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ORIGINAL STUDY

The Effect of Using a Ground Contact Angle Sensor on Improving Start Mechanics in Short-Distance Sprinters (100 m) among Youth Athletes

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Abstract

This study aims to investigate the effect of using a ground contact angle sensor on improving start mechanics among youth short-distance sprinters. The researcher employed an experimental approach using a control and experimental group design. The training program was applied to a sample of (n = 12) sprinters over an intervention period of (6) weeks. The experimental group followed a training program supported by ground contact angle detection technology, while the control group continued with conventional training.

The study relied on objective biomechanical measurements, including a ground contact angle sensor (electronic sensor), high-speed video analysis, and force platforms to measure contact angle, ground contact time, and the horizontal force ratio (RF%). The results revealed statistically significant improvements in favor of the experimental group in ground contact angle and contact time compared to the control group, with statistical significance values ($p < 0.05$) and a large effect size ($d > 1.0$), in addition to a noticeable increase in the horizontal force ratio (RF%).

The study concludes that the use of a ground contact angle sensor effectively enhances start mechanics in sprinters. It also emphasizes the importance of integrating modern biomechanical technologies into youth training programs to improve competitive performance efficiency, and this achieves one of the sustainable development goals of the United Nations in Iraq which is (Good Health).

Keywords: Ground contact angle, Start mechanics, Horizontal force ratio (RF%), 100-meter sprinters, Biomechanical measurements

1. Introduction

The 100-metre sprint is one of the most notable athletics events that require the highest possible speed within the shortest possible time. Success in this field relies on the variables of kinematic and biomechanical parameters, especially at the beginning and during the acceleration stage (Tawsi, 2024). It was established that the production of effective horizontal force and control over ground-contact angle are the key factors in determining high maximal sprint speed (Dakhel, 2013).

Ground-contact time, stride length and body-lean angle are key indicators that offer a strong empirical basis on the design of specialized training interventions (Al-Fadhli, 2010; Kadhim, 2024). In addition, the implementation of the devices which can measure ground-contact angle provide the data that can be used to optimize start mechanics between athletes who belong to younger age groups (Al-Janabi & Abdul Amir, 2016).

There is also empirical evidence that shows that physical self-efficacy and the level of performance on short sprints are correlated, which is why the impact of psychological factors on biomechanical ones is also essential (Abda, 2023). Also, ground-contact time, stride length, and instantaneous speed could be quantified, and such measures provide accurate measures of the effectiveness of the start phase (Tahshi et al., 2016; Amin, 2023).

It is supported by international studies, which state that the ability of elite sprinters to generate

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horizontal force and attain a more efficient angle of ground-contact is more advanced due to the use of non-invasive measurement tools and more accurate sensors (Blauberger et al., 2021; González et al., 2023). The reviews have also confirmed that a balance between the force and velocity along with directed forces application are critical aspects of high performance (Bezodis et al., 2019; Seidl et al., 2021).

The importance of block-start phase in defining result of the race by improving the contact angle and reducing the loss of speed has been emphasized in the classical literature (Hunter et al., 2004; Mann & Herman, 1985; Krzysztof & Mero, 2013). Modern biometric devices are seen as a viable tool for enhancing performance efficiencies among the sprinters, especially among the youth groups (Walker et al., 2021; Lockie et al., 2013; Maćkała et al., 2015). The significance of this research is based on a few factors accordingly:

- ➢ This research contributes to supporting contemporary trends in analyzing horizontal force during acceleration, a topic that has received increasing attention in recent years, particularly in understanding the relationship between horizontal force, speed, and ground contact time.
- ➢ The study provides an objective training approach based on a device capable of accurately determining the contact angle, which can enhance training effectiveness compared with traditional methods that rely solely on observation.
- ➢ It helps improve start quality, a phase that researchers have shown to be directly associated with an athlete's ability to reach maximal speed in a shorter time.
- ➢ This research may pave the way for developing training programs based on precise mechanical criteria rather than general methods, thereby contributing to a systematic improvement in youth sprinters' performance.

