# Abstract

Even pacing within the marathon has been associated with faster marathon performance times, however, little literature has investigated the association between pacing ability during a marathon and a recreational marathoner’s training characteristics and previous experiences. N = 136 participants completed an online questionnaire concerning training history in relation to a 2017 marathon and previous long-distance running experiences. Online databases were used to collect split times of the participants after successfully completing a 2017 marathon, identifying the percentage slowdown in pace between the first half and second half of the marathon, used for correlational analyses. The strongest correlates for pacing ability were marathon finishing time and previous distance race personal best finishing times (i.e. marathon, half-marathon, 10km and 5km). There were many weaker, however significant correlates for training history characteristics and long-distance running experience. The current findings demonstrate that larger accrued long-distance running and marathon experiences, higher weekly training distances and more marathon-specific training distances (≥19.8 miles) are associated with a) smaller declines in pace during the second half of the marathon in comparison to the first half and b) less variability in pace during the marathon.

Keywords: endurance, pace, regulation, training history

# Introduction

The marathon is a 42.195km foot race that is becoming progressively popular, with several single events hosting >40,000 runners (Association of International Marathons and Distance Races, 2016) who are predominately middle-aged recreational runners, that must regulate energy expenditure to avoid premature fatigue of one or more physiological systems placed under stress during the event (Sjodin & Svedenhag, 1985; Tucker & Noakes, 2009a). This regulation of energy expenditure is referred to as ‘pacing’ (Abbiss & Laursen, 2008). Given the intensities that are sustained during the marathon (~65-85%V̇O2max) (O’brien, Viguie, Mazzeo, & Brooks*,* 1993; Scrimgeour, Noakes, Adams, & Myburgh, 1986) in conjunction with the duration of the 42.2km race lasting from <2.5 to >4.5 hours (Gordon *et al.,* 2017), a substantial quantity of energy is required (~2500-3000kcal) (Rapoport, 2010) and the ability to appropriately regulate energy expenditure is significant. Misappropriation of energy expenditure can lead to sub-optimal performance outcomes, and potentially more serious medically related issues (De Koning *et al.,* 2011).

Faster marathon performances have been associated with a greater ability to maintain an even pacing strategy whilst slower performances demonstrate progressive slowing during the latter stages of the race (Ely *et al.,* 2008; March, Vanderburgh, Titlebaum & Hoops*,* 2011; Maughan, Leiper & Thompson, 1985). Within the last 50 years, pacing strategies for marathon world record holders have shifted from a more positive split (i.e. first half faster than the second half) to a more negative split (i.e. first half slower than the second half), however it has been argued that an even pacing strategy with minimal speed changes may be key for future marathon success (Díaz, Fernández-Ozcorta and Santos-Concejero, 2018). Indeed, marathon success is dependent upon the interaction of multiple factors, and the ability to sustain an even pace can be ascribed either internal factors such as thermoregulation (Cheuvront & Haymes, 2001; Ely *et al.,* 2008) and changes in metabolite concentrations and availability (Rapoport, 2010), to external factors such as the racecourse profile and environmental conditions (Jones *et al.,* 2013). It can be reasoned that certain training and experience related factors are correlated with pacing ability, and thus could be used to signpost potential ways to improve pacing ability and subsequently marathon performance. However, the paucity of literature on this topic makes such reasoning difficult (Deaner, Carter, Joyner & Hunter*,* 2015). Therefore, the aim of the current study is to investigate the association between recreational marathoner’s training characteristics and previous experiences on pacing ability within the marathon. It is hypothesised that faster and more experienced marathoners will demonstrate a greater pacing ability than slower and less experienced counterparts.

# Method

## Participants

Following local institutional ethical approval (Anglia Ruskin University, UK), n = 139 marathon runners gave informed consent to participate within the current study. All participants were recruited via local running clubs and an advertisement through an online running group’s social media profile. Eligibility to participate in the study required participants to complete a 2017 IAAF Gold-Bronze label marathons. Participants completed an online questionnaire concerning previous endurance related experience (e.g. years of long-distance training, marathons completed etc.) and specific training characteristics of the four-month period prior to the completed marathon (e.g. training frequency, weekly distance etc.). Participants were categorised into experience groups based upon the number of marathons previously completed: 1-3 marathons = inexperienced and ≥4 marathons = experienced.

