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Biomechanical Analysis of Sprinting Techniques in School-Level Athletes

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Abstract

The biomechanical examination of sprinting strategies used by school-level athletes offers useful insights into the optimisation of performance and the prevention of injuries. The complicated and high-speed locomotor activity known as sprinting demands perfect coordination of the actions of the muscles, the motions of the joints, and the posture employed. The purpose of this research is to assess the most important biomechanical characteristics among school-aged sprinters. These parameters include stride length, stride frequency, ground response force, joint angles, and body alignment. In order to enhance sprinting mechanics, coaches and trainers can adapt training interventions to improve the mechanics of sprinting by identifying typical technical inefficiencies. These inefficiencies include overstriding, poor arm-leg coordination, and inappropriate trunk placement. The research illustrates how biomechanical parameters directly impact acceleration, maximum velocity, and total sprinting performance. This is accomplished through the use of motion analysis tools and observational methodologies across the research. When it comes to young athletes, the findings highlight the significance of early biomechanical evaluation and technique correction in order to improve speed, minimise fatigue, and reduce the risk of musculoskeletal problems. The findings of this investigation will serve as the basis for the development of evidence-based coaching practices that are focused at fostering athletic talent within young athletes.

Keywords: Biomechanical, sprinting, school, athletes

Introduction

When it comes to athletic performance, sprinting is one of the most fundamental actions, and it is essential to performance in a broad variety of sports. Sprinting is not only an essential component of the track and field and physical education programs that are offered at the school level, but it also acts as an important indicator of the overall athletic potential of the student. It is possible for the speed, endurance, and susceptibility to injury of a young athlete to be strongly impacted by the efficiency and efficacy of the sprinting tactics and techniques. Sprinting technique is frequently taught with a limited grasp of the underlying biomechanics, which results in inferior performance and an increased risk of injury. This is despite the fact that sprinting technique is extremely important. A scientific foundation for evaluating sprinting performance may be found in the field of biomechanics, which is the study of human movement through the applied principles of mechanics. When it comes to sprinting speed and efficiency, there are a number of factors that contribute to it. Some of these factors include stride length, stride frequency, ground response force, body posture, limb coordination, and joint kinematics. It is possible for coaches and practitioners to uncover deviations from optimum technique through the use of a biomechanical method, which provides data-driven insights that may be used to improve training outcomes. The technique of sprinting is still in the process of being developed among athletes competing at the school level. Many young athletes exhibit technical defects, such as overstriding, asymmetrical arm movement, inappropriate trunk lean, or inefficient foot striking patterns. These errors might potentially hinder their performance. There are a few possible explanations for these problems, including a lack of strength, poor coaching, or diminished neuromuscular coordination. It is possible that early biomechanical evaluation and intervention might play a significant role in the correction of these defects, the enhancement of sprint performance, and the promotion of long-term athletic development. Within the context of school-aged athletes, this research investigates the biomechanical components of sprinting in order to identify typical technical flaws and make recommendations for changes. The purpose of this project is to create a realistic framework for the development of efficient sprinting tactics that promote speed, safety, and skill improvement from an early age. This will be accomplished by bridging the gap between observational coaching and scientific analysis.

There has been a significant amount of research conducted on the biomechanical efficiency of sprinting among elite and collegiate athletes; nevertheless, its applicability at the school level is still relatively underexplored. When it comes to younger athletes, having a solid understanding of the biomechanics of sprinting is absolutely necessary in order to establish a foundation for correct technique, injury avoidance, and long-term athletic development.

Sprinting Phases and Biomechanical Components

The start phase, the acceleration phase, and the maximum velocity phase are the three components that make up the sprinting process. In each phase, various biomechanical aspects influence the behaviour of the system. According to Mann (2011), explosive power, ideal joint angles, and body alignment during these phases are essential for effective propulsion and minimised brake forces. These factors need to be taken into consideration. The length and frequency of strides, the amount of time spent in contact with the ground, the pressures exerted vertically and horizontally, and the symmetry of limb movement are all important biomechanical aspects that influence sprinting (Novacheck, 1998).

