Analysis of running speed in the students with history of ankle injuries: running performance

Análisis de la velocidad de carrera en estudiantes con antecedentes de lesiones de tobillo: rendimiento en carrera

Authors

Fajar Awang Irawan [1*]
Fadzilah Sukmawati [2]
Ulfatul Azizah Awaliyyah [3]
Dhias Fajar Widya Permana [4]
Khoiril Anam [5]
Sandhya Kresna Jati [6]
Panita Khampoosa [7]
Sonthaya Sriramatr [8]

[1,2,3,4,5,6] Universitas Negeri Semarang (Indonesia)
[7,8] Srinakharinwirot University (Thailand)

Corresponding author:
Fajar Awang Irawan
fajarawang@mail.unnes.ac.id

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Abstract

Introduction: Running is an activity that is done to move faster, but it will not be effective if there are injuries that interfere with performance.
Objective: To examine the running speed of students with a history of ankle injuries regarding their running performance.
Methodology: This study's approach consists of a one-time case study design and descriptive analytics. 14 out of 120 samples were found to have a history of ankle injuries based on test and measurement results as well as physiotherapy evaluations. Kinovea software version 0.9.5 was utilized to analyze the video recordings that were used as the research instrument.
Results: This study found that the highest running speed was 19.91 m/s, with a stance phase time of 0.345 ± 0.040 seconds. Running speed can be affected by data-derived variables like stride length and knee flexion angle.
Discussion: According to this study, those with ankle injuries had an average stride length of 1.75 meters, while healthy people in the good category had an average stride length of 1.51 meters. The ankle flexion angle of a normal person is about 90 degrees, however the findings in this investigation showed that it was about 181.05 degrees.
Conclusions: This study indicated that students with a history of ankle injuries run less efficiently than healthy individuals. This study explains that when the injured leg is moved, it will move faster to reduce pain, particularly when the injured portion of the foot contacts the ground or another plane. Future research is anticipated to analyze running speed on a flat track to compare the injury risk associated with various track contours and running performance.

Keywords

Motion analysis; running speed; ankle injuries; performance.

Resumen

Introducción: Correr es una actividad que se realiza para moverse más rápido, pero no será efectiva si existen lesiones que interfieran en el rendimiento.
Objetivo: Examinar la velocidad de carrera de estudiantes con antecedentes de lesiones de tobillo en relación a su rendimiento en carrera.
Metodología: El enfoque de este estudio consiste en un diseño de estudio de caso único y analítica descriptiva. Se determinó que 14 de las 120 muestras tenían antecedentes de lesiones de tobillo en función de los resultados de pruebas y mediciones, así como de evaluaciones fisioterapéuticas. Se utilizó el software Kinovea versión 0.9.5 para analizar las grabaciones de vídeo que se utilizaron como instrumento de investigación.
Resultados: Este estudio encontró que la velocidad de carrera más alta fue de 19,91 m/s, con un tiempo de fase de apoyo de 0,345 ± 0,040 segundos. La velocidad de carrera puede verse afectada por variables derivadas de los datos, como la longitud de zancada y el ángulo de flexión de la rodilla.
Discusión: Según este estudio, las personas con lesiones de tobillo tenían una longitud media de zancada de 1,75 metros, mientras que las personas sanas de la categoría buena tenían una longitud media de zancada de 1,51 metros. El ángulo de flexión del tobillo de una persona normal es de unos 90 grados, sin embargo, los resultados de esta investigación mostraron que era de unos 181,05 grados.
Conclusiones: Este estudio indicó que los estudiantes con antecedentes de lesiones de tobillo corren con menos eficiencia que los individuos sanos. Este estudio explica que cuando se mueve la pierna lesionada, ésta se moverá más rápido para reducir el dolor, sobre todo cuando la parte lesionada del pie entra en contacto con el suelo o con otro plano. Se prevé que en futuras investigaciones se analice la velocidad de carrera en una pista plana para comparar el riesgo de lesión asociado a los distintos contornos de la pista y el rendimiento en carrera.

Palabras clave

Análisis del movimiento; velocidad de carrera; lesiones de tobillo; rendimiento.

