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Title: Home-Based Eccentrics Exercisers for Runners: The Effects on Hamstring Stiffness, Sprint, and Power

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ABSTRACT

Purpose: On the one hand, hamstring strain is the most common injury in sprinters, and on the other hand, eccentric exercise is one of the most successful interventions. Despite numerous studies in this field, the effect of home-based eccentric exercise (HBEE) on the sports performance of sprinters prone to injury due to hamstring stiffness has not been examined. Therefore, in the current study, the effect of four weeks of home-based eccentric exercise on the stiffness, speed, and power of sprinters was investigated.

Methods: The current quasi-experimental research was conducted on 32 sprinters (Control:16 Athletes, age: 21.50±1.63 years old; height: 176.81±5.54 cm; weight: 70.44±7.54 kg; sprintering background: 6.56±1.51 years, and BMI: 22.51±1.97, and Training: 16 athletes, age: 22.19±1.68 years old; height: 175.01±6.70 cm; weight: 67.31±7.50 kg; sprintering background: 7.19±1.55 years, and BMI: 21.94±1.74). Straight Leg Raising angle, Popliteal Angle, and Perceived Stiffness tests were used to assess hamstring stiffness, and 100 and 60-meter running and vertical jump tests were used to evaluate speed and power. The training group (eight without and eight with hamstring tightness) performed six progressive eccentric exercises at home for 12 sessions over four weeks.

Results: The analysis of covariance revealed that, after implementing this protocol, the hamstring stiffness and sprint records (60-meter and 100-meter sprint times) of the training group decreased significantly (P = 0.01). So that after four weeks of training, the SLR angle increased from 70.62 to 76.3 degrees (8% improvement), and the popliteal angle from 155.41 to 163.49 degrees (5% improvement), perceived stiffness decreased from 2.72 to 0.99 (62% improvement), 100m running record decrease from 12.96 to 12.62 seconds (2.6% improvement), and the 60m running from 7.10 to 6.69 seconds (5.7% improvement), but had no significant effect on power (vertical jump).

Conclusion: The implementation of the present protocol is recommended for sprinters with hamstring stiffness. Because of its implementation, in addition to improving the flexibility of the hamstring and reducing possible injuries due to its stiffness, it improves the speed running record. Also, running coaches can use this protocol as a training program to increase performance and reduce the risk of injury for sprinters with hamstring stiffness.

Keywords: Home-Based Exercise, Hamstring Stiffness, Sprinting, Injury Prevention, Eccentric Exercise

Highlights

● HBEE is associated with a significant decrease in hamstring stiffness (including SLR angle, Popliteal Angle, and Perceived Stiffness).

● Eccentric hamstring exercise improves running speed(100m and 60m) but has no significant effect on power (vertical jump).

● Sprinters and running coaches can use this protocol as a prevention of injury and an enhancement of performance program.

Plain Language Summary

Because hamstring strain is the most common injury in sprinters, it is essential to identify athletes with key risk factors (hamstring stiffness) and those susceptible to this injury. The results of the current study showed that performing HBEE can reduce stiffness and improve hamstring flexibility in sprinters with stiffness of this muscle. Because it is possible to perform HBEE at home without the need for special sports equipment, it also significantly improves running speed. Therefore, it is recommended that all sprinters and their coaches to do these exercises. It seems that implementing the current training protocol by modifying the key risk factor of hamstring strain (muscle stiffness) can be effective in reducing the risk of the most common muscle injury in sprinting (hamstring strain) and preventing secondary injuries caused by shortness and stiffness of the hamstring (such as ACL injury).

Introductions

In Olympic track and field athletes, the prevalence of injury is 64% [1, 2], in track and field 83% and in sprinting, 94% of these injuries occur in the lower limb [2]. The most common type of athletic injury is strain, with the highest incidence in sprinting (34%) [1, 2]. Hamstring injuries usually occur during sprinting and eccentric activities [2]. The most common injury in sprints, hurdles, jumps, combined events, and race walking is hamstring strain[3]. In sprinting, almost all injuries occur in the lower limb (92.7%), with about half of them being muscle injuries (49.0%) and one-third of all injuries being hamstring strains (33.4%) [4].

