Effects of 8 weeks in-season flywheel training on physical performance in female soccer players

Efectos de 8 semanas de entrenamiento flywheel durante la temporada sobre el rendimiento físico en jugadoras de fútbol

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How to cite in APA

González Alcántara, J. A., Núñez González, J. L., Valenzuela Barrero, C., & Núñez Sánchez, F. J. (2025). Effects of 8 weeks in-season flywheel training on physical performance in female soccer players. *Retos*, *66*, 479–490. https://doi.org/10.47197/retos.v66.111034

Abstract

Objective: The aim of this study was to analyze the effects of an 8-week in-season rotary inertia device (RID) training program on change of direction (COD) performance and the reduction of the unilateral deficit between legs in semi-professional female soccer players.
Methodology: 32 semi-professional female soccer players were divided into an experimental group (EG, n=16) and a control group (CG, n=16). All players participated in 3 soccer-specific training sessions per week, each lasting an hour and a half, in addition to their weekly league matches. The EG performed two training sessions per week using rotary inertia devices, while the CG did not perform any additional resistance training program during the 8-week intervention period.
Results: Time in the V-cut test, 10m and 20m curved sprints to the right (CSHr and CSFr, respectivelly), and to the left (CSHl and CSFl, respectivelly), time in 10 m (T10) and 20 m (T20) linear sprint test were assessed. In the sprint test, the time difference between CSHr-CSHl and between CSHr-CSHl was calculated. There is a significant reduction in the unilateral CSHr-CSHl deficit of the EG with respect to the CG (p-value=0.015; SE=0.375).
Conclusions: In conclusion, the use of this type of exercises carried out with rotary inertia resistance (frontal movements and lateral movements with rotary inertia devices) have achieved the balance of the unilateral deficit in a curved sprint task during 8 weeks of training in a group of semi-professional female soccer players.

Keywords

Change of direction; eccentric training; rotary inertia devices; unilateral deficit.

Resumen

Objetivo: El objetivo de este estudio fue analizar los efectos de un programa de entrenamiento con dispositivos inerciales rotatorios a lo largo de 8 semanas durante la temporada sobre el rendimiento del cambio de dirección (COD) y la reducción del déficit unilateral entre ambas piernas en jugadoras de fútbol semiprofesional.
Metodología: 32 jugadoras de fútbol semiprofesional fueron divididas en un grupo experimental (GE, n=16) y en un grupo control (GC, n=16). Todas las jugadoras participaron en 3 entrenamientos específicos de fútbol por semana de una hora y media de duración, además de sus partidos de liga semanales. El GE realizó dos sesiones de entrenamiento por semana con dispositivos inerciales rotatorios, mientras que el GC no realizó ningún programa adicional de entrenamiento de fuerza durante las 8 semanas del periodo de intervención.
Resultados: El tiempo en el test V-cut, el sprint en curva de 10m y 20m a derecha (SCMd y SCFd, respectivamente), y a izquierda (SCMi y SCFi, respectivamente), y el tiempo en 10 m (T10) y 20 m (T20) lineal fueron evaluados. En la prueba de sprint se evaluó la diferencia de tiempo entre SCMd-SCMi y entre SCFd-SCFi. Existe una reducción significativa del déficit unilateral de SCMd-SCMi del GE con respecto al GC (p-valor=0.015; TE=0.375).
Conclusiones: En conclusión, el uso de este tipo de ejercicios realizados con resistencia inercial rotatoria (movimientos frontales y movimientos laterales con dispositivos inerciales rotatorios) han conseguido el equilibrio del déficit unilateral en una tarea de sprint en curva durante 8 semanas de entrenamiento en un grupo de jugadoras semiprofesionales de fútbol.

Palabras clave

Cambio de dirección; entrenamiento excéntrico; dispositivos inerciales rotatorios; déficit unilateral.

Introduction

Women's soccer has developed exponential growth recently across all areas: conditional level, specialization of the professionals that take part into the clubs, greater audiovisual and socioeconomic impact (Okholm Kryger et al., 2022). In the conditional area, the main factors that contribute performance are technical, tactical and physical abilities, essentially of an intermittent nature (explosive actions such as sprinting, jumping, accelerating, decelerating or changing direction) which seem to influence performance (Romero Boza et al., 2015) and the results of the matches (Mujika et al., 2009). Regarding sprint actions, the distance performed in a sprint represents 6’5% of the total distance performed by soccer players (Mohr et al., 2003), and between 83 and 88% of them involve a change of direction (COD) from the initial movement in most player positions (Caldbeck, 2019).

