly, EOT is usually performed before specific technical-tactical sessions or even on the match day. As such, it would be interesting to know the acute responses of this type of training. Nevertheless, to the best of our knowledge, no data are currently available on the relationship between changes in EOT and COD. Therefore, the aims of this study were; 1) to analyze the effect of EOT in different kinetic measurements during 2 COD tasks (i.e., crossover and side-step cutting) and, 2) to examine its impact on jumping and sprinting performance.

Methods
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Subjects

20 young (U-19) highly trained male soccer players (age: 17.0 ± 1.0 years; height: 176.7 ± 3.9 cm; body mass: 69.8 ± 6.9 kg; BMI: 21.3 ± 1.4 $kg \cdot m^{-2}$) voluntarily participated in the study. Athletes belonged to a first Spanish soccer division (i.e., Liga BBVA) club academy squad. A physician reviewed the medical histories and assessed the suitability of the study. Participants with severe lower limb muscle injuries (strains for more than 27 days) during the previous 2 months were excluded. The study was approved by the University of Seville Research Ethics Committee and conducted according to the Declaration of Helsinki and as required by Harriss & Atkinson [27]. All participants provided informed consent.

Study design and procedure

In a randomized crossover study design, players randomly performed 2 different protocols separated by 72–96 h: 1) 5-min cycling warm-up (CON) and 2) 5-min cycling warm-up + YoYo half-squat exercise (EXP). Standardized cycling warm-up period was performed at 80 W and 80 rpm (Ergoline 900, Ergometrics, Bitz, Germany). During EOT sessions, subjects performed 4 sets of 6 maximal bilateral coupled CONC and ECC muscle actions in the YoYo half-squat exercise with 120 s of recovery between sets. Participants had to bend their knees up to 90° during the ECC phase and then perform the CONC phase as fast as possible.
One week before the beginning of the study, 2 familiarization sessions separated by at least 48 h were developed. In these sessions, a full explanation of the experimental protocol and recommendations were given to the participants and they were allowed to practice all the tests. In addition, the inertia used during the experiment in the flywheel device (i.e., YoYo squat) was selected. To ensure reliability, players performed the countermovement jump (CMJ) test and 10 and 20 m sprint associated with COD tests during 2 different testing sessions. The dependent variables for COD were vertical ground reaction force (vGRF) and propulsive force (PvGRF), time to vGRF (T_vGRF) and propulsive force (T_PvGRF), contact time (CT), eccentric impulse (ECC_IMP), concentric impulse (CONC_IMP) and total impulse (TOT_IMP). Furthermore, the moments in 3 planes (Mx, My and Mz) during the contact were also analyzed. Every force, moment and impulse variable was calculated relative to body mass (kg). Additionally, after each experimental session, subjects performed a CMJ and 10 and 20 m sprint associated with COD tests and separated by 2-min rest periods. 3 trials of each test were allowed with the average score being used in subsequent analysis.

Inertial power output test

An isoinertial, flywheel-training device YoYo™ (YoYo Technology AB, Stockholm, Sweden) was used (half-squat in YoYo Squat). With this device load is provided by the inertia of a rotating mass (flywheel), which in turn is a function of its geometrical (diameter, thickness) and physical properties (density of the material). During the CONC phase of the muscular action, the athlete rotates a flywheel by means of a strap connected to its shaft. At the end of the range of motion, the strap is completely untwined, the flywheel keeps spinning by virtue of its inertia and retracts the strap, requiring the athlete to decelerate it during the subsequent ECC action. By controlling the execution technique (i.e., delaying the braking action in the ECC phase), this device allows to achieve a given degree of ECC overload [1, 5, 38, 52].
One week prior to the beginning of the study, each player performed a testing protocol using a flywheel isoinertial device to know the inertia used throughout the study. Power output was measured during each CONC action (SmartCoach™ Power Encoder, SmartCoach Europe AB, Stockholm, Sweden) and real-time feedback was provided on a computer monitor with the associated SmartCoach software (v3.1.3.0). The total number of flywheels installed adjusts the overall inertia. Given their properties (material: PVC; density: 1.4 kg/cm^3, diameter: 380 mm; thickness: 20 mm), the resulting inertia of each flywheel was 0.11 $kg \cdot m^2$. To determine the inertia that was used during the study, an assessment with inertia 2 and 4 (4 repetitions per inertia with 180 s inter-inertia recovery) was performed. The inertia that achieved higher power output was selected.

