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Faulty Hip and Pelvis Biomechanics Do Not Differentiate Between 5k Performance in NCAA Division II Cross-Country Runners

Original Research

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Abstract

Introduction: Excessive hip adduction (HADD) and contralateral pelvis drop (CPD) angles during running are associated with running-related injuries. Their influence on performance is less known. Therefore, we aimed to determine if HADD and CPD could differentiate between high and low race performers, and if there were relationships between CPD, HADD and race performance.

Methods: Twenty-six healthy male and female NCAA Division II cross-country runners participated in this prospective study. They underwent 3D motion analysis of their HADD and CPD during pre-participation physical examinations. Times from the first race of the season were converted to International Association of Athletics Federation (IAAF) points and high and low performance groups were created. Pearson correlation coefficients were used to examine the associations between HADD, CPD and IAAF points, and Independent Samples T-tests were used to determine differences in HADD and CPD between high and low performance groups.

Results: There were no significant relationships between IAAF points and left HADD (r=0.11, p=0.59), right HADD (r=0.19, p=0.35), left CPD (r=-0.06, p=0.79), or right CPD (r=-0.06, p=0.76). There were no significant differences between high and low performance groups in left HADD ($t(24)$=0.48, p=0.64), right HADD ($t(24)$=0.45, p=0.33), left CPD ($t(24)$=0.62, p=0.27), or right CPD ($t(24)$=0.53, p=0.30).

Conclusions: The RRI biomechanics of excessive CPD and HADD do not influence 5k race performance in collegiate distance runners.

Key Words: distance runners, mechanics, 5k race

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Introduction

Race performance in distance runners is influenced by several variables.[1-3], with injury being a significant one.[4-6] Training availability has been shown to directly relate to success, meaning runners not available to train due to injuries have significantly decreased performance.[4-6] In a group of elite Australian track and field athletes, the likelihood of achieving a performance goal increased seven-fold in those who completed over 80 percent of the planned training weeks over a five-year period.[6] In a systematic review, Drew and colleagues[4] reported that there is strong evidence that injuries have a detrimental impact on team and individual athlete success. Specifically, increased athlete availability reduces the risk of failure and pre-competition, and

in-competition injuries were associated with an increased risk of failure. The researchers suggested that injury prevention should be a priority for maximizing performance.

A running gait biomechanical analysis is beginning to be a fundamental component of a university distance runner's pre-participation physical examination[7,8] so that injury prevention programs can be instituted to modify any faulty mechanics that are identified. Mechanics such as increased hip adduction (HADD) and contralateral pelvis drop (CPD) during the stance phase have been moderate to strongly associated with running-related injuries (RRI).[9-12] See figure 1 for sample runners with and without excessive HADD and CPD. University competitive runners with excessive HADD (cut-point of peak HADD maximized at 9°) have been reported to be more likely to sustain RRI.[7] Further, Mokha and colleagues[13] reported mean values of 10.5-11.2° and 6.0-7.2° for left and right limb HADD and CPD, respectively in a similar cohort of runners. The authors recommended team-based corrective exercises to reduce RRI risk associated with excessive values. Bramah et al.[9] studied the differences in the kinematics of injured runners versus injury-free controls and found that for every 1° of CPD there was an 80% increase in the odds of being classified as an injured runner. Further, these mechanics are modifiable[14-16] giving them a possible relevance with performance in distance runners. Therefore, this study aimed to determine if HADD and CPD could differentiate race performance success in National Collegiate Association (NCAA) Division II cross-country runners. Specifically, we examined the association between 5k race performance and HADD and CPD, and the difference in HADD and CPD between high and low 5k performers.

Figure 1. Sample Runners without (A) and with (B) Excessive Right HADD and Left CPD.

