MLS - SPORT RESEARCH

https://www.mlsjournals.com/Sport-Research

ISSN: 2792-7156

How to cite this article:
Ramírez Lucas, J. M. (2023). Efecto de un programa de entrenamiento con ejercicios isométricos sobre factores de riesgo de lesión de músculos isquiosurales en futbolistas amateurs. Pilot study. *MLS Sport Research, 3*(1), 37-58. doi: 10.54716/mlssr.v3i1.2216.

EFECT OF AN ISOMETRIC EXERCISE TRAINING PROGRAM ON HAMSTRING INJURY RISK FACTORS IN AMATEUR SOCCER PLAYERS. A PILOT STUDY

Juan Miguel Ramírez Lucas
University of Jaén (Spain)
jmrl0014@red.ujaen.es - https://orcid.org/0000-0002-9353-919X

Abstract. In soccer, muscle injuries represent 38%. The hamstring musculature (HSM) was the most frequently injured muscle group, accounting for 39.5% of all muscle injuries and 16.3% of all injuries. Eccentric training of the hamstrings has been shown to increase the length of the fascicles of the long head of the biceps femoris (BFlh), that is, this training decreases the risk of injury, but may lead to the development of muscle soreness. Although, a training program with isometric exercises is less likely to cause muscle soreness. Therefore, the aim of the present pilot study was to analyze the effects of an isometric exercise training program (10 weeks) on HSM injury risk factors in amateur soccer players. Participants (n=18) were randomly assigned to a control (n=9) and experimental (n=9) group. Symptoms and injury risk in HSM (Hamstring Outcome Score), power (vertical jump) and strength (single leg bridge test) of HSM were evaluated. The analyses showed that in the experimental group there were improvements in all variables, but only the improvements in right HSM strength (p=0.003, d=0.679) and total HSM strength (p=0.038, d=0.52) were significant. It can be concluded that a training program with isometric exercises before the technical-tactical session could reduce the risk of injury in HSM, although these results should be taken with caution and future studies with a larger sample are recommended.

Keywords: Hamstring muscles; Soccer; Prevention; Injury risk.

EFECTO DE UN PROGRAMA DE ENTRENAMIENTO CON EJERCICIOS ISOMÉTRICOS SOBRE FACTORES DE RIESGO DE LESIÓN DE MÚSCULOS ISQUIOSURALES EN FUTBOLISTAS AMATEURS. ESTUDIO PILOTO

Resumen. En el fútbol las lesiones musculares representan el 38%. La musculatura isquiosural (HSM) fue el grupo muscular más frecuentemente lesionado, representando el 39.5% de todas las lesiones musculares y el 16.3% de todas las lesiones. Se ha demostrado que el entrenamiento excéntrico de los isquiosurales aumenta la longitud de los fascículos de la cabeza larga del bíceps femoral (BFlh), es decir, este entrenamiento disminuye el riesgo de lesión, pero puede conducir a la aparición de dolor muscular. Aunque, es menos probable que un programa de entrenamiento con ejercicios isométricos provoque dolor muscular. Por ello, el objetivo del presente estudio piloto fue analizar los efectos de un programa de entrenamiento con ejercicios isométricos (10 semanas) sobre factores de riesgo de lesión en la HSM en jugadores de fútbol amateurs. Los participantes (n=18) fueron asignados aleatoriamente a un grupo control (n=9) y experimental (n=9). Se evaluaron los síntomas y riesgo de lesión en HSM (Hamstring Outcome Score), potencia (salto vertical) y fuerza (single leg bridge test) de HSM. Los análisis mostraron que en el grupo experimental hubo mejorías en todas las variables, pero solo resultaron significativas las mejorías en fuerza de HSM derechos (p=0.003, d=0.679), y total (p=0.038, d=0.52). Se puede concluir que un programa de entrenamiento con ejercicios isométricos antes de la sesión técnico-táctica podría reducir el riesgo de lesión en HSM, aunque estos resultados deben ser tomados con precaución y se recomienda la realización de futuros estudios con una muestra mayor.

Palabras clave: Musculatura isquiosural; Fútbol; Prevención; Riesgo de lesiones.

Introduction

Epidemiology

In soccer, the incidence of injuries is very high in the lower extremities representing 64.2% (Jones et al., 2019). In a study of amateur players by van Beijsterveldt et al. (2014), 60% of players were injured during a season, with muscle injuries accounting for 38% and 14% were relapses. Likewise, the thigh region was the most common site of injury (31.7%) followed by the knee (14.6%) and ankle (13%) (Jones et al., 2019). In another study by Ekstrand et al. (2011) observed that one third of all injuries in soccer are muscle injuries and that the vast majority (92%) affect the 4 main muscle groups of the lower extremities: hamstrings (37%), adductors (23%), quadriceps (19%) and calves (13%). The ischiosural musculature (HSM) was the most frequently injured muscle group, accounting for 39.5% of all muscle injuries and 16.3% of all injuries (Jones et al., 2019). In line with the above, MSH injury is known as the number one muscle problem in men's amateur soccer and they account for 15.9% of all injuries (van Beijsterveldt et al., 2014). On the other hand, it should be noted that a team of 25 players can expect about 15 muscle injuries each season, with a loss of time of approximately 2 weeks per injury (Ekstrand et al., 2011). Although, in a study by Ekstrand et al. (2016) observed an annual increase of 2.3% per 1000 match hours and an annual increase of 4% per 1000 training hours.

Training program

From the perspective of performance improvement as well as injury prevention (Van Hooren & Bosch, 2017b; Van Hooren & Bosch, 2018), the type of muscle contraction is important, as eccentric training of the hamstrings has been shown to increase the length of the fascicles of the BFlh, i.e., this type of training decreases the risk of injury (Timmins et al., 2016). The most commonly used exercise is the Nordic Hamstring Exercise (NHE) which is an eccentric exercise that improves hamstring strength production only around one joint (the knee). Add, that eccentric exercises can lead to the occurrence of muscle soreness, especially in the first weeks of the training program (Petersen et al., 2011) and in several studies has been a reason for some players to drop out of the intervention (Arnason et al., 2008; van der Horst et al., 2015). Thus, an isometric exercise training program is less likely to cause muscle soreness (Van Hooren & Bosch, 2017b; Van Hooren & Bosch, 2018). In the same way, it has been demonstrated that isometric training involves a lower mechanical cost than plyometric training and that after 6 weeks of training, tendon stiffness and Rate of Force Development (RFD) are significantly increased (Burgess et al., 2007). As the competitive load is too high, due to the competitive period and HSM is likely to be at risk, we can reduce these mechanical demands by using an isometric exercise training program rather than other training (Burgess et al., 2007).