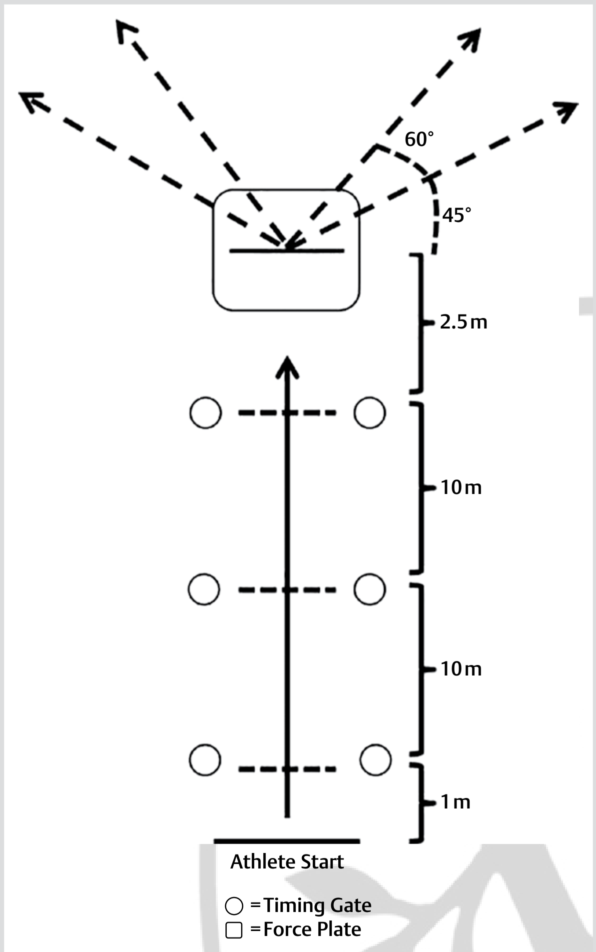

Fig. 1 Schematic illustration of change of direction performance test.

Change of direction protocol

The standardized COD maneuver consisted of a maximum running approach of 20-m with a 2.5-m adjustment to place the dominant foot on the force platform followed by a 60° cutting maneuver to the same side of the foot (crossover cutting) or a 45° cutting maneuver to the contralateral side of the foot (side-step cutting) (**Fig. 1**). The average of 3 trials was calculated for each variable. The dominant leg was defined as the leg used to kick a ball for distance. Instructions were given to the subjects to perform the COD as fast and forceful as possible to simulate a match situation. Cutting angle was monitored by tape markings placed 45° and 60° from the center of the ground force plate. COD type (i.e., crossover or side-step) was randomized over 6 trials (3 each type). Kinetic parameters were recorded during COD maneuvers.

Outcome measures

Kinetic parameters

Kinetic parameters were recorded with a multiple component force platform (Kistler Instruments, Inc., model 9286A, Winterthur, Switzerland) with a sampling rate of 1 000 Hz, which measured ground reaction forces (GRFs). Force data was calculated during the contact phase. The vGRF was used to identify the time of initial contact. The contact phase was defined as the time period between initial ground contact with the force plate until toe-off during the side-step cutting maneuvers [14]. The initial contact was operationally defined as the time when vGRF exceeded 10 N with toe-off defined as the time when vGRF dropped below 10 N [14, 36]. The variables included within the analysis were vGRF and PvGRF ($N \cdot kg^{-1}$), T_vGRF and T_PvGRF (s), CT (s), ECC_IMP, CONC_IMP and TOT_IMP ($N \cdot s^{-1} \cdot kg^{-1}$), and the moments (Mx, My, Mz) during the contact in all 3 planes ($N \cdot m \cdot kg^{-1}$). Due to the special shape of the vGRF, it was possible to divide the ground contact phase into 2 sections [4]. Gollhofer & Kyrolainen [23] showed that the highest amplitude of the second peak could be used as the instant at which the ECC landing phase changed to CONC push-off and it was used to determine both impulses. All forces, moments and impulses variables were relativized to body mass (kg). The mean values of 3 trials were used for posterior analyses.