1.1. *Research problem*

The first stage of short-distance sprint races is generally considered one of the key factors of general performance, as it is based on the ability of the sprinter to produce effective horizontal force during the first contact (Hicks et al., 2020). Ground force application effectiveness and direction is a core mechanical determinant of enhancing initial acceleration (Hicks et al., 2020). Similarly, a high level of horizontal force is directly linked to high levels of acceleration (Rabita et al., 2015). However, many young sprinters lack the ability to find the most effective contact angle, which causes the loss of the effective force (Colyer et al., 2018). Those who are able to push more horizontally achieve greater acceleration (Colyer et al., 2018). As a result, the introduction of a ground contact angle sensor is a modern training form, which can help address this gap and improve the quality of the start through the optimization of contact mechanics and the direction of force.

Thus, the following main question presents the research problem:

How does adding a ground contact angle sensor to the enhancement of start mechanics in youth short-distance sprinters (100 m) affect them?

1.2. *Research objective*

The research aims at clarifying how the use of a ground contact angle sensor can increase start mechanics in short-distance runners.

1.3. *Research hypothesis*

The application of a ground contact angle sensor has significant effect on the maximization of start mechanics among the youth short distance sprinters as seen in the comparative evaluation of post interventions results of the experimental and control group.

1.4. *Research scope*

- **Human Scope:** Youth short-distance sprinters (100 m) enrolled in specialized schools in the city of Baghdad.
- **Spatial Scope:** The experiment was conducted in Baghdad youth clubs at the following stadiums: Ministry of Youth Stadium for Talent Development, Salim Al-Awadi Stadium, and Al-Jadriya Stadium.
- **Temporal Scope:** The time period specified for implementing the training program using the ground contact angle device; the experiment was carried out over a period of six weeks, from 1/10/2025 to 15/11/2025.
- **Thematic Scope:** The research is limited to examining the effect of the device on the following variables: ground contact angle, start mechanics, and the ability to produce horizontal force during the initial acceleration phase.

1.5. *Research terms and operational definitions*

- **Ground Contact Angle:** One of the most important mechanical factors affecting a sprinter's acceleration during the start, as it is related to force direction and effectiveness (Means et al., 2013). *Operationally:* the angular value in degrees recorded by the ground contact angle device during the start before and after application.

- **Ground Contact Angle Device:** A biomechanical tool used to measure the contact angle and analyze start mechanics with precision (Winter, 2009). *Operationally:* a device equipped with an angular sensor and a digital display system used to measure differences in contact angle before and after the experiment.
- **Start Mechanics:** Related to leg angles, ground contact, and response time, and determine the quality of the start (Coh et al., 2006). *Operationally:* a set of tested performance values such as contact angle and start time as measured by the researcher before and after the program.
- **Short-Distance Sprinters:** Their performance depends on explosive power and initial acceleration associated with contact effectiveness (McGinnis, 2013). *Operationally:* youth athletes aged 15–18 years from specialized schools who undergo pre- and post-tests of start performance.

1.6. Previous studies

1. Morin et al. (2019) confirmed that increasing horizontal force and adopting an appropriate contact angle during the initial steps are directly associated with higher acceleration, and that RF% is an important indicator of start efficiency.
2. Hicks et al. (2020) indicated that tools for measuring force and contact angle help analyze performance and identify weaknesses for developing individualized training programs, and that elite sprinters maintain high levels of horizontal force.
3. Colyer et al. (2018) demonstrated that elite athletes direct force more horizontally compared with non-specialists, which improves acceleration effectiveness and movement mechanics.
4. Samozino et al. (2018) developed a field-based method to assess the relationship between horizontal force and speed without the need for advanced laboratories, thereby supporting the training of youth athletes.
5. Hunter et al. (2005) confirmed that the horizontal force impulse and contact angle during the initial steps determine the sprinter's final speed.
6. Weyand et al. (2000) clarified that vertical force governs maximal speed, whereas horizontal force is the decisive factor in acceleration.

1.7. Commentary on previous studies

The literature on the topic has produced a consensus on the importance of horizontal force generation and ground contact angle in improving acceleration performance among short-distance sprinters, which is supported by Morin et al. (2019), Hicks et al. (2020), and Colyer et al. (2018).

The current study is consistent with these results by focusing on the effectiveness of the force direction in the first acceleration period; it however deviates by directly applying its results through the implementation of a ground-contact-angle sensor to enhance the performance of adolescent sprinters. This strategy helps in closing the gap between biomechanical studies and field training.

