Теорія та методика фізичного виховання
Physical Education Theory and Methodology
Teorìâ ta Metodika Fizičnogo Vihovannâ

ISSN 1993-7989 (print)
ISSN 1993-7997 (online)
ISSN-L 1993-7989

ORIGINAL SCIENTIFIC ARTICLE

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

**Italo Sannicandro[1,2ABD], Giacomo Cofano[1,2BC] and Gaetano Raiola[3AC]**

[1]University of Foggia
[2]Professional soccer strength and conditioning coach
[3]University of Salerno

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

Corresponding Author: Italo Sannicandro, E-mail: italo.sannicandro@unifg.it
Accepted for Publication: February 9, 2022
Published: March 25, 2022

**DOI: 10.17309/tmfv.2022.1.11**

**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 assessment 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 used 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 show 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; Castillo 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, but 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., 2018; Leister et al., 2018). The identification at the young age of imbalances and strength asymmetries allow an early intervention that can contrast a potential injury risk scenario. Recent studies show that even in Under 20 soccer players the hamstring injury incidence has its relevance, reaching 18% of total traumas (Ribeiro-Alvares et al., 2020;) or about 35%, according to other epidemiological studies (Valle et al., 2018).; even young players have very high risk factors of injury, such as reduced active flexibility, lower limb asymmetry, functional and core stability deficits (Buckthorpe et al., 2019; Crossley et al., 2020; Lu et al., 2020).

Despite the high incidence of hamstring injuries in soccer players, the most recent literature does not seem exhaustive in addressing the strength asymmetries and muscle imbalances issues in young players following sport-specific exercises. The investigations are mainly limited to over 18 years old soccer players or/and adults (Daneshjoo et al., 2012, 2013; Śliwowski et al. 2015; Lehnert et al., 2018); therefore, an open problem remains the evaluation of eccentric strength and the evaluation of the asymmetry of strength of the lower limb in the young player.

*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/m$^2$. 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).

**Fig. 1.** The N3 Easytech dynamometer and the strength assessment: the young soccer player starts the assessment in the traditional start position of Nordic hamstring and slowly descends

### *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; Smpokos 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

| Hamstring strength parameters | Media ± ds | Δ (media ± ds) | p value |
|---|---|---|---|
| Strength peak (N) pre right limb | 259.10 ± 62.7 | 27.1 ± 40.7 | 0.018 |
| Strength peak (N) post left limb | 232.10 ± 30.4 | | |
| Strength peak (N) pre right limb | 256.30 ± 62,1 | 35.6 ± 66.1 | 0.041 |
| Strength peak (N) post left limb | 220.70 ± 40.2 | | |
| Peak strength asymmetry value pre (%) | 4.45 ± 3.1 | 10.9 ± 6.1 | 0.0001 |
| Peak strength asymmetry value post (%) | 15.40 ± 5.6 | | |
| Average strength 5 rep (N) pre right limb | 237.40 ± 41.8 | 26.1 ± 23.4 | 0.017 |
| Average strength 5 rep (N) post right limb | 211.30 ± 30.1 | | |
| Average strength 5 rep (N) pre left limb | 236.20 ± 42.6 | 33.1 ± 41.2 | 0.006 |
| Average strength 5 rep (N) post left limb | 203.20 ± 34.9 | | |
| Average strength asymmetry value pre (%) | 3.90 ± 2.4 | 16.1 ± 5.5 | 0.0001 |
| Average strength asymmetry value post (%) | 20.10 ± 5.2 | | |

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) , to 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

Esposito, G., Ceruso, R., & D'Elia, F. (2019). The importance of a technical-coordinative work with psychokinetic elements in the youth sectors of soccer academies. *Journal of Physical Education and Sport,* 19, 1843-1851.

Raiola, G., & Altavilla, G. (2020). Testing motor skills, general and special coordinative, in young soccer. *Journal of Human Sport & Exercise,* 15, Supplementary Issue, 1Proc Winter event Costa Blanca: 206-212.

Ceruso, R., Esposito, G., & D'Elia, F. (2019). Coordination attached to the qualitative aspects of football. *Journal of Physical Education and Sport,* 19, 260, 1773-1776.

