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Running World Cross-Country Championships: A Unique Model for Pacing

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The aim of this study was to describe the pacing distribution during 6 editions of the world cross-country championships. ***Methods:*** Data from the 768 male runners participating from 2007 to 2013 were considered for this study. Blocks of 10 participants according to final position (eg, 1st to 10th, 11 to 20th, etc) were considered. ***Results:*** Taking data from all editions together, the effect of years was found to be significant ($F_{5,266}$ = 3078.69, P < .001, ω^2 = 0.31), as well as the effect of blocks of runners by final position ($F_{4,266}$ = 957.62, P < .001, ω^2 = 0.08). A significant general decrease in speed by lap was also found ($F_{5,1330}$ = 2344.02, P < .001, ω^2 = 0.29). Post hoc analyses were conducted for every edition where several pacing patterns were found. All correlations between the lap times and the total time were significant. However, each lap might show different predicting capacity over the individual outcome. ***Discussion:*** Top athletes seem to display different strategies, which allow them to sustain an optimal speed and/or kick as needed during the critical moments and succeed. After the first group (block) of runners, subsequent blocks always displayed a positive pacing pattern (fast to slow speed). Consequently, a much more stable pacing pattern should be considered to maximize final position. ***Conclusions:*** Top-10 finishers in the world cross-country championships tend to display a more even pace than the rest of the finishers, whose general behavior shows a positive (fast-to-slow) pattern.

Keywords: running performance, racing strategies, elite athletes, position-based competition model

Endurance performance has been related to physiological factors (ie, VO_{2max}, running economy, anaerobic threshold, and anaerobic capacity). Final competitive performance is also the result of an optimal pacing strategy.[1,2] This "optimal pacing profile" should represent the most efficient way to manage the available energy stores throughout the whole distance.[3]

To date, different sports have been studied, including race walking,[4] running,[5] cycling,[6] swimming,[7] skating,[7] and triathlon.[8] Studies in different-duration events, lasting from a few seconds to several hours, have been reported.[9,10] Several pacing profiles have been described,[11] basically, even pace, negative pace (slow to fast), positive pace (fast to slow), and U-shape (fast-slow-fast). Different conditions have also been considered, from the laboratory to the field, from simulated to real competitions, and subjects from elite to recreational level.[1,5,6]

Running cross-country races include different surfaces (typically grass, mud, and dirt) along uneven or hilly terrain. Up until 2011, the International Amateur Athletics Federation (IAAF) organized the world cross-country championships annually. Since then, the championships have been made a biannual event. All IAAF track championships (including the Olympics) allow 3 participants per country in addition to the defending champion of the preceding edition (resulting in a maximum of up to 4 participants from the country of that edition's winner). However, the World Cross-Country Championship allows up to 6 participants per country, since in these championships there are both individual and team standings. Because of this, every position advantage might be of importance for team standings, even between individuals who are not competing to win the race. Thus, runners must focus on their relative position rather than on total time spent.

Every edition is conducted over 12 km: 6 laps of a 2-km circuit. Lap times are recorded through a shoelace, electronic-chip timing system, but this information is not given to the athletes during the race. Nevertheless, time is not rewarded as a world record, or race record, since the surface conditions may change from year to year, and the championship location changes from one country to another among different continents.

Since individual and team lap-to-lap standings feedback may not be given precisely to the athletes during the race, and several countries are not represented by all 6 allowed participants, we can suspect that runners compete both with the goal of individual position and the task of obtaining the best score to their national team.

This kind of competition represents a unique study model for pacing research. The goal of this study was to describe the pacing distribution adapted by participants. Our hypothesis was that in spite of different tactical behaviors, a general trend of even speed in the leading positions would be observed, whereas clear positive (fast-to-slow) trends would be observed among the rest of the participants as a consequence of selecting a pacing strategy based on the leading positions instead of a strategy based on self-selected, constant-speed, theoretically efficient distribution.