Stride Length and Frequency

The length of the stride and the frequency of the stride are major factors in sprint speed. Weyand et al. (2000) found that raising either of these factors can boost sprinting velocity; nevertheless, stride frequency tends to plateau at higher speeds. This was discovered by the researchers working on the study. When training athletes at the school level, it is frequently necessary to place more of an emphasis on stride control and frequency improvement rather than just stride elongation, which can result in overstriding and decreased efficiency.

Joint Kinematics and Muscle Coordination

It is absolutely necessary to have proper coordination of the joints, particularly the hips, knees, and ankles, in order to achieve excellent sprint mechanics. In their 2018 study, Nagahara and colleagues highlighted the fact that hip extension and knee drive are significant factors in determining horizontal velocity while running. It is common for younger athletes to lack the muscle strength and neuromuscular maturation necessary to maintain optimum joint kinematics, which can result in mechanical inefficiencies.

Arm-Leg Coordination and Posture

While sprinting, the arms are responsible for contributing to balance and rhythm. According to Bezodis et al. (2007), it is possible for the efficacy of sprinting to be diminished by improper arm motion, such as crossing the body or lacking sufficient elbow thrust. In a similar manner, the posture of the trunk have an impact on the direction of the force vector; an excessively lean or upright posture during the incorrect period might reduce forward propulsion.

Ground Reaction Forces and Contact Time

When compared to their elite counterparts, athletes competing at the school level typically have longer ground contact durations and lower ground response forces, which results in slower sprinting speeds. According to the findings of Clark and Weyand (2014), it is essential for sprint performance to minimise the amount of time spent in touch with the ground while simultaneously increasing the amount of force used to propel the body forward.

Biomechanical Assessment Tools

A comprehensive understanding of sprint mechanics may be obtained by the utilisation of technologies like as high-speed video analysis, force platforms, and motion capture systems. Despite the fact that these are more frequently utilised in more advanced settings, simpler observational tools have the potential to be utilised effectively in educational settings for the purposes of teaching and providing remedial feedback (Potdevin et al., 2018).

Objectives

1. **To evaluate key biomechanical parameters** such as stride length, stride frequency, ground contact time, joint angles, and trunk posture in school-level sprinters.
2. **To identify common technical deficiencies** in sprinting mechanics among young athletes, including overstriding, poor arm-leg coordination, and improper body alignment.
3. **To compare biomechanical performance** across different age groups or experience levels within the school athlete population.

Methodology

The methodology section must provide all the criteria for selecting participants, including those for both national and collegiate groups, to ensure the study's reliability and safety. Read on for some key takeaways that will help you give these details in the right order:

The descriptions of the groups and the selection criteria for the participants:

A. Guidelines for participant selection

General eligibility:

Age range: Participants who were between the ages of 18 and 30 were selected to ensure that they had attained a level of physical maturity and maintained capacity to take part in the study.

Health status: It was requested of the participants that they do all in their power to prevent any mental or physical disorders that may potentially have an impact on their ability to sprint. Each and every participant who had the goal of taking part in the study had either obtained permission from a medical professional or successfully completed the pre-screening procedure.

Experience level: The competition was restricted to just those persons who had previously participated in sprinting sports and were eligible to take part in it. As a consequence of this, it ensures that everyone is on the same level in terms of their previous experience and is comfortable with the challenges that are associated with sprinting.

Specific criteria for national-level sprinters:

- Performance Standards: sprinters are considered to be competing at the national level if they have finished in the top five percent of the country for their specific age group in the two years prior to the current competition. This includes all sprinting contests, including the 100-meter dash and the 200-meter dash among others.
- Competition Experience: Having a record from a national or international competition is one of the requirements for participant eligibility. In order to provide evidence, the results and scores of the official events were utilised.
- Recognition: The selection process is based on a number of factors, including a national record in athletic activities or multiple significant national honours.

Specific criteria for collegiate-level sprinters:

- Performance Standards: Individuals who competed in sprinting events at colleges and universities were categorised as those whose timings placed them in the top ten percent of their respective teams or leagues.
- Competition Experience: All individuals who competed in college track and field competitions at the regional or national level were required to do so, regardless of whether they were competing in the current academic year or the one before it.
- Academic Status: Participants were needed to be enrolled in a college or university and to be actively participating in sporting contests during the duration of the research.

