Original Article

Strength and power analysis in half squat exercise with suspension training tools

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Abstract:

Aim: The study aims to verify the load created by performing a squat, with both feet and with one, with suspension training equipment, on the parameters of strength and power compared to squats without equipment; furthermore, it aims to quantify any performance differences of the two limbs in muscle power, during the bipodalic execution with and without the aid of the suspension training instrument.

Methods: 24 players, youth premier league.

Results: statistically significant differences have emerged in performing bipodalic squats with or without the device, regarding the peak force in the eccentric phase ($p < 0.01$) and the concentric ($p < 0.0005$), the average force (in eccentric and concentric phases); in monopodalic squats there are significant differences for peak power and average power ($p < 0.0005$) during both the eccentric and concentric phases.

Significant differences have been found between performance with and without the device in peak power, (concentric phase, one-legged) for the left limb ($p < 0.05$); in bipodalic squats there are significant differences between the two limbs for peak power and peak time, both in eccentric ($p < 0.05$) and concentric phases ($p < 0.0005$).

Conclusion: this study has emerged as the suspension training tool causes a significant decrease of body weight, of the parameters of force to the ground and the increases in terms of power expressed, but also a significant decrease in terms of power of the differences between two limbs.

Key words: suspension training - functional training - muscle power – strength - young football players.

Introduction

In recent years the training methodology has directed more towards defined functional workouts, careful that the multi-planar and the solicitation of proprioceptive and kinesthetic sensitivity, stability dynamics complex of Hip / Core / Scapula, control preprogrammed (feed forward) and reactive (feedback) of motor responses, integration of motor patterns responses finalized. Finally, promoter of exploration controlled patterns of vulnerability, as well as integration perceptive sense of visual and vestibular afferents (1,2). In this area has found ample training in suspension or Suspension Training (ST), almost always identified with tools that allow you to reduce body weight.

The ST includes a set of exercises and movements different from the traditional ones, since the subject carries them out, having hands or feet are bound to a handle while the opposite end of the body is in contact with the ground (3,4) and has as its objective to encourage and enhance strength, balance, stability but also the intermuscular coordination (5). The instability determined by the device that binds the subject allows to have greater muscle activation, as demonstrated by studies that have evaluated the electromyographic signal relative to the external oblique muscle, multifidus and hamstring while performing the exercise of push-ups compared to the same task performed in other conditions (6).

In literature there are many studies regarding this tool and this methodology (6-17) and face especially endocrine changes after training with exercises with the device for training in suspension, analysis electromyographic muscles activation of the trunk or upper limb (6-17). An open problem in the context of this type of training is the understanding of what the actual load imposed to the subject that is exercised by the device for training in suspension, in order to modulate the parameters of the load, with particular reference to the volume, intensity and selection of exercises to be proposed. The study, therefore, aims to verify and quantify in young players, the load created by training suspension device in half squat with running bipodalic and monopodalic both during eccentric and concentric about the parameters of strength and power than half squat free body. The study aims also to verify and quantify any differences prestativa of individual limbs on muscle power, during the execution bipodalic with and without device training suspension.

Method

Participants

The study was performed on 24 young players of the category "Primavera" (age 17.8 ± 0.8 ; weight 73 ± 4.9 kg; height 179.1 ± 5.6 cm), in the 2011/2012 season appartenent a the youth sector of a team of Italian "Serie A".

Materials

To make the following study was used a suspension training tool (TRX Fitness Anywhere LLC, San Francisco, California) connected to the end of an gym espalier and the two force platforms (Twin Plates, Globus, Italy) connected to a portable PC to collect the data regarding the strength and muscle power.

The software connected to the two force platforms allows of quantifying and assess the parameters of strength and muscle power expressed by each legs. The software returns values of strength in kilograms (kg), of power in watt (W) and those related to the peak time in seconds (s).

