

# Differences in Spatiotemporal Parameters and Ground Reaction Forces between Soccer Players and Distance Runners

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## Summary

This study aimed to compare spatiotemporal parameters and ground reaction forces (GRFs) during running in soccer players and distance runners. Sixty-seven soccer players and forty-two distance runners performed treadmill running at 12, 15 and 20 km/h. Soccer players exhibited higher step frequency and contact time, compared to distance runners, regardless of running speed. Moreover, the time-series data of vertical GRF revealed that soccer players exhibited significantly higher values immediately after foot contact, but significantly lower values after 20% of the stance phase. In addition, soccer players demonstrated a significantly lower impulse of vertical GRFs. These findings suggest that soccer players adopt running strategies characterized by higher step frequency and longer contact time at a steady running speed, probably due to the lower impulse of GRFs compared to distance runners.

## Introduction

Soccer is a sport that combines intermittent and endurance exercise characteristics. Furthermore, as players rarely possess the ball during matches [1], improving running performance is crucial for overall athletic success. While there have been reports on the characteristics of GRFs and lower limb kinematics during sprinting in soccer players [2], the biomechanical characteristics of running at lower speeds, which are more common in actual matches, have not been elucidated. Therefore, this study aimed to identify the soccer-specific running techniques by comparing the spatiotemporal parameters and GRFs between soccer players and distance runners. Understanding the unique running technique of soccer players would inform the development of soccer-specific running training programmes in the future.

## Methods

Sixty-seven soccer players and forty-two distance runners ran on an instrumented treadmill at 12, 15 and 20 km/h for one minute each. Vertical, anterior-posterior and lateral GRFs during running were measured using the force plates embedded in the treadmill. Spatiotemporal parameters were analyzed from the time data of the recorded vertical GRF data. For each GRF component, peak values and impulses were calculated.

## Results and Discussion

The spatiotemporal results showed that, across all tested speed, soccer players had a significantly higher step frequency and longer contact time than distance runners ( $p < 0.05$ ).

Time-series analysis of vertical GRF showed that soccer players had significantly higher values immediately after foot contact, but significantly lower values after approximately 20% of the support phase ( $p < 0.05$ ). In addition, the peak value and impulse of the vertical GRF were significantly lower in soccer players ( $p < 0.05$ ). These findings suggest that soccer players may increase their step frequency to maintain steady running speed, as they exhibit lower GRFs compared to distance runners.

Table 1: Results of spatiotemporal parameters.

	Soccer players	Distance runners	$p$
Step frequency [steps/s]	$3.07 \pm 0.12$	$2.96 \pm 0.08$	0.01
Step length [m]	$1.41 \pm 0.05$	$1.46 \pm 0.04$	0.01
Contact time [s]	$0.19 \pm 0.002$	$0.18 \pm 0.002$	< .001

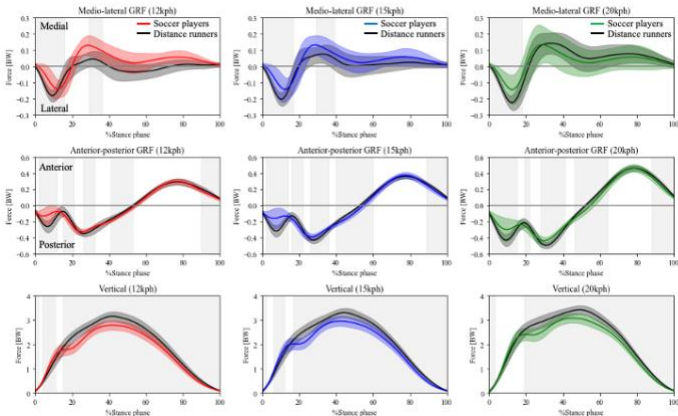


Figure 1: Mean ground reaction force curves during stance phase.

The vertical shaded area indicates a significant difference between soccer players and distance runners in SPM1d ( $p < 0.05$ )

## Conclusions

During steady-state speed running, soccer players showed different spatiotemporal variables and GRF characteristics than distance runners, with the smaller vertical GRF impulse and the higher step frequency.

## References

- [1] Carling, C. (2010). *J Sports Sci*, **28**: 319-26.
- [2] Kadlec, D. (2024) *Scand J Med Sci Sports*, **34**: e14763.