Group definitions

National-level sprinters:

Definition: Those athletes who have a track record of achieving the highest potential degree of success in their respective national or international sporting championships throughout their whole athletic careers. Individuals who have proved the capacity to compete at the top levels in the sport of sprinting and who have attained large positions in national rankings are considered to be members of this group.

Verification: During the process of grading and assessing performance, each and every piece of information that was employed was gathered from various government sources. These sources included national sports organisations, national databases, and individual top performances.

Collegiate-Level Sprinters:

Definition: Athletes that participate at the collegiate level while simultaneously attending college are able to accomplish remarkable results in their athletic careers. The athletes who are considered to be a member of this class are those who are still enrolled in college and who have a significant amount of potential for future success.

Verification: The performance data was given by collegiate sports teams, and the status was validated by university athletic departments and official competition results.

Participant selection

Thirty sprinters were involved in the study; fifteen of them were at the national level (NLP), and fifteen were at the college level (CLP). Everyone who took part was between the ages of 18 and 25. A total of eleven out of fifteen athletes competing in the National Long-Distance Program have competed at the national level, with four of those athletes having finished in the top 10 in their respective sprinting events at the national level in the last year. Male NLPs can clock 100 meters at a time between 10.3 and 10.5 seconds, while females can do it in 11.3 to 11.5 seconds. So, it looks like they can run really fast. All of the CLP athletes are current or former members of collegiate track teams who competed in intercollegiate track events the previous year. On the 100-meter dash, the CLPs have a time range for men that goes from 10.8 to 11.0 seconds, while for females it's 11.8 to 12.0 seconds. No athlete may compete in any event if they have had an injury in the last six months or if they have a chronic illness. Details about the study's participants are included in Table 1.

Table 1. Details of the participants.

Characteristic	NLP	CLP
Number of Participants	15	15
Age Range	20–25 years	18–22 years
Height Range	Males:180±2.5 cm Females:170 ±2.2 cm	Males:175±2.8 cm Females:165 ±2.3 cm
Weight Range	Males:75±3.6 kg Females:60±2.4kg	Males:70±4.5 kg Females:55±3.7kg
Sex Distribution	Males:10 Females:5	Males:8 Females:7
Competition Level	National	Collegiate
Background	11 competed in national championships; 4 ranked in top 10	Competed in at least five intercollegiate track events
Sprinting Capability(100mdashtime)	Males:10.4 ±0.12s Females:11.4±0.15 s	Males:10.9 ±0.28s Females:11.9±0.23 s
Personal Best (100mdash)	Males:10.2 ±0.14s Females:11.2±0.16 s	Males:10.7 ±0.25s Females:11.7±0.20 s
Season Best (100 m dash)	Males:10.3 ±0.11s Females:11.3±0.17 s	Males:10.8 ±0.22s Females:11.8±0.19 s
Screening Criteria	Exclusion of athletes with recent injuries or chronic conditions	Exclusion of athletes with recent injuries or chronic conditions
Medical Screening	Detailed medical history and physical examination by a sports medicine professional	Detailed medical history and physical examination by a sports medicine professional

Data collection

It is vital to establish the data collecting rate in the experimental environment in order to guarantee that the study can be carried out when a CNN-LSTM hybrid model will be employed to investigate the biomechanical analysis of sprinting. This will ensure that the investigation can thereafter be carried out. An description of all of the many types of data sources, the normal processes for collecting data for each type of data source, and the relevance of each type of data source is provided in the following paragraphs:

Camera frame rate: Frame rates that vary from 120 to 1000 frames per second (fps) are employed by high-speed cameras from the field of biomechanics in order to record rapid motions with a higher temporal resolution. It is essential to make advantage of higher frame rates in order to carry out an accurate and predicted biomechanical research of sprinting. This makes it possible to record each and every action that the athlete makes, which eventually results in greater velocity tracking.

