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Pacing strategy of the finishers of World major marathon series

Maailma maratonide sarja finiseerijate tempovalik

Magistritöö

Kehalise kasvatuse ja spordi õppekava

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Sisukord

ABSTRACT

Aim: General purpose of the study was to describe the pacing pattern of the finishers of the World Marathon Major series and the effect of sex and age on the pacing pattern.

Methods: Finishers of the World major marathon series, total 69 814 male runners and 46 858 female runners were included to the statistical analysis when the finishing time was ≤ 6 hours. Difference in pacing (dev%) was define as % of time the first half of the marathon was faster/slower from ideally evenly paced marathon (first and second half 50:50% respectively). Normality of all the variables was tested using Shapiro Wilk's test. Factorial analysis of variance (ANOVA) was used to evaluate the differences within and between the marathon time groups.

Results: The highest number of finishers among men was in time category of 3:45-4:00 (h:min) and 4:30-4:45 (h:min) for women respectivel. Runners who finished with time 3:00-3:15, the first half of the marathon was significantly faster compared to evenly paced marathon ($p < 0.05$). Male runners with finishing times 3:00 (h:min) and females with 4:00 (h:min) or slower had significantly faster first half of the marathon compared to evenly paced marathon ($p = 0.038$ and $p = 0.001$, respectively). The average difference the first and second half of the marathon was faster from evenly paced marathon was $3.90 \pm 2.04\%$ for male and $2.94 \pm 2.04\%$ for female runners.

Conclusions: Faster finishers of the marathon running maintain more constant velocity compared to slower finishers. Women with the same finishing time as men pace themselves more efficiently thus their pace on the second half of the marathon decline slightly less compared to men. Veteran runners maintain slightly more even pace throughout the marathon course compared nonveteran runners.

Keywords: marathon pacing, pacing strategy, marathon finishers, age, sex

LÜHIÜLEVAADE

Eesmärk: Käesoleva töö põhieesmärgiks oli kirjeldada maailma maratonide sarja lõpetajate tempovalikut, samuti vanuse ja sugude vahelist erinevust tempovalikule.

Metoodika: Uuringusse kaasati 2015 aasta Chicago, New Yorgi ja Londoni maratoni lõpetajad, kelle lõpuaeg oli ≤ 6 tundi. Uuritavate koguarv oli 116 598. Kasutati IBM SPSS Statistics v.20 (SPSS Inc., Chicago, IL, USA) tarkvara statistilise analüüsi läbiviimiseks. Normaalväärtusi kõigil muutujatel testiti kasutades Shapiro Wilk's testi. ANOVA analüüsi kasutati, et hinnata maratoni lõpetajate lõpuaegade erinevust.

Tulemused: Enim maratoni lõpetajaid on meestel ajavahemikul 3:45-4:00 (h:min) ja 4:30 - 4:45 (h:min) naiste puhul. Meestel lõpuajaga üle kolme tunni ja naistel lõpuajaga üle nelja tunni või aeglasemalt oli maratoni esimene pool märkimisväärselt kiirem võrdselt jaotatud maratonist ($p = 0.038$ ja $p = 0.001$). Keskmine erinevus võrdselt jaotatud maratoni poolte vahel oli meestel $3.90 \pm 2.04\%$ ja naistel $2.94 \pm 2.04\%$. Veteranid säilitavad maratoni vältel ühtlasemat tempot kui mitteveteranid.

Kokkuvõte: Kiiremad maratoni lõpetajad säilitavad jooksu vältel ühtlasemat tempot kui aeglasemad lõpetajad. Naistel sama lõpuajaga nagu meestel langes tempo maratoni teisespooles vähem. Veteranid säilitasid maratoni vältel ühtlasemat tempot kui mitte veteranid.

Märksõnad: maratoni tempovalik, jooksustrateegia, martonide finišeerijad, vanus, sugu

1. INTRODUCTION

1.1. Marathon progress

During the last 45 years has been a marked increase in the number of marathon races that occur annually - 644 races in 1990 to 2820 races in 2011 and in the number of participants - 234,000 registered in 1990 and 1.48 million in 2011 according Association of Road Racing Statisticians (ARRS, 2016). Six most prestigious marathons belong to The Abbott World marathon series which contain six of the largest and most renowned marathons in the world: Tokyo, Boston, London, Berlin, Chicago and New York City Marathon (AWMM, 2016). Marathon progress to the last 15 years are shown in Figure 1.

