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Can the neuromuscular and balance training on unstable and small surfaces decrease the lower limb functional asymmetry in the young soccer players?

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Abstract

Introduction. The literature in recent years has showed the requirement to analyse the differences in performance between the two lower limbs. The lower limbs functional asymmetries are determined by strength deficits between the two limbs and differ from muscular imbalances, which represent an alteration in the strength relationship between agonist and antagonistic muscle pairs. This asymmetry seems to significantly affect performance but above all it seems to represent an injury risk factor.

Aim of the study. The purpose of the study is to analyse and understand the lower limb asymmetry values in the young soccer players. The study also verify whether neuromuscular training on unstable and small surfaces provides an effective plan able to reduce functional asymmetries and allows the strength performance increase.

Materials and methods. 35 young male soccer players (all movement players) from youth national team in the 2020/21 season (14.46 ± 0.28 years, weight: 49.16± 4.92 kg; height: 162.5± 7.2 cm, age training: 7,9 ± 1,1 years) have been randomly divided into Experimental Group, EG (n=17) and Control Group, CG (n=20). The EG completed a total of 16 training sessions directed at balance and neuromuscular training on unstable or small surfaces: two 30-minute sessions/week over a 8-week period. The CG followed an identical training schedule, but training sessions consisted of soccer-specific drills only. The performances were assessed in the One-Leg Hop test, Side-Hop test, Triple-Hop test and Crossover-Hop test to quantify percent asymmetries in lower-limb strength before (T0) and following (T1) training.

Results. The data analysis returns the highlights significant intergroup results (T0 vs T1): the One-Leg Hop test left limb (p = .05, d = -2,67), the One-Leg Hop test asymmetry score (%, p = .0005, d = 10.77), the Side-Hop test asymmetry score (%, p = .0005, d = 4.25), the Triple-Hop test right limb (p = .0005, d = -6.40), the Triple-Hop test left limb (p = .0005, d = -7.32), the Triple-Hop test asymmetry score (%, p = .0005, d = 6,96), the Crossover-Hop test left limb (p = .05, d = -2.04), the Crossover-Hop test asymmetry score (%, p = .0005, d = -4.12).

Conclusions. The neuromuscular and balance training on small and unstable surfacess seem to respond effectively to two needs of the young soccer player: the injury prevention, by reducing the strength asymmetry values, and increasing the lower limb explosive strength values.

Keywords*:* *functional asymmetry – inter-limb asymmetry - young soccer players – balance training – neuromuscular training – unstable surfaces*

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Introduction

The literature in recent years has showed the requirement to analyse the differences in performance between the two lower limbs [1,2,3].

The lower limb strength asymmetry recently has been the subject of numerous investigations concerning many different contact, limited-contact and non-contact sports aimed to understand the role of conditioning in performance [1,2,3,4,5] and in the injury prevention [6,7,8,9].

The functional lower limb asymmetry is defined as the different force output between the two legs [10,11,12,13,14] and differ from muscular imbalances, which represent an alteration in the strength relationship between agonist and antagonistic muscle pairs [12,15].

This factor becomes relevant in the soccer performance because the game requires very high intensity actions carried out unilaterally by the single lower limbs: the kick, the deceleration, the skip, the jump to hit the ball with the head, etc. are all unilateral skills [16,17].

This asymmetry seems to significantly affect the performance [2,3,18,19,20,21,22] but above all it seems to represent an injury risk factor when it exceeds the cut off of 10% or 15% [12,16,23,24,25].

For these reasons, research is aimed at understanding which methods of training and teaching technical skills can counteract the increasing of the asymmetry value [2,12,26,27]. The debate moved to the theme of training exercises and teaching methodology [14,28,29,30,31,32,33].

Over recent years, athletic conditioning plans started to introduce balance training exercises, which may involve the use of resistances, with the goal of reducing injury risk [12,27,34,35,36]. The introduction and now the widespread use of training techniques that involves the use of unstable surfaces (i.e. balance training), represents an important methodological innovation in sports training [37,38,39,40,42,42,43,44].

