THE ACUTE EFFECTS OF SMALL-SIDED GAMES ON HAMSTRING STRENGTH IN YOUNG SOCCER PLAYERS

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Authors’ Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

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Abstract
The study purpose. The Small-side games (SSG) are high intensity drills very popular in soccer training. The knowledge of the acute effects of the exercises that make up the training session is very relevant especially to reduce youth soccer injury risk. This study aim to assess the acute effects of SSG on hamstring eccentric strength and to know the lower limb strength asymmetries (LLSA) in young soccer players.

Materials and methods. The sample is composed of male young soccer players Under 17 (n = 24, 16.6 ± 0.5 years, 168.8 ± 4.6 cm, 58.2 ± 3.5 kg). Before and after SSG (4vs4, 3×4 min, 3min recovery, no goalkeepers) the hamstring eccentric strength and the lower limb eccentric strength asymmetry were evaluated using a specific dynamometer (N3 Easytech, Italy) and relative software. Every young soccer player performed a single repetition of the Nordic hamstring exercise with dynamometer; after about 2 minutes, instead, they performed 5 repetitions of the same exercise, without interruption. For both assessments, were detected the eccentric strength and the LLSA.

Results. The hamstring eccentric strength assessment showed substantial and statistically significant differences in the assessment in comparison pre-post values. A significant reduction was observed for eccentric strength peak (p < 0.018 and p < 0.014 for right/left limb), for eccentric average strength (p < 0.017 and p < 0.006 for right/left limb). The eccentric peak strength asymmetry value and the average strength asymmetry value revealed a significant increase (p < 0.0001).

Conclusions. The reduction of strength after SSG requires careful consideration of the exercises order in the training session. The practitioners can plan training sessions and apply SSGs more effectively, with more attention to the effects on hamstrings.

Keywords: hamstring, prevention, young soccer player, small-sided games.

Introduction
Today research tends to always bring new knowledge to the young player training (Esposito et al., 2019; Raiola & Altavilla, 2020; Ceruso et al., 2019). These contributions concern both general defined training (Fischetti et al., 2019; Barbalho et al., 2018; D’Isanto et al., 2019) and the one defined as specific (Köklü et al., 2015; Sanchez-Sanchez et al., 2019; Sannicandro et al., 2019a).

Within the exercises mainly used in sport-specific training there are the so-called Small-Sided Games (SSG) (Halouani et al., 2017; Castillo et al., 2021).

The SSG are high intensity drills very popular in soccer training (Kunz et al., 2019; Selmi et al., 2018; Zurutuza et al., 2020). These exercises are used to achieve technical, tactical and conditioning goals, both with adult soccer players and with young players: today, in fact, the staff are continuously looking for exercises that can increase the soccer player performance effectiveness in all competitive levels (Miranda et al., 2021; Sannicandro et al., 2020, 2021b; Köklü et al., 2020).

The literature on the SSG topic is very wide and today allows us to know in an analytical way the internal and external load of many formats, from 1v1 to 10vs10 (Coutinho et al., 2018; Sanchez-Sanchez et al., 2019), with reference to the field different dimensions (Clemente et al., 2019; Goto & King, 2019) or to its spatial configuration (Coutinho et al., 2018; Sanchez-Sanchez et al., 2019; Sannicandro, 2019).
The relationship between the type of exercise chosen, motor load and soccer injury risk is a very topical research issue (Sannicandro et al., 2021b; Castilho et al., 2019): in fact, despite having a large number of knowledge on injury risk factors, numerous prevention exercises and greater knowledge on muscle, epidemiological studies describe that indirect trauma is on the rise in both men (Diemer et al., 2021; Ribeiro-Alvares et al., 2020; Vicens-Bordas et al., 2020) and female (Larruskain et al., 2018).

The diffusion of sport-specific exercises rather than general ones (which are easier to control in terms of intensity and volume) could lead to an overload on some muscle groups that are most frequently engaged in soccer ability (Madison et al., 2019; Wilmes et al., 2021; Ekstrand et al., 2016).

Infact, today there are few studies that have attempted to know whether SSGs and the most widespread sport-specific exercises in football player training can determine fatigue conditions on specific muscle groups (Greig, 2019; Rhodes et al., 2019; Greig and Siegler, 2009) and on hamstrings in particular (Madison et al., 2019; Wilmes et al., 2021; Small et al., 2010).

Whether for elite soccer players or for the healthy adult population there is research in the literature that allows us to understand how neuromuscular structures respond to high-intensity sport-specific exercises (Diemer et al., 2021; Ribeiro-Alvares et al., 2020; Lovell et al., 2016) or following real or simulated matches (Matthews et al., 2017; Marshall et al., 2014; Madison et al., 2019), for youth soccer the studies carried out are numerically lower (Perroni et al., 2018; Köklü et al., 2020).

Similarly, modest attention has been paid to assessing the hamstring strength for injury prevention in youth soccer (Sannicandro et al., 2019), although it is known, the relationship between values of hamstring eccentric strength and injury risk in sports where high running speeds are required (Lee et al., 2018; Beato et al., 2021; Opar et al., 2021).