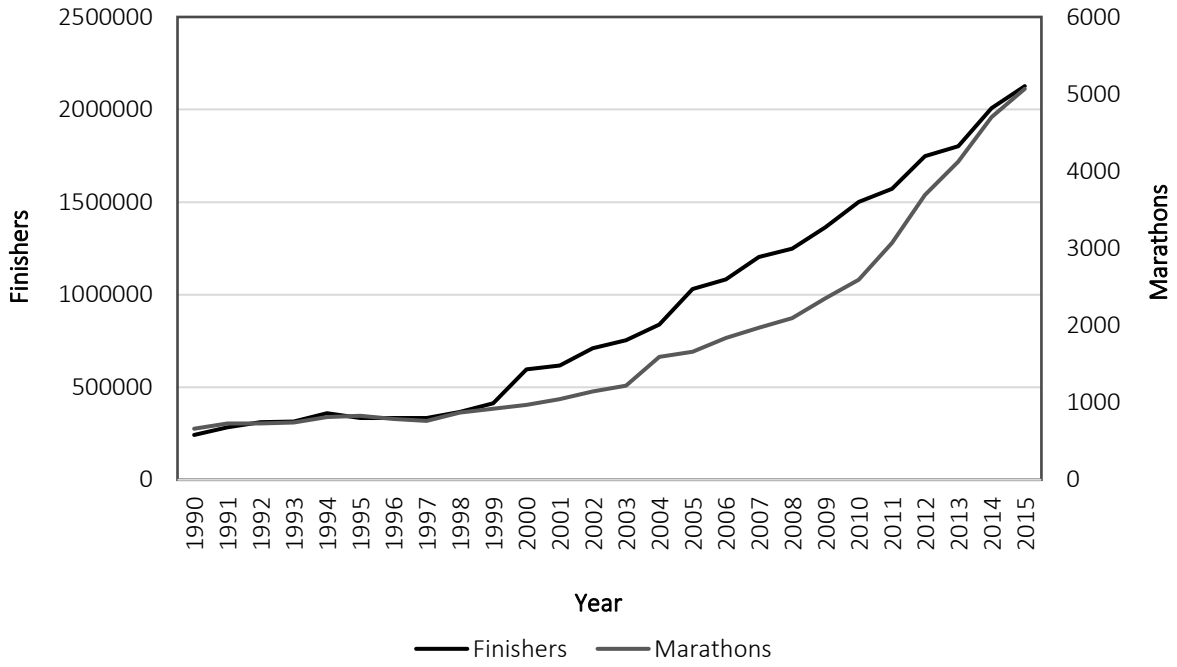

Figure 1. Number of marathon races and finishers 1990 – 2016 (ARRS, 2016)

Surprisingly, there is lack of available information on pacing over the 42.195 m distance especially given the popularity of the marathon running. It has been documented that regular running is beneficial for cardiorespiratory fitness to reduce all-cause and cardiovascular mortality (Gulati et al., 2003). However, recreational runners with moderate training the risk for cardiac dysfunction and injury is increased after completing a marathon, therefore appropriate preparation is important (Karlstedt et al., 2012; Lucia et al., 1999; Neilan et al., 2006). The marathon is an endurance event where choosing the best pacing strategy can be crucial to achieve the personal best performance (Hanley, 2016). Thus in the light of growing number of participants in marathon running events the optimal pacing deserves closer attention.

1.2. Pacing strategy

Pace and speed both describe how fast somebody is moving. In running event and thus runners generally use term pace, while cyclists are more familiar in using term speed. For example, pace 5 $min \cdot km^{-1}$ are equivalent with speed 12 $km \cdot h^{-1}$. Pacing is the actual distribution of speed and power output or energetic reserves during a given sporting event (Roelands et al., 2013) and this is a fundamental determinant factor of competitive endurance performance (Foster et al., 2004). Pacing strategy is the self-selected strategy or tactic that the athletes adopt from the beginning of an event (Roelands et al., 2013). Numerous studies (Abbiss & Laursen, 2008; Angus 2013; Hanley 2016; March et al., 2011) have recognized that advantageous pacing strategy can be significant impact on athlete performance. However limitation of the above mentioned studies are small sample size and/or only elite level athletes has been studied.

By applying mathematical modelling to athletic performances, coaches and researchers have examined six different pacing strategies (Abbis & Laursen, 2008).