Methods

Participants and Competition Model

Athletes were selected for the championships by their own countries, according to national federation criteria. The criteria used

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are based on national championships, which are commonly held 3 weeks before the world championship. This championship is always held on the third Sunday of March. Thus, it is reasonable to think that all participants peaked by these weeks in their winter season.

From a maximum of 6 participants, the best 4 athlete positions per country are considered for the final standings. These 4 runners are scored with their particular position, and the sum of their scores determines the final team score. The lower the score, the better the ranking for the team standings. Using this scoring method, advancing one position contributes the same to the final score no matter the location among participants (ie, passing from the fifth to the fourth position may have the same value for the team standings as advancing from the 29th to 28th position).

Data Processing

Data from 768 male athletes in 6 consecutive editions of the world cross-country championships (2007 to 2013) were considered for this study. Total finishers, distributed by year-to-year editions, were 134 athletes in 2007, Mombasa, Kenya; 165 in 2008, Edinburgh, UK; 137 in 2009, Amman, Jordan; 126 in 2010, Bydgoszcz, Poland; 110 in 2011, Punta Humbría, Spain; and 96 in 2013, Bydgoszcz, Poland. In 2011, the IAAF decided to establish the championship every 2 years, so there was no 2012 edition.

Since gender-specific pacing differences have been previously described,[12] the current study focused on men's pacing distribution.

All data were obtained from the IAAF Web page for the years 2007 to 2013. Athlete data were sorted according to final position. Lap times were considered only if the athlete had finished the race. Times were converted from minutes and seconds to decimal minutes. To simplify pacing trends according to final position, groups of 10 participants according to final position (ie, 1st to 10th, 11 to 20th, etc) were considered for the final analysis.

Particular year-to-year analyses were conducted on the top 50 runners. This group size was chosen because, according to official data, the top 4 runners (who account for the overall team ranking) for the best 5 teams have placed in the top 50 during the last 6 championships (http://www.iaaf.org/competitions/iaaf-world-cross-country-championships). We suspected that this would avoid biasing our findings since the other runners not placing in the top 50 (and not performing with a chance to win or qualify for top-5 team standings) would be tempted to reduce their exertion.

Finally, an all-editions description of the world championships was made considering the lead runner of every lap, as well as the final gold, silver, and bronze placers relative to both speed and position per lap. This was done to observe to what extent leading runners would influence global speed.

Statistical Analysis

Descriptive data were expressed as mean and standard deviation. The overall data analysis started by descriptive and visual inspection to observe the possible confounding effects of cohort, circuit characteristics, and lead-runner strategies. Taking all editions and participants together, a 3-way mixed ANOVA was performed, considering years and blocks of competitors as fixed factors, laps as a repeated-measures factor, and lap time as the dependent variable.

Due to the afore-mentioned reasons, particular 2-way ANOVA analyses (5 blocks × 6 laps) were applied on these subsamples of the first 50 runners from each edition. A Bonferroni-adjusted post hoc analysis was used to compare laps within groups. Standardized effect sizes were calculated using omega-squared for ANOVA effects and Cohen *d* for post hoc pairwise comparisons.

In addition, correlations between the partial times for running each lap and the total time were calculated. The statistical significance level was set at .05. When more than 1 comparison is cited, the interval of effect sizes is expressed.

To consider the amount of change in a standard way, and given that race conditions may be different, relative speed (according to mean speed) for each particular year was described in relation to the relative distance.

Finally, means of speed and position during the race from the 6 editions were calculated for the lead runner and second- and third-position runners after lap 1, as well as final gold, silver, and bronze placers.

Results

Taking data from all editions together, the effect of years was significant ($F_{5,266} = 3078.69$, $P < .001$, $\omega^2 = 0.31$), as well as the effect of blocks of runners by final position ($F_{4,266} = 957.62$, $P < .001$, $\omega^2 = 0.08$). A general decrease in speed by lap was to be found significant ($F_{5,1330} = 2344.02$, $P < .001$, $\omega^2 = 0.29$). In particular, every lap was slower ($P < 001$) than the previous one. These trends are shown in Figure 1. The 4 possible interactions between factors were all statistically significant. However, just year-by-block ($\omega^2 = 0.29$) and year-by-lap ($\omega^2 = 0.26$) interactions showed meaningful effect sizes.