In the club where the intervention was carried out, the sample is composed of amateur athletes with no or little experience in strength training (Raya-González et al., 2021). The authors suggest using a maximum of 2-3 exercises activating the HSM, with a volume of 15-25 minutes per session, with a duration of repetitions ≤ 10 seconds (to avoid muscle acidity) and with a maximum of 3 sets (McGill, 2010; Van Hooren & Bosch, 2017b; Van Hooren & Bosch, 2018). This will provide an effective stimulus, but will avoid excessive fatigue and allow the isometric training program to be combined with other training (Van Hooren & Bosch, 2018). A frequency of 2 times per week may be sufficient to improve and maintain strength (Peterson et al., 2004). However, eccentric training should not be replaced by an isometric training program (Van Hooren & Bosch, 2018). To our knowledge, there have been no studies in the scientific literature with isometric exercise programs focused on MSH injuries.

The main objective of this study was to conduct a pilot study to determine the effects of a 10-week isometric exercise training program on hamstring injury risk factors in amateur soccer players. We hypothesize that performing a 10-week isometric training program can decrease risk factors for injury in MSH.

Method

Design

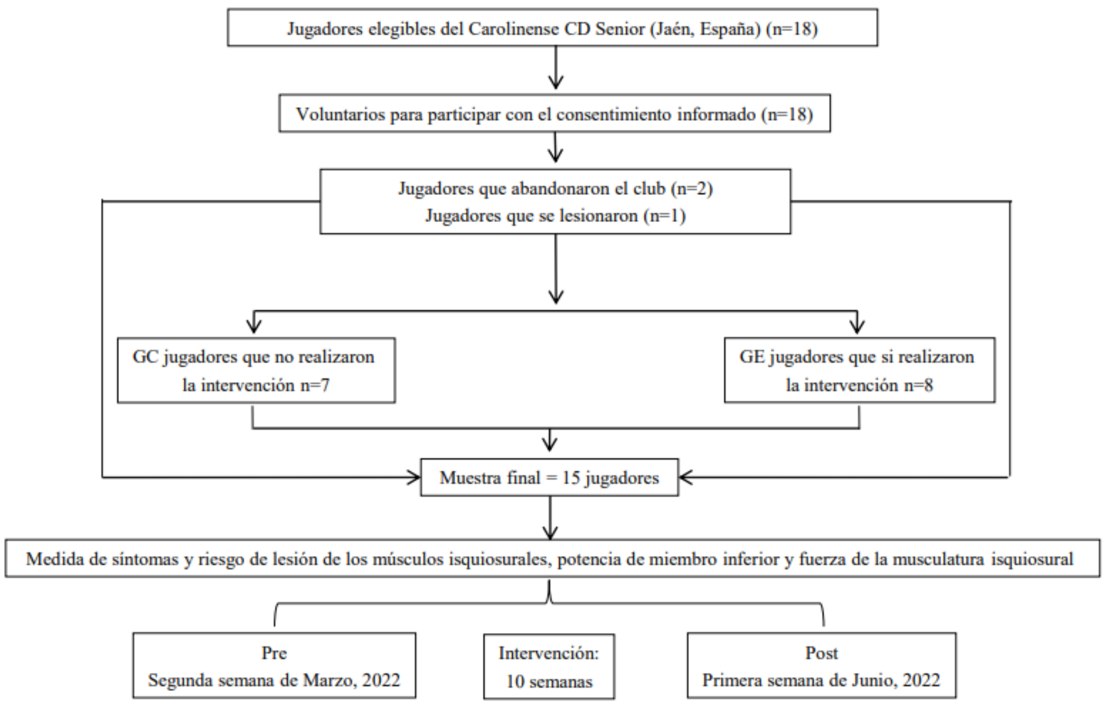
This is a longitudinal quantitative study and a randomized controlled trial composed of an experimental group (EG n=9) and a control group (CG n=9) was used. The SG was subjected to an isometric exercise training program for 10 weeks at a frequency of two sessions per week during the competition period beginning the week of March 14 and ending the week of May 23, 2022. Risk factors and physical performance were assessed before and after the strength program by means of the sociodemographic questionnaire, the Hamstring Outcome Score (HaOS) questionnaire, lower limb power and the Single Leg Bridge Test (SLBT). The questionnaires and jumps were performed in the locker room and the SLBT test was performed on the soccer field where the players train. Both assessment sessions were held between 7:20 p.m. and 8:00 p.m., and all players were instructed to give their best in both tests. No training program was applied to the CG, only the technical-tactical session. The GE conducted the strength session before starting the main training session. The procedure lasted between 15-30 minutes. All procedures were approved by the ethics committee of the University of Jaén (MAR.22/4.TFM) and were carried out in accordance with the Code of Ethics of the World Medical Association for human studies (Declaration of Helsinki).

Participants

Initially, 18 male players aged 18-38 years belonging to the Carolinense CD agreed to participate in the research. Players had to have participated in at least 70% of the training sessions during the 10-week duration of the EG. As inclusion criteria, players had to be federated and over 18 years of age. Exclusion criteria for the study were participation in any additional strength program during the weeks of the intervention, illness or musculoskeletal injuries that prevented the protocol from being carried out. A computer-generated random number table was used for group assignment. All participants continued with their usual training program and the GE also performed the isometric exercise program. The usual training consisted of a ball activation in small spaces, followed by possessions in medium and large spaces, and usually ended the session with attack-defense or modified games. The data were collected during the 2022 season by trained members of the research group. The distribution of the intervention can be seen in Figure 1.

Figure 1

Graphical Representation of Longitudinal Design with Study Intervention



Variables and instruments

Just before the start of the intervention period, a series of sociodemographic data were collected, such as age, educational, marital and occupational status, smoking habit. A SECA 634 scale and the SECA 22 stadiometer, Hamburg (Germany), were used to obtain weight and height measurements, respectively. Both measurements were performed with light clothing and without footwear. According to the World Health Organization (WHO, 2000), body typology was calculated by the Body Mass Index (BMI) using the formula: mass (kg)/height 2 (m). A BMI < 25 kg / m2 indicates normal weight, 25 ≤ BMI > 30 kg / m2 indicates overweight, and a BMI ≥ 30 kg / m2 indicates obesity. In addition, a series of data related to soccer practice were collected, such as experience playing soccer (years), games played (as starters and substitutes), dominant leg and position on the field. Finally, the history of lower limb injuries (ischiosural region, knee, leg and ankle/foot) was asked.