1.8. Theoretical framework

1.8.1. Ground contact angle and measurement devices

The angle of ground contact has been described as an important mechanical factor of acceleration efficiency in short-distance sprinting since the acceleration velocity is largely affected by the horizontal direction of the forces produced at the foot (Morin et al., 2019). The existing instrumentation uses force sensors and biometric modalities to measure horizontal and vertical forces on a step-by-step basis and calculate the ratio of horizontal force to the total force (RF%) as a direct measure of force-direction efficiency during the start phase (Hicks et al., 2020). Such approach is both feasible and valid, which allows its use during field training to improve the performance of both individual athletes and teams (Samozino et al., 2018). Empirical data show that the ideal angle of force gradually declines with the increase in sprinting speed, which confirms the use of a ground contact angle sensor as a useful instrument to adjust the techniques individually, enhance the level of mechanical efficiency, and reduce the number of non-directed forces losses (Morin et al., 2019).

1.8.2. Start Mechanics

Mechanical effectiveness of start mechanics, which refers to the ability of a sprinter to convert the muscular force into horizontal acceleration, directly correlates with the acceleration rate and consequently allows achieving the maximum speed in a shorter time period (Morin et al., 2019). It is a phenomenon that depends on a chain of interdependent variables, i.e. use of horizontal force, control of ground contact time and distribution of force during the first steps of the starting phase (Hicks et al., 2020).

Horizontal force velocity profiling is one of the most important assessment methods since it measures the force, velocity, and power output at the ground contact point with each stride and thus identifies strengths and weaknesses and allows the development of specific training regimes to address the weaknesses to improve performance (Morin et al., 2019). Also, the horizontal to total force ratio (RF percentage) is a salient measure of start efficacy; high ratio indicates an increased ability to project force in the horizontal plane, thus increasing acceleration and reducing dissipative losses (Colyer et al., 2018).

Optimal start mechanics are essential to injury prevention and long-term performance increase because deviant force distribution increases biomechanical loading on joints and muscles, which increases the risk of injury during the acceleration or explosive initiation phases of the movement.

1.8.3. *Short-distance sprinters*

The best results in short-distance sprinting are determined by speedy start and acceleration; therefore, it is important to perfect start mechanics (Hicks et al., 2020). The movement of the body in a stationary posture is the most conspicuous predictor of the final performance since the force in the horizontal direction in the initial acceleration phase determines the speed the athlete will reach the maximum speed (Morin et al., 2019).

In the case of adolescent sprinters, early training in terms of the correct ground-contact angle and horizontal force direction is one of the defining skills, as it allows individual technique to be adjusted to a more efficient work and prevents the loss of energy as a result of vertical or anatomically inappropriate force application (Colyer et al., 2018). Moreover, the cultivation of long-term horizontal force at the initial phases of acceleration enhances the speed of sprinting and strengthens the effectiveness of acceleration plans in short-range race events.

There is empirical evidence that the integration of ground-contact-angle-measuring devices into training regimes enhances the ability to accelerate the body at a faster rate without compromising technical stability, thus enhancing athletic performance and preventing injuries that may be caused by wrong use of force (Morin et al., 2019).

2. Research methodology

2.1. *Participants*

Experimental design methodology was adopted, where a ground contact angle sensor was adopted as an intervention tool to determine its effect on start mechanisms in short distance sprinters. The design will allow evaluation of variables of mechanical variables before and after the implementation of the training program and will allow comparing performance in the experimental condition and the pre-intervention baseline, thus providing unambiguous indicators of the effectiveness of the device in increasing the ground contact angle and mechanical efficiency of sprinters (Morin et al., 2019; Hicks et al., 2020).

2.1.1. *Research population*

The population of the study included all male short-distance sprinting adolescents (100 m) who were club athletes and was enrolled in specialized educational institutions simultaneously found in the city of Baghdad. It was based on the selection of a population with the existence of athletes who were able to meet the necessary physical and mechanical assessment protocols and were similar in the level of training experience, which guaranteed the maintenance of the same performance level in each of the participants before the introduction of the investigative device.

2.1.2. *Research sample*

A sample of (12) youth sprinters was selected after excluding (2) athletes who were used as a pilot sample. Athletes with previous lower-limb injuries or those who did not maintain regular attendance during the intervention period were also excluded. The participants were selected from Baghdad youth club sprinters enrolled in specialized sports schools in Baghdad. All were under the age of (20) years and trained at the Ministry of Youth Talent Care Stadium, Salim Al-Awadi Stadium, and Al-Jadriya Stadium. They regularly practiced sprinting and had no injuries that would prevent them from performing the required tests.