The biomechanical study was conducted according to the protocol outlined in Figure 2 for the sake of this inquiry. A Vicon MX T-Series motion capture system with twelve high-speed infrared cameras made up the setup. The cameras were set up at a height of 1.5 meters and had a broad enough field of vision to capture the whole motion range. As a whole, the cameras are spaced 2 meters apart. Figure 3 shows that these cameras captured the motion of reflective markers at key anatomical locations such as the hip, knee, ankle, shoulder, elbow, calf, toe, and wrist joints.

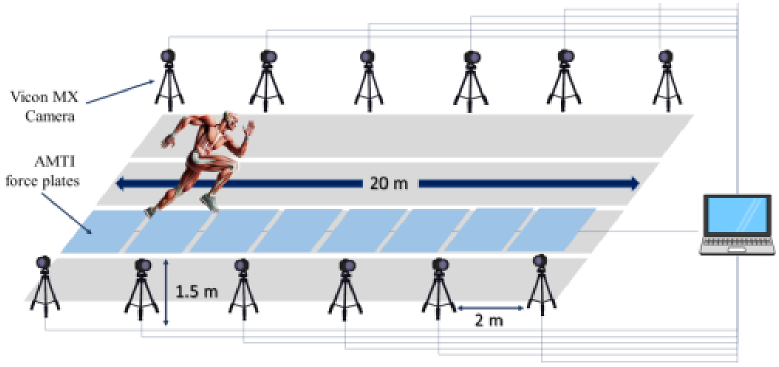


Figure 2. Study framework.

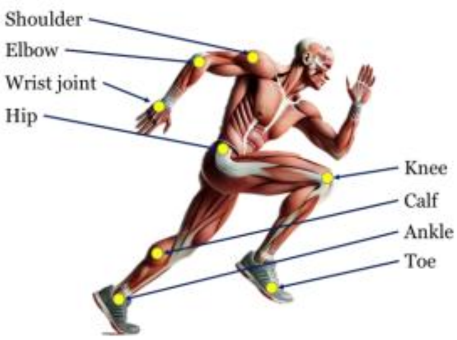


Figure 3. Sensor placement positions.

To do this, we measured the joint velocities and accelerations, as well as the joint angles, to get kinematic data. The ground response forces were measured simultaneously using the AMTI force plates that were implanted in the sprint track so that a comparison could be made. Upon each foot strike, these plates recorded the three-dimensional force data, which included the magnitude and direction of the force acting on the ground. Wearable sensors from Polar Team2 were used to collect physiological data, including heart rate variability and breathing rate. Along with the previously recorded kinematic and kinetic data, these additional actions were also executed. The video capture and biomechanical data collecting were synchronised using the Vicon Nexus software throughout the data acquisition procedure. The goal in doing this was to guarantee a successful data gathering. You may view the collected data in Table 2, which is located here. The examination consisted of four sessions spread out over two weeks, with two sessions held every week. For at least twenty-four hours before each test, the participants were instructed not to do anything physically taxing. This encompassed things like strenuous exercise sessions. This measure was used to ensure that the participants did not experience fatigue or muscle pain, which might affect their performance. Also, because they are stimulants, the participants were requested not to drink coffee or energy drinks on the day of the test. Nonetheless, they were to keep eating the way they normally did. Upon arrival at the testing site, all participants were required to complete a twenty-minute warm-up regimen. This particular warm-up routine includes a sequence of sprints done at escalating rates, as well as strengthening exercises and dynamic stretching and stretching. Stretching and other forms of flexibility training are often a part of the routine. The participants' bodies were marked at strategic points after they had done warming up with evidence tags to ensure they would be clearly visible. The next step was to lead the athlete to the 20-meter sprint starting line, where they were told to give it their all in the race.

Table 2. The information gathered and the apparatus utilised.