1. Negative pacing pattern refers to an increase in speed over the duration of the event (i.e. number which indicates that speed is increasing and number which indicates pace is decreasing and thus it is called negative pace). This kind of strategy is mostly used in competitions where the second half is fastest (tactical races, championchip races) (Foster et al., 2004) which is most often seen in middle-distance running events (Abbiss & Laursen, 2008).
2. All out pacing are used in events where the acceleration can significantly influence the pacing strategy required of optimal performance (van Ingen Schenau et al., 1992). All Out pacing is rational and mostly used events lasting up to 60 sec (Yamamoto et al., 1995), for example from 100 m up to 400 m run or as indicates elite level athletes optimal performance can be achieved during running events of <291 m (Abbiss & Laursen, 2008).
3. Positive pacing strategy is one where the speed of athletes gradually declines throughout the duration of the event (Abbiss & Laursen, 2008), such as a 800 m run (Sandals et al., 2006).
4. Even pacing or constant pace is „optimal" for prolonged (longer than 2 min) events such as running, swimming, rowing, skiing, speed skating and cycling (de Koning et al., 1999). There is consensus that even pacing is best for optimizing performance in races that take several hours to complete, such as the marathon (Abbis & Laursen, 2008).
5. Parabolic-shaped pacing specific example is fast start, following intermediate phase with moderate pace and the end of the race is fast again. (Garland, 2005). This type of pacing pattern is specific in rowing and cycling.

6. Variable pacing strategy is a term that has been used to define the fluctuations in exercise intensity or work rate observed during exercise (Atkinson & Brunskill, 2000).Variable pacing is a strategy where pace/power fluctuates depending on the external conditions (track profile, head- and/or tailwind etc) in attempt to maintain a constant distribution of pace/velocity (i.e. even pacing) (Abbiss & Laursen, 2008). Best example is competitions like a cross country races.

The precise pacing strategy that insure athlete best possible performance are yet unclear. Research generally suggests that short duration sprinting events are optimal "all out" pacing strategy. During middle distance events are optimal "positive" pacing strategy. Events that last >2 minutes there is optimal "even" or "variable" pacing strategy (Abbiss & Laursen, 2008).

1.3. Pacing during a marathon

To date marathon pacing strategies for elite athletes are well studied (Ely et al., 2008), however the majority of marathon participants are non-elite runners (Haney & Mercer, 2011). Little information is available in the literature regarding pacing patterns displayed by recreational runners (Foster et al., 2012; Roelands et al., 2013). There are minimal published data on variability of pacing in endurance running events (Haney & Mercer, 2011). Moreover, to our knowledge only few previous studies that has investigated sex differences in marathon pacing reporting that marathoners decreasing the speed independently of sex (Santos-Lozano et al., 2014) and that women tended to adopt a more steady pace than men (Deaner et al., 2014).

It has been shown that the best marathon performance is achieved by low variations in running velocity (Haney & Mercer, 2011) and elite runners completing a marathon have very little change in 5 km pace during a marathon (Ely et al., 2008). Also, elite athletes are considered to maintain an economical and efficient running strategy with few variations in pacing (Hottenrott et al., 2016). It has been indicated that a high variability of pacing impairs marathon performance (Haney & Mercer, 2011) possibly due to a higher energy demand, which is associated with an uneconomical running strategy (Hottenrott et al., 2016). High variability in pacing over the course of the race would mean that the runner is undergoing large changes in velocity which would seem disadvantageous to elite marathon performance (Haney & Mercer, 2011). Lambert et al., (2004) speculated that the inability to maintain running speed in the slower runners may be attributed to physiologic mechanisms such as exercise economy,

glycogen depletion, neuromuscular changes, variations in training habits, pacing practice, or genotype of the runners. Lambert et al., (2004) study was made from ultramarathon and this distance is much longer than the 42.2-km marathon to which the similar effect maybe difficult to infer.

According to previous studies, the pacing of the race winners is clearly different than that of the competitive slower runners over the marathon distance (Ely et al., 2008; March et al., 2011; Maughan et al., 1985). The fastest marathoners ran an even pace throughout the race while runners of lesser ability slow down as the race progress, particularly after 20–25 km (Ely et al., 2008; Renfree et al., 2013). Whereas winners ran an even velocity over the 42.2-km distance, slower runners started out relatively faster than their average velocity for the first 5 km before settling into a pace that they could maintain for 20 km or 25 km before decelerating for the remainder of the race until the end spurt (Ely et al., 2008). The consistency of this pacing pattern between finishing groups suggests that the winner and slower runners represent two unique populations with prospect to pacing. The different pacing of runners might be explained by different racing goals (Ely et al., 2008). It is understandable that race winners run to win or get good place and, therefore, are less concerned about early race running velocity as long as they are positioned at near the race leaders (Ely et al., 2008). The slower runners know that it is unlikely that they will win, and their primary objective is more likely to set a personal record. To achieve that goal, these runners select an early running velocity that is faster than the average running pace of their current personal best marathon time, mostly that running speed cannot be hold on and pace decelerates progressively during the second half of the marathon (Ely et al., 2008). It can be concluded that the pacing of marathon winners and slower finishers are distinctively different (Ely et al., 2008).