The cause of hamstring injuries is multifactorial. The most important modifiable risk factors include increased muscle tension, inadequate warm-up, muscle shortening, strength imbalance in the thigh area, decreased flexibility, muscle tightness, poor posture, history of hamstring or spinal injury, and fatigue. The most important non-modifiable risk factors include race, age, and muscle type [5, 6]. For example, fatigue, by reducing eccentric strength of the knee flexors, leads to a reduced hamstring-to-quadriceps ratio and an increased risk of hamstring injury. Also, a fascicle length shorter than 10.56 cm increases the risk of injury by 4 times, and a previous hamstring injury increases the risk of re-injury by 2-5 times[6, 7].

Hamstring stiffness is the key risk factor for injury to this muscle. A stiffer tendon-muscle unit, by changing the length-tension relationship, reduces the ability to produce maximum force and the ability to stretch quickly without injury. In the long term, the muscle will have more resistance to eccentric contraction, and this increases the risk of strain [8, 9]. 40% of athletes in high-speed sports have hamstring stiffness. High-intensity training, inadequate recovery time, muscle imbalances, and poor flexibility are the main factors that contribute to hamstring stiffness. A knee extension angle of less than 160 degrees and a hip flexion of less than 90 degrees is considered hamstring stiffness[9]. Hamstring stiffness can reduce running speed and agility [10], impair thigh muscle efficiency, and increase the risk of hamstring injury in runners [11] and professional ballet [12]. Accordingly, hamstring stiffness is considered a key risk factor for this injury to this muscle [13].

The two most common mechanisms of hamstring injury are the stretch-type and the sprint-type. The stretch-type occurs during simultaneous intense hip flexion and knee extension, such as when kicking a soccer ball, and the sprint-type occurs during near-maximal sprinting. The stretch-type involves the semimembranosus, and the sprint-type more commonly affects the long head of the biceps femoris[14]. Hamstring strains are often caused by a stretch-type mechanism[15]. However, the most common injury mechanism in sprinting is the sprint-type, and the most common injury site is the long head of the biceps femoris[16]. In sports, the most common isolated injury is to the long head of the biceps femoris muscle (70%), and the most common hamstring injury sites are the distal third (43%), the anterior third (31%), and the central third (26%)[16].

In high-intensity and high-speed sports, such as sprinting, the hamstring is often strained [17]. One of the main challenges of this injury is the high reinjury rate (38%) [18]. The amount of absence from an adult athlete per hamstring injury is 17 to 90 days[7], and 21 days in younger athletes [19]. In men's soccer teams, the annual occurrence of 5 to 6 hamstring injuries is estimated to cost $300,000, and in Primers League Baseball, each hamstring injury costs the team $330,000 (based on the average salary of league players and 30 days of absence) [7]. Accordingly, prevention of hamstring injuries is essential.

On the one hand, as running speed increases, the biomechanical load from eccentric hamstring contraction also increases. On the other hand, decreased eccentric strength is a key risk factor for hamstring injury. Accordingly, eccentric exercise is an important part of rehabilitation programs, and injury prevention and performance enhancement in speed running sports [20]. Nordic eccentric hamstring training increases eccentric strength and long head fascicle length of the biceps femoris[21]. Six weeks of eccentric hamstring training improves eccentric strength and passive flexibility[22]. Performing eccentric training even at a lower volume has positive effects on strength, hamstring muscle function, and injury prevention, because of reduces hamstring stiffness can reduce the risk of hamstring strains in sprinting[23]. Over the last two decades, the use of eccentric exercises has been introduced as an effective intervention in preventing hamstring injuries. However, some sprinters do not use HBEE due to fear of sports performance impairment, and the effect of HBEE on sprinters with hamstring stiffness has not been investigated. Therefore, in the present study, the effect of HBEE on hamstring stifness and running speed of sprinters with and without hamstring tightness was investigated.

