Original Research

Effect of GPS Feedback on Lactate Threshold Pacing in Intercollegiate Distance Runners

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ABSTRACT

International Journal of Exercise Science 6(1) : 74-80, 2013. In their roles as coaches, the authors have observed that first-year collegiate distance runners often have difficulty running at prescribed training paces during lactate threshold (LT) training runs. Previous research has validated the accuracy of global positioning system (GPS) devices in providing distance and velocity feedback during running. The purpose of this study was to determine the efficacy of using the Garmin Forerunner 305 GPS watch (Garmin) to reduce deviations from prescribed training paces during LT runs with first-year collegiate runners. Participants were two groups of varsity cross country runners who completed a three-week LT training intervention either with (n = 5) or without (n = 6) a Garmin device. Prescribed training paces were based off an initial time-trial. In both the pre- and post-test runs, in which all runners ran without a Garmin device, differences were calculated between the prescribed pace and actual pace. The comparisons revealed a significant difference between the training groups in the post-test. Those runners who trained with the Garmin device had a significant decrease in pacing variability. This suggests that GPS pacing feedback appears to be an effective tool at improving LT pacing in first-year collegiate distance runners.

KEY WORDS: GPS, lactate threshold, pacing, running, Garmin Forerunner

INTRODUCTION

Training aimed at improving the lactate threshold (LT) of distance runners is an objective of most distance running coaches. Research suggests that race pace in distance running endurance events is closely associated with LT (3) and that a strong relationship exists between LT and 10-km running race performance (6). Additionally, there is evidence that the correlation between LT and 10-km race performance is stronger than the correlation between VO_2max and 10-km race performance (3, 6). Because of its strong correlation to distance running race performance, LT training is a common component of many collegiate distance runners' programs. Although several training methods have been proposed to improve LT, continuous bouts of running at (or just below) an intensity (i.e. pace) that induces LT have been reported to be an effective training prescription (7). Physiologically, an intensity that is a couple of seconds per mile too fast may induce blood lactate increases which may change the nature of the workout by inducing fatigue more rapidly and causing premature training session termination. In their roles as coaches, the authors have observed that many first-year collegiate distance runners often have difficulty running at their prescribed training paces during LT runs; the runners either go too fast initially and slow down, or go too slow. As a result of this training error, maximal training benefits may not be attained, which can ultimately negatively influence physiological adaptation and thus race performance.

The use of global positioning system (GPS) devices to measure running speed has been previously validated (1, 9, 10). McGregor and Lauchu utilized Garmin Forerunner 305 (Garmin International, Inc.; Olathe, KS) GPS watches to record training duration, pace, and changes in grade in order to monitor overall training load in four male high-school runners; however, there is no evidence demonstrating the efficacy of these devices in improving pacing while running (8). Specifically, can feedback from a GPS device assist first-year, collegiate runners in learning appropriate pacing? Because research reporting the efficacy of utilizing GPS devices as a practical tool to enhance "real life" distance running training is lacking, the purpose of this study was to determine the efficacy of using the Garmin Forerunner 305 GPS watch (Garmin) in providing pacing feedback during LT runs with first-year collegiate runners. It was hypothesized that there would be a decrease in variability in running pace on LT runs with runners that used the Garmin device for distance and velocity feedback.

METHODS

Participants
Study participants were recruited from freshmen distance runners on an NCAA Division III cross country team. Eleven runners (6 male, 5 female) volunteered to participate and provided informed consent before the beginning of the study. All study procedures were approved by the Institutional Review Board of the university. Due to a limited number of Garmin devices (n=5) available, five participants were randomly placed in the experimental group (3M/2F), while the remaining six participants were placed in the control group (3M/3F). None of the study participants had previously used a Garmin device during training runs.

