

## The Effect of Preventive Exercises Using a Flywheel on Improving Eccentric Strength and Flexibility of the Hamstrings in Footballers

Ali Qais Mahmoud

College of Physical Education and Sports Sciences, University of Tikrit, Tikrit, Iraq

[ali.qais@tu.edu.iq](mailto:ali.qais@tu.edu.iq)

Correspondensi Author

Email: [ali.qais@tu.edu.iq](mailto:ali.qais@tu.edu.iq)

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### ABSTRACT

*The aim of this study was to investigate the effect of preventive exercises using a flywheel on improving eccentric muscle strength and flexibility of the hamstrings in football players. The researcher employed an experimental approach with a two-group design—an experimental group and a control group—using pre- and post-tests, as this was appropriate to the nature of the research problem and its objectives. The study sample consisted of 20 advanced footballers, who were randomly divided into two equal groups: 10 players in the experimental group and 10 in the control group. The experimental group undertook a preventive programme using a flywheel device for 12 weeks, comprising three training sessions per week, totalling 36 training sessions, with each session lasting 20 minutes. The loads were progressively increased from the structural adaptation and safety phase, through the eccentric strength development phase, to the phase of eccentric overload and speed. The researcher used the Nordic Drop test to assess eccentric strength of the hamstrings and the active straight leg raise (ASLR) test to assess flexibility of the hamstrings. The results presented in the study showed an improvement in eccentric strength in the experimental group from  $(42.30 \pm 2.15)$  to  $(61.80 \pm 1.90)$ , representing an improvement of (46.10 per cent), whilst the improvement in the control group was (5.48 per cent). Flexibility of the hamstrings in the experimental group also improved from  $(64.50 \pm 3.10)$  to  $(78.90 \pm 2.20)$ , representing an improvement of (22.32 per cent), compared with (3.37 per cent) for the control group. The results indicate that the proposed preventive programme using the flywheel device was more effective in developing eccentric strength and flexibility of the hamstrings compared with the conventional programme, within the limits of the study design and the data used.*

Keywords: Flywheel; Eccentric training; Eccentric strength; Hamstrings; Flexibility; Injury prevention; Football.

### ABSTRAK

Tujuan studi ini adalah untuk menyelidiki efek latihan pencegahan menggunakan roda gila dalam meningkatkan kekuatan otot eksentrik dan fleksibilitas hamstring pada

pemain sepak bola. Peneliti menggunakan pendekatan eksperimental dengan desain dua kelompok—kelompok eksperimental dan kelompok kontrol—menggunakan tes pra- dan pasca, sesuai dengan sifat masalah penelitian dan tujuannya. Sampel studi terdiri dari 20 pesepakbola tingkat lanjut, yang secara acak dibagi menjadi dua kelompok yang sama besar: 10 pemain dalam kelompok eksperimental dan 10 dalam kelompok kontrol. Kelompok eksperimental melaksanakan program pencegahan menggunakan perangkat roda gila selama 12 minggu, terdiri dari tiga sesi latihan per minggu, total 36 sesi latihan, dengan setiap sesi berdurasi 20 menit. Beban secara bertahap meningkat dari fase adaptasi struktural dan keselamatan, melalui fase pengembangan kekuatan eksentrik, hingga fase kelebihan eksentrik dan kecepatan. Peneliti menggunakan tes Nordic Drop untuk menilai kekuatan eksentrik hamstring dan tes active straight leg raise (ASLR) untuk menilai fleksibilitas hamstring. Hasil yang disajikan dalam studi menunjukkan peningkatan kekuatan eksentrik pada kelompok eksperimental dari  $(42,30 \pm 2,15)$  menjadi  $(61,80 \pm 1,90)$ , mewakili peningkatan sebesar (46,10 persen), sementara perbaikan pada kelompok kontrol adalah (5,48 persen). Fleksibilitas hamstring pada kelompok eksperimental juga meningkat dari  $(64,50 \pm 3,10)$  menjadi  $(78,90 \pm 2,20)$ , mewakili peningkatan (22,32 persen), dibandingkan dengan (3,37 persen) untuk kelompok kontrol. Hasil menunjukkan bahwa program pencegahan yang diusulkan menggunakan perangkat roda gila lebih efektif dalam mengembangkan kekuatan eksentrik dan fleksibilitas hamstring dibandingkan dengan program konvensional, dalam batas desain studi dan data yang digunakan.