Change of direction (COD) is defined as the ability to decelerate, change of direction and reaccelerate and it is a determining factor in sports performance in soccer (Sánchez-López et al., 2023). COD is a complex motor capacity that is really important in team sports, especially in soccer, allowing players to perform specific actions such as pressing in defensive tasks or dribbling in an offensive action (Gonzalo-Skok, 2015). Within these CODs, we can differentiate: on the one hand, those that are carried out through a sudden deceleration of the soccer player’s movement to subsequently accelerate in a different direction (Chaabene et al., 2018), and, on the other hand, the curved sprint, defined as a sprint with a gradual and continuous COD throughout the movement (Fílter et al., 2020a). In fact, COD performance is associated with greater eccentric strength in female soccer players, as stronger players are better able to decelerate during penultimate contact from faster approach velocities (Jones et al., 2017). So that the importance of COD lies more if possible in women’s soccer, because the success in achieving this type of physical demands will mean a decrease in injury risk in general and ligaments and ACL (anterior cruciate ligament) in particular, in addition to provide greater performance on the field (Mancini et al., 2021). COD movements are associated with non-contact ACL injuries in multidirectional sports and females appear at increased risk compared to males, which could be attributable to whole body kinematic strategies and greater multiplanar knee joint loads during COD which can increase ACL loading (Donelon et al., 2024). In order to reduce the prevalence of this injury in this population, improving COD technique could help reduce injury burden, as ACL injuries are 4.52 times more frequent in women’s soccer than in men’s soccer (Larruskain et al., 2017). That is why this capacity is essential in resistance training in women’s soccer.

Linear sprints, CODs and curved sprints are often considered similar accelerations actions, but several studies showed that they are different capacities (Young et al., 2001; Fílter et al., 2020b). For instance, while the contact time in the curved sprint varies between legs, in the linear sprint this contact time is the same, due to the fact that the degree of turn decreases (Fílter et al., 2020b). In line with this, Filter et al. (2020) confirmed that inside leg of the curve (IL) showed a longer contact time than outer leg of the curve (OL) during a curve sprint. However, this study showed that players who run faster in linear sprints were not necessarily faster in curvilinear trajectories (Filter et al., 2020c). In fact, this research showed that some soccer players had similar performance during the sprint in a curve towards his ‘good’ side than in the linear sprints, with significant differences with the sprint in a curve towards his ‘weak’ side (Filter et al., 2020c). In this sense, they showed a significant difference between IL of the ‘good’ and ‘weak’ side, while OL was barely affected (Filter et al., 2020c). Given that the IL possibly plays a determining role in limiting the maximum running speed during curvilinear sprints, each player must develop a training process that optimizes their sprint capacity in a curve towards their good side in order to achieve their maximum performance (Loturco et al., 2020). On the other hand, this situation will generate a unilateral deficit with the IL of the curve towards their weak side, which could be an injury risk factor (Fílter et al., 2021). Thus, soccer coaches are strongly recommended to include specific curved sprint training routines, especially for the purpose of enhancing the mechanical efficiency of the IL (i.e., increase its ability to apply greater forces in shorter contact times), and try to reduce the unilateral deficit in the curved sprint like key determining factors for performance (Fílter et al., 2020b). The unilateral deficit is the difference or decompensation that exists between one leg and the other, between the same muscle groups of different limbs or muscle groups of the same limb (Núñez et al., 2018). On this matter, players who have a good functional balance between one side and the other are able to move more efficiently and accurately on the field, reducing injury risk and improving their performance during the game (Hart et al., 2016).

