A COMPARISON OF BALANCE CONTROL BETWEEN JAVELIN THROWERS AND BASEBALL PITCHERS

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This study evaluated the balance control in javelin throwers and baseball pitchers. Twenty-four athletes took part in the study and for each we measured their static and dynamic balance by Biodex Balance System, AMTI AccuSway force plate and Y balance test. The paired t-test was conducted to compare all the variables within subjects. The independent t-test was used to compare trail leg (TL) of baseball pitchers with propulsive leg (PL) of javelin throwers and stride leg (SL) of baseball pitchers with braking leg (BL) of javelin throwers. The results showed that there was no difference between the PL and BL in dynamic and static balance in javelin throwers. However, the dynamic balance in the TL was significantly better than the SL in baseball pitchers. The static balance in the PL in javelin throwers was also better than the TL in baseball pitchers. The research improves the understanding of balance control in elite athletes.

KEY WORDS: dynamic balance, static balance, single leg standing, Y balance test, center-of-pressure

INTRODUCTION: The contributions of the lower limbs are considered to be vital in both javelin throwing and pitching. Researchers indicated that a javelin thrower's body position at the instant of final foot strike, his ability to transfer momentum between the lower body and the upper body during the delivery, and coordination of the working body segments in the most effective manner are linked to his success in the event (Morriss & Bartlett, 1996). The pitching motion of baseball pitchers is also a structural work, the linkage starts from the lower limbs, through the trunk, and finally reaches the upper limbs (Campbell, Stodden, & Nixon, 2010). The major work of the propulsive leg of javelin throwers is to provide support, transformation and propulsion in the final push phase and the braking leg of javelin throwers are mainly to provide breaking and support function during throwing (Menzel, 1986; Salo & Viitasalo, 1995; Bartonietz & Emrich, 1997). The major work of trail leg is the propulsion and supply of the initial power and the stride leg provides the function of transformation of energy and the support in pitching (Campbell et al., 2010). The athlete's both legs must create a stable base to stabilize their center of gravity in order to make the throwing and pitching process smoothly and stable. Javelin throwers performed 20-35 meter rapid run-up before releasing the javelin; however, pitchers only performed wind-up and stride before ball released. Each of pitching and throwing offers different challenges of balance control though they both need good coordination and dynamic postural stability. We hypothesized that the balance control abilities in pitchers and throwers were different from each other. Therefore, the study investigated: 1) the differences between the propulsive leg and braking leg of javelin throwers and the differences between the stride leg and trail leg in baseball pitchers in dynamic and static balance; 2) the differences between the trail leg of baseball pitchers and the propulsive leg of javelin throwers and the differences between the stride leg of baseball pitchers and braking leg of javelin throwers in dynamic and static balance.

METHODS: Twelve college baseball pitchers (level one, 20.0 ± 1.3years; 77.8 ± 6.2cm; 77.5 ± 8.2kg) and twelve college javelin throwers (level one, 21.4 ± 2.0years; 180.2 ± 5.8cm; 89.4 ± 14.7kg) participated in this study. All the subjects' static and dynamic balance were evaluated by three evaluation methods. The Medial-lateral stability index (MLSI), Anterior-posterior stability index (APSI) and an Overall stability index (OSI) were evaluated using the Biodex Balance System (BBS) (Biodex Medical System, Shirley, NY). The test level was set at Level six (dynamic) and Level statics in the Athletic Single Leg Stability Testing mode. The order of the testing level was randomized. The subjects performed single-leg standing on BBS with hands on their hips for twenty seconds, and a ten-second rest interval was conducted between each trial. Six trials were performed for each limb.

For the single leg stance balance test, the average radius, velocity and area of the center-of–pressure (COP) were measured using a force platform (Advanced Mechanical Technology, Inc., Watertown, Massachusetts, USA). The subjects performed single-leg standing on fore plate with eyes-opened and eyes-closed conditions for ten seconds. Three trials were performed for each limb.