Data Collected	Data Type	Unit of Measurement	Measurement Device
Joint Angles	Kinematic Data	Degrees (°)	Vicon MX T-Series Motion Capture System
Joint Velocities	Kinematic Data	Meters per second (m/s)	Vicon MX T-Series Motion Capture System
Joint Accelerations	Kinematic Data	Meters per second squared (m/s^2)	Vicon MX T-Series Motion Capture System
Ground Reaction Forces	Kinetic Data	Newtons (N)	AMTI Force Plates
Force Direction	Kinetic Data	Degrees relative to vertical	AMTI Force Plates
Heart Rate	Physiological Measurements	Beats per minute (bpm)	Polar Team2 Wearable Sensors
Heart Rate Variability	Physiological Measurements	Milliseconds (ms)	Polar Team2 Wearable Sensors
Respiratory Rate	Physiological Measurements	Breaths per minute	Polar Team2 Wearable Sensors

There was a starting cannon and an electrical trigger that would go off at the beginning of each sprint. According to the logs, the electrical trigger was synchronised with the Vicon Nexus software precisely when the sprint started. Depending on the athlete's speed, each sprint trial took three to five seconds. The runner captured the reflective markers' movements as they sped down the course at a high frame rate of 500 fps. Concurrently, AMTI force plates were used to measure the forces acting on the ground. The force plates captured the three-dimensional information of the athlete's foot impacts, including the amount and direction of application of force. During the sprinting experiment, participants' physiological reactions were monitored constantly. Each dash usually lasted less than 10 seconds. A total of five sprint trials were conducted, each separated by a five-minute break. So that they wouldn't be too exhausted to give their all, we made sure to give them plenty of time to unwind and rejuvenate. With a warm-up, marker placement, sprint trials, and cool-down all rolled into one, the entire testing session took each athlete around 90 minutes (Table 3). Researchers performed a consistency analysis inside and between sessions (on various days) to determine the measures' reliability. The main focusses of the inquiry were consistency within and between sessions. The results are shown in Table 3. The reliability of the kinematic data, especially the joint angles, was very high, with an intra-session reliability value of 0.95, a standard error of measurement (SEM) of ±0.5°, and a confidence interval ranging from 0.93 to 0.97. In the same session, the kinetic data was analysed using the ground reaction forces, which yielded an ICC of 0.92 and a SEM of ±15 N. The data also had a confidence interval of 0.90 to 0.94. An intra-session reliability coefficient (ICC) of 0.98, a standard error of measurement (SEM) of ±2 beats per minute (bpm), and a confidence interval range of 0.96 to 0.99 were the determining factors in the most dependable physiological data.

Table 3. Reliability analysis.

Measurement Type	Type of Reliability	Intraclass Correlation Coefficient (ICC)	Standard Error of Measurement (SEM)	Confidence Interval (95%)
Kinematic Data (Joint Angles)	Intra-session (same day)	0.95	± 0.5°	0.93–0.97
Kinetic Data (Ground Reaction Forces)	Intra-session (same day)	0.92	± 15 N	0.90–0.94
Physiological Data (Heart Rate)	Intra-session (same day)	0.98	± 2 bpm	0.96–0.99
Kinematic Data (Joint Angles)	Inter-session (across days)	0.88	± 0.8°	0.85–0.91
Kinetic Data (Ground Reaction Forces)	Inter-session (across days)	0.85	± 20 N	0.82–0.88
Physiological Data (Heart Rate)	Inter-session (across days)	0.93	± 3 bpm	0.90–0.95

The comparison across several days revealed kinematic data for joint angles, a confidence interval between 0.85 and 0.91, an inter-session reliability of 0.88, a standard error of ±0.8°, and more. The ICC of 0.85 was noted for the kinetic data acquired across sessions, which had a standard error of ±20 N and a confidence range of 0.82 to 0.88. Physiological data dependability was continuously high throughout sessions, with a heart rate ICC of 0.93, ±3 bpm for standard error of measurement (SEM), and a confidence interval between 0.90 and 0.95.

Data analysis

This study found that compared to national team sprinters, university sprinters had shorter strides, lower GRFs, and less efficient joint angles. The obvious differences in the patterns of muscle activation indicated distinct differences in biomechanical performance. In our research, we utilised a CNN-LSTM hybrid model because to its innovative approach to researching sprinting biomechanics and its ability to explain the complex interplay of several components that impact performance.

Contribution to the Field:

(a) Give greater weight to the study's conclusions about sprinting's biomechanics. According to Call, the most crucial aspect of their investigation was the discovery of new relationships between joint angles and GRFs.

(b) Through the identification of the differential effect of joint angles on GRFs, this research provides insight into the biomechanical variations that differentiate top sprinters. This work adds to our current understanding of the physical world and has promising implications for improving athletic performance and overall health.

