6-21-2023

An examination of race strategies in NCAA cross country championship events

Peter S. Finley
Nova Southeastern University, pfinley@nova.edu

Jeffrey J. Fountain
Nova Southeastern University, jeffjf@nova.edu

Journal of Coaching and Sports Science
Volume 2, Issue 1, 1-11.
e_ISSN: 2963-1483
https://www.journal.foundae.com/index.php/jcss/index

An Examination of Race Strategies in NCAA Cross Country Championship Events

Peter S. Finley*
Nova Southeastern University,
UNITED STATES OF AMERICA

Jeffrey J. Fountain
Nova Southeastern University,
UNITED STATES OF AMERICA

Article Info

Article history:
Received: April 29, 2023
Revised: May 18, 2023
Accepted: May 21, 2023

Keywords:
Running strategy;
NCAA cross country;
Racing performance;
Sports performance;
Cross-country coaching.

Abstract

This research sought to evaluate race strategies in Cross Country running to determine whether a fast, predicted, or slow start would yield the best results when coupled with an advancing or regressing strategy from the 1st checkpoint through to the finish. Twelve National Collegiate Athletic Association (NCAA) Championship races were analyzed from 2021 to 2022 (*N*=315 teams; 2,205 runners). Success was defined by each team's finish relative to their anticipated finish, as determined through pre-championship national rankings. Results indicated that starting well ahead of a predicted finishing place and advancing throughout the race can yield finishes well ahead of a team's ranking. Still, less than 5% of teams could employ that strategy. A more likely positive result came from a conservative start, coupled with consistently advancing through the field for the remainder of the race, as nearly 14% of teams could employ that strategy. Starting a race slowly did not typically lead to success, even if a team consistently advanced through the field after the 1st checkpoint. Teams that regressed throughout the race were not likely to have a successful race.

To cite this article: Finley, P.S., & Fountain, J.J. (2023). An examination of race strategies in NCAA cross country championship events. *Journal of Coaching and Sports Science, 2*(1), 1-11

INTRODUCTION

Pacing strategies in endurance sports receive considerable academic attention. This research is guided by the theory that team results in Cross Country can be maximized by running at a pace allowing the runners to consistently advance through the field instead of starting too quickly and regressing as the race progresses. Research on pacing in running races and other domains of endurance sports supports this theory. Earlier research on pacing favored even pacing over uneven pacing and regressing late in a race (Abbiss & Laursen, 2008; Gosztyla et al., 2006; Van Ingen Schenau et al., 1994). Recent research has developed on this, analyzing races with more accurate data, an increased number of split times, and consideration for finishing with an end spurt or acceleration. Marathon records tend to be set by running fast, settling into an even pace, and finishing with an end spurt (Pycke & Billat, 2022).

Similarly, elite runners seeking to cover a maximum distance in one hour, as opposed to running a specific distance as fast as possible, also benefit from pacing in such a way that they are accelerating at the end, as compared to regressing with fatigue (Girardi et al., 2022). In addition, runners in middle-distance races benefit from finishing quickly. An analysis of 37 world records set in the men's 1500-meter run determined that a fast end spurt was always present (Casado, García-Manso, et al., 2021). Further, in races as short as 800 meters, saving enough energy to accelerate over the final 300 meters positively correlates with finishing positions in major championships for both men and women (González-Mohíno et

al., 2021). Pacing adequately to save energy for an end spurt is also ideal for best performances in endurance sports other than running races. For example, swimmers in 800- and 1500-meter races who set season-best times also finished with an end spurt, and faster and more accomplished swimmers have more emphasized speed after races (Neuloh et al., 2023). Research has not evaluated whether running Cross Country races in a manner that allows teams to advance through the field yields better results than starting faster and regressing.