Currently, the use of resistance provided by rotating inertial devices (RID) is one of the most widely used training methods to improve eccentric performance of the muscle (Núñez & De Villarreal, 2017). These devices produce resistance by counteracting the athlete's effort with the inertial strength generated by a rotating axis (Norrbrand et al., 2008). During the concentric phase, the axis of these devices unwinds and rotates the pulley in one direction, after the end of this action, the pulley finishes unwinding to wind up again of its axis, occurring the eccentric phase here (Hart et al., 2016). When we allow for a short pause of not resisting immediately after completion of the concentric action, a sudden steep rise in force will occur while attempting to stop the movement at the end of ECC phase, and produce eccentric overload (Núñez et al., 2020). The relationship between unilateral RID training and improvements in COD (Núñez et al., 2018; Tous-Fajardo et al., 2016; De Hoyo et al., 2015), as wells as the reduction of muscle imbalances (Núñez et al., 2020) in soccer has been widely studied. Flywheel devices are improving performance in female population, affecting muscular adaptation in well trained female athletes (Wang et al., 2024). In fact, these types of devices are being used to improve eccentric strength in professional female soccer players, but not soccer-specific abilities like change of direction (Pecci et al., 2022). Consequently, the aim of this study was to analyze the effects of an 8-week in-season RID training program on COD performance and the reduction of the unilateral deficit between legs in semi-professional female soccer players. Our hypothesis was that 8 weeks of resistance training with rotary inertia devices would significantly improve the COD and reduce the unilateral deficit values.

Method

In this cohort study, a quantitative quasi-experimental design was carried out with the objective of analyzing the effects of training with rotary inertia devices (RID) on performance in sprint (ST), curved sprint (CS), change of direction (COD) and unilateral asymmetry in female soccer players. These variables were measured before (pre-test) and after (post-test) the complete training cycle.

Participants

Thirty-two semi-professional women soccer players participated voluntarily in this research. None of the participants had prior experience with resistance training using RID. The players were randomly divided into two groups: an experimental group [EG (n=16); mean ± SD: 21.24 ± 2.57 years, 70.87 ± 8.68 kg; 1.69 ± 0.1 meters and 6.8 ± 2.43 years of soccer practice] and in a control group [CG (n=16); mean ± SD: 24.21 ± 5.69 years, 58.5 ± 8.41 kg; 1.61 ± 0.08 meters and 7.12 ± 4.68 years of soccer practice]. All the players participated in 3 soccer-specific training sessions per week lasting an hour and a half, to which was added one weekly league match.

Injured players or those with some types of illness or circumstances that prevented them from participating in 90% of the training sessions were excluded from participating in the research. After finishing the training period, the total number of players used for the analysis was fifteen, 5 of them belonging to the EG (mean ± SD: 20.33 ± 1.86 years, 71.83 ± 10.09 kg, 1.67 ± 0.04 meters y 6.5 ± 2.17 years of soccer practice) and 10 to the CG (mean± SD: 23 ± 4.42 years, 58.1 ± 7.31 kg, 1.62 ± 0.06 meters y 6.9± 4.51 years of soccer practice). The decrease in the number of subjects was caused by: 1) Injury or illness with ongoing research; 2) Failure to attend established training sessions; 3) Withdraw of soccer practice.

In this case, due to operational reasons and ease of access to the sample, participants were selected by casual non-random sampling and the data that was collected was anonymized. All subjects were informed about the potential risks and benefits of participating in the research and they gave their written informed consent in accordance with current national and international laws and regulations governing the use of human beings in research (Declaration of Helsinki II). The study was approved by the Virgen Macarena and Virgen del Rocío University Hospitals ethics committee (0398-N-17).

Procedure

Subjects performed the tests in the following order: 20-meter linear sprint and COD test (V-cut) on one day and curved sprint to both sides (first to the right and second to the left) on the following day, all of them carried out in the same week. The two tests that were performed on the same day had a recovery period of approximately 3-5 minutes. The players had a familiarization period with the tests done to avoid possible effects of learning and thus ensure the correct technique. All measurements were made at the same time (20:30 hours ± 30 minutes), on the same surface (third generation artificial grass) and under similar weather conditions (no rain, no wind and similar atmospheric temperature). Prior to carrying out these tests, a standardized warm-up part was done, consisted in 2 minutes of slow running, dynamic stretching of the main muscle groups and 1 series of: 10 repetitions of squats (body weight), 5 repetitions of counter movement jump (CMJ), 4 repetitions of dynamic accelerations and decelerations in a circle; 4 repetitions of bipodal and monopodal landings, 20 seconds of front plank and 15 seconds of lateral plank to each side; 3 progressive series of accelerations of 20 meters (70%, 80%, 90% of the maximum speed subjectively by each player). This warm up was identical in all the measurements and we did it due to the fact that in this way, the main muscles that were later going to be used in the tests were warmed-up. Participants were verbally encouraged during all test trials to exert maximal intentional effort.