The sample was divided into two groups:

- **Experimental group:** six (6) athletes who received the training program using the ground contact angle sensor.
- **Control group:** six (6) athletes who continued with traditional training without using the device.

This split was meant to help the researcher to compare the performance measures of the two groups

Table 1. Basic physical characteristics of the research sample before the intervention.

Variable	Experimental Group (n = 6)	Control Group (n = 6)	T value	Significance
Age (years)	17.1 ± 0.6	17.0 ± 0.7	0.45	Not significant
Height (cm)	176.4 ± 4.8	175.9 ± 5.1	0.31	Not significant
Weight (kg)	67.8 ± 5.3	68.1 ± 5.6	0.14	Not significant

pre- and post-intervention and determine the effectiveness of the device in improving starting mechanics and acceleration in young sprinters.

As shown in Table 1, the two groups were physically homogeneous before the implementation of the program.

2.2. *Training program*

2.2.1. *Training program using the ground contact angle measurement device*

The training program was developed based on established mechanical and biomechanical training principles aimed at enhancing horizontal force application and optimizing ground contact angle during the sprint start phase (see Appendix 1). The intervention was implemented over a six-week period at a frequency of two training sessions per week, resulting in a total of twelve structured training units. Each session lasted between 50 and 60 minutes and specifically targeted improvements in ground contact angle and reduction of ground contact time during the initial acceleration phase.

Each training unit consisted of three primary components:

- **Warm-up phase**

This phase included dynamic stretching exercises, activation drills targeting the primary muscle groups involved in sprint start mechanics (quadriceps, hamstrings, gluteals, and calf muscles), as well as neuromuscular coordination exercises to prepare the athletes for high-intensity acceleration tasks.

- **Main training phase**

During this phase, the ground contact angle measurement device was used to assess the contact angle for each acceleration step. Training drills were individually adjusted based on the measured angle to guide each athlete toward achieving an optimal contact trajectory. The main training component included:

  - Short sprint starts (5–15 m) with real-time monitoring of contact angle.
  - Targeted strength exercises for the lower limbs and trunk to enhance horizontal force production capacity.
  - Progressive repetitions structured to minimize muscular fatigue while refining sprint technique and force application efficiency.

- **Cool-down phase**

The recovery phase included static stretching exercises and relaxation drills aimed at reducing muscle stiffness and minimizing injury risk following high-intensity sprint efforts.

2.3. *Instrument*

2.3.1. *Instrumentation and biomechanical measurements*

An electronic sensor was used to measure the ground contact angle during the start phase. The device was non-wearable and operated in synchronization with a high-speed video-based motion analysis system. Sensor data were temporally aligned with video recordings to accurately determine contact angle and ground contact time.

Additionally, ground reaction force platforms were employed to extract horizontal and vertical force components. These measurements enabled calculation of the horizontal force ratio (RF%), providing a quantitative indicator of the effectiveness of horizontal force application during the acceleration phase.

2.3.2. *Research instruments*

Mechanical start measurements

Start-phase mechanical measurements were designed to evaluate the technical and biomechanical performance of the sprinter during the start phase (see Appendix 2). The assessment included the following quantifiable variables:

1. **Ground Contact Angle at Start:** Measured using the device to determine the optimal contact angle for each sprinter.
2. **Ground Contact Time (GCT):** The time during which the foot remains in contact with the ground during the initial start steps.
3. **Initial Stride Length:** The distance between the feet during the first start step.
4. **Horizontal Force Application (RF%):** The percentage of horizontally applied force relative to the total ground reaction force produced.

It should be emphasized that the variables adopted in this study do not constitute psychometric or questionnaire-based measures. Rather, they represent direct biomechanical measurements derived from electronic sensors and force platforms, reflecting actual kinematic and kinetic performance parameters during the sprint start phase.

2.3.3. *Psychometric properties of start mechanics measurements*

The psychometric properties of the start mechanics measurements were calculated as follows:

Table 2. Validity and reliability coefficients of the research instruments.

