COMPARING POSTURAL CONTROL IN ADOLESCENTS (10-14 YEARS) INVOLVED/NOT INVOLVED IN AFTER-SCHOOL SPORT ACTIVITIES: A PILOT STUDY

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This study characterized postural control (PC) of adolescents who were involved (A=athletes) or not involved (NA=non-athletes) in after-school sport activities. PC was determined by the median velocity (MVelocity, mm/sec) of the center-of-pressure (COP) on a force plate when removing vision (eyes closed) and manipulating somatosensation (standing on firm or foam surface) while in two-foot, tandem, and one-foot stances (12 stances). Fifty-one youth, 22 A (age 12.1±0.9 yrs, 10 females) and 29 NA (age 12.3±0.7 yrs, 10 females) performed two, 30-sec trials in all 12 stances, with the best trial used for data analysis. The Mann-Whitney test revealed lower MVelocity (i.e., less sway) in the COP in all 12 stances for the A group: however, significant differences were seen in only two stances: Tandem eyes open on firm and foam.

KEYWORDS: athletes, youth, center-of-pressure, balance, vision, somatosensation

INTRODUCTION: Postural control (PC) is the ability of the body to respond to sensory input (somatosensory, visual and vestibular systems) with muscular output to maintain an upright position during standing (Cuisinier et al., 2011). Postural control is necessary to achieve, maintain and restore one's center of pressure (CoP) within their base of support (BoS) (Winters & Stark, 1985). Postural control is not only important during quiet standing but provides the starting point for the successful and safe execution of activities of daily living (Woollacott & Shumway-Cook, 2002). For example, a good PC is essential for a stable gait (Ganz et al., 2007). In addition to the necessity of PC for purposeful movement, it is also associated with overall musculoskeletal and neurological health (Riley, & Turvey, 2002). Studies that have considered whether adolescents involved in athletic activities or participated in a training regimen demonstrate better PC than controls reported mixed outcomes (Andreeva et al., 2020). In these studies, stability of PC is usually based on the velocity of COP (VCOP, mm/sec; the lower the VCOP and more stable the PC) or COP path length (mm; length of trajectory of COP sway) while standing on a pressure platform during 10 to 90 sec trials. However, in studies investigating the effect of athletic activities/exercise regimen on PC in adolescents, only two stances (two-feet [2F] and one-foot [1F]) and one visual (eyes open [EO] vs eyes closed [EC]) challenges have been used (Andreeva et al., 2020). When considering the relationship between sport participation and postural skills, research has shown that scores of postural performances in athletes are related to the sport practiced (Paillard, 2019). Given that athletic activities develop specialized motor patterns that generate sport specific movements, improvements of PC may not have been identified in the studies limited to two stances (2FT and 1FT) and one sensory (vision) challenge (Andreeva et al., 2020). Therefore, the hypothesis of this study was that PC of adolescent athlete's (A) would be significantly ($p<0.05$) better (i.e., lower VCOP) than adolescent nonathlete's (NA) when either BoS (2F, tandem [TD], 1F), vision (EO, EC) and somatosensory (firm vs foam surface) are) separately or in combination.

METHODS: Fifty-one youth, 22 athletes (A) (age 12.1±0.9 years, 10 females) and 29 nonathletes (NA) (age 12.3±0.7 years, 10 females) were chosen as a sample of convenience from a Midwestern metropolitan area (population ~ 350,000) in the United States. Tests were performed during students' regular physical education (PE) class in a classroom separate from the gymnasium. Eligible participants had no comorbidities that would hinder their ability to perform evaluation maneuvers. Participant parents/guardians gave their written consent and participants their written assent prior to data collection. The Institutional Review Board IRB) of the university had approved the study. Inclusion criteria for athletes (A) were as follows: engaged at least 8 hours of sports (American football, cross country, volleyball, basketball, wrestling, gymnastics) activity (including practice, game, conditioning program) per week for at least 6 weeks prior to testing. The nonathlete (NA) were students from the same PE classes but were not participating in any organized sport activities after school. On the day of testing, standing height (in centimeters) and mass (in kilograms) were obtained with participants not wearing shoes by using a portable stadiometer and portable electronic scale, respectively. Body mass index (BMI: using mass in kilograms/height in meters squared) was calculated from measured data.

