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Human Kinetics
ORIGINAL INVESTIGATION

Enhancing Change-of-Direction Speed in Soccer Players by Functional Inertial Eccentric Overload and Vibration Training

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Purpose: To examine the effects of a novel isoinertial eccentric-overload and vibration training (EVT) paradigm on change-of-direction (COD) speed and multiple performance tests applicable to soccer. ***Methods:*** Twenty-four young male players were assigned to an EVT (n = 12) or conventional combined (CONV, n = 12) group, once weekly for 11 wk. EVT consisted of 2 sets of 6–10 repetitions in 5 specific and 3 complementary exercises. CONV used comparable volume (2 sets of 6–10 reps in 3 sequences of 3 exercises) of conventional combined weight, plyometric, and linear speed exercises. Pre- and postintervention tests included 25-m sprint with 4 × 45° COD every 5th m (V-cut test), 10- and 30-m sprints, repeat-sprint ability, countermovement jump, and hopping (RJ5). ***Results:*** Group comparison showed very likely to likely better performance for EVT in the COD (effect size [ES] = 1.42), 30-m (ES = 0.98), 10-m (ES = 1.17), and average power (ES = 0.69) and jump height (ES = 0.69) during RJ5. There was a large (r = –.55) relationship between the increase in average hopping power and the reduced V-cut time. ***Conclusions:*** As EVT, not CONV, improved not only COD ability but also linear speed and reactive jumping, this "proof-of-principle" study suggests that this novel exercise paradigm performed once weekly could serve as a viable adjunct to improve performance tasks specific to soccer.

Keywords: acceleration and deceleration, flywheel resistance training, football, muscle power

In most team sports characterized by high-speed running while carrying, passing, kicking, or throwing a ball (eg, soccer, American football, rugby, basketball, European handball), the vast majority of actions or movements require 3-dimensional deceleration and acceleration calling for rapid, agile changes of direction (COD).[1,2] Strength- and power-training programs carried out by athletes in the quest for enhanced speed and maneuvering in multiple planes typically make use of weights offering constant concentric and eccentric load in exercises emphasizing vertical actions (eg, barbell squat and/or plyometric jumps) but rarely encompass horizontal/lateral actions offering eccentric overload. While some of these conventional combined training programs also include linear speed drills, they seem to provide good results in sprinting and jumping abilities or in very young athletes[3] but not in more experienced competitors[4,5] aiming to improve COD ability. However, such ability appears to dictate performance[1] and discriminate between players' competitiveness.[6] Being multifactorial,[7] COD correlates with eccentric knee-flexor strength[8] or maximal eccentric lower-body strength,[9] explaining, at least in part, performance success across individuals. Despite those obvious physical requirements, there is a lack of information regarding the effects of eccentric-overload training on COD performance.[10]

While training using weights or weight stacks or certain functional whole-body exercise routines might produce eccentric overload, inherently nonmotorized apparatuses using the inertia of rotating flywheels offer unrestricted force or power throughout the entire range of any concentric action.[11,12] Hence this method, allowing for build-up of energy beyond what is possible with weights, challenges muscle to significant overload in the subsequent eccentric action. Available research after the introduction of the isoinertial flywheel resistance exercise by Berg and Tesch[11] more than 2 decades ago suggests that training using this method elicits early and robust neuromuscular adaptations.[12] The magnitude of such effects, promoting enhanced muscle strength, power, and size,[13,14] is far greater than changes produced by training using gravity-dependent weights.[13] Likewise, with this particular exercise paradigm, significant performance adaptations are evident in both injured[15] and healthy, competitive athletes.[16,17] Notwithstanding, the cited studies explored training using closed- or open-chain exercises (ie, leg extension, leg curl, or leg press) rather than multimovements.

Similarly, inertial unrestricted concentric resistance could be provided[18] with use of a cone-shaped device and transmission pulleys, allowing for multidirectional movements, as well. Despite being widely used in professional sports,[19,20] its efficacy to benefit athletic performance remains to be shown.