Linear sprint

Two 20-meter sprints were performed, separated by a 3-minute passive rest. The best attempt was selected for analysis, that is, the one that the subject completed in the shortest time. Wireless photocells (Polifemo Radio Light, Microgate, Bolzano, Italy) were placed at 0, 10 and 20 meters. The starting position was upright, with one foot forward and located 1 meter behind the first photocell, without allowing initial oscillations to facilitate the initial contact. Once the sprint start was given, the subject could start it whenever she felt ready, so she did not have to react to any audible signs.

Players were asked to exert maximum effort on both attempts. The warm-up protocol was the indicated previously, so that this was the first test that was carried out. In addition to the pre-test and post-test, this linear sprint test was carried out weekly in order to analyze the evolution of T10 and T20 variables throughout the entire process.

Change of direction

The test selected to evaluate the COD was the V-cut (7). In this test, players performed a 25-meter sprint with 4 CODs of 135º every 5 meters. For the test validation, players had to step with one foot on an imaginary line established by the cones. The distance between each pair of cones was 0'7 meters. For the measurement, wireless photocells (Polifemo Radio Light, Microgate, Bolzano, Italy) were used, which were placed on the start and finish lines. The starting position was upright, with one foot forward and located 1 meter behind the first photocell, without allowing initial oscillations to facilitate the initial contact. Once the sprint start was given, the subject could start it whenever she felt ready, so she did not have to react to any audible signs.

Each player made two attempts separated by 3 minutes of passive recovery and the best of them was selected for analysis. All the players performed two submaximal repetitions (70 and 80% of the maximum speed subjectively by each player) as a specific warm-up for the test.

Curved sprint

The trajectory used in this test was the arc line of the penalty area (Fílter et al., 2020b). Two 17-meter curved sprints were performed to the right and another 2 to the left, separated by a 3-minute passive rest, selecting the best attempt towards each of the sides for analysis. Wireless photocells (Polifemo Radio Light, Microgate, Bolzano, Italy) were placed at 0, 8'5 and 17 meters, which allowed obtaining data from 0-half of the test and 0-end of the test. The starting position was upright, with one foot forward and located 1 meter behind the first photocell, without allowing initial oscillations to facilitate the initial contact. Once the sprint start was given, the subject could start it whenever she felt ready, so she did not have to react to any audible signs. Players were asked to make a maximum effort in both attempts and were told that they needed to sprint over the line, otherwise the test would not be considered as valid. Each player performed two submaximal repetitions (70 and 80% of maximum speed subjectively by each player) to each side as a specific warm-up for the test.

Unilateral deficit

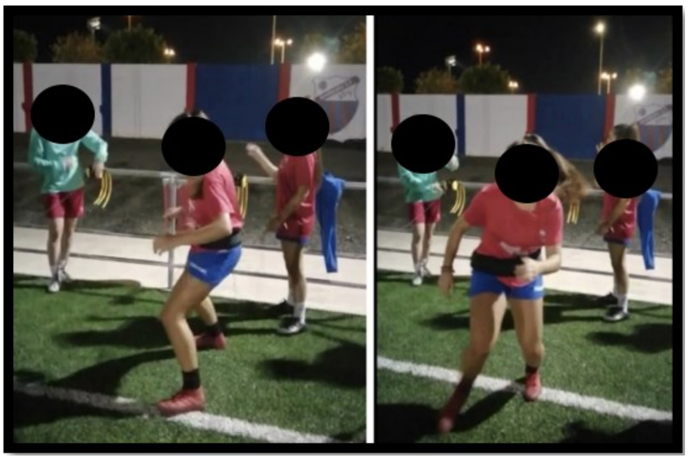
Unilateral deficit in the curve sprint is the difference or decompensation that exists between one leg and the other, between the same muscle groups of different limbs or muscle groups of the same limb (Núñez et al., 2018). For this study, we calculated unilateral deficit based on percentages (positive or negative in relation to which side was faster) between sides. We assume that the curved sprint to the right was the faster side in each subject and percentages differences between curved sprint to the right and to the left were calculated (half and final sprints). For this reason, there are two data: curved sprint half and curved sprint final. The differences between each one was the unilateral deficit.

