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“Effects of Resisted Sprint With Changes of Direction Training Through Several Relative Loads on Physical Performance in Soccer Players” by Rodríguez-Osorio, D, Gonzalo-Skok O, Pareja-Blanco F
International Journal of Sports Physiology and Performance

EFFECTS OF RESISTED SPRINTS WITH CHANGES OF DIRECTION THROUGH SEVERAL RELATIVE LOADS ON PHYSICAL PERFORMANCE IN SOCCER PLAYERS

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Abstract

Purpose: to compare the effects of resisted change of direction (COD) movements, using several relative loads, on soccer players' physical performance. **Methods:** Fifty-four male soccer players were randomly assigned to one of the following 3 groups, which differed only in the magnitude of the external load used during the COD training: COD training without external load (COD-0; n = 16); COD training with a 12.5% body mass (BM) external load (COD-12.5; n = 19); and COD training with a 50% BM external load (COD-50; n = 19). Participants performed the specific COD training twice per week for 6 weeks. Before and after the training period a battery of tests was completed: countermovement jump (CMJ); 30 m running sprint (time in 10-m [T_{10}], 20-m [T_{20}] and 30-m [T_{30}]); L-RUN test; and V-CUT test. **Results:** Within-group comparisons showed substantial improvements in CMJ and T_{10} (*likely*) in COD-0, whereas CMJ, T_{10} and T_{20} were substantially enhanced (*possibly to likely*) in COD-50. COD-12.5 induced substantial improvements in all analyzed variables (*likely to most likely*). Between-groups comparisons showed better effects on all analyzed variables for COD-12.5 compared to COD-0 group (*possibly to very likely*), whereas COD-50 only showed *possibly* better effects than COD-0 on T_{10}. In addition, COD-12.5 induced a better effect on L-RUN and V-CUT tests than COD-50 (*possibly to likely*). **Conclusions:** These results indicate that COD training, especially moderate load (12.5% BM) resisted COD training, may have a positive effect on COD skills, running sprint performance and jumping ability in young soccer players.

Keywords: resisted sprint training, strength training, speed, running sprint, vertical jump

1. Introduction

The physical abilities associated with accelerations, decelerations and rapid changes of direction (COD) are considered key components in the game demands of many team sports.[1] For example, a recent systematic review showed there are between 500 and 3000 changes of activity over the course of a normal soccer competition, or once every 2-4 s.[2] Furthermore, soccer studies show the most frequent action is cutting, which often exceeds 800 events per game.[2] Specifically, a total of 726 CODs were reported in a Premier League soccer game, with 609 of these being between 0º and 90º.[3] Thus, COD ability seems to be of crucial importance in soccer players. Consequently, the search for training methods to improve COD ability has been emphasized in recent years.

Several training strategies have been used to improve COD ability, including resistance training,[4,5] eccentric overload training,[6-8] and combined resistance training with COD training.[5,9] Although the above-mentioned training strategies can be effective, if a training strategy follows the principle of specificity, a greater positive transfer of training to athletic performance can be achieved if the conditioning program emphasizes similar motor patterns and contraction types to those used in actual games.[10] In this regard, resisted sprint training, such as sled towing and weighted vest training, is commonly performed to enhance sprinting performance.[10] In fact, there are several studies that have analyzed the effects of resisted sprint training on COD performance.[11,12] However, there is a lack of information about the influence of resisted COD movements on the ability to rapidly change direction.

One of the key concerns regarding resisted movements is the relative intensity used. Recently, heavy loads have been assessed to determine their impact on acceleration and maximal linear sprinting.[13,14] Even though low-to-moderate loads are effective in improving both acceleration and maximal speed,[10] heavy loads (30-80% of body mass, BM) may be important to achieve greater magnitude effects in acceleration.[14] However, to the best of our knowledge, no previous research has compared the training effects of resisted COD movements using different magnitudes of external loads in soccer players. Therefore, the aim of the current study was to examine the effects of resisted COD movements involving several relative loads on soccer players' physical performance. We hypothesized that resisted COD training would lead to superior improvement at COD, sprint and jump performance in comparison to unresisted COD training.