There is sparse support that vibration training per se could aid in enhancing strength, speed, or power in athletes.[21] However, it seems that vibration training with challenging exercises performed on the platform boosts adaptations of several functional abilities in the long term.[22,23] This method has also been proposed as a means to restore muscle function after or between exercise bouts, hence favoring a greater overall exercise stimulus. For example, when applied in conjunction with eccentric or high-intensity exercise, brief episodes of vibration enhanced muscle recovery[24] and maintained eccentric hamstring in vivo force during a soccer game.[25] Thus, the current study was designed to assess the combined efficacy of several established exercise methods, rather than an isolated routine, to improve performance features such as jumping, hopping, or sprinting in multiple directions.[5,26]

The current investigation explored the efficacy of 1 weekly session of brief episodes of eccentric overload and vibratory stimulus,

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added to regular in-season exercise routines in young soccer players. More specifically, this "proof-of-principle" study assessed performance in tasks calling for horizontal, vertical, and multidirectional speed and power in young soccer players subjected to an 11-week training regimen. We hypothesized that the employed exercise paradigm would improve COD ability, a performance feature critical in soccer—horizontal speed, COD ability, and vertical power—and do so more than conventional plyometric, linear speed, and weight-loaded exercise training.

Methods

Subjects

Twenty-four young men (17.0 ± 0.5 y, 174.4 ± 6.4 cm, 67.6 ± 7.9 kg) were recruited from 2 teams of the Spanish National U-18 Soccer League. Their regular weekly exercise routine consisted of 3 or 4 soccer practices (~6 h), 1 session of strength/power exercises, and 1 competitive match (weekend). All players were previous novices in structured eccentric overload and/or vibratory training. Furthermore, they were not accustomed to plyometric and weight training. Although they had performed occasional preseason weight and plyometric exercises in their career, they were novice in systematic weekly in-season plyometric/weight training. Written informed consent was obtained from the players and, if needed, their parents before the investigation. Complying with the Declaration of Helsinki, the study protocol was approved by the institutional research ethics committee at the University of Zaragoza.

Study Design

Using a nonrandomized, controlled study design, participants were assigned to 11 weeks of either functional eccentric overload and vibratory training (EVT, n = 12) or conventional plyometric, linear speed, and weight-loaded, mainly vertical, exercise (CONV, n = 12) training. All players belonged to the same club and carried out 3 or 4 identical weekly 90-minute field sessions compounded by warm-up, technical actions, small-sided games, and tactical activities. In addition, they performed 1 weekly session of either EVT or CONV. Players were familiarized with the exercise procedures only, as tests employed were mandatory and administered frequently in-season. Outdoor tests were performed on artificial turf 1 week before the commencement of training and >5 days after the last exercise session. Before and after either intervention the participants performed a battery of tests: COD time (ie, V-cut test), 10- and 30-m sprint time, repeated-sprint ability (RSA; best and mean time), jump height in a countermovement jump (CMJ) and rebounding jump (RJ5), and mean contact time (CT), average hopping power (AP), and stiffness in a rebounding jump. Participants were asked to refrain from intense exercise for at least 48 hours before any performance assessment and to consume no food or caffeine within 3 hours of any test.

Procedures

Training Intervention. EVT was performed every Wednesday at 7 PM, after a standardized warm-up and before any technical, agility, or tactical training. In addition to mandatory routines, training consisted of (Figure 1) diagonal trunk rotations (reverse wood chops), backward lunges and unilateral hamstrings "kicks" using an isoinertial portable conical pulley (Versa-Pulley, Costa Mesa, CA; Inertia 0.27 kg/m^2), lateral squats employing the YoYo Squat (YoYo Technology AB, Stockholm, Sweden; Inertia 0.11 kg/m^2), and unilateral squats on a custom-made vibration platform (30-Hz frequency and 4-mm amplitude; custom-made platform, Laboratory of Human Performance, VFSport, Seville, Spain). The rationale for this load setting was the power maximization in both flywheel devices and the previous excellent results found with this vibratory load.[22] In addition, these players performed (2 × 6–8 reps) Nordic-hamstring lowers, rotational side-bridge, and partner-resisted hip abductions and adductions. Thus, the circuit-like training program was compounded by 8 exercises (6–10 reps) and was progressive such that weeks 1 to 2 comprised familiarization with each exercise mode; weeks 3 to 5, 2 sets of 6 reps; weeks 6 to 8, 2 sets of 8 reps; and weeks 9 to 11, 2 sets of 10 reps. The unilateral vibration squats consisted of sets of 15 to 20 seconds instead of a number of repetitions. During training on the flywheel devices, players were encouraged to perform the concentric phase as fast as possible, while delaying the braking action to the last third of the eccentric phase. Between exercises and circuit sets, 1 minute and 2 minutes of passive recovery were provided, respectively.