Training program

Participants completed an 8-week training program using RID (Handy Gym PRO, Vigo, Spain). The program consisted of 2 sets of 6 repetitions per leg for 2 exercises (2 discs of 120 grams in each device, with an inertia of 90 lb/in^2 per disc): the front step (Figure 1) and the crossed lateral step (Figure 2). During execution, the player had to apply force at the maximum intentional speed during the concentric action, as well as brake the rotation of the axis (when going backwards) to brake in the last third of the movement, all of this allowing them to exert more force on the following concentric action when accelerating. They rested passively 2 minutes between series. Subjects performed 2 sessions per week with more than 48 hours of recovery between sessions. Before the training sessions, the same warm-up protocol carried out in the measurements was done. Prior to the specific soccer training, the sessions were done with a duration of 15 minutes approximately. Before the training period, a familiarization session with the rotary inertia devices was carried out, to make sure the principles of execution.

Figure 1. Front step exercise.

Figure 2. Crossed lateral step exercise.



Data analysis

Data is presented as the mean ± SD (standard deviation or typical deviation). Before performing the relevant statistical analyses, we tested the data distributions using a Shapiro Wilk normality test. For this analysis, a 2 x 2 mixed ANOVA was carried out, with a factor between groups (Group) with two levels (experimental, control) and an intragroup factor (Time) with two levels (pretest and postest). In case that there was a Time x Group interaction, or at least an effect of Time, we compared different pairs using a post-hoc analysis with Bonferroni adjustment. In the week-by-week sprint analyses, a 1 x 9 repeated measures ANOVA was carried out, adjusting the post-hoc analyses with Bonferroni. The effect size (ES) of the selected variables were calculated using Hedges' g. For these analyses, we used the statistical package SPSS version 29.0 (SPSS, Inc. Chicago, IL).

Results

The comparison of intergroup and intragroup data for the different variables is found in Table 1. In the intergroup analysis, there is a significant reduction in the unilateral CSHr-CSHl deficit of the EG compared to the CG (p-value=0.015; ES=0.375). In the intragroup analysis, we found that the EG significantly decreases its performance in the CSHl (5.53%; ES=0.372), T10 (5.02%; ES=0.442) and T20 (2.91%; ES=0.384) variables. This group increases performance with signs of significance in CSHr (p=0.08; ES=0.384), as well as there is a significant decrease in the unilateral CSHr-CSHl deficit (8.73%; ES=0.308). Likewise, we also found in the CG a significant performance decrease in T10 (3.85%; ES=0.468) and T20 (3.09%; ES=0.564) variables, as well as a significant increase in the unilateral CSHr-CSHl deficit (36.3%; ES=0.308).

Table 1. Changes in the physical performance variables assessed. Values presented as mean ± SD.

	EG				CG			
	Pretest	Postest	ES	p-value	Pretest	Postest	ES	p-value
V-Cut (s)	7.598 ± 0.508	7.568 ± 0.468	0.015	0.666	7.211 ± 0.443	7.192 ± 0.447	0.018	0.631
CSHl (s)	1.706 ± 0.142	1.806 ± 0.159[a]	0.372	0.016	1.732 ± 0.109	1.720 ± 0.067	0.017	0.646
CSHr (s)	1.920± 0.155	1.802 ± 0.143	0.217	0.080	1.735± 0.149	1.712 ± 0.111	0.028	0.548
CSFl (s)	3.222 ± 0.265	3.224 ± 0.228	0	0.961	3.110 ± 0.212	3.088 ± 0.176	0.043	0.457
CSFr (s)	3.282 ± 0.268	3.276 ± 0.230	0.001	0.934	3.136 ± 0.242	3.109 ± 0.217	0.021	0.602
T10 (s)	1.930 ± 0.140	2.032 ± 0.108[a]	0.442	0.007	1.898 ± 0.109	1.974 ± 0.096[a]	0.468	0.005
T20 (s)	3.532 ± 0.244	3.638 ± 0.193[a]	0.384	0.014	3.391 ± 0.221	3.499 ± 0.214[a]	0.564	0.001
CSHr-CSHl (%)	10.072 ± 7.615	**-0.380±7.382*[a]**	0.308	0.032	-0.091 ± 4.858	**-0.661±3.989*[a]**	0.308	0.032
CSFr-CSFl (%)	1.728 ± 5.365	1.542 ± 3.495	0.001	0.902	0.742 ± 2.495	0.583 ± 1.910	0.001	0.902