Procedures

The players, after a warm up of 15 minutes, have carried out 3 bipodalic executions of half squat with and without the suspension training tool; the next day, they have carried out 3 monopodalic executions to half squat with and without the suspension training tool. It was considered the performance in which the subject has expressed the highest values of strength and muscle power. Whether for both executions that for both the two conditions, the variables measured by the strength were: the force peak (pkforce), the peak time (Tpeak) and the average force (AvgF) while for the power were recognized: the power peak (pkpower), the peak time (Tpeak) and the average power (AvgP) either during the eccentric phase than in the concentric phase.

The peak time is defined as the time required to reach the maximum value of the parameter evaluated. Each player, finally, was subjected to evaluation of the body weight during the executions with and without the suspension training tool (TRX).

Statistical Analysis

The data are reported as mean $\pm$ SDs; in order to verify the existence of differences statistically significant between the variables pkpower (W), pkforce (kg), Tpeak (s), AvgP (W), AvgF (kg) during the executions with and without the suspension training tool (TRX), in eccentric and concentric phase, was used the t-Student's test for paired data.

The level of significance was set at $p < 0.05$.

Results

The measurement of body weight in the condition of subject used the suspension training tool has returned an average value equal to $38.1 \pm 3.4\%$.

a) Bipodalic ½ squat - left limb

The left limb returned values summarized in table 1.

During the execution with suspension training tool, in the eccentric phase, the pkforce, the AvgF and Tpeak showed a decrease respectively of 46.8% ($p < 0.01$), 13.8% ($p < 0.0005$) and 14.1%.

In the concentric phase, the use of the suspension training tool has caused a decrease of 12.6% ($p < 0.0005$) of the pkforce, of 12.8% ($p < 0.0005$) of the AvgF and a decrease of 61.5% of Tpeak

Tabel 1. Differences during the bipodalic execution (analysis left leg) with and without the suspension training tool (TRX), in eccentric and concentric phase on strength parameters

Tab. 1	ECN eccentric	TRX eccentric	Diff. %	Df	T	P VALUE
pkforce (kg)	10,374 $\pm$ 6,61	5,516 $\pm$ 2,7	- 46,8%	18	3,591	0,002**
Tpeak (s)	0,113 $\pm$ 0,11	0,097 $\pm$ 0,07	- 14,1%	18	0,628	0,538
AvgF (kg)	36,437 $\pm$ 3,97	31,405 $\pm$ 2,88	- 13,8%	18	5,851	0,000****
	ECN concentric	TRX concentric	Diff. %	Df	T	P VALUE
pkforce (kg)	81,289 $\pm$ 11,28	70,984 $\pm$ 7,74	- 12,6%	18	6,769	0,000****
Tpeak (s)	0,013 $\pm$ 0,02	0,005 $\pm$ 0,01	- 61,5%	18	1,609	0,125
AvgF (kg)	37,774 $\pm$ 2,9	32,932 $\pm$ 3,51	- 12,8%	18	7,375	0,000****

ECN: execution without the suspension training tool; TRX: suspension training tool

b) Bipodalic ½ squat - right limb

The right limb returned values summarized in table 2.

In the eccentric phase, during the execution with suspension training tool, the pkforce has decreased by 42.9% ($p < 0.01$), the average force a decrease of 11.7% while the Tpeak has not changed.

In the concentric phase, during the execution with suspension training tool, the pkforce and AvgF showed a decrease respectively of 11.9% ($p < 0.0005$) and 13.2 ($p < 0.0005$); while the Tpeak remained substantially unchanged.

Tabel 2. Differences during the bipodalic execution (analysis right leg) with and without the suspension training tool (TRX), in eccentric and concentric phase on strength parameters

Tab. 2	ECN eccentric	TRX eccentric	Diff. %	Df	T	P VALUE
pkforce (kg)	9,95±6,14	5,68±2,99	-42,9%	18	3,576	0,002**
Tpeak (s)	0,12±0,11	0,12±0,08		18	,212	0,835
AvgF (kg)	37,05±3,24	32,7±3	-11,7%	18	5,436	0,000****
	ECN concentric	TRX concentric	Diff. %	Df	T	P VALUE
pkforce (kg)	83,48±14,59	73,51±10,63	- 11,9%	18	5,506	0,000****
Tpeak (s)	0,01±0,03	0,01±0,01		18	1,149	0,265
AvgF (kg)	38,9±3,23	33,76±2,55	- 13,2%	18	7,205	0,000****

ECN: execution without the suspension training tool; TRX: suspension training tool

c) Monopodalic ½ squat - left limb

The left limb during the monopodalic execution returned values summarized in table 3.

