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SHORT COMMUNICATION

Comparison of Spatiotemporal Parameters between Athletes and Non-Athletes at Upslope Running

EXERCISE IS MEDICINE

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Key points

1. Athletes adapt better to running at level and upslope inclinations compared to non-athletes.
2. At higher inclination angles of 9%, athletes show a decreased angle of foot rotation compared to non-athletes, which represents a biomechanical advantage.

Introduction

Upslope locomotion is challenging in our day to day life for which neuromuscular system have to work extraordinarily [1]. Despite increasing popularity of trail running, trekking, hiking that include various slope inclination, the majority of running biomechanics studies have only considered level running [2]. To understand the control of human locomotion better, physiological and biomechanical variables related to incremental slopes running during the gait cycle is imperative. Several studies have examined upslope running but the results are inconclusive [2-6]. Running at higher upslope inclination showed higher step frequency [2] and reduced stride length [6]. Conversely some studies examining various parameters did not observe any difference between level and uphill running at constant speed [4,7]. Previous studies comparing spatiotemporal characteristics in varying level of trained runners [5,8-10] indicated longer flight time and better adaptation in elite runners compared to amateur runners with increased inclination [5]. Conversely, a study showed no difference in adaptation of spatiotemporal characteristics between amateur and highly trained athletes while running upslope at given speed [2]. This leaves questions whether non-athletes adapt to different slopes gradient in the same way as trained athletes. We aimed to determine the effect of different slope gradients on spatiotemporal gait parameters between athletes and non-athletes during running on an instrumented treadmill.

Materials and methods

We included 50 healthy participants (29 men and 21 women) aged 18-30 years. 25 of them were track and field athletes (age 24.6 ± 1.0 years; BMI 21.6 ± 2.2 kg/m2) and 25 were non-athletes (age 20 ± 1.6; BMI 24.9 ± 4.2). Athletes trained in running, muscle strengthening and balancing for at least one hour a day, 3 days a week for the past 3 months. Non-athlete participant did not engage in any daily physical training, but were not sedentary in the past 3 months. We excluded participants who had lower limb injuries in the past 3 months. The subjects were informed about the procedure and signed an informed consent. This study was approved by Institutional Ethical Committee of Guru Nanak Dev University, Amritsar (Numbered: 36/HG, Dated: 13/03/2020).The testing was done in our department biomechanics lab under standard testing procedure. The subjects were asked to run bare foot on instrumented treadmill system (Zebris FDM-T, hp-Cosmos, Finland) at constant treadmill belt velocity of 2.7 meter per seconds [11] for 1 minute (30 seconds for acclimatization and 30 seconds of recording) at three upslope inclinations: 0%, 5%, 9% [2]. At each stage of upslope running, cadence, spatial and temporal parameters were recorded using Zebris application software MR 3.8. Participants performed total 10 minutes of warm up including 5 minutes lower limb stretching and dynamic mobility exercises (including side bending, toe touches, sit-ups and jumping jacks for 12-15 repetitions) followed by walking on treadmill at a speed of 2 m/s for 5 minutes. After analyzing normality distribution of the data, using Shapiro-Wilk test (through IBM SPSS software version 21.0.), independent t-test was used to compare spatiotemporal parameter between athletic and

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non-athletic group. Repeated measure ANOVA test was used to analyze the influence of level of inclination within group. Statistical significance level was set at $p<0.05$.

Results

Athletes showed less right foot rotation at 9% of elevation as compared to non-athletes (table 1). Other variables such as left foot rotation, left and right step length, stride length, step width, left and right step time, stride time and cadence (not mentioned in the table) showed no difference between groups at any inclination levels. There was a significant difference in foot rotation and step width between the groups. Figure 1 shows an increase in right and left foot rotation angle with increase in slope elevation relative to level running in athletes.

	0%				**5%**				**9%**			
Varia-bles	Athlete (Mean ±SD)	Non Athlete (Mean ±SD)	t value	p value	Athlete (Mean ±SD)	Non Athlete (Mean ±SD)	t value	p value	Athlete (Mean ±SD)	Non Athlete (Mean ±SD)	t value	p value
Foot rotation (right) (deg)	9.1± 3.4	10.8± 3.5	-1.72	0.09	10.2± 3.3	11.8± 3.7	-1.54	0.13	10.8± 2.9	13.1± 3.9	-2.30	0.03

The table shows a significant difference ($p<0.05$) in right foot rotation at 9% elevation. Deg: degree.