The CONV protocol included 3 exercise sequences, in which a general, a special, and a specific exercise were performed in a correlative order. This training program included 9 exercises (6–10 reps or 2–15 s) and was periodized similarly to EVT. The first sequence consisted of lunges at 50% of body mass, 10-m skipping, and 10-m maximal sprint. The second sequence consisted by half-squats at 100% of body mass, CMJ, and 10-m maximal sprint. The third sequence included calf raises at 50% of body mass, calf reactive jumps (minimal ground-contact time), and jumps to head the ball. Each sequence was repeated twice. Two minutes of passive recovery were provided between sequences and 1 minute between sets.

Measurement. Running speed, COD, and jump flight and contact time were recorded with photoelectric cells (Musclelab, Ergotest Technology, Langesund, Norway). Data were acquired and calculated using software provided by the manufacturer (Musclelab, Ergotest Technology).

V-Cut. Players performed a 25-m sprint with 45° COD every 5th m (ie, 4 CODs) by stepping between each pair of cones separated by 0.7 m (Figure 2). The subjects were asked to pass the line, indicated on the turf surface, with the entire foot at each turn. The COD test was executed twice with 3 minutes rest between. If considered invalid, additional trials were allowed. The best performance was chosen for analysis. In our laboratory, this test has shown high reliability scores (intraclass correlation coefficient [ICC] = .91, CL90% .74; .97; typical error of measurement [TEM] = 1.5%, CL90% 1.1%; 2.3%).

Speed (10- and 30-m Sprint). Running speed was assessed by means of 30-m sprint time from standing (front foot 0.5 m behind the start line) with a 10-m split time. Three sprints were performed with 3 minutes rest between. The best attempt was chosen for analysis.

Repeated-Sprint Ability. The RSA test[27] comprised 6 bouts of 2 × 20-m sprints with 180° COD and 20 seconds rest between bouts. The best (RSA_b) and average (RSA_m) sprint times and the percentage of decrement (%Dec) in sprint time were chosen for subsequent analysis. Verbal encouragement was provided at all times. Test reliability was very high for RSA_m (ICC = .94, CL90% .87; .97; TEM = 0.8%, CL90% 0.7%; 0.11%) and RSA_b (ICC = .87, CL90% .76; .94; TEM = 1.3%, CL90% 1.1%; 1.8%) but very low for %Dec (ICC = .57, CL90% .27; .77; TEM = 28.3%, CL90% 22.1%; 39.8%).