The sample of the top 50 runners was used for the subsequent analyses. An analysis of lap-to-lap differences within each block of 10 runners was performed. Taking the average of all editions, the 3 blocks corresponding to the 21st to 50th positions showed significant differences ($P < .001$) for all pairwise comparisons of laps, reflecting a progressively lower speed as the race went forward.

The block of 11th to 20th positions showed significant differences between all 6 laps ($P < .01$) except between laps 2 and 3. The block of 1st to 10th positions showed significant differences between all 6 laps ($P < .01$) except between laps 2, 3, and 4.

As shown in Figure 2, each edition shows different pacing patterns. The different shapes reflect the significant interaction between years, blocks, and laps (as mentioned before). This interaction is analyzed following.

The ANOVA effect of lap number on lap time was found to be significant in every edition ($P < .001$), as it was found when considering all editions' data. Large effect sizes were found in every edition (ω^2 .31–.91). The difference between blocks of runners was also found to be significant in every edition ($P < .001$). Large effect sizes were found in 2007 ($\omega^2 = .17$), 2010 ($\omega^2 = .46$), 2011 ($\omega^2 = .38$), and 2013 ($\omega^2 = .29$), meaning that performance was significantly lower as the final performance level was worse. However, in 2008 ($\omega^2 = .05$) and 2009 ($\omega^2 = .06$) the effect sizes reflected that the differences were not meaningful. The interaction between lap and block effects, even being statistically significant in all the 6 editions ($P < .001$), showed small effect sizes (ω^2 .01–.08).

The post hoc analysis revealed different patterns for each year of pairwise comparison of times between laps within each block. These patterns are analogous to speed changes shown in Figure 2. Splitting the analysis of the race in 2 halves for a better interpretation, the first half (laps 1 to 3) showed a common trend for every block of runners to reduce the speed significantly at some point. This difference took place during the second lap in 2007 (d = [0.67,1.21]), 2009 (d = [6.38, 6.82]), and 2011 (d = [0.58, 1.34]) and during the third lap in 2008 (d = [4.99, 6.01]) and also in 2010 for the blocks 3 to 5 of runners (d = [0.63, 0.82]). In contrast, in 2013 all participants ran lap 2 significantly faster (d = [0.99, 1.47]).

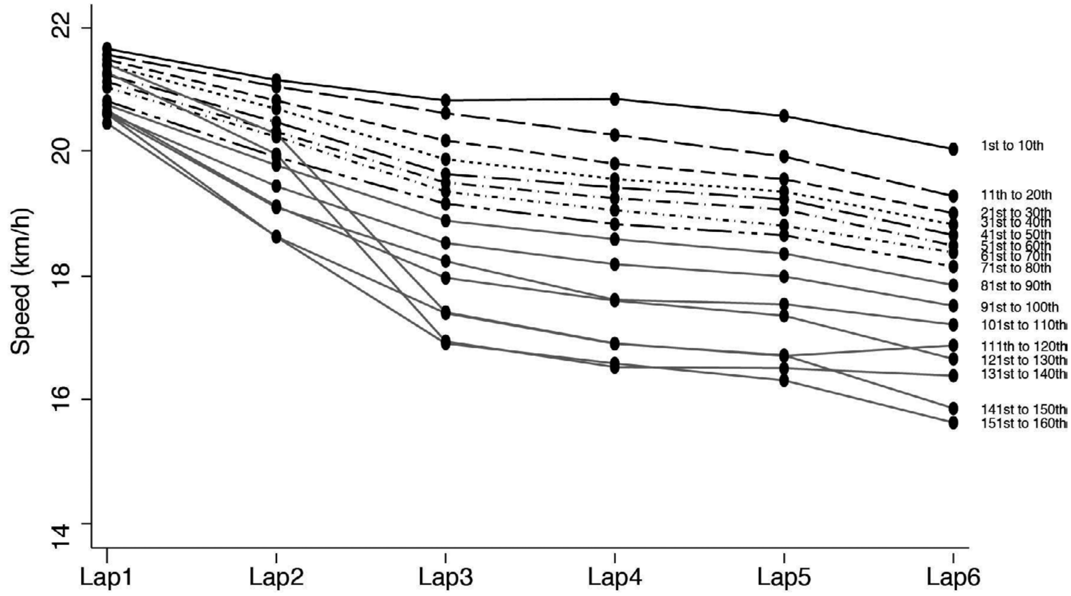

Figure 1 — Mean speed on each lap in the world cross-country championships 2007–2013.