Table 1: Comparison of spatiotemporal variable at 0%, 5% and 9% of elevation between athletes and non-athletes

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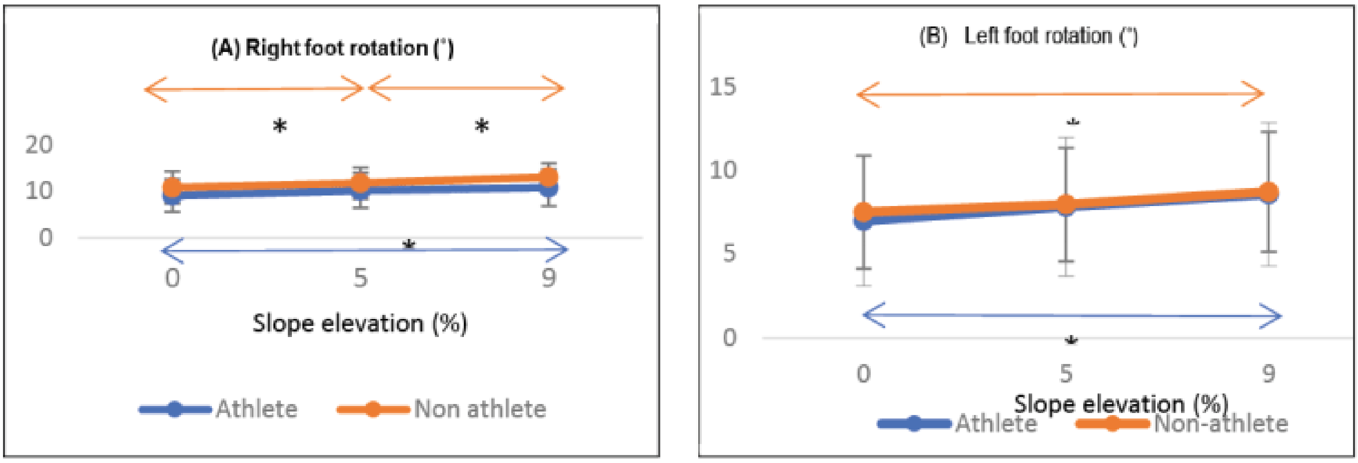

(A) significant increase in right foot rotation between all three elevations (0%,5%,9%) in non-athletes whereas athletes shows increase in right foot rotation between 0% and 9% of elevation. (B) significant increase in left foot rotation between 0% and 9% of elevation in both the groups. The figures show a significant difference in foot rotation (1A. Right foot rotation, 1B. Left foot rotation in degrees) within the group with increase in slope elevation. *significant difference ($p<0.05$) between elevation in both groups. Error bar = standard error. Arrows show multiple comparisons between the three degrees of inclination. Red arrows indicate difference in foot rotation in non-athletes, blue arrows indicate difference in foot rotation in athletes.

Figure 1: Foot rotation at various slopes

Discussion

We found a significant difference in the right foot rotation at 9% inclination between athletic and non-athletic participants. Athletic group demonstrated a decreased external foot rotation as compared to non-athletes during running at 9% of inclination. The normal foot rotation angle is 13° in adults [12]. While at 9% of upslope running non-athletes have shown mean foot rotation angle of 13.1°. Rutherford et al. reported that external foot rotation angle more than normal is associated with heightened quadriceps activity, which indicates higher metabolic cost and may decrease muscle endurance during walking [13]. We found no other differences in spatiotemporal adaptation between athletes and non-athletes. There is a lack of studies examining the influence of upslope running on angle of foot rotation. This was the first study to evaluate such comparisons. There is a significant increase in right and left foot rotation in athletes and left foot rotation in non-athletes at 9% of elevation compared to level running (0%). While,right foot rotation of non-athletes has showed significant increase at all level of running. This increase in external foot rotation may be an adaptation to reduce the medial tibio-femoral load by reducing knee adduction moment which may prevent injuries [14]. Another reason may be the lack of strength in the foot musculature in non-athletes, which forces the foot to land in a more external rotation with increasing slopes. Further studies can be done on the other variables of the gait as this study was limited only for spatiotemporal parameters of the gait.

In conclusion, our study suggests that athletes adapt better while running level and upslope than non-athletes. At 9% of elevation, there was decreased angle of foot rotation in athletes, which may represent a biomechanical advantage due to a more capable lower limb musculature and an adaptive mechanism to reduce injury risk. It may be used by coaches to improve running performance of novice athletes. Our study indicated that slope elevation influences the angle of foot rotation and step width when compared to

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level running.

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