Fischetti, F., Cataldi, S., & Greco, G. (2019). A combined plyometric and resistance training program improves fitness performance in 12 to 14-years-old boys. *Sport Sciences for Health, 15*(3), 615-621. https://doi.org//s11332-019-00560-2

Barbalho, M., Gentil, P., Raiol, R., Del Vecchio, F. B., Ramirez-Campillo, R., & Coswig, V. S. (2018). Non-Linear Resistance Training Program Induced Power and Strength but Not Linear Sprint Velocity and Agility Gains in Young Soccer Players. *Sports (Basel, Switzerland), 6*(2), 43. https://doi.org/10.3390/sports6020043

D'Isanto, T., D'Elia, F., Raiola, G., & Altavilla, G. (2019). Assessment of sport performance: Theoretical aspects and practical indications. *Sport Mont,* 17, 79-82.

Köklü, Y., Sert, Ö., Alemdaroğlu, U., & Arslan, Y. (2015). Comparison of the physiological responses and time-motion characteristics of young soccer players in small-sided games: the effect of goalkeeper. *Journal of strength and conditioning research, 29*(4), 964-971. https://doi.org/10.1519/JSC.0b013e3182a744a1

Sanchez-Sanchez, J., Sánchez García, M., Asián-Clemente, J.A., Nakamura, F.Y, & Ramírez-Campillo, R. (2019). Effects of the Directionality and the Order of Presentation Within the Session on the Physical Demands of Small-Sided Games in Youth Soccer. *Asian J Sports Med,* 10, 1-8.

Sannicandro, I, Traficante, P, & Cofano, G. (2019a). Hamstring injury prevention: the strength assessment in young soccer players. *MOJ Sports Med., 3*(2), 28-32. https://doi.org/mojsm.2019.03.00075

Halouani, J., Chtourou, H., Dellal, A., Chaouachi, A., & Chamari, K. (2017). Soccer small-sided games in young players: rule modification to induce higher physiological responses. *Biology of sport, 34*(2), 163-168. https://doi.org/10.5114/biolsport.2017.64590

Castillo, D., Raya-González, J., Sarmento, H., Clemente, F. M., & Yanci, J. (2021). Effects of including endurance and speed sessions within small-sided soccer games

periodization on physical fitness. *Biology of sport, 38*(2), 291-299. https://doi.org/10.5114/biolsport.2021.99325

Kunz, P., Engel, F. A., Holmberg, H. C., & Sperlich, B. (2019). A Meta-Comparison of the Effects of High-Intensity Interval Training to Those of Small-Sided Games and Other Training Protocols on Parameters Related to the Physiology and Performance of Youth Soccer Players. *Sports Medicine - Open, 5*(1), 7. https://doi.org/10.1186/s40798-019-0180-5

Selmi, O., Marzouki, H., Ouergui, I., BenKhalifa, W., & Bouassida, A. (2018). Influence of intense training cycle and psychometric status on technical and physiological aspects performed during the small-sided games in soccer players. *Research in Sports Medicine, 26*(4), 401-412.

Zurutuza, U., Castellano, J., Echeazarra, I., Guridi, I., & Casamichana, D. (2020). Selecting Training-Load Measures to Explain Variability in Football Training Games. *Front. Psychol.,* 10, 2897. https://doi.org/fpsyg.2019.02897

Miranda, G., Aliberti, S., & Invernizzi, P.L. (2021). Effects of an 8-week intermittent aerobic training program on aerobic power in a professional soccer team. *Journal of Human Sport and Exercise, 16*(3proc), S1031-S1038. https://doi.org/10.14198/jhse.2021.16.Proc3.20

Sannicandro, I., Piccinno, A., Rosa, A.R., Raiola, G., Cofano, G. (2020). Analysis of external load during SSG 5vs5 with and without external wildcard (jolly) soccer players. *Sport Science,* 14, 65-71.

Sannicandro, I. (2021b). Small-sided games and size pitch in elite female soccer players: A short narrative review. *Journal of Human Sport and Exercise, 16*(2proc), S361-S369.