Test	Type of Validity/Reliability	Value	Judgment
Ground contact angle measurement	Reliability (ICC)	0.92	High
	Concurrent validity (r)	0.90	Very appropriate

2.3.4. Reliability

Table 2 shows high reliability (ICC = 0.92) and strong validity (r = 0.90) for the ground contact angle measurement. Device reliability was verified through repeated measurements of ground contact angle conducted across three separate testing days. The instrument demonstrated a high intraclass correlation coefficient (ICC = 0.92), indicating high measurement accuracy and precision across repeated trials.

2.3.5. Validity

Concurrent validity was assessed by comparing the device measurements with laboratory-based assessments using high-speed motion capture cameras and ground reaction force platforms (force plates). The comparison revealed strong agreement between the systems (r = 0.88–0.91), confirming the accuracy of the device in measuring ground contact angle.

Furthermore, the ICC values confirmed the stability of measurements. The recorded measurements were also compared with reference biomechanical data reported in international literature, demonstrating high concordance and supporting the validity of measurements in evaluating sprint start mechanics.

2.4. Statistical analysis

The following procedures were implemented:

- Pre- and post-intervention measurements of ground contact angle were obtained using the ground contact angle measurement device. Ground contact angle was recorded via the electronic sensor, while horizontal force ratio (RF%) was extracted from ground reaction force platform data.
- A 10-meter sprint start test was conducted from starting blocks to assess initial acceleration time.
- Motion analysis was performed using high-speed video cameras to determine ground contact time and initial stride length.
- A structured performance observation form was completed by the researcher to document technical execution.

2.4.1. Implementation of the main experiment

The experimental intervention was conducted over a six-week period at a frequency of two training sessions per week, from October 1, 2025 to November 15, 2025. The procedure included the following steps:

1. Pre-test assessment of all mechanical variables for both groups.
2. Implementation of the training program exclusively for the experimental group, while the control group continued conventional sprint training.
3. Weekly recording of ground contact angle and performance improvements to adjust training load when necessary.
4. Post-test assessment conducted under identical conditions to the pre-test for both groups.

2.4.2. Statistical procedures

Data normality was examined using the Shapiro Wilk test. An independent samples t-test was used to compare differences between the experimental and control groups. A paired samples t-test was applied to compare pre and post intervention measurements within each group. Effect size was calculated using Cohen's d to determine the magnitude of the effect.

3. Results

3.1. Main hypothesis

There is an effect of using a ground contact angle sensor on improving start mechanics among youth short-distance sprinters. The analysis was based on the post-test results of start mechanics measurements for both research groups: the experimental and the control groups. This analysis reflects the effectiveness of the training program using the device in enhancing the mechanical variables associated with the start phase, compared to conventional training methods.

As shown in Table 3, the comparison of post-test results between the experimental and control groups showed that the ground contact angle recorded 45.8 ± 2.1 versus 41.2 ± 2.3 ($t = 5.12$, $p = 0.001$). Ground contact time was 115 ± 6 versus 128 ± 7 ($t = -6.34$, $p = 0.001$). The horizontal force ratio was 72.5 ± 3.2 versus 65.8 ± 3.5 ($t = 6.05$, $p = 0.001$), and initial stride length was 1.82 ± 0.08 versus 1.74 ± 0.07 ($t = 3.25$, $p = 0.004$).

These findings indicate statistically significant differences in favor of the experimental group across all measured variables.

Table 3. Comparison of the experimental and control groups' post-test results in start mechanics measurements.

Variable	Experimental Group (n = 6)	Control Group (n = 6)	t value	Significance level (p)	Notes
Ground contact angle (°)	45.8 ± 2.1	41.2 ± 2.3	5.12	0.001	Significant increase in the experimental group
Ground contact time (ms)	115 ± 6	128 ± 7	−6.34	0.001	Marked decrease indicating improved acceleration
Horizontal force ratio (RF%)	72.5 ± 3.2	65.8 ± 3.5	6.05	0.001	Substantial improvement in forward force direction
Initial stride length (m)	1.82 ± 0.08	1.74 ± 0.07	3.25	0.004	Moderate and significant increase

Note: RF% = Horizontal Force Ratio; ms = milliseconds.