Post hoc analysis of the last half (laps 4–6) revealed a common pattern over years to slow down the speed progressively. A positive pacing trend was detected in 2007, although no significant differences were revealed; in 2009, all participants ran slower during the laps 4 to 6, especially during the last lap (d = [2.33, 3.78]). This also happened in 2010, when the last 2 laps were slower for all participants (d = [0.12, 0.78]), and in 2013, when the speed was slower during the last 3 laps, especially the last lap (d = [1.03, 1.84]). However, in 2008 no significant speed loss was detected, and in 2011 all participants increased speed from lap 5 to lap 6 (d = [0.31, 0.57]).

In every edition the block of runners who finished at positions 1 through 10 posted significant differences at a given lap. In 2007 they showed (nonstatistically significant) faster speed during the fourth and sixth laps compared with the immediately prior laps. In 2008 they ran faster during lap 4 (d = 0.32). In 2009 the first (d = 1.18) and second (d = 1.08) blocks of runners ran faster during the third lap; in 2010 the first block of runners significantly increased speed during lap 2 (d = 0.45) and lap 4 (d = 0.32); and in 2013 the third lap was also significantly faster for the first (d = 1.20) and second (d = 0.63) blocks of runners. In 2011, during the third lap, while the rest of runners started losing speed (d = [0.14, 0.72]), the first block showed no statistical change (d = 0.09).

All correlations between lap times and total time were significant, as shown in Table 1. However, each lap had different predicting capacity over the total time. In 2007 and 2008 the first lap was not as correlated with total time. In 2007 the second lap predicted 80% of total time, and laps 3 and 4 predicted above 90%. In 2008 correlations above 90% appeared after lap 4. In 2009, 2010, and 2011 the correlations above 80% started in lap 2 and stayed above 90% until the end of the race. In 2013, lap 1 was close to predicting 80% and the rest of the laps predicted above 90% of the total time.

The amount of speed change in a standard way, in relation to total covered distance, is shown in Figure 3. It shows lap-speed difference relative to mean speed for the entire race and total covered distance.

From a descriptive point of view, Figure 4 shows means of speed and position of all editions for the lead runner of each lap, the second- and third-position runner for each lap, and final gold, silver, and bronze placers.

Discussion

According to the current data, there are general trends toward a reduced-speed, positive-pacing trend (Figure 1 to 3). However, a global pacing trend cannot be generalized for the world cross-country championships. Similar to what has been previously found in road cycling[13] and triathlon,[14] some kind of stochastic behavior can be described for this event. The top-10 group (based on final position) seems to display a more even speed regulation. Given the lack of lap-time and reference feedback, together with the importance of every positional finishing, it is reasonable to consider that leading runners' behavior is determining all runners' pacing. Actually, a rough analysis shows that keeping a constant-speed strategy, even starting by positions 30 to 50, may allow finishing in the top 20 at the end of the race (Figure 1). Moreover, since our grouping criterion is based on final position, there may be many differences between individual runners within the groups.

Particular conditions might be taken into account for some runners from very different training conditions (mud, snow, temperature, humidity). However, even considering these and other particular conditions such as hills and altitude, pacing behavior does not seem to be merely attributed to these factors. Only the 2008 and 2013 editions presented mud, but speed trends were different. Editions in 2011 and 2007 showed very similar trends, but 2011 displayed an even all-grass surface, 14°C, and 65% humidity, while 2007 had a dusty surface, many turns, 28°C, and >90% humidity.

