A BIOMECHANICAL COMPARISON BETWEEN STRONGMAN EVENTS AND TECHNICALLY SIMILAR TRADITIONAL WEIGHT TRAINING EXERCISES: A NARRATIVE REVIEW

Ben Hindle[1], Paul Winwood[2], Anna Lorimer[1,3] and Justin Keogh[1,3]

Faculty of Health Sciences and Medicine, Bond University, Gold Coast, Australia[1]; Faculty of Community Health and Wellbeing, Toi Ohomai Institute of Technology, Tauranga, New Zealand[2]; Sport Performance Research Institute New Zealand, Auckland University of Technology, Auckland, New Zealand[3]

A literature search was conducted to identify studies comparing biomechanical parameters of strongman events and technically similar traditional weight training exercises. While many similarities were identified, it was found that the farmer's lift may reduce the stress placed on the lumbar spine when compared to the deadlift performed under identical loading conditions. The heavy sled pull was suggested to better develop anterior force production than the back squat, while the log lift may be used to better develop forceful hip extension during a triple extension movement than the clean and jerk. The identification of biomechanical similarities and differences between strongman and traditional weight training exercises may be used by strength and conditioning coaches to better prescribe exercises suited to an individual athletes' conditioning requirements.

KEYWORDS: biomechanics, functional, resistance

INTRODUCTION: The sport of strongman has rapidly increased in popularity over the past ten years (Winwood et al., 2018). Strongman events, described as a functional form of traditional weightlifting, generally involve an athlete lifting, carrying, pulling or pushing awkward and heavy objects for a number of repetitions or for a set distance (Berning, Adams, Climstein, & Stamford, 2007). Unlike traditional weight training exercises which typically require a weight to be lifted vertically and use bilateral load distribution, strongman events are said to test athletes in multiple planes, incorporating both bilateral and unilateral loading phases (Keogh, Payne, Anderson, & Atkins, 2010). This narrative review investigates existing literature which has compared the biomechanics of a strongman event with that of a technically similar traditional weight training exercise. Such data will be of interest to strongman athletes and strength and conditioning coaches looking to incorporate strongman exercises into their athletes' strength and conditioning programs.

METHODS: A literature search was conducted using MEDLINE, SportDiscus and AusportMed databases for papers published up until 21st March 2018. A two-level keyword search strategy was employed to establish relevant literature on the topic. The search strategy used for the SportDiscus database was: (strongman) AND (compar*). Inclusion criteria required the peer-reviewed journal article to describe a study that directly compared some biomechanical parameters between a strongman event and a technically similar traditional weight training exercise. Exclusion criteria was outlined as literature consisting of a primary exercise comparison other than strongman and traditional weight training exercises.

RESULTS: The three databases returned a total of 21 results from the initial search. After screening the title and abstract of the 21 results, three primary studies were identified as being adherent to the inclusion criteria and thus were included in the review. One additional training study found in the initial search was also included in the review as it was deemed to be of relevance to the over-arching theme of the review. The article was also considered to provide readers with valuable insight into performance outcome benefits of a strongman training protocol when compared to a traditional weight training protocol consisting of biomechanically similar exercises.

In each of the primary literature reviewed, a different strongman event was compared with a technically similar traditional weight training exercise. The studies reviewed used two methods to compare biomechanical measures of the strongman event to those of the weight training exercise. Method one saw the comparison of biomechanical measures at defined instantaneous measurement points (IMPs) in time throughout the exercise. Method two saw each exercise sectioned into defined phases (DPs) with a comparison of biomechanical parameters observed within these phases. Both techniques enabled a direct comparison of biomechanical parameters between the similar exercises. The biomechanical parameters collected at defined IMPs during the strongman and traditional weight training exercises in all studies reviewed, were joint/segment angular kinematics. In all three studies these parameters were collected using 2-D video camera recordings. The biomechanical parameters collected throughout DPs of the strongman and traditional weight training exercises in all studies, were ground reaction forces (GRF) and range of motion (ROM). These parameters were collected using force plates and video camera recordings, respectively. Each study also presented a biomechanical measure specific to the individual pair of exercises performed. A summary of the measures included in the studies is given in Table 1.