Every Cross Country course is unique and poses a significant challenge for runners navigating various terrains, such as grass and trails, as they run over hills and flats. The length of the races typically varies from 5-12 kilometers, depending on the level of competition and the gender of the competitors. Intercollegiate Cross Country is also a team sport, further complicating the creation of an effective racing strategy (Galloway, 2023). Achieving the lowest score is the primary objective of the Cross Country team. Teams of 7 runners take the starting line, occasionally amid hundreds of competitors. The first five finishers from each team constitute the "scoring runners," with the 1st finisher in the race receiving 1 point, the 2nd finisher receiving 2 points, and so on. A perfect score of 15 points will occur if all five scoring runners from a single team finish in the top 5 positions, which is a rarity in competitive meets. Typically, scores between 50 and 100 points win most major college meets.

While they do not contribute to the team score, the 6th and 7th runners still try to finish as fast as they can for two primary reasons; first, they want to be in the best position possible should a teammate ahead of them falter, putting them in position to be a scoring runner. Secondly, by finishing ahead of the scoring runners from other teams, they effectively push those runners back one position and add 1 point to the team total of their opponents. For example, if a team places its 6th runner ahead of the 4th and 5th runners from another team, their 6th runner would have effectively added 2 points to that opponent's total.

While prior research of distance running suggested that even pacing or finishing races with an end spurt has a strong relationship with finishing times (Girardi et al., 2022), most runners demonstrate a sub-optimal pacing strategy, as the runners begin at a pace that is too fast and cannot be maintained (Lane, 2017). While coaches emphasize pacing in a variety of practice settings, "humans are not naturally good at it in race conditions" (Lane, 2017). Recent research on running strategy has primarily focused on marathons and races on the track, which provide the most reliable split times. Research on sex-based differences in these events has found that women are better at running even-paced races, as they are more conservative in the early stages (Filipas et al., 2021). However, part of the explanation for men running more uneven splits is that they tend to accelerate later in races rather than slow down. As Hanley and Williams found, men successfully qualifying from the heats in major steeplechase races ran the second half of races faster than the first half, which has implications for coaching and preparation for such events. Further, analyzing courses to determine how pacing can reflect the course profile, which athletes and coaches can use to plan training and race strategy, has received attention (Oficial-Casado et al., 2022). Runners with a combination of risk-taking attitude and overconfidence can be at particular risk of dramatically slowing in races, particularly in the marathon (Deaner et al., 2019).

Studying pacing strategy in Cross Country is difficult because the courses seldom follow the same layout or design. Runners face various challenges at different points in each race, including hills, tight turns, sidehill running, and softer and firmer running surfaces. As such, runners would not be expected to run the same pace through a kilometer with large hills as through a flat kilometer with hard-packed ground. Running around bends tends to slow runners in races on the track (González-Mohíno et al., 2021), generally making even-paced running impossible (Mercier et al., 2021), and this challenge would likely be pronounced on Cross Country courses. Regardless, using perceived exertion levels (heart rate and respiration) as a proxy and maintaining a generally manageable energy output throughout the race would be desirable (Brick et al., 2016; Casado, Hanley, et al., 2021), as even-paced running has a lower energy output cost than racing with varied tempos (Noorbergen et al., 2016).

In events that have followed a loop course and allowed for pacing to be accurately recorded, such as the World Cross Country Championships, evidence showed that even the world's best Cross Country runners typically started the races very quickly and slowed as the race went on (Casado, Hanley, et al., 2021). The unique nature of Cross Country leads even the best runners to demonstrate pacing strategies that are different from races of similar length on a track (Redcay, 2023). Track races often follow a parabolic j-shaped profile, where the start, often led by paid pacemakers, is faster than the middle. Still, the sprint to the finish is the fastest segment of all. In contrast, Cross Country races typically follow a positive-split strategy, in which the opening segment of the race is faster than the closing effort as the athletes tend to fade (Auganæs et al., 2023; Casado, Hanley, et al., 2021).

A reasonable explanation for this could be that time is not an important metric in Cross Country running. The real goal is to finish ahead of the other runners. As everyone is tightly grouped at the beginning, slowing even slightly in the early going could mean losing dozens of places or more, so runners trying to keep pace with the leaders for as long as possible, even though they may be overexerting themselves (Hanley, 2014).