The exercises performed on unstable or small surfaces (on one leg too) can be included into a training plan as part of an injury prevention/management strategy; otherwise with the primary aim of improving the athlete performances, mostly in relation to the open skill sports. An unstable/small surface places to the neuromuscular system an effort to stabilize the joints involved in the execution of the movement. All the advantageous effects of the movements performed on unstable surfaces are transferred in sport-specific performances; in fact, in soccer, the correct activation of the core muscles achieved when performing balance training exercises is a prime example of the positive transfers that can be obtained in the sport-specific movements execution [43,45]. However, the relationships between training on unstable surfaces, injury prevention and the reduction of strength asymmetries are not completely clear yet [8,41,42,43,46,47].

The aims of this study are (i) to examine the presence of functional strength asymmetries in the young soccer player lower-limbs; (ii) to verify whether neuromuscular and balance training on unstable and small surfaces provides an effective plan able to reduce functional asymmetries and allows the increase in strength performance.

Materials and methods

Study participants

35 young male soccer players (all movement players) from youth national team (season 2020/2021) participated in the study (average age:14.46 ± 0.28 years, weight: 49.16± 4.92 kg; height: 162.5± 7.2 cm, age training: 7,9 ± 1,1 years). The sample was randomly divided into an Experimental Group (EG, n = 17) and a Control Group (CG, n = 20). The 82.2% of the sample prefer the right limb and the 17.8% the left limb to kick.

The sample included all the players that did not report any injuries at the study time, and all the players that were training and playing in matches in the last 6 weeks. One young soccer player did not complete the assessments and was excluded from the statistical analysis. The study was approved by the club's manager, by FIGC (Federazione Italiana Giuoco Calcio) regional ethics committee and was performed according to the principles expressed in the Declaration of Helsinki. The written informed consent was obtained from the parents, while the young soccer players have signed the informed assents.

Study organization

The study was conducted in the winter break of the Under 15 national championship.

The assessments were conducted in the last competitive micro-cycle before the suspension of official matches and in the first micro-cycle when the competitive phase was resumed.

The Hop test, the Side Hop test. The Triple Hop test and the Crossover test were used to assess the lower limb functional asymmetry [12,47,48,49]; the asymmetry calculation was carried out using the formula:

$$(NDL / DL) \times 100$$ [48,49].

Procedures

The EG completed 2 of 30-minute sessions per week oriented into neuromuscular and balance training on unstable or small surfaces (16 sessions in 8 weeks). The two weekly training sessions proposed to the EG were structured differentially (see Tables 1 and 2 for details).

The training session consisted in 15 minutes of warm-up (aerobic running, dynamic stretching and speed exercises) and 45 minutes of soccer-specific drills.

In the other 2 sessions the EG performed only soccer specific drills (90 minutes).

Exercise	Task	Sets x repetitions	Recovery time
1.Balance and stability	High skipping with single leg halt every 5 skips.	6 x 5 x limb	20 sec
2.Balance and strength	4 diagonal single-legged bounds, maintaining equilibrium before the last bound for 3 sec.	4 x 6	30 sec
3. Balance and strength	6 forward bounds, maintaining equilibrium before the last bound for 3 sec.	3 x 4 x limb	30 sec
4. Balance and strength	Rebound on single leg on inflatable disk.	4 x 10	20 sec
5. Balance and strength	2 Kg medicine ball chest passes whilst balancing with one-leg on inflatable disk. (Fig.1)	4 x 6 x limb	45 sec
6. Balance and strength	2 Kg medicine ball passes with torsion whilst standing on one leg. (Fig.2)	4 x 6 (twice x limb)	45 sec

Table 1. Exercise of session 1.

