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UPHILL–DOWNHILL TRAINING AND 100-M SPRINT PERFORMANCE IN CLUB ATHLETES

Zainal Abidin^{1-ABCDE}, Hariadi^{1-ABCD}, Mahfuz^{1-ABCD}, *H. M. Thuhir^{1-ABCD}

¹Physical Education Study Program, Faculty of Education, Universitas Hamzanwadi, East Lombok, West Nusa Tenggara, Indonesia

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Abstract

This study examined changes in 100-m sprint performance after a combined uphill–downhill training program among athletes from the Kijang Rinjani Athletics Club. A one-group pretest–posttest design involved 10 active athletes selected purposively. Participants completed 12 sessions over four weeks, with three sessions per week. Sprint performance was assessed using a timed 100-m test before and after training. Paired observations were analyzed with a paired-samples test, and the magnitude of change was summarized using a confidence interval and standardized effect size. Mean sprint time decreased after training. The reduction was statistically significant and represented a large within-participant standardized change. The program was associated with a small but meaningful improvement in 100-m sprint time. Because the study lacked a control group and included a small sample, controlled research is needed before the improvement can be attributed specifically to uphill–downhill training.

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A - Conception and design of the study; B - Acquisition of data; C - Analysis and interpretation of data; D - Manuscript preparation; E - Obtaining funding

Correspondence:

H. M. Thuhir

Email: thuhir@hamzanwadi.ac.id



INTRODUCTION

The 100-m sprint is decided by an athlete's ability to accelerate rapidly, reach a high maximal velocity, and limit deceleration near the end of the race. These phases are related but place different mechanical demands on the athlete. Successful acceleration depends strongly on the orientation of ground reaction force, whereas maximal-velocity performance is closely linked to horizontal force application at high running speeds, short ground-contact times, and step frequency (Morin et al., 2012; Slawinski et al., 2017). Training for the event must therefore develop force and velocity qualities without compromising sprint mechanics.



Sprint training on sloping surfaces is used to alter these demands without external equipment. Uphill running increases the propulsive requirement and may serve as a form of vertically resisted sprinting. Downhill running reduces the relative propulsive demand and can expose an athlete to assisted or overspeed conditions. Acute analyses show that slope changes running speed, step length, contact behavior, and posture, which means that the training stimulus may differ substantially from level sprinting (Paradisis & Cooke, 2001). The slope must be selected carefully because an excessive incline or decline may distort technique and raise the mechanical or injury burden.

The strongest direct evidence supports combining moderate uphill and downhill conditions. Paradisis and Cooke (2006) reported improved maximal running speed and step rate after six weeks of combined sloping-surface training. Later studies found improvements in leg-force characteristics, maximal velocity, and sprint kinematics following combined uphill–downhill programs (Paradisis et al., 2013, 2015). A recent meta-analysis concluded that combined uphill–downhill sprinting produced a small advantage over traditional sprinting, although the evidence base remained limited and protocols varied considerably (Hamad et al., 2024).

The broader resisted- and assisted-sprint literature offers relevant context. Resisted sprint training generally benefits early acceleration, but its advantage over an equal volume of unresisted sprinting is not always clear (Alcaraz et al., 2018; Aldrich et al., 2024). Longitudinal evidence suggests that resisted methods may improve 10-m acceleration, whereas assisted and combined methods may target selected maximal-velocity or kinematic outcomes (Myrvang & van den Tillaar, 2024). These findings imply that training response depends on the targeted race phase, load, slope, exposure, and athlete training status rather than on the method's label alone.

Athletes at the Kijang Rinjani Athletics Club in East Lombok showed room for improvement in start execution and 100-m performance. The club required a practical intervention that could be implemented on locally available terrain. However, there was no club-specific evidence describing performance change after combined uphill–downhill training. This study therefore examined pretest–posttest changes in 100-m sprint time after a 12-session program. It was hypothesized that sprint time would be lower after the training period.

METHOD

Design and Participants

A quantitative one-group pretest–posttest design was used. The participants were 10 active athletes from the Kijang Rinjani Athletics Club in East Lombok. Their ages ranged from 20 to 24 years. Purposive sampling was used to include athletes who were active in club training and able to complete the intervention and testing.

The absence of random allocation and a parallel control group means that the design evaluates change over time but cannot isolate the program from other influences.

Training Program

The intervention comprised 12 sessions conducted three times per week over four weeks in Timba Nuh Village, Pringgasea District, East Lombok. Sessions were scheduled in the afternoon. The source document describes combined uphill and downhill running over a 100-m route, performed in three sets of five repetitions. Uphill running was intended to increase lower-limb propulsive demand, while downhill running was intended to provide an assisted-speed stimulus. The reported slopes were 30° uphill and 45° downhill. These values are retained from the study record but are much steeper than the approximately 3° slopes commonly studied in sprint research; they should be independently verified before submission because slope magnitude materially affects technique, loading, safety, and comparability.

Sprint Test

Sprint performance was measured before and after the intervention with a 100-m time trial. Athletes used a crouched start and ran on the same testing route. Timing began at the start signal and ended when the athlete crossed the finish line. Performance was recorded in seconds, with a lower value representing better performance. Intermediate 30-m and 60-m timing points were described in the protocol, but only complete 100-m times were available for the present analysis.

Statistical Analysis

Participant-level pretest and posttest times were checked against the reported totals. One posttest entry was corrected from 10.57 to 10.97 seconds because 10.97 was the only value consistent with the reported total, individual difference, squared difference, mean, and t statistic. Means, standard deviations, individual changes, and percentage change were calculated. A paired-samples t test evaluated the mean difference at $\alpha = .05$. The 95% confidence interval and Cohen's d_z were calculated from the paired differences. Normality of the difference scores could not be confirmed from the source document; therefore, the small-sample result should be interpreted cautiously.