2. Methods

Participants

Fifty-four male soccer players (anthropometric measures provided in **Table 1**) volunteered to participate in this study. Athletes belonged to two club academy squads and the first squad of a club that competed in the third-to-top Spanish soccer division. All players had been training with a soccer club for at least 6 years and participated on average in ~10 hours of soccer training (5 sessions) plus 1 competitive match per week. Data collection took place during the sixth month (i.e., in the middle of the season) of the competitive season. Written informed consent was obtained from both the players and their parents before beginning the investigation. The current study was approved by the institutional research ethics committee and conformed to the recommendations of the Declaration of Helsinki.

Design

A randomized study design (A-B-B-A distribution) was used. Based on their ranked physical performance, players were divided into one of the following 3 groups, which differed only in the magnitude of external load used during COD training: COD training without external load (COD-0; n = 16); COD training with a 12.5% BM external load (COD-12.5; n = 19) or COD training with a 50% BM external load (COD-50; n = 19). All participants continued their normal soccer training sessions. Participants performed the specific change of direction training twice per week (72 h apart) over a 6-week period. All participants were tested before and after the 6 week training period to determine the effects of the 3 training interventions. Tests were completed in the following order: (a) anthropometric measures; (b) countermovement jump (CMJ); (c) 30 m running sprint; (d) L-RUN test; and (e) V-CUT test. Players were asked to not perform intense exercise on the day before testing and to consume their last meal at least 3 hours before the scheduled testing time. All sessions were fully supervised by a certified strength and conditioning specialist and were performed at the same time of the day for each participant. These sessions were carried out on an outdoor soccer field equipped with synthetic grass.

Testing procedures

Standing height and body mass were measured during these sessions (Seca 710, Seca Ltd., Hamburg, Germany). All tests were conducted during a testing session. Given that circadian rhythms can affect performance, testing times for each athlete were standardized for both baseline and post-testing sessions.[15] Strong verbal encouragement was provided to each participant during all testing sessions. Before testing, all participants carried out a standardized warm-up consisting of 5 min submaximal running at 9 km·h^{-1} followed by joint mobilization exercises and a specific warm-up for each test.

Countermovement Jump (CMJ) Test. Jump height was determined using an infrared timing system (OptojumpNext, Microgate, Bolzano, Italy). All participants were instructed to rest their hands on their hips while performing a downward movement followed by a maximal effort vertical jump. Additionally, they were instructed to land in an upright position and to bend the knees after landing. Three trials were completed with a 20 s rest between each trial. The mean of the 3 trials was then used for subsequent analyses. The standardized warm-up consisted of two sets of five submaximal jumps. Test-retest reliability measured by the coefficient of variation (CV) was 2.4%. The intraclass correlation coefficient (ICC) was 0.994 (95% confidence interval, CI: 0.991-0.996).

Running sprint. Participants performed two maximal, 30 m sprints, with a 3 min rest between sprints. Sprint times over 10, 20 and 30 m (T_{10}, T_{20} and T_{30}) were measured using photocells (Witty, Microgate, Bolzano, Italy). A standing start with the lead-off foot placed 0.5 m before the first timing gate was used. A standardized warm-up protocol that incorporated several sets of progressively faster 30 m running accelerations was followed. Two trials, separated by 3 min rest, were completed, and the best performance trial was used for further analysis. Test-retest reliabilities as measured by CV were 0.9%, 0.6% and 0.5% for T_{10}, T_{20} and T_{30}, respectively. The ICC values were 0.987 (95% CI: 0.978-0.993) for T_{10}, 0.993 (95% CI: 0.988-0.996) for T_{20}, and 0.996 (95% CI: 0.994-0.998) for T_{30}.

L-RUN test. Three cones were placed 5 m apart in an "L" shape. Players started in the standing position and were required to run forward 5 m, then turn to their left, run forward 5 m, then turn 180°, and follow the same course to return to the start/finish line.[16] The test was completed when the participant crossed the start/finish line. The cones used were 1.2 m in height. Players were instructed to run as quickly as possible along the "L". The warm-up protocol consisted of one submaximal trial. Two trials, separated by 3 min rest, were completed, and the best performance trial was used for further analysis. Times were registered through timing gates (Witty, Microgate, Bolzano, Italy). The front foot was placed 0.5 m before the first timing gate at the beginning of the test. The CV for test-retest reliability was 2.3% and the ICC was 0.981 (95% CI: 0.970 to 0.989).