Understanding variability of pacing may lead to a better understanding of factors that influence marathon performance and help runners either complete a marathon successfully or improve race performance. Specifically, the intriguing aspect of investigating variability of pace is that the runner, theoretically, selects a pace to maintain homeostasis (Haney & Mercer, 2011). However, if the wrong pace is selected then fatigue will result and the runner will slow down or possibly not finish the race (Haney & Mercer, 2011).

2. AIM

General purpose of the study was to describe the pacing pattern of the finishers of the World Marathon Major series and the effect of sex and age to the pacing pattern.

Specific aims of the study were:

1. To describe the distribution of the male and female finishers according to 15 min time intervals of the World Marathon Major series marathons.
2. To compare split times of the first and second half marathon between male and female runners of the World Marathon Majors series marathons.
3. To compare split times of the first and second half marathon between veteran older than 40 years and non-veterans runners (younger than 40 y) of the World Marathon Major series marathons.

3. METHODS

3.1. Subjects

2015 Abbot World Marathon series included London, Chicago, New York, Boston, Tokyo and Berlin marathon. In current analysis publicly available data of the London (n = 34 644), Chicago (n = 36 393) and New York (n = 45 561) marathons finishers were analysed. Finishing protocols of these marathons included finishers sex, age, half-marathon time and total time. Boston marathon was excluded because the course is not eligible requirements for international record settings due to not meeting IAAF Competition Rules (IAAF 2014): (i) the start and finish points of a course, measured along a theoretical straight line between them, shall not be further apart than 50% of the race distance; (ii) the decrease in elevation between the start and finish shall not exceed an average of one in a thousand, i.e. 1 m per km. Finishing protocols of the Tokyo and Berlin marahtons were publicly available on the race organisers webpage, however the data format was not suitable for data analyses. The organisers of the Tokyo and Berlin marathons were contacted via e-mail to provide database of the finish protocols (sex, age, half-marathon time and finishing time), but it was turned down referring to the protection of personal information. Before the study University of Tartu Ethics Committee was contacted in regards of ethical approval, however it was confirmed that approval for this study is not necessary due to the fact that all the data is publicly available.

Finishers of the marathon were included to the statistical analysis when the finishing time was ≤ 6 hours. For slower runners, half marathon time of the number of runners was missing in the finish protocol and therefore they were excluded. Race organisers categorized participants as (i) 18-39 y (non-veteran) or (ii) 40 y and older (veteran).

Difference in pacing (dev%) was define as % of time the first half of the marathon was faster/slower from ideally evenly paced marathon (first and second half 50:50% respectively (dev%) and was calculated as follows:

$$dev\% = 50 - (\frac{T2}{T} \times 100)$$

where T2 is time of the second half of the marathon in seconds, T is total time of the marathon in seconds. Negative value indicates relatively faster first half of the marathon compared to even pacing.

3.2. Statistical Methods

The IBM SPSS Statistics v.20 (SPSS Inc., Chicago, IL, USA) software was used for performing statistical analysis. Normality of all the variables was tested using Shapiro Wilk's test. Factorial analysis of variance (ANOVA) was used to evaluate the differences within and between the marathon time groups. In case of a significant main effect, Tukey's HSD post hoc analysis was used. The differences between the first and second half of the marathon was analysed using linear regression and controlled for sex and timegroup. Significance was set at $p < 0.05$.

4. RESULTS

In total of 116 598 participants from London, Chicago and New York marathons were included to the study, respectively. In total there were more male runners compared to female as well as more non-veteran runners compared to veteran runners (Table 1).

Table 1. Participants of the study

	N	Men	Women	Veterans	Non veterans
Chicago	34644	19150	15508	14403	20255
London	36393	23430	13004	16480	19941
New York	45561	27234	18344	24163	21415
Total	116598				

The highest number of finishers among men was in time category of 3:45-4:00 (h:min) and 4:30-4:45 (h:min) for women respectively. Distribution of the participants in 15 min time categories are shown in Figure 2.