Dependent variables

Testing procedures were conducted one week prior to the start of the program on March 8 (Tuesday) and March 10 (Thursday), 2022, 40 min before the training session. The HaOS questionnaire and the SLHB test were conducted on March 8. On March 10, the vertical jumps were performed, and before performing the two vertical jump tests, all players performed a 10 min warm-up of continuous running with dynamic stretching (Venturelli et al., 2011). When the 10-week training program was completed, the tests were repeated again in the same order and at the same time, but on May 31 (Tuesday) and June 2 (Thursday), 2022 (Rey et al., 2017).

Symptoms and risk of injury to the hamstring muscles

Each player completed a baseline questionnaire that included the HaOS questionnaire score and the sociodemographic characteristics and previous injuries of the soccer players

(Engebretsen et al., 2010; van de Hoef et al., 2021). The original HaOS (Engebretsen et al., 2008) was translated into Spanish (Cronbach's alpha of 0.949 for items and 0.850 for domains) and consists of two parts. The first part collects the injury history of the HSM. Only the second part was used for the pre-post intervention analysis and consists of five dimensions: (1) Symptoms, (2) Inflammation/Anxiety, (3) Pain, (4) Function, Daily Life and Sport, and (5) Quality of Life (Sierevelt et al., 2015; Tak et al., 2018). The first four domains are relevant to daily life and to soccer and sport-specific tasks, while the quality of life domain measures fear of re-injury (Engebretsen et al., 2010; van de Hoef et al., 2021). The questions were scored from 0 to 4, from no discomfort to a lot of discomfort/pain (Engebretsen et al., 2008; van de Hoef et al., 2021). The HaOS questionnaire score can be calculated as an overall score and a score for each domain. Scores were calculated as percentages of the maximum score, with a player with no complaints scoring 100%, therefore, a higher score implies a lower level of discomfort. The scores were calculated using the following formula which is 1-(score/maximum score) * 100%. A score of 80% or more was considered to indicate a low risk of hamstring injury (Engebretsen et al., 2010; van de Hoef et al., 2021).

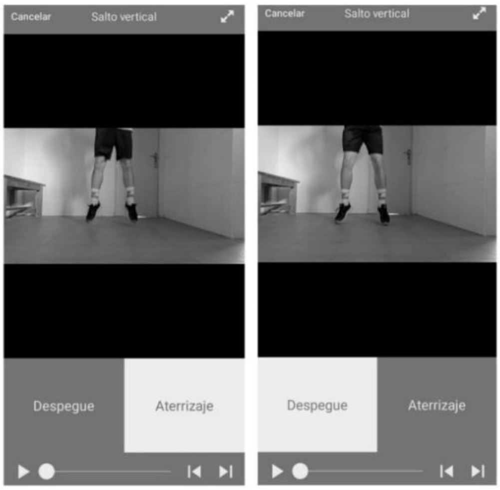
Lower limb power

The most common tests to assess explosiveness in soccer players are the vertical jump tests of both the SJ and CMJ (Bogataj et al., 2020; Gallardo-Fuentes et al., 2016). Three jumps were performed per player, the first two jumps were not recorded and the third jump was recorded for video analysis with the My Jump 2 app. A rest interval of 30 seconds was established between each jump (Bogataj et al., 2020).

The My Jump 2 app was used (created by Balsalobre-Fernández et al. (2015) which was designed to analyze vertical jumps). This app is capable of measuring vertical jump height accurately (without the need for prior experience in video analysis) for most populations, including trained athletes (Gallardo-Fuentes et al., 2016). To calculate the height of the jump, the take-off and landing frames of the video are manually selected (Figure 2). All recordings were made with the same phone and by the same researcher with no professional experience in video analysis (Bogataj et al., 2020). To record the execution of the jumps with the app, a researcher lay on the ground face down facing the player (in the frontal plane) at approximately 1.5 meters from the player and zooming in on the feet (Balsalobre-Fernandez et al., 2015; Gallardo-Fuentes et al., 2016). The researcher always recorded from the same position (Balsalobre-Fernandez et al., 2015; Bogataj et al., 2020; Gallardo-Fuentes et al., 2016). For data reliability, the videos were re-monitored twice for each player (Coswig et al., 2019).

Figure 2

Stills of the Takeoff and Landing Phase in My Jump 2 application



Strength of the ischiosular muscles

The SLHB test has been validated (Freckleton et al., 2014). The SLHB test followed the procedures proposed by Freckleton et al. (2014) that they conducted with Australian soccer players. Players were instructed to position themselves on the floor in the supine position with one heel on a box. A 60 cm high box was used for all participants (Figure 3). The test leg was placed in a knee flexion of approximately 20°. Players were instructed to cross the arms over the chest and push down through the heel to lift the buttock off the ground. Players were advised that the objective of the test was to do as many repetitions as possible until they could do no more. Constant feedback was provided throughout the procedure to ensure that the correct technique was achieved. It was essential that each test included the player touching his buttock to the ground, without resting, and then extending the hip to 0°. The non-working leg was to be kept stationary in an upright position to ensure that no momentum was gained by swinging this leg. When the correct form was lost, a warning was given and the test was stopped at the next technical failure. The maximum repetition was recorded and the test was repeated with the opposite leg. The side tested first alternated between participants (Freckleton et al., 2014; Mahnič et al., 2021; Rey et al., 2017). Using the recommended classification criteria (Freckleton et al., 2014), the results were categorically divided into three groups according to their performance on the SLBT test. The group with a poor score included all players who achieved less than 20 repetitions with at least one leg, while the group with a medium score included players who achieved between 20 and 25 repetitions with both legs and the group with a good score included those who achieved values of 30 or more repetitions with at least one leg (Freckleton et al., 2014; Mahnič et al., 2021).

Figure 3

Single Leg Bridge Test

One week before the test, the players performed 1 familiarization session with the SLHB test which was on March 1 (Tuesday) 2022 (Rey et al., 2017).

Independent Variable (Strength training program with isometric exercises)

A strength training program was designed with 4 isometric exercises. The strength training sessions ranged from 15 min to 30 min in duration. In addition, the sessions were conducted prior to the soccer training session, which lasted approximately 80 minutes. The strength training sessions were supervised by the physical trainer and first trainer (coaching staff) one day before for the preparation of the technical-tactical session. The strength training program with isometric exercises was applied twice a week (Tuesdays and Thursdays) with at least 48 hours of rest between training sessions, for a total of 10 weeks, with the first week being in March (March 15, 2022, first session) and the last week being in May (May 26, 2022, last session).

