THE INFLUENCE OF WEARING A LUMBAR SUPPORT BELT UPON JAVELIN THROWING PERFORMANCE.

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Six male javelin throwers (mean ±SD age 25 ± 4 years: height 1.82 ± 0.06 m; weight 891 ± 105 N) were filmed at 150 Hz throwing an 800g javelin from a polyflex athletic track with and without a lumbar support belt, to allow three-dimensional kinematic analysis. Two typical throws at similar run up velocities were analysed. Wearing the belt was associated with significantly greater peak velocity at the shoulder relative to the hip when the hyper-extended torso flexed forwards to release the javelin (P=0.046). With the belt there was not a significant increase in the velocity of the arm segments or javelin release velocity, attitude angle, release height, though an insignificant increase of 1.45m in mean distance occurred (P>0.05) possibly due to javelin aerodynamic factors.

KEY WORDS: back, javelin, kinematics, speed, torso, velocity.

INTRODUCTION: There is a high incidence of injury in javelin throwers (Hurrion et al., 1998). This possibly arises from the maximal effort involved in throwing the javelin as far as possible. Many elite, national and recreational athletes wear lumbar support belts during training and competition to prevent injury and aid performance. This study analysed the influence of wearing a lumbar support on javelin throwing during the final delivery stride as the javelin was released. The aims were to establish the effect of a lumbar support on important kinematic parameters during the delivery phase of the javelin throw, particularly the linear velocities of the joint centres and javelin. In addition, the segmental timing of the movement to release the javelin was investigated. The third aim was to determine the velocity at which the torso moved from a hyper-extended position through to a flexed position as this seems to be a key factor influencing overhead throwing performance (Hurrion et al., 2000).

METHOD: Six male javelin throwers provided written informed consent to participate in this study. The subjects were 25 ± 4 years of age (mean ±SD), height was 1.82 ± 0.06 m and weight was 891 ± 105 N. All had competitive experience at county (regional) or national league level. Experimental testing was carried out over the period of a month, during the competitive athletic season on dry ground with air temperatures of 22-27°C and no wind. Each athlete had worn a lumbar support belt of some description at some time previously during regular training or competition. During testing the participants wore their personal javelin throwing shoes and were asked to wear tight fitting clothing. Florescent yellow wooden markers (0.020 m diameter, 0.015 m high) mounted on 0.004 m black plastic base plates (University College Chichester, UK) were placed over the joints to facilitate joint centre determination during the analysis procedures. The throwers were asked to perform their typical throwing action, throwing the 800g javelin implement into the 40° sector from a polyflex athletic track. Every effort was made to ensure each athlete was throwing to his typical competition performance. After familiarisation, the throwers were required to perform two series of throws, either with a Vulcan 3049 lumbar support belt (Vulcan Ltd. Leicester, UK) or without it. It should be noted that the series order was allocated to participants randomly. During each series, throws were recorded at 150 Hz using cinematography. Subjective feedback from the performers regarding the quality of the performance was recorded also. For analysis, two of the throws performed when wearing the belt and two of the throws performed without the belt were selected from each series. Two battery powered Photosonics 500 16mm cine cameras (Thame, UK) fitted with 28mm lens and loaded with Kodak 16mm Ektachrome 7251 film were used to record the delivery stride of the throw. The cameras were mounted on tripods at a height of 1.5 metres each 10 metres distant from the position of the thrower during the delivery stride and separated by an angle of 90°. Camera shutter speed and aperture size were determined at the time of filming by using a Gossen Six light meter (Whitby's, Chichester, UK). To aid in recall, and possibly subsequent data interpretation a video recording (Sony Hi8 EVO 9100 P, Sony, UK) of the experimental work was made. A three-dimensional, twenty-five point spherical calibration unit (Peak Performance, Colorado, USA) was recorded on each new reel of cine film. Internal cine camera timing lights pulsed at 100 Hz during filming, to allow confirmation that the film had reached the correct speed for kinematic analysis. For each subject two javelin delivery stride sequences from both series were subjected to biomechanical kinematic analysis to determine relevant timing, velocity and angular data for comparison purposes. After processing, the film image was projected using a Nac analysis projector fitted with a prism rotating lens, onto a high resolution TP1067 digitiser tablet (Terminal Display Systems Ltd, Blackburn, UK). This tablet was connected to an Archimedes A440/1 computer running Bartlett three-dimensional cine analysis digitisation, smoothing and analysis software (Bartlett & Bowen, 1993). A fourteen-segment performer model of the javelin thrower and a four-point javelin model were adopted for the digitisation procedure. Three-dimensional scaling was carried out prior to digitisation. Prior to any experimental analysis, the equipment and digitisation procedure were checked for accuracy and repeatability by analysing a single throw on three occasions. Throws were analysed at a rate of 150Hz and in each case two control points were used to correct for any image movement during filming or analysis. Digitisation began ten frames prior to back foot contact in the delivery stride and on average between 60 and 75 frames were digitised for each throw. The data was saved onto floppy disc prior to generalised cross-validated quintic spline procedures. Descriptive statistics were calculated for the key cinematography variables by calculating average values for each subject and determining mean SD and SE values for the group of six throwers. Due to the relatively small sample size, paired t-test comparisons were used and the nominal significance level was set at $P=0.05$, hence each independent comparison was tested at $\alpha = 0.05/9 = 0.006$. A further paired one tailed t-test was used to investigate if there was any significant difference between the relative shoulder-to-hip joint velocity, and the relative timing of these velocities in each series. The use of the one tailed t-test was based on previous experimental investigations which had indicated that throwing was not hindered by the wearing of a lumbar support belt (Hurrion et al., 2000)