V-Cut = time in V-CUT test; CSHl: time in curved sprint half to the left; CSHr: time in curved sprint half to the right ; CSFl: time in curved sprint final to the left ; CSFr: time in curved sprint final to the right; T10 = time in 10m sprint; T20 = time in 20m sprint; CSHr-CSHl: difference in percentage between the curved sprint half to the right and to the left; CSFr-CSFl: difference in percentage between the curved sprint final to the right and to the left; ES = effect size.
* Significant differences ($p \leq 0.05$) intergroup. a significant differences ($p \leq 0.05$) intragroup.

Discussion

The aim of this study was to analyze the effects of 8-week in-season RID training program on COD performance and the reduction of the unilateral deficit between legs in semi-professional female soccer players. The main finding that we found in this work is that the proposed training program has significantly reduced the unilateral deficit based on the comparation between each side of the curved sprint in female soccer players. Strength and conditioning coaches could integrate this type of training into their players' technical-tactical routines to enhance essential variables for achieving higher performance on the field without interfering with technical-tactical training, due to this training program will not take up a long duration and will not induce high levels of fatigue.

High-intensity actions are most of the actions that a soccer player has to do during a match, being decisive in the performance of them (Faude et al., 2012). Most studies have focused on examining maximal linear efforts (Buchheit et al., 2014) or sprints with successive CODs (Brughelli et al., 2008). However, it has been shown that sprinting activities during soccer matches rarely occur in a linear trajectory (Fitzpatrick et al., 2019), or through punctual COD using cutting maneuvers or turns between sequences, so they occur through a curved trajectory (Fílter et al., 2020b). In fact, approximately 85% of the actions performed at maximum speed in a professional soccer league are curvilinear sprints (Caldbeck, 2019). Only one study on elite female soccer players has examined the associations between linear sprint, curve sprint, COD speed, and jump performance, suggesting that training methods designed to improve linear sprint and curve sprint velocities may benefit from the implementation of oriented plyometric exercises (Kobal et al., 2021). Moreover, it has been shown that there can be significant differences between sprinting in a curve towards one side, let's call it "good" and the other side, let's call it "weak" (Filter et al., 2020c), so the comparison of both sprints could be an indicator of asymmetries based on a unilateral deficit between the strong and the weak side. It seems that this imbalance in this test is fundamentally dependent on the IL of the curved sprint. Filter et al. (2020) concluded that during a curved sprint, the IL of the weak side has a longer contact time (and is therefore slower) than the IL of the strong side, without finding differences in the OLs. In our study we have been able to verify how the EG has tended to balance this deficit by improving the performance of the weak side and reducing the performance of the strong side. These results agree with those obtained by Filter et al. (2020), where the IL of the weak side improved its contact time more than the IL of the strong side. Moreover, another recent study made in male soccer players, showed a significant performance improvement in the curved sprint performed to the right and there were indications of significance in this test performed to the left (Romero et al., 2024). Both studies suggest the presence of a weak side in curved sprints. A possible explanation made by these authors is that the percentage of right-footed players in both groups was higher than that of left-footed players. As the authors discussed in that paper, there is a need to confirm if the improved balance between the strong and weak side of the curve sprint relates to player performance enhancement. Asymmetries are also considered a performance limitation factor (Coratella et al., 2018), as well as injury risk factors, guiding rehabilitation and return to play processes on numerous occasions (Croisier et al., 2008). The relationship between unilateral strength and COD performance in soccer has been widely studied (Lockie et al., 2014). Although this is the first study that demonstrates a unilateral deficit reduction in the curved sprint test in women's soccer, there are studies in men's sports in general (Gonzalo-Skok et al., 2017) and in soccer in particular (Ascenzi et al., 2022), that show the reduction of unilateral deficits with the use of RID systems to resist the movement. The use of the proposed resisted exercises by RID seems to improve the rebalancing of the functional deficit between both legs in an action of curved sprint. More studies would be needed to verify whether it was the trained movement itself, the use of a movement restriction using RID, or both that caused that rebalancing.