Köklü, Y., Cihan, H., Alemdaroğlu, U., Dellal, A., & Wong, D. P. (2020). Acute effects of small-sided games combined with running drills on internal and external loads in young soccer players. *Biology of sport, 37*(4), 375-381. https://doi.org/10.5114/biolsport.2020.96943

Coutinho, D., Gonçalves, B., Santos, S., Travassos, B., Wong, D. P., & Sampaio, J. (2019). Effects of the pitch configuration design on players' physical performance and movement behaviour during soccer small-sided games. *Research in Sports Medicine, 27*(3), 298-313. https://doi.org/10.1080/15438627.2018.1544133

Clemente, F. M., Sarmento, H., Rabbani, A., Van Der Linden, C. M. I. (Niels), Kargarfard, M., & Costa, I. T. (2019). Variations of external load variables between medium- and large-sided soccer games in professional players. Research in Sports Medicine, 27(1), 50-59. https://doi.org/10.1080/15438627.2018.1511560

Goto, H., & King, J.A. (2019). High-intensity demands of 6-a-side small-sided games and 11-a-side matches in youth soccer players, Pediatr Exerc Sci, 31(1):85-90.

Sannicandro, I. (2019). Small-Sided Games configuration pitch and external motor load relationship in young soccer players: narrative literature review, Journal of Physical Education and Sport, 19 (Supplement issue 5), 1989-1993.

Sannicandro, I., Belli, E., & La Torre, A. (2021b). Warm up and postactivaction potentiation: a very topical debate. *J Sports Med Phys Fitness,* 61, 331-332.

Castillo, D., Rodríguez-Fernández, A., Nakamura, F. Y., Sanchez-Sanchez, J., Ramirez-Campillo, R., Yanci, J., Zubillaga, A., & Raya-González, J. (2019). Influence of Different Small-Sided Game Formats on Physical and Physiological Demands and Physical Performance in Young Soccer Players. *Journal of strength and conditioning research.* Advance online publication. https://doi.org/10.1519/JSC.0000000000003114

Diemer, W. M., Winters, M., Tol, J. L., Pas, H., & Moen, M. H. (2021). Incidence of Acute Hamstring Injuries in Soccer: A Systematic Review of 13 Studies Involving More Than 3800 Athletes With 2 Million Sport Exposure Hours. *The Journal of orthopaedic and sports physical therapy, 51*(1), 27-36. https://doi.org/10.2519/jospt.2021.9305

Ribeiro-Alvares, J. B., Dornelles, M. P., Fritsch, C. G., de Lima-E-Silva, F. X., Medeiros, T. M., Severo-Silveira, L., Marques, V. B., & Baroni, B. M. (2020). Prevalence of Hamstring Strain Injury Risk Factors in Professional and Under-20 Male Football (Soccer) Players. *Journal of sport rehabilitation, 29*(3), 339-345. https://doi.org/10.1123/jsr.2018-0084

Vicens-Bordas, J., Esteve, E., Fort-Vanmeerhaeghe, A., Clausen, M. B., Bandholm, T., Opar, D., Shield, A., & Thorborg, K. (2020). Eccentric hamstring strength is associated with age and duratiom of previous season hamstring injury in male soccer players. *International journal of sports physical therapy, 15*(2), 246-253.

Larruskain, J., Lekue, J. A., Diaz, N., Odriozola, A., & Gil, S. M. (2018). A comparison of injuries in elite male and female football players: A five-season prospective study. *Scandinavian journal of medicine & science in sports, 28*(1), 237-245. https://doi.org/10.1111/sms.12860

Madison, G., Patterson, S. D., Read, P., Howe, L., & Waldron, M. (2019). Effects of Small-Sided Game Variation on Changes in Hamstring Strength. *Journal of strength and conditioning research, 33*(3), 839-845. https://doi.org/10.1519/JSC.0000000000002955

Wilmes, E., de Ruiter, C. J., Bastiaansen, B., Goedhart, E. A., Brink, M. S., van der Helm, F., & Savelsbergh, G. (2021). Associations between Hamstring Fatigue and Sprint Kinematics during a Simulated Football (Soccer) Match. *Medicine and science in sports and exercise.* Advance online publication. https://doi.org/10.1249/MSS.0000000000002753