V-CUT test. Players performed a 25 m sprint with 4 changes of direction, one every 5m, of 45°.[17] For the trial to be valid, players had to cross a line, drawn on the floor, with one foot completely at every turn. If the trial was considered unsatisfactory, a new trial was allowed. The distance between each pair of cones was 0.7 m. The warm-up protocol consisted of one submaximal trial. Two trials, separated by 3 min rest, were completed, and the best performance trial was used for further analysis. Times were registered using timing gates (Witty, Microgate, Bolzano, Italy). The front foot was placed 0.5 m before the first timing gate at the beginning of the test. The CV for test-retest reliability was 0.6% and the ICC was 0.991 (95% CI: 0.985-0.994).

Training Protocol

Training took place twice per week, always in the afternoon (6–8 PM), over a period of 6 weeks, and was performed before the specific soccer training session. Each session lasted around 20 min and consisted of the following components: 10 min of standard warm-up (5 min submaximal running at 9 $km \cdot h^{-1}$ and 5 min of joint mobilization exercises and a specific warm-up consisting of several submaximal changes of direction) and 10 min of the main exercise. Each player trained with the load previously determined, according to the load group to which the player had been assigned (0 vs. 12.5 vs. 50% of BM). This load was added using a weighted vest (Surreal, London, UK). Training sessions consisted of 3–5 repetitions of V-CUT tests (weeks 1 and 2: 3 repetitions; weeks 3 and 4: 4 repetitions; and weeks 5 and 6: 5 repetitions), always at maximal effort, with 3 minutes of recovery time. The training was performed using the V-CUT pathway in order to standardize the between-group training conditions (total distance covered, number of CODs, COD angles, distance between CODs). Strong verbal encouragement was provided to each player in all sets.

Statistical Analysis

Values are expressed as mean ± standard deviation (SD). The normality of distribution of the variables and the homogeneity of variance across groups were verified using the Shapiro-Wilk test and Levene's test, respectively. Effect sizes (ES) were calculated using Hedge's g on the pooled SD and 90% confidence limits (CL) were calculated for all dependent variables.

Probabilities were also calculated to establish whether the true (unknown) differences were lower, similar or higher than the smallest worthwhile difference or change (0.2 x between-subject SD).[18] Quantitative chances of *better* or *worse* effects 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%, most likely.[15,16] If the chances of obtaining *beneficial/better* or *detrimental/worse* were both >5%, the effect was assessed as *unclear*.[19,20] Inferential statistics based on the interpretation of magnitude of effects were calculated using a purpose-built spreadsheet.[21] A post hoc power analysis was calculated using the G Power software (version 3.1.9). Using an ES set at 0.20, a correlation between measures set at 0.50 for a sample size of 54, the statistical power was 0.80.

3. Results

No substantial between-group differences were found at pre-test for any of the variables analyzed. Only those players who complied with at least 85% of all training sessions were included in the statistical analyses. Due to injury or illness, four players missed too many training sessions or were absent from the post testing session. Thus, of the 58 initially enrolled players, 54 players remained for statistical analyses. Changes in performance variables from pre- to post-training for each group are presented in **Table 2**.

Vertical jump test

The magnitude-based inferences approach is reported in **Figure 1**. COD-0, COD-12.5 and COD-50 groups attained substantial (*likely to most likely*) improvements in CMJ height (**Fig. 1**). In addition, COD-12.5 induced a *possibly* better effect on CMJ height than COD-0 group, whereas the other between-groups comparisons did not show any substantial differences (**Fig. 2**).

Running sprints

COD-0 group only showed a very *likely* positive effect on T_{10}, whereas COD-50 showed a *very likely/possibly* positive effect on T_{10} and T_{20}. Likewise, COD-12.5 induced a *most likely/ possibly* positive effect on T_{10} and T_{20}, together with a *likely* positive effect on T_{30}. In addition, COD-12.5 showed *possibly* better effects on T_{10}, T_{20} and T_{30} compared to COD-0 group, whereas COD-50 only induced a *possibly* better effect on T_{10} than COD-0 group (**Fig. 2**). No substantial differences were observed between COD-12.5 and COD-0 in running sprint variables.