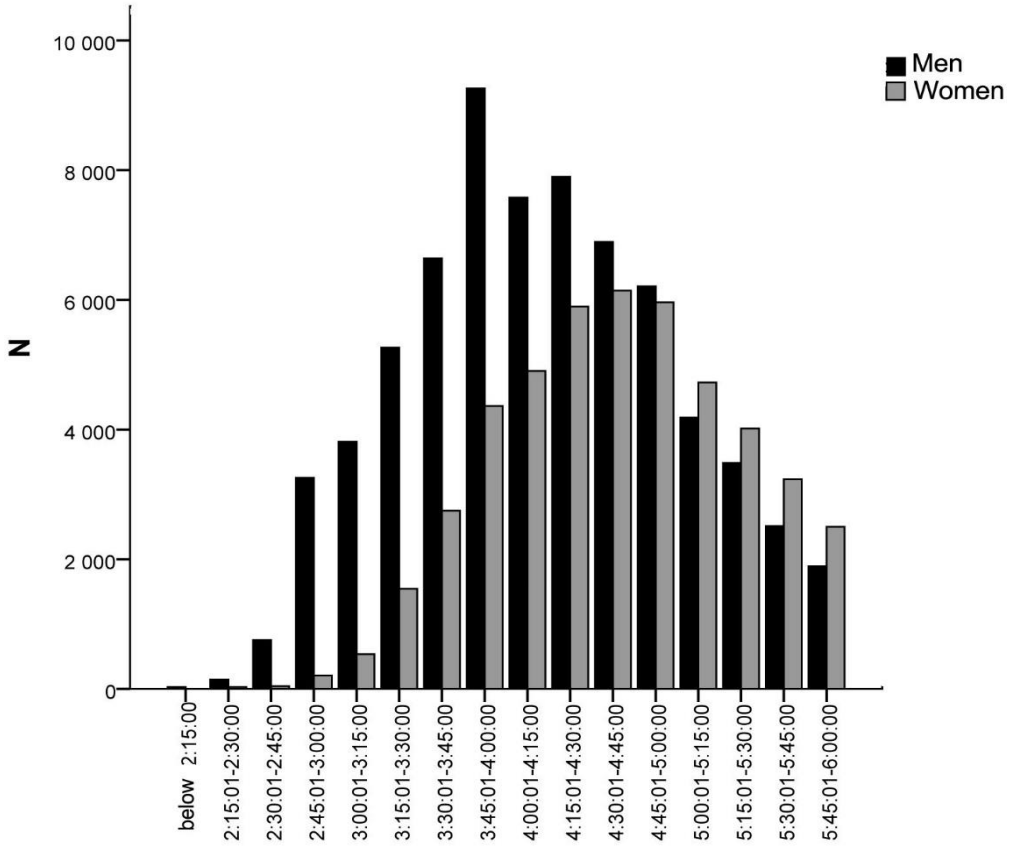

Figure 2. Distribution of the participants in 15 min time categories

Track profile between the marathon races were taken into account as comparing pacing (duration of first half of the marathon in relation to the second half) for the best 25 finishers from all the three marathons. Difference between first and second half of the marathon for first 25 finishers was not different between the marathons ($p = 0.751$) thus indicating smiliar marathon track profile.

As for the pacing strategy, runners who finished with time 3:00-3:15, the first half of the marathon was significantly faster compared to evenly paced marathon ($p < 0.05$). Male runners with finishing times 3:00 (h:min) and females with 4:00 (h:min) or slower had significantly faster first half of the marathon compared to evenly paced marathon ($p = 0.038$ and $p = 0.001$, respectively) (Figure 3). It is important to note female runners trend towards significantly faster start compared to second part of the race ($p = 0.051$) in the time group of 3:45-4