Introduction

Sport is one of the media to make humans become healthy, have better conditions, and maintain physical fitness (Rahadian, 2019). Among the several sports, running is the most convenient to undertake in daily life. Running is the act of moving the body from one place to another while maintaining a balanced gait, arm swings, and footfalls. The ideal running technique will be produced by these good and proper actions, especially for fitness and injury prevention (Faizah & Herdyanto, 2019). Running is both an athletic activity and a regular physical exercise for humans. Running is often associated with aspects of physical fitness, such as endurance and speed.

The length of one's stride can affect one's running pace; the number of steps in each time and the number of steps attained during a run are equal to the frequency of steps. The runner's physical attributes and the running technique employed at each step define the ideal stride length. The body's structural components, running methods, and inter-body synchronization all influence the ideal stride frequency (Amir, 2017). Physiological characteristics, such as the strength, explosion, and flexibility of the leg muscles employed, can also influence running speed. While posture and body proportions are physical characteristics that influence running speed (Carlos et al., 2017). In order to maximize running speed, Saputri, (2016) asserts that the length of the step and the time obtained have an impact on how fast one should run.

Ankle injuries, also known as lateral ankle sprains, are among the most common injuries in athletes and the public (Irawan, Anjanı, et al., 2024; Koldenhoven et al., 2022). The main symptoms of ankle sprains are partial or complete tearing of the ligaments and periosteal stripping at the point of attachment caused by a reverse sprain of the ankle joint (Khamis et al., 2021; Xia, 2018). It has been noted that many people who have suffered ankle injuries will regain their pre-injury level of physical fitness, but an additional 40% will continue to sustain repetitive foot injuries with long-term consequences that will raise concerns and exacerbate the injury. When an injury occurs and no corrective action is taken, the person's quality of life and level of physical activity decline (Koldenhoven et al., 2019).

Through biomechanical analysis, many benefits can be taken, because biomechanics provides a lot of information for various kinds of human movement analysis, especially to improve athlete performance and reduce the risk of injury. In connection with previous research (Amir, 2017), it was suggested that the angle, length, and frequency of footsteps are needed to produce maximum running speed. Another study by Liu et al., (2021) also means a very strong and significant relationship exists between height and weight with running speed. In addition, research by Sunardi et al., (2019) states a relationship between leg length and leg muscle explosiveness and running results.

Fourteen individuals were found to have an aberrant running style in the measurement and evaluation test, based on observations of the 120 samples in this study. Through biomechanical evaluation, researchers hope to investigate the running speed of students with a history of ankle injuries. This is significant since an ankle injury will impact the running style and pace because the foot utilized as a fulcrum or swing will be affected. Analyzing running speed in students with a history of ankle injuries was the aim of this study. The researchers believe that coaches will be able to assist athletes in running more effectively if they educate the public about stride length, time at maximum running speed, and relative angle.

Method

Research Design

This study method using research is descriptive-analytic (Irawan et al., 2023) with a design using a one-short case study. This analytical descriptive study discusses its focus on motion analysis with an attempt to explain the investigation related to distance, body segments, time, and speed in running gait (Irawan, Setiawati, et al., 2024). The technique for collecting data is to use the observation method, conduct measurement and evaluation tests, and video documentation using a camera Nikon D5200, camera Tripod Motion Analysis, and laptop using Kinovea software version 0.9.5. This study also was approved by the Health Research Ethics Committee of Universitas Negeri Semarang, Indonesia.

Participants

The population in this study were 14 students who were identified as having a history of ankle injuries based on test and measurement results as well as physiotherapy evaluations. Each sample provided fully informed consent, indicating that they intended to participate in the study until its completion. Sampling using purposive sampling technique in which the sample is selected based on the criteria and certain considerations that have been determined by the researcher, such as male students who have a history of an ankle injury based on the results of physiotherapy identification and do the test their running style on a treadmill.

Procedure

This research was conducted at Prof. Soegijono's Laboratory at Universitas Negeri Semarang Indonesia with the provision that test participants would be given directions before carrying out the test and warming up sufficiently. The research procedures carried out are: (1) preparing stationery, tripods, and cameras used to record and write test participant data; (2) the prepared camera is placed perpendicular to the sample to record the sample's running speed on the treadmill; and (3) the research sample was given 1 minute to run on the treadmill with running speed 10 km/hour. After everything is done, the best data will be used by researchers to analyze the video using the research instrument by Kinovea application version 0.9.5.

