HHS Public Access

Author manuscript

*Int J Perform Anal Sport*. Author manuscript; available in PMC 2017 February 07.

Published in final edited form as:

*Int J Perform Anal Sport*. 2016 August ; 16(2): 602–611.

# The Motivational Influence of Milestone Times on 10-km Running Performance

**Daniel M. Cushman, MD**[1], **Ashwin Babu, MD**[2], **Benjamin Marshall, DO**[2], and **Monica Rho, MD**[2]

[1]University of Utah– Department of Physical Medicine & Rehabilitation

[2]Rehabilitation Institute of Chicago/Northwestern University Feinberg School of Medicine

## Abstract

To date, little research has been conducted to evaluate the potentially motivating effect of completing a race at a specific "milestone" finishing time. As this is difficult to perform in a laboratory setting, we examined 10-km runners from a large cohort to see if they were more likely to complete a race before rather than after a set milestone time (40:00, 45:00, and 50:00). Frequency distributions for finishers of each sex were created in 30-second time groups, with ideal normal distributions modeled based on this data. The actual time group frequencies were compared to the "expected" values from the modeled normal distributions. We included time groups that contained at least 1,000 finishers, thus were constrained to 36:00 – 52:00 for men and 43:30 to 52:00 for women. A total of 180,731 men and 53,047 women were included in the analysis. Men showed significant positive deviations (more finishers than expected) in the 39:30–40:00, 44:30–45:00, and 48:30–50:00 time groups (3 groups); they showed significant negative deviations only at 40:00–40:30 and 50:00–50:30. Women only showed significant positive time group deviations from 48:30–50:00 (1 group) with no significant negative deviations. In conclusion, despite the relatively arbitrary nature of milestones, they appear to exert a motivational influence on 10-km runners.

### Keywords

time; running; motivation; goals

## 1. Introduction

Running, as a sport, consists of an external competition (to be faster than other participants) as well as internal competition (to be faster than one's own personal finishing time). Runners routinely try to beat their own personal record times, times of their friends/family, and milestone times, such as 1 hour. Motivational influences, such as music (Lim, Karageorghis, Romer, & Bishop, 2014; Simpson & Karageorghis, 2006; Szabo, Small, & Leigh, 1999), video stimuli (Barwood, Weston, Thelwell, & Page, 2009; Onestak, 1997), deceptive clock manipulation (Morton, 2009), and optic flow (Parry & Micklewright, 2014), have been

**Author Correspondence Details**. Please send any and all correspondence to: Dan Cushman, 590 Wakara Way, Salt Lake City, UT 84108, dan.cushman.work@gmail.com, Phone: 305-588-1425, Fax: 801-587-5482.

demonstrated to increase performance. To our knowledge, the possible performance-enhancing effects of achieving a milestone time have not been directly investigated, though it potentially exists in every timed race. This is at least partly due to the difficulties of establishing a cohort of subjects around a specific milestone time in the laboratory setting. It would be extremely difficult to identify a subset of runners who would not be too fast for an examined milestone time (and thus easily eclipse the time), yet not be too slow for the time (and thus be unable to physiologically attain such a goal); only the runners who are very close to achieving a specific milestone time at their fastest pace would be appropriate subjects.

One of the most common running distances run in the United States is the 10-kilometer (km) distance - approximately 1.3 million runners participated in 2010 (more than double the amount that ran marathons) (RunningUSA, 2012). The larger races attract tens of thousands of runners of all abilities and speeds. The median finishing times are 55:56 (minutes:seconds) and 1:04:41 (hours:minutes:seconds) for men and women, respectively (RunningUSA, 2012). For the non-elite runners, popular goal times include 40 minutes (6:20 per mile), 45 minutes (7:12 per mile), 50 minutes (8:00 per mile), and one hour (9:36 per mile).

The effect of time on performance by means of deception (altering the clock or other factors) has been studied and does demonstrate alterations in performance in some situations in the laboratory setting (Ansley, Robson, St Clair Gibson, & Noakes, 2004; Hampson et al., 2004; Morton, 2009). The potentially motivating effect of a milestone time likely would only affect participants who were within striking distance of such a time at their maximal effort, which would be a relatively small percentage of the population. Coaches could potentially identify realistic, personalized milestone times to improve performance. We examined a large cohort of runners to look for relatively small differences in finish times; specifically, we looked at the number of finishers before and after popular “milestone” finishing times. We hypothesized that in 10km races, men and women were more likely to finish just under a 5-minute milestone time (40:00, 45:00, and 50:00) than just over that time.