Each injury prevention training session included 2 strength training exercises that are hip dominant, knee dominant and two core stability exercises with isometric muscle actions only. These exercises were selected based on their effects on injury prevention in HSM (Bourne et al., 2018; Raya-Gonzalez et al., 2021; Van Hooren & Bosch, 2017a; Van Hooren & Bosch, 2017b). A progressive overload was applied during the intervention (Annex 1). The soccer players were familiarized with the strength training program with isometric exercises during the intervention period and all exercises had variants from lower to higher difficulty (Annex 2).

Procedure

Before starting the study, we contacted the club, which authorized us to inform the players and coaching staff about the research. Subsequently, the rest of the club's directors were informed and provided with the necessary information for the development of the project. Once the participation and collaboration was accepted, a calendar of actions was established by the researchers in order to carry out the study without affecting the normal development of the training sessions. During the intervention period (March through May), the players performed their normal soccer training routines as the intervention was performed at the beginning of training without taking up too much time. Regarding the way it was set up during the week, the strength sessions were performed during the first and second training of the microcycle, thus ensuring that both sessions were not performed on consecutive days, i.e., they were performed on Tuesdays and Thursdays. During the intervention period, the week was carried out in the same way as before, with 3 days of training (Tuesday, Thursday and Friday) and an official competition match. Players from whom we obtained informed consent for subsequent participation in the research were informed. The name of each participating player was coded to ensure anonymity and confidentiality.

Statistical analysis

The data of the present TFM were shown as means and standard deviations and as frequencies and percentages for continuous and categorical variables, respectively. Student's t-test (continuous variables) and Chi-square (continuous variables) were used to study the differences between groups. To analyze the differences between the values before and after the intervention, a mixed analysis of variance was carried out, the between-group factor being the isometric exercise program (control vs. experimental) and the intra-group factor the measurement time (pre- and post-treatment). The dependent variables were: Symptoms and risk of injury in HSM (HaOS questionnaire), lower limb power (SJ and CMJ) and hamstring strength (SLHB). The independent variable was the isometric exercise intervention. The interaction "group x measurement time" was also analyzed. Cohen's d statistic was used to calculate the effect size in the exhaustive analysis of the possible group x time interactions. An effect size < 0.2 expresses an insignificant difference, a small difference between ≥ 0.2 and ≤ 0.5, a moderate difference between ≥ 0.5 and ≤ 0.8 and a value ≥ 0.8 refers to a large difference (Cohen, 1992). Results were considered statistically significant at a p value < 0.05. SPSS software (SPSS Inc, Chicago, IL, USA) for Windows, version 20, was used for statistical analysis.

Results

After the time of the experimental period had elapsed, there were three losses to follow-up, 2 in the CG (left the club, and the other due to an injury unrelated to the training program) and one in the GE (left the club). The general descriptive characteristics before the start of the intervention are shown in Table 1. The mean age of the participants was 24.61 ± 6.22 years and the BMI was within the normopese parameters (22.84 ± 2.44 kg/m2). Most of the participants were students (44.44%), were single (83.33%), had university studies (and were non-smokers 72.22% for both parameters). The analysis at baseline showed no significant difference between groups with respect to these variables (Table 1).

Table 1
General Descriptive Characteristics of the Participants

		Total (n=18)		Control (n=9)		Experimental (n=9)		
		Media	DT	Media	DT	Media	DT	P-value
Age		24.61	6.22	24.67	7.18	24.56	5.55	0.971
BMI (kg/m^2)		22.84	2.44	22.25	2.13	23.44	2.71	0.317
				Freq.	%	Freq.	%	P-value
Occupational status	Student	8	44.44	4	50.00	4	50.00	0.370
	Worker	7	38.89	4	57.14	3	42.86	
	Student and worker	1	5.56	1	100.00	0	0.00	
	Unemployed	2	11.11	0	0.00	2	100.00	
Marital status	Single	15	83.33	7	46.67	8	53.33	0.527
	Married	3	16.67	2	66.67	1	33.33	
State educational	No education	4	22.22	0	0.00	0	0.00	1.000
	Primary education	10	55.56	2	50.00	2	50.00	
	Secondary education	4	22.22	5	50.00	5	50.00	
	University studies	13	72.22	2	50.00	2	50.00	
Smoker	No	13	72.22	6	46.15	7	53.85	0.599
	Yes	5	27.78	3	60.00	2	40.00	

Note. DT: Standard deviation. Freq: Frequency. BMI: Body Mass Index.

Regarding the characteristics related to sports practice and (Table 2), the mean experience playing soccer of the participants was 15.33 ± 8.82 years and 16.11 ± 5.32 games as a starter. Almost all participants were right-handed (66.7%) and most had no history of hamstring, calf, or knee injuries, although 61.11% claimed to have suffered at least one previous ankle sprain. The pre-intervention analysis showed no significant differences between groups with respect to these variables (Table 2).

Table 2
Descriptive Characteristics Related to the Soccer Practice of the Participants

				Control (n=9)		Experimental (n=9)		
		Media	DT	Media	DT	Media	DT	P-value
Experience playing soccer (years)		15.33	8.82	16.11	9.75	14.56	8.29	0.720
Games played		16.11	5.32	14.22	6.57	18.00	3.00	0.145
Games played as starter		10.56	6.31	10.44	6.46	10.67	6.54	0.943
Games played as substitute		5.56	5.85	3.78	1.72	7.33	7.92	0.222
		Freq.	%	Freq.	%	Freq.	%	P-value
Dominance	Left	3	16.67	2	66.67	1	33.33	
	Right	12	66.67	5	41.67	7	58.33	0.607
	Both	3	16.67	2	66.67	1	33.33	
Position	Goalkeeper	2	11.11	1	50.00	1	50.00	
	Lateral	4	22.22	2	50.00	2	50.00	
	Central	3	16.67	0	0.00	3	100.00	
	Midfielder	2	11.11	2	100.00	0	0.00	0.502
	Half tip	3	16.67	2	66.67	1	33.33	
	End	2	11.11	1	50.00	1	50.00	
	Forward	2	11.11	1	50.00	1	50.00	
Injury ischiosurals prior to	No	14	77.78	7	50.00	7	50.00	
	Yes	4	22.22	2	50.00	2	50.00	1.000
Previous ACL injury	No	17	94.44	9	52.94	8	47.06	
	Yes	1	5.56	0	0.00	1	100.00	0.303
Another previous knee injury	No	13	72.22	7	53.85	6	46.2	
	Yes	5	27.78	2	40.00	3	60.0	0.599
Calf injury previous	No	18	100.00	9	50.00	9	50.00	
	Yes	0	0.00	0	0.00	0	0.00	1.000
Previous ankle sprain	No	7	38.89	2	28.57	5	71.43	
	Yes	11	61.11	7	63.64	4	36.36	0.147

Note. DT: Standard deviation. Freq: Frequency. LCA: Anterior cruciate ligament.