Ekstrand, J., Waldén, M., & Hägglund, M. (2016). Hamstring injuries have increased by 4% annually in men's professional football, since 2001: a 13-year longitudinal analysis of the UEFA Elite Club injury study. *British journal of sports medicine, 50*(12), 731-737. https://doi.org/10.1136/bjsports-2015-095359

Greig, M. (2019). Concurrent changes in eccentric hamstring strength and knee joint kinematics induced by soccer-specific fatigue. *Physical therapy in sport : official journal of the Association of Chartered Physiotherapists in Sports Medicine,* 37, 21-26. https://doi.org/10.1016/j.ptsp.2019.02.003

Rhodes, D., McNaughton, L., & Greig, M. (2019). The temporal pattern of recovery in eccentric hamstring strength post-soccer specific fatigue. *Res Sports Med., 27*(3), 339-350. https://doi.org/15438627.2018.1523168

Greig, M., & Siegler, J. C. (2009). Soccer-specific fatigue and eccentric hamstrings muscle strength. *Journal of athletic training, 44*(2), 180-184. https://doi.org/10.4085/1062-6050-44.2.180

Small, K., McNaughton, L., Greig, M., & Lovell, R. (2010). The effects of multidirectional soccer-specific fatigue on markers of hamstring injury risk. *Journal of science and medicine in sport, 13*(1), 120-125. https://doi.org/10.1016/j.jsams.2008.08.005

Lovell, R., Siegler, J. C., Knox, M., Brennan, S., & Marshall, P. W. (2016). Acute neuromuscular and performance responses to Nordic hamstring exercises completed before or after football training. *Journal of sports sciences, 34*(24), 2286-2294. https://doi.org/10.1080/02640414.2016.1191661

Matthews, M. J., Heron, K., Todd, S., Tomlinson, A., Jones, P., Delextrat, A., & Cohen, D. D. (2017). Strength and endurance training reduces the loss of eccentric hamstring torque observed after soccer specific fatigue. *Physical therapy in sport : official journal of the Association of Chartered Physiotherapists in Sports Medicine,* 25, 39-46. https://doi.org/10.1016/j.ptsp.2017.01.006

Marshall, P. W., Lovell, R., Jeppesen, G. K., Andersen, K., & Siegler, J. C. (2014). Hamstring muscle fatigue and central motor output during a simulated soccer match. *PloS one, 9*(7), e102753. https://doi.org/10.1371/journal.pone.0102753

Perroni, F., Pintus, A., Frandino, M., Guidetti, L., & Baldari, C. (2018). Relationship Among Repeated Sprint Ability, Chronological Age, and Puberty in Young Soccer Players, *Journal of Strength and Conditioning Research, 32*(2), 364-371.

Lee, J., Mok, K. M., Chan, H., Yung, P., & Chan, K. M. (2018). Eccentric hamstring strength deficit and poor hamstring-to-quadriceps ratio are risk factors for hamstring strain injury in football: A prospective study of 146 professional players. *Journal of science and medicine in sport, 21*(8), 789-793. https://doi.org/10.1016/j.jsams.2017.11.017

Beato, M., Young, D., Stiff, A., & Coratella, G. (2021). Lower-Limb Muscle Strength, Anterior-Posterior and Inter-Limb Asymmetry in Professional, Elite Academy and Amateur Soccer Players. *Journal of human kinetics,* 77, 135-146. https://doi.org/10.2478/hukin-2020-0058

Opar, D. A., Timmins, R. G., Behan, F. P., Hickey, J. T., van Dyk, N., Price, K., & Maniar, N. (2021). Is Pre-season Eccentric Strength Testing During the Nordic Hamstring Exercise Associated with Future Hamstring Strain Injury? A Systematic Review and Meta-analysis. *Sports medicine (Auckland, N.Z.)*. Advance online publication. https://doi.org/10.1007/s40279-021-01474-1

Opar, D. A., Williams, M. D., Timmins, R. G., Hickey, J., Duhig, S. J., & Shield, A. J. (2015). Eccentric hamstring strength and hamstring injury risk in Australian footballers. *Medicine and science in sports and exercise, 47*(4), 857-865. https://doi.org/10.1249/MSS.0000000000000465

White, A. K., Klemetson, C. J., Farmer, B., Katsavelis, D., Bagwell, J. J., & Grindstaff, T. L. (2018). Comparison of clinical fatigue protocols to decrease single-leg forward hop performance in healty individuals. *International journal of sports physical therapy, 13*(2), 143-151.