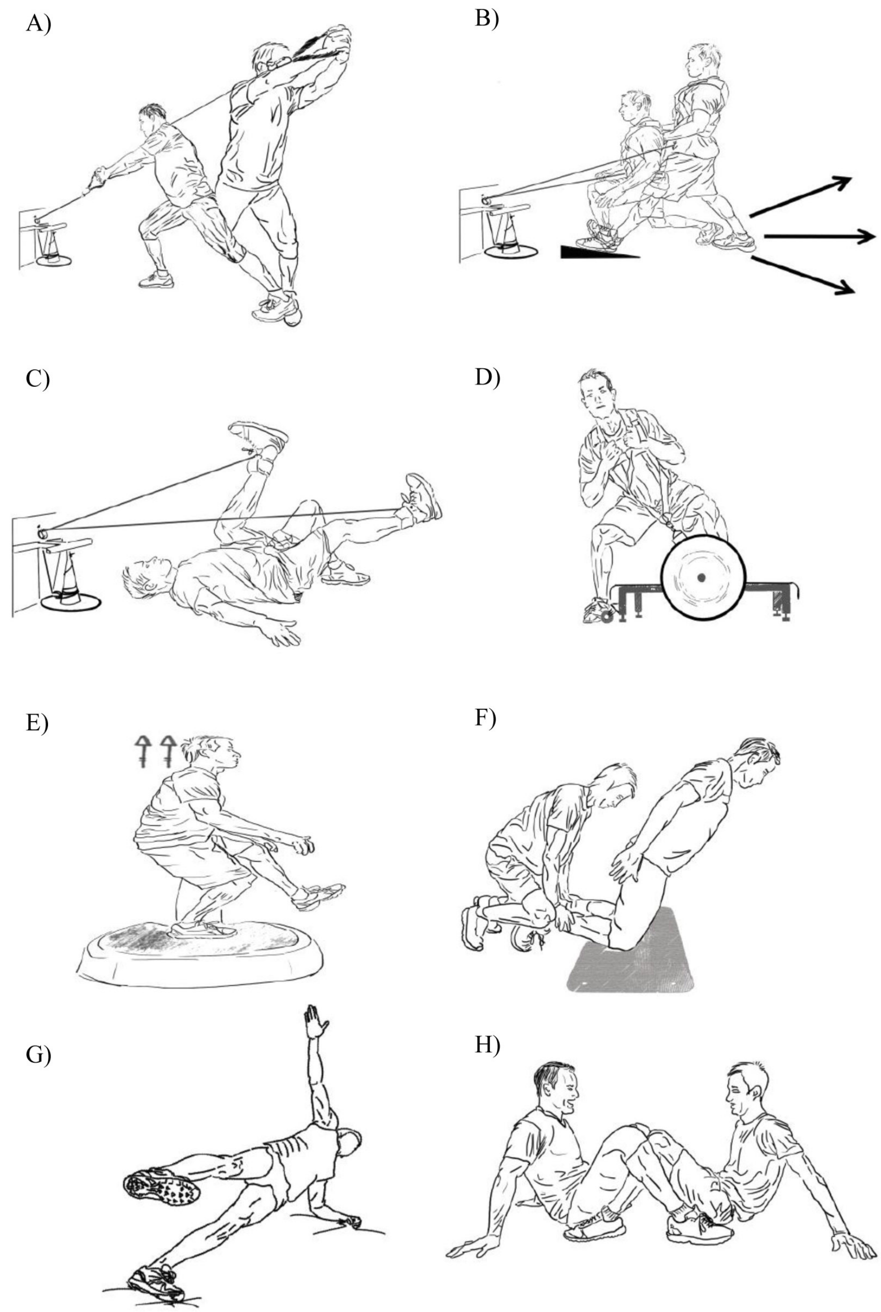

Figure 1 — Functional eccentric-overload and vibratory training program. (A) diagonal trunk rotations (reverse wood chops), (B) backward lunges, (C) unilateral hamstrings kicks, (D) lateral squats, (E) vibration-platform unilateral squat, (F) Nordic-hamstring exercise, (G) rotational side-bridge, and (H) partner-resisted hip abductions and adductions.

Countermovement Jump. By measuring flight time in a vertical CMJ, jump height and power were subsequently calculated. Visual inspection confirmed that landing occurred without any flexion about the knee joint with hands kept at the hips/waist. The depth of the CMJ was self-selected. Out of 3 attempts interspersed by 45 seconds, the best performance was chosen for analysis. Reliability scores were ICC = .97 (CL90% .9; .99) and TEM = 2.9% (CL90% 2.1%; 5.0%).

Hopping. Six consecutive rebound jumps were executed and aimed at minimizing contact time. As the first jump was considered a CMJ, the subsequent 5 jumps were chosen for analysis. RJ5, CT, AP, and muscle stiffness were subsequently analyzed using Musclelab software (version 7.20). ICC was .83 (CL90% .62; .93) and TEM 5.7% (CL90% 4.4%; 8.5%).

Statistical Analysis

Data are presented as mean ± SD. All data were log-transformed for analysis to reduce bias arising from nonuniformity error and then analyzed for practical significance using magnitude-based inferences.[28] Analysis of covariance (ANCOVA), using pretest values as covariate, was employed to detect possible between-groups differences after training. The chance that any performance difference was better/greater (ie, greater than the smallest worthwhile change [0.2 multiplied by the between-subjects SD, based on the Cohen *d* principle, ES]) or similar or worse/smaller than the other group was subsequently calculated. Quantitative chances of beneficial/better or detrimental/worse effect were assessed qualitatively as follows: <1%, almost certainly not; >1% to 5%, very unlikely; >5% to 25%, unlikely; >25% to 75%, possible; >75% to 95%, likely; >95% to 99%, very likely; and >99%, almost certainly. If the chance of having beneficial/better or detrimental/worse performances was >5%, the true difference was considered unclear.[28] The Pearson product–moment correlation coefficient was used to determine the relationship between different variables. The following criteria were adopted for interpreting the magnitude of correlation (*r*) between test measures: ≤.1, trivial; >.1 to .3, small; >.3 to .5, moderate; >.5 to .7, large; >.7 to .9, very large; and >.9 to 1.0, almost perfect.[28] If the CL90% overlapped small positive and negative values, the magnitude of the correlation was deemed unclear; otherwise it was deemed the observed magnitude.[28]