We analysed kinetic, kinematic, and physiological variables to understand how biomechanical factors impacted sprinting performance. Athletes' motion dynamics were recorded using kinematic variables, which included joint angles, velocities, and accelerations, throughout critical sprint stages such as the stance and swing. Ground reaction forces (GRFs) in three dimensions were the focus of kinetic variables in an effort to quantify the efficacy of force generation and transmission during foot impacts. By tracking physiological variables including heart rate, respiration rate, and heart rate variability, we were able to assess the athletes' internal workload and recovery status.

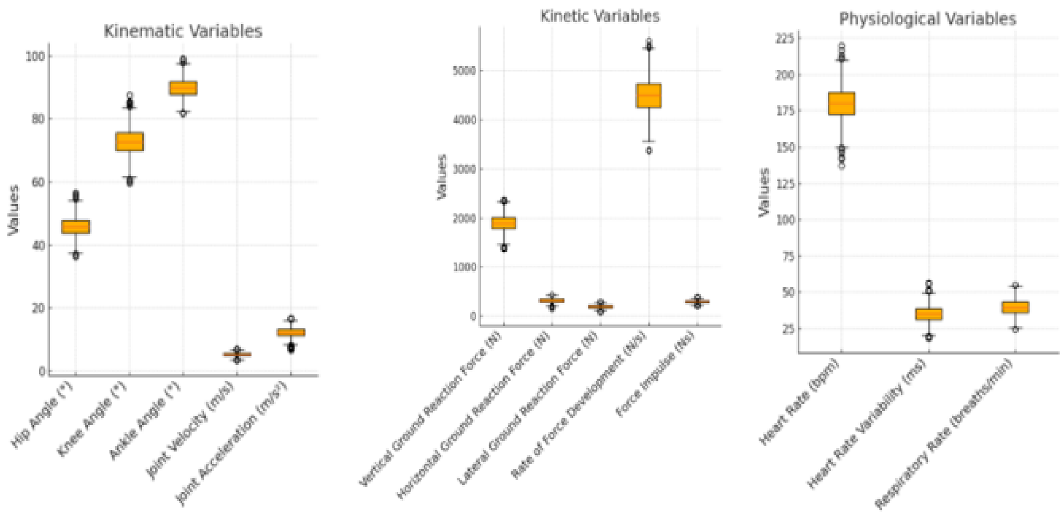
Descriptive statistics

To further improve the accuracy of the measurements and the reliability of the model predictions, confidence intervals may be incorporated into any study of biomechanical data. Find out how accurate the forecasts are, look at the data's range and reliability, and check the data so you can see whether the changes or impacts you found are statistically significant. This method not only improves the credibility of these findings, but it also makes data reuse and comparison with other studies feasible. You may see the tabular version of the descriptive statistics analysis in Table 4. One of the kinematic variables analysed was the hip angle, which had a mean of 45.63 degrees and a standard deviation of 3.18. This demonstrates a great deal of hip angle movement. While sprinting, there was a greater variety in knee angles (average 72.37 degrees) and a broader range of motion overall. This demonstrates the superior efficiency of sprinting with extended legs. The regularity of the athletes' ankle flexion, an important factor in improved propulsion, was encouraged by the fact that it followed a predictable pattern. Figure 5b shows that the kinetic variables reveal a great deal of variation in the ground response forces. An average vertical force of 1896.48 Newtons was exerted by a wide range of collision types. The average ground response force in the horizontal direction is 321.47 N, whereas in the lateral direction it is 199.84 N. In Figure 5c, we can see that the average heart rate is 179.63 beats per minute and the average respiratory rate is 39.87 beats per minute. These are only a handful of the numerous factors that athletes need to master in order to perform at their best. These figures demonstrate the seriousness of the cardiovascular strain that running causes. During high-intensity workouts, the athletes' heart rates varied by 34.72 milliseconds, which indicated their stress levels and the amount of time it took for them to recover.

Table 4. Findings from the descriptive analysis.