Symptoms and risk of injury to the hamstring muscles

The comparison between pre-intervention groups shows that there were no significant differences with respect to any of the sections or questions of the HaOS questionnaire. Table 3 presents the data related to the first part of this questionnaire, which refers to the history of hamstring injuries.

Table 3
Pre-Intervention Differences from HaOS Questionnaire Part 1

HaOS. Part 1		Left leg					Right leg				
		Control group		Experimental group			Control group		Experimental group		
		Freq.	%	Freq.	%	P-value	Freq.	%	Freq.	%	P-value
Question 1	0	5	50.00	5	50.00	0.766	6	50.00	6	50.00	0.717
	1	3	60.00	2	40.00		2	66.67	1	33.33	
	2	1	33.33	2	66.67		1	33.33	2	66.67	
	3	0	0	0	0		0	0	0	0	
	4	0	0	0	0		0	0	0	0	
	5	0	0	0	0		0	0	0	0	
	>5	0	0	0	0		0	0	0	0	
Question 2	0-6 months	2	50	1	25	0.069	2	66.67	1	33.33	0.343
	6-12 months	0	0	0	0		1	33.33	0	0	
	1-2 years	2	50	0	0		0	0	1	33.33	
	2-3 years	0	0	3	75		0	0	1	33.33	
Question 3	4-7 days	2	50	1	25	0.264	2	66.67	1	33.33	0.513
	1-4 weeks	2	50	1	25		1	33.33	1	33.33	
	> 4 weeks	0	0	2	50		0	0	1	33.33	
Question 4.1	No	1	25	3	60	0.294	0	0	3	75	0.143
	Yes	3	75	2	40		3	100	1	25	
Question 4.2	Almost never	2	66.67	2	66.67	1.000	2	66.67	1	50	0.709
	Sometimes	1	33.33	1	33.33		1	33.33	1	50	
	Often	0	0	0	0		0	0	0	0	

The analysis of the HaOS questionnaire in its second part (Table 4) showed that the post-intervention values in the CG and SG for both domains and for the total score of the right and left leg were higher compared to the values obtained in the pre-intervention measurements (Table 4), and more specifically in the HaOS questionnaire total score for the sum of both lower limbs the CG experienced an increase in score (and therefore a decrease in risk) of 5.53%, while in the SG this increase was 9.4%. Significant changes of the Time variable could be seen in domains 3 (p=0.021), 4 (p=0.038), and 5 (p=0.010) of the left leg, in domain 5 of the right leg (p=0.032), and total score of the left leg (p=0.011) and total of both legs (p=0.046). No significant changes were observed in the Group variable. No significant changes were found in the Group x Time interaction either.

Lower limb power

The study of lower limb power evaluated by the SJ and CMJ tests (Table 5) indicated that there were no significant differences between groups in the pre-intervention measurements. It could also be seen that all participants showed improvements after the intervention period, although the difference was greater in the GE than the CG (1.89 cm vs 0.31 cm respectively for SJ and 2.34 cm vs 0.86 cm respectively for CMJ). No significant differences were found with respect to the main effect for the Group variable nor for the Group x Time interaction, although they could be observed for the Time variable in both tests, $F(1,18)=23.801$, $p=0.001$, $\eta 2=0.575$ for the SJ test and $F(1,18)=6.136$, $p=0.001$, $\eta 2=0.566$ for the CMJ test.

Strength of the ischiosular muscles

Finally, the data obtained with respect to MSH strength (Table 5) showed that there were no significant differences between the two groups before the intervention period. Furthermore, in the post-intervention measurements, the group of participants who received the training program with isometric exercises showed much higher values in relation to those obtained in the pre-intervention measurements: left leg (-2.22 vs -8.39 repetitions for GC and GE, respectively) and right leg (0.7 vs -9.52 repetitions), as well as in overall strength (-1.53 vs -17.91 repetitions).

After analysis of the data obtained with respect to the strength of the HSM, the results indicated that no significant results could be seen with respect to the group effect, while they were seen for the variable Time effect in SJ ($p=0.001$), CMJ ($p=0.001$), and strength in both legs ($p=0.040$). Significant Group x Time interactions were also observed for right leg strength, $F(1,18)=8.923$, $p=0.010$, $\eta 2=0.407$, and for the total strength variable, $F(1,18)=5.494$, $p=0.036$, $\eta 2=0.297$.

The exhaustive analysis of this Group x Time interaction showed us that, with respect to HSM strength in the right leg, significant differences appeared between both groups in the post-intervention measure, $t(13)=-3.664$, $p=0.003$, with a large effect size (Cohen's $d=0.679$), as well as between pre- and post-intervention values in the GE $t(7)=-2.877$, $p=0.038$, with a large effect size (Cohen's $d=0.521$).

Similarly, in relation to total HSM strength, significant differences could be appreciated between both groups in the post-intervention measure, $t(13)=-3.719$, $p=0.003$, with a large effect size ($d=0.687$), as well as between pre- and post-intervention values in the GE $t(7)=-2.522$, $p=0.038$, with a large effect size ($d=0.521$).