Method

Study design and Participants

The present study, which used the Declaration of Helsinki guidelines, is considered a quasi-experimental research with a pre-test and post-test design. For this reason, examining the effect of an exercise intervention on the problems of a specific segment of society is applied research. Based on research background and the results of G * Power 3.1 (α=0.05, power ($1 - \beta$)=0.95, effect size=0.4, groups=2, measurement=6), the sample size was estimated to be 28 subjects. After screening, 32 sprinters were selected among 98 volunteers and were randomly divided into two groups of 16 people (8 with and 8 without hamstring stiffness). Inclusion criteria for the study included having hamstring stiffness or no stiffness, normal BMI, no history of surgery or serious injury in the past year, no postural abnormalities such as knee valgus, at least three years of sprinting history, and performing at least three training sessions per week in the past three years. Exclusion criteria included unwillingness to complete the exercise protocol, performing less than two exercise sessions per week, missing more than three exercise sessions, and experiencing acute injury during the study.

The exercise group participated in the BEE for 4 weeks, and the control group participated only in the pre-test and post-test. The included sample was relatively homogeneous because only players from the sprinters were recruited. Before measurements, consent forms and a personal information record form were provided. Subjects were fully informed about the study, including the research process, benefits, goals, and potential problems. To minimize assessment bias, assessors were blinded to group allocation.

The pre-test and post-test assessments (described in the Assessment Tests section) were administered after 21 Dynamic warm-up exercises, and six stretching exercises (Gastrocnemius, Standing Adductor, Supine Gluteus, Lunge Rotation or Hip Flexor, Seated Hamstring, Standing Quadriceps)[24]. The order of tests in both sessions was random. To ensure the best accuracy in the assessments, subjects were asked to follow the instructions on the pre-test and post-test day, including: no eating two hours before testing, maintain normal hydration status before and during testing procedures, void completely before the assessment, please wear appropriate clothing for the assessments, no exercise 12 hours before testing, no alcohol consumption 48 hours before testing, no caffeine 12 hours before testing, no diuretic medications seven days before testing .

Assessment Tests

Sprint Test (100-m,60-m)

The sprint was assessed using the 100-m and 60-m sprint tests .The athlete was instructed to run from the starting line to the finish line at maximum speed and in the shortest possible time. The time was recorded, according to the athlete's record [25, 26].

Power Test (Vertical Jump)

The vertical jump test was used to assess power. The athlete stood sideways to a wall, raised one arm as high as possible, and touched the highest point. He then immediately jumped as high as possible and touched the highest point of the wall. The difference between the two points and the best record of three attempts was recorded as the score[27] .

Straight Leg Raise Test (SLR)

The athlete is placed in a supine position with the hip and knee straight. The non-dominant hip is restrained with a belt to prevent flexion. The athlete slowly flexes and raises the hip of the dominant leg as far as possible, while the knee is straight and the non-dominant leg is kept straight on the table. The angle of displacement is measured using a standard goniometer[28].

Popliteal Angle Test

To measure the popliteal angle, bony landmarks of the lateral malleolus, lateral epicondyle, and greater trochanter of the hip were used. The athlete was positioned in the same position as in the SLR test, and the nondominant leg was also restrained. Initially, the dominant leg was passively flexed at the hip and knee at a 90-90 degree angle, and the hip was blocked by a vertical barrier. Then, the examiner extended the leg until firm resistance was felt or the subjects reported feeling maximum stiffness in the posterior aspect of their hip, but without pain. The amount of angle displaced was recorded as the popliteal angle[28].

Perceived Stiffness Test

A standard visual analogue scale (VAS) stiffness. The athlete was asked to mark with a pencil the point corresponding to the perceived level of hamstring stiffness during the SLR test (zero: no stiffness and 10: maximum stiffness), and the value was recorded in millimeters [29].

Intervention (HBEE)

Athletes in the exercise group met with another researcher to familiarize themselves with the intervention program, which they performed unsupervised in their home environment after the pretest. During these four weeks, participants submitted a log of the exercises they performed after each session (Table 1). The protocol consisted of six exercises (1.Walking Single-Leg Dead Lift, 2.Glute bridge with walk out, 3.Glute bridge with Single Leg slide out, 4.Nordic Hamstring Exercise, 5. Razor Curls, 6.Single-Leg Hamstring Bridge). Initially, sets and repetitions were prescribed, which were increased over 4 weeks using the principles of progressive resistance training [30].