In Cross Country championship races, there is typically a mad dash for position early on, with participants running much faster than the overall pace they can sustain through to the finish (Tiefenthaler, 2021). The first minutes of these races, featuring fields of over 200 runners, are hectic. Runners attempt to solidify positions toward the front, wanting to avoid having to pass throngs of runners later. Thus, they employ an aggressive strategy to have them in an advantageous position before the course turns or narrows. As noted by Lane, these strategies can be "sensible gambles, but if everyone in a race is trying to get out, most are getting in over their heads without improving their position relative to the field. An overly aggressive start won't work if everyone uses it" (Lane, 2017).

In addition to starting a race aggressively for strategic reasons, the runners may be responding to external signals, including the pace of the surrounding field, the noise of the crowd, and the yelling of coaches. While athletes train their bodies to respond to a given pace and should perceive their exertion levels accurately and modulate their pace accordingly, the excessive stimuli and competitive stress, particularly in championship racing, might cause them to over-extend (Tucker & Noakes, 2009). In some cases, the feeling of starting a Cross Country race has been described as creating a sense of panic that can lead athletes to run well ahead of their intended pace, with each second gained in the opening minutes

costing the athlete as much as five seconds later in the race (Bentley et al., 2012). While a race cannot be won in the first mile, conventional wisdom suggests it can be lost by overexerting too soon (Buns, 2016). Therefore, coaching articles on successful race strategy often list the importance of not going out too fast as the first tip (Tiefenthaler, 2021).

Adding to this complex mix of stimuli, the fast, early pace for each runner would be affirmed as appropriate by the fact that hundreds of other runners are all doing the same thing. An additional challenge is that the runners do not receive pacing information for at least several minutes. During races on a track of similar length, runners receive accurate information every 4oo meters in the form of split times and can amend their pace accordingly. In Cross Country, they will likely not have such information until they reach one kilometer, or in some races, one mile, which can be too late if they have gone out too hard, and they could pay a physical price later.

This research aimed to explore various pacing strategies in NCAA Cross Country Championships for both men and women to determine which were more likely to yield successful results. Given that recording running pace is difficult in Cross Country, the placement of each team compared to the other teams was used as a proxy. To assess the success of a team's championship race, their final position was compared against an anticipated finish based on pre-race national rankings. The pacing strategies that were the focus of the research were divided into two phases of the race. The first phase divided teams into fast, predicted, or slow starting groups based on their placement at the 1st checkpoint relative to the predicted final placement. Then phase two examined how teams progressed from the 1st checkpoint through to the finish of the race. Teams were grouped in phase two based on whether they advanced through the field or did they fall back from the position they held at the 1st checkpoint. An analysis of the correlation between predicted and actual finishing places was conducted first to determine whether comparing actual finishes to predicted finishes was meaningful. Based on the theory that advancing through the field yields the best results in distance running, it was anticipated that teams that begin races conservatively and consistently advance through the field would be the most likely to finish better than their predicted finish, as based on pre-championship rankings.

METHOD

Participants were the qualifying teams for the NCAA National Championship races in 2021 and 2022 for both men and women in Divisions I, II, and III (12 races in total). The results were presented as descriptive statistics. Comparisons were made based on the percentage of teams that employed each of the six-race strategies and to what extent those strategies produced better or worse finishes than expected for each team. National Rankings were used to assign each team an expected finish. National Rankings were produced by the U.S. Track and Field and Cross Country Coaches Association (USTFCCCA). The poll is conducted by counting the votes from 11 member coaches, one each from the nine regions of the United States of America (The Great Lakes, Mid-Atlantic, Midwest, Mountain, Northeast, South, South Central, Southeast, and the West) and two from the members of the Cross Country Executive Committee. The rankings are published weekly and reflect each team's performance in Invitationals, Conference, and Regional Championships. Thirty teams from each division are ranked weekly, with additional teams listed as "receiving votes." The final rankings before the NCAA Championships were used for this study. Teams that did not qualify for the Championships were removed, and teams below them were moved up. Thus,

each team in the Championship race had an expected finish that reflected their ranking, from the highest ranked down to the team that received the fewest ranking votes.