Change of direction is a key performance indicator for any team sport athlete, even more in the performance of soccer players. They are frequently involved in sudden and unexpected CODs during different actions of the game (Reilly, 2003), as well as in the implication of this type of actions in terms of playing time, having a 32% of presence in carrying out these efforts (Bloomfield et al., 2007). In our study, we have not been able to significantly improve the performance of a 135º COD that alternates right and left 2 times consecutively (V-cut test). Our baseline values are higher than those obtained by Tous-Fajardo et al. (2016) in a sample of young soccer players (mean ± SD: 7.59 ± 0,51s EG and 7.21 ± 0.44s CG in our study, versus 7.09 ± 0.31s EG and 6.94 ± 0.12s CG in the cited study). These authors evaluated an 11-week training program divided into two groups: one of them carried sessions based on functional eccentric overload and vibration training (n=12) and another group carried out plyometric and traditional resistance training based on weight lifting vertical loads (n=12). Only the group that trained with RID, significantly improved the V-cut (mean ± SD: 6.70 ± 0.29s). Although COD performance depends on numerous motor skills such as proper technique, linear sprint speed, reactive strength, the ability to accelerate and decelerate quickly and muscle balance between legs (Loturco et al., 2017), it is possible that the differences between our results and those obtained in the cited study lies in the intervention time (8 versus 10 weeks), in the different level of initial physical condition of both samples or on the sex factor (female versus male). Regarding to the intervention time, perhaps greater number of weeks of training are needed for the necessary neuromuscular adaptations that cause a significant improvement in a sample that is not used to perform a systematic resistance training program and without previous experience in this type of work. This aligns with findings by Shalfawi et al. (2013) in women's soccer and Gonzalo-Skok et al. (2015) in men's soccer. Theoretically, longer interventions could increase the probability of greater improvements in certain specific abilities, using CODs as an example (Gonzalo-Skok, 2015). Therefore, perhaps if we had continued with the intervention, after several more weeks of training this intragroup statistical significance could have occurred. On the other hand, another reason why there are no significant intergroup differences may be because soccer training per se is capable to generate a sufficient stimulus in the COD performance of the players, since CODs are carried out constantly during training and matches (Christou et al., 2006). Furthermore, it is possible that in modern women's soccer, improving motor control due to the lack of experience performing this type of complex motor patterns is equally relevant as strength. In this way, other authors describe that the older the age of maturation, the better the valued of the V-cut test (Gonzalo-Skok, 2015), so we think that the greater the number of years of sports practice, the better result in this type of efforts. This supports the previous theory: the greater number of years of practice of the female soccer player, the better the values on the V-cut test. Based on these findings we suggest the importance of beginning to introduce specific COD training and movement quality exercises in women's soccer academies from an early age.