Leister, I., Mattiassich, G., Kindermann, H., Ortmaier, R., Barthofer, J., Vasvary, I., Katzensteiner, K., Stelzhammer, C., & Kulnik, S. T. (2018). Reference values for fatigued versus non-fatigued limb symmetry index measured by a newly designed single-leg hop test battery in healthy subjects: a pilot study. *Sport sciences for health, 14*(1), 105-113. https://doi.org/10.1007/s11332-017-0410-5

Valle, X., Malliaropoulos, N., Párraga Botero, J. D., Bikos, G., Pruna, R., Mónaco, M., & Maffulli, N. (2018). Hamstring and other thigh injuries in children and young athletes. *Scandinavian journal of medicine & science in sports, 28*(12), 2630-2637. https://doi.org/10.1111/sms.13282

Buckthorpe, M., Wright, S., Bruce-Low, S., Nanni, G., Sturdy, T., Gross, A. S., Bowen, L., Styles, B., Della Villa, S., Davison, M., & Gimpel, M. (2019). Recommendations for hamstring injury prevention in elite football: translating research into practice. *British journal of sports medicine, 53*(7), 449-456. https://doi.org/10.1136/bjsports-2018-099616

Crossley, K. M., Patterson, B. E., Culvenor, A. G., Bruder, A. M., Mosler, A. B., & Mentiplay, B. F. (2020). Making football safer for women: a systematic review and meta-analysis of injury prevention programmes in 11 773 female football (soccer) players. *British journal of sports medicine, 54*(18), 1089-1098. https://doi.org/10.1136/bjsports-2019-101587

Lu, D., McCall, A., Jones, M., Kovalchik, S., Steinweg, J., Gelis, L., & Duffield, R. (2020). Injury epidemiology in Australian male professional soccer. *Journal of science and medicine in sport, 23*(6), 574-579. https://doi.org/10.1016/j.jsams.2020.01.006

Daneshjoo, A., Mokhtar, A. H., Rahnama, N., & Yusof, A. (2012). The effects of injury preventive warm-up programs on knee strength ratio in young male professional soccer players. *PloS one, 7*(12), e50979. https://doi.org/10.1371/journal.pone.0050979

Daneshjoo, A., Rahnama, N., Mokhtar, A. H., & Yusof, A. (2013). Bilateral and unilateral asymmetries of isokinetic strength and flexibility in male young professional soccer players. *Journal of human kinetics,* 36, 45-53. https://doi.org/10.2478/hukin-2013-0005

Śliwowski, R., Jadczak, Ł., Hejna, R., & Wieczorek, A. (2015). The Effects of Individualized Resistance Strength Programs on Knee Muscular Imbalances in Junior Elite Soccer Players. *PloS one, 10*(12), e0144021. https://doi.org/10.1371/journal.pone.0144021

Lehnert, M., Croix, M. S., Xaverova, Z., Botek, M., Varekova, R., Zaatar, A., Lastovicka, O., & Stastny, P. (2018). Changes in Injury Risk Mechanisms after Soccer-Specific Fatigue in Male Youth Soccer Players. *Journal of human kinetics,* 62, 33-42. https://doi.org/10.1515/hukin-2017-0157

Ceroni, D., Martin, X. E., Delhumeau, C., & Farpour-Lambert, N. J. (2012). Bilateral and gender differences during single-legged vertical jump performance in healthy teenagers. *Journal of strength and conditioning research, 26*(2), 452-457. https://doi.org/10.1519/JSC.0b013e31822600c9

Ros, A. G., Holm, S. E., Fridén, C., & Heijne, A. I. (2013). Responsiveness of the one-leg hop test and the square hop test to fatiguing intermittent aerobic work and subsequent recovery. *Journal of strength and conditioning research, 27*(4), 988-994.