The preventive strategies organization can not characterize the top player or the adult athlete, must be placed above all in the athlete training and athlete evolution process: in this phase the risk factors monitoring offers greater guarantees of long-term success (Opar et al., 2015; White et al., 2019; Greig and Siegler, 2009) and on hamstrings in particular (Greig, 2019; Rhodes et al., 2019; Lehnert et al., 2018).

The purpose of this study was to determine the effects of SSG variations on hamstring strength and in strength asymmetry values in elite young soccer players.

Materials and methods

Study participants

The sample is composed of male young soccer players Under 17 (n = 24) belonging to a professional team, whose age, height, weight and Body Mass Index were respectively (mean ± ds) 16.6 ± 0.5 years, 168.8 ± 4.6 cm, 58.2 ± 3.5 kg e 20.7 ± 1.1 kg/m². The young soccer players who had an hamstring injury in the previous 12 months were excluded from the assessment.

The evaluation tool was routinely employed by staff, however, the evaluation was carried out after receiving the parent informed consent and with the presence of the team’s medical staff. Moreover, all participants were informed about the aim of the study and the relevance of the assessment. Additionally, the research design and procedures complied with the standards set out in the Declaration of Helsinki and was approved by the regional soccer ethics committee.

Study organization

To assess the hamstring eccentric strength and the lower limb eccentric strength asymmetry have been used a specific dynamometer (N3, Easytech, Italy) with specific software. This tool detects the strength expressed during the Nordic Hamstring exercise (Fig.1). The tool and the software allow to measure the peak force and the average force if you perform a number of repetitions higher than one.

The study participants became familiar with the used dynamometer in the two sessions before the evaluation. The evaluation was carried out in the field at a temperature of 23°C.

Before the evaluation all the participants followed a warm-up phase that was the same for everyone and included a low intensity running period (10 minute at 60% HRmax), exercises for dynamic stretching and mobility for the lower limbs, for a total duration of about 15 minutes.

The assessment session organization had two phases: in the first, every young soccer player performed a single repetition of the Nordic hamstring exercise with constraint to the N3 dynamometer; after about 2’ minutes, instead, they performed 5 repetitions of the same exercise, without interruption. All values were acquired using N3 software: for both assessments, were detected the eccentric strength and the lower limbs strength asymmetry. The asymmetry calculation was obtained through the formula already used in the literature (Ceroni et al., 2012).

The evaluations were carried out after the warm up (pre test) and after the SSG session (post test). The SSG session consisted of 4 vs 4 (3×4 minutes, 3 minutes recovery) in a 24x36m field with ball possession mode and without limitation of consecutive touches.

20 balls were distributed around the perimeter of the pitch and introduced by 4 assistants to avoid moments of pause. At the end of the post-SSG evaluation, the participants returned the perceived exertion assessed by the CR10 Borg scale (Borg, 1982).
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Statistical Analysis

Descriptive statistics (M ± SD) were calculated for all assessed variables; Student’s paired t-test was used to verify the existence of statistically significant differences between the average values obtained. The significance was set at p < 0.05.

Results

The hamstring eccentric strength assessment show substantial and statistically significant differences in the Nordic exercise test with reference to pre-post exercise values.

In particular, the strength peak of right limb in the comparison between pre and post test showed a reduction of about 27.1N (259.1 ± 62.7N vs 232.1 ± 30.4N, p < 0.018); the strength peak of left limb in the comparison between pre and post test showed a reduction of about 35.6N (256.3 ± 62.1N vs 220.7 ± 40.2N, p < 0.041). The peak strength asymmetry value revealed an increase of about 10.9% (4.45 ± 3.1 vs 15.4 ± 5.6%, p < 0.0001).

The average strength of right limb in the comparison between pre and post test showed a reduction of about 26 N (237.4 ± 41.8N vs 211.3 ± 30.1N, p < 0.017). The average strength of left limb in the comparison between pre and post test showed a reduction of about 33 N (236.2 ± 42.6N vs 203.2 ± 34.9N, p < 0.006). The average strength asymmetry value revealed an increase of about 16.9% (3.9 ± 2.4 vs 20.1 ± 5.2%, p < 0.0001). The results are summarized in table 1.

The average value of Borg scale was equal to 7.8±0.7.

Discussion

This study aimed to describe the acute effects deriving from the SSG practice on the hamstring eccentric strength values and on the strength asymmetry values in elite young soccer players.

In the literature, as available, this is the first study that evaluates the hamstring eccentric strength and investigates the lower limb asymmetries in young soccer players after SSG session.

As is the first study that uses a specific dynamometer for the strength hamstring with this type of sample and this type of exercise with young soccer players of elite team.

The care of player preventive factors can not start when the athlete reaches high levels of performance, but must characterize the entire sports training process both for functional and cultural reasons (Sannicandro et al., 2019; Ros et al., 2013).

The attention towards hamstring muscles in the field of soccer strength and conditioning must be even more assertive when looking at the data on the muscle trauma increase related to hamstring in the last 10-15 years (Edouard et al., 2016; Jones et al., 2019; Smokos et al., 2018). And this incidence is also relevant in youth sport (Valle et al., 2018).