L-RUN test

The magnitude-based inferences approach showed a *likely* positive effect on L-RUN performance for the COD-12.5 group, whereas *possibly negative/unclear* effects were observed for COD-0 and COD-50 groups, respectively (**Fig. 1**). Between-groups comparisons showed a better effect on L-RUN performance for COD-12.5 compared to COD-0 and COD-50 groups (*very likely* and *possibly*, respectively), whereas no substantial differences were observed between COD-0 and COD-50 groups (**Fig. 2**).

V-CUT test

Practical worthwhile differences between groups seemed evident as supported by the magnitudes of the ES and qualitative outcomes (**Fig. 1**). The COD-12.5 group showed *most likely* positive effects on V-CUT performance, whereas the other two groups showed *very likely* trivial effects. In addition, COD-12.5 induced a *likely* better effect on V-CUT test than COD-0 and COD-50 groups, whereas no substantial differences were observed between COD-0 and COD-50 groups (**Fig. 2**).

4. Discussion

To our knowledge, this is the first study to analyze the effects of resisted COD movements, using several relative loads, on jump, sprint and COD performance. The main finding of this study is that COD training with a 12.5% BM external load (COD-12.5) produced greater improvements in soccer players' physical performance, mainly in COD skills, than COD training either without an external load (COD-0) or with a 50% BM external load (COD-50). In addition, COD training was linked to both linear sprinting and vertical jumping improvements.

Despite the relevance of COD ability to athletic performance[1] overall in team sports, there is a lack of information about the influence of resisted COD movements on the ability to rapidly change direction. COD ability is certainly multifactorial and dictated by linear running speed, strength/power, anthropometry and other neuromuscular features such as running technique.[22] Recently, heavy load (~80% BM) resisted sprint training has been recommended to improve both acceleration and maximal linear sprinting, since it allows athletes to produce higher force in a forward-oriented body position throughout sprinting.[13,14] However, the effect of heavy load COD training is unknown. In the present study, only the COD-12.5 group showed a beneficial impact on COD performance following the training period, assessed in this case by V-CUT and L-RUN tests. It is worth noting that both the COD-0 and COD-50 groups showed no positive effect on COD performance. In this regard, it is worth recalling that all groups performed a theoretical strength-specific training, since the training consisted of performing several sets of the V-CUT test, which requires players to accelerate, decelerate, brake, and reaccelerate while changing direction 4 times at a 45° angle. Therefore, our findings suggest that the magnitude of the overload employed in resisted COD training may influence the training-induced adaptations. Spiteri et al.[23] suggested that a greater braking impulse contributes to both the storage and utilization of elastic energy during COD tasks, improving the propulsive ability and allowing a rapid reacceleration in the new direction. In this sense, future studies should analyze which loads used during COD skills training allow athletes to apply higher horizontal forces in each step, and higher levels of braking and propulsive force. To sum up, our findings strongly recommend the inclusion of resisted COD training with moderate loads (12.5% BM), since this training provided greater gains in COD performance than either heavy (COD-50) or no external load (COD-0).

As has been previously mentioned, heavy load resisted sprint training has recently been suggested as an effective stimulus for improving both sprinting and acceleration.[24] In this regard, while beneficial positive effects (small to moderate ESs) have been found in 5 and 20 m sprint performance after an 8-week heavy-load sled towing program (80% BM), no substantial improvements were achieved after the same volume of a non-resisted training program.[14] Our findings seem to partly support this hypothesis, since the unresisted training group (COD-0) only showed improvements in T_{10}, whereas the resisted COD training groups (COD-12.5 and COD-50) improved sprinting performance over all distances analyzed (T_{10}, T_{20} and T_{30}). Therefore, it seems that both moderate (12.5% BM) and heavy (50% BM) overloads during COD training require more horizontal force application and horizontal impulses in comparison with unresisted COD training (0% BM), which may induce greater gains in sprinting performance. Interestingly, it seems possible that resisted COD training induces gains in areas other than COD performance, since linear sprinting was also enhanced. In consequence, resisted COD training could be used as part of a systematically varied and multidirectional training program for athletes who need to develop both COD and linear sprinting performance.