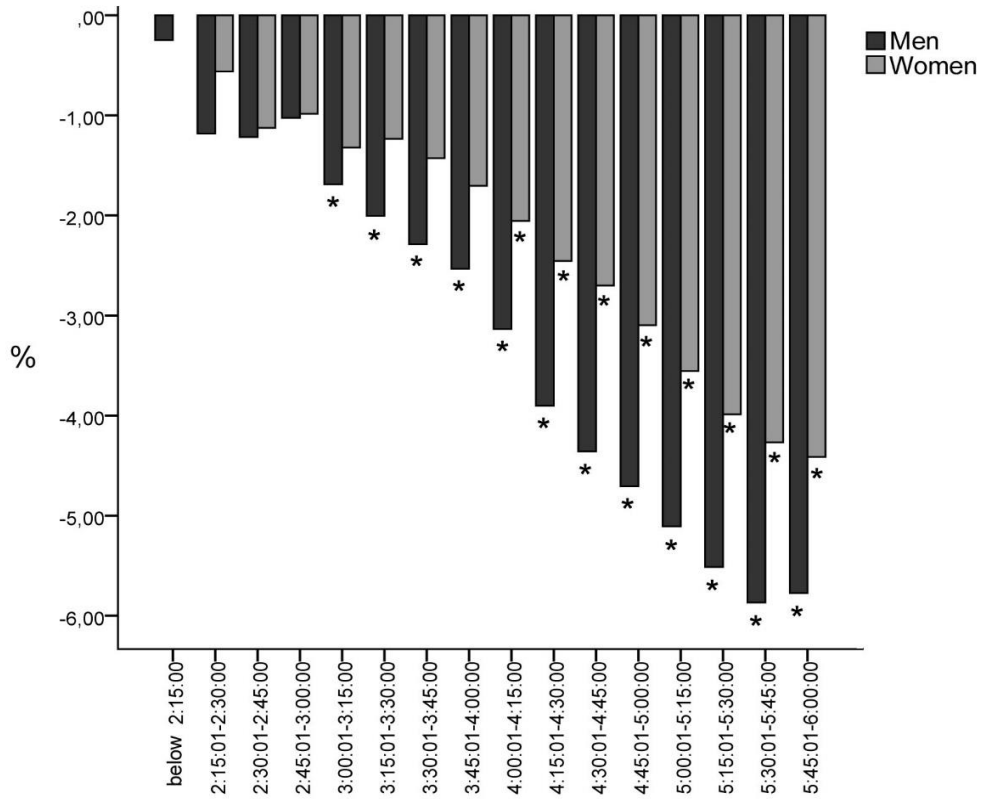

Figure 3. Percentage differences between the first and second half of the marathon in different time groups. * significantly different from the group of the fastest finishers of the same gender ($p < 0.05$)

The average difference the first and second half of the marathon was faster from evenly paced marathon was 3.90 ± 2.04% for male and 2.94 ± 2.04% for female runners. Men and women in slower finish time groups had more pronounced decline in the running speed during the second half of the race (Figure 3). When comparing male and female runners in the same time group, the decline in the pace for men was significantly more pronounced compared to female runners in the time group 2:15-2:30 (h:min) and from the time group of 3:00-3:15 until the 6:00 (h:min). Regression analysis revealed that in the case of the same age and time group, female runners have 0.26% smaller difference between first and second half of the race compared to male runners ($R^2 = 0.256$; $p = 0.000$).