This competition model is unique. Lap time itself has little importance, in terms of initial speed, since circuits differ greatly from each other and they also depend on both the weather and previous races conducted (several races are conducted the same weekend before the men's championship over sometimes wet, muddy, grass terrain). Thus, pacing strategies related to a given personal-best time, as has been referenced in road championships,[5]

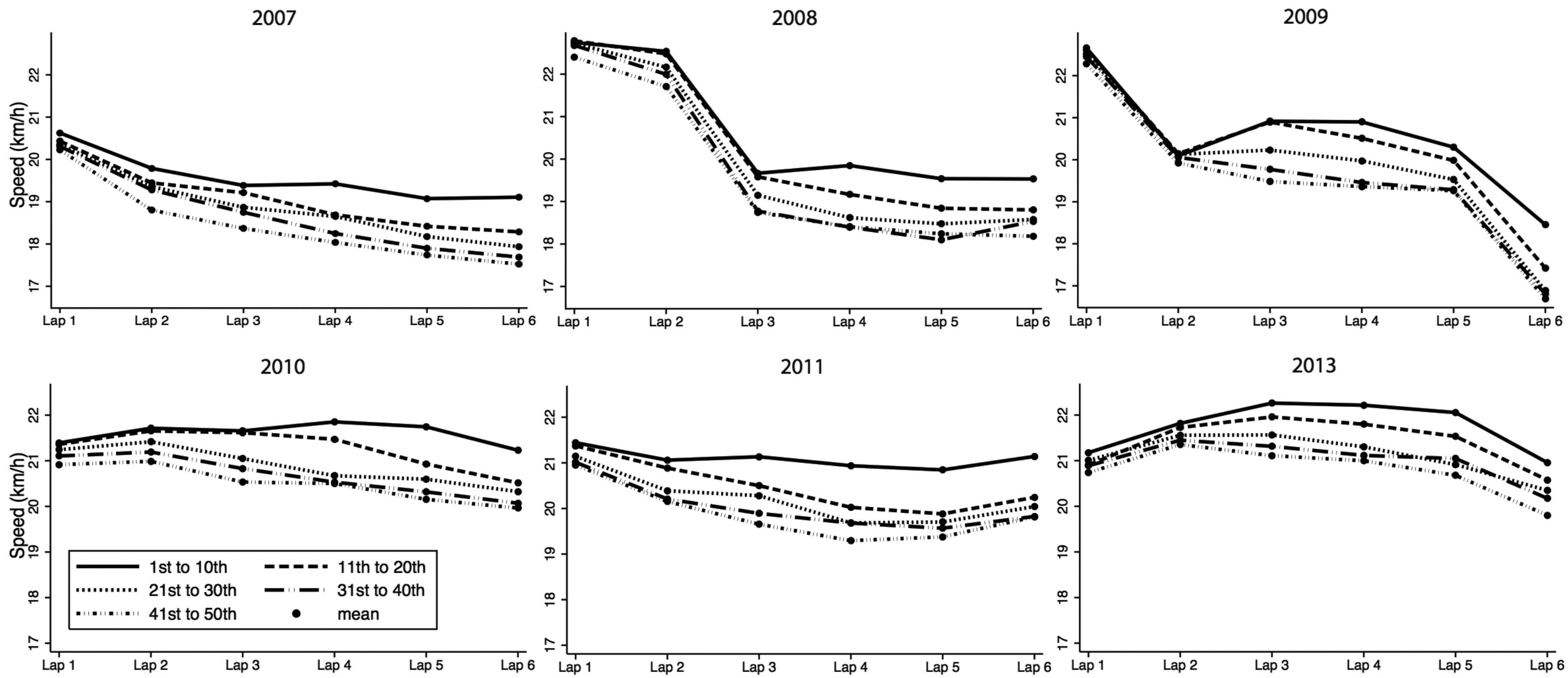

Figure 2 — Changes in speed throughout the race in the world cross-country championships 2007–2013.

may not serve for this competition model for promoting perceptual and race-position references.