## 2. Methods

The study was approved by the Northwestern University Institutional Review Board as an “exempt” study as it utilized publicly-available data for analysis. We collected data from publicly-available sources for ten of the largest 10km running races held in the United States (Cushman, Markert, & Rho, 2014). This data was collected from the official websites of all the races. In cases of missing or incomplete data, personal communication was undertaken with race organizers, who were often able to furnish additional data. The ten races included in the study are listed in the appendix. A total of 408,296 finishing times were collected, ranging from the years 2002 through 2011. Data were not obtained past one hour, as several races stopped timing at one hour or had incomplete times past that point.

Statistical analysis was performed utilizing a frequency distribution for each sex based on 30-second finishing-time increments, which we will refer to as "time groups," which can be

viewed as a histogram (Cushman et al., 2014). A best-fit normal distribution model was fitted to all finishers based off of this data. For each time group, an “expected” number of finishers for each time group was identified. The difference between the actual and modeled distribution was collected for each time group, which we will refer to as the "time group deviations." For example, if 4,000 runners in our cohort completed 10km races between 39:30 and 40:00, and a best-fit normal distribution predicted that 3,500 runners should finish the races in that time, we calculated a 39:30–40:00 time group deviation of +500 runners. If the number of runners in each time group perfectly matched the modeled normal distribution, all time group deviations would effectively be zero. Fewer runners than expected by our model would make the time group deviations negative, and more runners than expected made the time group deviations positive. As we assumed that a normal distribution would break down when there were too few finishers (large percentage deviations would be created despite relatively small frequency deviations) and too many finishers (large races create "clumping" of participants who are not able to thus finish as quickly as they would like), we constrained our normal model. We chose to set the lower end of the time groups to frequencies of greater than 1,000 finishers to exclude small time groups. We also chose to set the upper end of our model to 52 minutes to still include both sides of the 50 minute group we wanted to examine, and avoid the plateau phenomenon that would occur with later times around an hour, where race crowding would limit the number of runners (causing a spurious deviation from a normal distribution). Our cohort did not include finishing times greater than one hour due to unreliable timing past that point in several races.

Statistically-significant deviation from the modeled curve was defined as values greater than 1.96 standard deviations above and below a given value. This leaves a 95% likelihood that the actual histogram frequency lays within the calculated upper and lower limits. Statistical analysis was performed with PSPP (Gnu Project, Boston, MA).

## 3. Results

A total of 180,731 men and 53,047 women were included in the analysis. For men around 40 minutes, a significant positive deviation was found in the 39:30–40:00 time group (7.39% more finishers than expected) and significant negative deviations were present in the 40:00–40:30 (−4.89%) and 40:30–41:00 (−4.01%) time groups. For men around 45 minutes, a significant positive deviation was present for the 44:30–45:00 (+3.46%) time group. For men around 50 minutes, significant positive deviations were found in the 48:30–49:00 (+3.53%), 49:00–49:30 (+3.28%), and 49:30–50:00 (+4.07%) groups, while a significant negative deviation was found in the 50:00–50:30 group (−2.47%) (Figure 1 and Figure 2). There were no other significant deviations noted for men in other time groups. The largest time group deviation for men was the 39:30–40:00 time group, which had 7.39% more runners than expected. Furthermore, the largest time group deviation change between two consecutive time groups (possibly suggesting more runners from the slower group moving up to the faster group) was between the 39:30–40:00 and 40:00–40:30 time groups, which showed a percentage change of 12.3%. For women, there were three time groups that displayed a significant positive deviation - the 48:30–49:00 (+4.72%), 49:00–49:30 (+3.57%), and 49:30–50:00 (+4.07%) (Figure 3 and Figure 4). It should be noted that the 40 minute time

group for women did not have enough participants to be included in the analysis (n = 276 finishers).

## 4. Discussion

Our study demonstrates that runners are more likely to finish immediately prior to, and are less likely to finish immediately after, a milestone time. This finding was true for men at the 40:00 and 50:00 milestones. For women at 50:00 and men at 45:00, more runners were likely to finish just prior to those times but did not demonstrate a significant drop after the times. There were no other time groups that demonstrated significant deviations from the expected frequencies.