Counter movement jump test (CMJ)

Countermovement jump (CMJ) test was assessed using an infrared-light platform built into the OptoJump system (MICROGATE, Bolzano, Italy). Players jumped 3 times as high as possible with their hands on their hips without any pause between ECC and CONC phases. Knee flexion was self-selected. A 30-s passive recovery phase was provided between jumps. Elevation of the center of gravity (height in m) was calculated for all jumps as flight time (t_v) in seconds, applying the laws of ballistics: $H = t_v 2 \cdot g \cdot 8\text{-}1$ (m); where H is the height and g is the gravitational acceleration ($9.81\,m \cdot s^{-2}$). The mean height was used for the subsequent analyses.

10-m and 20-m sprint test

Sprint time was measured using a dual-beam electronic timing gates (MICROGATE, Bolzano, Italy). All players were assessed in a 20-m sprint with a 10-m split time. The starting position was standardized with the left toe 1 m back from the starting line and the right toe approximately in line with the heel of the left foot. All assessments were performed on a natural grass surface, and subjects wore specific soccer shoes. The participants performed 3 trials with the mean time used for subsequent analysis. A recovery time of 120 s between each attempt was provided. The next variables were used for posterior analyses: 10-m sprint time (0–10 m) and 20-m sprint time (0–20 m).

Statistical analysis

Data is presented as mean ± standard deviation (SD). All data were first log-transformed to reduce bias arising from non-uniformity error. The standardized difference or effect size (ES, 90 % confidence limit) in the selected variables was calculated using the control SD. Threshold values for Cohen ES statistics were > 0.2 (small), > 0.6 (moderate), and > 1.2 (large) [29]. For acute responses, the chances that the differences in performance (i.e., kinetic variables, jumping and sprinting) were better/greater (i.e., greater than the smallest worthwhile change, SWC [0.2 multiplied by the between-subject standard deviation, based on Cohen's d principle]), similar or worse/smaller were calculated. Quantitative chances of beneficial/better or detrimental/poorer effect were assessed qualitatively as follows: < 1 %, almost certainly not; > 1–5 %, very unlikely; > 5–25 %, unlikely; > 25–75 %, possible; > 75–95 %, likely; > 95–99 %, very likely; and > 99 %, almost certain [29]. A substantial effect was set at > 75 % [49]. If the chance of having beneficial/better or detrimental/poorer performances was > 5 %, the true difference was

