

Kinematic Variations in Joint Angles between Grass Track and Treadmill Surfaces

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Abstract- Efficient long-distance running depends on well-coordinated joint movements, especially during the landing and take-off phases. This study aimed to compare the joint angles of the ankle, knee, hip, and shoulder during running on a grass track versus a treadmill. Ten male athletes (aged 19–25 years, height 170–183 cm, weight 58.6–68.9 kg) from Aligarh Muslim University participated. Each athlete ran 750 meters on both surfaces recorded by a high-speed camera (Canon Legria HF S10, 1/1200 shutter speed, 50 Hz). Joint angles were measured during the landing and take-off phases using Silicon Coach Pro software. paired t-test was used to identify significant differences between the two surfaces. Results showed significant differences in ankle and hip angles at take-off, and shoulder angles during both landing and take-off. However, knee and hip angles during landing did not differ significantly. These results suggest that running surface affects certain joint movements, especially at the shoulder and ankle. Understanding these differences can help coaches and athletes tailor training strategies to improve performance and reduce injury risk.

Index Terms- Long-distance running, Joint angles, Ankle kinematics, Knee movement, Hip joint, Shoulder movement

I. INTRODUCTION

Running is among the utmost well-liked forms of physical activity. Individuals run on various types of surfaces. Surfaces used for outdoor running encompass concrete and asphalt, synthetic rubber sports tracks, natural grass, and treadmills, which are frequently used in laboratories for training and investigations that require regulation of speed and incline. When running on various surfaces, runners adjust their leg motions and stiffness to maintain uniform impact forces. Researchers discovered that these kinematic adjustments are linked to neuromuscular changes during running on diverse surfaces. (Hong Y., et al., 2014).

The most of previous researches have been conducted biomechanical kinetic research on treadmill and over ground, however, there appears to be gaps in the literature, specially relating to compared on grass ground and treadmill running mechanics. Colin F., et al in 2018 have studied on Joint kinematics and ground reaction forces in overground versus treadmill graded running and they found Joint kinematics and ground reaction forces during level running were mostly alike in both overground and treadmill settings, indicating that there are slight variations in kinematics and ground reaction forces when comparing overground and treadmill graded running. Despite these differences, we are of the opinion that overground kinematics and ground reaction forces in graded running are adequately reproduced on a treadmill.

Therefore, The objective of the study was to examine the kinematic variations in joint angles of the ankle, knee, hip, and shoulder while running on both grass track and treadmill surfaces. The study investigated the variations in the kinematics of the hip, knee, and ankle joints during treadmill versus overground running. Nonetheless, it only analyzed the maximum and minimum angles throughout the complete gait cycle. as a result, Franz J., et al. in 2008 found that since most of these angles occurred during the swing phase, comparisons for the stance phase were not made. Similarly, Davis I., et al. in 2010 examined the movement of the lower limbs during treadmill and overground walking; their method utilized a trend symmetry design, which successfully detects similarities in kinematic patterns but fails to evaluate the differences in lower limb angles across the two environments.

Locomotion technique of human was studied on treadmill by many researchers in laboratory setup. The treadmill offers a setting where factors like speed and incline can be consistently controlled and reproduced (Blanch P., et al., 2001). Additionally, it enables the capture of a larger number of gait cycles, ensuring that kinematics of continuous movement are collected. Therefore, the treadmill may encourage a more consistent movement pattern compared to the brief, intermittent trials typical of over-ground assessments (Davis L., et al 2010). While this benefit is significant, it's essential to establish that treadmill use does

not change the mechanics of the movements being analyzed when compared to over-ground walking (Brand et al., 1984).

Bas Van Hooren et al in 2020 found in study that The spatiotemporal, kinematic, kinetic, muscle activity, and muscle-tendon metrics are mostly similar between running on a motorized treadmill and running overground. However, special attention should be paid to the kinematic variations in the sagittal plane at footstrike when applying treadmill running biomechanics to overground running. Treadmill measurements exhibited consistently lower values compared to both overground conditions for all sensor positions. Nonetheless, the two overground conditions demonstrated a strong agreement. (Fohrmann D.,et al 2022)

Grass surfaces have been shown to be similar to asphalt in terms of the elastic energy they return, which aids in vertical propulsion. The surface of the grass demands that the legs put in extra effort to maintain the same performance as when running on pavement, though it comes with less impact. This quality makes grass an excellent training surface for athletes aiming to enhance leg strength and turnover while minimizing the risk of injury. As long as the grass is well-maintained and the terrain is relatively flat, some adventurous runners opt to train barefoot, which provides additional benefits for foot and ankle strength. Nonetheless, runners who have weak ankles need to be careful when training on grass and should slowly incorporate it into their weekly running schedules. (Feehery et al.,1986).

II. METHODOLOGY

A total of ten male athletes from Aligarh Muslim University (A.M.U) took part in the study. Every selected player willingly agreed to be subjects for this study. None of the participants had any injuries to their lower limbs at the time the video was recorded. The ages of the participants ranged from 19 to 25 years.

In the examination of the film, particular video clips of the grass track and treadmill were selected. The heel contact point of the foot during running and the position of take-off were identified as the start and finish of the running sequence, respectively. The running motion is split into two stages: (a) Take-off phase (At the instant the foot departs from the ground, the center of gravity is located ahead of the toe of the foot that is taking off) and (b) Landing phase (When the runner makes contact with the surface, the toe of the leading foot is situated in front of the center of gravity).