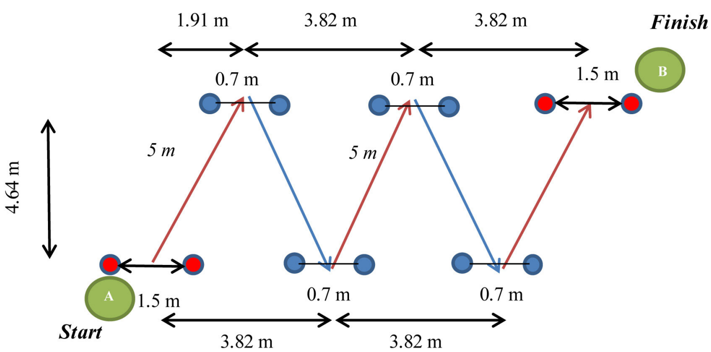

Figure 2 — Schematic illustration of the V-cut test.

Results

Within-Group Changes

Exercise-induced changes in performance for groups EVT and CONV group are shown in Tables 1 and 2, respectively.

Between-Groups Changes

EVT produced substantially better results in the V-cut test (% = 5.1, [CL90% 2.3; 8.0], with chances for greater/similar/lower performance of 99/1/0%), 10-m (% = 8.0, [–0.3; 17.0], 91/6/3%), 30-m (% = 6.5, [2.3; 10.9], 98/2/0%), AP (% = 13.3, [5.2; 22.2], 97/3/0%), and RJ5 (ES = 10.3, [0.6; 20.9], 90/9/2%) compared with CONV (Figure 3).

Relationships Between Physical-Performance Indices

Changes (pooled data from groups CONV and EVT) in COD and 30-m were largely correlated (*r* = .52, CL90% .21; .73). The correlation was moderate for 10-m (*r* = .41, CL90% .07; .66). Furthermore, there was a strong relationship between changes in COD time and AP (*r* = –.55, CL90% –.75; –.25).

Discussion

The current study explored the efficacy of functional isoinertial EVT to alter COD and jumping and sprinting ability in soccer players versus a conventional combined training method. There was a very robust improvement in COD imposed by EVT, and a strong relationship noted between changes in hopping power and COD. As these changes did not occur in players subjected to CONV training, we attribute these adaptations to the weekly eccentric-overload stimulus elicited by EVT.

Table 1 Changes in Performance After Eccentric-Overload + Vibration Training (n = 12)

Variable	Pretraining, mean ± SD	Posttraining, mean ± SD	% difference (90% CL)	Standardized difference (90% CL)	Chances of better/trivial/worse effect	Qualitative assessment
V-cut test (s)	7.09 ± 0.31	6.70 ± 0.29	5.7 (3.2; 8.4)	1.22 (0.68; 1.76)	100/0/0%	Almost certainly
10-m (s)	1.93 ± 0.07	1.92 ± 0.27	1.6 (–5.8; 9.5)	0.1 (–0.36; 0.56)	35/52/14%	Unclear
30-m (s)	4.51 ± 0.2	4.53 ± 0.33	–0.2 (–3.5; 3.2)	–0.03 (–0.45; 0.4)	18/58/24%	Unclear
RSAb (s)	7.26 ± 0.20	7.24 ± 0.26	0.3 (–1.6; 2.3)	0.08 (–0.42; 0.59)	35/49/17%	Unclear
RSAm (s)	7.57 ± 0.23	7.52 ± 0.22	0.5 (–0.6; 1.7)	0.17 (–0.2; 0.54)	44/51/5%	Possibly
%Dec (%)	7.5 ± 3.8	7.9 ± 3.1	–8.8 (–26.6; 13.5)	–0.17 (–0.58; 0.24)	7/48/45%	Unclear
CMJ (cm)	35.1 ± 5.3	36.4 ± 4.4	4.4 (0.5; 8.4)	0.25 (0.03; 0.46)	64/35/0%	Possibly
CT (ms)	211.1 ± 41.6	205.4 ± 37.5	2.6 (–1.9; 7.3)	0.15 (–0.11; 0.41)	37/61/2%	Possibly
RJ5 (cm)	29.7 ± 4.8	31.0 ± 4.9	4.2 (–4.8; 14.1)	0.23 (–0.28; 0.75)	55/37/8%	Unclear
AP (W/kg)	39.0 ± 7.6	42.4 ± 6.3	9.5 (4.3; 15)	0.44 (0.2; 0.67)	95/5/0%	Likely
Stiffness[a]	99.6 ± 27.4	108.4 ± 28.7	9.3 (–2.8; 22.8)	0.25 (–0.08; 0.57)	60/39/2%	Possibly