		CONTROL vs. HALF SQUAT (n=20) Pre-	Post-	% Difference (90% CL)	Chances
Crossover cutting	vGRF	24.1 ± 8.4	32.2 ± 7.9	36.9 (20.2; 56.1)	100/0/0%
	PvGRF	15.4 ± 2.7	17.5 ± 2.7	14.0 (6.8; 21.6)	99/1/0%
	T_vGRF	0.05 ± 0.01	0.05 ± 0.01	8.2 (−5.4; 23.9)	64/30/6%
	T_PvGRF	0.09 ± 0.02	0.09 ± 0.02	6.3 (−2.0; 15.4)	67/30/2%
	CT	0.14 ± 0.02	0.13 ± 0.02	7.1 (2.3; 12.0)	93/7/0%
	ECC_IMP	0.73 ± 0.22	0.84 ± 0.24	15.9 (0.9; 33.2)	84/15/1%
	CONC_IMP	0.70 ± 0.23	0.73 ± 0.25	5.4 (−5.0; 17.0)	25/74/1%
	TOT_IMP	1.43 ± 0.37	1.57 ± 0.41	8.5 (−3.1; 21.4)	62/35/2%
	Mx	1.98 ± 0.74	2.27 ± 1.05	12.2 (−7.3; 35.9)	64/30/5%
	My	2.89 ± 1.37	3.63 ± 1.63	32.9 (1.5; 74.0)	78/22/1%
	Mz	0.71 ± 0.41	0.95 ± 0.57	30.5 (−5.2; 79.6)	78/19/3%
Side-step cutting	vGRF	30.0 ± 11.5	34.9 ± 11.9	15.3 (4.7; 24.8)	89/11/0%
	PvGRF	16.77 ± 2.7	18.0 ± 3.1	7.4 (−1.7; 17.3)	74/23/2%
	T_vGRF	0.07 ± 0.02	0.05 ± 0.02	21.9 (2.2; 45.5)	91/8/1%
	T_PvGRF	0.08 ± 0.02	0.08 ± 0.01	0.0 (−9.9; 10.9)	33/34/33%
	CT	0.15 ± 0.03	0.14 ± 0.03	8.3 (−1.0; 18.4)	85/12/3%
	ECC_IMP	0.94 ± 0.22	0.93 ± 0.36	−5.2 (−18.5; 10.2)	11/41/48%
	CONC_IMP	0.70 ± 0.22	0.78 ± 0.42	4.2 (−11.2; 22.3)	35/54/11%
	TOT_IMP	1.74 ± 0.54	1.63 ± 0.45	−6.8 (−17.2; 4.8)	3/41/55%
	Mx	2.40 ± 1.84	2.04 ± 2.02	−20.6 (7.4; −56.9)	2/35/63%
	My	2.02 ± 1.80	3.26 ± 2.08	36.2 (15.4; 51.9)	94/6/0%
	Mz	0.79 ± 0.45	0.88 ± 0.50	4.6 (−23.2; 26.1)	24/67/10%

vGRF: vertical ground reaction force; PvGRF: propulsive force; T_vGRF: time to vertical ground reaction force; T_PvGRF: time to propulsive force; CT: contact time; ECC_IMP: eccentric impulse; CONC_IMP: concentric impulse; TOT_IMP: total impulse; Mx: mediolateral moment; My: anteroposterior moment; Mz: vertical moment; %Difference: percentage difference; CL: confidence limits; Chances: percentage chance of having better/similar/poorer values

Table 1 Acute kinetic responses in change of direction task following eccentric overload training. Data are mean ± SD.

assessed as unclear. Otherwise, we interpreted that change as the observed chance [29].

Results

Kinetic parameters

Relative changes and qualitative outcomes resulting from the acute kinetic responses analysis are shown in **Table 1** and illustrated in **Fig. 2** (crossover cutting) and **Fig. 3** (side-step). Substantially better results were found following the acute bout of EOT in CT, vGRF, vAGRF, My, Mz and ECC_IMP during the crossover cutting maneuver, whereas CT, Time_ECC, vGRF and My were substantially enhanced during the side-step cutting maneuver.

Performance tests

Results from jumping and sprinting performance are provided in **Table 2**. Substantially better performance was found in CMJ. Furthermore, a possibly better 0–20 m was observed.

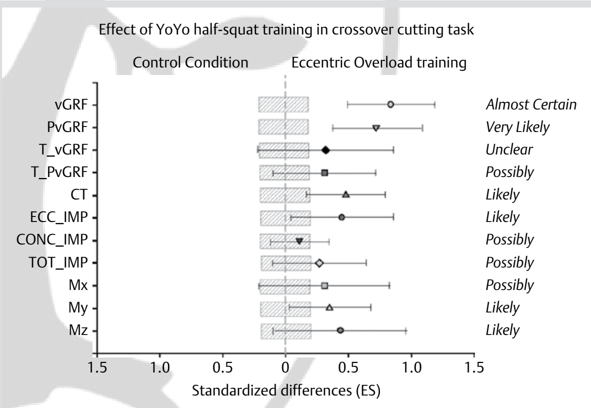

Fig. 2 Efficiency of the eccentric overload training (YoYo half-squat) in comparison to control condition to improve vertical ground reaction force (vGRF) and propulsive force (PvGRF), time to vGRF (T_vGRF) and propulsive force (T_PvGRF), contact time (CT), eccentric impulse (ECC_IMP), concentric impulse (CONC_IMP), total impulse (TOT_IMP), and the moments in 3 planes (Mx, My and Mz) in the crossover cutting maneuver (bars indicate uncertainty in the true mean changes with 90% confidence intervals). Trivial areas were calculated from the smallest worthwhile change (SWC) (see methods).