Data analysis

Data analysis employing kinematic data gathered during the running motion phase in accordance with (Irawan, Anjanı, et al., 2024) in walking study as a motion suitability indicator. The results of the video recording were then analyzed using kinovea software with slow motion mode and kinematic data analysis consisting of two phases, namely stance phase, and swing phase. kinematic data collected in the form of time, distance, speed, and segment angle data from active movements that contribute to running movements.

Results

The results of this study used a sample of 14 colleges with data used in the form of age, height, weight, and BMI, which are presented in tabular form 1. In comparison, the criteria for active students having a history of ankle injuries and being able to complete the research by filling out informed consent.

Table 1. Anthropometric Data of Sample

N=14	Mean ± SD	Min	Max
Age (year)	20 ± 0,7	20	22
Height (m)	1,68 ± 5	1,57	1,75
Weight (kg)	61,78 ± 8,3	51	81
BMI (kg/m)	21,8 ± 2,9	18	29,4

Anthropometric data is used to analyze the kinetic data contained in the video recording. The collected data is then presented to find out the distance, time, angle, and speed data for each sample in the study. The results of anthropometric data from this study found that the average age of the sample is 20 ± 0.7 years. The average height data is 1.68± 5 meters, and the average weight is 61.78 ± 8.3 kg. The average BMI showed 21.8 ± 2.9 kg/m in the normal category. Other research data displayed include footstep data consisting of stride length and stride speed. Kinovea software version 0.9.5 was used to video analyze the sample's footsteps when running on a treadmill for 1 minute with a history of ankle injury. Kinematic analysis data of running gait motion analysis can be seen in Table 2.

Table 2. Analysis of Footstep

N=14	Mean ± SD	Min	Max
Right Step Length (m)	1,492 ± 0,248	1,086	2,028
Left Step Length (m)	1,523 ± 0,249	1,171	2,129
Right Foot Speed (m/s)	2,210 ± 0,321	1,597	2,897
Left Foot Speed (m/s)	2,311 ± 0,385	1,86	3,13

The results obtained from the analysis of footsteps using Kinovea 0.9.5 software in Table 2 show the average right footstep length of 1.492 ± 0.248 meters and the left footstep length with an average of 1.523 ± 0.249 meters. The average speed of the right foot was at a standard deviation of 2.210 ± 0.321 m/s, and the average speed of the left foot was 2.311 ± 0.385 m/s. The right footstep distance averages 1.492 ± 0.248 meters, and the average left footstep distance is 1.523 ± 0.249.

Table 3. Kinematic Data of Running Gait Motion Analysis

n=14	Mean ± SD	Min	Max
Running Speed (m/s)	14,11 ± 3,27	6,37	19,91
Stance Phase			
Time of Stance Phase (s)	0,345 ± 0,040	0,28	0,4
Left Knee Flexion Angle (°)	91,16 ± 16,46	51	120,6
Left Heel Height (cm)	68,89 ± 14,92	46,22	97,24
Swing Phase			
Time of Swing Phase (s)	0,318 ± 0,051	0,24	0,4
Right Knee Flexion Angle (°)	89,45 ± 13,77	65,6	119
Right Heel Height (cm)	65,30 ± 14,60	43,39	89,9

The results obtained from the analysis of running gait motion using Kinovea 0.9.5 software in Table 2 show the average running speed of students is 14.11 ± 3.27, with a maximum speed value of 19.91 m/s and a minimum of 6.37 m/s. In the stance phase movement, we obtained an average time of 0.345 ± 0.040 seconds, a maximum of 0.4 seconds and a minimum of 0.28 seconds. While in the swing phase movement, the average time obtained was 0.318 ± 0.051 seconds, with a maximum time of 0.4 seconds and a minimum of 0.24 seconds. The stance phase also produced a left knee flexion angle with an average of 91.16 ± 16.46°; the swing phase produced an average right knee flexion angle of 89.45 ± 13.77°. The average left heel height was 68.89 ± 14.92 cm, and the average right heel height was 65.30 ± 14.60 cm. The study's findings included information on heel height in the sample and a difference between the right and left stride times in a single running movement that included stance and swing phases. Given that the average sample still retains motion limits from the performance, this suggests that samples with a history of injury still have limitations when it comes to running. The lack of data pertaining to Range of Motion in both the ankle and knee joints is the study's main weakness.