Table1. Home-Based Eccentric Exercise (HBEE)

Week number	Session per week	Exercise	Sets of exercise	Reps per set
First Week	Two sessions	Walking Single-Leg Dead Lift	1	20
		Glute bridge with walk out	2	10
		Glute bridge with Single Leg slide out	2	10
		Nordic Hamstring Exercise	2	6
		Razor Curls	2	6
		Single-Leg Hamstring Bridge	2	10
Second Week	Three sessions	Walking Single-Leg Dead Lift	1	20
		Glute bridge with walk out	2	15
		Glute bridge with Single Leg slide out	2	15
		Nordic Hamstring Exercise	2	6-8
		Razor Curls	2	6-8
		Single-Leg Hamstring Bridge	2	15
Third Week	Three sessions	Walking Single-Leg Dead Lift	1	20
		Glute bridge with walk out	3	10
		Glute bridge with Single Leg slide out	3	10
		Nordic Hamstring Exercise	3	8-10
		Razor Curls	3	8-10
		Single-Leg Hamstring Bridge	3	10
Fourth Week	Four sessions	Walking Single-Leg Dead Lift	1	20
		Glute bridge with walk out	3	10
		Glute bridge with Single Leg slide out	3	10
		Nordic Hamstring Exercise	3	12 to 8 to 6
		Razor Curls	3	12 to 8 to 6
		Single-Leg Hamstring Bridge	3	10

Analyzing statistics

Because the results of the Shapiro-Wilk test indicated the normality of the data distribution, and the results of Levene's Test indicated the homogeneity of variance of the research variables. To compare the mean changes of the control and exercise groups' variables in the post-test by removing the possible effect of the pre-test, the analysis of covariance (ANCOVA) test was employed (Table 2). The significance level was set at p 0.05, and statistical analysis was done with SPSS software (version 26, SPSS Inc. 2000).

Results

Demographic information for the exercise group includes age: 21.50±1.63 years old; height: 176.81±5.54 cm; weight: 70.44±7.54 kg; sprinting background: 6.56±1.51 years, and BMI: 22.51±1.97), and the control group includes (age: 22.19±1.68 years old; height: 175.01±6.70 cm; weight: 67.31±7.50 kg; sprinting background: 7.19±1.55 years, and BMI: 21.94±1.74) .According to the results of ANCOVA (Table 3), performing four weeks of HBEE by removing the possible effect of the pre-test caused a significant improvement ($p < 0.01$), With a large effect size (partial eta squared greater than 0.15), in SLR (from 70.62 to 76.3), Popliteal angle (from 155.41 to 163.3), Percived Stiffness (from 2.72 to 0.99), 100 Meter Records (from 12.96 to 12.60), and 60 Meter Records (from 7.10 to 6.69), in the training group. But due to the non-significance (P=0.122) of the power record changes in the post-test between the two groups (from 42.31 to 43.4), it can be said that doing four weeks of HBEE has no effect on the power of sprinters.

Table 2. Mean and standard deviation (SD) of variables (by removing the possible effect of the pre-test)