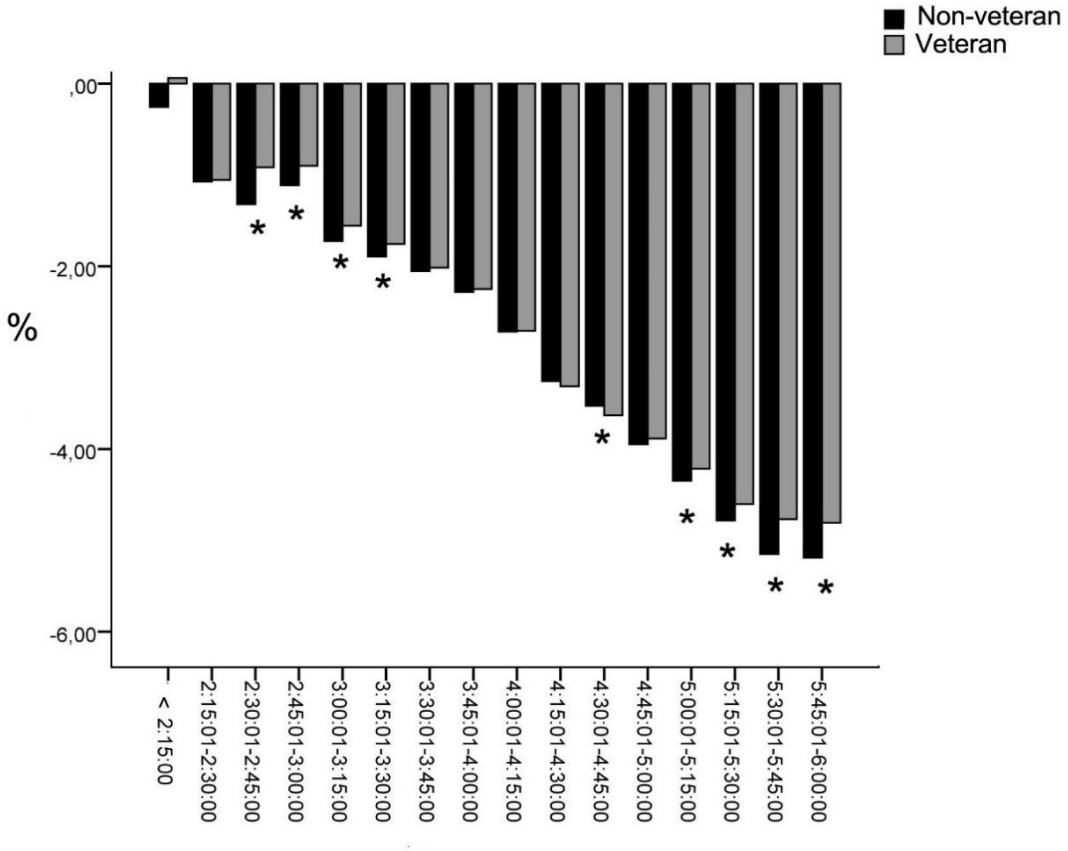

Figure 4. The distribution of percentage change in pace by finishing time group differenciated by veterans and non veterans. * significantly different from veteran of the same group ($p < 0.05$).

The distribution of percentage change in pace by finishing time group differenciated by veterans and non veterans is shown in figure 4. Following regression analysis revealed ($R^2 = 0.256$; $p = 0.000$) that if we are controlling for the time group and sex, then veterans has 0.05% smaller difference between first and second half of the marathon compared to nonveteran runner.

5. DISCUSSION

The aim of the present study was to compare the pacing profiles of marathon finishers between first and second half of the running marathon races which belong to the 2016 World Marathon Major series. The main finding of the present study was that faster runners had smaller difference between first and second half of the marathon compared slower runners and that sex and age are important factors affecting the pacing strategy.

The highest number of finishers among male are in the time group of 4:00-4:15 (h:min) and 4:30-4:45 (h:min) for female runners. Since > 2:15 (h:min) up to 4:45-5:00 there are more male finishers than male finishers. Since 5:00-5:15 (h:min) there are more female finishers than male finishers.

5.1. Effect of sex

Marathon runners whose finishing time was > 3:00 (min:s) for male and > 4:00 (min:s) for female started the race relatively faster pace compared to faster finishers. Present findings are somewhat in line with earlier studies (Ely et al., 2008; Santos-Lozano et al., 2014) where it was shown that faster runners ran an even velocity over the marathon distance, however slower runners started out relatively faster than their average velocity for the first 5 km before settling into a pace that they could maintain for 20 km or 25 km. After that runners with slower finish times slow down pace. Furthermore, Ely et al., (2008) and March et al., (2011) indicated that faster marathoners maintain a more consistent race speed throughout the race than slower marathoners. Both before mentioned study limitations was rather small data sets or particpants were only females. Study demonstrates that the sex difference in pacing among non-elite marathon runners is robust and greater between slower runners. The results imply that women are generally more effective than men in their marathon pacing (Deaner et al., 2014). (March et al., 2011) showed that age, sex and finish time were each statistically significant factors to influence pacing.

In the present study we showed (Figure 3) that woman run marathon more constant pace compared to men. It can be concluded that faster runners (<3:00 h:min and <4:00 h:min, male and female respectively) choose or slightly negative pacing strategy whereas slower runners

adopt a positive pacing pattern. Present study shows that sex difference in marathon pacing among non-elite runners is large in several aspects. Hanley (2016) found strong evidence that women are better at evenly pacing marathons than men: women ran the second half of the race closer to the pace of the first half. Participants was only elite athletes, who compete in World Championchips and Olympic Games, total 1222 athletes data were included. Approximately, 95% of men and 87% of women ran the second half of the race slower than the first.

There is several hypothesis (Deaner et al., 2015; Hanley, 2016; March et al., 2016) that has been advert to sex differences in marathon pacing. First states that the sex difference in marathon pacing is caused to men's greater sensibility to muscle glycogen depletion (March et al., 2011; Tarnopolsky, 2008), a major contributor to dramatic decline in marathon pace towards the end of the race (Coyle, 2007). There is considerable amount of facts indicating that, for any given intensity of endurance exercise, women enjoy advantages in low glycogen conditions (Thibault et al., 2010). During endurance exercise, women generally have a lower respiratory exchange ratio indicating they utilize proportionately more fat and less carbohydrate at a given intensity of exercise (Lamont 2005). It can be summed up that various physiological factors might contribute to the sex difference in marathon pacing. An alternative hypothesis (Allen & Dechow, 2013) is that the sex difference in marathon pacing is due to sex differences in decision making. For example, men may select more ambitious starting paces which increase the risk of slowing due to they are more oriented to time goals (Allen & Dechow., 2013) and more prone to take risks (Deaner et al., 2015). Men may be more sensitive to slow down because, they are more likely to adopt a risky pace, relative to their ability, which could increase their probability of slowing later part of race.

