A PRELIMINARY KINEMATIC GAIT ANALYSIS OF A STRONGMAN EVENT: THE FARMERS WALK

Justin Keogh[1,2], Anthony Kattan[2], Scott Taylor[2], James Bensley[2], Che Muller[2] and Linda Powell[1]

Bond University Research Centre for Health, Exercise and Sports Sciences, Bond University, Gold Coast, Australia, [1]Sports Performance Research Institute New Zealand, AUT University, Auckland, New Zealand[2]

This study sought to obtain some preliminary normative sagittal plane kinematic data on a strongman event called the farmers walk and gain some insight into its kinematic determinants of performance. Five experienced resistance trained males performed three 20 m farmers walks with 90.5 kg in each hand at maximal speed. Farmers walk velocity increased from the initial acceleration phase to the middle and latter stages, with this associated with significant increases in step length, step rate and reductions in contact time. Analysis of the three fastest and three slowest trials also indicated the fastest trials had significantly greater step length, step rate and reduced contact time. Based on the impulse-momentum relationship, the production of high anterior-posterior impulses over short contact times may be crucial for farmers walk performance.

KEY WORDS: gait, kinematics, resistance training.

INTRODUCTION: As strongman competitions become increasingly popular, many strength and conditioning coaches are including strongman exercises like the farmers walk, sled pushing/pulling and the tyre flip in their athletes conditioning programs (Waller, Piper, & Townsend, 2003). The farmers walk requires a very strong grip and utilizes forceful ankle, knee, hip and back extension to pick the bars off the ground (like a deadlift) and to cover the set distance, generally between 20-50 m as quickly as possible.

To date, relatively few biomechanical studies have examined any of the strongman events. McGill et al. (2009) reported high to very high (but somewhat event-specific) spinal compression and shear forces, joint torques and hip and trunk muscle activity in a variety of strongman exercises including the farmers walk, yoke walk, tyre flip and log press. Keogh and colleagues (Keogh, Newlands, Blewett, Chun, & Payne, 2010; Keogh, Payne, Anderson, & Atkins, 2010) have also examined the kinematics of the tyre flip and heavy, sprint-style sled pull. Keogh, Payne et al. (2010) found that the strongest determinant of tyre flip performance was the duration of the second pull. Keogh, Newlands et al. (2010) observed more significant differences in the maximum velocity than acceleration phase of the sled pull, with the fastest trials generally characterized by significantly greater step lengths, step rates and shorter contact times.

As a fast walking event, the characteristics and determinants of farmers walk performance would appear to be well described by typical gait analysis variables such as step rate, step length, ground contact time and swing time. Therefore, the purpose of this study was to: 1) describe the kinematic characteristics of the farmers walk at various phases of the event (e.g. initial, middle and latter stages); and 2) compare the fastest and slowest walks in order to gain additional insight into its kinematic determinants. It was hypothesized that: 1) the middle and latter stages of the event would differ significantly in many ways e.g. greater step length, greater step rate and a shorter ground contact time compared to the initial stage; and 2) that similar differences would exist between the fastest and slowest trials.

METHODS: Five male athletes (27 ±4 y, 93 ±7 kg, 1.76 ±0.10 m) gave informed consent to participate in this study. All athletes were experienced in resistance training and familiar with commonly utilised exercises including the squat, dead lift, power clean, push press and bench press. Four of the five athletes had also competed in strongman competitions involving the farmers walk. Athletes completed a warm-up and familiarization session which consisted of some sub-maximal sets of deadlifts and lighter farmers walks for approximately 15-20 minutes. After this was completed, each athlete performed three trials of the farmers walk with 90.5 kg in each hand over a distance of 20 m, with a 3 minute rest period between each trial. All trials were timed by stopwatch from the moment all of the plates left the ground, until the front of the farmer's bars crossed the finish line. The aim of each trial was to complete the 20 m course as quickly as possible. Kinematic variables were recorded in the sagittal plane using three digital video cameras (Sony, PAL, 50 Hz, 1/1000s) that were positioned 0.8m above the ground. The cameras were positioned at the start, middle and finish of the 20 m course to have a field of view of 3 m, so that they covered the 0-3 m, 8.5-11.5 m and 17-20 m portions of the 20 m course, respectively. Two linear kinematic (average velocity and step length), three temporal (step rate, ground contact time and swing time) and three segment/joint angle (thigh, knee and ankle) variables were calculated for all full steps recorded by each camera. The thigh angle was measured in relation to the vertical axis, whille the knee and ankle were relative (joint) angles. All angles were recorded at foot-strike and toe-off (Figure 1). A general measure of the range of motion (ROM) of these joint/segments was obtained by subtracting the angle at toe-off from that at foot-strike.