As the number of finishers after, and not before these time milestones is significantly reduced it is implied that the majority of these finishers are improving upon an expected time outcome. Though both intrinsic and extrinsic motivational factors are likely to have significant effect on the course completion time (Cerasoli, Nicklin, & Ford, 2014) the data may support the intrinsic motivation of a milestone time as prime determinant of these discrepancies in race completion times. Additional extrinsic motivational factors possible in our cohort have also been demonstrated to benefit athletic performance. For example, music has been shown to increase performance and/or lower physical discomfort (Lim et al., 2014; Simpson & Karageorghis, 2006; Szabo et al., 1999), and there is some evidence that this effect is more profound on less trained individuals (Brownley, McMurray, & Hackney, 1995). Video stimuli are less well described but also have shown some efficacy (Barwood et al., 2009; Onestak, 1997). However, the possible additional effort put forth by these sub-milestone finishers is not apparent at other time intervals suggesting less of a contribution from these extrinsic motivators that would have been present for all competitors (i.e. larger crowds, music at the end of the race, etc.). This post-milestone decrease in finishers could also reflect a combined effective shift of runners to latter times which may be representative of their unexpected inability to achieve a goal time and its effect on mood and perceived exertion (Baden, McLean, Tucker, Noakes, & St Clair Gibson, 2005). Gender differences may alter motivational drive in competitive environments (Gneezy, Leonard, & List, 2009; Gneezy & Rustichini, 2004; Niederle & Vesterlund, 2011); prior work by Morton has also shown that deceptively altering clock calibration can increase endurance times in men, but not women (Morton, 2009). Though our data demonstrated a more profound effect in men, both men and women runners improved their finishing time based on the clock milestones. What is interesting about these specific milestone times as possible motivational factors is that they are arbitrary in nature. If they were one minute more or less, one could imagine that the same association would be seen at the different time. Nevertheless this goal-specific focus has been cited as a major contributor to ongoing participation in competitive races by endurance athletes (Krouse, Ransdell, Lucas, & Pritchard, 2011) and in establishing pre-race pacing strategies (Roelands, de Koning, Foster, Hettinga, & Meeusen, 2013). To our knowledge, the effect of a specific milestone time has not been evaluated as a possible motivational factor. Testing this in the laboratory is difficult, as it would require a cross section of runners who were capable of running close to a specific milestone time without being too fast or too slow. However, future research could prospectively examine the effect of athlete-specific milestone times on running performance. Based on these results, it is

conceivable that one's performance can be improved simply by having an ambitious goal time for which to aim, which is a common thought amongst runners, anecdotally.

Pacing strategies for moderate distance races, including the 10km distance, tends to follow a traditional U-shaped pattern where elite runners run the first and last kilometers faster than the bulk of the course (Tucker, Lambert, & Noakes, 2006), similar to that seen in non-elite runners (Lima-Silva et al., 2010) with the limiting factor at this distance generally considered to be core temperature elevation (de Koning et al., 2011). At the 5km distance in non-elite runners, the optimal pacing strategy has been demonstrated to be establishing an initial pace that is 3–6% faster than one’s current average race pace (Gosztyla, Edwards, Quinn, & Kenefick, 2006), while conflicting strategies have been seen in other distances (Leger & Ferguson, 1974; Robinson, Robinson, Mountjoy, & Bullard, 1958) and sports (Foster et al., 1993). Multiple studies have shown that athletes change their pacing strategies based on the distance of their race (de Koning et al., 2011). Our study could imply that a large percentage of participants either implement or adapt their pacing strategy based on the goal milestone time before or during the race. However, it is unclear which strategy would predominate as we did not track the runners' paces throughout the race.

There are a few limitations to this study. First, we cannot prove causation; we only demonstrate that there is an association between milestone times and differences in frequencies of finishers. Second, the finding that runners are completing the race under a specific milestone does not necessarily suggest that runners are running at their maximum speed. For example, a man capable of running a 45 minute 10-km run may be running at a 50:10 pace, but then speeds up at the end just to beat the clock. This still suggests a motivational influence on performance, but does not necessarily suggest that the participants are all performing personal bests. The personal bests and each runner’s finishing times at other races were not recorded. Third, there is no literature to suggest that runners complete the races in a normal distribution; an alternate model could be superior. As no more accurate distribution has been described, and very few time groups show significant deviation from a normal distribution model, we feel this distribution is appropriate for our large cohort. Fourth, we were limited by the number of women runners finishing between 38 and 52 minutes. The first time-group for women that met our inclusion criteria of 1,000 finishers was in the 43:30–44:00 time group, thus missing the possibility of analyzing their finishing frequencies at the 40 minute range. It should also be noted that none of these times are close to the finishing times of elite runners, so one cannot extrapolate these results to performance enhancement amongst the fastest runners. Finally, we did not track the training regimens of these runners. It is likely that the runners set their training goals for a particular time, so the degree to which training or race-day pacing played a part in performance gains remains unknown.