For the Y balance test, the normalized reach distances in anterior, posterior-medial and posterior-lateral directions were collected. Leg length was measured from the anterior superior iliac spine to the medial malleolus for normalization. The starting direction and support leg were chosen randomly during the Y balance test. The subjects maintained a base of support on the testing leg, while using the other leg to reach as far as possible. After a light tap on the floor was made, the subjects returned the leg to the center of the Y. The distance from the center of the Y to the tap is measured. Three trials are performed for each leg and then averaged. The anterior research distance (ARD), posterior-medial research distance (PMRD) and posterior-lateral research distance (PLRD) were normalized by each subject's leg length.

The paired t-test was analyzed for comparing the differences of all the variables between the propulsive leg and braking leg in javelin throwers and stride leg and trail leg in baseball pitchers respectively. The independent t-test was conducted to compare trail leg of baseball pitchers with propulsive leg of javelin throwers and stride leg of baseball pitchers with braking leg of javelin throwers. The dependent variables were OSI, APSI and MLSI of level six and level static; the average radius, velocity and area of the COP and the normalized ARD, PMRD and PLRD. α level of 0.05 was set for the analyses.

RESULTS: The results demonstrated that the APSI of level 6 and the normalized PLRD of the trail leg were significant better than the stride leg. (Table 1) No significant difference was found between the propulsive leg and braking leg in all the variables. The average radius and area of the COP during single-leg standing with eyes-opened conditions of the propulsive leg were better than the trail leg. (Table 2)

Table 1 Comparison of mean values for propulsive leg with braking leg and trail leg with stride leg on different balance parameters

Measurement	conditions	variables	Pitchers		Javelin throwers	
			trail leg (Mean ± SD)	stride leg (Mean ± SD)	propulsive leg (Mean ± SD)	braking leg (Mean ± SD)
single leg stance balance test	Eye-opened	RCOP (in)	0.29±0.08	0.29±0.06	0.23±0.04	0.28±0.09
		VCOP (in/s)	1.60±0.48	1.54±0.49	1.42±0.38	1.34±0.35
		ACOP (in sq)	1.04±0.59	0.90±0.36	0.56±0.18	0.78±0.38
	Eye-closed	RCOP	0.48±0.18	0.52±0.12	0.48±0.09	0.47±0.18
		VCOP	2.86±1.42	3.17±1.16	2.98±0.50	3.16±0.56
		ACOP	2.79±2.41	3.06±1.56	2.62±1.04	3.19±1.72
BBS test	Level static	MLSI	0.48±0.18	0.53±0.26	0.49±0.16	0.42±0.12
		APSI	0.50±0.13	0.49±0.14	0.51±0.14	0.52±0.22
		OSI	0.74±0.22	0.78±0.29	0.78±0.19	0.72±0.21
	Level 6	MLSI	1.26±0.27	1.32±0.32	1.35±0.47	1.38±0.44
		APSI	1.18±0.19	1.31±0.24*	1.33±0.49	1.41±0.56
		OSI	1.85±0.31	1.97±0.41	2.04±0.71	2.09±0.70
YBT		ARD (%)	90.17±18.01	88.25±17.75	90.00±18.66	88.13±12.97
		PMRD (%)	117.42± 22.90	114.83± 21.57	117.13± 33.59	117.08±29.95
		PLRD (%)	103.25± 19.65	89.50±18.50*	101.25± 32.94	100.25±32.14

RCOP = the radius of COP, VCOP = the velocity of COP, ACOP = the area of COP, MLSI = Medial-lateral stability index, APSI = Anterior-posterior stability index, OSI = Overall stability index, ARD = anterior research distance, PMRD = posterior-medial research distance, PLRD = posterior-lateral research distance. *p<0.05

Table 2 Comparison of mean values for the trail leg of baseball pitchers with propulsive leg of javelin throwers and stride leg of baseball pitchers with braking leg of javelin throwers.

