Unleashing Speed and Power: A Biomechanical Look at NASCAR Pit Crew Performance

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Summary

In this study, NASCAR pit crew athletes performed several plyometric exercises on force plates overlaid with concrete, mirroring pit road conditions. Force and power metrics were compared between positions and experience levels. Jackmen exhibited the fastest and significantly higher rate of force development of all positions during the isometric mid-thigh pull (IMTP) (5929 ± 2009 N/s), suggesting that speed-focused strength training may be particularly important for this position. Peak vertical force during the concentric phase and lateral power were greater in the highest-level of athletes, potentially highlighting the lateral athleticism required to run around the car.

Introduction

The biomechanics of motorsports, particularly NASCAR, remains largely unexplored despite significant physical demands on athletes [1]. NASCAR pit stops, performed by five crew members, are critical to race performance, with 4-6 pit stops per race. Average stop times have dropped from 14 to 11 seconds in the past decade, driving the need for more specialized athletes. Each crew role—carrier, fueler, jackman, and changer—requires distinct physical and technical skills, highlighting the importance of studying each position's physical demands [2]. However, the specific physical characteristics associated with optimal performance in each role remain poorly understood. This study aims to investigate how biomechanical profiles—quantified by force and power metrics—differ among NASCAR pit crew athletes based on their position and experience level.

Methods

This study assessed the biomechanics of 27 NASCAR pit crew athletes:16 Cup-level (the highest tier, 4/position) and 11 development athletes. Four tests were performed: isometric mid-thigh pull (IMTP), countermovement jump (CMJ), lateral CMJ (LCMJ) and single-leg hop (SLH). Ground reaction forces were recorded via tri-axial force plates (1000 Hz), and low-pass filtered at 20 Hz. To simulate the real-time environment, tests were conducted in pit crew shoes on concrete with embedded force plates. Variables included rate of force development (IMTP), peak force, vertical power (CMJ) and peak horizontal force (LCMJ/SLH). Position, experience, and interaction effects were assessed using a mixed model design in IBM SPSS Statistics 29 ($p < 0.05$).

Results and Discussion

Table 1 summarizes peak force outcomes. Jackmen had the fastest IMTP rate of force development (5929 ± 2009 N/s), while fuelers had the slowest (1906 ± 480 N/s) ($p<0.05$, Figure 1). Cup athletes showed higher CMJ concentric force ($p=0.013$) and greater LCMJ peak power. No differences were found between levels or positions for the SLH, and no interaction effect was observed across all tests.

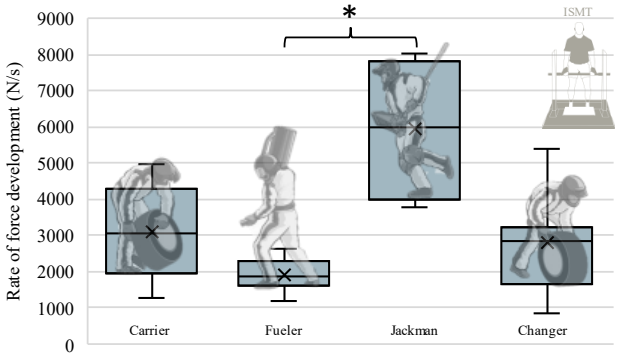

Figure 1: Rate of force development during IMTP.

Conclusions

This study offers initial insights into the force and power development of NASCAR pit crew athletes in their real-world surface—on concrete. Jackmen exhibited the fastest force development, perhaps emphasizing the need for speed-focused strength training. Additionally, power improved with experience. To further tailor position-specific training, kinematic data during pit stops could provide valuable additional insights. Furthermore, biomechanical analysis during pit stops would reveal a more detailed look at the movement requirements of these athletes during their sport.

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References

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Table 1: Mean ± SD for pit crew athletes at experienced (Cup) and development (Dev) levels during four standardized tests.

	Isometric mid-thigh pull		Counter movement jump		Lateral counter movement jump		Single leg jump	
	Peak force(N)	Rate force(N/s)	Con for r (BW)	Con for l (BW)	Power r (BWm/s)	Power l (BWm/s)	Con force r (BW)	Con force l (BW)
Cup(n=16)	2941±716	2779±1710	1.37±0.1	1.40±0.1	239.1±48	234.6±50	5.42±3.5	4.14±2.7
Dev(n=11)	2728±703	3571±1834	1.32±0.1	1.30±0.1	203.4±40	189±34	5.5±3.2	5.83±4.8
p	0.581	0.323	0.445	**0.013**	0.190	**0.013**	1.000	0.266