Interestingly, although no specific vertical jump training was performed, all training groups improved their CMJ performance. COD-12.5 induced a *most likely* positive effect on CMJ height, whereas COD-0 and COD-50 attained a *likely* positive effect (**Fig. 1**). The present results thus indicate that 6 weeks of COD training had a beneficial impact on jumping performance. Previous studies have found CMJ height improvements after resisted sprint training (12.5-20% BM).[12,25,26] This could be explained by the fact that the "explosive force" of leg extensor muscles has traditionally been closely related to jumping and acceleration.[26,27] This finding has significant practical applications since it seems that COD training, especially moderate load (12.5% BM) resisted COD training, could provide a practical way to develop both specific force output (COD skills) and the ability to orient this force output with effectiveness (running sprint and jumping ability).

5. Practical Applications

In a soccer-training environment, there is limited time available for strength and conditioning training. Time-efficient strategies that concurrently enhance several specific actions are crucial. We therefore suggest that moderate load (12.5% BM) resisted COD training may allow players to develop behaviors that generate optimal movement synergies (simultaneous force-vector improvements). Using such an approach, soccer players could concurrently increase their performance in COD, sprinting and jumping. Finally, considering that the approach applied in this study was of short duration, it could easily be included twice a week before technical-tactical soccer training.

6. Conclusions

The lack of quantification of training load may be a study limitation. However, players were randomly assigned to one of three groups and all of them continued their normal soccer training sessions. Despite this possible limitation, our results indicate that COD training, especially resisted COD training performed with moderate loads (12.5% BM), may have a positive effect on COD skills, sprinting performance and jumping ability in soccer players.

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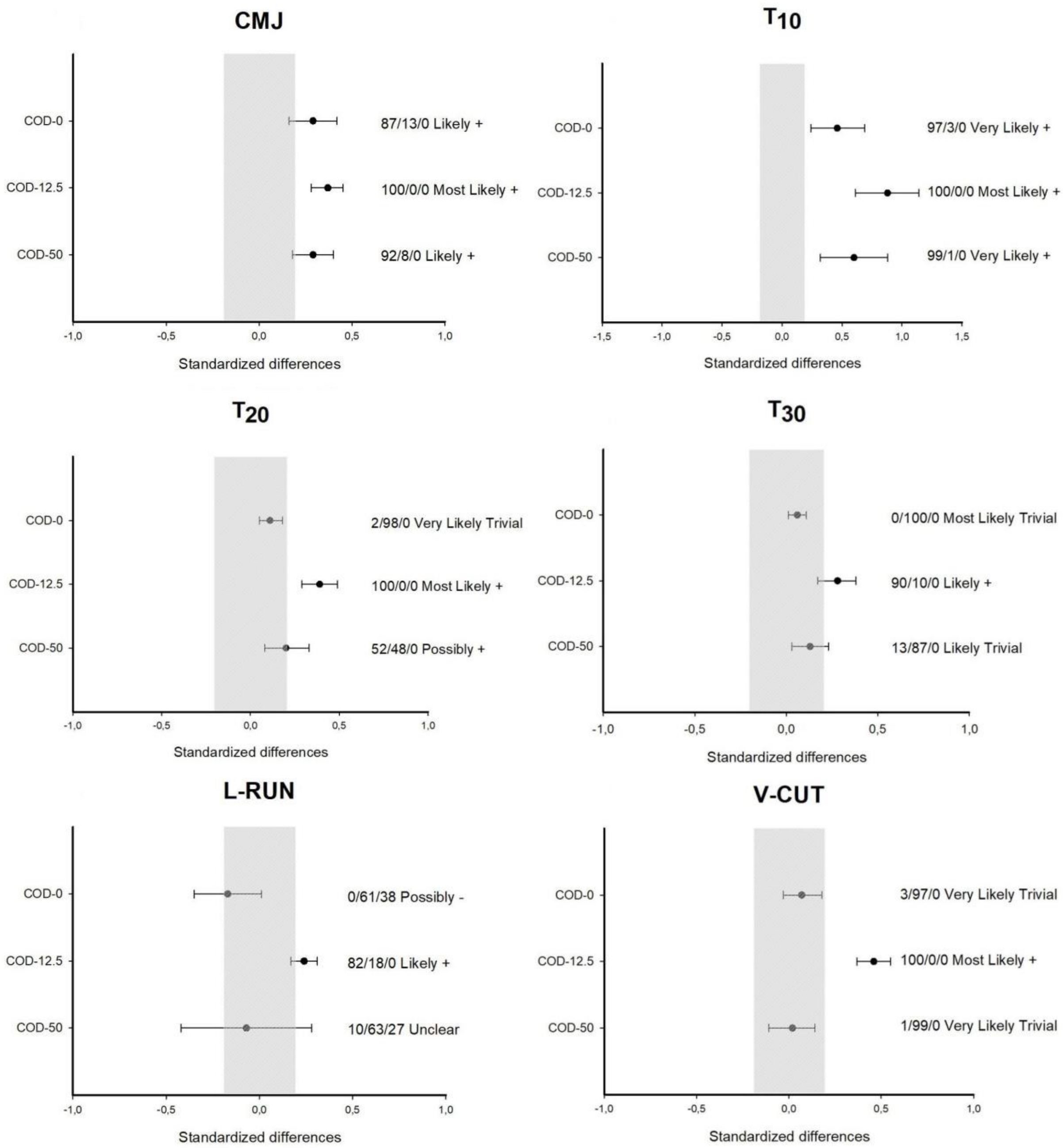