Scientific Methods

Participants

Thirty-one participants from the same National Collegiate Athletic Association Division II cross-country team were recruited for this study. All underwent the running mechanics evaluation, but five were removed from the study because they did not compete in the first Fall season race for unknown reasons. Thus, eight male and 18 female (height, 1.70±0.09m; mass, 58.98±8.57kg) healthy runners participated in this prospective cohort study. Participants were cleared by the sports medicine staff for participation, provided written informed consent, and the study was approved by the university's Institutional Review Board.

Protocol

Running mechanics were captured in a laboratory using a 10 infrared camera (120 Hz) Vicon motion analysis system (Vicon Peak, Lake Forest, CA, USA) with Vicon Nexus software (version 2.4) during the pre-season preparticipation physical examination. Anthropometric measures were measured (i.e. height, weight, pelvis breadth, leg length) and 16 ½" retroreflective markers were placed bilaterally on the subject's pelvis, thighs, knees, lower legs, ankles, and feet according to the specifications of Vicon's Plug-in Gait model. The runners wore sports bra (women), spandex shorts, and their own running shoes. Runners began the testing session with a warm-up consisting of general dynamic stretching and a 6 min run on a treadmill at a self-selected pace, with an average of 3.4±0.4 m/s. Data were captured

for 10 sec beginning at minute 7 on the treadmill and five consecutive steps were evaluated. Specific kinematic variables of interest were peak values of right and left hip adduction (HADD) and contralateral pelvis drop (CPD) during the stance phase. Values for these variables were calculated using Vicon Nexus software, identified in Vicon Polygon (ver. 4.4), and then averaged per participant.

Performance from the first race of the season was evaluated. This was chosen for two reasons: (1) the distance for both men and women was identical at 5k, and (2) most new injuries are known to occur within the first month of the preparation season.[6] Times were converted to International Association of Athletics Federations (IAAF) points scores (0-1400)[17] to facilitate statistical analysis.

Statistical Analysis

Statistical analyses of data were performed using Statistics Package for Social Sciences (ver. 28; IBM Corporation, New York, NY, USA). Data were screened for normality of distribution and homogeneity of variance using a Shapiro-Wilk normality test and a Levene test, respectively. Pearson's correlations were calculated between running performance (IAAF points) and peak HADD and CPD (degrees). Correlation effects were interpreted as small (r value of 0.10–0.29), moderate (0.30–0.49), large (0.50–0.69), or very large (≥0.70).[18] Participants were divided into high and low performance based on the median IAAF scores for the male and female participants which were 453.0 and 464.5, respectively. This yielded two groups, high and low performance. An Independent Samples T-test was used to determine significant differences in HADD and CPD between the high and low performance groups. Statistical significance for both tests was determined a priori, $p \leq 0.05$.

Results

Table 1 represents overall and performance group descriptive statistics for right and left HADD and CPD, and IAAF 5k points. There were no significant differences between high and low performance groups in left HADD ($t(24)=0.48$, $p=0.64$), right HADD ($t(24)=0.45$, $p=.33$), left CPD ($t(24)=0.62$, $p=0.27$), or right CPD ($t(24)=0.53$, $p=0.30$). IAAF 5k points were significantly different ($t(17.8)=6.35$, $p<.001$) between performance groups, which was expected. Note the adjusted degrees of freedom were used for this comparison since the variance of IAAF 5k points was not equal between groups. Pairwise correlations between HADD, CPD and performance (IAAF 5k points) are shown in Table 2. There were no significant relationships between HADD and performance and CPD and performance, $p>0.05$. Figures 2 and 3 display the correlations between the variables.

Table 1. Means and Standard Deviations for HADD, CPD and performance for All Participants and by Performance Group (High, Low).