## 5. Conclusions

We present a large cohort of 10-km runners to illustrate the motivational influences of milestone times. Male runners demonstrated significantly more finishers prior to 40 minute, 45 minute, and 50 minute finishing times while female runners demonstrated significantly more finishers prior to 50 minutes. Though not necessarily indicating that runners improve

to personal best times in these cases, our results are suggestive that an arbitrarily adopted milestone time has a strong intrinsic motivational effect on 10-km pacing in race participants. This finding can be used to improve performance in recreational runners by identification and training plan designed for an appropriate milestone time.

## Acknowledgments

The authors would like to thank Todd Lyster for his invaluable computing expertise.

## References

Ansley L, Robson PJ, St Clair Gibson A, Noakes TD. Anticipatory pacing strategies during supramaximal exercise lasting longer than 30 s. Medicine and Science in Sports and Exercise. 2004; 36(2):309–314. [PubMed: 14767256]

Baden DA, McLean TL, Tucker R, Noakes TD, St Clair Gibson A. Effect of anticipation during unknown or unexpected exercise duration on rating of perceived exertion, affect, and physiological function. British Journal of Sports Medicine. 2005; 39(10):742–746. discussion 742–746. [PubMed: 16183771]

Barwood MJ, Weston NJ, Thelwell R, Page J. A motivational music and video intervention improves high-intensity exercise performance. Journal of Sports Science & Medicine. 2009; 8(3):435–442. [PubMed: 24150008]

Brownley KA, McMurray RG, Hackney AC. Effects of music on physiological and affective responses to graded treadmill exercise in trained and untrained runners. International Journal of Psychophysiology. 1995; 19(3):193–201. [PubMed: 7558986]

Cerasoli CP, Nicklin JM, Ford MT. Intrinsic Motivation and Extrinsic Incentives Jointly Predict Performance: A 40-Year Meta-Analysis. Psychological Bulletin. 2014

Cushman DM, Markert M, Rho M. Performance trends in large 10-km road running races in the United States. Journal of Strength and Conditioning Research. 2014; 28(4):892–901. [PubMed: 24077377]

de Koning JJ, Foster C, Bakkum A, Kloppenburg S, Thiel C, Joseph T, Porcari JP. Regulation of pacing strategy during athletic competition. PloS One. 2011; 6(1):e15863. [PubMed: 21283744]

Foster C, Snyder AC, Thompson NN, Green MA, Foley M, Schrager M. Effect of pacing strategy on cycle time trial performance. Medicine and Science in Sports and Exercise. 1993; 25(3):383–388. [PubMed: 8455455]

Gneezy U, Leonard KL, List JA. Gender Differences in Competition: Evidence From a Matrilineal and a Patriarchal Society. Econometrica. 2009; 77(5):1637–1664.

Gneezy U, Rustichini A. Gender and competition at a young age. American Economic Review. 2004:377–381.

Gosztyla AE, Edwards DG, Quinn TJ, Kenefick RW. The impact of different pacing strategies on five-kilometer running time trial performance. Journal of Strength and Conditioning Research. 2006; 20(4):882–886. [PubMed: 17149992]

Hampson DB, St Clair Gibson A, Lambert MI, Dugas JP, Lambert EV, Noakes TD. Deception and perceived exertion during high-intensity running bouts. Perceptual and Motor Skills. 2004; 98(3 Pt 1):1027–1038. [PubMed: 15209320]

Krouse RZ, Ransdell LB, Lucas SM, Pritchard ME. Motivation, goal orientation, coaching, and training habits of women ultrarunners. Journal of Strength and Conditioning Research. 2011; 25(10):2835–2842. [PubMed: 21946910]

Leger LA, Ferguson RJ. Effect of pacing on oxygen uptake and peak lactate for a mile run. European Journal of Applied Physiology and Occupational Physiology. 1974; 32(3):251–257. [PubMed: 4836732]

Lim HB, Karageorghis CI, Romer LM, Bishop DT. Psychophysiological effects of synchronous versus asynchronous music during cycling. Medicine and Science in Sports and Exercise. 2014; 46(2): 407–413. [PubMed: 24441216]