Meet results were available through the National Collegiate Athletic Association Webpages for Men's and Women's Cross Country. In recent years the type of data made available has significantly increased, from just showing finishing scores to now showing the point totals of each team at checkpoints along each course in real-time, which allows for a greater understanding of how pacing strategies unfold. Races ranged from 31 to 34 teams per event. All the women's races were 6 kilometers in length. The men's races were 10 kilometers long for the Division I, and II meets and 8 kilometers in length for Division III. The number of checkpoints per race was not uniform. Men's races had between 6 and 11 checkpoints, and women's races had between 5 and 7 checkpoints. The first checkpoint was typically placed close to 1 kilometer into the race. In all cases, the finish line was considered the final checkpoint.

To analyze race performance by pacing strategy, the teams were first divided into three groups based on the difference between their actual place in the team score at the 1st checkpoint and their predicted finish. The teams at each race were ranked from the team farthest ahead of its predicted finish down to the team farthest behind its predicted finish. The ranked list was then subdivided into three nearly equal groups; those that were farthest ahead of their predicted finish were labeled as Fast starters, those closest to their predicted finish were labeled Predicted starters, and those farthest behind their predicted finish had a Slow start. One concern with subdividing the teams this way was that teams predicted to finish in the top spots could not be more than a place or two ahead of their predicted finish at the 1st checkpoint. Similarly, teams predicted to finish last, or close to it, could not be more than a place or two worse than their predicted finish. The remedy was that the teams predicted to finish in the top and bottom three places were removed from the dataset. In so doing, every team in the dataset could have been a minimum of 3 places ahead or behind its predicted finish when its score at the 1st checkpoint was recorded.

Given that the field for each race did not subdivide equally by 3, the Predicted start group was selected to be the larger group. For example, a race with 34 teams would have 28 teams considered in the sample (after removing the teams predicted to finish in the top and bottom three places) and would then yield 9 Fast starters, 10 Predicted starters, and 9 Slow starters. These three groups were then subdivided based on how each team progressed from the 1st checkpoint to the finish line. Teams that improved their position at half or more of the remaining checkpoints were deemed to be Advancing. Those that fell back at more than half the checkpoints were deemed to be Regressing. A premium was placed on consistency by dividing the groups based on whether they improved their scores at more or fewer than half the checkpoints remaining.

Once all the teams were assigned to 1 of the six subgroups, based on their performance within their own race, the groups were aggregated into men's and women's overall results for analysis. The final population consisted of 157 men's teams and 158 women's teams, represented by 1,099 men and 1,106 women.

RESULTS AND DISCUSSION

Results

To determine whether using predicted finishes based on the USTFCCCA rankings was appropriate, bivariate correlation tests were performed to examine the correlation between the USTFCCCA rankings and the actual team finishing places for each race. The two variables were significantly correlated in all the races analyzed. For the Men's races, the correlations ranged from ($r = .673$; $p = 0.001$) in the Division I raced in 2021 to ($r = .840$; $p = 0.001$) in the Division III race in 2021. The correlations for the Women's races ranged from ($r = .718$; $p =$

0.001) in the Division II race in 2022 to (r = .901; p = 0.001) in the Division III race in 2022. These findings supported the position that when a team finishes higher than their predicted finish, particularly when it occurs by several places, that team had a successful race.

Fast Start Group

There were 51 (32.5%) Men's teams designated to the Fast starters group. These teams arrived at the 1st checkpoint an average of 9.02 places (SD = 5.78) ahead of their predicted finishing places. 48 (30.4%) women's teams arrived at the 1st checkpoint an average of 8.32 places (SD = 4.39) ahead of expected.

Predicted Start Group

The next group of teams arrived at the 1st checkpoint in positions similar to their predicted finishing place. These teams were labeled the Predicted start group. This group had 55 (35.0%) men's teams, with an average rank difference of -0.09 places (SD = 3.28) between the 1st checkpoint position and their predicted finishing place. For the Women's Championships, there were 56 (35.4%) teams in the Predicted start group. They had an average rank difference of -0.05 places (SD = 2.62) off their predicted finishing places.