Postural control was assessed using a portable force platform (AccuSway, Advanced Mechanical Technology Inc. [AMIT], Watertown, MA, USA). Postural data were acquired and recorded using Balance Clinic software version 2.03.00)(AMTI) loaded on a Dell laptop. Total mean velocity was calculated by determining the path length (mm) divided by the time in stance. The acquisition sampling frequency was set at 100 Hz and was filtered using a fourth-order zero phase Butterworth low-pass filter with a cut-off frequency of 10 Hz (Ruhe et al., 2010). Twelve (12) experimental conditions, with two visions (EO v EC) by three stances (2F, TD, 1F) by two surface conditions (Firm v Foam) were included. Participants either stood directly on the force platform (solid surface) or on a 30 x 41 x 6 cm foam (Airex® Balance Pad, Airex AG, Sins, Switzerland) placed on top of the force platform (complaint surface) (See Figures 1-3). Prior to testing, participants performed a practice session either on the day of testing or the day before testing. Participants were tested in a single session, which lasted approximately 60 minutes.

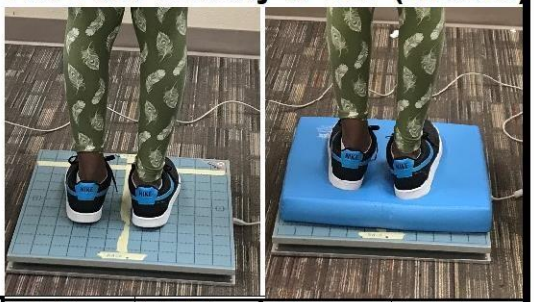
Force plate data was collected from two blocks of testing that were repeated twice. Each block consisted of 12 consecutive 30-s trials in each stance, yielding 24 trials. In the first block, the sequence of trials was as follows: TD EO, 1F EC, 2F EO, TD EC, 1FEC, 2FEC all on solid surface and repeated in the same sequence on foam. This sequence was reversed in the second testing block. Participants sat for 60-90 s to rest between trials. During testing, participants stood in their normal footwear and were encouraged to stand as still as possible throughout the 30-sec trial. When vision was allowed, participants were instructed to look straight ahead at an X marked in tape at approximately eye level on a wall 1.5 m away. Participants were allowed to sway from the ankle or hip ('ankle strategy' or 'hip strategy'), which is commonly described as fix-support strategies (Horak & Nashner, 1986). Arm movement was also allowed. The same investigator supervised foot placement and stance position and gave the instructions for all participants.

A two-sample t-test was used to determine if differences existed between ages and body mass index (BMI; kg/m^2) for the two activity groups. An Anderson-Darling test for normality was performed on the mean velocity data for each of the 12 stances *a priori* and rejected normality in all stances and therefore median velocity (mm/sec) rather than mean velocity was used for data analysis. Median velocity was calculated using the equations provided by Prieto (Prieto et al, 1996). Median velocity (M/Velocity)has been identified as one of the most reliable parameters when determining PC ability (Palmieri et al, 2002). The literature states that smaller values of M/Velocity imply better ability to control posture. A Mann-Whitney U test was performed to determine if differences existed between the means of MVelocity (mm/sec) for each of the 12 stances between A vs NA. Statistical significance was set a $p < 0.05$). All data was reported as mean ± standard deviation.