Regarding sprint actions, this type of efforts represents 6.5% of the total distance that a soccer player has to do during a match competition (Mohr et al., 2003). Furthermore, it is known that elite soccer players have greater performance in sprints (10, 20, 30 and 40 meters) compared to those in lower divisions, the duration of these efforts' ranges between 2 and 4 seconds and the distances are, in general, less than 20 meters (Haugen et al., 2014). In our study, we could not improve the performance of a linear sprint of 10 and 20 meters, even there has been a significant reduction in performance in both groups. The data collected in Table 1 concerning to the 10m linear sprint (T10) prior to the intervention were similar to those obtained by Tous-Fajardo et al. (2016) (mean ± SD: 1.93 ± 0.14s EG and 1.898 ± 0.11s CG in our study, versus 1.93 ± 0.07s EG and 1.78 ± 0.10s CG in the cited study). These authors evaluated an 11-week training program divided into two groups: RID versus traditional (Tous-Fajardo et al., 2016). While in our work there was a significant intragroup deterioration in terms of performance in this variable (both for the group that trained with RID and the control group), in the cited study performance was not altered in response to the training program with these devices. Therefore, although in men's soccer this type of devices can help us to maintain performance, in women's soccer other alternatives of training or longer interventions must be studied to, at least, maintain performance in the linear sprint variables. Another study carried out on elite soccer players, RID training was done during 10 weeks, showing that the group using these devices showed better sprint performance in 30 meters (Askling et al., 2003). The differences between this study and ours may be due to the fact that it occurs in a different sample determined by sex, that the linear sprint is evaluated over greater distance or due to the type of exercise that was used (RID exercises targeting hamstring muscles: these authors determined that eccentric overload in this muscle group should be carried out to improve or maintain linear sprint speed). Moreover, when comparing our previous data in terms of time to those obtained by de Hoyo et al. (2015) (mean ± SD: 1.93 ± 0.14s EG and 1.898 ± 0.11s CG for T10; 3.532 ± 0.24s EG and 3.391 ± 0.22s CG for T20 in our study versus 1.73 ± 0.12 EG and 1.71 ± 0.08 for T10; 3.03 ± 0.14s EG and 2.99 ± 0.11s CG for T20 in the cited study), our results are superior to those obtained from a sample of young male soccer players (De Hoyo et al., 2015). These authors evaluated a 10-week training program divided into two groups: a group trained with RID (n=18) and a control group (n=15). Non-significant improvements were obtained in the 20m sprint test, so that this type of devices can help to maintain performance according to the authors. It is possible that the differences in the results between this study and the cited one lies in the intervention time (8 versus 10 weeks), in the different level of initial physical condition of both samples or on the sex factor (female versus male). In addition, the deterioration of the performance for this variable in our study could be also due to the fact that in non-professional women's soccer, there are different number of HSR (high speed running or high intensity distance running) and sprints compared to elite women's soccer. It may be also due to not being adapted to reach minimum values in these distances and this could in turn be due to the excessive use of small sided games for the technical-tactical improvements of the players in order to be able to come into contact with the ball more frequently (Mohr et al., 2008). Therefore, further studies would be needed to determine the optimal resistance training programs that should be integrated with other field training content in women's soccer to effectively enhance linear sprint performance.

The present study is not exempt of some limitations. The small sample size we examined could be considered the main limitation of our study, as well as the experimental death (more than 60% of the initial sample does not participate in this work). The loss of participants significantly reduced the sample size, which affects the statistical power of the study. This can be explained by the underlying characteristics of women's soccer to a greater injury predisposition, as well as the lack of adherence to training with their respective teams, due to the non-professional nature of the teams involved. In this sense, other of our main limitations are the differences in the number of subjects between groups: EG has half of the players of the CG. Other of the key limitations of this study may be the time intervention, so that this could explain how a longer intervention or with a larger number of participants could generate more robust results. Another important limitation is that participants had no previous experience in resistance training with RID. Previous research has demonstrated that the mechanical response of athletes when executing with RID is greater when they have previous experience using this technology. The literature shows very good long-term results when experienced high-level athletes train with RID. It is possible that variables that have not changed in our study could have been greater with a more experienced sample. Despite this limitation, a familiarization session with these devices was conducted prior to the training program. Finally, another limitation was the lack of monitoring of the repetitions after an experimental period has not allowed us to know the influence of the improvements of the different manifestations of strength. This has been due to the prioritization of more functional analysis variables that would entail a shorter assessment time in teams whose reduced weekly training time limited the implementation of a broader assessment protocol. These factors should be considered when interpreting our findings, addressing these limitations in future research to further explore the effects of RID in female soccer players.

Conclusions

Through the results obtained in this study, we can conclude that in a sample of female soccer players where the level of generic physical condition was low, the work of this type of exercises performed with rotational inertial resistance (front step and crossed lateral step) have achieved the balance of the unilateral deficit in a curved sprint task in the proposed 8 weeks of training. This study helps to continue advancing on the path of the optimization of sports performance in women's soccer in general and training with RID as a toll of resistance training with the purpose of optimize the training process in particular.

Acknowledgements

We acknowledge to the soccer teams that selflessly participated in this study, as well as their availability and time spent.

Financing

There has been no funding related to the development of the research shown in this document.

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