Discussion

The primary aim of this study was to determine the acute effects of performing an EOT in the half-squat exercise on kinetic parameters during COD tasks. Furthermore, the impact of an EOT on jumping and sprinting performance was also examined in young soccer players. To our knowledge, this is the first study that has examined the acute effects of EOT on COD kinetics and fitness performance. As expected, EOT produced greater performance during COD tasks without showing acute fatigue (proprioceptive disturbance) measured through kinetic parameters. Regarding performance, a possible potentiation was found in jumping and sprinting (0–20 m) abilities through different mechanisms such as an increase in reactive strength, leg stiffness [48] and PAP response [51].

The analysis of force platform results showed a shorter stance phase following EOT compared to CON. As such, a lower CT during side-step cutting was observed (ES: +0.64) following completion EOT. Additionally, a lower CT during crossover cutting was also found (ES: +0.48). These results are in contrast with those found following a submaximal warm-up strategy (3 sets at 50%, 60% and 90% RM in parallel back squat), which no showed a relevant change (ES: +0.28) in the stance phase time during a COD manoeuvre [49]. Furthermore, an ECC isokinetic quadriceps protocol observed a greater stance phase time in relation to unfatigued protocol (ES: −0.24) [41]. Differences in the load used and exercises might explain these inter-study differences and, consequently, it may be possible that a lower load could prompt a potentiation response instead of fatiguing.

This shorter stance phase was only accompanied only by a relevant change in the IMP_ECC during crossover cutting (ES: +0.45). ECC impulse has recently been associated with the storage and utilisation of elastic energy during sprinting [30] and, consequently, subsequent improvement during the propulsive phase in COD tasks [9], where it is important to get a rapid acceleration in the new direction [37, 47, 58]. In this phase, the force absorption and tension-producing properties (positive stiffness) of the quadriceps femoris and hamstring muscle groups are very important [18, 40]. Efficient ECC activation timing and torque production from these muscle groups during the early stance phase would seem necessary to provide better elastic energy absorption and storage for the impulse during the take-off-phase [40]. Thus, the fatigue of these muscle groups could produce alterations in COD strategies to avoid knee stress [40]. In this regard, no fatigue symptoms (i.e., kinetic variables) were observed after the EOT. Moreover, the PvGRF showed an average increase in the amplitude in both COD tasks after the experimental protocol. As such, PvGRF revealed an increase after side-step cutting (ES: +0.38) and crossover cutting (ES: +0.72). A lower CT associated with a greater PvGRF may be due to better neuromuscular coordination during the COD task [4]. Furthermore, previous studies have reported that a decline in PvGRF probably reflects an overall decline in the absolute force-producing capacity of the specific muscles following fatigue [22, 32, 33]. Interestingly, Kellis et al. [32] indicated that one of the general features of performing a task with fatigue is the tendency for the absolute force producing capacity to decline over time. Additionally, a decrement in the vGRF and moment amplitude and variability (SD) following an exercise-induced fatigue is observed [13]. Conversely, vGRF, Mx and My were substantially greater in both COD tasks after the ECC protocol performed in our study. Accordingly, it seems that this warm-up strategy might produce greater muscle activation and no local fatigue.