RESULTS: No significant differences were seen between the two groups for age (A = 12.1±.94 yrs; NA =12.3±.84 years) and BMI (A=21.6±5.0 kg/m^2; NA=24.3±8. kg/$m^2$1). For the two-foot stance (Figure 1) and the one-foot stance (Figure 3), no significant differences were seen among the four stances (EO firm, EC firm, EO, foam, EC foam) between activity groups. The athletic group demonstrated significantly lower median velocities during the tandem stance for EO, firm and EO, foam while no significant differences were seen for EC, firm and EC, foam (Figure 2).

Figure 1

Two Feet Velocity of COP (mm/sec)



	EO Firm	EC Firm	EO Foam	EC Foam
A	9.3±2.6	12.3±4.2	15.2±9.0	21.6±9.0
NA	10.5±4.7	13.5±4.0	16.9±11.8	22.5±7.3
All	10.0±4.7	13.0±4.1	16.2±10.6	22.1±8.0

EO = Eyes open; EC = Eyes closed
A = Athletes; NA = non-athletes
A: n=22; NA: n=29

Figure 2

Tandem Feet Velocity of COP (mm/sec)

	EO Firm	EC Firm	EO Foam	EC Foam
A	21.1±5.4*	46.7±18.3	28.4±6.7*	72.8±36.0
NA	25.2±6.7	48.8±14.0	33.4±10.3	75.5±29.6
All	23.4±6.4	47.9±15.9	31.2±9.2	74.2±32.1

EO = Eyes open; EC = Eyes closed
A = Athletes; NA = non-athletes
A: n=22; NA: n=29
* = $p < 0.05$

DISCUSSION: The purpose of this study was to examine if differences existed in PC between middle school adolescents participating (A) and not participating (NA) in afterschool athletic activities. Postural control was operationalized by differences in MVelocity (mm/sec) of COP during 30-s trials when removing vision and manipulating somatosensation (standing on firm or foam surface) while in two-foot, tandem, and one-foot stances (12 stances). Significant differences between groups were only seen in two (TD, EO firm; TD, EO, foam) of the stances. In that sport activities develop sport specific skills that would include balance, it was thought that the development of such skills should have had a clearer positive effect on PC. However, similar results were found (i.e., no differences in activity groups) in a study by Ludwig and colleagues (2020) in four different age groups (6-8 yrs; 9-11 yrs; 1214 yrs; and 15-17 yrs) independent of age and sex. Although PC was operationalized using the COP path length (mm; length of trajectory of COP sway) in 30 second trials in this study (Ludwig et al., 2020), COP path length has been proven as a measurement of PC. The results of the present study complement and expand the findings of Ludwig et al (2020) in that only two stances (2F, EO and EC) were used in their study. That is, the present study (1) expanded the challenges to posture by including TD for BoS, challenging proprioception in all stances and altering visual status and (2) identified two stances in which PC was more stable in the athletic group.

Figure 3

One Foot Velocity of COP (mm/sec)

	EO Firm	EC Firm	EO Foam	EC Foam
A	29.5±6.3	61.0±27.6	39.9±12.4	88.7±42.2
NA	32.7±9.3	63.0±19.2	45.0±20.9	88.8±29.8
All	31.3±7.4	62.1±23	42.8±17.8	88.8±35.2

EO = Eyes open; EC = Eyes closed
A = Athletes; NA = non-athletes
A: n=22; NA: n=29

CONCLUSION: Although youth engaged in athletic sports demonstrated significantly better scores in only two of the 12 stances tested, they consistently reported better PC across the spectrum of stances. Whether or not participation in sports improved PC or poor PC hinders a youth's ability to master fundamental movement skills necessary to participate in sporting events needs further research. This is the first study that measured PC via a pressure plate when removing vision and manipulating somatosensation in three different stances (i.e., three different bases of support). The results of this study not only substantiated the feasibility of adolescents performing these tests, but gathered data allows for assessment of the different contributions of the sensory system, e.g., implementing the Romberg ratio (EO/EC) to determine proprioceptive contribution and visual dependency to postural stability in these 12 different stances. Although the latter was not the focus of this study, the success of this study greatly enhances the possibilities of such research agendas.

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