**Kata Kunci:** Roda gila; Latihan eksentrik; Kekuatan eksentrik; Hamstring; Fleksibilitas; Pencegahan cedera; Sepak bola.

## **INTRODUCTION**

Football is a sport characterised by high physical and neuromuscular demands, as performance involves repeated sprinting, acceleration, deceleration, changes of direction, jumping and shooting, which places repetitive mechanical loads on the lower limb muscles, particularly the hamstrings.

Hamstring injuries are of particular importance in sport due to their direct impact on a player's ability to train and compete, as well as their potential for recurrence. The scientific literature indicates that eccentric training is a key component of programmes for the prevention of hamstring injuries, as systematic reviews and meta-analyses have shown a reduction in injury rates with programmes that include eccentric exercises. (Al Attar et al., 2017; van Dyk et al., 2019)

A recent development in the field of sports training is the use of flywheel devices, which rely on inertial resistance and allow for the generation of high loads during the eccentric phase of movement. This method offers the possibility of controlling the training load according to the amount of force produced by the athlete, making it suitable for developing muscular strength and improving movement control.

A systematic review examining the long-term effects of flywheel training in footballers indicates that this type of training can improve strength, power, jumping ability and change of direction, with effects varying according to programme design and training duration.

Hence the importance of the present study in attempting to incorporate the pendulum machine into a preventive programme aimed at developing eccentric strength and flexibility of the hamstrings in footballers, in line with the physical demands of sporting performance.

Research Problem:

Despite advances in physical conditioning and injury prevention programmes, hamstring injuries remain a problem affecting players' continuity, particularly with the repetition of high-speed movements, sudden deceleration and changes of direction.

The researcher believes that one of the key aspects in addressing this problem lies in developing the hamstrings' ability to withstand eccentric loads and control movement within an appropriate range of motion.

Through field observations, the researcher noted that some traditional exercises may not provide a sufficient degree of dynamic eccentric resistance to mimic the movement demands of sprinting and deceleration.

The researcher therefore devised preventive exercises using a flywheel to improve eccentric strength and flexibility of the hamstrings in footballers.

Research objectives:

1. To develop preventive exercises using a flywheel for footballers.
2. To investigate the effect of the proposed exercises on the development of eccentric muscle strength in the hamstrings.

Research Hypotheses:

There are statistically significant differences between the experimental and control groups in the post-test measurements of the variables under study, in favour of the experimental group.

Research population:

1. Human subjects: Advanced football players at Salah al-Din Club aged 20-24 years.
2. Temporal scope: From 2 April 2026 to 9 July 2026.
3. Spatial scope: The physical training and sports rehabilitation hall in Tikrit.

## **METHODS**

Research Methodology

The researcher employed an experimental approach with a design comprising two equivalent groups—an experimental group and a control group—using pre- and post-tests, as this was deemed appropriate for the nature of the problem and the research objectives.

Research Population and Sample

The research population comprised advanced football players at the Salah al-Din Club in the First Division for the 2025-2026 football season, whilst the research sample comprised 20 players, who were purposively selected according to specific criteria, who were then randomly divided by drawing lots into two equal groups, with 10 players in each group.

Sample criteria:

The researcher stipulated the following criteria for selecting sample members:

**Table 1.** Sample criteria

| Criterion   | Variable |
|-------------|----------|
| 20–24 years | Age      |
| 180–190 cm  | Height   |
| 70–80 kg    | Weight   |

**Table 2.** Homogeneity of the study sample in anthropometric and basic variables (n = 20)

| Skewness coefficient | Standard deviation | Arithmetic mean | Unit of measurement | Variable     |
|----------------------|--------------------|-----------------|---------------------|--------------|
| 0.35                 | 1.04               | 21.65           | Year                | Duration     |
| 0.12                 | 2.85               | 184.20          | cm                  | Length       |
| 0.45                 | 2.40               | 74.80           | kg                  | Mass         |
| -0.15                | 0.92               | 6.80            | Year                | Service life |

The values of the skewness coefficient shown in the table indicate the homogeneity of the sample in terms of the basic variables; the study also indicated that the two groups were equivalent in the pre-tests and that there were no statistically significant differences.

Equipment and instruments used:

1. A medical Restameter for measuring height.
2. A calibrated electronic balance for measuring mass.
3. A flywheel training device fitted with variable inertia discs.
4. A digital goniometer for measuring angles and range of motion.

Tests used:

First: Nordic Drop Test to assess eccentric strength of the hamstrings.