Exercise	Task	Sets x repetitions	Recovery time
1.Balance and stability	Lateral raises (2 Kg dumb-bells) whilst standing on one leg on a Bosu balance trainer	3 x 6 x limb	30 sec.
2.Balance and strength	Balancing on an inflatable Skimmy cushion (Sixtus, Italy) for 30 sec.	2 x 4 x limb	30 sec.
3. Balance and strength	4 one-legged successive jumps on the ground from an inflatable disk, maintaining landing position for at least 3 sec.	4 x 4 x limb	30 sec.
4. Balance and strength	Step-up jump on a Bosu balance trainer.	4 x 5 x limb	30 sec.
5. Balance and strength	One-leg jump and 90 degree rotation, and landing on one-leg for at least 3 sec	3 x 6 x limb	30 sec.
6. Balance and stability	Hold on one leg for 10 sec, while the upper limbs "draw" a box	3 x 4 x limb	30 sec.

Table 2. Exercise of session 2.

Fig.1. 2 Kg medicine ball chest passes whilst balancing with one-leg on inflatable disk

Fig.2. 2 Kg medicine ball passes with torsion whilst standing on one leg.

The CG followed a plan that consisted only in soccer-specific drills; 4 sessions of 90-minutes per week were performed in total of 32 sessions (i.e. 8 weeks).

The experimental design is summarized in table 3.

	Session 1	Session 2	Session 3	Session 4
EG	Neuromuscular and balance training on unstable or small surfaces (session 1) & soccer drills	Soccer drills	Neuromuscular and balance training on unstable or small surfaces (session 2) & soccer drills	Soccer drills
CG	Soccer drills	Soccer drills	Soccer drills	Soccer drills

Table 3. The experimental design in the every week microcycle.

Statistical analysis

The descriptive statistics (mean, standard deviation, confidence interval) were determined for all test data.

To verify the intergroup differences (EG vs CG) in the pre and post test (T0 vs T1) the T-test for independent data was used, with significance fixed at p <0.05; for the differences between the averages that were significant, Cohen's d was used to check the effect size index. As for the effect size index (Effect Size), after calculating the δ index it is possible to convert it into Effect Size: ≤ 0.20 small; 0.50 average; ≥ 0.80 large [50].

The statistical package SPSS 15.0 for windows (SPSS Institute, Chicago, IL) was used to analyse all data.

Results

No significant between-group differences were shown at baseline.

The data analysis returns the highlights significant intergroup results (T0 vs T1):

- the hop test left limb: $t(34) = -2.673$, $p = .05$, $d = -2{,}67$, 95% CI [-29.35, -4.02];
- the hop test asymmetry score (%): $t(34) = 7.118$, $p = .0005$, $d = 10.77$, 95% CI [9.07, 16.31];
- the side hop test asymmetry score (%): $t(34) = 4.255$, $p = .0005$, $d = 4.25$, 95% CI [4.29, 12.10];
- the triple hop test right limb: $t(34) = -6.403$, $p = .0005$, $d = -6.40$, 95% CI [-199.17, -103.34];
- the triple hop test left limb: $t(34) = -7.325$, $p = .0005$, $d = -7.32$, 95% CI [-198.686, -112.51];
- the triple hop test asymmetry score (%): $t(34) = 6.968$, $p = .0005$, $d = 6{,}96$, 95% CI [14.14, 25.75];
- the crossover hop test left limb: $t(34) = 2.045$, $p = .05$, $d = -2.04$, 95% CI [.45,112.35];
- the crossover hop test asymmetry score (%): $t(34) = 4.127$, $p = .0005$, $d = -4.12$, 95% CI [9.33,27.34]. In the table 4 are summarized all data.

