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# Influence of Different Performance Levels on Pacing Strategy During the Women's World Championship Marathon Race

**Andrew Renfree and Alan St Clair Gibson**

***Purpose:*** To analyze pacing strategies displayed by athletes achieving differing levels of performance during an elite-level marathon race. ***Methods:*** Competitors in the 2009 IAAF Women's Marathon Championship were split into groups 1, 2, 3, and 4 comprising the first, second, third, and fourth 25% of finishers, respectively. Final, intermediate, and personal-best (PB) times of finishers were converted to mean speeds, and relative speed (% of PB speed) was calculated for intermediate segments. ***Results:*** Mean PB speed decreased from groups 1 to 4, and speeds maintained in the race were 98.5% ± 1.8%, 97.4% ± 3.2%, 95.0% ± 3.1%, and 92.4% ± 4.4% of PB speed for groups 1–4 respectively. Group 1 was fastest in all segments, and differences in speed between groups increased throughout the race. Group 1 ran at lower relative speeds than other groups for the first two 5-km segments but higher relative speeds after 35 km. Significant differences ($P < .01$) in the percentage of PB speed maintained were observed between groups 1 and 4 and groups 2 and 4 in all segments after 20 km and groups 3 and 4 from 20 to 25 km and 30 to 35 km. ***Conclusions:*** Group 1 athletes achieved better finishing times relative to their PB than athletes in other groups, who selected unsustainable initial speeds resulting in subsequent significant losses of speed. It is suggested that psychological factors specific to a major competitive event influenced decision making by athletes, and poor decisions resulted in final performances inferior to those expected based on PB times.

***Keywords:*** decision making, regulation, competition

Pacing is a fundamental requirement of competitive endurance performance[1] that has been widely documented in numerous athletic disciplines in recent years. Previous research has investigated mechanisms underpinning the selection and maintenance of an appropriate strategy[2] and described strategies adopted by athletes during competition in running,[3,4] cycling,[5,6] speed skating,[7] rowing,[8,9] and triathlon.[10] Although there is some evidence that individuals may have uniquely optimal pacing strategies,[11] a consistent finding in endurance events lasting more than 2 minutes is that athletes start quickly, slow through the middle stages, and then produce an acceleration, or "end spurt," in the final stages, an observation that has been shown to be repeatable[12,13] in cycling and provides evidence for the existence of a control system that regulates muscle work rate to maintain physiological homeostas.[14]

Although pacing strategies of athletes in a variety of sports have been described,[15] a common feature of many studies is a focus on successful or winning athletes. Through retrospective analysis of race-performance data, Tucker et al[3] demonstrated a consistent strategy in 32 and 34 world-record performances in the 5000-m and 10,000-m running events, respectively. Similarly, Noakes et al[4] demonstrated that in the previous 32 world-record performances in the 1-mile run, mean times for the second and third laps were both significantly slower than for the first or final laps but that there were no significant differences between first and last lap times.

Although pacing has been suggested to be regulated through complex centrally regulated processes,[16] there is also evidence that the selected strategy can be influenced by psychological factors that alter the perception of the current muscle work rate.[17] The rating of perceived exertion (RPE)[18] and the psychological construct of affect[19] have been suggested to be important regulators of muscle work rate during self-paced exercise, and both have been demonstrated to be influenced by other factors that are pertinent when considering direct competition between groups of athletes. Carver and Scheier[20] emphasized the importance of perceived progress toward a goal in the generation of the affective response, and Gaudreau et al[21] reported that the discrepancy between goal performance and actual performance also influences the affective response. One can therefore hypothesize that the presence of direct competitors (who may have superior physiological potential) striving to achieve the same outcome goals may interfere with psychological factors implicated in the

The authors are with the Institute of Sport and Exercise Science, University of Worcester, Worcester, United Kingdom.

regulation of pacing. Any interference would be expected to negatively influence the ability of some competitors to effectively regulate their muscle work rates over the duration of the event. Although there is some consensus regarding pacing strategies displayed by successful athletes, little information is available in the literature on strategies displayed by less successful competitors. However, there are sound theoretical reasons for suggesting there is the potential for interference with proposed regulatory processes in athletes of differing performance levels engaged in direct competition. In addition, it would seem conceivable that tactical considerations that are less relevant in laboratory-based time trials or deliberate record attempts may have greater influence on pacing profiles in a competitive event where rewards are based on finishing position rather than finishing time.[22] The aim of this study was therefore to analyze overall pacing strategies displayed by successful and less successful elite athletes during a competitive running event.

