COP MEASURES OF POSTURAL SWAY DURING TANDEM STANCE UNDER EYES OPEN- AND CLOSED-CONDITIONS: A PILOT STUDY COMPARING NON-CONTACT SPORT ATHLETES AND FOOTBALL PLAYERS

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INTRODUCTION

The prevalence of sports-related concussions ranges from 1.6-3.8 million per year, with 50-80% unreported incidences [1]. Sports-related concussions result in subacute/chronic deficits and functional limitations, including the control of balance, with increased risk for subsequent musculoskeletal injuries [1]. Research purports that many athletes return to play (RTP) prior to the resolution of full central nervous system (CNS) recovery, suggesting that current RTP protocols are insufficient [1]. The inverted pendulum model has been used to describe the control of the center of mass during bipedal stance [2]. The medio-lateral (M/L) and antero-posterior (A/P) excursions and velocities of the center of pressure (COP) are commonly used to quantify postural control in non-contact (NC) and contact sport (CON) athletes [3]. However, there is limited information on these COP metrics for tandem stance postural control in healthy and concussed athletes [4]. Also, there is limited information regarding the effect of leg dominance [5], and eyes-open (EO) and eyes-closed (EC) testing conditions [6]. Thus, the purpose of this study was to measure COP range and mean velocity in the M/L and A/P directions in collegiate NC sport and football athletes in tandem stance postures, under EO and EC conditions.

CLINICAL SIGNIFICANCE

Our findings are consistent with previous studies that have shown the importance of the visual system in postural control. Moreover, our results suggest that potential differences in COP metrics between types of athletes should be considered when creating control data sets to be used when testing concussed athletes. Within the limits of our project, we conclude that there appears to be a need to include COP metrics as part of RTP decisions for concussed athletes.

METHOD

Ethics approval was obtained from the Grand Valley State University Human Research Review Committee (IRB# 17-102-H). CON sport athletes including 19 Division II football players (18.5$\pm$0.5 yrs.; height 186.0$\pm$6.0 cm; mass 110.9$\pm$22.4 kg; BMI 31.8+5.9 kg/m^2) and 17 NC sport athletes (19.4$\pm$0.5 yrs.; height 192.4$\pm$6.2 cm; mass 76.3$\pm$9.5; BMI 22.9$\pm$2.0) participated. Ground reaction force data were collected (200 Hz) using AMTI NetForce software (Advanced Mechanical Technology, Inc., Watertown, MA), as participants stood with one foot in front of the other, with the back foot on the force plate, and the heel of the front foot placed on a mark approximately 1 cm in front of the force plate. Athletes were instructed to stand with equal weight on each limb, hips, and knees extended, with arms crossed in front of the chest, and to look straight ahead. Participants stood on the force plate with the foot aligned along the plate's x-axis, thus COP movement along the x-axis represented the A/P COP excursion. Five good trials (no significant loss of balance or opening of eyes) were collected for 10 seconds for each foot on the force plate under two conditions (EO and EC), for a total of 20 trials. A custom MATLAB program was used to extract raw GRF data (filtered with a 2nd-order lowpass Butterworth filter cutoff at 5 Hz) and determine the dependent variables: maximum M/L and A/P

COP range and M/L and A/P COP mean velocity. SAS JMP (SAS, Cary, NC) was used to determine descriptive measures of participant demographics and COP variables. A mixed-model ANOVA was used to analyze data with $p < 0.05$ to determine significance, with Bonferroni corrections. Primary response variables were analyzed with a three-factor design ANOVA with factors of sport, eye condition, and limb. Random factors of participant within sport and leg within-participant were included. Main effects and the two-way interaction between sport and eye conditions were also analyzed. A Tukey's post hoc HSD analysis was used as needed. The effect size was defined as the difference between the means of the two groups defined by the factor levels after correcting for the other factors in the model. Effect sizes for the COP range were reported using the units of the dependent variables, and defined as large (≥30 mm), medium (11-20 mm), and small (≤10 mm), based on the clinical judgment of the researchers.

RESULTS & DISCUSSION

Variation in dependent variables between trials was not significant and there was no difference in COP range and mean COP velocity between limbs. Likewise, there was no significant interaction between type of sport and eye condition. However, within groups, there was a greater mean COP range and velocity in both M/L and A/P directions in the EC condition ($p<0.0001$) (Table 1). Between groups, a significant interaction between type of sport and eye condition was found in the mean COP velocity M/L direction ($p=0.058$).

Table 1. COP Range in Anterior/Posterior and Medial/ Lateral Directions with Varying Conditions (Sport Type, Limb Position, and Eyes Open or Closed).

			Mean (±SD)	Median	CV (%)	Range (Min-Max)	P-Value	Effect Size
COP A/P Range	Sport	Football Athletes	42.94 (26.98)	34.56	62.82	174.49 (0.14-174.63)	0.2117	
		Non-Contact Athletes	50.36 (30.40)	42.11	60.37	152.65 (0.80-153.50)		
	Eyes	Eyes Closed	59.28 (32.83)	50.71	55.38	174.49 (0.14-174.63)	<0.0001*	25.36
		Eyes Open	33.87 (16.57)	31.33	48.92	125.46 (0.80-126.27)		
COP M/L Range	Sport	Football Athletes	32.04 (14.96)	31.35	46.70	75.68 (0.04-75.72)	0.1707	
		Non-Contact Athletes	36.31(15.05)	35.04	41.45	101.60 (0.55-102.23)		
	Eyes	Eyes Closed	42.65 (14.97)	42.29	35.10	102.19 (0.04-102.23)	<0.0001*	17.06
		Eyes Open	25.62 (9.51)	24.73	37.11	70.45 (0.55-71.00)		

* Indicates significant difference with p<0.05 with Bonferroni correction of 0.0125
Data displayed in Millimeters
Coefficient of Variation = CV (%)

Although there are discrepant findings in the literature, our finding of the effects of EC conditions on postural sway was consistent with previous reports [6,7], suggesting the importance of the visual system in postural control. As reported by others, limb dominance does not appear to be a factor in postural control [5].

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DISCLOSURE STATEMENT. There are no conflicts of interest to disclose.