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Technical Note

Pacing of an Untrained 17-Year-Old Teenager in a Marathon Attempt

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ABSTRACT

International Journal of Exercise Science 11(6): 856-866, 2018. Although there has been increased scientific interest for physiological responses to endurance running and pacing, limited information exists for adolescents participating in endurance events. We are reporting the case of an untrained 17-year-old female teenager (body mass 50.6 kg, height 167 cm and body mass index 18.1 kg/m^2) who intended to run a marathon within 6 hours without preparation. The young woman missed her goal by just 2 km. When the average running speed per hour was analysed, there was a major effect of race hour on running speed ($p = 0.013$, $\eta^2 = 0.320$), where the running speed in the fifth hour (6.3 ± 0.2 km/h) was lower than in the second hour (6.9 ± 0.1 km/h). Despite a progressive decrease in running speed, she was still able to put on a final spurt, indicated by a 4th degree non-linear regression (R^2=0.55). Creatine-kinase reached the initial value again after 5 days and the fall of hemoglobin and hematocrit indicated expansion of plasma volume. Running a marathon as a teenager did not impair physical health, especially when a self-selected pace was adopted. Laboratory parameters during running showed similar changes as have been reported for teenagers and adults after running a marathon. Increased values returned to base line within a few days. In summary, a female teenager at the age of 17 years without specific running preparation is able to achieve nearly a marathon distance during 6 hours of continuous running without harmful effects on health.

KEY WORDS: Adolescent, body composition, blood physiology, endurance performance, female athlete, running

INTRODUCTION

In recent years there has been a clear trend that more and more people are running marathons. Considering running data from the United States of America, the number of marathon runners multiplied twenty-fold from 25,000 finishers in 1976 to over half a million finishers in 2016 (www.runningusa.org/marathon-report-2017). From larger marathon studies it is well-known that the increase of the number of marathon runners is mainly due to the increased proportion of older runners, the so-called 'master runners' (29).

In addition to the distance-limited races in the discipline of running, such as 10km, half-marathon, marathon and ultra-marathon (30), there are also races that are limited over time, such as 6-hour runs, 12-hour runs, 24-hour runs and 6-day runs (18). Over the past few decades, the number of finishers in these time-limited races has also increased significantly (36).

An important aspect in endurance sports is the pacing of the athlete. Pacing describes the behaviour of an athlete during the competition resulting in the division of the race in single parts (1). In running, pacing has mostly been studied for top runners over different distances such as the marathon (12) and ultra-marathon (20), but little is known for pacing in time-limited races. In ultra-marathon running - defined as a race longer than the classic marathon distance of 42.195 km or a race time of 6 hours or longer - there are only a few studies investigating the pacing of runners, especially male top runners competing in 100 km (20) and 100 mile (38) ultra-marathon races.

In addition to the top runners, pacing was also examined for various age groups of runners competing in marathons (29) and 100-km ultra-marathons (17). However, the youngest age in official marathon and ultra-marathon races is 18 years old (30). Although younger runners under the age of 18 years can run marathons, for example in the United States of America (16), there is no information on how a person under the age of 18 years paces during a marathon run.

It is undisputed that regular training before a marathon is essential (9). An analysis of the data on more than 2,000 runners before the 'Copenhagen Marathon' showed that ~50% of the runners run ~30-60 km per week and ~25% of the runners more than 60 km per week (14). It was also shown that intensive training in preparation for a marathon significantly increases maximum oxygen uptake (VO_2max), which is an important performance-influencing factor (6). In this case report, we describe the attempt of a 17-year-old woman who intended to achieve the marathon distance during an official 6-hour run without specific running preparation.

METHODS

Participants

Our runner (17-year, 50.6 kg, 167 cm, BMI 18.1 kg/m^2) was in her second year of apprenticeship as a medical assistant in a large primary care centre. In the spring of 2017, she spontaneously decided that she wanted to run a marathon. Since in Switzerland the age limit to run a marathon is 18 years old in all large city marathons, she decided to run the marathon distance of 42.195 km in a 6-hour run. Since she regularly practiced weight training at a fitness centre, she felt she could easily run a 6-hour marathon with 10 minutes of warm-up on the treadmill before strength training. The runner gave her consent that her results would be evaluated and published. The participant's parent provided informed consent after having been informed about the benefits and risks of the present case study. The case study has been approved by the Institutional Review Board of the Exercise Physiology Laboratory, Nikaia, Greece, and has been assigned the ethical approval number EPL2017/1.