Table 4

Effects of Strength Training with Isometric Exercises on the Domains and Total Score of the HaOS Questionnaire

HaOS	Pre-intervention				Post-intervention				Group			Weather			Group x time		
	Control		Experimental		Control		Experimental										
	Media	DT	Media	DT	Media	DT	Media	DT	F	P-value	Partial Stage^2	F	P-value	Partial Stage^2	F	P-value	Partial Stage^2
Dom. 1 left	83.33	21.65	75.00	25.00	85.71	24.40	87.50	23.15	0.000	1.000	0.000	4.603	0.051	0.262	1.421	0.255	0.099
Dom. 1 right	88.19	15.76	88.89	11.60	97.22	5.51	92.36	18.69	0.096	0.762	0.007	1.474	0.246	0.102	.205	0.658	0.015
Dom. 2 left	86.11	15.71	89.93	8.24	92.36	15.63	96.18	5.80	0.074	0.789	0.006	2.303	0.153	0.151	.499	0.492	0.037
Dom. 2 right	90.28	13.30	87.50	14.32	94.44	12.67	99.31	2.08	0.565	0.466	0.042	.895	0.361	0.064	.002	0.967	0.000
Dom. 3 left	76.39	30.26	83.33	19.76	87.50	21.65	97.22	5.51	0.444	0.517	0.033	6.860	0.021	0.345	.415	0.530	0.031
Dom. 3 right	83.75	20.28	83.27	12.81	90.97	16.21	94.79	8.08	0.000	1.000	0.000	0.353	0.562	0.026	.223	0.644	0.017
Dom. 4 left	83.33	21.65	75.00	25.00	85.71	24.40	87.50	23.15	0.068	0.799	0.005	5.329	0.038	0.291	2.231	0.159	0.146
Dom. 4 right	93.75	8.27	90.97	11.32	96.88	8.84	94.44	11.02	0.140	0.714	0.011	1.003	0.335	0.072	.355	0.562	0.027
Dom. 5 left	90.63	9.76	90.97	9.94	93.36	11.38	94.79	10.36	1.173	0.298	0.083	8.935	0.010	0.407	.110	0.745	0.008
Dom. 5 right	93.06	8.53	90.28	14.01	96.09	8.80	97.22	8.33	0.957	0.346	0.069	5.758	0.032	0.307	.399	0.539	0.030
Score Total left	81.94	19.87	87.50	18.75	93.75	11.57	95.83	6.25	0.173	0.684	0.013	8.744	0.011	0.402	.611	0.449	0.045
Score Total right	88.54	11.43	86.95	13.73	93.52	12.05	94.24	9.87	0.001	0.970	0.000	1.981	0.183	0.132	0.049	0.828	0.004
Total Score both	86.15	15.06	85.11	12.92	91.68	11.76	94.51	5.82	0.085	0.775	0.006	4.860	0.046	0.272	0.237	0.635	0.018

Dom: Domain. HaOS: Hamstring Outcome Score. Dom 1: Symptoms. Dom 2: Inflammation/Allergies. Dom 3: Pain. Dom 4: Function, Daily Life and Sport. Dom 5: Quality of life.

Table 5

Effects of Strength Training with Isometric Exercises on Hamstring Muscle Strength and Lower Body Power

	Pre-intervention				Post-intervention				Group			Weather			Group x time		
	Control		Experimental		Control		Experimental										
	Media	DT	Media	DT	Media	DT	Media	DT	F	P-value	Partial Stage^2	F	P-value	Partial Stage^2	F	P-value	Partial Stage^2
SJ (cm)	27.34	5.48	29.87	3.21	27.65	5.32	31.76	2.69	3.403	0.088	0.207	17.616	0.001	0.575	0.509	0.488	0.038
CMJ (cm)	27.80	5.03	31.19	4.02	28.66	6.12	33.53	3.22	2.647	0.128	0.169	16.928	0.001	0.566	3.682	0.077	0.221
Strength left leg (rep)	17.78	8.61	23.11	10.43	20.00	7.37	31.50	5.37	4.428	0.055	0.254	4.103	0.064	0.240	2.102	0.171	0.139
Strength right leg (rep)	20.56	8.31	22.11	10.97	19.86	7.97	31.63	4.14	2.074	0.173	0.138	4.617	0.051	0.262	8.923	0.010	0.407
Strength both legs (rep)	38.33	16.32	45.22	18.82	39.86	15.06	63.13	8.77	3.591	0.081	0.216	5.175	0.040	0.285	5.494	0.036	0.297

CMJ: Countermovement jumping. Rep: Repetitions. SJ: Squat Jump.

Discussion

The main objective of this pilot study was to analyze the effects of a 10-week isometric exercise training program on MSH injury risk factors in amateur soccer players. The results showed significant results with respect to right leg muscle strength and total strength. In addition, improvements could be observed with respect to the HaOS questionnaire and the vertical jump tests, but they did not reach statistical significance. These results suggest that increasing the number of hours in prevention programs could help decrease the risk of injury in HSM and increase physical performance in soccer.

Symptoms and risk of injury to the hamstring muscles

Pain on palpation and discomfort during and after (sport-specific) exercise, pain and discomfort during daily activities, and fear of re-injury are associated with muscle injuries (Jones et al., 2019; Van Der Horst et al., 2015). The HaOS questionnaire is useful in identifying gamblers with these symptoms (van de Hoef et al., 2021). The main difference of our study compared to previous investigations (Engebretsen et al., 2008; Engebretsen et al., 2010; van de Hoef et al., 2021), is that we conducted a longitudinal study and the other investigations are prospective cohort studies whose aim was to detect risk factors for MSH in soccer players.

For this reason, in the study by van de Hoef et al. (2021) players who had suffered an injury in the previous season and players who suffered a new HSM injury (during the new season) had in the total score and the mean of the HaOS questionnaire domains a lower score than players without HSM injury. The same is true in a previous study (Engebretsen et al., 2010). The results of our study show that the players were not at risk of HSM injury (because their score was > 80%), i.e., our results indicate that the players do not experience bad symptoms, do not have discomfort and no pain, have a good ability in their sport and a correct quality of life in terms of HSM. Although, statistical significance was not reached, the GE participants experienced a 9.4% increase in the HaOS total score, which would signify an evident decrease in the risk of HSM injury.

Lower limb power

It should be noted that jumping is a variable to evaluate lower extremity explosiveness and the most common tests to evaluate athletes are the vertical jump tests of both the SJ and CMJ (Bogataj et al., 2020; Gallardo-Fuentes et al., 2016). Likewise, the research by Venturelli et al. (2011) reported for the first time that a lower and negative ΔJH between CMJ and SJ height is a risk factor for MSH.

Therefore, in soccer the tactical indications commanded by coaches such as, for example, "individual pressing" and "pressing after loss" in order to have an immediate recovery of the ball are considered high-intensity actions, i.e. explosive actions (Križaj et al., 2019). Thus, it has been found that a 10-week eccentric training program in Danish players improved CMJ height over time in both CG and GE, but GE obtained better results (GE: 2.1 cm vs. GC: 0.55 cm). The same is true for the results of our study after the isometric exercise training program for 10 weeks (GE: 1.89 cm vs GC: 0.31 cm for SJ and GE: 2.34 cm vs GC: 0.86 cm for the CMJ). In any case, these results should be taken with caution because no statistical significance was found. On the other hand, the results of vertical jumps (SJ and CMJ) in our study are lower compared to other investigations (Krommes et al., 2017; Venturelli et al., 2011).