## Data Screening & Processing

All questionnaire data were exported to Microsoft Excel 2013 (Microsoft, USA) and screened for duplicates, errors and outliers; removed accordingly. A small minority (n = 3) of participants had completed >100 marathons/half-marathons, skewing the marathon experience mean data, and were therefore excluded. Data reported as a range (e.g. 40-50 miles) were converted to a single value by computing the average. Average steady state speed was calculated from the distance and duration of the reported weekly steady state runs. Participants opting for an even pacing strategy were only included for analysis, as other pacing strategies would bias/skew the findings. Therefore, of the original n = 132, n = 82 were deemed eligible.

Online public databases provided by the marathon race organisers were used to obtain the participant’s halfway and finish split times of the marathon. Pacing ability was calculated as the percentage change in pace between the second half and first half of the marathon, denoted as %Pchange. Based on the magnitude of the %Pchange, participants were categorised into three pacing ability groups based upon thresholds by Deaner *et al.* (2015): <10%Pchange ‘maintaining pace’, 10-20%Pchange ‘moderate slowdown’ and >20%Pchange ‘marked slowdown’. Regarding the participants (n = 45) that completed the London marathon; 5km split times were collected. The coefficient of variation (CV) was calculated from each 5km split, denoted as 5kmCV to reflect pace variability. To minimise sex-based difference in endurance performance personal best times (e.g. 5km, 10km, 21km and 42km), a 12% adjustment factor was applied to women’s performance times. Details regarding the adjustment factor can be found elsewhere (Deaner *et al.,* 2015).

## Statistical Analyses

 Using SPSS Version 24 (Chicago, IL), all data were assessed for normality with the Shapiro-Wilk test and graphical inspection of histograms and Q-Q plots. Correlational analysis was conducted for participants training, experience and performance characteristics against %Pchange and 5kmCV using Pearson’s Product Moment. Should any data violate the assumptions necessary for the Pearson’s Product Moment or contain non-parametric ordinal data, a Spearman’s rank-order correlation was used. All statistical tests were conducted with an alpha value set at 0.05. An independent sample t-test was used to compare the difference in %Pchange and 5kmCV between the experienced and inexperienced marathoners. Any data violating the assumptions of the t-test were analysed using the Mann-Whitney U test. Distributions of the independent variable were assessed for equality between the dichotomous variables through population pyramids. Effect sizes were computed using Hedges’ G to account for sample size differences. The thresholds for small, medium and large effects were 0.20, 0.50 and 0.80 respectively. Odds ratios were computed between the two experience groups and the three pacing outcome groups.

# Results

## Marathon locations

The most popular marathon course was the 2017 London marathon; completed by 55% of participants (n = 45). The second most popular course was the Manchester marathon; completed by 7% of participants (n = 6). The other 38% of participants completed marathons in n = X other locations.

***Training Characteristics correlation with Pacing Ability & Variability***

Table 1 displays the correlation coefficients observed between participants training characteristics, previous endurance related experience and personal best times (PBs) against pacing ability (%Pchange­) and variability (5kmCV). Data are presented in descending order relative to the 5kmCV correlation coefficient. Table 2 displays the participants training characteristics.

\*\*\*\*Table 1 near here\*\*\*\*

## Experienced vs Inexperienced Marathoners

Distributions of the %P­change mean ranks were not significantly different between the experienced (n = 28) (40.10) and inexperienced runners (n = 54) (33.53) (U = 418, z = 1.24, *p* = .216). However, the experienced group’s smaller mean %Pchange (-5.97 ± 4.45% vs. -8.25 ± 7.42%) revealed a small effect size (Hedges’ *G* = 0.35). Distributions of the 5kmCV mean ranks were significantly different between the experienced (n = 14) (16.07) and inexperienced (n = 29) (24.86) runners (U = 120, z = -2.15, *p* = .031) with the experienced group presenting a smaller 5kmCV compared to the inexperienced group (3.66 ± 2.76 vs. 6.54 ± 4.57) with a medium effect size (Hedges’ *G* = 0.71). Odds ratios (95% confidence intervals) were calculated and are displayed in Table 3.