RESULTS: The kinematics results derived from the performance of the javelin throwers with and without the lumbar support belt are summarised in terms of joint centre velocities in Table 1 and Table 2. The kinematics data relating to the movement of the torso from the hyper-extended position prior to release into the flexed postion is considered within Table 2 and Table 3.

Table 1. Mean (± SE) peak joint centre velocities (ms^{-1}) and the distance thrown (m) for the six javelin throwers with and without a lumbar support belt.

	Mass Centre	**Hip**	**Shoulder**	**Elbow**	**Wrist**	**3rd Finger**	**Javelin (Grip)**	**Distance**
Belt	6.24 ± 0.13	6.73 ± 0.11	8.79 ± 0.25	14.29 ± 0.66	21.30 ± 0.97	24.63 ± 1.13	25.76 ± 1.33	61.01 ± 5.07
No Belt	6.39 ± 0.25	6.82 ± 0.19	8.59 ± 0.35	14.17 ± 0.58	21.10 ± 0.85	24.52 ± 1.09	25.31 ± 1.51	59.56 ± 5.15
Difference	-0.15	-0.09	0.20	0.11	0.21	0.12	0.45	1.45
P value	0.44	0.53	0.28	0.78	0.49	0.75	0.29	0.27

Table 2. Difference in peak linear velocities (mean ±SE) between shoulder and hip joints for the six javelin throwers.

	(Shoulder - Hip) ms^{-1}
Belt	2.06 ± 0.21
No Belt	1.77 ± 0.18
Difference	0.29
P value	0.046

Table 3. Javelin throwing: Comparison of important release parameters (mean ±SE).