Discussion

An analysis of running motion for students with a history of ankle injuries to provide notes and recommendations regarding speed, performance and how to prevent recurring injuries. The running motion analysis in this study is divided into two phases: the stance phase and the swing phase (Figure 1).

Figure 1. Running Gait Motion

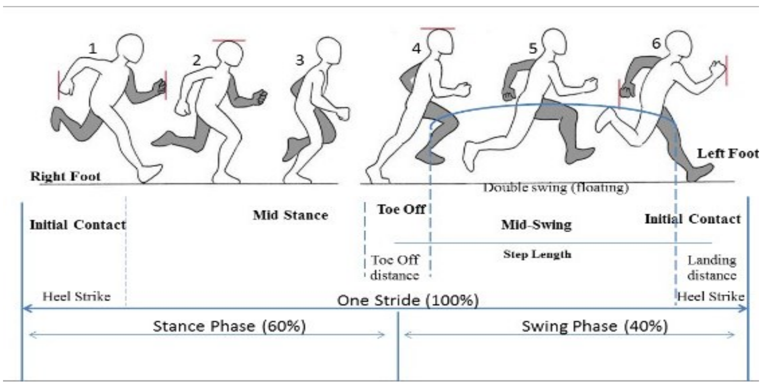

Figure 1 explains the phases of running motion (Pamies et al., 2018), consisting of the stance and swing phases. In the stance phase, there are several periods, such as initial contact, midstance, and toe-off. While in the swing phase, it consists of mid-swing and initial contact.

Figure 2. Step Speed

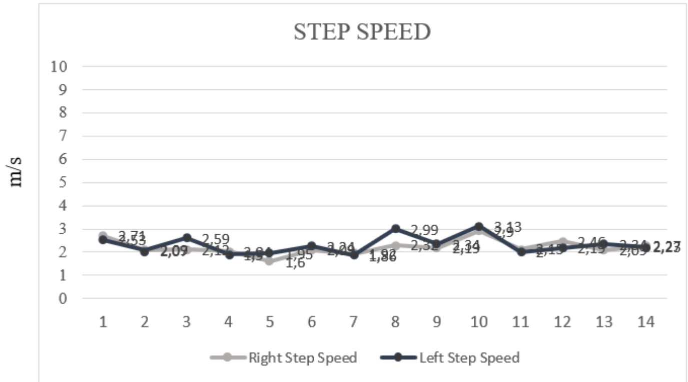

Figure 2 shows the graph of the average speed of the right footsteps was 2.210 ± 0.321 m/s, with the fastest number produced by the sample being 2.897 m/s and the slowest being 1.597 m/s. In the left footstep speed, the average speed was 2.311 ± 0.385 m/s, with the fastest number produced by the sample being 3.13 m/s and the slowest produced by the sample being 1.86 m/s.

In normal people, the resulting stride length between the left and right legs is relatively the same (Chumanov et al., 2008; Fukuchi et al., 2019). The difference in stride length can be caused by limited motion in the injured leg. This is characterized by an imbalance in the legs to reduce pressure on the injured leg, thereby shortening the time during the stance phase (Liu et al., 2021). Furthermore, differences is in stride length caused by injury could lead to asymmetrical stride patterns, which strongly relate to the propulsive forces generated by the paretic leg (Irawan, Anjanı, et al., 2024; Muro-de-la-herran et al., 2014).

A person's ideal stride in their running gait can also be determined by the link between stride length, cadence, and pace. in line with the conservative speed regulation approach for individuals proposed by Kapri & Mehta, (2021). The angles of the hip, knee, and ankle joints at various points throughout the action are additional factors that contribute to better speed performance. In contrast, walking or running pace can be slowed down by a slower tempo, slower stride rate, and shorter stride length. Miqueleiz et al., (2024) stated consistent running can offer a steady stride length by increasing speed gradually.