## Methodology

A quasi-experimental design was used to address the aims of the study. Final results and intermediate split times (individual 5-km segments and final 1.195 km) of all finishers (N = 60) in the women's marathon event at the 2009 IAAF World Athletic Championships were accessed via the championship Web site (http://berlin.iaaf.org/documents/pdf/3658/AT-MAR-W-F-1-.RS5.pdf), along with personal-best (PB) performances at the time of the competition for all competitors. Data from the men's event at the championship were not incorporated in the analysis, as March et al[23] demonstrated gender differences in pacing ability during marathon running. As speeds are more symmetric, normally distributed, and linearly related to other variables,[24] times were converted to average running speeds (m/s).

Competitors were split into 4 groups depending on finishing position. Groups 1, 2, 3, and 4 comprised the first, second, third, and fourth 25% of finishers, respectively. Average absolute speed maintained in both PB performances and during the World Championship event was calculated for all groups, along with relative speed expressed as a percentage of average speed maintained during PB performances. The same methods were used to calculate absolute and relative speeds during each intermediate segment of the race. The percentage change in speed relative to the first 5-km split was also calculated for each group to display the magnitude of changes in speed throughout the race.[25]

Pearson product–moment correlation was used to assess the relationship between speeds maintained in the race and in PB performances, and the coefficient of variation was calculated to indicate segment-to-segment variability in running speed for each group throughout the race. One-way analysis of variance (ANOVA) was used to identify differences in overall performance characteristics (overall PB and race speeds), and 2-way ANOVA followed by the Bonferroni post hoc test was used to identify significant differences in speed between groups in each intermediate segment. Statistical significance was accepted at the $P < .05$ level, and analyses were performed using IBM SPSS version 19 software.

## Results

There was a noticeable relationship between PB time and the group in which each competitor finished. Average speed maintained during PB performances of finishers decreased from group 1 to group 4 (Figure 1; $P < .0001$, $\eta_p^2 = .380$). Group 1 PB speeds were significantly faster than groups 3 and 4 (both $P < 0.001$), and group 2's were significantly faster than group 4's ($P = .017$). The correlation coefficient between mean race speed and mean PB speed was $r = .62$.

Group 1 athletes recorded finishing times that were closer to their PB performances than athletes in other groups (Figure 2; $P < .0001$, $\eta_p^2 = .351$). Group 1 athletes maintained 98.5% ± 1.8% of the speed achieved in their PB performance, and this decreased to 97.4% ± 3.2%, 95.9% ± 3.1%, and 92.4% ± 4.4% for groups 2, 3, and 4, respectively. Statistically significant reductions in the

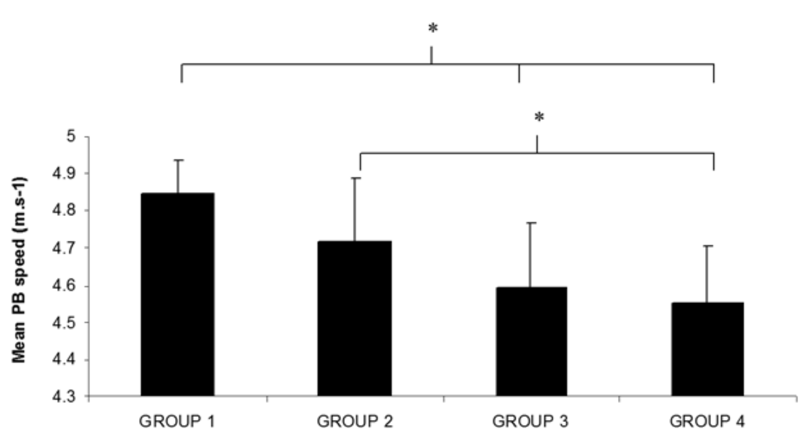


**Figure 1** — Mean personal-best (PB) running speed in groups 1–4. *Significant difference between groups ($P < .05$).

percentage of PB speed maintained over the race were found between groups 1 and 4 ($P < .001$), 2 and 4 ($P = .001$), and 3 and 4 ($P = .025$).