Figure 1: Pictorial representation of the three angles measured in the farmers walk. The top row from left to right depicts the ankle, knee and hip angles at foot-strike and the bottom row the same angles at toe-off.

Means and standard deviations were calculated for all variables across all trials and for the three fastest and slowest trials. One-way ANOVAs were used to compare the kinematics at each of the three stages across all trials and for the fastest vs slowest trials. Gabriel post-hoc tests were used where needed to determine the location of the significant differences. All statistical analyses were conducted using SPSS ver 18.0, with statistical significance set at $p<0.05$.

RESULTS: Table 1 highlights the differences in the kinematic variables across the three stages of the 20 m farmers walk (8.25 ±1.05 s). Average velocity, step length and step rate significantly increased while contact time significantly reduced from the initial to the latter two stages. A number of significant differences in joint/segment angles were also observed.

Table 1: Differences in the kinematics of the farmers walk across the three stages.

	Stage 1 (0-3 m)	Stage 2 (8.5-11.5 m)	Stage 3 (17–20 m)
Average velocity (m/s)	2.41 ±0.32 [a, b]	3.29 ±0.38	3.15 ±0.32
Step Length (m)	1.35 ±0.12 [a, b]	1.67 ±0.10	1.62 ±0.16
Step rate (Hz)	1.79 ±0.14 [a, b]	1.97 ±0.13	1.93 ±0.12
Ground contact time (s)	0.36 ±0.04 [a, b]	0.30 ±0.03	0.30 ±0.04
Swing time (s)	0.20 ±0.02	0.21 ±0.01	0.21 ±0.02
Thigh Angle @ FS (^{o})	32 ±3	34 ±3	33 ±5
Thigh Angle @ TO (^{o})	5 ±4 [a]	-4 ±3	0 ±13
Thigh ROM (^{o})	-27 ±5 [a, b]	-38 ±4	-33 ±14
Knee Angle @ FS (^{o})	150 ±6 [a, b]	155 ±6 [b]	161 ±10
Knee Angle @ TO (^{o})	124 ±7 [a]	130 ±8 [b]	123 ±11
Knee ROM (^{o})	-24 ±8 [b]	-25 ±10 [b]	-38 ±17
Ankle Angle @ FS (^{o})	100 ±8 [b]	110 ±9	117 ±9
Ankle Angle @ TO (^{o})	111 ±5	114 ±6	117 ±8
Ankle ROM (^{o})	-12 ±8 [a, b]	-4 ±7	0 ±11

All data are mean ±SD. [a] – Significant difference to Stage 2; [b] – Significant difference to Stage 3; FS – foot-strike; TO – toe-off; ROM=range of motion.

Table 2: Differences in the kinematics of the three fastest and slowest farmers walks at each of the three stages.

	Stage 1 (0-3 m)		Stage 2 (8.5-11.5 m)		Stage 3 (17–20 m)	
	Slowest	Fastest	Slowest	Fastest	Slowest	Fastest
Average velocity (m/s)	2.19 ±0.27	2.61 ±0.38	2.83 ±0.36*	3.64 ±0.15	2.56 ±0.28*	3.66 ±0.17
Step Length (m)	1.33 ±0.09	1.38 ±0.16	1.57 ±0.12*	1.77 ±0.03	1.40 ±0.17*	1.83 ±0.04
Step rate (Hz)	1.64 ±0.12*	1.88 ±0.10	1.79 ±0.10*	2.05 ±0.05	1.83 ±0.04*	2.01 ±0.13
Ground contact time (s)	0.39 ±0.04*	0.32 ±0.03	0.33 ±0.02*	0.28 ±0.01	0.34 ±0.03*	0.29 ±0.02
Swing time (s)	0.21 ±0.01	0.19 ±0.02	0.22 ±0.02	0.20 ±0.00	0.20 ±0.03	0.21 ±0.02
Thigh Angle @ FS (^{o})	36 ±3*	30 ±3	33 ±4	37 ±2	31 ±4*	38 ±3
Thigh Angle @ TO (^{o})	7 ±2	2 ±5	-3 ±5	-5 ±1	-4 ±2	-6 ±3
Thigh ROM (^{o})	-30 ±4	-27 ±6	-36 ±4*	-42 ±3	-35 ±6*	-44 ±4
Knee Angle @ FS (^{o})	151 ±5	147 ±7	159 ±8	151 ±5	166 ±16	156 ±6
Knee Angle @ TO (^{o})	122 ±3	124 ±6	130 ±9	127 ±7	122 ±7	128 ±9
Knee ROM (^{o})	-26 ±4	-21 ±6	-30 ±9	-24 ±11	-44 ±21	-28 ±12
Ankle Angle @ FS (^{o})	106 ±6	99 ±8	113 ±5*	101 ±6	110 ±4	113 ±8
Ankle Angle @ TO (^{o})	114±3*	108 ±4	113 ±5	111 ±7	118 ±5	117 ±7
Ankle ROM (^{o})	-8 ±6	-10 ±10	1 ±5*	-10 ±4	-7 ±8	-3 ±4