	Mean ± SD							
	Control Groups				Exercise Groups			
	All	**Health**	**Stiffness**	**All-AM**	**All**	**Health**	**Stiffness**	**All-AM**
SLR-Pr	71.2±12.6	82.4±2.9	60.0±6.7	70.62	70.1±13.6	82.1±1.81	58.0±7.95	70.62
SLR-Po	67.0±10.1	74.6±6.8	59.4±6.2	66.6±1.4	75.9±10.3	84.0±2.73	67.9±8.47	76.3±1.4
P0P-Pr	157.0±14.6	170.0±6.1	144.1±6.4	155.41	153.8±15.7	166.0±11.7	141.5±6.7	155.41
P0P-Po	148.3±12.0	151.2±15.3	145.2±7.4	147.6±2.3	162.9±8.9	169.8±5.7	156.8±7.4	163.5±2.3
STI-Pr	2.56±2.45	0.25±0.46	4.87±0.64	2.72	2.87±2.68	0.25±0.46	4.87±0.64	2.72
STI-Po	2.63±2.02	1.0±1.06	4.25±1.28	2.7±0.27	1.06±0.98	0.50±0.76	1.62±0.91	0.99±0.27
100m-Pr	12.9±0.85	12.4±0.60	13.4±0.75	12.96	13.0±0.79	12.5±0.57	13.5±0.62	12.96
100m-Po	13.0±0.59	12.9±0.74	13.1±0.39	13.1±0.12	12.6±0.76	12.1±0.57	13.2±0.55	12.6±0.12
60m-Pr	6.98±0.64	6.68±0.53	7.29±0.62	7.10	7.21±0.43	6.84±0.64	7.59±0.38	7.10
60m-P0	7.29±0.44	7.26±0.52	7.33±0.37	7.36±0.09	6.74±0.51	6.48±0.41	7.01±0.46	6.69±0.09
Pow-pr	42.0±5.22	42.7±6.09	41.2±4.56	42.31	38.6±3.56	37.8±4.06	39.5±2.98	42.31
Pow-po	41.7±5.42	41.2±4.86	42.1±6.24	40.8±1.11	42.6±4.03	41.5±4.56	43.6±3.38	43.4±1.11

AM: Adjusted Mean, SLR: Straight Leg Raise, PR: Pre-test, PO: post-test, POP: Popliteal angle, STI: Stiffness, POW: Power test, AM-All: Adjusted Mean of All subjects (with and without stiffness)

Table 3. Tests of Between-Subjects Effects (ANCOVA)

Dependent Variable	Mean Square	F	Sig.	Partial Eta Squared	Observed Power
SLR.post	746.271	22.934	.000	.442	.996
Popliteal.post	1987.450	23.804	.000	.451	.997
Stiffness.post	23.223	19.614	.000	.403	.990
100-m.post	1.627	6.592	.016	.185	.699
60-m.post	3.451	27.738	.000	.489	.999
Power. post	46.342	2.531	.122	.080	.337

Based on the feasibility results of the HBEE protocol, only one sprinter (international level) was able to perform exercise number five (Razor Curls). However, both groups (with and without stiffness) were successful in performing the other five exercises (Table 4). Therefore, it is recommended that the present protocol be modified to include the other five (1-4,6) exercises for professional and semi-professional sprinters.

Table 4. Feasibility Results of the HBEE

Exercise Number	Groups	Mean ± SD
1	No Stiffness	11.0±0.92
	Stiffness	10.5±0.92
2	No Stiffness	13.13±0.83
	Stiffness	10.63±0.51
3	No Stiffness	10.88±0.83
	Stiffness	10.50±0.53
4	No Stiffness	11.13±0.83
	Stiffness	10.38±0.91
5	No Stiffness	0.50±0.92
	Stiffness	0.0±0.0
6	No Stiffness	9.25±2.43
	Stiffness	8.00±1.92

1.Walking Single-Leg Dead Lift, 2.Glute bridge with walk out, 3.Glute bridge with Single Leg slide out, 4.Nordic Hamstring Exercise, 5. Razor Curls, 6.Single-Leg Hamstring Bridge.

Discussion

The research findings showed that, four weeks of HBEE resulted in adjustment of all three risk factors for hamstring injury, that is significant improvement ($p < 0.01$), and 8.37% SLR angle (with stiffness 17.01%, without stiffness 2.28%), 5.93% popliteal angle (with stiffness 9.91%, without stiffness 2.25%), and 63.06% perceived stiffness (with stiffness 69.83%, without stiffness -35.13%). A meta-analysis of 23 randomized controlled trials (RCTs) of 14,721 participants on the effects of eccentric hamstring exercises on injury prevention found that performing these exercises reduced lower limb injuries by 28%, hamstring injuries by 46%, and knee injuries by 34%. The number of sessions performed twice a week was most important, and these exercises were most effective in preventing injuries in elite athletes and adult amateur athlete populations compared to adolescents [31]. Additionally, a comparison of the effects of eccentric exercise and traditional stretching exercises on hamstring flexibility and strength in healthy young dancers revealed that eccentric exercise significantly enhanced hamstring flexibility and strength, whereas traditional stretching exercises had a more modest effect on hamstring flexibility. Eccentric exercises have greater exercise benefits than traditional stretching exercises [32].