This may be because the players in our study are amateur players compared to players in other studies who were elite professional players (Krommes et al., 2017; Venturelli et al., 2011), where the IAD performed by players during a match separates world-class professional footballers from amateur footballers (Mohr et al., 2003), i.e., this is because professional footballers perform more IAD and explosive actions than an amateur player because the physical demands of their competition are lower.

Strength of the ischiosular muscles

Testing the hamstrings in a more functional capacity similar to the late swing phase of running may better assess strength as a risk factor for injury (Freckleton et al., 2014). The study conducted by Freckleton et al. (2014) developed a simple clinical field test to measure hamstring strength known as the SLBT test. The use of SLBT in soccer is scarce and has only been used twice in youth soccer players (Mahnič et al., 2021; Rey et al., 2017).

Regarding mean leg repetitions (left and right) and strength in both legs the data agree with previous research (Freckleton et al., 2014; Mahnič et al., 2021), but the group that received the training program with isometric exercises showed much higher values in relation to previous studies. On the other hand, the study by Rey et al. (2017) showed higher values than the results of our study. This could be explained by the relative strength levels of the player, which are related to the body mass of the individual (Mahnič et al., 2021). Especially the players in our study were heavier compared to (72.1 kg vs. 68.3 kg) players in the other study (Rey et al., 2017). Although after applying an eccentric strength program in the HSM (GE1 vs GE2 vs GC) their two GE (who performed an eccentric training program) obtained better results with respect to their GC.

It is usually common to hear that a muscle injury has had an inadequate recovery, therefore, prevention of the first injury should be a priority, because relapses result in significantly longer sports absences than previous injuries (Ekstrand et al., 2011). The most likely explanation for a previous injury being such a consistent risk factor is that the joints or muscles in question are not fully restored structurally and/or functionally. Based on this, it seems reasonable to suggest that one thing teams can do, even at the lowest levels, is to focus on improving post-injury rehabilitation and implement appropriate return to play guidelines by measuring risk factors for muscle injury (Engebretsen et al., 2008). Add, that players should undergo a rehabilitation program and experts advise that the "absence of pain" is a criterion to return to play safely and to prevent relapses (Engebretsen et al., 2008; Van Der Horst et al., 2015).

Therefore, we recommend that all players participate in strength programs at HSM. In the future, it may be possible to target prevention programs to those amateur players at greatest risk of injury to this musculature (van de Hoef et al., 2021). Recall, that hamstring injuries are a multifactorial problem, and a multifactorial approach to their prevention and treatment is needed (Freckleton et al., 2014; Van Dyk et al., 2017).

In the case of the HaOS questionnaire and vertical jumps have beneficial effects, although they did not reach the range of statistical significance, but we did detect significant differences between both groups in the strength of the right leg and the total strength of both legs in the SLBT test, therefore, we can affirm that a 10-week strength training program seems to be an excellent content to reduce risk factors in MSH. This is in line with the study by Rey et al. (2017) who after applying a 10-week eccentric training program obtained improvements in their GE and Raya-González et al. (2021) who examined the short- and long-term effects of a strength training program on muscle injury prevention in youth soccer players, reducing the incidence of muscle injuries during its implementation period. Therefore, the implementation of a strength training program in soccer players seems to be a valid option to reduce the risk of injury (Petersen et al., 2011; Raya-Gonzalez et al., 2021; van der Horst et al., 2015).

The results obtained in this study indicate that a strength training program with isometric exercises applied as complementary training for amateur soccer players can reduce the risk factors for MSH in the short term in this group of athletes. The strength training program was specially designed to be applied without expensive equipment, in order to be massively implemented in soccer training programs with senior teams belonging to teams such as the "Primera Andaluza Senior". The current results may be of relevance to players, coaches and researchers.

Limitations and future research

This study has some limitations. First, the low number of participants included per group makes the statistical power of the results limited and could explain why some results, despite showing evident improvements, did not reach statistical significance. On the other hand, only short-term outcomes were measured, i.e., immediately after the intervention. It is recommended that future studies be conducted with a larger number of participants, using various indicators of power or strength measurement and evaluating the medium and long-term effects.

Conclusion

The results of this study allow us to conclude that the performance of an isometric exercise program, in addition to regular training, has positive effects on the prevention of ischiosural muscle injuries. More specifically, statistically significant benefits were found in muscle strength assessed with the Single Leg Bridge Test. Improvements could also be found in scores on both the Hamstring Outcome Score questionnaire and vertical jump height, although they did not reach statistical significance, possibly in relation to the sample size. This should be taken into account when interpreting the results, which should be considered with caution. Therefore, it is suggested that the practice of a strength training program with isometric exercises before the technical-tactical session does not negatively affect soccer players and could reduce injury risk factors associated with the ischiosural musculature, and future studies with a larger number of participants are recommended.

References

Arnason, A., Andersen, T. E., Holme, I., Engebretsen, L., & Bahr, R. (2008). Prevention of hamstring strains in elite soccer: an intervention study. *Scandinavian journal of medicine & science in sports, 18*(1), 40–48. https://doi.org/10.1111/j.1600-0838.2006.00634.x

Burgess, K. E., Connick, M. J., Graham-Smith, P., & Pearson, S. J. (2007). Plyometric vs. isometric training influences on tendon properties and muscle output. *Journal of strength and conditioning research, 21*(3), 986–989. https://doi.org/10.1519/R-20235.1

Ekstrand, J., Hägglund, M., & Waldén, M. (2011). Epidemiology of muscle injuries in professional football (soccer). *The American journal of sports medicine, 39*(6), 1226–1232. https://doi.org/10.1177/0363546510395879

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

Engebretsen, A. H., Myklebust, G., Holme, I., Engebretsen, L., & Bahr, R. (2010). Intrinsic risk factors for hamstring injuries among male soccer players: a prospective cohort study. *The American journal of sports medicine, 38*(6), 1147–1153. https://doi.org/10.1177/0363546509358381

Freckleton, G., Cook, J., & Pizzari, T. (2014). The predictive validity of a single leg bridge test for hamstring injuries in Australian Rules Football Players. *British journal of sports medicine, 48*(8), 713-717. https://doi.org/10.1136/bjsports-2013-092356