\*\*\*\*Table 3 near here\*\*\*\*

# Discussion

The aim of the current study was to investigate the association between marathoners training characteristics, previous experience and performance times against pacing ability (%Pchange) and variability (5kmCV). The main findings from the current study were that the strongest correlators for pacing ability were marathon finishing time, previous endurance PBs in the 5km, 10km and 21km (half-marathon) races and accumulated training mileage (years of long-distance running, weekly training distance and weekly training volume). It was also observed that experienced marathoners who had completed ≥4 marathons previously were more likely to maintain pace than those that had completed 1-3 previous marathons. The above findings are consistent with several other studies (Ely *et al.,* 2008; March, Vanderburgh, Titlebaum & Hoops*,* 2011; Maughan, Leiper & Thompson, 1985). Other significant, however weaker correlates for (%Pchange) were weekly training distance, years of long-distance running, weekly training volume, average steady run speed, distance ran outside of the competition phase, runs ≥19.8 miles and number of marathons previously completed. All variables listed in Table 1 aside from age were significantly correlated to 5kmCV.

Due to the correlational design of the current research, whether the observed significant relationships ‘caused’ pacing ability to improve cannot be established. Nonetheless, as faster marathoners demonstrated superior pacing abilities, it was unsurprising that superior training characteristics, PBs and previous experiences were also strongly correlated to pacing ability. Previous research on recreational marathoners by Gordon *et al.* 2017 have observed that faster marathoners train with higher volumes, at faster speeds, and have done so for longer, than slower counterparts. Indeed, faster marathoners have been observed to have more developed physiological parameters such as maximal oxygen uptake, lactate turn-point and running economy to lesser trained counterparts which can be, in part, reflected by the accumulation of larger training volumes eliciting a greater training stimulus and adaptation (Billat *et al.,* 2001; Karp, 2007; Seiler, 2010; Stöggl and Sperlich, 2015; Gordon *et al.,* 2017). Interestingly, the components of training volume (weekly training frequency and distance) favoured training distance to be more strongly associated with pacing ability. It is speculated, however, that training frequency may have presented a curvilinear relationship with pacing ability should more faster marathons have participated in the current study. However, ‘how much’ training appears to be more important than ‘how frequent’. Data from Gordon *et al.* 2017 identified that recreational marathoners grouped in accordance with marathon finish times similar to that of the current study (3-3.5h, 3.5-4h, 4-4.5h and >4.5h) displayed little between-group differences in training frequency (~4-5sessions per week), however observed significant between-group differences in training distances per week.

A potential suggestion as to the difference in pacing ability arises when considering the data with regard to the perception-based model (Tucker & Noakes, 2009b). This proposes that individuals integrate previous experiences and related knowledge of the anticipated exercise task to create a ‘rating of perceived exertion (RPE) template’ which is then compared against the ‘conscious RPE’ (i.e. the present feeling of perceived exertion) to regulate exercise intensity. Therefore, the model suggests, within the present context, that runners with more ‘global’ endurance running experience and specific marathon racing experience have developed a more sophisticated and robust RPE template(s), enabling an enhanced predisposition to manipulate pace appropriately to avoid premature fatigue during a marathon compared to those who possess less sophisticated RPE template(s). The correlations observed from the present study support this concept in that more ‘global’ endurance related training and experience are associated with improved pacing ability. More specifically, the significant correlation found between number of runs ≥19.8 miles to %Pchange and 5kmCV, indicate that more specific training sessions, close to marathon distances are associated with smaller pace changes and pace variability. In accordance with the perception-based model, these sessions may offer valuable training experience for pacing ability in the sense that they expose runners to similar psychophysiological stresses that are likely to be experienced within the marathon itself, supporting the development of the aforementioned ‘template RPE’ that can be used to inform appropriate pacing (Tucker & Noakes, 2009b; Utter *et al.,* 2002). Additionally, it was observed that experienced participants (≥4 marathons) that were competing in the London marathon displayed a significantly lower variation in pace (5kmCV) compared to inexperienced participants (1-3 marathons) with a medium/large effect size (Hedges’ G = 0.71). The %Pchange between experience groups was non-significant, though a small effect (*d* = 0.35) was found in favour of the more experienced runners slowing less (-5.97 ± 4.45% vs. -8.25 ± 7.42%), however it is argued that the measurement of %Pchange lacked appropriate temporal resolution to support the notion of matching a ‘template RPE’ to a ‘conscious RPE’. Nonetheless, odds ratios revealed that more experienced runners were ~35% more likely to maintain pace in the second half of the marathon relative to the first half within <10% compared to inexperienced runners that were ~35% more likely to slow by 10-20% and >20%. This is also in support of the significant correlation observed between years of long-distance running and pacing ability, thus, those who have trained longer, have had more opportunities to race and develop a highly specific ‘template RPE’. Comparable findings have been observed by Deaner *et al.* (2015) within a similar population of recreational runners; those that had completed fewer total marathons and fewer races at any distance, displayed a greater slowing (*p* < .05).