Figure 1. Intra-group changes for the change of direction training without external load group (COD-0; n = 16); the change of direction training with 12.5% body mass of external load group (COD-12.5; n = 19); and the change of direction training with 50% body mass of external load group (COD-50; n = 19) in: countermovement jump (CMJ); 10 m sprint time (T_{10}); 20 m sprint time (T_{20}); 30 m sprint time (T_{30}); change of direction running test with the shape of L (L-RUN); change of direction running test with the shape of V (V-CUT). Bars indicate uncertainty in the true mean changes with 90% confidence intervals. Trivial (shaded) areas were calculated from the smallest worthwhile change. Note: the percent values indicate the likelihood of each experimental manipulation having a positive, trivial, or negative effect. A reduction of time in the running variables was interpreted as a positive effect.

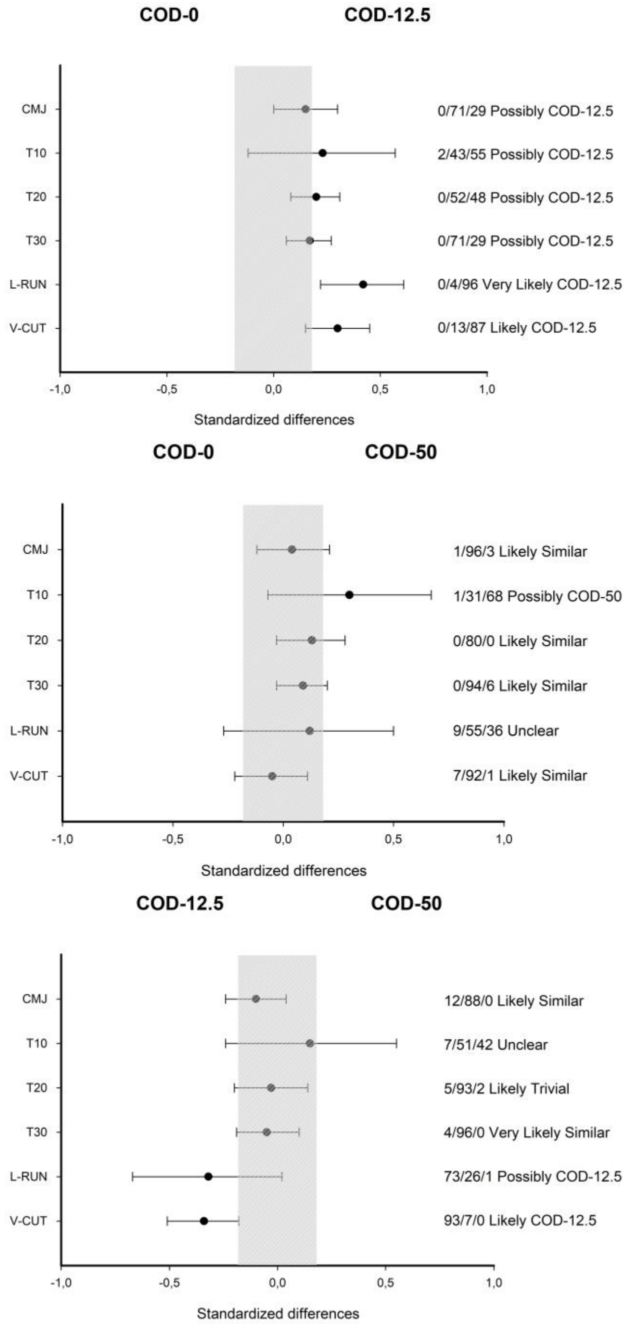

Figure 2. Between-group comparisons for countermovement jump (CMJ), 10 m sprint time (T_{10}), 20 m sprint time (T_{20}), 30 m sprint time (T_{30}), change of direction running test with the shape of L (L-RUN) and change of direction running test with the shape of V (V-CUT). Change of direction training without external load group (COD-0; n = 16); change of direction training with 12.5% body mass of external load group (COD-12.5; n = 19); and change of direction training with 50% body mass of external load group (COD-50; n = 19). Bars indicate uncertainty in the true mean changes with 90% confidence intervals. Trivial (shaded) areas were calculated from the smallest worthwhile change. Note: the percent values indicate the likelihood of having a beneficial/better, similar, or detrimental/poorer effect for the first group compared with the second group (i.e., COD-0 vs. COD-12.5). A reduction of time in the running variables was interpreted as a positive effect.

Table 1: Age, height, and body mass of the three groups.