Protocol
All participants completed an initial maximal effort time trial which was used to determine their respective LT training run pace. Female participants completed a 4-kilometer (km) time trial, while male participants completed a 6.4-km time trial. The time trial course consisted of loops on flat, grassy terrain. Time trial distances and courses were determined by the teams' coaching staffs based on the coaches' beliefs about which training would produce the best performance outcomes and based on logistical considerations such as what courses were available for use. Male participants completed four loops on a 1.6-km course while female participants completed two 2-km loops. Individual participant LT training paces were calculated through a series of two mathematical derivations utilizing each participant's time trial performance as an input. First, an equivalent 3-km race time was calculated for each participant based upon previously published conversions (2). Based on those conversions, the coaching staff considered LT training run pace to be at 88% of 3-km race pace. Similarly, the coaching staff considered the men's time trial performances to be at 93.5% of 3-km

race pace and the women's time trial performances to be at 97.5% of 3-km race pace. During the study duration (5 weeks), a participant's LT training paces were adjusted, if necessary, to compensate for fitness changes as determined from actual race performance. Race distances ranged from 6-km to 8-km for men and 5-km to 6-km for women. The coaches attempted to account for factors such as course terrain and weather conditions (both for the races and for the training runs) when adjusting training paces. These adjusted LT training paces were computed using the same 2-step process previously outlined. Alteration of LT training paces insured that each participant continued to train at the equivalent relative exercise intensity throughout the study.

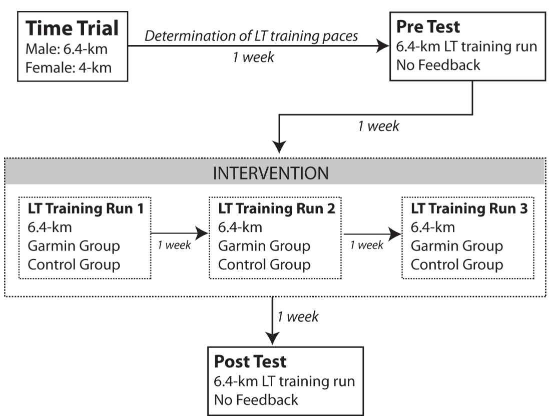

Figure 1. Individual lactate threshold (LT) training paces were determined from initial time trial performances. The Pre Test, Post Test, and three intervention sessions were all 6.4 km in duration and were conducted on the same 1.6 km loop.

During the five weeks following the time trial, the participants completed their normally prescribed LT training runs, 1 time per week. The LT training runs for all of the participants were 6.4-km in distance and were completed on the same 1.6-km loop that was used for the male time trial. The first LT training run after the time trial served as a pre-test. Each of the next three LT runs served as intervention sessions. The fifth LT run served as a post-test (Figure 1).

During the LT training runs, the time of each 1.6-km loop was recorded for each participant and the overall average pace was calculated. In order to eliminate pacing feedback during the pre-test and the post-test, participants were not allowed to wear a watch and did not receive any pacing information from the coaching staff. During the LT training runs in the three intervention weeks, participants in the intervention group wore a Garmin device and participants in the control group were only allowed to wear non-GPS watches. Use of non-GPS watches was permitted in the control group to best simulate typical feedback experienced by runners, and thus the control group runners were theoretically capable of mentally calculating their split times. For both the testing and training runs, participants were not permitted to run with the other group to insure that the control group did not receive additional, indirect feedback. Furthermore, all study participants began their LT training and testing runs at staggered 30-second intervals in order to avoid influencing each other's paces. Additionally, for both testing and training runs, the runners were explicitly instructed to run with even pacing as close to the prescribed pace as possible. In addition to the fact that racing was strongly discouraged, the teams' coaches monitored the pace and intensity of each runner to insure that the runners were not racing. With the exception of the aforementioned days, no restrictions were placed on participants pertaining to run partners, and all study participants completed all of their non-study team training in the same manner as the other non-study team members. Specifically, the study participants did not utilize GPS watches on non-study training days.

Each Garmin device was set to visually display the following information: (i) overall run time, (ii) time for current 1.6-km loop, (iii) average pace for entire LT run, and (iv) average pace for current 1.6-km loop. Pace information was displayed as minutes:seconds per mile. Additionally, each Garmin device was programmed to take an auto-split every 400-meters (m). With each auto-split, the Garmin device beeped and visually displayed the time of the 400-m split for several seconds.