	All Runners (N = 26)	**High Performing (n = 13)**	**Low Performing (n =13)**
Left HADD (deg)	8.4 ± 3.5	8.7 ± 3.8	8.0 ± 3.3
Right HADD (deg)	10.4 ± 3.7	10.8 ± 3.8	10.1 ± 3.8
Left CPD (deg)	4.5 ± 2.9	4.9 ± 2.8	4.1 ± 3.0
Right CPD (deg)	4.1 ± 2.9	4.4 ± 3.1	3.8 ± 2.8
IAAF 5k Points (0-1400)	449.9 ± 197.3	603.1 ± 78.4*	296.7 ± 155.3*

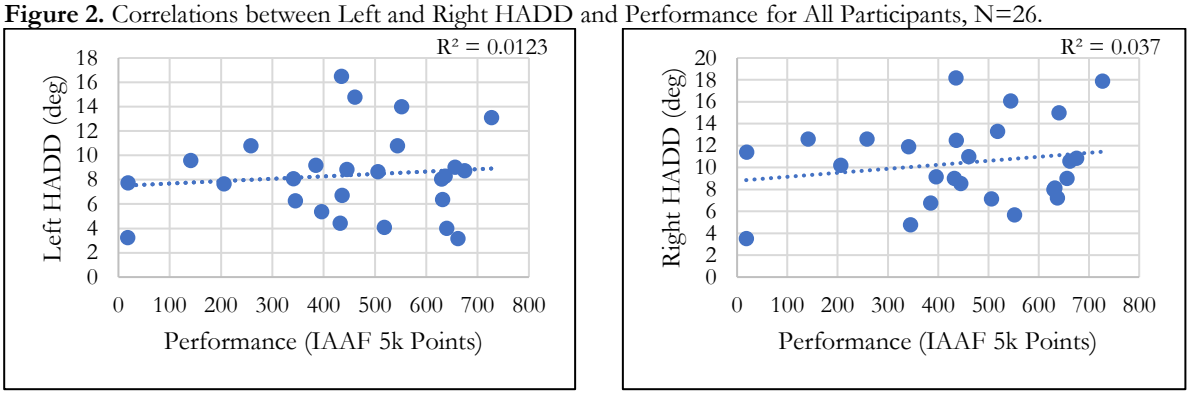
*Significantly higher IAAF 5k points for High Performing group, $p < 0.001$.

Table 2. Pairwise Correlations between HADD, CPD and Performance for All Participants, N=26.

Variable	**Left HADD**	**Right HADD**	**Left CPD**	**Right CPD**	**IAAF 5k Points**
Left HADD	1.00				
Right HADD	0.36	1.00			
Left CPD	-0.18	-0.24	1.00		
Right CPD	0.08	-0.41*	0.63**	1.00	
IAAF 5k Points	0.11	0.19	-0.06	-0.06	1.00

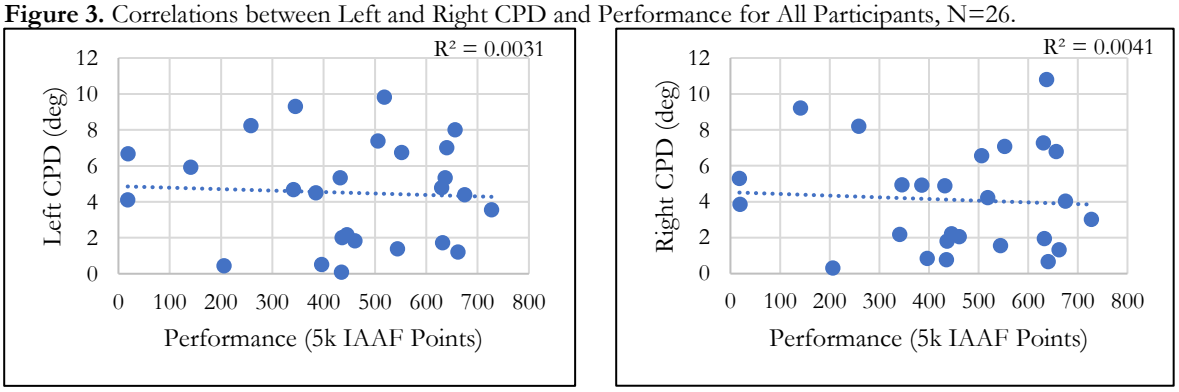
*Significant correlation, $p<0.05$; **Significant correlation, $p<0.001$.