	COD-0	**COD-12.5**	**COD-50**
Age (yr)	17.8 ± 4.2	18.8 ± 5.3	17.7 ± 3.4
Height (cm)	164.8 ± 4.0	174.2 ± 8.1	173.5 ± 6.1
Body mass (kg)	64.7 ± 9.2	63.9 ± 11.5	63.2 ± 8.1

Data are mean ± SD, N = 54; COD-0: change of direction training without external load (n = 16); COD-12.5: change of direction training with 12.5% body mass of external load (n = 19); COD-50: change of direction training with 50% body mass of external load (n = 19).

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Table 2: Changes in selected neuromuscular performance variables from pre- to post-training for each group.

	COD-0			COD-12.5			COD-50		
	Pre	**Post**	**Change Score (%)**	**Pre**	**Post**	**Change Score (%)**	**Pre**	**Post**	**Change Score (%)**
CMJ (cm)	33.9 ± 5.1	35.4 ± 4.6	5.1 ± 5.4	32.6 ± 6.5	35.1 ± 6.5	7.9 ± 5.2	32.3 ± 5.9	34.2 ± 5.4	6.2 ± 6.0
T_{10} (s)	1.79 ± 0.10	1.74 ± 0.10	-2.6 ± 2.9	1.83 ± 0.07	1.76 ± 0.10	-3.7 ± 2.8	1.82 ± 0.13	1.73 ± 0.09	-4.3 ± 4.9
T_{20} (s)	3.10 ± 0.17	3.08 ± 0.18	-0.7 ± 0.9	3.15 ± 0.12	3.10 ± 0.13	-1.6 ± 1.0	3.13 ± 0.22	3.08 ± 0.18	-1.4 ± 2.1
T_{30} (s)	4.33 ± 0.27	4.31 ± 0.28	-0.4 ± 0.7	4.39 ± 0.20	4.33 ± 0.21	-1.3 ± 1.2	4.37 ± 0.32	4.32 ± 0.29	-1.0 ± 1.8
L-RUN (s)	5.87 ± 0.25	5.92 ± 0.27	0.8 ± 1.8	5.90 ± 0.25	5.84 ± 0.24	-1.0 ± 0.8	5.91 ± 0.22	5.93 ± 0.24	0.3 ± 3.4
V-CUT (s)	7.04 ± 0.32	7.02 ± 0.34	-0.4 ± 1.2	6.98 ± 0.23	6.87 ± 0.24	-1.6 ± 0.7	7.11 ± 0.34	7.11 ± 0.34	-0.1 ± 1.6

Data are mean ± SD, N = 54. Change score is expressed as mean ± SD. COD-0: change of direction training without external load (n = 16); COD-12.5: change of direction training with 12.5% body mass of external load (n = 19); COD-50: change of direction training with 50% body mass of external load (n = 19). CMJ: countermovement jump; T_{10}: 10 m sprint time; T_{20}: 20 m sprint time; T_{30}: 30 m sprint time; L-RUN: change of direction running test with the shape of L; V-CUT: change of direction running test with the shape of V.