The outcome of these differences in ability to replicate PB performance in the competitive event was that athletes in groups 2, 3, and 4 finished farther behind group 1 athletes than comparison of PB times would suggest. The mean differences between expected time behind group 1 athletes (as predicted by PB performances) and actual time behind were 104.6 seconds for group 2, 254.7 seconds for group 3 ($P = 0.005$), and 643.3 seconds for Group 4 ($P < .001$).

Assessment of mean running speed during consecutive 5-km segments indicates differences in pacing strategies employed by competitors who finished in different groups (Figure 3). Comparison of absolute running speeds reveals that group 1 athletes were faster than athletes in other groups in all segments from the outset of the race and also displayed less segment-to-segment variability in speed. The coefficient of variation for mean speed over intermediate segments increased from 1.87% to 3.70%, 4.88%, and 8.14% for athletes finishing in groups 1, 2, 3, and 4, respectively. Differences in speed between groups continually increased as the race progressed. Group 1 athletes were significantly faster than group 4 athletes in all intermediate stages (all $P < .001$ other than $P = .007$ between 20 and 25 km and $P = .003$ between 30 and 35 km); group 3 from 5 to 10 km ($P = .014$), 10 to 20 km ($P < .001$), and 35 km onward ($P < .001$); and group 2 from 35 to 40 km ($P < .001$) and 40 km onward ($P = .002$).

Although absolute speed was highest in group 1 athletes from the beginning of the race, the opposite is true of speeds relative to PB performances (Figure 4). Group 1 athletes ran at a lower percentage of PB speed than competitors in other groups for the first and second 5-km segments, whereas they were running at a higher percentage than other groups from 35 km onward. Whereas group 1 ran at 97.1% ± 1.8% of PB speed during this segment, groups 3 and 4 were running at 102.5% ± 3.7% and 103.5% ± 3.5%, respectively (both $P < .001$). However, group 1 was significantly faster than group 3 from 25 to 30 km ($P < .001$), 35 to 40 km ($P = .02$), and 40 km onward ($P = .016$) and faster than group 4 from 20 to 25 km ($P = .038$), 25 to 30 km ($P < .001$), and 35 km onward ($P < .001$).

Analysis of the magnitude of changes in speed relative to the first 5 km indicates clear differences in the overall strategies displayed by each group. Whereas group 1 ran faster than the mean speed displayed in the first 5 km in all subsequent segments, groups 2, 3, and 4 ran slower in all segments from 15 km, 5 km, and 10 km, respectively. All groups (other than group 1, who were running 0.7% faster than initial 5-km speed) displayed the greatest reduction in speed between 35 and 40 km. During this segment, speeds were 8.8%, 12.0%, and 18% slower than those achieved in the first 5 km for groups 2, 3, and 4, respectively. Although group 1 did not record

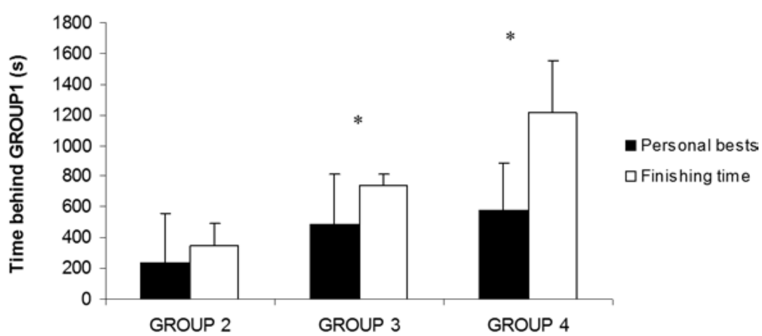


**Figure 2** — Time behind personal best and finishing time of group 1 athletes for groups 2–4. *Significant difference between personal best and finishing times behind group 1 ($P < .01$).

