



INTRODUCTION & PURPOSE

Walking slope and cadence are important factors influencing the physiological and biomechanical demands of walking. Although the effects of slope and cadence on metabolic responses have been widely investigated^{1,2}, their combined effects on wearable sensor-derived mechanical indicators remain less understood. In particular, limited information is available regarding changes in Form Power (FP) and Form Power Ratio (FPR) under different walking conditions. Therefore, this study investigated the effects of walking slope and cadence on oxygen uptake (VO_2), FP, and FPR.

METHOD

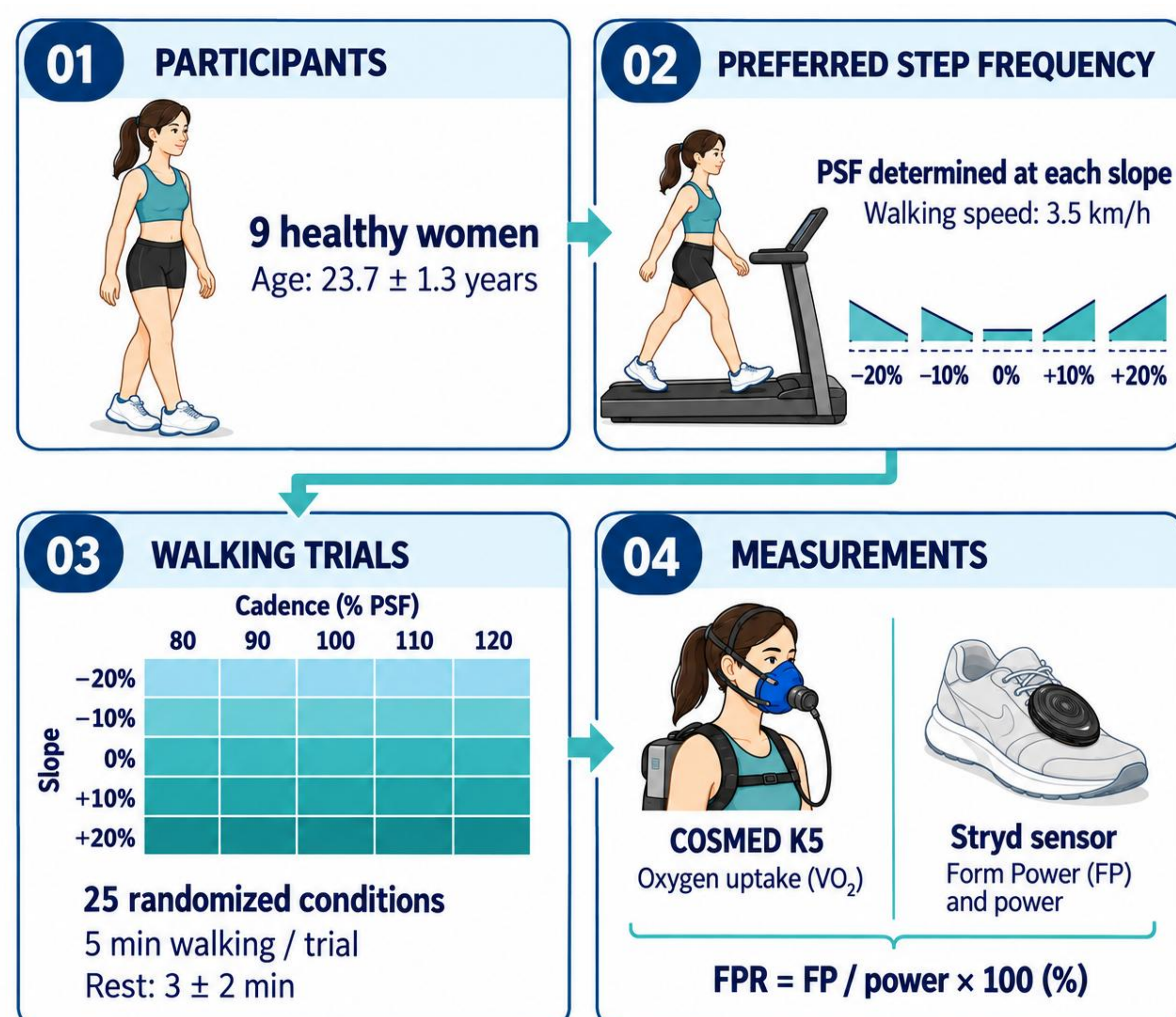


Figure 1. Experimental Design

Nine healthy women participated in this study (Table 1). Participants completed 25 randomized treadmill walking trials at 3.5 km/h, combining five slopes and five cadence levels (Figure 1). Data were analyzed using two-way repeated-measures ANOVA with Greenhouse–Geisser correction and Bonferroni-adjusted follow-up comparisons.

Table 1. Characteristics of the participants (M±SD)

Age (yrs)	Height (cm)	Weight (kg)	BMI (kg/m ²)
23.7±1.3	160.8±3.5	58.1±8.9	22.4±3.2

CONCLUSION

- Slope × cadence interactions were significant for FP and FPR, but not VO_2 . During -20% downhill walking, FP and FPR increased significantly at 120% PSF compared to lower cadence.
- These findings indicate that cadence-dependent changes in FP and FPR vary by slope and suggest that high-cadence downhill walking imposes mechanical demands not captured by VO_2 .
- Thus, elevated FP/FPR under steep downhill, high-cadence conditions should not be directly interpreted as reduced walking efficiency, and direct biomechanical measurements are required to confirm actual lower-limb loading.