The race: In the 'Brugger Laufwochenende' held in Brugg, Canton Aargau, Switzerland, 6-hour runs, 12-hour runs and 24-hour runs have been held during the last 10 years (www.24stundenlauf.ch). The course is located on the Schacheninsel in Brugg and is a completely flat circuit of 0.934 km. Runners started at 12 noon (24-hour race) on Saturday, at midnight (12-hour run) or on Sunday morning at 6 o'clock (6-hour run) in order to finish the race together at noon on Sunday. Each completed lap was measured by an official timekeeper with an electronic chip on the ankle (www.raceresults.com). When the runner entered the last lap, they took a small bag with their start number on it and deposited it on the roadside at the final whistle. The organizer then measured the remaining distance so that the distance covered in the 6 hours was measured exactly to 1 m. The organizer offered a buffet along the course with different drinks (*e.g.* water, hot tea, Coca Cola®, Sponser® iso drink, soup, malt beer, Red Bull®, warm coffee) as well as various foods (*e.g.* pasta, potatoes, bread with cheese or jam, pretzels, chips, peanuts, energy bars, cakes, chocolate, biscuits, fruits such as bananas, oranges, watermelon and grapes). The runners could also have their own support crew along the track. At 6:00 am on September 24, 2017, the temperature was at 9.6 ° C and rose to 20.7 ° C by noon. The sky was virtually cloudless (http://ch.wetter.com/wetter_aktuell/rueckblick /?id=CH0CH0002). At the beginning, the runner used her leased GPS watch Garmin vívoactive black activity tracker (Garmin Vivoactive 3 Smart Activity Tracker, Garmin GPS, Bucher + Walt SA, Route de Soleure 8, 2072 St-Blaise, Switzerland) to set a pace of 08:00 min:s to 8:30 min:s per km, corresponding to a running speed of around 7.0 km/h to 7.5 km/h. Running at this speed for 6 hours will achieve a marathon distance. Over time, she could not keep the planned pace and stopped watching the GPS. After every lap, she looked at her time for the last lap, which was displayed on a large screen by the organizer.

Protocol

Before the start of the competition, percentage of fat was measured using Tanita BC-545 Bioelectrical Impedance Scale (Tanita, Arlington Heights, IL). On the day before the race, as well as on day 1, day 3 and day 5 after the finish, Hb (hemoglobin), Hkt (hematocrit), Lc (leucocytes), Tc (platelets), CRP (C-reactive protein), CK (creatine kinase), Krea (creatinine), K (potassium) and Na (sodium) were measured in the practice laboratory of the primary care centre using capillary blood samples. The haematological analysis was carried out using the ABX Micros CRP 200 laboratory equipment (HORIBA Medical, Montpellier, France) and the analysis of the serum parameter was performed using the Fuji Dri-Chem 4000i analyzer system (FUJIFILM Corporation, Tokyo, Japan).

Statistical Analysis

Based on the lap times, we analysed the trend over time for running speed using a 4th degree non-linear regression. An ANOVA (analysis of variance) analysed the difference in average lap running speed for each of the 6 hours. Depending on the result, the extent of the differences was classified as trivial ($\eta^2 < 0.01$), minor ($0.01 \leq \eta^2 < 0.06$), medium ($0.06 \leq \eta^2 < 0.14$) or major ($\eta^2 \geq 0.14$). The significance level was set at $\alpha = 0.05$.

RESULTS

The runner achieved a total of 42 laps during the 6 hours, as well as an additional distance 0.789 km after the last full lap, resulting in a total distance of 40.050 km. Therefore, she missed the length of a marathon by 2.145 km. Over the course of the 6 hours, the time per lap increased continuously, and the running speed decreased accordingly (Figure 1). For most of the laps, the runner ran at a pace of ~8 min per lap (Figure 2). When the average running speed per hour was analysed, there was a major effect of race hour on running speed ($p = 0.013$, $\eta^2 = 0.320$), where the running speed in the fifth hour (6.3 ± 0.2 km/h) was lower than in the second hour (6.9 ± 0.1 km/h) (Figure 3).

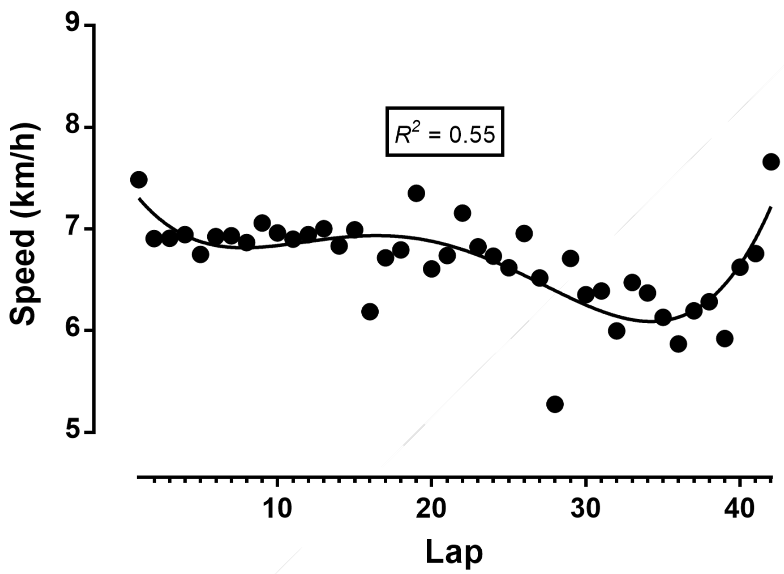

Figure 1. Running speed (km/h) per lap for the 42 laps.