Edouard, P., Branco, P., & Alonso, J. M. (2016). Muscle injury is the principal injury type and hamstring muscle injury is the first injury diagnosis during top-level international athletics championships between 2007 and 2015. *British journal of sports medicine, 50*(10), 619-630. https://doi.org/10.1136/bjsports-2015-095559

Jones, A., Jones, G., Greig, N., Bower, P., Brown, J., Hind, K., & Francis, P. (2019). Epidemiology of injury in English Professional Football players: A cohort study. *Physical therapy in sport : official journal of the Association of Chartered Physiotherapists in Sports Medicine,* 35, 18-22. https://doi.org/10.1016/j.ptsp.2018.10.011

Smpokos, E., Mourikis, C., Theos, C., & Linardakis, M. (2019). Injury prevalence and risk factors in a Greek team's professional football (soccer) players: a three consecutive seasons survey. *Research in sports medicine (Print), 27*(4), 439-451. https://doi.org/10.1080/15438627.2018.1553779

Kalata, M., Maly, T., Hank, M., Michalek, J., Bujnovsky, D., Kunzmann, E., & Zahalka, F. (2020). Unilateral and Bilateral Strength Asymmetry among Young Elite Athletes of Various Sports. *Medicina (Kaunas, Lithuania), 56*(12), 683. https://doi.org/10.3390/medicina56120683

Maly, T., Zahalka, F., & Mala, L. (2016). Unilateral and ipsilateral strength asymmetries in elite youth soccer players with respect to muscle group and limb dominance. *Int. J. Morphol.,* 34, 1339-1344. https://doi.org/S0717-95022016000400027

Hewitt, J., Cronin, J., & Hume, P. (2012). Multidirectional leg asymmetry assessment in sport. *Strength & Cond Journal,* 34, 82-86.

Fort-Vanmeerhaeghe, A., Bishop, C., Buscà, B., Aguilera-Castells, J., Vicens-Bordas, J., & Gonzalo-Skok, O. (2020). Inter-limb asymmetries are associated with decrements in physical performance in youth elite team sports athletes. *PloS one, 15*(3), e0229440. https://doi.org/10.1371/journal.pone.0229440

Marques, V. B., Medeiros, T. M., de Souza Stigger, F., Nakamura, F. Y., & Baroni, B. M. (2017). The Functional Movement Screen (FMS™) in elite young soccer players between 14 and 20 years: composite score, individual-test scores and asymmetries. *International journal of sports physical therapy, 12*(6), 977-985.

Atkins, S. J., Bentley, I., Hurst, H. T., Sinclair, J. K., & Hesketh, C. (2016). The Presence of Bilateral Imbalance of the Lower Limbs in Elite Youth Soccer Players of Different Ages. *Journal of strength and conditioning research, 30*(4), 1007-1013. https://doi.org/10.1519/JSC.0b013e3182987044

Maloney, S. J. (2019). The Relationship Between Asymmetry and Athletic Performance: A Critical Review. *Journal of strength and conditioning research, 33*(9), 2579-2593. https://doi.org/10.1519/JSC.0000000000002608

Rush, J. L., Norte, G. E., & Lepley, A. S. (2020). Limb differences in hamstring muscle function and morphology after anterior cruciate ligament reconstruction. *Physical therapy in sport : official journal of the Association of Chartered Physiotherapists in Sports Medicine,* 45, 168-175. https://doi.org/10.1016/j.ptsp.2020.06.012

Sherman, D. A., Rush, J. L., Glaviano, N. R., & Norte, G. E. (2021). Hamstrings Muscle Morphology After Anterior Cruciate Ligament Reconstruction: A Systematic Review and Meta-Analysis. *Sports medicine (Auckland, N.Z.).* https://doi.org/10.1007/s40279-021-01431-y

Loturco, I., Nakamura, F. Y., Kobal, R., Gil, S., Pivetti, B., Pereira, L. A., & Roschel, H. (2016). Traditional Periodization versus Optimum Training Load Applied to Soccer Players: Effects on Neuromuscular Abilities. *International journal of sports medicine, 37*(13), 1051-1059. https://doi.org/10.1055/s-0042-107249

Owen A.L., Dunlop G., Rouissi M., Haddad M., Mendes B., & Chamari K. (2016). Analysis of positional training loads (ratings of perceived exertion) during various-sided games in European professional soccer players. *International Journal of Sports Science & Coaching, 11*(3), 374-381.