Table 1: Summary of literature reviewed

	Winwood 2014	Winwood 2015a	Winwood 2015b
Strongman	Farmer's lift	Heavy sled pull	Log lift
Traditional	Deadlift	Back squat	Clean and jerk
IMPs	Lift off Point of hand pass knee Max. point of concentric. lift.	Start of concentric. phase Max. knee extension.	Lift off Top of first pull Start of second pull Middle of second pull Max. point of plantarflex. Top retrieve Bottom of dip and drive Lift completion.
DPs	Lift off to max point of concentric lift	Start of concentric phase to max. knee extension	First pull Second pull Jerk/push press
Exercise specific biomechanical measurements	Peak vertical velocity Concentric lift time	Total resultant GRF (TRGRF) % TRGRF in horizontal. direction	Log/bar path Log/bar velocity

In general, all three studies demonstrated many more similarities than differences between the strongman and traditional weight training exercises. The significant differences between these exercises are summarised.

Winwood, Cronin, Brown, & Keogh (2014) observed greater mean vertical (2893 ± 442 N versus 2679 ± 471 N; $p = 0.021$) and anterior force production (66 ± 23 N versus 41 ± 15 N; $p = 0.007$) in the farmer's lift than the deadlift. However, significantly less ($p = 0.001$) trunk ROM was observed in the farmer's lift (33.0 ± 10.7° versus 85.8 ± 10°) than the deadlift.

Winwood, Cronin, Brown, & Keogh (2015a) found that mean vertical force production in the heavy sled pull (1326 ± 463 N) was approximately half of that observed in the back squat (2579 ± 648 N), conversely mean anterior force production was approximately thirteen times greater ($p \leq 0.001$) in the heavy sled pull (555 ± 107 N) than in the back squat (43 ± 22 N). Significantly less hip and knee ROM was observed in the heavy sled pull (hip: 51.8 ± 19°; knee: 37.4 ± 14.7°) than in the back squat (hip: 106.0 ± 9.3°; knee: 104.8 ± 9.8°).

Winwood, Cronin, Brown, & Keogh (2015b) found 24% greater trunk ROM (82.7 ± 8.4° versus 66.8 ± 12.0°; $p = 0.010$) and 8% greater hip ROM (125.5 ± 8.9° versus 115.7 ± 10.4°; $p = 0.028$) in the log lift than in the clean and jerk.

Table 2: Peak forces and joint/segment range of motion results.

	Winwood et al. (2014)		Winwood et al. (2015a)		Winwood et al. (2015b)	
	Farmer's lift Mean (SD)	Deadlift Mean (SD)	Sled pull Mean (SD)	Back squat Mean (SD)	Log lift Mean (SD)	Clean & Jerk Mean (SD)
Peak VF (N)	3215 (508)	3175 (494)	1736 (463)	3503 (1268)d	4552 (1306)	4616 (1486)
Mean VF (N)	2893 (442)	2679 (471)g	1326 (364)	2579 (648)a	1940 (424)	1921 (385)
Peak AF (N)	184 (80)	132 (62)	810 (174)	126 (73)a	1238 (899)	1433 (1173)
Mean AF (N)	66 (23)	41 (15) e	555 (107)	43 (22) a	76 (36)	82 (31)
Peak PF (N)	-98 (38)	-101 (34)	-53 (48)	-133 (79)	-1257 (1015)	-1431 (1096)
Mean PF (N)	-36 (21)	-39 (12)	-32 (24)	-35 (13)	-67 (14)	-91 (27)i
Trunk ROM (°)	33.0 (10.7)a	85.8 (10)	-20.2 (19.7)	-28.8 (5.1)	82.7 (8.4)	66.8 (12.0)f
Thigh ROM (°)	-35.5 (7.1)	-34.0 (11.5)				
Hip ROM (°)			51.8 (19.0)	106.0 (9.3)b	125.5 (8.9)	115.7 (10.4)h
Knee ROM (°)	44.8 (13.4)	44.0 (17.5)	37.4 (14.7)	104.8 (9.8)c	52.7 (9.3)	62.8 (18.7)
Ankle ROM (°)	6.2 (9.4)	8.8 (8.0)	31.8 (9.4)	24.0 (6.1)	9.0 (4.6)	15.0 (7.6)

a: p =<0.001 b: p = 0.002 c: p = 0.004 d: p = 0.005 e: p = 0.007 f: p = 0.010 g: p = 0.021 h: p = 0.028 i: p = 0.034