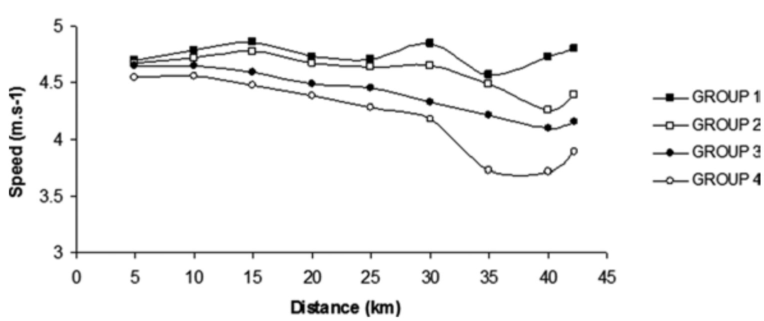


**Figure 3** — Mean running speed in each intermediate 5-km segment (error bars and statistical significance removed for clarity).

a statistically significant change in speed relative to the first 5 km during any individual segment of the race, all other groups recorded segments where their changes in speed were much greater than those experienced by group 1. In group 2 these differences occurred late in the race between 35 and 40 km ($P$ = .003) and 40 to 42 km ($P$ = .019), whereas they occurred much earlier for groups 3 and 4. Group 3 produced changes in speed of a greater magnitude than those by group 1 from 5 to 10 km ($P$ = .002), 10 to 15 km ($P$ < .001), 30 to 35 km ($P$ = .002), and 35 km onward ($P$ < .001). Magnitude of changes in speed displayed by group 4 were greater than group 1 in all segments other than between 20 and 25 km ($P$ = .040 from 5 to 10 km and $P$ = .002 from 25 to 30 km; all others are $P$ < .001).

## Discussion

The results of this investigation demonstrate that during the 2009 World Championship women's marathon event, there were differences in pacing strategies displayed by successful and less successful athletes. It is evident that strategies adopted by the most successful athletes resulted in better relative performances than those in other groups, as they achieved finishing times closer to their PBs.

These different strategies effectively resulted in underperformance by athletes finishing in lower positions as they recorded times farther behind group 1 than comparison of PBs suggests should be the case. In addition to the impact on finishing time, underperformance by groups 2, 3, and 4 had potentially major implications for finishing position in the race. If all other competitors had performed in the manner reported, a relative level of performance similar to those achieved by group 1 (completion of the race at 98.5% of PB speed) would have seen an improvement of 4.1 ± 2.1, 10.7 ± 3.5, and 20.9 ± 7.8 positions for individual athletes in groups 2, 3, and 4, respectively.

Closer inspection of speeds throughout the race illustrates that a likely explanation for the relative underperformance of groups 2, 3, and 4 was selection of initial speeds that were unsustainable for the entire distance. This resulted in later significant reductions in speed (Figures 3, 4, and 5) and an overall pacing profile characterized by a positive split (second half of the race being slower than the first). As it has been demonstrated that performance in longer-duration events is likely to be optimized by a negative pacing strategy with an increase in power output or speed at the end of the event,[1] it would appear that these inappropriate initial work rates compromised the ability to fully realize physiological performance potential.

Analysis of the percentage changes in running speed relative to the initial 5 km reveals important differences between groups. Groups 2, 3, and 4 all displayed substantial reductions in speed as the race progressed, and the magnitude of these reductions increased the farther each group finished behind Group 1. The overall profiles displayed by groups 2 to 4 are similar to that presented