Abbreviations: CL, confidence limits; RSA, repeated-sprint ability; RSA_b, best RSA time; RSA_m, mean RSA time; %Dec, percentage decrement during the RSA test; CMJ, countermovement-jump height; CT, mean contact time; RJ5, mean jump height; AP, mean average relative power. For clarity, all results are presented as positive improvements, so that negative and positive differences are in the same direction.

[a] Muscle stiffness during a rebounding jump test.

Table 2 Changes in Performance After Conventional Combined Strength Training (n = 12)

Variable	Pretraining, mean ± SD	Posttraining, mean ± SD	% difference (90% CL)	Standardized difference (90% CL)	Chances of better/trivial/worse effect	Qualitative assessment
V-cut test (s)	6.94 ± 0.12	6.90 ± 0.16	0.6 (–0.4; 1.6)	0.24 (–0.16; 0.65)	58/39/4%	Possibly
10-m (s)	1.78 ± 0.10	1.89 ± 0.09	–5.9 (–8.3; –3.4)	–1.22 (–1.74; –0.70)	0/0/100%	Almost certainly not
30-m (s)	4.57 ± 0.37	4.87 ± 0.35	–6.3 (–9.0; –3.5)	–0.87 (–1.25; –0.48)	0/0/99%	Almost certainly not
RSAb (s)	7.35 ± 0.16	7.30 ± 0.19	0.7 (–0.8; 2.3)	0.27 (–0.29; 0.83)	58/34/8%	Unclear
RSAm (s)	7.7 ± 0.21	7.65 ± 0.12	0.7 (–0.8; 2.2)	0.41 (–0.47; 1.28)	66/26/12%	Unclear
%Dec (%)	11.6 ± 10.1	8.4 ± 2.0	12.5 (–17.7; 53.8)	0.47 (–0.77; 1.71)	65/18/18%	Unclear
CMJ (cm)	34.9 ± 3.8	37.0 ± 3.7	5.9 (1.8; 10.3)	0.48 (0.14; 0.82)	92/8/0%	Likely
CT (ms)	203.1 ± 26.2	202.3 ± 29.1	0.5 (–5.1; 6.4)	0.03 (–0.35; 0.41)	22/63/15%	Unclear
RJ5 (cm)	32.4 ± 2.7	30.7 ± 3.4	–5.5 (–9.7; –1.0)	–0.61 (–1.11; –0.11)	1/8/92%	Likely not
AP (W/kg)	44.7 ± 5.6	43.1 ± 5.0	–3.4 (–8.5; 2.0)	–0.25 (–0.65; 0.15)	3/37/59%	Possibly not
Stiffness[a]	120.7 ± 39.6	120.8 ± 32.9	1.2 (–11.3; 15.6)	0.04 (–0.35; 0.42)	23/62/15%	Unclear

Abbreviations: CL, confidence limits; RSA, repeated-sprint ability; RSA_b, best RSA time; RSA_m, mean RSA time; %Dec, percentage decrement during the RSA test; CMJ, countermovement-jump height; CT, mean contact time; RJ5, mean jump height; AP, mean average relative power. For clarity, all results are presented as positive improvements, so that negative and positive differences are in the same direction.

[a] Muscle stiffness during a rebounding jump test.