Slow Start Group

The third and final group was those teams that arrived at the 1st checkpoint well below their expected finishing places. The total number of men's teams in the Slow Start group was 51 (32.5%), with an average rank difference of -9.51 places (SD = 4.09) behind their predicted finish. There were 54 (34.2%) women's teams in the Slow Start group with an average rank difference of -8.54 places (SD = 4.10) behind expectations.

Advancing and Regressing Subgroups

The Fast, Predicted, and Slow starting groups were further divided into subgroups based on their performance from the 1st checkpoint to the race's conclusion. The teams identified as Advancing improved their score at half or more of the checkpoints from the 1st checkpoint to the finish. The finish line was considered the final checkpoint. This group accounted for 67 of the 157 men's teams (42.6%) and 75 of the 158 women's teams (47.5%). The remaining teams were Regressing, as they had achieved worse scores at more than half of the checkpoints.

Subgroup Results

Table One shows the results for each of the subgroups for the men's and women's championships regarding how the teams finished, on average, compared to their predicted finishing places. The subgroups are ordered from the most successful to the least successful. The order of each subgroup's success was the same for both genders. Results for each are discussed in that order.

Table 1. The success of race strategies relative to predicted finish

	Teams	Mean Finish*	Standard Dev.	Range*
Men's Results				
Fast-Advancing	9 (5.7%)	8.78	5.85	-1 to 17
Predicted-Advancing	20 (12.7%)	2.05	4.14	-4 to 10
Fast-Regressing	42 (26.8%)	0.05	5.54	-14 to 11
Slow-Advancing	38 (24.2%)	-0.50	4.11	-10 to 7
Predicted-Regressing	35 (22.3%)	-2.94	4.26	-13 to 6
Slow-Regressing	13 (8.3%)	-4.92	4.44	-12 to 1
Women's Results				
Fast-Advancing	6 (3.8%)	8.00	3.16	4 to 11
Predicted-Advancing	24 (15.2%)	2.25	3.30	-7 to 9
Fast-Regressing	42 (26.6%)	0.76	4.44	-7 to 12
Slow-Advancing	45 (28.5%)	-0.96	4.65	-13 to 11
Predicted-Regressing	32 (20.3%)	-1.75	4.44	-13 to 8
Slow-Regressing	9 (5.7%)	-7.00	4.56	-15 to -1

*The mean finish is relative to each team's anticipated finish based on pre-race national rankings. For example, teams in the Men's Fast-Advancing subgroup finished an average of 8.78 places better than predicted, and the range was from one place worse to 17 places better than predicted.

Employing a Fast-Advancing strategy yielded the best chance for teams to finish far ahead of their predicted finish but was also the least likely to occur. Only 5.7% of the men's and 3.8% of the women's teams could move up through the field consistently after starting the race well ahead of their predicted finish. On average, teams in this subgroup finished about eight places ahead of their predicted finish. Only 1 of the 15 teams in this group (a men's team) finished below expected, which was only by one place. The Predicted-Advancing strategy for both men's and women's teams was the second-best subgroup in terms of finishing higher than anticipated, and it was far more achievable than the Fast-Advancing strategy. While the teams in this subgroup only exceeded their predicted finish by just over two places on average, nearly three times as many teams were able to successfully employ this strategy when combining genders.

A Fast start often led to teams moving in the wrong direction for the remainder of the race; 82% of the men's teams and 88% of the women's teams that had a Fast start saw their score increase at more than half of the remaining checkpoints, placing them in the Fast-Regressing subgroup. These teams recorded average results, as the men's teams finished almost exactly as predicted. The women did slightly better, finishing nearly one place ahead of predicted, on average.

Discussion

Three subgroups yielded results that were worse than predicted. The best of the 3, with teams of both genders, was the Slow-Advancing group. Teams in this group, on average, overcame their slow start to finish nearly as predicted. For men, the average result was half a place worse than predicted, and for women, it was slightly worse, at nearly one place worse than predicted. This subgroup demonstrated that when teams start slowly, they are typically able to advance through the field for the remainder of the race; for the Slow starters, 74.5% of the men's teams and 76.9% of the women's teams improved their scores at half or more of the remaining checkpoints.