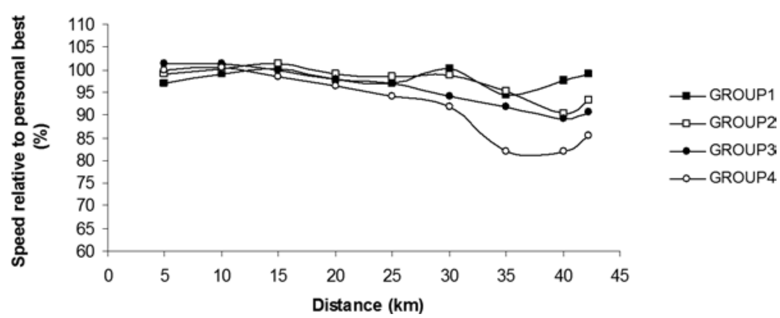


**Figure 4** — Relative speed for each 5-km segment (error bars and statistical significance removed for clarity).

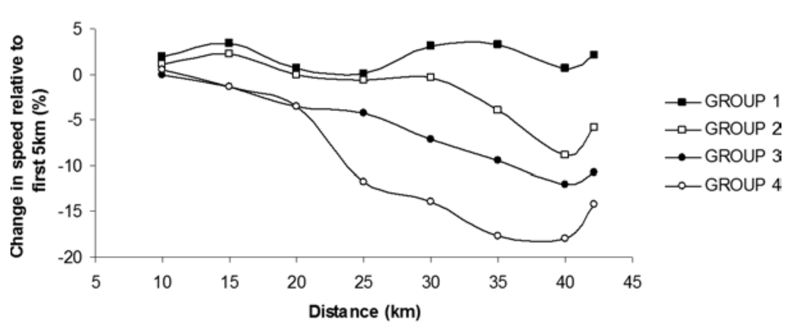


**Figure 5** — Changes in speed relative to initial 5 km (error bars and statistical significance removed for clarity).

by Vernillo et al,[25] who analyzed the pacing strategy displayed during a failed attempt at the 5-km race-walking world record. In both the failed record attempt and groups 2 to 4 in this analysis, the greatest reduction in speed was displayed in the penultimate segment analyzed, before acceleration in the final segment. This suggests that even though athletes had experienced significant reductions in muscle work rate, they still maintained some degree of physiological reserve capacity until the final stages of the event.[14]

The reductions in speed identified in this analysis are of a greater magnitude than those described by Vernillo et al.[25] Whereas the greatest deviation in initial speed observed during the race walking event was 3.57%, in this event groups 2, 3, and 4 displayed reductions in speed of 8.8%, 12.0%, and 18%, respectively, a finding that could be partly a result of the longer duration of the race and consequent greater degree of physiological disruption incurred. However, because the magnitude of reductions increased the farther athletes finished behind the leaders, it would appear that the discrepancy between the speed that was initially selected and what physiological capacities could sustain also increased. Given that Hopkins and Hewson[26] have reported a typical coefficient of variation for the competitive performance of national-level distance runners of ~2.5% in half- and full-marathon races, it is clear that most competitors in the event had very small likelihoods of winning the race or finishing close to the medal positions. This raises the interesting question of the underpinning motivational factors in athletes unlikely to finish in the leading positions. The relatively slow initial speeds in group 1 athletes may be explained by tactical considerations that are important in such a championship event, where rewards are based on finishing position as opposed to finishing time.[22] Due to gender differences in competitiveness and win orientation,[27] it is particularly interesting that these findings have been made in an all-female event. As males typically display higher levels of competitiveness than females, it may be expected that differences in pacing profiles between competitors achieving differing relative levels of success may be more pronounced in an all-male event.

Regardless of athletes' underpinning motivational drives, the pacing profiles of athletes outside group 1 demonstrate that overall outcome was compromised by initial speeds that were too high. This is emphasized by the finding that although speeds for groups 3 and 4 were above mean PB speed for the first 10 km of the race, overall speeds in these groups represented only 95.9% ± 3.1% and 92.4% ± 4.4%, respectively. Although it is acknowledged that individuals may have uniquely optimal pacing strategies,[11] it is clear that the general strategies adopted by groups 2 to 4 were not optimal because relative levels of performance were inferior to those achieved by group 1. Of particular interest are the mechanisms underpinning the selection of these unsustainable work rates in the early stages of the race. Tucker[18] proposed that the RPE is used to mediate muscle work rate in a feed-forward anticipatory manner, and Renfree et al[19] suggest that the psychological construct of affect may be the primary mediator of pacing strategy. Regardless of the precise mechanisms governing the selection of work rate in the initial stages of an exercise bout, it seems that during the 2009 women's World Championship event, some other factors interfered with the ability of finishers in groups 2, 3, and 4 to select appropriate initial running speeds.