Statistical Analysis

From the data collected, pace deviation scores were calculated for each participant for each LT run. Pace deviation scores were defined as the absolute value of the difference in seconds between the prescribed pace (minutes:seconds per 1.6-km) and the actual pace (average minutes:seconds per 1.6-km) for the overall LT run. Due to the small sample size and non-parametric nature of the data, Komolgorov-Smirnov tests were used to compare differences between groups, and the Wilcoxon Signed Ranks tests were utilized to compare within group changes (4). All statistical calculations were completed using SPSS V. 16 (IBM Corp., Somers, NY).

RESULTS

Comparison of group means on the pre-test with a 2-tailed, 2-sample Komolgorov-Smirnov test showed no significant differences, $D(9) = .716$, $p = .685$. Because the groups were initially the same, the changes in the pace deviations scores between the groups were then compared. Runners who wore a Garmin device showed a significant reduction in their pace deviations scores by 14 seconds per 1.6-km compared to runners who did not wear a Garmin device, who averaged a reduction of only 3 seconds per 1.6-km, $D(9) = 1.376$, $p = .045$ (Figure 2). Runners with a Garmin device showed significant improvement in the ability to decrease their pace deviations ($Mdn = 6$), $z = -2.03$, $p = .04$, $r = -.91$. However, runners who trained without a Garmin device displayed no significant changes in their pacing ability, ($Mdn = 4$), $z = -.37$, $p = .71$, $r = -.15$. Mean pace deviation scores and standard deviations for the runners are reported in Table 1. The deviation scores of all of the runners who wore a Garmin device improved from the pre-test to the post-test, while only one runner in the control group improved their pacing ability.

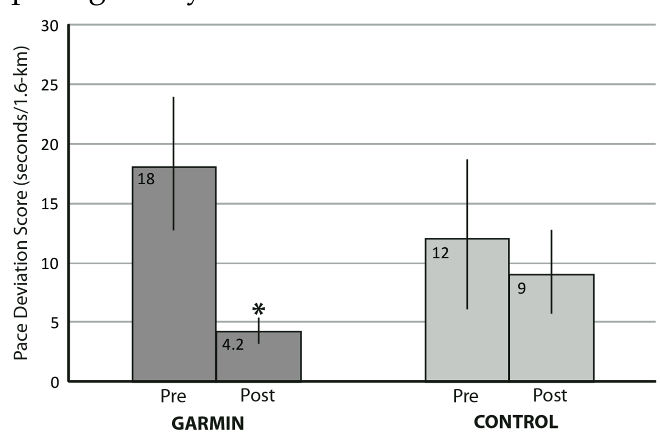

Figure 2. Pace deviation scores were significantly reduced (p = .045) in the Garmin group following the intervention while pace deviation scores were not significantly different (p = 0.71) in the Control group.

DISCUSSION

This study hypothesized that there would be a decrease in deviation from the

Table 1. Pace deviation was defined as the absolute difference between the prescribed-1.6 km pace (seconds/1.6-km) and the average 1.6-km pace. Pace deviation scores are reported in seconds. Negative numbers indicate faster than prescribed pace. All calculations (e.g. means) and statistics were determined using the absolute values. [G = Garmin group, C = Control group]

Group	Gender	Pre-Test Prescribed Pace	Pre-Test Deviation	Post-Test Prescribed Pace	Post-Test Deviation
Pace Deviation					
G1	*f*	7:45	10	7:42	-3
G2	*f*	6:48	-16	6:20	-2
G3	*m*	6:15	-7	6:00	5
G4	*m*	6:30	-20	6:10	-6
G5	*m*	6:50	-37	5:56	-5
|Mean| ± SD (sec)			18.0 ± 11.8		4.2 ± 1.6
C1	*m*	6:20	1	6:15	1
C2	*m*	6:50	-38	5:44	-4
C3	*f*	7:00	-2	6:48	2
C4	*f*	7:40	-10	7:16	-11
C5	*f*	7:24	-9	7:00	23
C6	*m*	6:20	-12	6:10	-13
|Mean| ± SD (sec)			12.0 ± 13.5		9.0 ± 8.4