Measurement	conditions	variables	trail leg (Mean ± SD)	propulsive leg (Mean ± SD)	stride leg (Mean ± SD)	braking leg (Mean ± SD)
single leg stance balance test	Eye-opened	RCOP (in)	0.29±0.08	0.23±0.04*	0.29±0.06	0.28±0.09
		VCOP (in/s)	1.60±0.48	1.42±0.38	1.54±0.49	1.34±0.35
		ACOP (in sq)	1.04±0.59	0.56±0.18*	0.90±0.36	0.78±0.38
	Eye-closed	RCOP	0.48±0.18	0.48±0.09	0.52±0.12	0.47±0.18
		VCOP	2.86±1.42	2.98±0.50	3.17±1.16	3.16±0.56
		ACOP	2.79±2.41	2.62±1.04	3.06±1.56	3.19±1.72
BBS test	Level Static	MLSI	0.48±0.18	0.49±0.16	0.53±0.26	0.42±0.12
		APSI	0.50±0.13	0.51±0.14	0.49±0.14	0.52±0.22
		OSI	0.74±0.22	0.78±0.19	0.78±0.29	0.72±0.21
	Level 6	MLSI	1.26±0.27	1.35±0.47	1.32±0.32	1.38±0.44
		APSI	1.18±0.19	1.33±0.49	1.31±0.24	1.41±0.56
		OSI	1.85±0.31	2.04±0.71	1.97±0.41	2.09±0.70
YBT		ARD (%)	90.17±18.01	90.00±18.66	88.25±17.75	88.25±17.75
		PMRD (%)	117.42± 22.90	117.13± 33.59	114.83± 21.57	114.83± 21.57
		PLRD (%)	103.25± 19.65	101.25± 32.94	89.50±18.50	100.25±32.14

RCOP = the radius of COP, VCOP = the velocity of COP, ACOP = the area of COP, MLSI = Medial-lateral stability index, APSI = Anterior-posterior stability index, OSI = Overall stability index, ARD = anterior research distance, PMRD = posterior-medial research distance, PLRD = posterior-lateral research distance. *$p<0.05$

DISCUSSION: The purpose of this study was to compare the static and dynamic balance in javelin throwers and baseball pitchers through three balance evaluation methods. To the best of our knowledge, this is the first research reveals the differences between javelin throwers and pitchers in static balance in eye-opened condition. These results indicate that javelin throwers are more stable with eye-opened for static balance control than pitchers. Also, no significant difference was found in dynamic balance. It is possible that the throwers and pitchers have both developed well dynamic balance control. One possibility is that the methods used in current study might not be sensitive enough to investigate the difference between their dynamic balance abilities. Measuring balance control in task specific activities is suggested in the future study.

The trail leg demonstrated better dynamic balance than the stride leg in pitchers while no significant difference was found between the propulsive leg and braking leg in all the variables in javelin throwers. Both trail leg and stride leg performed single-leg standing to support the body weight respectively while pitching (Fleisig, Escamilla & Barrentine,1998). The trail leg performed single-leg standing during wind-up and stride phase in pitching while the stride leg performed single-leg standing after ball release (i.e. arm deceleration and follow-through phase). The javelin throwing doesn't require precise accuracy as much as pitching though it is also a dynamic process and both propulsive leg and braking leg perform single-leg standing to support the body weight respectively in different throwing phases. For the accuracy of the baseball pitching, the trail leg might contribute more to the stability than the stride leg. Also, the dynamic balance might be a better indicator than static balance while evaluating the balance control in baseball pitcher.

CONCLUSION: It is concluded that both the javelin throwers and baseball pitchers demonstrated unique characteristics in balance control. There is no difference between the propulsive leg and braking leg of javelin throwers in dynamic and static balance performance. However, the dynamic balance in the trail leg is significantly better than the stride leg in baseball pitchers. The static balance in the propulsive leg of javelin throwers is also better than the trail leg of the baseball pitchers. The research improves the understanding of balance control in javelin throwers and pitchers; however, the cause of these differences requires further research.

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