RPE and the affective response during exercise have been demonstrated to be relevant factors when considering direct competition between large groups of athletes. For example, St Clair Gibson et al[2] suggested that RPE may be influenced by both the presence of crowd support and current performance relative to other competitors. Hall et al[28] demonstrated that individuals displaying high levels of approach motivation underestimate RPE at low intensities, but during maximal exercise sensory cues relating to physiological status dominate over psychological factors. It would therefore appear possible that during the early stages of the race, a number of psychological factors could have led to overestimation of performance ability and therefore selection of unsustainable running speeds in group 2, 3, and 4 athletes. However, as the race progressed, greater levels of physiological disruption would have led to the domination of physiological cues and the necessity to reduce speed to prevent the possibility of catastrophic physiological system failure.

Although a limitation of these data are that psychological parameters cannot be measured during the course of a competitive event of this kind, it can also be suggested that poor decision making (with regard to the selection of an appropriate initial speed) occurred in the case of group 2, 3, and 4 athletes. Slovic et al[29] propose that when decision making is complex or mental resources are limited, using an overall affective impression is easier and more efficient than performing a rational analysis of the various options available. The affective response is generated as a result of simple assessment of the relative perceived risks and benefits of a behavior. If perceived benefits outweigh perceived risks the overall response is positive, whereas the response is negative if risks are perceived to outweigh benefits. When faced with a range of possible decisions, individuals will pick the option that results in the most positive affective response. If decisions in a sporting environment are indeed made in this manner, then to increase the likelihood of them being successful there is clearly a requirement for accurate assessment of both benefit and risk incurred by possible actions. Epstein[30] suggests that risk assessment results from a dual processing system, the rational, which operates via established rules of logic and evidence, and the experiential, which encodes reality by way of images and metaphors to which affective feelings are attached. Later work[31] suggests that the experiential system dominates and that, on most occasions, individuals follow a strategy of imaging positive outcomes while neglecting negative ones, as these are more likely to convey positive affect that subsequently motivates choice. With regard to deciding what initial work rate to select during a competitive athletic event, it would therefore seem conceivable that the decision a competitor is most likely to make is to follow the pace set by the leading athletes. To do otherwise may more likely convey images of negative outcomes, especially if athletes perceive themselves to be performing poorly relative to their expected result in terms of either finishing time or position relative to their competitors.

This suggestion that the decision an athlete is most likely to make regarding the selection of an initial work rate during a competitive event is to simply follow the behavior of direct competitors is in line with the "herd principle" that has been previously identified in business and organizational settings.[32,33] This model suggests that the easiest decision to make is to do exactly the same as other individuals in the same environment, as to do otherwise is perceived to entail a high degree of risk, even if objective analysis suggests that this is not necessarily true. The data presented in this paper indicate that for many of the competitors decisions made in the early stages of the race were poor, as there was a large discrepancy between the chosen initial work rates and the work rates that could be maintained. The differences in PB performances between groups and the significant reductions in speed by group 3 and 4 athletes in particular indicate that initial speeds were beyond those that their physiological capacities would allow.

## Practical Applications

This analysis generates some important practical applications for competitive athletes, as well as identifying avenues for future research. For athletes competing in similar championship events, it is clear that the pacing strategy selected has a major influence on the final result achieved. If athletes who (on the basis of PB performances) appear unlikely to realistically challenge for the first few finishing positions are able to realize the same relative fraction of their performance potential as the leading athletes through the adoption of similar, more even, pacing strategies, they will be able to record faster times and finish ahead of athletes with superior physiological capacities who paced themselves less effectively.

In terms of future research, the current article can only speculate as to the possible mechanisms underpinning the selection of inappropriate initial running speeds by the majority of competitors in this event. Further work should investigate the precise factors underpinning the selection of pacing strategies in similar events. This may lead to the development of interventions that increase the likelihood of more successful decision making and the realization of a greater fraction of physiological performance potential. It should be emphasized that this was a championship event where achievement of a fast time is typically of secondary importance to overall finishing position. It would be interesting to perform similar analyses in the major city marathons where reward is based partly on finishing time, a factor that may well influence competitors' goal setting and strategic planning. Although we identify an overall trend when we look across the competitors in the race as a whole, we do acknowledge that tactical factors in Group 1 athletes possibly influence individual pacing profiles displayed. Therefore, analysis of a more homogeneous group of competitors may allow greater understanding of the factors influencing tactical decision making. In addition, men's championship events should be analyzed to identify gender differences in the ability to select the most appropriate pacing strategies.

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