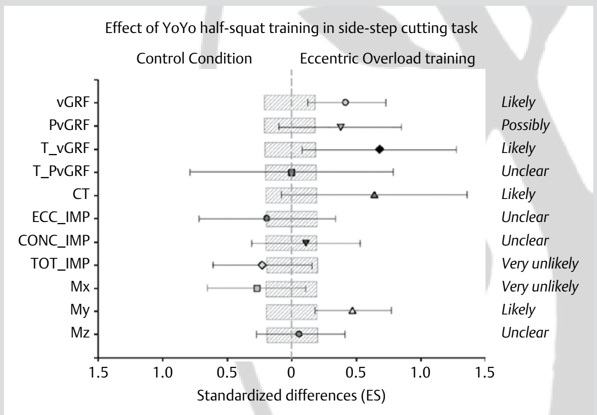

Fig. 3 Efficiency of the eccentric overload training (YoYo half-squat) in comparison to control condition to improve vertical ground reaction force (vGRF) and propulsive force (PvGRF), time to vGRF (T_vGRF) and propulsive force (T_PvGRF), contact time (CT), eccentric impulse (ECC_IMP), concentric impulse (CONC_IMP), total impulse (TOT_IMP), and the moments in 3 planes (Mx, My and Mz) in the side-step cutting maneuver (bars indicate uncertainty in the true mean changes with 90% confidence intervals). Trivial areas were calculated from the smallest worthwhile change (SWC) (see methods).

Regarding performance tests, a CMJ enhancement (ES: +0.47) was found after the EXP protocol while a possible effect was reflected in the 0–20 m test (ES: +0.20). These results are in contrast with those found by Bogdanis et al. [7], who observed that ECC back squat exercise performed at 70% (it was characterized by high force and rate of force development (RFD), according to the authors) RM, failed to elicit a better CMJ response. It is likely that this response is related to the PAP phenomenon. Since muscle performance following a conditioning muscle action depends on the balance between PAP and fatigue [51], the possibly ECC load used by Bogdanis et al. [7] may have produced fatigue. Interestingly, only 2 out of 20 players in our study achieved a poorer CMJ performance. Thus, it may be suggested that EOT might produce a benefit in the ability to jump higher. With regard to 0–20 m sprinting, several studies have been developed different training methods to acutely enhance sprint performance [50, 51]. In this regard, no significant differences were found in sprint performance following different warm-up protocols (deadlifts 5 RM, tuck jumps and isometric knee extensions) in junior soccer players [50]. These authors suggest that there is a large variability in the PAP response to improve sprint performance. Similarly, our players showed wide variability (−4.6% to +7.1%). It seems that, irrespective of the exercise performed prior to sprint, an individual basis to prompt PAP should be considered. However, this is the first study which has analyzed the effect of an EOT in the acute response of CMJ and 0–20 m sprinting and, therefore, further studies are needed to confirm the present results.

Table 2 Acute performance responses following eccentric overload training. Data are mean ± SD.

	CONTROL vs. HALF SQUAT (n=20)					
	Pre-	Post-	% Difference (90% CL)	Standardized difference (90% CL)	Chances	Qualitative Assessment
CMJ (cm)	34.7 ± 4.3	36.8 ± 3.4	6.3 (3.1; 9.5)	0.47 (0.24; 0.70)	97/3/0%	Very Likely
0–10 m (s)	1.78 ± 0.10	1.78 ± 0.07	0.2 (−2.0; 2.4)	0.04 (−0.50; 0.59)	31/46/23%	Unclear
0–20 m (s)	3.10 ± 0.13	3.08 ± 0.11	0.7 (−0.6; 2.0)	0.20 (−0.16; 0.56)	50/46/4%	Possibly

CMJ: countermovement jump; 0–10 m: 10-m sprint time; 0–20 m: 20-m sprint time; %Difference: percentage difference; Standardized difference: effect size; CL: confidence limits; Chances: percentage chance of having better/similar/poorer values

In conclusion, EOT produced a better muscle activation during 2 different COD tasks and greater jumping and sprinting performance. These responses are very important to coaches, as these strength protocols are frequently used before soccer training sessions. Finally, due to the absence of fatigue, it would be expected that to enhance physical performance and injury prevention, EOT should be implemented before soccer trainings and matches. Additional research with players of different sports, gender, age and playing standards should be conducted before the applicability of the current results can be generalized.

Conflict of interest: The authors have no conflict of interest to declare.

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