Lima-Silva AE, Bertuzzi RC, Pires FO, Barros RV, Gagliardi JF, Hammond J, Bishop DJ. Effect of performance level on pacing strategy during a 10-km running race. European Journal of Applied Physiology. 2010; 108(5):1045–1053. [PubMed: 20012450]

Morton RH. Deception by manipulating the clock calibration influences cycle ergometer endurance time in males. Journal of Science and Medicine in Sport. 2009; 12(2):332–337. [PubMed: 18356107]

Niederle M, Vesterlund L. Gender and Competition. Annual Review of Economics. 2011; 3(1):601–630. doi:

Onestak D. The effect of Visuo-Motor Behavior Rehearsal (VMBR) and videotaped modeling (VM) on the free-throw performance of intercollegiate Athletes. Journal of Sport Behavior. 1997; 20(2): 185–198.

Parry D, Micklewright D. Optic flow influences perceived exertion and distance estimation but not running pace. Med Sci Sports Exerc. 2014; 46(8):1658–1665. [PubMed: 24500533]

Robinson S, Robinson DL, Mountjoy RJ, Bullard RW. Influence of fatigue on the efficiency of men during exhausting runs. Journal of Applied Physiology. 1958; 12(2):197–201. [PubMed: 13525261]

Roelands B, de Koning J, Foster C, Hettinga F, Meeusen R. Neurophysiological determinants of theoretical concepts and mechanisms involved in pacing. Sports Medicine. 2013; 43(5):301–311. [PubMed: 23456493]

RunningUSA. 2011 Marathon, Half-Marathon and State of the Sport Reports. 2012 Retrieved from http://www.runningusa.org/node/%2076115#76664.

Simpson SD, Karageorghis CI. The effects of synchronous music on 400-m sprint performance. Journal of Sports Sciences. 2006; 24(10):1095–1102. [PubMed: 17115524]

Szabo A, Small A, Leigh M. The effects of slow- and fast-rhythm classical music on progressive cycling to voluntary physical exhaustion. Journal of Sports Medicine and Physical Finess. 1999; 39(3):220–225.

Tucker R, Lambert MI, Noakes TD. An analysis of pacing strategies during men's world-record performances in track athletics. International Journal of Sports Physiology and Performance. 2006; 1(3):233–245. [PubMed: 19116437]

## Appendix

Races included in study:

| Race Name | Race Location |
|---|---|
| AJC Peachtree Road Race | Atlanta, GA |
| Bellin 10k Run | Green Bay, WI |
| Cincinnati Thanksgiving Day Race | Cincinnati, OH |
| Cooper River Bridge Run | Charleston, SC |
| Dicks Sporting Goods Bolder Boulder | Boulder, CO |
| Richard S. Caliguiri City of Pittsburgh Great Race | Pittsburgh, PA |
| Rodes City Run | Louisville, KY |
| Scotland Run | New York City, NY |
| Statesman Capitol 10k | Austin, TX |
| UAE Healthy Kidney 10k | New York City, NY |
| Wharf-to-Wharf (only top 200 participants per year) | Santa Cruz, CA |