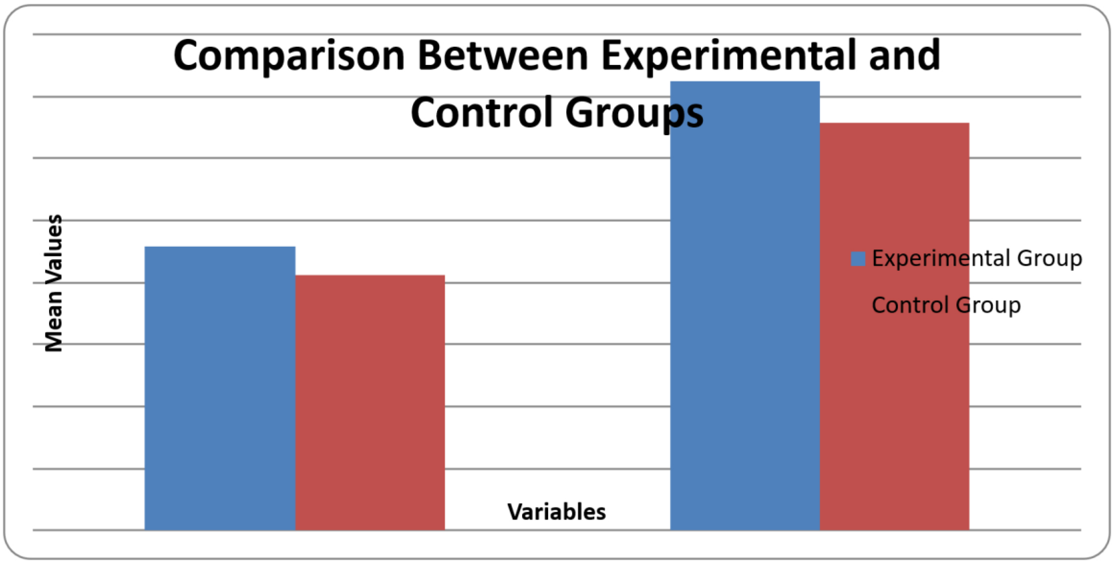

Fig. 1. Comparison between the experimental and control groups in horizontal force ratio (RF%) and ground contact angle after the post-test.

The results are presented statistically, as shown in Fig. 1, which illustrates these differences between the experimental and control groups.

Accordingly, effect size was calculated using Cohen's equation, and the results are presented in Table 4.

The effect size (Cohen's d) for the start mechanics variables after the intervention showed that the ground contact angle reached 2.05, ground contact time 1.99, and horizontal force ratio 2.00, indicating a very large effect. Meanwhile, the initial stride length reached 1.11, indicating a moderate effect.

4. Discussion

The study results demonstrate a significant improvement in start mechanics among participants in the experimental group. However, the importance of these findings lies not merely in the occurrence of improvement, but in explaining the mechanism underlying this enhancement. This improvement is primarily attributed to the nature of the training intervention based on the use of a ground contact angle sensor, which provided immediate and accurate feedback regarding the direction of force application during the start phase.

This effect is closely associated with the characteristics of the selected sample, as adolescents are generally more responsive to motor learning and neuromuscular reorganization compared to older age groups. The immediate feedback provided by the device accelerated the formation of what is known as the "mental map of movement," enabling athletes to directly associate kinesthetic sensation with performance outcomes. This resulted in automatic adjustments in contact angle and force direction. Such information-supported motor learning is particularly effective during adolescence due to the high plasticity of the nervous system at this developmental stage.

From a mechanical perspective, the improvement in ground contact time can be interpreted as a direct consequence of enhanced ground contact angle and force orientation. Increasing the contact angle toward the horizontal direction reduces the time required to apply effective force, thereby shortening ground contact time. This indicates an integrated mechanical relationship between contact angle and contact time, as

Table 4. Effect size (Cohen's d) for start mechanics variables after the intervention.

Variable	Experimental Mean	Experimental SD	Control Mean	Control SD	Cohen's d	Interpretation
Ground contact angle (°)	45.8	2.1	41.2	2.3	2.05	Very large effect
Ground contact time (ms)	115	6	128	7	1.99	Very large effect
Horizontal force ratio (RF%)	72.5	3.2	65.8	3.5	2.00	Very large effect
Initial stride length (m)	1.82	0.08	1.74	0.07	1.11	Moderate effect

both variables work together to improve acceleration efficiency during the initial steps. This interaction reflects improved effectiveness in force direction rather than merely an increase in force magnitude.