prescribed running pace on LT runs for runners that used the Garmin device for distance and pace feedback. The results from this study support the original hypothesis suggesting that a GPS watch providing pace and velocity feedback may play an important role in pacing during LT runs. The results are especially notable given that the Garmin device intervention included only three LT runs. The three-week intervention period was designed to allow for enough use of the Garmin, but was also not so long as to allow all study participants to become familiar with LT pacing and mask the potential benefit to training that the Garmin device may provide. With just this limited feedback, LT pacing was significantly improved; on inspection of the individual data, each Garmin device user improved in absolute terms following the intervention.

In their roles as coaches, the authors have observed that many first-year collegiate distance runners struggle to correctly run the prescribed training paces during LT training runs. This problem most likely stems from both a practical (e.g. lack of experience) and physiological factors. While not as much of a concern to most coaches as running too fast, running a few seconds per mile too slow does not induce as much fatigue and may shunt the desired physiological stress that is intended for the LT training runs. As a consequence, the stimulus for adaptation is diminished. In order to maximize adaption, LT workouts must be run within a specific pace range. That specificity, however, leads to difficulties for studies such as this one because the corresponding effect sizes can be very small. Small effect sizes generally require studies to have large numbers of participants in order to have enough power to detect statistically significant differences (if those differences truly exist). As is the case with many sport-related activities, small absolute differences may have large practical significance, but, by definition, have very little statistical significance. Despite this disadvantage, the results of this study clearly showed that the use of the Garmin device significantly improved performance on the post-test for the intervention group. In just three intervention training sessions, the Garmin group was better at running a pace without any feedback. This difference was statistically significant and potentially practically significant.

There are other types of training for which GPS devices could be useful, such as long runs, various types of intervals, and recovery runs. Future research on the effects of GPS watches on the performance during these other types of training would be beneficial from a coaching perspective. Because of the current lack of research on the efficacy of GPS watches on run training and performance, it is difficult for coaches and individual athletes to evaluate if the cost of the device is justified by the potential improvement in performance. If the majority of training runs completed by distance runners were LT runs, then the results of this study would indicate that the GPS watches are probably worth the cost. However, because LT runs represent only one of the many different types of training runs utilized by distance runners, more research is needed. We speculate that the results of this study would apply to those training runs and that improvements in pacing are inversely related to the experience of the runners. If that hypothesis is correct, then GPS devices may provide the greatest improvement for the most inexperienced runners.

Despite every effort to control for confounding variables, this applied sport study was limited by practical factors. For example, the cost of the Garmin devices limited this study to five participants in the intervention group, and the distances of the time trials was constrained by the decisions of the coaching staff based on considerations such as training venue characteristics and the overall development of all the runners on the teams. Similarly, the number of total participants was limited by the nature of this study and the population sampled (first-year collegiate runners). Another study limitation was potential inaccuracies in prescription of training paces. Although prescribed training paces were derived from races and/or time trials based on commonly utilized correlations between race performances and LT paces (2, 5, 11, 12), there is an inherent ambiguity associated with prescription of LT paces. Despite the limitations associated with prescription of LT paces, every effort was made to ensure that each runner was prescribed a pace that approximated their true physiological LT pace for each LT run.

Advancements in GPS technologies have made real-time run pacing feedback a possibility in both affordable and portable devices. While previous studies have evaluated the accuracy of GPS devices and their ability to record training variables (8, 9, 10), the efficacy of using GPS technology as a coaching tool has never been investigated. The present study demonstrated that first-year intercollegiate runners have an improved ability to deviate less from prescribed LT pacing following only a three-week intervention using GPS watches. Improved run pacing can lead to maximized training stimulus and potentially to improved race performances. It is important that future studies investigate the efficacy of GPS technologies on run pacing in other populations (i.e. experienced runners) and at other intensities.

ACKNOWLEGDEMENTS

The authors wish to acknowledge and thank the participants from the 2008 SUNY Cortland men's and women's cross country teams as well as their head coach, Steve Patrick, for all of their support and contributions.

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