Mendiguchia, J., Alentorn-Geli, E., & Brughelli, M. (2012). Hamstring strain injuries: are we heading in the right direction? *British journal of sports medicine, 46*(2), 81-85. https://doi.org/10.1136/bjsm.2010.081695

# ГОСТРИЙ ВПЛИВ МАЛОСТОРОННІХ ІГОР НА СИЛУ ПІДКОЛІННОГО СУХОЖИЛЛЯ У МОЛОДИХ ФУТБОЛІСТІВ

**Італо Саннікандро[1,2ABD], Джакомо Кофано[1,2BC], Гаетано Райола[3AC]**

[1]Університет Фоджа
[2]Професійний футбольний тренер із силової і кондиційної підготовки
[3]Університет Салерно

Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 8 с., 1 табл., рис. 1, 70 джерел.

**Мета дослідження.** Малосторонні ігри (SSG) – це інтенсивні тренування, які дуже популярні у тренуванні з футболу. Знання гострих наслідків вправ, які складають тренування, є дуже важливими, особливо для зниження ризику травм у молодіжному футболі. Це дослідження спрямоване на оцінку гострого впливу SSG на ексцентричну силу підколінного сухожилля та на визначення асиметрії сили нижніх кінцівок (LLSA) у молодих футболістів.

**Матеріали і методи.** Вибірку склали молоді футболісти-чоловіки до 17 років (n = 24, 16,6 ± 0,5 років, 168,8 ± 4,6 см, 58,2 ± 3,5 кг). До і після SSG (4 на 4, 3×4 хв, відновлення 3 хв, без воротарів) ексцентричну силу підколінного сухожилля та асиметрію ексцентричної сили нижньої кінцівки оцінювали за допомогою спеціального динамометра (N3 Easytech, Італія) та відповідного програмного забезпечення. Кожен юний футболіст виконував одноразове повторення скандинавської вправи на підколінне сухожилля з динамометром; приблизно через 2 хвилини вони виконали 5 повторень однієї і тієї ж вправи без перерви. Для обох оцінок були виявлені ексцентрична міцність і LLSA.

**Результати.** Оцінка ексцентричної сили підколінного сухожилля показує суттєві та статистично значущі відмінності в оцінці в порівнянні з допостовими значеннями. Значне зниження спостерігалося для піку ексцентричної сили ($p < 0,018$ і $p < 0,014$ для правої/лівої кінцівки), для ексцентричної середньої сили ($p < 0,017$ і $p < 0,006$ для правої/лівої кінцівки). Значення ексцентричної пікової асиметрії сили та середнього значення асиметрії сили виявили значне збільшення ($p < 0,0001$).

**Висновки.** Зниження сили після SSG вимагає ретельного врахування порядку виконання вправ на тренуванні. Практикуючі тренери можуть планувати тренування та ефективніше застосовувати SSG з врахуванням впливу на підколінні сухожилля.

**Ключові слова:** підколінне сухожилля, профілактика, юний футболіст, малосторонні ігри.

**Information about the authors:**

**Sannicandro Italo:** italo.sannicandro@unifg.it; https://orcid.org/0000-0003-1284-2136; Department of Humanities, Literature, Cultural Heritage, Education Sciences, University of Foggia, Italy; Professional soccer strength and conditioning coach, Viale Virgilio 16, 71100 Foggia, Italy.

**Cofano Giacomo:** giacomo.cofano@unifg.it; https://orcid.org/0000-0001-9973-1740; Master degree in Sciences and techniques of preventive and adapted motor activities, University of Foggia, Italy, Viale Virgilio 16, 71100 Foggia, Italy.

**Raiola Gaetano:** graiola@unisa.it; https://orcid.org/0000-0002-7659-1674; Department of Political and Social studies, University of Salerno. Via Giovanni Paolo II, 132 - 84084 Fisciano (SA), Italy.

**Cite this article as:** Sannicandro, I., Cofano, G., & Raiola, G. (2022). The acute effects of Small-sided games on hamstring strength in young soccer players. *Teorìâ ta Metodika Fizičnogo Vihovannâ, 22*(1), 77-84. https://doi.org/10.17309/tmfv.2022.1.11

Received: 13.01.2022. Accepted: 9.02.2022. Published: 25.03.2022