Based on the examination of running gait motion using Kinovea 0.9.5 software, the average running speed of students is 14.11 ± 3.27, with a maximum speed value of 19.91 m/s and a minimum speed value of 6.37 m/s, as shown in Table 2. The average time for the stance phase movement was 0.345 ± 0.040 seconds, with a maximum of 0.4 seconds and a minimum of 0.28 seconds. The average time of the swing phase movement was 0.318 ± 0.051 seconds, with a minimum of 0.24 seconds and a maximum of 0.4 seconds. Additionally, an average left knee flexion angle of 91.16 ± 16.46̊ was formed during the stance phase, while an average right knee flexion angle of 89.45 ± 13.77̊ was produced during the swing phase. The average height of the left and right heels was 68.89 ± 14.92 cm and 65.30 ± 14.60 cm, respectively.

In this study, the running phases are the stance and swing phases. Studies have shown that a shorter stance phase movement duration will result in a faster shift in pace for a runner. Meanwhile, the swing phase movement has a percentage of 60% if the stance phase is shorter in the running (Baktiyaningsih & Irawan, 2023). The data in this study shows that the stance phase time produced by students with a history of ankle injury is 0.345 ± 0.040 seconds, resulting in a maximum running speed of 19.91 m/s. Step frequency and step length are factors of a person's running speed. In normal people, the step length category is good when running is 1.51 meters (Amir, 2017). According to Maćkała & Mero, (2013) stated that one of the determining factors in increasing a person's running speed is the length of their footsteps when running. Speed changes are also caused by changes in the frequency of steps a person takes when running. The angular flexion of the knee also affects running speed because it is related to the time when a person performs stages in running, namely the stance phase and swing phase.

In previous study by Kivi et al., (2002) stated to maximize speed during running, and a runner will limit the range of motion of the lower extremity foot to minimize stance phase and swing phase movements. If this works, the athlete will be in a good position to accelerate. While running, it is observed that arm swings and foot motions are executed simultaneously. Notably, when the runner covers a greater distance, there is a corresponding decrease in the knee flexion angle and a reduction in step length (Carlos et al., 2017). From the sample data, 14 people who have been obtained show different running speeds. This happens because of the various injury histories experienced by each sample. Stance phase and swing phase time, stride length, and knee flexion angle are some of the factors generated from the data that can affect a person's speed in the running.

In addition, increasing speed performance may also increase injury risk. Various factors may influence the development of an injury, such as biomechanics, individual susceptibility, training intensity, and overall conditioning (Gribble et al., 2012; Irawan & Long-ren, 2019). Another study (Chumanov et al., 2008) found that inappropriate movement, like the late swing phase at high-speed performance, substantially increased the risk of hamstring injury. Another study investigated that lower limb and trunk kinematics correlate with maximal acceleration at full sprinting speed (Irawan, Anjanı, et al., 2024; Lulic et al., 2010). It may suggest that raising the running pace increases the probability of injury, particularly in the hamstring. However, that is also related to hip, knee, and ankle kinematics (Anjani et al., 2023; Baktiyaningsih & Irawan, 2023; Irawan, Anjanı, et al., 2024).

Conversely, a higher risk of acute injuries including ligament rips and muscle strains is typically associated with increased training intensity (Irawan et al., 2021). According to this research, increasing training intensities to improve speed performance is associated with an increased risk of injury. To prevent or lower the risk of injury, it is crucial to recommend suitable exercise intensities and sufficient rest time. According to the findings of the earlier study by Gussanto et al., (2022); dan Irawan et al., (2022), the particular training regimen for elite long-distance runners should include warm-ups and cool-downs, easy runs, long runs, uphill runs, threshold runs, fartleks, and progressive long runs (Pamies et al., 2018). Hill repeats, lactate tolerance, VO2MAX, and threshold are all components of interval training. However, the right training regimen needs to be applied gradually while taking the athlete's condition into account (Pamies et al., 2018).