	Average	Belt	No Belt	Difference
Attitude angle° at release	31.2 ± 1.04	30.7 ± 1.90	32.0 ± 2.33	-1.61 ± 1.16
Shoulder Alignment °				
BFC	174 ± 1.34	174 ± 2.67	174 ± 2.86	-0.50 ± 0.72
FFC	191 ± 1.64	192 ± 3.63	191 ± 2.58	1.25 ± 3.10
Release	280 ± 2.72	280 ± 2.72	281 ± 1.87	-0.58 ± 1.84
Change FFC to release	88.8 ± 1.94	87.9 ± 3.04	89.8 ± 4.06	-1.83 ± 2.60
Hip/shoulder separation°				
BFC	-33.0 ± 2.62	-33.1 ± 5.49	-32.8 ± 5.48	-0.31 ± 1.50
FFC	-31.9 ± 1.68	-31.4 ± 2.88	-32.3 ± 3.37	0.87 ± 2.56
Release	4.70 ± 5.73	4.77 ± 12.6	4.64 ± 11.9	0.13 ± 0.91
Hip velocity at BFC (ms^{-1})	5.95 ± 0.09	6.00 ± 0.18	5.91 ± 0.15	0.09 ± 0.06
Torso Angle at Release°	10.3 ± 3.16	9.91 ± 6.82	10.6 ± 6.66	-0.69 ± 0.47
Max. Torso Angle°	4.93 ± 4.93	5.32 ± 4.26	4.54 ± 4.49	0.77 ± 1.02
Range° of torso movement	19.2 ± 2.25	19.5 ± 4.38	19.0 ± 5.17	0.54 ± 1.03
Time (second):	0.23 ± 0.01	0.23 ± 0.02	0.23 ± 0.02	-0.00 ± 0.00
Front Knee Angle°				
FFC	167 ± 0.94	167 ± 1.35	166 ± 1.29	0.68 ± 1.64
Release	157 ± 2.42	155 ± 3.88	160 ± 4.40	-5.75 ± 1.45
(Release-FFC)	-9.38 ± 2.33	-12.6 ± 3.90	-6.17 ± 3.94	-6.43 ± 1.06
Back Knee Angle°				
BFC	139 ± 2.22	140 ± 4.96	138 ± 4.26	1.55 ± 1.44
FFC	139 ± 1.36	140 ± 2.59	138 ± 2.83	1.62 ± 1.91
Release	123 ± 3.19	121 ± 6.59	124 ± 6.41	-3.17 ± 1.36
Release Height (m)	1.96 ± 0.02	1.95 ± 0.03	1.96 ± 0.04	-0.01 ± 0.02
% Height	107 ± 0.65	107 ± 1.05	108 ± 1.35	-0.42 ± 0.88
Delivery Stride (m)	1.36 ± 0.04	1.37 ± 0.10	1.36 ± 0.09	0.01 ± 0.01
% Height	74.0 ± 2.05	73.8 ± 4.54	74.3 ± 4.06	-0.50 ± 1.10

Note: Average = (Belt and No Belt); Difference = (Belt - No Belt)
BFC: Back Foot Contact; FFC: Front Foot contact;

Table 4. Progressive time of occurrence of peak velocity (seconds) before (+) and after (-) release of the javelin.

	Mass Centre	Hip	Shoulder	Elbow	Wrist	3rd Finger	Shoulder - Hip
Belt	+0.28	+0.20	+0.09	+0.05	+0.01	+0.00	0.12
No Belt	+0.28	+0.20	+0.09	+0.09	+0.01	+0.00	0.11
Average	+0.28	+0.20	+0.09	+0.07	+0.01	+0.00	0.11

Assessment of accuracy and reliability of the digitisation procedure yielded the following estimates of experimental error based on the SD for the variables analysed. For linear velocities (ms^{-1}): right hip ±0.2; shoulder ±0.3; elbow ±0.4; wrist ±0.5; finger ±0.9; and javelin grip ±0.7. For other variables: release height ±0.04 m; delivery stride length ±0.04 m; torso angle at release ±1.7°; maximum torso angle ±1.3°; attitude angle at release ±1°; front knee angle at front foot contact ±2.2°.

DISCUSSION: Table 1 shows that the peak linear velocities were similar at all the joint centres and at the javelin grip whether the lumbar support belt was worn or not. The mean distance thrown was 1.45 m greater (equivalent to 2.4%) when the throwers wore the lumbar support belt, but this difference was not significant (P=0.27) and was possibly related to javelin aerodynamic factors. However when the belt was worn, there was a significant difference (P=0.046) with a greater mean peak velocity (+0.29ms^{-1}) at the shoulder relative to the hip as shown in Table 2. The general comparison in Table 3 of wearing a lumbar support belt on kinematic parameters in the javelin delivery stride indicated the similarity of run up (hip velocity) and parameters relevant to body movement (e.g. the range of torso movement and the time of the movement time). Also, Table 3 indicated that there were no significant changes in the javelin attitude angle, release height and release velocity when the lumbar support belt was worn. Table 4 indicated that the progression of peak linear velocities through the body segments was similar with and without the lumbar support belt.

CONCLUSION: At a similar run up velocity, wearing the belt was associated with significantly greater peak velocity at the shoulder relative to the hip when the hyper-extended torso flexed forwards to release the javelin (P<0.05). The warmth and support provided by the lumbar support belt may have which enabled more effective muscular flexion of the torso and reduced the fear of injury associated with insufficient warm up, which is a major concern especially in an intermittent activity such as javelin throwing. With the belt there was not a significant increase in the velocity of the arm segments or javelin release velocity, attitude angle, release height, though an insignificant increase of 1.45m in mean distance occurred (P>0.05), possibly have been due to javelin aerodynamic factors. The availability of high speed video recording systems in biomechanics will aid javelin throwing research by eliminating the high costs associated with cinematography.

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