Biomechanical Variable	Mean	Standard Deviation (SD)	Minimum	Maximum	Range
Kinematic Variables					
Hip Angle (°)	45.63	3.18	40.14	52.34	12.20
Knee Angle (°)	72.37	4.12	64.73	81.61	16.88
Ankle Angle (°)	89.78	2.79	85.21	94.32	9.11

Joint Velocity (m/s)	5.23	0.57	4.12	6.36	2.24
Joint Acceleration (m/s^2)	12.27	1.43	9.81	14.69	4.88
Kinetic Variables					
Vertical Ground Reaction Force (N)	1896.48	149.62	1647.32	2201.45	554.13
Horizontal Ground Reaction Force (N)	321.47	45.31	250.24	410.59	160.35
Lateral Ground Reaction Force (N)	199.84	29.78	150.23	259.97	109.74
Rate of Force Development (N/s)	4503.67	348.96	3912.45	5097.36	1184.91
Force Impulse (Ns)	298.72	24.85	261.48	339.84	78.36
Physiological Variables					
Heart Rate (bpm)	179.63	11.78	161.45	199.34	37.89
Heart Rate Variability (ms)	34.72	5.96	25.48	45.13	19.65
Respiratory Rate (breaths/min)	39.87	5.24	32.14	48.29	16.15



(a) (b) (c)

Figure 5. Descriptive statistics for. (a) Factors related to motion; (b) factors about motion; and (c) factors related to physiological state.

Training implications

Training for the stance phase: Some physical activities that may improve performance during the stance phase include plyometrics, strength training, and stability exercises. A few more ideas would be cardiovascular and stability workouts. Enhancements to power production, impact absorption, and balance will result from these treatments.

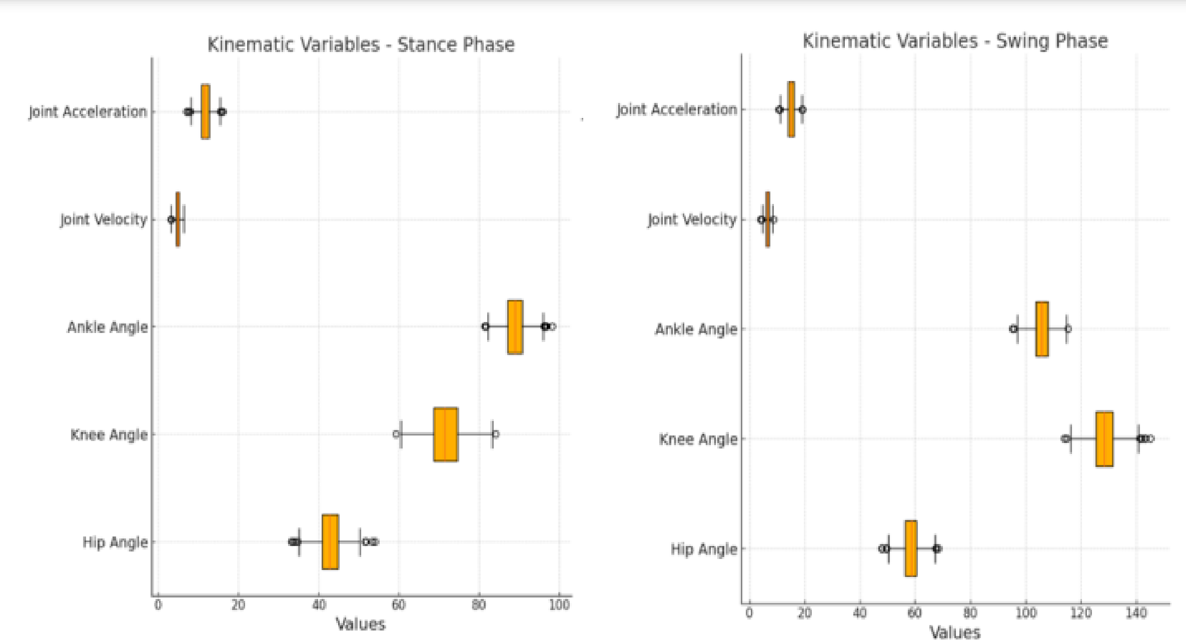
Preparation for the turning point: The mechanics and execution of the swing phase may be trained using exercises such as high-knee drills, sprint drills, and technique training. Leg speed, knee lift, and proper foot alignment are the cornerstones of these workouts and drills.