During the execution with suspension training tool, in the eccentric phase, the pkforce has suffered a decrease of 41.8% ($p < 0.0005$), the AvgF a decrease of 18.1% ($p < 0.0005$) and the Tpeak a decrease of 38.8% that is not statistically significant.

In the concentric phase, instead, the use of the suspension training tool caused a decrease of 13.5% ($p < 0.0005$) of pkforce, of 15.8% ($p < 0.0005$) of the AvgF value and a decrease of 27.2% of the time to reach the Tpeak of force that is result not statistically significant.

Tabel 3. Differences during the monopodalic execution (analysis left leg) with and without the suspension training tool (TRX), in eccentric and concentric phase on strength parameters

Tab. 3	ECN eccentric	TRX eccentric	Diff. %	Df	T	P VALUE
pkforce (kg)	24,316±9,88	14,137±9,26	- 41,8%	18	6,902	0,000****
Tpeak (s)	0,108±0,12	0,066±0,07	-38,8%	18	1,644	0,117
AvgF (kg)	74,111±5,05	60,679±4,16	- 18,1%	18	10,052	0,000****
	ECN concentric	TRX concentric	Diff. %	Df	T	P VALUE
pkforce (kg)	135,316±17,25	116,942±14,97	- 13,5%	18	5,495	0,000****
Tpeak (s)	0,011±0,02	0,008±0,01	- 27,2%	18	,696	0,495
AvgF (kg)	77,795±6,44	65,479±3,09	- 15,8%	18	8,301	0,000****

ECN: execution without the suspension training tool; TRX: suspension training tool

d) Monopodalic ½ squat - right limb

The right limb during the monopodalic execution returned values summarized in table 4.

In the eccentric phase, during the execution with suspension training tool, the pkforce has decreased by 45.1% ($p < 0.0005$), the average force a decrease of 17.4% ($p < 0.0005$) and the Tpeak a decrease of 42.8% which is not statistically significant.

In the concentric phase, the use of the suspension training tool caused a decrease of 12.4% ($p < 0.0005$) of pkforce and 14.3% ($p < 0.0005$) of AvgF value while relatively to strength Tpeak, the use of the suspension training tool, caused a 100% increase that is not statistically significant.

Tabel 4. Differences during the monopodal execution (analysis right leg) with and without the suspension training tool (TRX), in eccentric and concentric phase on strength parameters

Tab. 4	ECN eccentric	TRX eccentric	Diff. %	Df	T	P VALUE
pkforce (kg)	23,98±9,1	13,15±7,18	- 45,1%	18	7,217	0,000****
Tpeak (s)	0,14±0,16	0,08±0,07	- 42,8%	18	1,721	0,102
AvgF (kg)	74,42±4,88	61,41±5,21	- 17,4%	18	9,430	0,000****
	ECN concentric	TRX concentric	Diff. %	Df	T	P VALUE
pkforce (kg)	138,17±16,36	121,02±14,01	- 12,4%	18	4,316	0,000****
Tpeak (s)	0,01±0,02	0,02±0,03	+ 100%	18	-,343	0,735
AvgF (kg)	79±6,69	67,68±3,32	- 14,3%	18	6,068	0,000****

ECN: execution without the suspension training tool; TRX: suspension training tool

Concerning the analysis of muscular power showed the following results.

e) Monopodal ½ squat – left limb

The left limb returned values summarized in table 5.

During the execution with suspension training tool, in the eccentric phase, the pkpower showed an increase of 8.8%, the AvgP showed a up 7.9% and the Tpeak, which is the time to reach peak power has decreased by 5.7%.

In the concentric phase, instead, during the execution with suspension training tool was observed an increase by 7.1% ($p < 0.05$) of pkpower, an increase of 1.6% of AvgP and an increase of Tpeak of 9.4%.