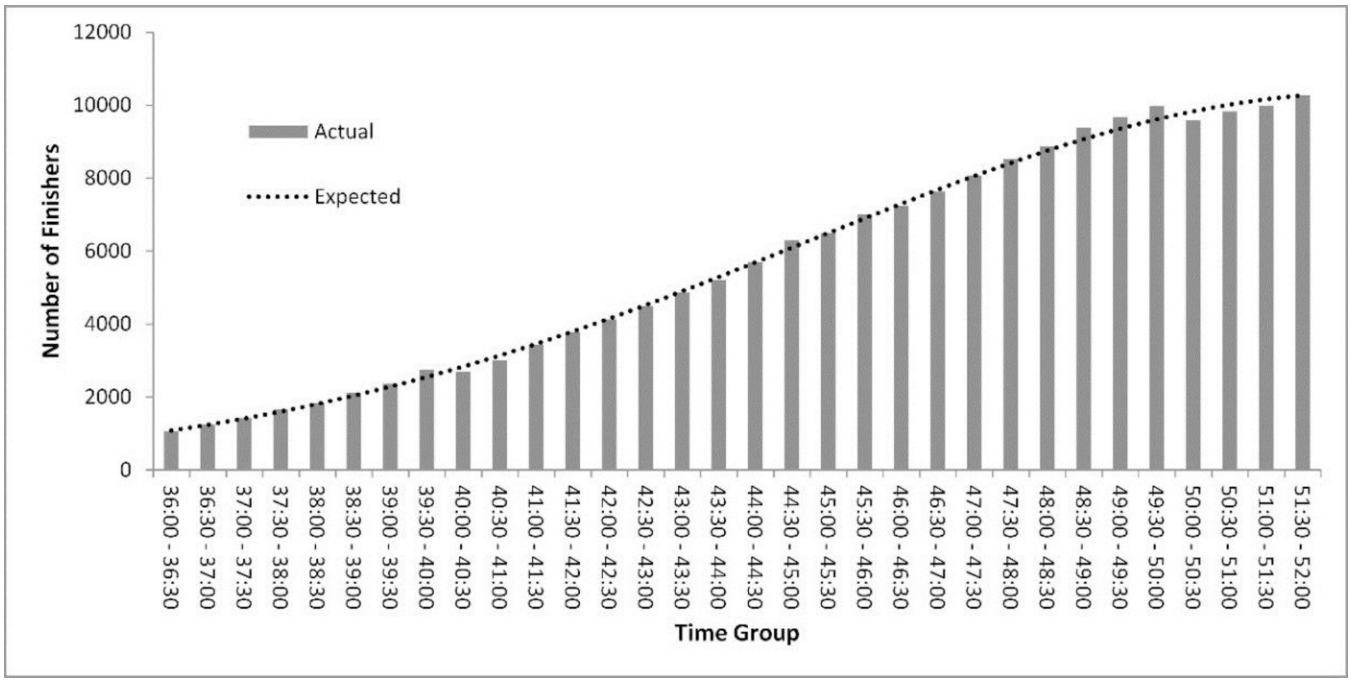


**Figure 1.**
Histogram of finishers in each time group overlying a normal distribution for men.

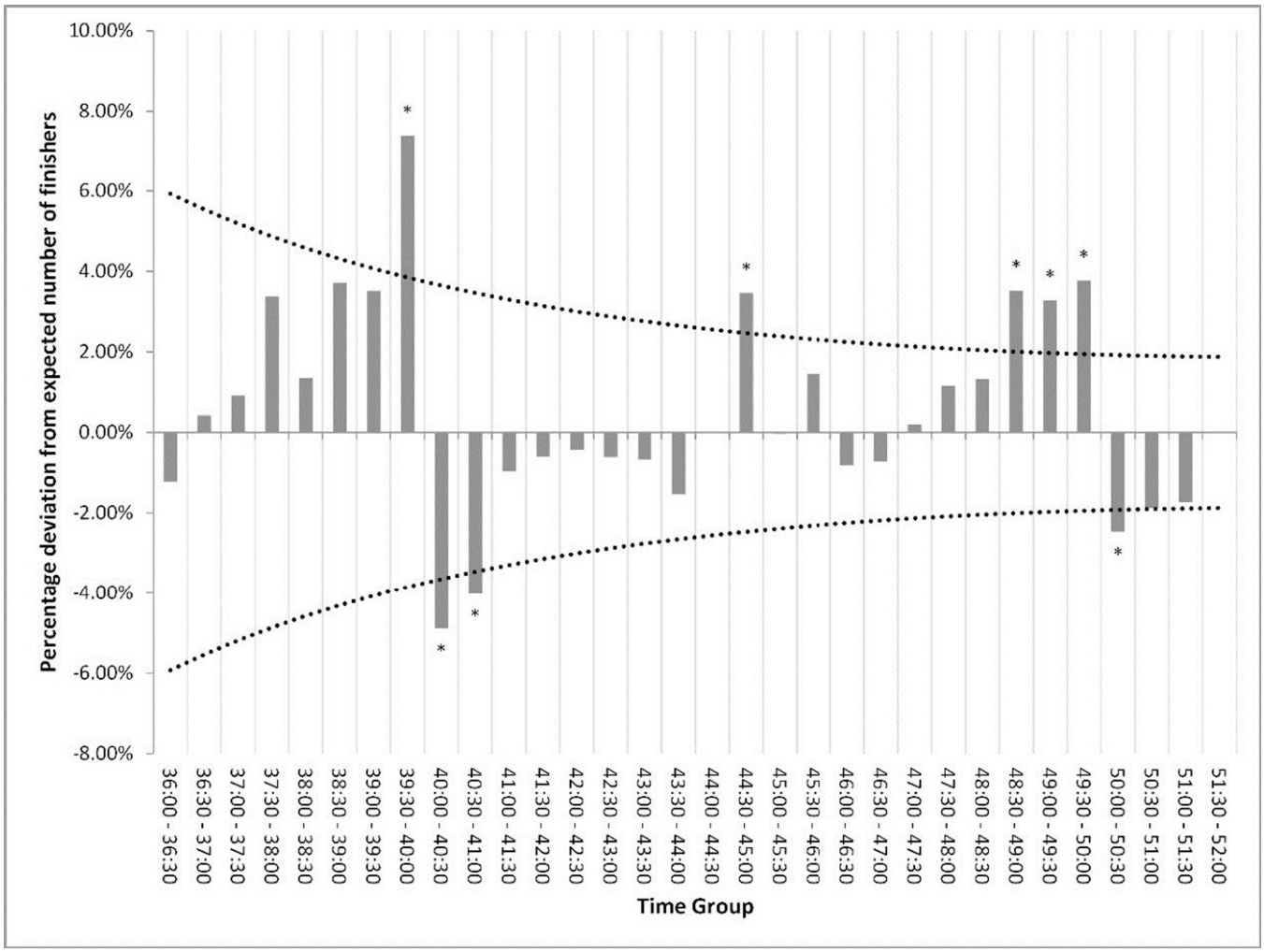


**Figure 2.**

Each bar represents the deviation from an expected number of finishers for a given time group. The dashed lines represent the upper and lower 95% confidence intervals for the expected number of finishers at each time group. Statistically significant results are denoted by an asterisk.