The Predicted-Regressing group demonstrated the importance of consistently moving forward after the first checkpoint. By failing to do so, teams in this group finished worse than predicted, on average, by nearly three places for men's teams and almost two for women's teams. It is important to note the difference between this subgroup and the Predicted-Advancing teams. While they were equally matched through the 1st checkpoint and thus put into the Predicted start group, the teams that moved up at half or more of the checkpoints finished well ahead of the teams that failed to do so. On the men's side, advancing through the field yielded a finish about five places better, compared to predicted results, and for the women, the Predicted-Advancing teams were about four places better off than the Predicted-Regressing teams. This suggested that making a predictable start only has value if the runners can then move through the field consistently across the remainder of the race (Loh et al., 2023).

The worst-performing group was the Slow-Regressing group. Teams in this group finished nearly 5 (men) and seven places (women) worse than predicted. It certainly could be said that starting slowly and holding on or regressing is not a strategy but an outcome (Sivaramakrishnan et al., 2023). It is the quintessential "bad day." Fortunately, most teams that started slowly were at least able to advance through the field at more than half the checkpoints. The Slow-Regressing subgroup only accounted for 8.2% of the men's and 7.6% of the women's teams. The findings of this research supported the theory that Cross Country teams are more likely to have a successful championship race if they pace themselves to advance through the field consistently and avoid regressing (DeJong Lempke et al., 2022). While the two highest performing groups started the races differently, either fast or as predicted, they advanced through the field at over half of the checkpoints from the 1st checkpoint to the finish line. However, This is tempered by the finding that if teams start too slowly, compared to their predicted place, they are unlikely to overcome the deficit even if they advance through the field consistently (Chadwick, 2023).

CONCLUSION

The results of this study support the theory that teams that are more conservative in the early going of races, holding back sufficient energy to continue to advance through the field for the duration of the race, were most likely to complete the event better than anticipated in the team scoring. Conversely, teams that spent much of the race regressing less frequently bettered their anticipated finish.

The application of this research for coaches is that it can guide the development of race strategy. It is, of course, the coach's responsibility to understand his or her athletes and

train them in ways that reinforce a selected race strategy. From this research, we learn that starting fast by running well ahead of a predicted finish can yield great results, but advancing through the field after a fast start is hard to do and seldom occurs. This should not be surprising. Starting fast takes a physical toll and likely leaves athletes unable to advance, despite their best intentions or desire. The success of teams that start fast and move up throughout the race may be a driver of the common practice of starting races very hard, trying to establish positions toward the front.

The most likely route to a good day in the NCAA Championship races was to have a conservative start and then advance consistently from the 1st checkpoint to the finish. Coaching athletes to start more moderately should be coupled with an emphasis on passing athletes consistently from checkpoint to checkpoint for the remainder of the race. A conservative start loses value if the athletes either hold onto their position or regress as the race progresses (Mondello et al., 2013).

Conversely, a slow start is difficult to overcome, even for teams that advance through the field consistently. There could be several reasons to explain why a slow start so often leads to a poor finish. It could be those slow starters had missed their physical peak. These teams might have peaked for the regional, specifically to qualify for the National Championships, but by the Championship race, they were in a state of physical decline. It is also possible that runners knew by their place in the field that they had gotten off to a slow start and felt demoralized and lost motivation. It is also possible that slow starters could not navigate through the dense field, were forced to run wide around corners, and were otherwise hamstrung by their placement behind hundreds of runners. Finally, these issues may combine to thwart the slow starters, resulting in worse finishes than predicted.

Implications for coaches and athletes are that they can create training plans and strategies around the importance of moving up through the field after starting conservatively. This challenges the typical pattern of Cross Country racing, in which athletes are very aggressive in the early going and regress for much of the race. This research is limited by the size of the data set and by the fact that not every race has the same number of checkpoints, and their locations on the courses vary. Another limitation is that the analysis required that the top and bottom teams, per the pre-race predictions, were not included for each race. Further research should add more races and varied levels to include American High School State Championships, such that courses have sufficient checkpoints to yield usable data. Also, research should be conducted on the race strategies the teams predicted to finish in the top three places.