Tabel 5. Differences during the monopodal execution (analysis left leg) with and without the suspension training tool (TRX), in eccentric and concentric phase on power parameters

Tab. 5	ECN eccentric	TRX eccentric	Diff. %	Df	T	P VALUE
pkpower (W)	649,463±135,24	707,263±165,26	+ 8,8%	18	-1,347	0,195
Tpeak (s)	0,279±0,1	0,263±0,06	- 5,7%	18	,696	0,495
AvgP (W)	304,905±52,92	329,074±107,54	+ 7,9%	18	-,945	0,357
	ECN concentric	TRX concentric	Diff. %	Df	T	P VALUE
pkpower (W)	810,168±144,25	867,911±185,62	+ 7,1%	18	-2,623	0,017*
Tpeak (s)	0,158±0,06	0,173±0,08	+ 9,4%	18	-1,985	0,063
AvgP (W)	389,195±64,62	395,532±67,92	+ 1,6%	18	-,635	0,533

ECN: execution without the suspension training tool; TRX: suspension training tool

f) Monopodal ½ squat - right limb

The right limb returned values summarized in table 6.

During the execution with suspension training tool, in the eccentric phase, the pkpower showed an increase of 9.9%, the AvgP showed an increase of 0.5% and the Tpeak a decrease by 16%.

In the concentric phase, instead, during the execution with suspension training tool was detected an increase of 5.4% of the pkpower, 4.7% of the AvgP and a decrease of Tpeak power equal to 4% .

Tabel 6. Differences during the monopodal execution (analysis right leg) with and without the suspension training tool (TRX), in eccentric and concentric phase on power parameters

Tab. 6	ECN eccentric	TRX eccentric	Diff. %	Df	T	P VALUE
pkpower (W)	677,779±120,13	745,095±146,02	+ 9,9%	18	-1,687	0,109
Tpeak (s)	0,312±0,16	0,262±0,08	- 16%	18	1,775	0,093
AvgP (W)	296,632±50,9	298,242±61,55	+ 0,5%	18	-,091	0,928
	ECN concentric	TRX concentric	Diff. %	Df	T	P VALUE
pkpower (W)	854,953±107,75	901,847±165,41	+ 5,4%	18	-1,874	0,077
Tpeak (s)	0,149±0,05	0,143±0,04	- 4%	18	,758	0,458
AvgP (W)	415,058±32,08	395,379±60,81	- 4,7%	18	1,416	0,174

ECN: execution without the suspension training tool; TRX: suspension training tool

g) Comparison of the two arts in the bipodalic execution of ½ squat

As it regards the assessment of muscle power in the execution of bipodalic ½ squat it is wanted to describe and quantify the behavior of individual limbs in the performance without versus with suspension training tool. The percentage of asymmetry was calculated on the basis of different performances obtained by individual arts.

The values of the differences between the two limbs prestativa are reported in table 7.

The suspension training tool, in the eccentric phase, reduced prestativa differences between the two limbs of approximately 55.2% ($p < 0.05$) relative to pkpower, 33.1% relative to value of AvgP and 56.5% ($p < 0.05$) relative to Tpeak power.

In the concentric phase, instead, the use of the suspension training tool reduced prestativa differences between the two limbs of about 54.1% ($p < 0.01$) relative to pkpower, 38.4% relative to value of AvgP and 63.5% ($p < 0.0005$) relative to Tpeak power.

Table 7. Asymmetry differences between two leg during the bipodalic execution with and without the suspension training tool (TRX) in eccentric and concentric phase on power parameters

Tab. 7	ECN eccentric	TRX eccentric	Diff. %	Df	T	P VALUE
pkpower % asym.	18,689±17,16	8,368±8,51	- 55,2%	18	2,902	0,010*
Tpeak % asym.	8,947±7,58	3,889±3,36	- 56,5%	18	2,457	0,024*
AvgP % asym.	14,563±12,29	9,737±6,94	- 33,1%	18	1,243	0,230
	ECN concentric	TRX concentric	Diff. %	Df	T	P VALUE
pkpower % asym.	16,695±10,1	7,653±6,24	- 54,1%	18	3,573	0,002**
Tpeak % asym.	9,484±4,54	3,453±3,27	- 63,5%	18	6,023	0,000****
AvgP % asym.	14,732±12,55	9,074±6,2	- 38,4%	18	1,704	0,106