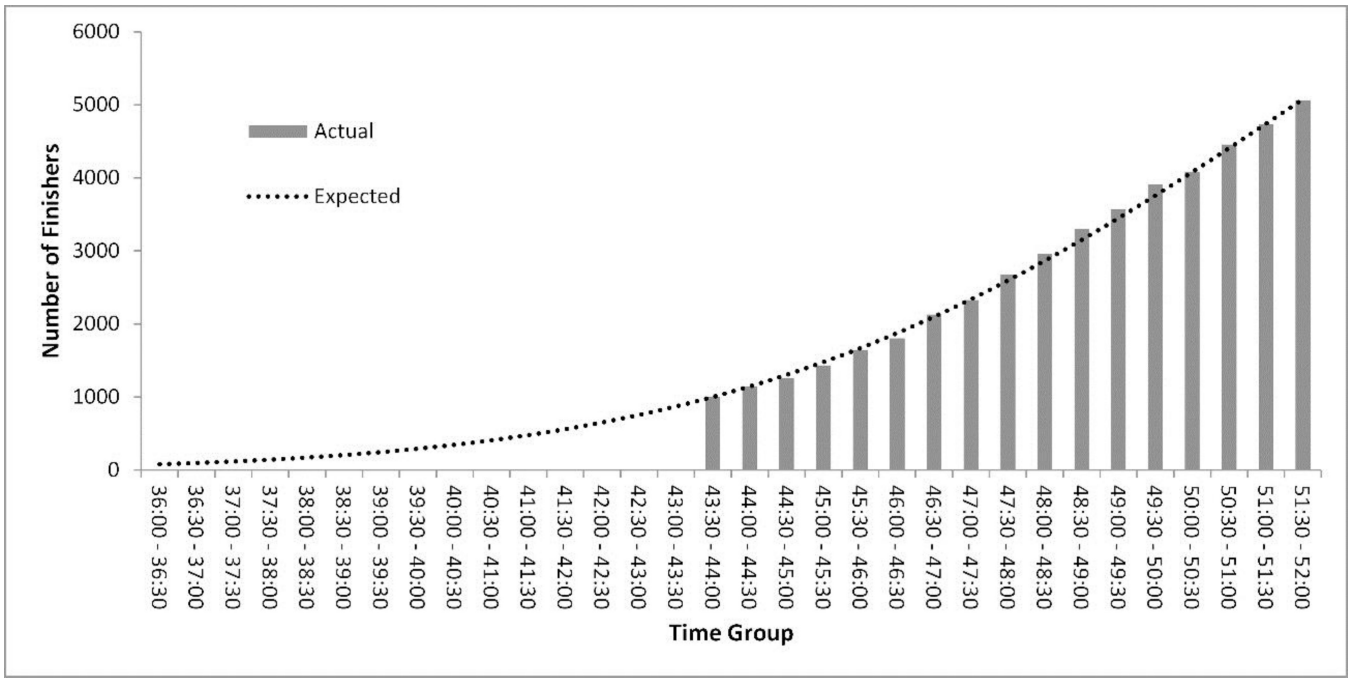


**Figure 3.**
Histogram of finishers in each time group overlying a normal distribution for women.

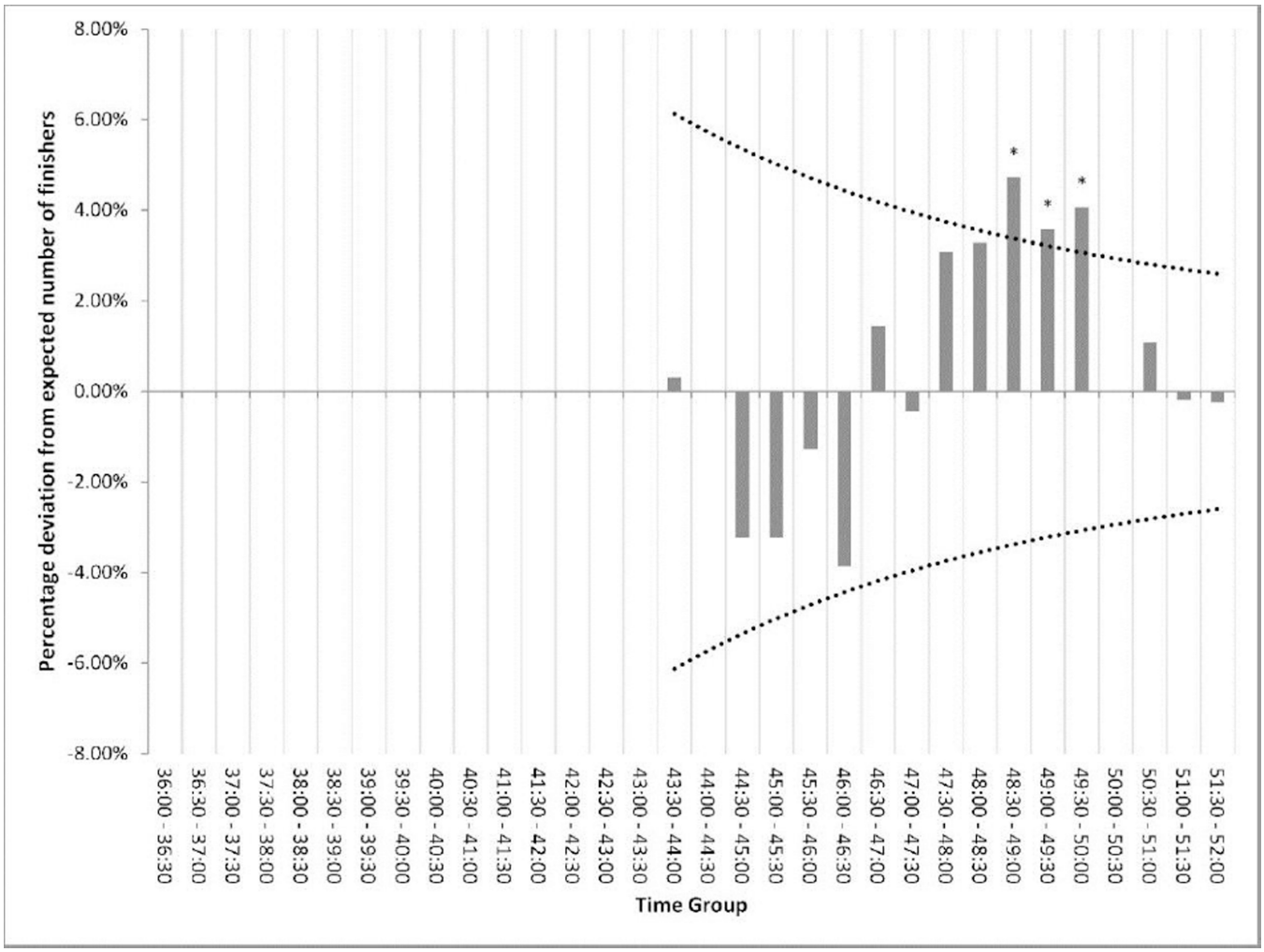


**Figure 4.**

Each bar represents the deviation from an expected number of finishers for a given time group. The dashed lines represent the upper and lower 95% confidence intervals for the expected number of finishers at each time group. Statistically significant results are denoted by an asterisk.