Purpose of the test: To measure the ability to control movement and resist falling whilst the hamstrings are being stretched.

Method: The player kneels with their ankles secured from behind by an assistant, then slowly lowers their torso forwards with as much resistance as possible, using the hamstrings to resist gravity and brake before falling.

Second: Active Straight Leg Raise (ASLR) test

Purpose of the test: To measure the range of motion associated with the flexibility of the hamstrings.

Method: The player lies on their back, then raises one leg, keeping it straight without bending the knee, to the greatest possible extent; the angle between the leg and the floor is measured using a goniometer.

Proposed preventive exercises:

The preventive programme was implemented with the experimental group for a continuous period of 12 weeks, at a rate of 3 sessions per week, totalling 36 training sessions. The exercises were incorporated at the start of the main part of each training session, lasting 20 minutes.

**Table 3.** Stages of the preventive programme using the goniometer

| Rest | Volume and intensity | Inertial force | Main exercise | Weeks | Stage |
|------|----------------------|----------------|---------------|-------|-------|
|------|----------------------|----------------|---------------|-------|-------|

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|       |        |                         |                                                 |      |                                            |
|-------|--------|-------------------------|-------------------------------------------------|------|--------------------------------------------|
| 90 s  | 3 × 10 | 0.025 kg·m <sup>2</sup> | Single-leg squats and rope-pulling conditioning | 1-4  | First: Structural adaptation and safety    |
| 120 s | 3 × 8  | 0.050 kg·m <sup>2</sup> | Romanian Deadlift (RDL)                         | 5-8  | Second: Developing eccentric strength      |
| 150 s | 4 × 6  | 0.075 kg·m <sup>2</sup> | Dynamic impact                                  | 9-12 | Section 3: Excess Eccentric Load and Speed |

The programme shows a clear progression in the load, with the first phase beginning with a low load for adaptation and safety, followed by an increase in load in the second phase with a focus on eccentric strength, whilst the third phase involved a higher load and faster, more explosive performance.

Statistical Analysis:

The data were analysed using SPSS, and the researcher utilised the arithmetic mean, standard deviation, t-test and percentage improvement, as the formula for the percentage improvement was provided in the study. The percentage improvement is calculated according to the following formula:

$$\text{Percentage improvement} = (\text{post-test mean} - \text{pre-test mean}) \div \text{pre-test mean} \times 100$$

## RESEARCH RESULTS

**Table 4.** Differences between pre- and post-tests and rates of improvement in isometric strength and flexibility of the hamstrings

| Percentage improvement | Significance              | Calculated t-value | Post-test    | Pre-test     | Group        | Variable                          |
|------------------------|---------------------------|--------------------|--------------|--------------|--------------|-----------------------------------|
| 46.10%                 | Statistically significant | 7.42               | 61.80 ± 1.90 | 42.30 ± 2.15 | Experimental | Eccentric strength<br>Nordic Drop |
| 5.48%                  | Not significant           | 1.85               | 44.20 ± 2.40 | 41.90 ± 2.10 | Control      | Nordic Drop<br>eccentric strength |
| 22.32%                 | Statistically significant | 6.15               | 78.90 ± 2.20 | 64.50 ± 3.10 | Experimental | Muscle elasticity<br>ASLR         |
| 3.37%                  | Not significant           | 1.40               | 67.30 ± 2.50 | 65.10 ± 2.90 | Control      | Muscle elasticity<br>ASLR         |

The values in the table are based on the results reported in the original study, including the standard deviations for the two groups.

## DISCUSSION

The results for the experimental group showed a clear improvement in the isometric strength of the hamstrings, with the arithmetic mean rising from (42.30 ± 2.15) at the pre-test to (61.80 ± 1.90) at the post-test, representing an improvement of (46.10 per cent), whereas the improvement in the control group was limited, with the mean rising from (41.90 ± 2.10) to (44.20 ± 2.40), representing an improvement of (5.48 per

cent). This development can be explained by the nature of the training programme used with the experimental group, as it was based on progressive eccentric loading using a flywheel device, progressing from an adaptation and safety phase to the development of eccentric strength and then to higher eccentric loads and speed.