ECN: execution without the suspension training tool; TRX: suspension training tool

Discussion

This study, therefore, is configured substantially as the first work which aims to describe the load imposed to the subject which uses a device for suspension training in the execution of a task very widespread such as ½ squat; the device for suspension training could be likened to a tool that attempts to recreate an antigravity condition, similar that occurs in aquatic environment. Consequently, and because of the values relating to the body weight reduction described, it seems plausible to compare the values obtained with studies that have used methodologies for training in anti-gravitational environments, such as the aquatic environment, in which the muscular activity of the lower limbs (18-24), measured by means electromyography, is reduced significantly compared to what happens on earth. To confirm the load reduction in anti-gravitational environments, there are other studies that have monitored and quantified the difference (reduction) in the execution of the same task on the ground versus aquatic environment, with particular reference to the vertical ground reaction force (25-29). Is known in fact that the condition of load reduction determines a change in force production, as well as occurs in aquatic environment (24). Relatively to the values of muscle power (pkpower, Tpeak, AvgP), this study found that the execution with the Suspension Training tool provokes increases in terms of average power and peak power and decreases in terms of time to reach the peak power compared to the execution at natural load. In according with the literature which indicates that the athlete's ability to accelerate a load and, consequently, to obtain values of high power it is compatible with the use of very low loads (30-38). From the literature, in fact, it is known that the reduced body weight can determine the expression of greater power values: some authors suggest that the ideal percentages for this training tipology are ranging from 10 and 30% of 1RM (30-38); the only body weight too may be sufficient to increase the muscular power values (39,40).

The decrease of the prestativa differences between the two limbs in the bipodalic ½ squat with the suspension training tool, with regard to power parameters analyzed, it induces to hypothesize that, the tool in question, conditions the subject to distribute more uniformly and effectively the load on both limbs with respect to what occurs in the natural load condition. From this study, in addition, according to the results reported above, it is clear, that during a training session, the use of suspension training tool significantly reduces the load of work performed, making it be less intense than a bodyweight training done with the same execution methods and with the same sets and reps. These results allow to deduce that if you wish to perform a strength training session with suspension training tool should re-modulate the load with a greater number of sets and repetitions compared to the external load planned a bodyweight training session. Moreover, in consideration of the reduction of the values relating to the body weight and the expression of the force levels described in the ½ squat execution with suspension training tool, both in monopodalic or bipodalic, the tasks evaluated may be effective for use in the

first stages of rehabilitation in closed kinetic chain conditions. In this regard, the results obtained from the assessment of gestural expressiveness measured appear to superimposed with other similar studies that have suggested water as environment helpful to return to sports the subject's lower limb injury (41-53).

Conclusions and practical applications

The fitness market and marketing tools for athletic training and muscle conditioning propose new tools that are introduced in the training sessions, without elaborating, sometimes, the real effects and the demands imposed on the subject that will be exercised. Among the tools introduced recently in the context of the physical efficiency for adults and for athletic conditioning in the sports, there is the tool for suspension training (or TRX). Either by itself used in the initial warm-up either by itself adopted for the increase of strength, it is appropriate to know the effective demands in terms of load assigned to the subject. This study aimed to describe the load imposed that the subject using the suspension training tool, performs two tasks very commons in fitness and sport: the ½ squat in bipodalic and monopodalic, comparing them with the same execution performed without tool. From this study has emerged as the suspension training tool causes a significant decrease of body weight, of the parameters of force to the ground and the increases in terms of power expressed, but also a significant decrease in terms of power of the differences between two limbs. Therefore based on these results, relatively to the tasks observed, it could be suggested the practice of the suspension training in the first stages rehabilitative in of closed kinetic chain conditions, in training sessions with subjects that have considerable different between two limbs and in the phases of warm up.

Conflicts of interest

The authors of the following article have not received any funding and have no contractual relationship with the companies that produce the products mentioned in the text.

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