Figure 2. Correlations between Left and Right HADD and Performance for All Participants, N=26.



Note there were no significant correlations, p >.05.

Figure 3. Correlations between Left and Right CPD and Performance for All Participants, N=26.



Note there were no significant correlations, p >.05.

Discussion

This study sought to determine if race performance in collegiate cross-country runners was influenced by hip and pelvis running mechanics known to be moderate to strongly associated with RRI.[12] Two key findings were that (a) HADD and CPD were not significantly associated with 5k race performance, and (b) HADD and CPD were not significantly different between high and low race performers. We expected slower runners to exhibit greater HADD and CPD. The overall and group averages for right HADD are in excessive of the cut-point of 9° found to predict RRI[7] and may warrant intervention since injury prevention has been cited as key for keeping runners available for training.[4] Right and left CPD of 4.5° and 4.1°, respectively, are within normal limits of other reports of 3.7-7.0°.[7,9,13] Researchers have long suggested that biomechanical factors likely contribute to running performance.[19,20] Cavanagh et al.[21] first compared the biomechanics of elite and good distance runners in 1977 reporting "minor differences" in stride length between runners. Results of a seminal study investigating the relationship between distance running mechanics, running economy ($VO_{2submax}$, VO_{2max}), and 10k performance showed that runners with lower economy had different biomechanics (e.g., greater shank angle at initial contact, greater trunk lean) but that no single variable or small subset of variables could statistically explain differences in running economy.[22] In a more recent study, Folland et al.[20] reported that pelvis vertical oscillation during ground contact, minimum knee joint angle during ground contact, and minimum horizontal pelvis velocity explained 39% of running economy while minimum horizontal pelvis velocity, shank touchdown angle, ground contact % time, and trunk forward lean combined to explain 31% of the season's best performances (reported using IAAF points) for 97 endurance runners. These studies focused on a broad range of biomechanical variables, but none included frontal plane pelvis or hip measures such as HADD or CPD, nor were their hypothesis injury driven. To the authors' knowledge, the only other investigated that has focused on running injury related biomechanics and performance is a pilot study of two bottom performers and two top performers from both men's and women's university cross-country teams.[23] Race performances were tracked over a complete season, and results of their laboratory-based gait evaluation were used. Researchers reported that the male bottom performers had excessive HADD, CPD, hip internal rotation, rearfoot eversion and higher impact forces than top performers. Female bottom performers had excessive hip internal rotation and higher impact forces but similar HADD, CPD and

rearfoot eversion when compared to top performers. Race performances of the runners in the current study were sampled from the first race of the season which was a 5k distance and 10-14 days from their laboratory running evaluation. While this assisted in ensuring the running technique captured was close in time to performance, there may not have been enough tissue loading (training runs) for performance to be affected in those with aberrant HADD and CPD. Races of longer distances such as 10k or 15k may be more negatively affected by faulty biomechanics than shorter distances. Future studies may investigate performance and injury development over multiple races, race distances and track runners who do not compete. There were five runners who did not compete in the race. Their HADD was 9.4±5.4° and 9.7±3.0° for the right and left, respectively. These values put them at risk for RRI,[7] but are not larger than those reported in Table 1 of the current study. CPD was 7.0±2.5° and 6.4±2.0° for the right and left, respectively. CPD is greater in these five runners than those reported in Table 1 suggesting they may have not competed due to injury since for every 1° of CPD, there is 80% odds of being classified as injured.[9] However, this is speculation. In summary, while there seems to be an intuitive negative relationship between running performance and biomechanics related to RRI, HADD and CPD were not shown to influence 5k performance in this cohort.

Conclusions

While having moderate to strong associations with running-related injuries, hip adduction and contralateral pelvis drop angles during stance do not significantly influence 5k performance in NCAA Division II collegiate cross-country runners.

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