The data in Table 1 show different lap-time-predicting capacity over the total time. This reinforces the concept that every race may be different, since the highest correlations are found in different laps depending on the year. Tactical conditions may also vary according to individual decisions of the leaders or team strategies. The lower correlations found for lap 1 might also reveal the lower importance of this lap when we consider all participants.

Table 1 Pearson Product–Moment Correlations Between Lap Times and Total Time in the World Cross-Country Championships (2007–2013)

Year	N	$r_{1 \cdot t}$	$r_{2 \cdot t}$	$r_{3 \cdot t}$	$r_{4 \cdot t}$	$r_{5 \cdot t}$	$r_{6 \cdot t}$
2007	134	.70	.89	.92	.94	.36	.45
2008	165	.69	.74	.75	.98	.97	.96
2009	137	.83	.92	.97	.98	.98	.94
2010	126	.40	.93	.98	.99	.97	.96
2011	110	.83	.92	.95	.97	.95	.91
2013	96	.89	.96	.98	.98	.97	.96

Note: Subscript numerals identify the correlation between the lap time in a specific lap number and total time. All correlations were significantly not null at least for $P < .01$.

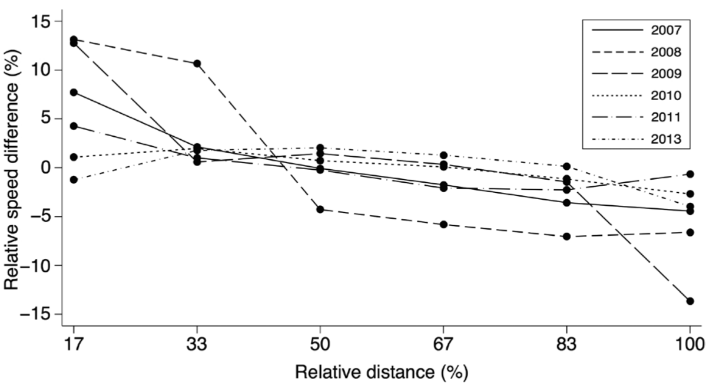

Figure 3 — Mean lap-speed difference relative to mean speed for the entire race and total covered distance for the cross-country championships 2007–2013.

Athletes in this competition model may set their goals according to the race characteristics (ie, amount of hill terrain), their presumable level in relation to other participants, and the country goals both individually and for the team's results.

For a runner who would not be expected to be leading the race or to perform among the final top 10, it becomes vital to keep both a given distance in relation to runners leading the race, teammates and other teams' runners, to keep external pacing references. In addition, momentary perceptions related to the remaining distance may be considered as the race goes on. As has been extensively discussed, this perceptual rate may prevent homeostatic disturbances from threatening the physiological system.[2,11,15,16]

At the beginning of the race, the first decision to be made is whether to choose a personal speed or to follow what the others do. It seems that even for these elite-level athletes, following the leading runners may be a likely decision at the beginning of the race,[5] as has been stated in the so-called "herd principle."[5,17,18]

As has been discussed by Renfree and St Clair Gibson[5] relative to the world's marathon championships, psychological factors at the beginning of the race may lead to overestimation of performance ability, a high level of physiological disruption, and the necessity of reducing speed later during the race. Since these kinds of decisions are complex, it is suggested that the overall impression may be easier to select than a more rational analysis.[19] In these cases, affective responses related to risk/benefit balances may be selected,[20] and subjects tend to choose experiential, rather than rational, risk assessments,[21] which may be studied before the race presuming several possible scenarios.

According to this fatigue model,[1] in case of selecting what may result in a fast start at a long-distance event, this will produce worsening lap times at the midpart of the race, resulting in a positive-pacing (fast-to-slow) global trend.

For athletes and coaches, a contribution of this study is the recommendation to conduct a deep analysis of predicting global speed at the particular circuit, setting realistic individual even speed, practicing perceptually based pacing on the basis of real-time controlled split times in similar circuits, and avoiding all types of desperate herd strategy.