Variable	group	M±DS	Gl	t	P Value	Effect size
Hop test right limb (T0) (cm)	CG	146.71±15.7	34	.494	.625	
	EG	143.71±21.84				
Hop test right limb (T1) (cm)	CG	150.71±12.76	34	-1.633	.111	
	EG	153.88±19.76				
Hop test left limb (T0) (cm)	CG	151.9±21.14	34	.790	.435	
	EG	145.76±26.81				
Hop test left limb (T1) (cm)	CG	146.19±17.67	34	-2.673	.01	2,67 (Large)
	EG	164.47±20.75				
% Asymmetry Hop (T0)	CG	18.92±8.69	34	.313	.756	
	EG	18.16±5.5				
% Asymmetry Hop (T1)	CG	17.20±6.57	34	7.118	.000	10.77 (Large)
	EG	4.50±3.63				
Triple hop test right limb (T0) (cm)	CG	462.67±88.49	34	-1.473	.149	
	EG	501.87±37.18				
Triple hop test right limb (T1) (cm)	CG	369.66±75.84	34	-6.403	.000	-6.40 (Large)
	EG	561.12±67.86				
Triple hop test left limb (T0) (cm)	CG	443.1±111.78	34	-917	.365	
	EG	475.33±103.989				
Triple hop test left limb (T1) (cm)	CG	371.81±57.88	34	-7.325	.000	-7.32 (Large)
	EG	527.41±73.15				
% Asymmetry Triple Hop (T0)	CG	25.37±16.91	34	-1.497	.143	
	EG	16.88±17.95				
% Asymmetry Triple Hop (T1)	CG	25.79±11.15	34	6.968	.000	6,96 (Large)
	EG	5.84±4.19				
Crossover test right limb (T0) (cm)	CG	384.71±91.83	34	.538	.594	
	EG	462.52±86.97				

Crossover test right limb (T1) (cm)	CG	458.95±80.56	34	1.611	.116	
	EG	474.44±91.34				
Crossover test left limb (T0) (cm)	CG	393.81±103.19	34	.491	.627	
	EG	377.94±93.76				
Crossover test left limb (T1) (cm)	CG	406.12±81.43	34	2.045	.046	-2.04 (Large)
	EG	466.24±26.81				
% Asymmetry Crossover (T0)	CG	23.94±9.42	34	1.958	.058	
	EG	18.52±7.13				
% Asymmetry Crossover (T1)	CG	24.25±17.25	34	4.127	0.000	-4.12 (Large)
	EG	5.92±6.68				
Side Hop test right limb (T0) (cm)	CG	1.22±.15	34	-.147	.884	
	EG	1.23±.28				
Side Hop test right limb (T1) (cm)	CG	126.62±.13.1	34	-1.058	.297	
	EG	128.47±20				
Side Hop test left limb (T0) (cm)	CG	116.76±14.94	34	.990	.329	
	EG	111.06±20.54				
Side Hop test left limb (T1) (cm)	CG	126.62±13.1	34	-.193	.848	
	EG	128.48±20				
% Asymmetry Side Hop test (T0)	CG	17.60±5.18	34	-.593	.557	
	EG	19.11±10.14				
% Asymmetry Side Hop test (T0)	CG	15.26±5.93	34	4.255	.000	4.25 (Large)
	EG	7.06±5.86				

Table 4. The results.

Discussion

This study aimed to verify the percentage of functional asymmetry of the lower limbs in the young soccer players; it aimed to describe whether neuromuscular and balance training on unstable and small surfaces provides an effective schedule to reduce lower limb functional asymmetries and to enable the strength performance increase.

The strength asymmetry values detected in this sample of the young soccer players are high and require careful analysis.

The effects of training on inter-limb asymmetries constitutes a literature topic issue [9,19,20,51].

Currently, the needs of each sport require that the phase prevention must be of limited duration and compatible with the other needs of training session: in particular, the sport teams should provide an high numbers of exercises that must respond the match profile demands.

The type of training to be propose must try to meet at least two needs: a) to reduce the strength asymmetry and b) to determine positive adaptations in the young athlete motor skills.

The integrative training plans must be effective and limited within a compatible duration with the technical and tactical needs of young athletes [38] ; vice- versa, it becomes difficult to implement them and obtain adequate compliance [52].

The post test results showed increases in unilateral jumping performance in the One-Leg Hop test (left limb), in the Triple-Hop test (right and left limb) and in the Crossover-Hop test (left limb): the 16 training sessions of neuromuscular and balance tasks on unstable surfaces showed respectively an increase approximately of 14%, 11%, 11.5% and 23.6%.

Other studies conducted on under-17 young soccer players using unilateral tasks with conical pulley tools, have led to less increase performances in jumping assessment [26]; indeed, other studies with young soccer players have reported very similar risings in performance using strength training with body weight [53,54], with free weights [55] or with loaded and unloaded plyometric tasks [56].