Although there is consensus on the effect of eccentric hamstring exercises on reducing injury risk, previous studies have not examined the effect of HBEE on sprinters, and the subjects were healthy and not hamstring tight. The main objective of the present study was to investigate the effect of four weeks of HBEE on modifying key risk factors for hamstring injury in sprinters with and without hamstring tightness. In the present study, the modification of SLR and popliteal angle, and perceived stiffness after HBEE training resulted from improved range of motion and reduced muscle stiffness in sprinters with hamstring tightness. For example, the significant improvement in SLR was 17.01% in sprinters with tightness, but only 2.28% in sprinters without tightness.

The subjects in the present study had hamstring tightness and shortness. Shortening of muscle tissue reduces the muscle's ability to absorb force and increases the risk of injury. It can also be a contributing factor to a longer recovery period. In the lower extremities, the hamstring muscles are often tight and short, and this tightness is a key risk factor for hamstring strain [31, 32]. The results of the present study showed that performing eccentric hamstring exercises improved flexibility, range of motion, and hamstring tightness. Stiffness and shortening in the muscle-tendon unit are caused by reduced muscle flexibility and reduced joint range of motion. Eccentric contraction stretches the muscle and gradually creates micro-tears in the muscle fibers, which are replaced by longer muscle fibers during the regeneration process, resulting in increased muscle length. It can also help reduce muscle tension and spasms by stimulating blood circulation and releasing trigger points [31, 33]. It seems that performing HBEE can reduce the risk of injury in sprinters by reducing hamstring stiffness and increasing flexibility. Eccentric exercises increase muscle length and reduce muscle tension, which in turn increases joint range of motion [31, 33]. Eccentric exercises increase the number of parallel sarcomeres, and thus the diameter of the muscle fiber. This increases the total muscle size and the maximum force that the muscle can produce. These exercises cause adaptations in muscle force control by changing the shape of the endomysium collagens of the muscle fibers at the muscle-tendon junction, and consequently reduce the risk of hamstring injury [34].

Another objective of this study was to investigate the effect of 12 HBEE sessions on the performance (speed and power) of sprinters with and without hamstring stiffness. The research findings showed that,, despite the lack of a significant effect (p=0.12) on power, four weeks of HBEE significantly improved ($p < 0.01$) the sprint record, 2.77% the 100-meter record (with stiffness 2.29%, without stiffness 3.23%), and 6.51% the 60-meter record (with stiffness 7.64%, without stiffness 5.26%). Therefore, it can be said that the improvement in sprinting speed following HBEE training is due to the improvement in sprinting speed in both groups of sprinters with and without hamstring tightness. For example, in the significant improvement in the 60-meter running record of the exercise group, the increase in speed in sprinters with stiffness was 7.64%, and without stiffness was 5.26%, and was approximately the same. A systematic review of 40 studies on the effects of eccentric training in healthy adults (17 to 35 years old) showed that this exercise improves muscle mechanical function, morphological adaptations, muscle-tendon unit architecture, and is superior to traditional resistance training in improving performance variables related to strength, power, and speed [35]. However, the results of some studies indicate that eccentric exercise does not affect speed and power. For example, performing four weeks (two sessions per week) of eccentric exercises in basketball players had no significant effect on change of direction and squat jump power [36]. The differences between the results of the studies are due to differences like sports disciplines, the subjects, the type of sport, and sport variables, and the measurement methods.