All data are mean ±SD. * – Significant difference between slowest to fastest trials; FS – foot-strike; TO – toe-off; ROM=range of motion.

Table 2 compares the fastest (7.08 ±0.19 s) and slowest (9.94 ±0.15 s) 20 m trials. The slowest 3 trials came from two subjects, with the fastest 3 trials from another two subjects. Average velocity, step length and step rate were generally significantly greater and contact time significantly less for the fastest trials. Relatively few significant differences were found for the joint/segment angles, with these tending to be confined to the thigh angle.

DISCUSSION: This study sought to obtain some normative data on the kinematics of the farmers walk and gain some insight into the kinematic determinants of performance. The normative results presented in Table 1 appeared qualitatively similar to that of the literature for resisted (Keogh, Newlands, et al., 2010) and bodyweight sprinting (Hunter, Marshall, & McNair, 2004), whereby significant increases in step length and step rate and reduced contact time were observed when comparing the initial to latter stages. Many significant differences in joint/segment angles were also observed across the three stages, with the most obvious finding being a greater ROM for the thigh and knee during the latter stages. When comparing the differences in the fastest vs slowest trials at each of the three stages, significantly greater step lengths and rates and shorter contact times were again associated with increased velocity. Interestingly, relatively few significant differences were found in the joint/segment angles between the fastest and slowest trials. Based on the impulse-momentum relationship, these results suggest that success in the farmers walk might be related to the ability to produce high levels of anterio-posterior propulsive impulses over short ground contact times. While such a view would need to be supported by kinetic studies, if it was found to be correct, it would suggest that the kinetic determinants of the farmers walk are similar to sprinting (Hunter, et al., 2004).

CONCLUSION: The results of this study provide the first kinematic description of a common strongman event called the farmers walk and provide some insight into its kinematic determinants. Based on the kinematic differences observed between the different stages of the farmers walk and between the fastest and slowest trials, it would appear that greater step lengths and step rates and reduced contact times are key kinematic determinants of performance in this event. These results have applications to strongman athletes looking to improve their performance in this event as well as to strength and conditioning coaches who are considering whether to use this exercise in their athletes' conditioning programmes. Future studies should use longitudinal as well as cross-sectional designs, involve elite and sub-elite subjects and assess kinetic and electromyographic variables to better understand the determinants of farmers walk performance.

REFERENCES:

Hunter, J. P., Marshall, R. N., & McNair, P. J. (2004). Interaction of step length and step rate during sprint running. *Medicine and Science in Sports and Exercise, 36*(2), 261-271.

Keogh, J. W. L., Newlands, C., Blewett, S., Chun, E.-L., & Payne, A. (2010). A kinematic analysis of a strongman-type event: the heavy sprint-style sled pull. *Journal of Strength and Conditioning Research, 24*(11), 3088-3097.

Keogh, J. W. L., Payne, A., Anderson, B., & Atkins, P. (2010). A brief description of the biomechanics and physiology of a strongman event: the tire flip. *Journal of Strength and Conditioning Research, 24*(5), 1223-1228.

McGill, M. S., McDermott, A., & Fenwick, J. M. C. (2009). Comparison of different strongman events: Trunk muscle activation and lumbar spine motion, load, and stiffness. *Journal of Strength and Conditioning Research, 23*(4), 1148-1161.

Waller, M., Piper, T., & Townsend, R. (2003). Strongman events and strength and conditioning programs. *Strength & Conditioning Journal, 25*(5), 44-52.