The peak strength values for right and left limb showed a significant percentage decrease respectively of about 10.5% and 13.9%. This decrease is consistent with the results observed in elite soccer players after SSG session on large field (Madison et al., 2019).

Table 1. Peak strength values, average strength values and asymmetry values referred to the Nordic Hamstring assessment

<table>
<thead>
<tr>
<th>Hamstring strength parameters</th>
<th>Media ± ds</th>
<th>Δ (media ± ds)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strength peak (N) pre right limb</td>
<td>259.10 ± 62.7</td>
<td>27.1 ± 40.7</td>
<td>0.018</td>
</tr>
<tr>
<td>Strength peak (N) post left limb</td>
<td>232.10 ± 30.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strength peak (N) pre right limb</td>
<td>256.30 ± 62.1</td>
<td>35.6 ± 66.1</td>
<td>0.041</td>
</tr>
<tr>
<td>Strength peak (N) post left limb</td>
<td>220.70 ± 40.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak strength asymmetry value pre (%)</td>
<td>4.45 ± 3.1</td>
<td>10.9 ± 6.1</td>
<td>0.0001</td>
</tr>
<tr>
<td>Peak strength asymmetry value post (%)</td>
<td>15.40 ± 5.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average strength 5 rep (N) pre right limb</td>
<td>237.40 ± 41.8</td>
<td>26.1 ± 23.4</td>
<td>0.017</td>
</tr>
<tr>
<td>Average strength 5 rep (N) post right limb</td>
<td>211.30 ± 30.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average strength 5 rep (N) pre left limb</td>
<td>236.20 ± 42.6</td>
<td>33.1 ± 41.2</td>
<td>0.006</td>
</tr>
<tr>
<td>Average strength 5 rep (N) post left limb</td>
<td>203.20 ± 34.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average strength asymmetry value pre (%)</td>
<td>3.90 ± 2.4</td>
<td>16.1 ± 5.5</td>
<td>0.0001</td>
</tr>
<tr>
<td>Average strength asymmetry value post (%)</td>
<td>20.10 ± 5.2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The average strength values for right and left limb showed a significant percentage decrease respectively of about 11% and 14%. No studies have been found in the literature that have monitored the trend of the hamstring strength values following multiple repetitions with Nordic hamstring exercise.

The available studies concern young subjects over the age of 18 years (Daneshjoo et al., 2012, 2013; Śliwowski et al., 2015) or with young adults assessed using isokinetic dynamometer (Lehnert et al., 2018).

This value, however, is extremely important because the execution of more repetitions allows to better analyze the muscular behavior when the effects of fatigue begin to appear (Greig & Siegler, 2009).

The strength decrease observed following SSG exercises agrees with what emerged after 45 minutes of match (Greig & Siegler, 2009) or following technical exercises (Madison et al., 2019; Greig, 2019; Rhodes et al., 2019).

The asymmetry values revealed that the differences in performance between the hamstrings of the two limbs increase after SSG exercise: this increase is statistically significant both for the value of the eccentric strength peak (+10.9%, p < 0.0001) and for the average strength produced after more repetitions (+16.9%, p < 0.0001).

Regarding functional asymmetries of lower limb strength in young football players, the literature is more attentive to the differences between dominant / non-dominant limb (Kalata et al., 2020; Maly et al., 2016; Hewitt et al., 2012), as asymmetries in functional movements (Fort-Vanmeerhaeghe et al., 2020; Marques et al., 2017) to those concerning imbalances (Atkins et al., 2016; Maloney, 2019) rather than what occurs in the hamstring muscle district (Sannicandro et al., 2019).

This aspect seems to be more frequently investigated with reference to the post traumatic picture (Rush et al., 2020; Sherman et al., 2021).

The different strength production in fatigue conditions, on the other hand, can constitute an interesting investigation field especially in sports where high running speeds and high accelerations and decelerations are required (Loturco et al., 2016; Owen et al., 2016) because it exposes the athlete to distribute the load between the two limbs in a way not homogeneous.

The monitoring of this value, on the other hand, represents a relevant indicator for hamstring injury risk reducing (Śliwowski et al., 2015; Mendiguchia et al., 2012); it allows us to understand the effects of peripheral fatigue deriving from sport-specific exercises and the performance relationships (Wilmes et al., 2021; Castillo et al., 2021).

**Conclusions**

The study requires further analysis in relation to the influence of fatigue resulting from more repetition of SSG exercises to try to understand if the sport-specific exercises volume can affect the lower limb asymmetry increase.

This study has some limitations: it did not monitor the performance differences between the preferred limb for kicking and the other, just as it did not investigate the effects on the strength decrease following SSG exercises carried out on fields of different sizes.

Subsequent studies will have to investigate this issue: a wider sample must be envisaged and eccentric strength and asymmetry must be monitored throughout the competitive season; it is necessary to understand if there are variations related to the session scheduling, to the exercises order structuring or to the competitive season phases.

**Conflict of interest**

The authors declare no conflict of interest.

**References**


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