RESULTS

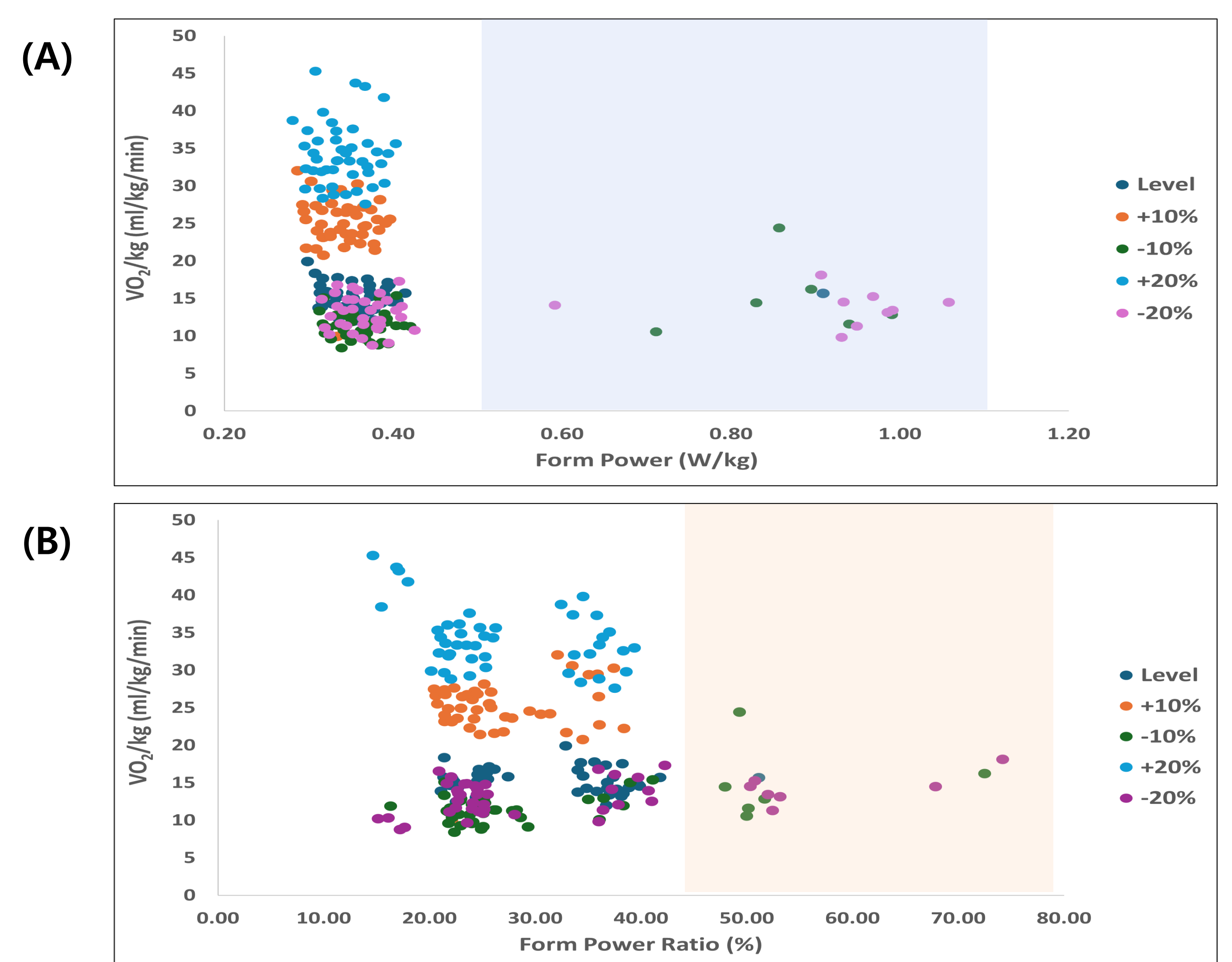


Figure 2. Relationships of VO_2 with FP (A) and FPR (B) across walking slopes

Most observations clustered within a relatively narrow FP range despite substantial variation in VO_2 . However, some downhill observations showed markedly higher FP and FPR values while VO_2 remained relatively low (Figure 2).

Table 2. Effects of slope and cadence on VO_2 , FP, and FPR

Variable	P-value			Partial η^2
	Slope	Cadence	Slope × Cadence	
VO_2	<.001	.044	.230	.166
FP	.002	<.001	.001	.499
FPR	.126	<.001	<.001	.452

Table 3. Bonferroni-adjusted comparisons of FP and FPR between cadence levels at -20% slope

Cadence comparison	FP, adjusted p	FPR, adjusted p
120% vs 80% PSF	.005	.003
120% vs 90% PSF	.006	.007
120% vs 100% PSF	.008	.001
120% vs 110% PSF	.102	.015

Slope × cadence interactions were significant for FP and FPR, but not VO_2 (Table 2). At -20% slope, FP at 120% PSF exceeded values at 80-100% PSF, while FPR exceeded values at all lower cadence levels (all adjusted $p < .05$; Table 3).

1. Jessup LN, Kelly LA, Cresswell AG, Lichtwark GA. It is not just the work you do, but how you do it: the metabolic cost of walking uphill and downhill with varying grades. *J Appl Physiol* 135: 1263-1267, 2023.

2. Russell, D. M., & Apatoczky, D. T. (2016). Walking at the preferred stride frequency minimizes muscle activity. *Gait & Posture*, 45, 181-186.