The comparison can be beneficial only when the studies report the training and assessment's season phase; otherwise it is very difficult to make comparisons because the literature describes the variations in the young soccer player performances in the different season phases [57].

The statistically significant strength increase only for the left lower limb, in the One-Leg Hop test and in the Crossover-Hop test can be explained by the preferred limb for kick of this sample of study: the 82.2% of the sample stated they preferred the right limb to kick.

It follows that the left limb is the one that is mostly chosen to give support to the body and to manage the landing ground phase in a one-leg position; therefore it could be the limb mostly capable of managing and overcoming resistance in the low balance conditions [39,40].

The other objective of the study aimed to describe and to quantify the lower limb functional asymmetry in the young soccer players and, consequently, to verify the effect of integrative neuromuscular training on unstable surfaces reducing this asymmetry.

The Hop tests are a valid tool for analyzing and monitoring inter-limb asymmetry [6,58]: they, in fact, rather than evaluations with isokinetic dynamometers [59], reproduce the same movements required to the young soccer players by the performance model [60].

The issue of inter-limb asymmetries has been widely investigated in the recent years [9,12,19,26,51] and it tried to understand which interventions are more functional for the value reduction [1,51].

Some studies describe differences between trained and untrained young people and in both the indicate values are higher than 20% [21,22].

In this study, we wanted to implement the balance training used with young tennis players [12] with integrative neuromuscular tasks that required explosive movements and light loads.

The EG showed in all three one-leg jump tests presented significant decreases in the inter-limb asymmetry value.

Considering the literature knowledges in the relationship between strength asymmetry and risk of injury, these results are rilevants [6,9,51,61].

In fact, the previous research has highlighted the discrepancies surrounding asymmetries and injury risk. During a variety of hop tests, a threshold of 15% has been indicated as a cut-off to involve a risk of injury [9,25,58] whereas, during return to play after rehabilitation, has been proposed a value asymmetry of 10% as a sufficient target [6,62]. Given these different conclusions, the staff should be analyze the strength asymmetry values to move the young athlete away from the risk threshold [19].

The relationship between balance exercises and the reduction of inter-limb asymmetry can be explained according to the type of motor task: when the young athlete is on top of an unstable platforms he forced to distribute the weight and the thrust on both limbs in the even way to stay on the tool or on the assigned area.

Instead, if he adopted a different strategy (for example, he continued to push more with the stronger limb) he would be forced to fall or to land (if the task requires jumping) outside of the tool.

Furthermore, the balance tasks may have increased the function of stabilization muscles, allowing the prime movers to increase the body propulsion [37].

In fact, some Authors demonstrated that an individual with an unstable base may not concentrate all their propulsive strength in the optimal direction [34]. Additionally, it was suggested that even 4 weeks of unstable surfaces may increase the rate of explosive strength development of the leg extensors, as a consequence of the enhanced reflex contribution acting on the spinal level [37,63], and withdrawal of presynaptic inhibition of the terminals of the primary afferent fibers (Ia) which has a determined role in stretching and monitoring the speed with which the muscle spindle changes [63,64].

Limitations of the study

This study has some limitations. It was deliberately chosen to use the balance exercises and the resistance exercises on unstable surfaces because both types of training are responding to the young soccer player needs: the injury prevention and the performance increase. However, this choice prevents us to understand the role and the "*value*" of each type of exercise to reduce the inter-limb asymmetry.

Future studies will be able to assign to different groups, the two types of training (balance and neuromuscular training) to describe exactly the effectiveness of them.

In the end, more information can derive from the outcomes analysis when the training is interrupted: understanding if the asymmetry value after the interruption are the same or are increased can help the staff to schedule an effective preventive training.

Conclusions.

The supplementary training program seems to respond effectively to the two objectives that the staff set in youth soccer: the performance increase and the injury risk reduce. These two objectives seem achievable by dedicating only a limited part of the young soccer's training session. The technical staff can use the exercises proposed in the study in any type of club (amateur or professional) because they do not require special tools.

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