The results of a recent study (2024) showed that there is a significant relationship between hamstring flexibility and vertical jump performance of young basketball players. Therefore, the researchers recommended the need for targeted interventions to improve the flexibility of the hamstrings to improve sports performance and prevent injuries[37]. An investigation of the effect of hamstring stiffness on lower extremity muscle recruitment during jumping maneuvers in 30 male athletes with high and low stiffness showed that the high stiffness group landed with a lower vertical reaction force in the vertical jump[38]. Eccentric exercises focus primarily on slow-twitch muscle fibers, which play a lesser role in power generation, as power is achieved by performing explosive power movements in a short time. Eccentric hamstring exercises can help improve sprinting performance by increasing muscle recovery and hip range of motion. Increasing hip range of motion can help increase stride length and, therefore, increase running speed[36]. The vertical jump is a complex movement that requires not only hamstring strength but also coordination and power output of other lower limb muscles during the movement. Performing hamstring exercises alone and not practicing the jumping movement cannot improve vertical jump performance. To improve vertical jump performance, a comprehensive training program including various aspects of the movement, such as power output exercises (plyometric jumps and technique improvement exercises) is necessary [37-39]. One of the main factors in increasing force production is the use of the muscle shortening cycle to store and use its elastic energy. An athlete must be able to use the full range of the muscle and use the stretch-shortening cycle for ultimate performance; muscle stiffness prevents the use of this mechanism [39]. Overall, the lack of significant effect of these exercises on power requires further investigation, and the nature of the exercises, individual differences, jumping technique, number of training sessions, and the severity of hamstring tightness should be considered. In the present study, four weeks of HBEE resulted in an increase in SLR angle, popliteal angle, and a significant decrease in perceived stiffness, especially in sprinters with hamstring stiffness

Study limitations

Small sample size (n=32) limits generalizability. The subjects of the present study were male sprinters aged 18–25 years. Future research should be conducted on male sprinters younger than 18 years and older than 25 years. Since 26% of female track and field injuries occur in sprinting[3], the effect of HBEE on female sprinters should be investigated. Based on a review of the literature, eccentric hamstring exercises reduce the risk of hamstring strain by 46%, and therefore, the long-term effect of HBEE on injury prevention in sprinters should be investigated[31]. Because the present study was short-term (4 weeks), it limits the conclusion of injury prevention. The use of force plates was difficult for the present researchers. However, it is recommended to use a force plate to further understand the effect of HBEE on ground reaction force and lower extremity kinetics. Self-reported adherence to the home program (Feasibility Results of the HBEE, Table 4) may bias results.

Conclusion

Hamstring stiffness is a key risk factor for the most common athletic injury in sprinters (hamstring strain) [2,7]. One of the most effective measures to prevent hamstring strain is eccentric exercise, which reduces the risk of this injury by 46% [31]. Based on the results of the present study, performing HBEE for four weeks can reduce hamstring stiffness, especially in sprinters with hamstring stiffness, and improve sprinting performance. These exercises can be performed at home and without the need for special sports equipment, and can be done as supplementary exercises in the athlete's free time without overtraining. In addition to reducing hamstring stiffness and improving range of motion, it does not impair athletic performance and even improves sprinting performance. Overall, it seems that performing HBEE by modifying the key risk factor of hamstring strain (stiffness and shortness) can be effective in reducing the risk of the most common sports injury in sprinters and minimizing performance impairment and injuries caused by hamstring tightness. Since the initial findings are promising, coaches and sprinters can be recommended to perform HBEE, especially in sprinters with hamstring stiffness.

Moral Considerations

The funding process

This article is based on the master's thesis of the second author, supervised by the first author. No financial support was received from any governmental, commercial, or non-governmental organization for the conduct of this research.

Data Availability

The responsible author can provide the data used in this article to support the results of the current research, upon request.

Conflict of interest

Due to the absence of a commercial or financial relationship in the current research, there is no potential conflict of interest.

Consent to be informed

All the subjects of the research should have given their written consent before performing the study procedures.

The authors' contributions

The research idea, statistical analysis, and article writing were carried out by the responsible author, and the field research was carried out by the second author.

Competing interests

There were no conflicts of interest between the two authors of the present study.

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Following ethical guidelines

In the present study, all ethical principles and rules, such as voluntary participation, anonymity of participants, confidentiality and privacy of information, and allowing participation or stopping participation, were observed.And the Research Ethics Committee of the University of Kurdistan (IR.UOK.REC.1403.024) has approved it.

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