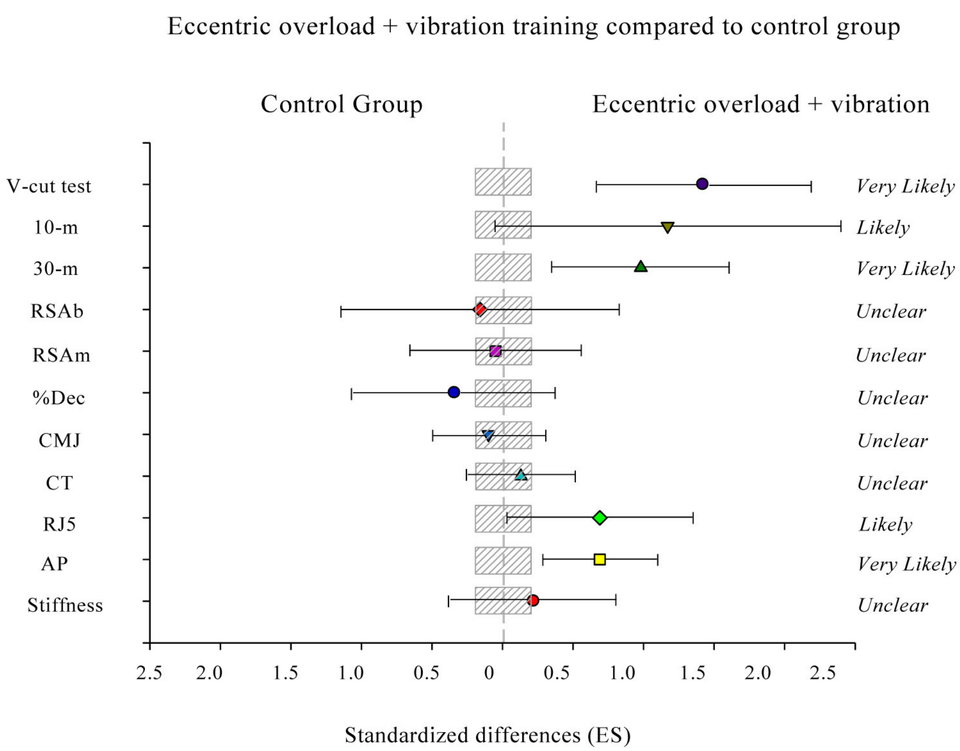

Figure 3 — Effects of eccentric-overload and vibration training (right) and conventional combined strength training (left) on various performance indices: change of direction (V-cut test); acceleration (10-m) and linear (30-m), mean (RSAm), and best (RSAb) sprint time; decrement (%Dec) in repeated-sprint ability; jump height during countermovement jump (CMJ); mean contact time (CT); mean jump height (RJ5); average power (AP); and muscle stiffness in 5 rebounding jumps. Bars indicate uncertainty in the true mean changes with 90% confidence limits. Trivial areas were calculated from the smallest worthwhile change.

COD ability is certainly multifactorial[7] and dictated by linear running speed, strength, power, and other neuromuscular features including agility and running technique.[10] Past research shows eccentric hamstring and maximal eccentric strength and reactive quadriceps strength or power, assessed by unilateral drop jumps, correlate[8,9,29] with COD ability. No previous study has analyzed the effect of eccentric-overload training on COD ability. However, a protocol very similar to the current CONV[5] failed to significantly improve this ability (ES 0.30 vs 0.24 in CONV). The EVT program used here was construed to challenge power in the critical transition from eccentric to concentric action—stretch shortening in a single-plane movement—but also, and more important, the ability to execute power while performing multidirectional tasks (ie, backward, forward, and lateral). Thus, rather than offering the instant short-lasting impact typical of plyometric exercise, various isoinertial tasks aimed to simulate the complex movement patterns typical of COD while simultaneously producing eccentric overload. Indeed, EVT prompted marked increases (almost certainly) in COD, and more so (very likely) than CONV using weights, speed, and plyometric exercise modalities.

Notably, linear sprint (ie, 10- and 30-m) performance was unaltered (unclear outcome) in response to EVT. If anything, linear speed was compromised after CONV. Previously, elite soccer players subjected to a 10-wk training regimen using isoinertial-flywheel leg-curl exercise showed improved 30-m sprint performance.[16] That particular exercise mode prompts marked use of all aspects of the hamstring muscle group.[30] The current EVT regimen also employed the Nordic-hamstring and hamstring-kick exercises with unknown, but likely much less, knee-flexor muscle involvement. Hence we are tempted to attribute the finding of no increase in linear speed to modest hamstring-muscle use. Therefore, we suggest that resistance exercise favoring eccentric overload of this muscle group should be carried out preseason and in-season, as a powerful stimulus to enhance or maintain linear sprint speed.