AUTHOR CONTRIBUTIONS STATEMENT

Peter S. Finley was the primary author, collected the data, and reviewed the literature. Jeffrey J. Fountain analyzed the data and supported the writing effort.

REFERENCES

Abbiss, C. R., & Laursen, P. B. (2008). Describing and understanding pacing strategies during athletic competition. *Sports Medicine*, *38*(3), 239–252. https://doi.org/10.2165/00007256-200838030-00004

Auganæs, S. B., Buene, A. F., & Klein-Paste, A. (2023). The effect of load and binding position on the friction of cross-country skis. *Cold Regions Science and Technology*, *212*, 103884. https://doi.org/10.1016/j.coldregions.2023.103884

Bentley, D. J., Millet, G. P., Vleck, V. E., & McNaughton, L. R. (2012). Specific aspects of contemporary triathlon. *Sports Medicine*, *32*(6), 345–359. https://doi.org/10.2165/00007256-200232060-00001

Brick, N. E., Campbell, M. J., Metcalfe, R. S., Mair, J. L., & Macintyre, T. E. (2016). Altering pace control and pace regulation. *Medicine & Science in Sports & Exercise*, *48*(5), 879–886. https://doi.org/10.1249/MSS.0000000000000843

Buns, M. (2016). Race strategy for distance runners. *Coach up Nation*. https://www.coachup.com/nation/articles/race-strategy-for-distance-runners

Casado, A., García-Manso, J. M., Romero-Franco, N., & Martínez-Patiño, M. J. (2021). Pacing strategies during male 1500 M running world record performances. *Research in Sports Medicine*, *29*(6), 593–597. https://doi.org/10.1080/15438627.2021.1878459

Casado, A., Hanley, B., Jiménez-Reyes, P., & Renfree, A. (2021). Pacing profiles and tactical behaviors of elite runners. *Journal of Sport and Health Science*, *10*(5), 537–549. https://doi.org/10.1016/j.jshs.2020.06.011

Chadwick, A. (2023). *Challenging behaviours - what to know and what to do: the professional development file for all staff*. Taylor & Francis. https://books.google.co.id/books?id=mTW9EAAAQBAJ

Deaner, R. O., Addona, V., & Hanley, B. (2019). Risk taking runners slow more in the marathon. *Frontiers in Psychology*, *10*. https://doi.org/10.3389/fpsyg.2019.00333

DeJong Lempke, A. F., Hart, J. M., Hryvniak, D. J., Rodu, J. S., & Hertel, J. (2022). Prospective running assessments among division I cross-country athletes. *Physical Therapy in Sport*, *55*, 37–45. https://doi.org/10.1016/j.ptsp.2022.02.003

Filipas, L., La Torre, A., & Hanley, B. (2021). Pacing profiles of olympic and IAAF world championship long-distance runners. *Journal of Strength and Conditioning Research*, *35*(4), 1134–1140. https://doi.org/10.1519/JSC.0000000000002873

Galloway, J. (2023). *Cross-country running: The best training plans for peak performance in the 5K, 1500M, 2000M, and 10K*. Meyer & Meyer Sport. https://books.google.co.id/books?id=WQbCEAAAQBAJ

Girardi, M., Gattoni, C., Sponza, L., Marcora, S. M., & Micklewright, D. (2022). Performance prediction, pacing profile and running pattern of elite 1-h track running events. *Sport Sciences for Health*, *18*(4), 1457–1474. https://doi.org/10.1007/s11332-022-00945-w

González-Mohíno, F., Casado, A., Renfree, A., González-Ravé, J. M., & Hanley, B. (2021). The influence of running wide on the bend on finishing times and positions in men's and women's 800 m finals at major global championships. *Kinesiology*, *53*(2), 280–287. https://doi.org/10.26582/k.53.2.13