## Strengths and Weaknesses

The current study adopted a large sample size that completed a recent 2017 marathon with intentions to racing with an even pacing strategy. Additionally, sub-group analysis was performed on participants completing the London marathon to investigate a more detailed pacing profile for every 5km split. The questionnaire collected race-specific data on how participants prepared for a specific 2017 marathon. Data lacking normal distributions were accounted for statistically. Limitations of the questionnaire data arise from recall bias. Due to the nature of correlational research, there lacked control of potential confounding variables that may have led to the correlation coefficients to be skewed or underestimated due to an increase in data variance. It is also possible that some correlates may have followed a curvilinear relationship rather than a linear one, thus potentially underestimating the correlation coefficient(s). The influence of pacemakers many commercial marathon races offer was not considered, which may have favoured runners following a pacemaker in maintaining a more even pace to those wishing to ‘just finish’ the race. However, just over half the participants in the current study completed the London marathon, which includes pacers from 3:00h to 7:30h finishing times, the use of pacemakers may have only become problematic in smaller marathons with fewer, if any pacers. Additionally, the %Pchange data were derived from many different marathons with varying racecourse profiles, thus some runners may have been unable to sustain an even pace or have decided to pace differently based on racing conditions. However, given that the participants knew what marathon they were going to race when completing the questionnaire, and specified their pacing strategy for the marathon, it is unlikely that this would have been a major limitation. Caution must also be taken when interpreting the %Pchange data as there may have been major fluctuations in pace within a given half of the race that may have gone undetected due to the lack of temporal resolution. This was better controlled for with the 5kmCV data, however global position system (GPS) measurements would have been desirable.

## Practical Applications and Implications for Future Research

Data from the present study provide evidence to suggest that faster endurance runners, greater accumulative training mileage and endurance related racing experiences are associated with improved pacing ability during the marathon. Therefore, it can be proposed that athletes wishing to improve pacing ability may benefit from accruing greater ‘global’ endurance running experiences and weekly training volumes. More specific training sessions, such as ‘long runs’ (≥19.8miles) expose runners to similar psychophysiological stressors that are likely to be experienced during the marathon itself, and therefore may too be valuable, especially when completed on several occasions, in developing the so-called ‘RPE template’. However, these recommendations must be judged with caution, due to the correlational design of the research, and if implemented, must be done so appropriately. It is also speculated that future research investigating the current topic may benefit from a larger sample size, and a more evenly spread skill level of marathoners, to investigate whether there appear to be curvilinear relationships with training characteristics and previous experiences on pacing ability. It is apparent that the current studies participants were relatively homogenous and represented a recreational running population and were therefore unable to detect possible curvilinear relationships. It remains to be elucidated whether the ‘more is better’ ideology is an appropriate one, however anecdotal evidence from our data suggest that it is not past a certain ‘threshold’ with regards to pacing ability. Lastly, future research may wish to consider the degree to which mis-pacing is based on a conscious judgment error, or a physiological feedback error. It would be therefore appropriate to following marathoners pre, during and post-race to understand why participants slowed down from an integrated psychophysiological standpoint.

# Conclusion

The current study’s main findings are that certain training characteristics and previous distance running experience are significantly correlated with pacing ability. Faster marathon times were associated with a better pacing profile and may be linked to the greater accumulation of ‘global’ endurance running experience compared to lesser-trained counterparts. In relation to the perception-based model, the greater the experience one accrues during marathon specific training and prior distance races can help develop a robust ‘template RPE’ that is compared to a ‘conscious RPE’ to regulate exercise intensity appropriately. Those with less marathon experience and ‘global’ endurance running are more likely to slow during the marathon and display more pace variability than experienced runners, potentially due to having a novice ‘template RPE’.

# Disclosure of interest

The authors report no conflict of interest.

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