Biomechanical aspects of stance and swing that are present during a sprint impact overall performance. The stance phase is all about letting go, taking blows, and staying steady. The swing phase, on the other hand, accounts for things like stride length, frequency, and leg recovery. Recognising and paying attention to these stages, together with participation in specific training programs aimed at increasing speed and efficiency, may greatly enhance sprinting performance. Explanation of the descriptive statistics for the kinematic variables recorded throughout the sprint stance and swing stages may be found in Table 5. During the Stance phase, the hip angle remains rather consistent, with a mean of 42.87 degrees and a standard deviation that varies to a certain extent (Figure 6a). The average hip angle rises to 58.32 degrees when we go from the Leg phase into the Swing phase (Figure 6b), suggesting a larger range of motion is needed for effective leg recovery and sustained forward momentum. The average knee angle in Stance is 71.54 degrees, which allows it to simultaneously absorb the impact of a foot strike, similar to how knee angles shift from phase to phase. This angle rises to an average of 128.47 degrees during the swing phase, indicating the flexion required to propel the leg forward and prepare for the stride that follows.

Table 5. Mean, standard deviation, and range are calculated for each kinematic variable during sprint phases.

Kinematic Variable	Sprint Phase	Mean	Standard Deviation (SD)	Minimum	Maximum	Range
Hip Angle (°)	Stance	42.87	2.91	38.45	47.63	9.18
	Swing	58.32	3.05	53.72	64.21	10.49
Knee Angle (°)	Stance	71.54	4.23	65.38	79.12	13.74
	Swing	128.47	4.76	120.34	136.89	16.55
Ankle Angle (°)	Stance	88.93	2.58	84.31	93.45	9.14
	Swing	105.76	3.19	100.12	112.84	12.72
Joint Velocity (m/s)	Stance	4.83	0.56	3.96	5.67	1.71
	Swing	6.52	0.68	5.39	7.68	2.29
Joint Acceleration (m/s^2)	Stance	11.73	1.32	9.58	14.25	4.67
	Swing	14.92	1.45	12.54	17.39	4.85

On average, the ankle angles changes from 88.93 degrees in stance to 105.76 degrees in swing, which is a significant variation between phases. This elevation makes the leg more ready for the impending collision by allowing it to keep its clearance above the ground. The rapid changes in joint velocity and acceleration that characterise sprinting highlight the dynamic nature of the sport. The speed increases from 4.83 m/s in stance to 6.52 m/s in swing, showing that the limbs recover faster to maintain the racing rhythm. Similarly, moving from Stance to Swing causes the joint acceleration to jump from 11.73 m/s2 to 14.92 m/s2, illustrating how much effort needs to be used to reach top speeds.



(a) **(b)**

Figure 6. Descriptive statistics for Kinematic variables for. first, the launch site; second, the sailing phase.

Conclusion

An examination of the biomechanical aspects of sprinting strategies utilised by school-level athletes gives significant insights into the optimisation of performance and the prevention of injuries. The ability to sprint is a complicated motor skill that demands precise control over stride patterns, posture, and the application of force. It also needs the synchronised activity of several joints and muscle groups. According to the findings of this study, a significant number of school-aged athletes have technical shortcomings that limit their performance and may increase the likelihood of injury. These weaknesses include overstriding, extended ground contact time, and poor upper-limb coordination. Coaches and trainers are able to devise age-appropriate, focused treatments to address these inefficiencies if they have a thorough grasp of the biomechanical factors that are involved in good sprinting. These variables include stride frequency, joint angles, and trunk placement. A significant finding of the study is that it highlights the importance of doing early biomechanical evaluations in order to uncover problems before they become embedded in movement patterns. It is ultimately the case that incorporating biomechanical concepts into sprint training at the school level not only improves athletic performance in the short term but also builds the groundwork for long-term success in competitive sports. In the future, research and practical application should continue to concentrate on making biomechanical input accessible and actionable in young sports contexts. This will enable coaches to cultivate athletic potential via the use of approaches that are founded on scientific principles.

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