GAIT PATHOMECHANICS AS DIFFERENTIATORS OF PERFORMANCE IN COLLEGIATE DISTANCE RUNNERS: A TEAM CASE ANALYSIS

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This study determined if gait pathomechanics could differentiate between top and bottom performing runners. Two top-performers and two bottom-performers from both men's and women's college cross-country teams underwent motion analysis while running on a treadmill in the pre-participation medical examination. Bottom-performing males had greater peak hip adduction, hip internal rotation, contralateral pelvis drop, rearfoot eversion, and initial impact (vGRF) during stance than top-performing males. Bottom-performing females had greater hip internal rotation and vGRF than top-performing females. Coaches may use these results to promote proper running mechanics, especially in younger runners to not only reduce injury risk but to improve performance.

KEY WORDS: Running biomechanics, high-performance, kinematics

INTRODUCTION: Faulty running biomechanics such as excessive hip adduction (HADD), hip internal rotation (HIR), contralateral pelvis drop (CPD), and rearfoot eversion (REV) have been associated with running-related injuries such as patellofemoral pain (Noehren, Hamill, & Davis, 2013; Souza & Powers, 2009; Wilson & Davis, 2008) and iliotibial band syndrome (Ferber, Noehren, Hamill, & Davis, 2010; Noehren, Schmitz, Hempel, Westlake, & Black, 2014) in runners. Stress fractures have been associated with high loading rates and initial impact ground reaction forces (vGRF) (Milner, Ferber, Pollard, Hamill & Davis, 2006; Zadpoor & Nikooyan, 2011). These studies indicate that abnormal hip, pelvis, and rearfoot motion, and impact vGRF have long been associated with running-related injury. The connection between these factors and running performance, though, is less clear. It may be inferred that runners with higher performance capabilities would exhibit less pathomechanics, however, this has not yet been investigated. Further, most of the research done with respect to gait pathomechanics has involved recreational runners who when studied as a group may be more variable in terms of age, general health status, motivation, miles per week, and training. Collegiate runners when studied as a group are considerably less variable as they are in training for a similar event under a single coach, with the aim to be at their highest level of performance at approximately the same time, adding a consistency that probably was not as existent in groups of recreationally running subjects. Collegiate distance runners are likely to train more, which could possibly lead to exacerbated effects from faulty biomechanics. Also, since many of the athletes are focused on their sport and may even have scholarship money riding on their performances, one would expect to get true indicators of current running capabilities when examining race performances over the course of the season. A better understanding of this relationship, specific to competitive runners, would aid coaches and athletes to have a better grasp of the factors that go into running performance, which could then lead to methods that increase the capabilities of competitive runners. Therefore, this study was designed to explore the relationship between these previously highlighted biomechanical markers and race performance in National Collegiate Association (NCAA) Division II cross-country runners. We hypothesized that runners with the least excessive values of HADD, HIR, CPD, and REV would have lower race times over the course of the season.

METHODS: Eight runners, two top-performers (TP) and two bottom-performers (BP) from both men's and women's university cross-country teams were studied [males (TP; 20.5 ± 0.7 yrs, 64.6 ± 3.5 kg, 1.77 ± 0.1 m) (BP; 18.5 ± 0.7 yrs, 57.5 ± 0.6 kg, 1.82 ± 0.0 m)], [females (TP; 18.0 ± 0.0 yrs, 59.45 ± 4.6 kg, 1.67 ± 0.0 m) (BP; 18.0 ± 0.0 yrs, 57.8 ± 4.1 kg, 1.68 ± 0.1 m)]. They were selected from a men's team of 8 and women's team of 11 athletes. Athletes were categorized based on consistent race performance during five NCAA races (5-10 k) in the fall 2017 season. All were rearfoot strikers, as was determined by visual analysis of running video. Average race times for their championships were as follows: Males: TP = 27.43 ± 1.1 min; BP: 31.35 ± 1.4 min (8k); Females: TP = 25.67 ± 1.9 min; BP: 28.58 ± 1.3 min (6k). The University's Institutional Review Board approved this study, and written consent was obtained from the participants.

Running kinematics and kinetics: Running mechanics were captured using a 10 infrared camera (120 Hz) Vicon motion analysis system (Vicon Peak, Lake Forest, CA, USA) with Vicon Nexus software (version 2.6). Anthropometrics were measured and 16 retroreflective markers were placed bilaterally on the subject according the specifications of Vicon's Plug-in Gait model. The runners began both testing sessions with a warm-up consisting of general dynamic stretching and a 7 min run on an instrumented treadmill (Bertec, Columbus, OH, USA) at a self-selected pace that ranged from 2.4-4.0 m/s during their pre-participation medical examination. Data were captured at 1000 Hz at minute 8 for a total of 10 sec, processed with a low-pass Butterworth filter with a cut-off frequency of 50 Hz, and were averaged over two successive steps for the right leg. Specific variables of interest were peak excursion values of hip adduction (HADD), hip internal rotation (HIR), contralateral pelvis drop (CPD) and rearfoot eversion (REV) in degrees during stance; and peak initial impact force (vGRF) in body weights (BW).