Gosztyla, A. E., Edwards, D. G., Quinn, T. J., & Kenefick, R. W. (2006). The impact of different pacing strategies on five-kilometer running time trial performance. *Journal of Strength and Conditioning Research*, *20*(4), 882–886. https://doi.org/10.1519/00124278-200611000-00026

Hanley, B. (2014, April 7). Cross country: Paced to perfection. *Athletics Weekly*. https://athleticsweekly.com/performance/cross-country-paced-perfection-2055/

Lane, S. (2017). Pacing strategy: Can analytics help us run faster in cross country? *USTFCCCA News & Notes*. https://www.ustfccca.org/2017/08/featured/pacing-strategy-can-

analytics-help-us-run-faster-in-cross-country

Loh, T. C., Tee, C. C. L., Pok, C., Girard, O., Brickley, G., & James, C. (2023). Physiological characteristics and performance of a world-record breaking tower runner. *Journal of Sports Sciences*, 1–5. https://doi.org/10.1080/02640414.2023.2221957

Mercier, Q., Aftalion, A., & Hanley, B. (2021). A model for world-class 10,000 m running performances: Strategy and optimization. *Frontiers in Sports and Active Living*, *2*. https://doi.org/10.3389/fspor.2020.636428

Mondello, M., Piquero, A. R., Piquero, N. L., Gertz, M., & Bratton, J. (2013). Public perceptions on paying student athletes. *Sport in Society*, *16*(1), 106–119. https://doi.org/10.1080/17430437.2012.690408

Neuloh, J. E., Venhorst, A., Forster, S., Mauger, A. R., & Meyer, T. (2023). The association of end-spurt behaviour with seasonal best time in long-distance freestyle pool swimming. *European Journal of Sport Science*, *23*(4), 469–477. https://doi.org/10.1080/17461391.2022.2043943

Noorbergen, O. S., Konings, M. J., Micklewright, D., Elferink-Gemser, M. T., & Hettinga, F. J. (2016). Pacing behavior and tactical positioning in 500- and 1000-m short-track speed skating. *International Journal of Sports Physiology and Performance*, *11*(6), 742–748. https://doi.org/10.1123/ijspp.2015-0384

Oficial-Casado, F., Uriel, J., Jimenez-Perez, I., Goethel, M. F., Pérez-Soriano, P., & Priego-Quesada, J. I. (2022). Consistency of pacing profile according to performance level in three different editions of the Chicago, London, and Tokyo marathons. *Scientific Reports*, *12*(1), 10780. https://doi.org/10.1038/s41598-022-14868-6

Pycke, J.-R., & Billat, V. (2022). Marathon performance depends on pacing oscillations between non symmetric extreme values. *International Journal of Environmental Research and Public Health*, *19*(4), 2463. https://doi.org/10.3390/ijerph19042463

Redcay, E. (2023). *HowExpert Guide to Cross Country Running: 101 Tips to Learn How to Run Cross Country, Build Endurance, Improve Nutrition, Prevent Injuries, and Compete in Cross Country Races*. Hot Methods, Incorporated. https://books.google.co.id/books?id=01-5EAAAQBAJ

Sivaramakrishnan, H., Quested, E., Cheval, B., Thøgersen-Ntoumani, C., Gucciardi, D. F., & Ntoumanis, N. (2023). Predictors of intentions of adults over 35 years to participate in walking sport programs: A social-ecological mixed-methods approach. *Scandinavian Journal of Medicine & Science in Sports*. https://doi.org/10.1111/sms.14368

Tiefenthaler, D. (2021, December 27). Tips 4 running – running tips and training programs for beginners to marathon runners. *Race Strategy*. https://tips4running.com/running-tips/race-strategy/

Tucker, R., & Noakes, T. D. (2009). The physiological regulation of pacing strategy during exercise: a critical review. *British Journal of Sports Medicine*, *43*(6), e1–e1. https://doi.org/10.1136/bjsm.2009.057562

Van Ingen Schenau, G. J., de Koning, J. J., & de Groot, G. (1994). Optimisation of sprinting performance in running, cycling and speed skating. *Sports Medicine*, *17*(4), 259–275. https://doi.org/10.2165/00007256-199417040-00006