The film was recorded in bright and clear weather at the athletic ground of the A.M.U, Aligarh, and adequate lighting was provided in the private separate hall in Aligarh for the video recording during the treadmill exercises. All the data was collected over two consecutive days.

The running motion of the subject on both a grass track and a treadmill was captured using a synchronized Canon Legria HF S10 video camera. The camera's shutter speed was adjusted to 1/1200, with a frame rate of 50 Hz. For the grass track recording, the camera was mounted on a stable tripod positioned 20 meters away from the first lane of the grass track at A.M.U, Aligarh, on the left side of the subject. The camera lens was positioned perpendicular to the sagittal plane and aligned with the medio-lateral axis to measure the following parameters: Ankle Angle(AA), Knee Angle(KA), Hip Angle (HA), and Shoulder Angle(SA) during both the landing and take-off phases. For the treadmill running, the camera was mounted on a stable tripod located 2m to the left side of the treadmill in the private separate hall in Aligarh. The camera lens was again oriented perpendicular to the sagittal plane and parallel to the medio-lateral axis for measuring the same parameters.

Following the video recording, the data was examined using Silicon Coach Pro8 software to assess the angles of the ankle, knee, hip, and shoulder. Microsoft Office Excel and SPSS version IBM 20 were utilized to compute the chosen parameters as well as perform statistical analysis including mean and standard deviation. A paired t-test, often referred to as a dependent t-test, was employed to compare the movement techniques on grass tracks and treadmills.

III. RESULT

Table-1: Comparison of joint angle between grass track and treadmill running at take-off phase and landing phases

Phase	Variable name	Surface	N	Mean	Std. Deviation	t- value
Take-off	AA	Grass Track	10	125.23	8.99	2.40*
		Treadmill	10	116.09	7.31	
	KA	Grass Track	10	158.99	5.01	4.32*
		Treadmill	10	160.58	5.11	
	HA	Grass Track	10	188.04	5.98	4.01*
		Treadmill	10	181.01	6.70	
SA	Grass Track	10	8.00	6.77	2.27*	
	Treadmill	10	4.99	5.97		
Landing	AA	Grass Track	10	114.03	10.01	1.51*
		Treadmill	10	110.20	8.11	
	KA	Grass Track	10	164.00	4.91	1.16
		Treadmill	10	162.89	5.01	
	HA	Grass Track	10	163.87	6.99	1.26
		Treadmill	10	166.01	6.02	
SA	Grass Track	10	38.76	6.13	3.29*	
	Treadmill	10	46.00	5.23		

significant at 5% level

t.05, 09 = 2.26 at 5% level of significant

Since $|t|_{cal}$ is greater than $|t|_{tab}$, therefore the means exist differ significantly at 5% level of significant.

Table-1 reveals that the comparison of means of AA,KA,HA and SA at Take-off phase and AA and SA at landing phase on grass track and treadmill running mechanics has shown $|t|_{cal}$

is greater than the $|t|$ value at 5% level of significant. This statistical finding exhibit that the AA,KA,HA and SA at take-off and AA and SA at landing phase on grass track and treadmill running mechanics at take-off phase differ and landing phase significantly and hence influences grass track and treadmill running mechanics. Conversely, the calculated $|t|$ value for Kee Angle and Hip Angle during the landing phase is lower than the tabulated $|t|$ value. As a result, this statistical outcome indicates that there is no significant difference in KA and HA between grass track and treadmill running mechanics at the landing phase, and therefore, these factors do not impact the running mechanics on either surface.

IV. DISCUSSION

The landing and take-off phases are critical in long-distance running, as they directly influence running efficiency and performance. The objective of this research was to examine the kinematic variations in the angles of the ankle, knee, hip, and shoulder joints while running on grass tracks compared to treadmill surfaces. This study compared running mechanics on grass and treadmill surfaces, focusing on kinematic differences, particularly at the shoulder, hip, knee, and ankle joints. The results revealed that shoulder angles during both landing and take-off, along with ankle angle at take-off, significantly impacted running performance. Efficient long-distance running is characterized by a smooth transfer of body weight, minimizing vertical displacement and reducing foot thrust (Derrick's T.R., et al., 2000). Shoulder motion, predominantly at the joint rather than the blades, stabilizes upper body movement (Williams et al., 1998). The study found no significant influence of knee and hip angles during landing. However, flexion-extension coordination at these joints compensates for hip movements, especially at heel-strike and toe-off (Gladys, 1970). Treadmill incline conditions altered joint behavior, increasing plantar-flexion at push-off and reducing dorsiflexion at footstrike compared to level running (Caldwell et al., 2000). While the knee maintained a relatively stable angle on inclines, level running saw greater flexion during impact and more flexion at toe-off. Forefoot landings allowed better ankle energy generation than heel strikes, crucial for propulsion in endurance running (Delp et al., 2010). Attermeyer in 1998 noted, variability in hip and knee accelerations distinguished runners' efficiency. These findings suggest that optimizing upper and lower limb coordination is key to enhancing long-distance running mechanics.

V. CONCLUSION

This study highlights significant kinematic differences between grass track and treadmill running, particularly at the shoulder and ankle joints during both landing and take-off phases. Notably, shoulder angles were significantly affected

on both surfaces, indicating the importance of upper body coordination in maintaining running efficiency. Ankle and hip angles at take-off also varied significantly, underscoring the role of lower limb mechanics in propulsion. However, knee and hip angles during landing remained consistent, suggesting compensatory joint coordination during this phase. These findings emphasize the need for surface-specific biomechanical assessments and training adaptations to enhance running performance and reduce injury risk in long-distance runners.

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