Based on the present study and previous findings it can be concluded that woman tend to run marathon more constant pace compared to men which is most likely due to men's greater likelihood of glycogen depletion (March et al., 2011; Tarnopolsky, 2008), and male runners have an evolutionary predisposition to be over-ambitious (Deaner, 2013) and by contrast women start more conservatively.

5.2. Effect of age

Present study showed that, veteran runners run with more constant pace trough the marathon. It has been hypothesis that older runners are pacing more evenly because their larger

experiences (March et al., 2011). Possible reason is that older runners have greater racing experience, therefore they feel their own abilities better and are more skillful in distributing pace over the marathon distance (March et al., 2011).

Running with constant pace is more beneficial, than running with positive pacing pattern. Previous studies has been shown that the adoption of a positive pacing strategy results in an increased VO_2 (Sandals et al., 2006; Thompson et al., 2003), greater accumulation of fatigue-related metabolites (Thompson et al., 2004; Thompson et al., 2003) as well as an increase in the rating of perceived exertion (Thompson et al., 2003) during the early stages of an exercise task. As a result, a reduction in the exercise intensity and the observed positive pacing profile likely evolves in response to these signals to avoid catastrophic failure, such as muscle cramp and sudden decline in running speed (Marino, 2004; Thompson et al., 2004).

Limitation of the present study was comparing first and second half of marathon and not including 5 or 10 km split times. However strength of the study was including high number of finishers compared to previously published studies (Hanley 2016; Haney & Mercer 2011; March et al., 2011).

It can be concluded that non-elite marathoners adopt mostly a positive pacing pattern i.e., decreasing the speed throughout the race independently of sex and performance level. However irrespective of sex and age faster finishers maintain a more constant velocity than the slower ones. Furthermore women are generally more effective than men in choosing their marathon pacing. This conclusion should be considered provisional because an evenly paced race does not automatically indicate a well-paced one. The causes of the sex difference in pacing are presently unknown, but they likely involve the interplay of physiological and psychological factors. Studying this sex difference and related pacing phenomena should yield performance insights for scientists, coaches, and athletes.

6. CONCLUSION

Based on the results of the current study, the following conclusions were made:

1. The highest number of finishers among male are in the time group of 4:00-4:15 (h:min) and 4:30-4:45 (h:min) for female runners.
2. Marathon participants finishing time slower thant 3:00 (h:min) and 04:00 (hh:min) for men and women, respectively, run the first half of the marathon significantly faster pace compared to second half thus leading to positive pacing strategy. Faster finishers of the marathon running maintain more constant velocity compared to slower finishers. Women with the same finishing time as men pace themselves more efficiently thus their pace on the second half of the marathon decline slightly less compared to men.
3. When timegroup and sex are taken into account then veteran runners maintain slightly more even pace throughout the maraton course compared nonveteran runners.

7. PRACTICAL APPLICATION

As the number of recreational runners taking part of the numerous maratons held in each year, number of participants have increased over the years. Thus the results of the present study would be greate interest of high level marathon runners and their coaches as well as recreational runners who like to finish their first marathon successfully. Vast majority of recreational athletes start their marathon competition relatively fast pace compared thus make them decline the speed on the second half of the race. The results of the present study showed that these finishers who had smallest difference between first and second half of the marathon race, performed better compared to finishers with the biggest difference between first and second half of the marathon. Furthermore female runners tend to choose slightly more even pacing strategy compared to male runners.

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Autori lihtlitsents töö avaldamiseks

Mina Ülari Kais
sünnikuupäev: 06.09.1988

1. annan Tartu Ülikoolile tasuta loa (lihtlitsentsi) enda loodud teose
   Maailma maratonide sarja finiseerijate tempovalik,

mille juhendaja on Martin Mooses ja Kerli Mooses

1.1. Reprodutseerimiseks säilitamise ja üldsusele kättesaadavaks tegemise eesmärgil, sealhulgas digitaalarhiivi DSpace-is lisamise eesmärgil kuni autoriõiguse kehtivuse tähtaja lõppemiseni;

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Tartu, 23.08.2016