Neither EVT nor CONV produced markedly improved RSA, in agreement with a recent study that measured RSA to assess the effects of combined strength- and power-training programs in soccer players.[31] Notably, CONV did not enhance (almost certainly worse) running speed (ie, 10-m and 30-m) without CODs. However, there was a slight increase in RSA_b performance (0.7%). It appears that RSA_b relies on different determinants than linear speed, as it requires the athlete to decelerate, block, and reaccelerate for the second part of the run. These results support previous studies that indicated no relationship between linear RSA and RSA with CODs.[32]

It is noteworthy that the 2 protocols showed comparable increases in CMJ height. Nonetheless, CONV improved CMJ but not functional abilities typical of football or soccer. In contrast EVT, not CONV, improved AP in the rebounding jump, and changes in AP, but not CMJ, and COD were highly correlated. These results are at odds with those found in male college athletes subjected to slightly different COD (ie, 90° and 180° angles) and hopping tests.[33] In this regard, it is worth recalling that in the COD, higher propulsive forces are produced at 45° than at other angles.[34] The V-cut test requires players to accelerate, decelerate, brake, and reaccelerate while changing direction 4 times at a 45° angle. Thus, it appears that this task depends on the ability to execute consecutive explosive jumps (ie, RJ5). It is therefore tempting to suggest that power produced in each step of the COD task contributed to the improved COD ability.

Obviously, the complex EVT paradigm imposed offers a very powerful exercise stimulus to enhance COD ability. However, given the multiple-task characteristic of the EVT, the current results do not allow us to pinpoint what stimuli could be held responsible for the adaptations noted. Evidence about several challenges that might have affected functional performance outcomes can be found in the literature, for example, exercise tasks that produced eccentric overload,[17] unilateral training,[31] multidirectional movements (backward and/or forward and lateral directions),[26] and angle- or movement-specific tasks.[35] While this might present a limitation of the current study, it should be recalled we set out to explore the efficacy of a multitask program to enhance COD performance. In addition, the EVT provided vibratory stimulus, potentially aiding recovery and restoring muscle function between sets, which in turn could have enhanced the cumulative exercise-induced effects.

We acknowledge several limitations of the current study. Notwithstanding, to explore and eventually understand to what extent the imposed exercise challenges could explain adaptations to training, assessing eccentric strength and ground-reaction forces exerted in different axes during cutting maneuvers is necessary. Descriptive studies of this nature provide the foundation for subsequent mechanistic research challenges. While the young players examined here were trained, they were novice to advanced in-season high-intensity strength training. Thus, transfer of the current results to more experienced athletes should be exercised with caution. Further studies should assess the effects of multitask conditioning programs on reactive agility and other functional abilities (eg, kicking, throwing, or landing). Given our anecdotal data, and the finding of less absence from injury in trainees using flywheel ergometers compared with controls,[17] there is also a call for investigating EVT as an injury-prevention aid in experienced soccer players.

Practical Applications and Conclusion

In the real-world soccer-training environment, limited time is available for strength training and conditioning sessions during the in-season period. The search for time-efficient strategies that concurrently enhance several locomotive-specific actions while preventing injuries seems crucial. Given the highly dynamic and stochastic nature of soccer movements, there is a need to introduce more-challenging training methods that allow players to perceive affordances (possibilities of action) that may induce emergent behaviors for generating optimal movement synergies.[36] We therefore suggest differential training,[37] and/or variability[38] of practice principles must be introduced to enhance complex-skill efficiency in real game situations. Despite the fact that there was no change in the inertia and vibratory loading or exercise modalities used throughout the 11-week intervention, these and other variables (eg, unexpected events and loads, dynamic instability, antiphase movements) should be constantly manipulated. Using this approach, we believe that players may increase their ability to anticipate and/or react to a changing environment and hence optimize specific performance while potentially reducing risk of injury. In conclusion, the current "proof-of-principle" study showed that the unique EVT paradigm employed (a single weekly 25-min high-intensity session) improves COD ability. In addition, the strong relationship between changes in power and COD highlights the importance of applying reactive power—accelerating, decelerating, braking, and reaccelerating—throughout highly propulsive 45° CODs. Thus, gains in lower-body eccentric strength and power elicited by this regimen appear to be carried over to COD performance.

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