The marked increase in the horizontal force ratio (RF%) further supports this interpretation, demonstrating that athletes in the experimental group became more capable of converting produced force into effective forward motion, a key indicator of start quality in sprint events. This confirms that the improvement was not random or solely the result of general training, but rather a direct outcome of targeted mechanical optimization.

Based on these findings, it can be concluded that the use of the ground contact angle sensor contributed to interconnected mechanical adjustments involving contact angle, ground contact time, and horizontal force ratio, leading to comprehensive enhancement of start mechanics among youth sprinters. These results highlight the importance of integrating modern biomechanical technologies into youth training programs to accelerate motor learning and enhance performance quality.

The study findings align with previous research. Morin et al. (2019) indicated that greater horizontal force and optimal contact angle are associated with higher acceleration, and that RF% is a key indicator of start efficiency. Hicks et al. (2020) emphasized the importance of force and contact angle measurement tools in performance analysis and individualized training design. Colyer et al. (2018) demonstrated that elite sprinters direct force more horizontally, improving acceleration. Samozino et al. (2018) developed field-based methods to evaluate the relationship between horizontal force and velocity in youth training. Hunter et al. (2005) and Weyand et al. (2000) highlighted the role of force impulse and contact angle in determining acceleration and maximal speed.

5. Conclusions and recommendations

1. The research findings demonstrated a clear and positive effect of using the ground contact angle sensor in improving start mechanics among youth short-distance sprinters, compared to the control group that did not receive training with the device.
2. The device contributed to improving the ground contact angle, enabling sprinters to apply force more effectively in the forward direction during the start phase.
3. A significant reduction in ground contact time was observed in the experimental group, reflecting faster force transfer and improved early acceleration capacity.
4. The horizontal force ratio (RF%) increased, indicating enhanced ability to properly direct force and improve technical performance during the initial steps.
5. The experimental group recorded a moderate increase in initial step length, reflecting overall technical improvement as a result of training with the device.
6. Overall, the study confirms that mechanical intervention using the device can serve as an effective tool for developing both physical and technical performance in short sprint events.

Accordingly, the researcher recommends the following:

1. Integrating the ground contact angle sensor into regular training programs for short-distance sprinters, particularly during the start and acceleration phases, to enhance performance efficiency and technique.
2. Focusing on individual biomechanical analysis for each sprinter to tailor training programs according to their technical and physical capacities.
3. Implementing continuous training and periodic monitoring of start variables such as contact angle, ground contact time, and horizontal force direction to maximize the benefits of the intervention.
4. Encouraging coaches to emphasize optimal horizontal force application during training to enhance early acceleration in short sprint races.
5. Expanding research to include different age categories, including early and late adolescence, to compare effects across stages of physical development.
6. Investigating the device's impact on other performance variables such as maximal acceleration, phase transition speed, and muscular endurance during short sprint events.

7. Comparing the effects of the device with both traditional and other modern biomechanical technology-based training methods to determine the most effective strategy for improving start mechanics.
8. Conducting future research using more advanced measurement systems, such as advanced ground force systems and high-speed cameras, to monitor subtle changes in force production and start angles during training and competition.

Conflict of interest

The author declares that there are no conflicts of interest that could have influenced the study design, implementation of procedures, or interpretation of the results.

Ethical approval

Parental consent was obtained for all participants, and the study procedures were conducted in accordance with ethical principles governing scientific research in the field of sports.

Author contribution

The author designed the study, developed the training program, collected the biomechanical data, analyzed the results, and prepared the final manuscript draft.

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Data availability

The data used in this study are available from the author upon reasonable request for scientific research purposes, in compliance with approved ethical standards.

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Appendix (1): Training Program for Short-Distance Sprinters

Program Objective:

To increase start mechanics through the improvement of the angle of contact with the ground, the horizontal force, the initial stride length, and the decreasing contact time with the ground.

Program Duration:

A six-week session, two sessions a week, with 60 to 75 minutes of duration.