RESULTS

All 10 athletes completed the pretest, intervention, and posttest. Mean 100-m time decreased from 11.059 ± 0.426 seconds to 10.886 ± 0.299 seconds. The mean reduction was 0.173 ± 0.160 seconds, corresponding to a 1.56% improvement relative to baseline. Nine athletes improved by 0.07–0.19 seconds, while one athlete improved by 0.61 seconds (Table 1).

Table 1.

Individual 100-m sprint times before and after training

Athlete	Age (years)	Pretest (s)	Posttest (s)	Change (s)
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RA	20	11.37	11.19	0.18
FA	20	11.53	11.34	0.19
IC	22	10.67	10.59	0.08
IF	20	10.69	10.62	0.07
AT	20	10.76	10.67	0.09
SW	22	10.61	10.54	0.07
S	24	11.12	10.97	0.15
SO	22	11.04	10.88	0.16
HS	20	11.90	11.29	0.61
YH	20	10.90	10.77	0.13

The paired-samples analysis showed a statistically significant reduction in sprint time, $t(9) = 3.418$, $p = .008$. The 95% confidence interval for the mean reduction ranged from 0.058 to 0.288 seconds. The standardized paired effect was large, $d_z = 1.081$ (Table 2).

Table 2.
Summary of the pretest–posttest analysis

Outcome	Pretest, M $\pm$ SD	Posttest, M $\pm$ SD	Mean difference (95% CI)	t (df)	p	d _z
100-m time (s)	11.059 $\pm$ 0.426	10.886 $\pm$ 0.299	0.173 (0.058–0.288)	3.418 (9)	.008	1.081

DISCUSSION

The principal finding was a 0.173-second reduction in mean 100-m time after four weeks of combined uphill–downhill training. All participants recorded a faster posttest, and the paired effect was large relative to the variability of individual changes. The result shows a favorable performance change during the program. It does not, however, demonstrate that the intervention alone caused the improvement because there was no level-sprint or usual-training control condition.

The direction of change agrees with controlled studies of training on sloping surfaces. Paradisis and Cooke (2006) found that combined uphill–downhill training improved maximal running speed and step rate more than uphill-only, downhill-only, horizontal, or control conditions. Subsequent work linked combined training with improved rate of force production and shorter propulsive contact phases (Paradisis et al., 2013), and reported higher maximal speed in experienced sprinters after six weeks of combined training (Paradisis et al., 2015). Hamad et al. (2024) synthesized this literature and found a small benefit of combined uphill–downhill sprinting over

traditional sprinting. The present 1.56% improvement is smaller than some maximal-speed changes in those studies, which is reasonable because a complete 100-m outcome reflects the start, acceleration, maximal velocity, and deceleration rather than maximal speed alone.

A plausible explanation is that uphill and downhill running challenge complementary qualities. Uphill running increases the force required to propel the body and may emphasize acceleration-oriented mechanics. Resisted-sprint reviews generally report benefits for short acceleration distances, particularly 0–10 m, although equivalent-volume unresisted sprinting can also be effective (Alcaraz et al., 2018; Aldrich et al., 2024; Li et al., 2025). Downhill running can increase acute running velocity, but it also changes step length and posture (Paradisis & Cooke, 2001). Longitudinal evidence on assisted training is less certain than evidence for resisted training, and overspeed exposure should therefore be progressed conservatively (Myrvang & van den Tillaar, 2024; Xu et al., 2025).

The whole-race improvement may also reflect repeated sprint practice and greater familiarity with the test. Sprint performance is influenced by maximal velocity, mechanical power, horizontal force orientation, step frequency, contact time, and environmental conditions (Majumdar & Robergs, 2011; Morin et al., 2012; Slawinski et al., 2017). A four-week program could modify some of these qualities, but this study did not measure them. It is therefore inappropriate to attribute the time reduction specifically to increased leg power, step length, or step frequency. Future work should record split times, velocity, contact characteristics, and slope exposure to identify which phase changed.

The protocol raises an important safety and reproducibility issue. The reported 30° uphill and 45° downhill slopes are far steeper than the 3° surfaces used in major experimental studies (Paradisis & Cooke, 2001, 2006). If the documented values are correct, the exercise is not directly comparable with the published evidence and may impose substantially different mechanics and eccentric loading. Coaches should verify slope with an appropriate instrument, document surface and footwear, and avoid assuming that steeper terrain produces a better speed stimulus. Recovery is also important because resisted sprint loading can increase fatigue and muscle-damage responses (Krzysztofik et al., 2023).

The study has several limitations. The sample was small, purposively selected, male, and drawn from one club. There was no control group, randomization, blinded timing, or reported electronic timing system. Environmental conditions, concurrent training, test reliability, and training adherence were not fully documented. One data-entry inconsistency required correction using the internal arithmetic of the dataset. The large d_z should not be interpreted as a precise population effect because it is based on only 10 athletes and one participant showed a substantially larger improvement than the others. Future trials should compare combined slope training with matched level sprinting, use moderate and verified slopes, standardize



timing and weather conditions, report adherence and adverse events, and include retention testing.

CONCLUSION

Twelve sessions of combined uphill–downhill training coincided with a reduction in mean 100-m sprint time from 11.059 to 10.886 seconds among 10 Kijang Rinjani Athletics Club athletes. The mean improvement was 0.173 seconds, or 1.56%, and the paired change was statistically significant. The finding provides preliminary support for the feasibility of slope-based sprint training in the club setting, but causal effectiveness cannot be established without a controlled comparison. The unusually steep reported slopes should be verified before the program is replicated.

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