This explanation is consistent with findings from scientific reviews indicating that eccentric training can contribute to the development of eccentric strength in the hamstrings, and that regular adherence to training is an important factor in the emergence of its preventive and training effects (Al Attar et al., 2017; Goode et al., 2015; van Dyk et al., 2019). Furthermore, the nature of the flywheel device allows the muscles to be loaded during the eccentric phase as a result of inertial resistance. A systematic review specific to footballers has shown that flywheel training can improve strength, power, jumping ability and change of direction, with the response varying according to the programme's design, volume and duration (Allen et al., 2021). The marked improvement observed in the experimental group can therefore be explained as resulting from the combination of the specificity of the exercises, the progression in load, and the eccentric resistance provided by the flywheel device, whilst the control group's adherence to the traditional programme may explain the limited extent of improvement observed in that group.

The results for the experimental group showed an improvement in hamstring flexibility, with the arithmetic mean rising from  $(64.50 \pm 3.10)$  at the pre-test to  $(78.90 \pm 2.20)$  at the post-test, representing an improvement of (22.32 per cent); In contrast, the control group achieved only a limited improvement, from  $(65.10 \pm 2.90)$  to  $(67.30 \pm 2.50)$ , representing an improvement of (3.37 per cent). This result can be explained by the fact that the programme did not rely solely on force production, but also involved performing movements within a progressive range of motion, particularly in the Romanian deadlift and lunge exercises, which allowed the hamstrings to work under load within an increasing range of motion. Furthermore, eccentric training may be associated with improved flexibility and range of motion alongside strength development; a systematic review has shown that eccentric training can improve lower limb flexibility as measured by range of motion, whilst more recent reviews have supported the existence of improved joint flexibility following eccentric training (O'Sullivan et al., 2012; Diong et al., 2022). The improvement in the ASLR test can therefore be interpreted as a reflection of regular exposure to eccentric movements within a progressive range of motion, although this interpretation must be considered within the context of the nature of the test and the programme used.

Overall, the results indicate that the experimental group outperformed the control group on the two variables under study; this can be explained by a number of factors related to the programme's design. The first of these factors is the specificity of the training; the exercises were designed to target the hamstrings with a focus on eccentric work. The second factor is the progression in load, as the programme began with a low load for adaptation and safety, then moved to a higher load to develop strength, and finally to a phase involving speed and greater eccentric load. The third factor is the nature of the flywheel apparatus, which allows the muscles to be loaded during both the concentric and eccentric phases, whilst enabling relatively high eccentric loads to be achieved. This finding is consistent with a systematic review on flywheel training in footballers, which concluded that strength, power, jumping ability and change of

direction can be improved following the implementation of various flywheel training protocols (Allen et al., 2021). It is also consistent with the evidence on eccentric training, which points to its role in developing eccentric strength and reducing the risk of hamstring injuries when applied regularly and at an appropriate training dose (Al Attar et al., 2017; van Dyk et al., 2019). Furthermore, adherence to the programme is a key factor influencing the effectiveness of preventive eccentric interventions (Goode et al., 2015). Consequently, the improvements observed in this study can be explained comprehensively by the specific nature of the exercises, the progression of the load, the nature of the flywheel's inertial resistance, and the regularity with which the programme was followed, whilst the results remain linked to the characteristics of the sample, the study design and its duration.

It should be noted that improvements in isometric strength and flexibility are physical indicators associated with prevention, and do not in themselves indicate a reduction in the actual incidence rate; demonstrating a direct preventive effect requires monitoring of incidence rates and hours of exposure, or an appropriate follow-up period.

## **CONCLUSIONS AND RECOMMENDATIONS**

### **Conclusions:**

1. The preventive programme using the flywheel device contributed to an improvement in isometric strength of the hamstrings in the experimental group.
2. The experimental group achieved a higher rate of improvement than the control group in the eccentric strength test.
3. The preventive programme contributed to an improvement in the flexibility of the hamstrings in the experimental group.
4. The experimental group showed greater improvement than the control group in the ASLR test.
5. The progression of eccentric load is one of the key factors in the design of the preventive programme using the flywheel device.

### **Recommendations:**

1. Incorporate eccentric training into preventive programmes for footballers, using carefully planned training loads.
2. Utilise the flywheel device to develop eccentric strength in the hamstrings where appropriate equipment and facilities are available.
3. Conduct periodic tests of eccentric strength and flexibility of the hamstrings to monitor the players' physical development.
4. Apply the principle of progressive overload when using the flywheel machine.
5. Ensure adherence to the training programme, as adherence is a key factor in the effectiveness of preventive isometric training programmes.
6. Conduct future studies on larger samples and over longer time periods.

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