VF = vertical force AF = anterior force PF = posterior force

Based on the results of the above three studies Winwood et al. (2015) devised a training study to provide evidence on the implementation of these exercises into a strength and conditioning program. The study compared changes in body composition, strength, power, speed and change of direction (COD) of resistance trained amateur and semi-professional rugby athletes, before and after undertaking a seven-week training program consisting of either strongman or traditional weight training equivalent exercises. This study utilised the strongman and traditional exercises presented in Table 2, along with the arm over arm prowler pull and axle press (strongman group) and the single arm dumbbell row and military press (traditional group), throughout each of the programs. Between-group differences indicated small positive effects in muscle mass (ES = 0.44: -0.4 vs. 0.0 kg) and acceleration sprinting performance (ES = -0.33: 0.01 vs. -0.02 s), and large improvements in 1 repetition maximum (1RM) bent over row strength (ES = 1.10: 13.6 vs. 4.3%) associated with strongman compared with traditional training. Small to moderate positive changes in 1RM squat strength (ES = 0.47: 7.5 vs 2.7%), 1RM deadlift strength (ES = 0.66: 11.0 vs 5.7%), horizontal jump (ES = 0.56: -0.09 vs -0.03 m), COD turning ability (ES = -0.38: 0.05 vs <0.01 s), and 15 m sled push performance (ES = -0.46: 0.14 vs 0.05 s) were associated with traditional compared with strongman training.

DISCUSSION: The results presented provide insight into kinematic and kinetic output similarities and differences between strongman and traditional weight training exercises. Such results may be relevant to strongman athletes as well as strength and conditioning coaches who may look to utilise these alternative resistance training exercises for their athletes.

In the study by Winwood et al. (2014), the significantly greater mean vertical and anterior forces produced during the farmer's lift when compared to the deadlift may suggest that the farmer's lift could be used as an alternate exercise to the deadlift in order to train athletes to generate greater propulsive forces. As a function of the higher starting position of the farmer's lift, it requires significantly reduced trunk ROM than the deadlift. This reduced trunk ROM may reduce the stress placed on the lumbar spine, and thus be useful to athletes recovering from injury or from heavy training and/or competitive demands.

While the heavy sled pull resulted in significantly lower vertical force production than in the squat, the heavy sled pull required significantly greater peak and mean anterior forces (Winwood et al., 2015a). This may be relevant for athletes who require greater horizontal force production during sprinting acceleration, scrummaging or when making and breaking tackles. Conversely, variations of the squat may be a better tool for developing greater vertical force and power production in athletes required to jump or move explosively in a vertical direction.

Results from the study by Winwood et al. (2015b), demonstrated that both the log lift and the clean and jerk are effective training mechanisms to develop forceful triple extension of the lower body, as well as shoulder flexion and elbow extension. The implementation of these exercises into the strength and conditioning program may be considered where jumping, side stepping or moving quickly from a universal athletic position to full extension is required. In the case of an athlete having a deficiency in the ability to generate forceful hip extension during a maximal triple extension effort, the greater trunk and hip ROM seen throughout the log lift suggest the log lift may teach the athlete to produce this force through a larger range of motion.

The similarities in the acute kinetic and kinematic profiles of the strongman and traditional weight training exercises demonstrated in the literature were consistent with the findings of the training study by Winwood et al. (2015) which compared the effects of a strongman to a traditional weight training program. These results suggest the use of either strongman or traditional weight training exercises in strength and conditioning programs result in similar body composition, strength and functional performance adaptations.

CONCLUSION: Based on the biomechanical similarities between strongman and technically similar traditional weight training lifts, strongman events may be used as an alternate training tool to traditional weight training exercises in order to develop muscular hypertrophy and strength and power. The significantly greater vertical force production and reduced trunk ROM of the farmer's lift than deadlift, and the significantly greater horizontal force production of the heavy sled pull than squat, may be of particular interest to strength and conditioning coaches. One limitation of the research in this area has been the utilisation of a single load for the strongman and traditional exercise comparisons. Future research should investigate force-velocity-power relationships across multiple loads in the strongman and traditional lifts to better understand the application of strongman exercises in strength and conditioning practice.

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