Gallardo-Fuentes, F., Gallardo-Fuentes, J., Ramírez-Campillo, R., Balsalobre-Fernández, C., Martínez, C., Caniuqueo, A., Cañas, R., Banzer, W., Loturco, I., Nakamura, F. Y., & Izquierdo, M. (2016). Intersession and Intrasession Reliability and Validity of the My Jump App for Measuring Different Jump Actions in Trained Male and Female Athletes. *Journal of strength and conditioning research, 30*(7), 2049–2056. https://doi.org/10.1519/JSC.0000000000001304

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

McGill, S. (2010). Core training: Evidence translating to better performance and injury prevention. *Strength & Conditioning Journal, 32*(3), 33-46. https://doi.org/10.1519/SSC.0b013e3181df4521

Petersen, J., Thorborg, K., Nielsen, M. B., Budtz-Jørgensen, E., & Hölmich, P. (2011). Preventive effect of eccentric training on acute hamstring injuries in men's soccer: a cluster-randomized controlled trial. *The American journal of sports medicine, 39*(11), 2296-2303. https://doi.org/10.1177/0363546511419277

Peterson, M. D., Rhea, M. R., & Alvar, B. A. (2004). Maximizing strength development in athletes: a meta-analysis to determine the dose-response relationship. *Journal of strength and conditioning research, 18*(2), 377–382. https://doi.org/10.1519/R-12842.1

Raya-Gonzalez, J., Suarez-Arrones, L., Sanchez-Sanchez, J., Ramirez-Campillo, R., Nakamura, F. Y., & Saez De Villarreal, E. (2021). Short and Long-Term Effects of a Simple-Strength-Training Program on Injuries Among Elite U-19 Soccer Players. *Research quarterly for exercise and sport, 92*(3), 411–419. https://doi.org/10.1080/02701367.2020.1741498

Rey, E., Paz-Domínguez, Á., Porcel-Almendral, D., Paredes-Hernández, V., BarcalaFurelos, R., & Abelairas-Gómez, C. (2017). Effects of a 10-Week Nordic Hamstring Exercise and Russian Belt Training on Posterior Lower-Limb Muscle Strength in Elite Junior Soccer Players. *Journal of strength and conditioning research, 31*(5), 1198– 1205. https://doi.org/10.1519/JSC.0000000000001579

Timmins, R. G., Bourne, M. N., Shield, A. J., Williams, M. D., Lorenzen, C., & Opar, D. A. (2016). Short biceps femoris fascicles and eccentric knee flexor weakness increase the risk of hamstring injury in elite football (soccer): a prospective cohort study. *British journal of sports medicine, 50*(24), 1524–1535. https://doi.org/10.1136/bjsports-2015-095362 van Beijsterveldt, A. M., Steffen, K., Stubbe, J. H., Frederiks, J. E., van de Port, I. G., & Backx, F. J. (2014). Soccer injuries and recovery in Dutch male amateur soccer players: results of a prospective cohort study. *Clinical journal of sport medicine: official journal of the Canadian Academy of Sport Medicine, 24*(4), 337–342. https://doi.org/10.1097/JSM.0000000000000028

van der Horst, N., Smits, D. W., Petersen, J., Goedhart, E. A., & Backx, F. J. (2015). The preventive effect of the nordic hamstring exercise on hamstring injuries in amateur soccer players: a randomized controlled trial. *The American journal of sports medicine, 43*(6), 1316-1323. https://doi.org/10.1177/0363546515574057

Van Hooren, B., & Bosch, F. (2017b). Is there really an eccentric action of the hamstrings during the swing phase of high-speed running? Part II: Implications for exercise. Journal of sports sciences, 35(23), 2322-2333. https://doi.org/10.1080/02640414.2016.1266019

Van Hooren, B., & Bosch, F. (2018). Preventing hamstring injuries-Part 2: There is possibly an isometric action of the hamstrings in high-speed running and it does matter. *Sport Perf Sci Rep*, *1*, 1-5.

Venturelli, M., Schena, F., Zanolla, L., & Bishop, D. (2011). Injury risk factors in young soccer players detected by a multivariate survival model. *Journal of science and medicine in sport, 14*(4), 293–298. https://doi.org/10.1016/j.jsams.2011.02.013

World Health Organization (2000). *Obesity: preventing and managing the global epidemic.* Who technical report series.

Annexes

Annex 1

Strength Training Program with Isometric Exercises

	Weeks									
Exercises	1	2	3	4	5	6	7	8	9	10
Split step	2 x 3 C/L x 6"	3 x 3 C/L x 6"	3 x 5 C/L x 8"	2 x 4 C/L x 6"	3 x 4 C/L x 6"	2 x 3 C/L x 6"	3 x 3 C/L x 6"	2 x 4 C/L x 8"	3 x 4 C/L x 6"	3 x 5 C/L x 8"
Prone bridge	2 x 4 x 8	3 x 5 x 8	3 x 4 x 8	2 x 4 x 8	3 x 4 x 8	2 x 4 x 8	3 x 4 x 8	2 x 4 x 8	3 x 3 C/L x 6"	3 x 3 C/L x10"
Supine straight	2 x 4 x 6	3 x 4 x 6	3 x 5 x 10"	2 x 4 C/L x 8"	3 x 4 C/L x 8"	2 x 4 C/L x 8"	3 x 4 C/L x 8"	2 x 4 C/L x 8"	3 x 4 C/L x 8"	3 x 5 C/L x 8"
Side bridge	2 x 2 C/L x 8"	3 x 2 C/L x 8"	3 x 2 C/L X 8"	2 x 2 C/L x 8"	3 x 2 C/L x 8"	2 x 3 C/L x 4"	3 x 3 C/L x 8"	2 x 3 C/L x 4"	3 x 3 C/L x 8"	3 x 3 C/L x 8"

Note. 2 x 3 x 8" means 2 sets of 3 repetitions with a duration of 8 seconds, while 2 x 2 C/L x 8" means 2 sets of 2 repetitions each side with a duration of 8 seconds.

Annex 2

Variants of isometric exercises

Split step squat	Prone bridge	Supine straight leg bridge	Side bridge
			

Note. The exercises are arranged in order of intensity, i.e., the first exercise is in the upper left corner being the exercise of less difficulty and the progression ends with the exercise of greater intensity, corresponding to the right side of the lower corner.

Date received: 14/06/2023
Revision date: 03/07/2023
Date of acceptance: 11/07/2023