However, in this particular competition model, biomechanical, performance, and perceptual factors may support this kind of strategy. Although drafting effects are greater in cycling or swimming, keeping the speed of a group that is ahead of individual runners,

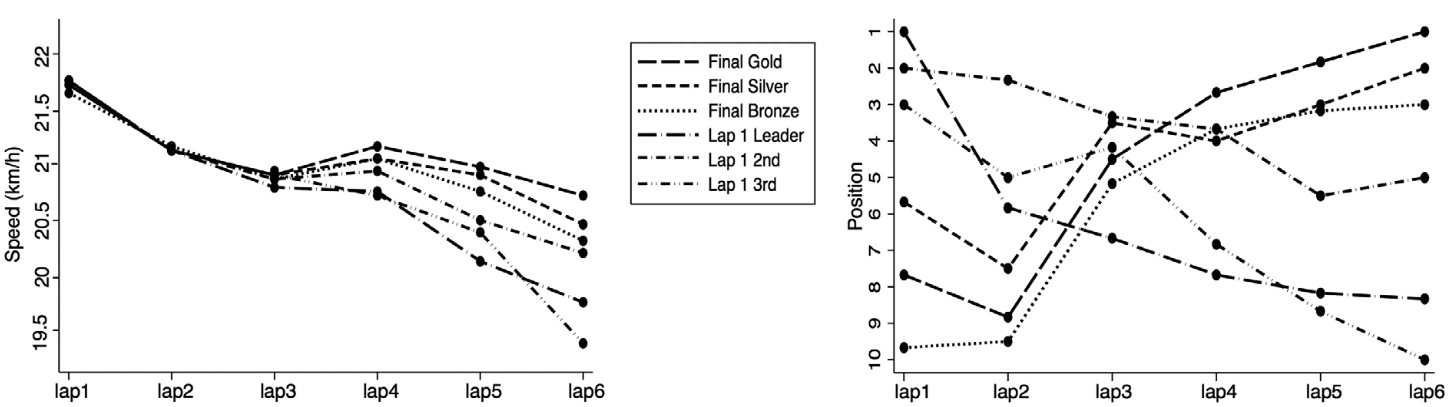

Figure 4 — Global pacing comparisons between leading runners. Left: speed comparison between the 3 leading positions during lap 1 with the final top 3 positions. Right: same comparison based on race positions lap by lap. All data are mean data from 2007–2013 editions.

while getting the advantage of a drafting effect, may allow similar or lower energy cost than running alone.[22] Among all runners located in a team's scoring positions, perception may also be influenced by current performance relative to other competitors.[23] We may suspect that positive performance (ie, feeling fast and fairly ahead of expected goals) will lead to positive affect[24] and persistent striving[5] in spite of slightly greater physiological response[6] and mental fatigue.[25,26] As these physiological disruptions may not be sufficient to down-regulate the magnitude of the central nervous system drive, and performance benefits do not outweigh the risks at a given race stage, this decision may allow a better performance in spite of a positive-pacing approach. This fragile balance of both physiological and mental fatigue factors interplays in unison with other top-level athletes.

Taken all together, top athletes seem to display different strategies. Whether they set an initial high speed (as in 2008 and 2009, over 22km/h) or they "kick" somewhere during laps 2 to 4, block 1 shows a particular pattern. However, being the race leader in the initial laps is not as relevant for final performance as keeping back in that leading group, since all the runners who medal are within the top 10 positions the entire race, no matter what pacing distribution is depicted, and no matter whether they spend time in the lead early on or are responsible for (or take part in) race accelerations (Figure 4).

A limitation of the current study is the lack of a physiological or perceptual reference to corroborate the previously described assumptions (ie, energy savings, psychophysiological measurements). However, data collected during World Championship competition are so unique as to be considered of inherent interest.

Conclusion

Top-10 finishers in the world cross-country championships tend to display a more even speed than the rest of the finishers, whose general behavior shows a positive (fast-to-slow) pattern. It remains unclear to what extent this is relative to particular strategies of the leaders in a given edition and what the optimal pacing distribution should be for those who are not expected to win.

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