Data analysis: This case control study was evaluated by qualitatively comparing the peak excursion values of the variables of interest between two TP and two BP for each of the teams.

RESULTS: Table 1 presents the gait mechanics variables and running speed for each runner. BP males had greater peak HIR, and REV than TP. BP females had greater hip internal rotation than TP. All BP runners had higher initial impact vGRFs.

Table 1. Gait Mechanics for Top and Bottom Performing Runners

Runner	HADD (deg)	HIR (deg)	CPD (deg)	REV (deg)	Speed (m/s)	vGRF (BW)
TP Male 1	2.6	2.9	5.3	*	4.00	1.74
TP Male 2	9.9	18.4	4.2	7.9	3.45	1.47
BP Male1	9.1	*	4.7	13.7	2.75	*
BP Male 2	12.7	24.8	6.6	*	3.40	2.03
TP Female 1	10.8	14.3	11.3	6.4	3.30	1.47
TP Female 2	3.4	12.7	4.2	8.9	3.06	1.60
BP Female 1	9.4	25.5	6.2	*	3.84	1.74
BP Female 2	5.5	18.6	1.8	6.1	2.42	1.57

Note: * denotes data not available.

Figures 1 and 2 provide visual illustration of the differences between a TP and BP male subject.

Figure 2. Visual comparison of TP and BP male runners.

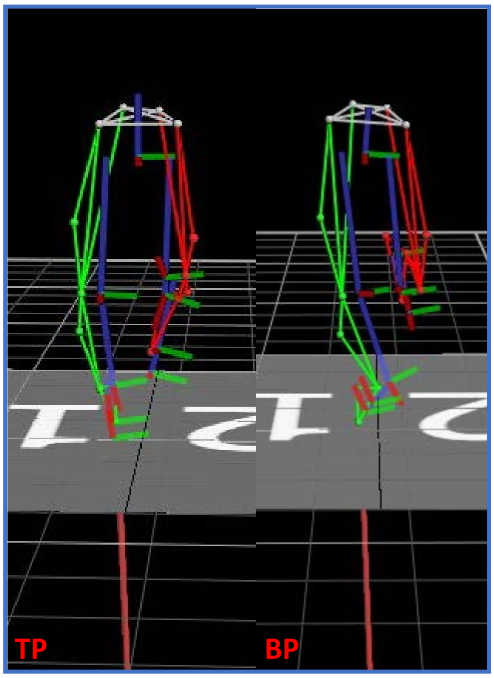

Figure 3. 3D visual comparison of TP and BP male runners.

DISCUSSION: The purpose of this study was to determine if selected running biomechanics could differentiate between high and low performance in collegiate cross-country runners. The running biomechanics were chosen in this exploratory study of two collegiate teams because of their association with running related injury. As was hypothesized, the male TP group had less excessive faulty biomechanical values, across all four measures, when compared to that of the BP group. The TP females, on the other hand, had much less excessive HIR, than the BP group, with all other values being either very close or more excessive. HIR variability may have been affected by the marker placement protocol used in this study. A probable factor overall to explain the presence of consistent differences between the TP and BP males and the lack of such consistency between the TP and BP females could be the age difference between groups; the TP males were older than the BP males (20.5 ± 0.7 yrs versus 18.5 ± 0.7 yrs), while the TP and BP females were all the same age (18.0 yrs). Age or more specifically, college running experience may have affected the results with younger runners exhibiting a greater number of pathomechanics. It is unknown whether mechanics would improve from one season to the next. Another possible factor is the speed at which the athletes ran during the test; looking at the mean values, there is a sizeable difference between the self-selected speeds of the TP and BP male groups. Finally, because this is a case analysis of two cross country teams, generalization of results is limited, and further study is warranted to determine the value of pathomechanics as differentiators of performance in runners.

CONCLUSION: Despite this study's limitations, we conclude that the approach for examining faulty running mechanics, specifically excessive HADD, HIR, CPD, REV, and impact vGRF and its association with running performance in collegiate cross-country runners has merit. Further research warrants examining the relationship between faulty biomechanics and performance, with a larger sample size. It also may be of interest to conduct longitudinal gait analyses of collegiate athletes to determine if biomechanics change over time. Examining gait biomechanics during the pre-participation examination appears warranted for coaches to identify modifiable aspects of technique to not only reduce the risk of injury but possibly to improve performance.

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