For instance, three weeks of three times-weekly, 45-minute sessions of high-intensity intermittent exercise may enhance the physiological mechanisms and speed performance of young soccer players (Irawan, Anjanı, et al., 2024). Similarly, a 2-week procedure consisting of 4–7 bouts of 30 seconds at maximal intensity separated by 4 minutes of recovery was performed thrice weekly. The maximal aerobic speed (MAS), the time to exertion at 90% of MAS before the test (Tmax at 90% MAS), and the 3,000-meter time trial (TT3000) all significantly improved speed performance (SALIH, 2024). It may suggest that appropriate exercise positively impacts speed performance and reduces injury risk. In addition, twelve weeks of high-speed resistance training, including bench press, bicep curls, 10 m sprints, etc., performed three times per week is effective for enhancing the functional capacity and muscle performance of elderly individuals (Carlos et al., 2017). Furthermore, examining one joint at a time is best when analyzing the gait cycle. Objective and subjective methods can be used. According to Khamis et al., (2021); and Siamak et al., (2021), people with chronic ankle injuries tend to walk in an inverted position at the ankle. In fact, during the loading response phase, the foot should be balanced with eversion to relieve shock to the ankle so that there is less chance of the ankle being injured (Baker, 2006). Differences in stride can also be caused by the response of the hip joint to an injury to the ankle. The reaction shown is that the hip joint moves more in adduction, which means that movement in this joint causes the leg to move more dominantly when it approaches the medial side of the body (Liu et al., 2021). Ortega et al., (2021) found female runners had a longer time to peak eversion than male runners (36.92 ± 5.79% vs. 26.37 ± 5.12%, p <.01), which could be because females are more likely to have overuse running injuries. López Elvira et al., (2017) also found an increase in foot fall velocity when running with shoes, especially in girls, but not in gait, which may be due to changes in technique and/or shoe characteristics according to gender. Finally, the data showed a 1 cm forward displacement of the metatarsal flexion axis with shoes (p <.05 and high effect size), which suggests that shoe design should be more accurately adapted to the pediatric population. It is advised to balance the foot with eversion during the loading response phase to lessen ankle shock and make the ankle possible in order to minimize injury. Additionally, the shoe's design must be better tailored to the runner's foot's features.

According to the study's findings, participants with a history of ankle injuries ran slower than average compared to healthy individuals. It's likely that the sample in this study still has trauma and hasn't fully healed to be able to function at their best, even if they were indirectly hurt throughout the study. Gait needs to be corrected because it can lead to and potentially worsen injuries, particularly those to the ankle. Using Kinesio taping is a way to help the ankle joint maximize the eversion of the foot at the heel strike without limiting inversion at the end of the stepping phase (Hisham et al., 2017). However, this tool only functions as a supporting tool. Regular therapy and monitoring are still needed and balanced with weight training to rehabilitate injuries that have occurred to strengthen muscles and avoid repeated injuries.

Conclusions

This study's conclusion found that students with a history of ankle injury have less than optimal running speed when compared to normal people. The results of this study show that the resulting stance phase time of 0.345 ± 0.040 seconds produces a maximum running speed of 19.91 m/s. This can be concluded because of the difference and influence of the indicators of the results of motion analysis during running, and the main ones are the length of the step and the angle of knee flexion. The length of the step in normal people is categorized as good 1.51 meters, while in students with a history of an ankle injury, the average is 1.5075 meters. The angle of knee flexion in normal people is 90° while in students with a history of ankle injury, it is 181.05°. This study's shortcoming is that it just addresses the examination of running speed using a treadmill that maintains a set speed. In order to ascertain the difference in running speed between a treadmill and the outdoors in students with a history of ankle injuries, it is hoped that more study will be able to discuss the analysis of running speed in the outdoor field.

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Authors' and translators' details:

Fajar Awang Irawan	fajarawang@mail.unnes.ac.id	Author
Fadzilah Sukmawati	fadzilahsukma@students.unnes.ac.id	Author
Ulfatul Azizah Awaliyyah	ulfatulazizah@students.unnes.ac.id	Author
Dhias Fajar Widya Permana	dhiaspermana17@mail.unnes.ac.id	Author
Khoiril Anam	khoiril.ikor@mail.unnes.ac.id	Author
Sandhya Kresnajati	sandhyakresna@mail.unnes.ac.id	Translator
Panita Khampoosa	panita@g.swu.ac.id	Author
Sonthaya Sriramatr	sonthase@g.swi.ac.id	Author