A. Warm-up Phase – 10–15 minutes

1. **Dynamic stretching exercises:**
   - High knees × 2 × 20 m
   - Butt kicks × 2 × 20 m
   - Hip and shoulder rotations × 10 seconds for each joint
2. **Core muscle activation exercises:**
   - Bodyweight squats × 2 × 12 repetitions
   - Forward lunges × 2 × 10 repetitions for each leg
3. **Coordination drills:**
   - Ladder drills to improve step control

B. Main Training Phase – 40–45 minutes

1. **Short start drills with contact angle monitoring:**
   - 5–15 m × 6 repetitions, using the ground contact angle device to correct technique for each sprinter
   - Rest between repetitions: 60–90 seconds
2. **Targeted strength exercises for the legs and trunk:**
   - Incline contacts × 3 × 10 repetitions
   - Step-ups onto a platform × 3 × 12 repetitions for each leg
   - Plank with alternating leg lift × 3 × 30 seconds
3. **Progressive repetitions to reduce fatigue and improve technique:**
   - 20–30 m × 4 repetitions at moderate speed, focusing on horizontal force application

C. Cool-down Phase – 10–15 minutes

1. **Stretching exercises:** Thigh, gluteal, and lower back muscles, duration × 20–30 seconds.
2. **Relaxation exercises:** Deep diaphragmatic breathing together with slow walking of a duration of 3–5 minutes.

Appendix (2): Sprint Start Mechanical Assessment Scale

Purpose of the Scale:

The proposed study will assess the performance of sprinters in the initial stage of starting and will compare the mechanical variables before and after the intervention.

Measured Variables

Variable	Measurement Method
Ground contact angle (°)	Ground contact angle device for each starting step
Ground contact time (ms)	Motion analysis system/high-speed cameras
Initial stride length (m)	Measurement of the distance between the feet during the first starting step
Horizontal force (RF%)	Ratio of horizontal force to total force using force measurement devices

أثر استخدام جهاز تحديد زاوية الدفع الأرضي (Ground Contact Angle Sensor) في تحسين ميكانيكية الانطلاق لدى عدائي المسافات القصيرة (100 متر) لفئة الشباب.

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الملخّص

يهدف هذا البحث إلى الكشف عن أثر استخدام جهاز تحديد زاوية الدفع الأرضي في تحسين ميكانيكية الانطلاق لدى عدائي المسافات القصيرة لفئة الشباب. تم اعتماد المنهج التجريبي بتصميم المجموعتين الضابطة والتجريبية. حيث خضعت المجموعة التجريبية لبرنامج تدريبي متقدم يعتمد على استخدام جهاز تحديد زاوية الدفع الأرضي، بينما تلقت المجموعة الضابطة التدريب التقليدي الذي يعتمد على الأساليب القديمة دون الاستعانة بالتكنولوجيا الحديثة. تم استخدام مقياس مقنن لقياس ميكانيكية الانطلاق.

أظهرت نتائج الدراسة وجود فروق ذات دلالة إحصائية بين القياس البعدي للمجموعتين، حيث كانت النتائج لصالح المجموعة التجريبية التي استخدمت جهاز تحديد زاوية الدفع الأرضي. تعكس هذه النتائج أهمية البيانات التي تم جمعها، والتي تشير بوضوح إلى فعالية استخدام هذا الجهاز في تحسين ميكانيكية الانطلاق. كما أنه يسلط الضوء على كيفية تأثير التكنولوجيا الحديثة على التدريب الرياضي، خاصةً عند التعامل مع فئة الشباب، تعتبر ميكانيكية الانطلاق أحد العوامل الأساسية التي تحدد نجاح العدائين في المنافسات، حيث تعتمد على عدة عوامل تتعلق بالقوة، السرعة، والتوقيت. من خلال تحسين زوايا الدفع الأرضي، يمكن للرياضيين زيادة فعالية انطلاقتهم، مما يؤدي إلى أدائهم بشكل أفضل في السباقات.

توصي الدراسة بتبني التقنيات الحديثة في تدريب عدائي السرعات، مما قد يسهم في تطوير مهاراتهم وزيادة كفاءتهم. كما تؤكد على ضرورة دمج أدوات القياس التكنولوجية في برامج الإعداد البدني والمهاري لتحقيق أفضل النتائج وتحسين الأداء العام للرياضيين. تعتبر هذه النتائج دليلاً هاماً على أهمية الابتكار في مجال التدريب الرياضي.

الكلمات المفتاحية: زاوية الدفع الأرضي، ميكانيكية الانطلاق، عدائي المسافات القصيرة (100 متر) لفئة الشباب.