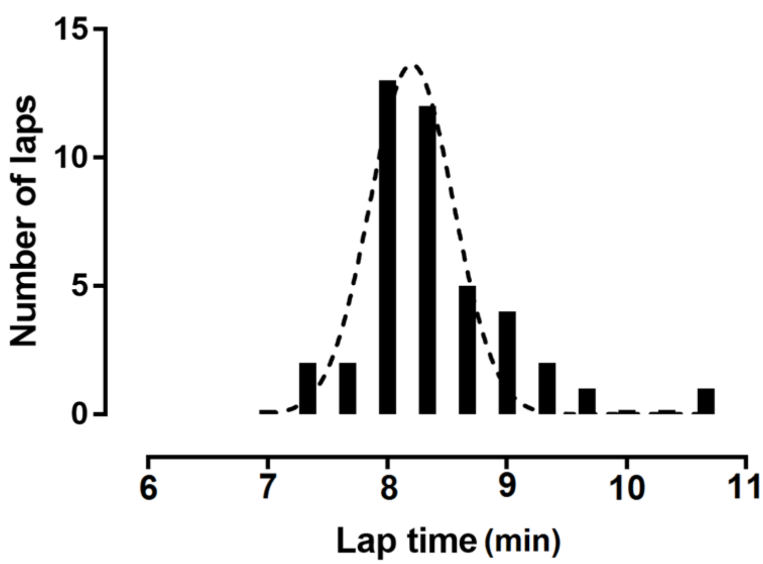

Figure 2. Distribution of the lap times.

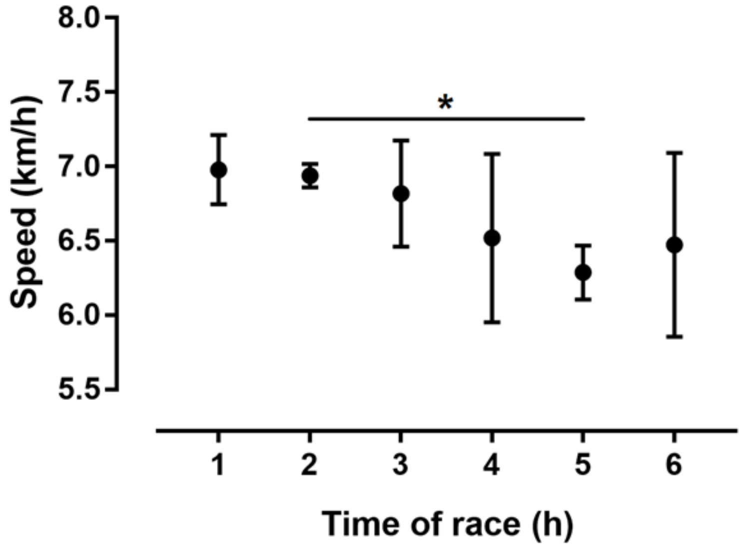

Figure 3. Mean lap running speed (km/h) for the single race hours. Normal distribution is marked by the dashed line. The lap times are divided into 20 s ranges, *e.g.* 7:50 min:s - 8:10 min:s. *p < 0.05. No difference was observed, except between the second and the fifth hour of the race. Dots denote mean lap speed for a single race hour. Error bars show standard deviation.

The laboratory analyses showed a decrease in hemoglobin and hematocrit after the race (Table 1). The leukocytes as well as the CRP increased slightly and returned to resting values after 5 days. The CK was above 1'500 U/l before the race, rose to 2'000 U/l after the race and returned to resting values after 5 days. Creatinine and sodium were within physiological levels throughout the observation period.

Table 1 Results of the laboratory measurements.

Parameter	Reference range	Before the race	Day 1	Day 3	Day 5
Haemoglobin	12.3-16.4 mg/l	13.9	14.9	11.5*	11.9*
Haematocrit	37-51 %	42.7	44.7	34.5*	36.9
Leukocytes	3.8-10.7 G/l	6.4	6.6	7.2	6.6
Thrombocytes	130-394 G/l	272	180	210	251
CRP	< 5 mg/l	0.0	8.3*	1.1	0.0
CK	30-150 U/l	1,503*	2,000*	591*	193*
Creatinine	35-80 µmol/l	56	65	76	59
Potassium	3.8-5.0 mmol/	4.3	4.1	4.2	3.9
Sodium	136-149 mmol/l	145	142	141	140

*out of reference range, CK = creatine kinase, CRP = C-reactive protein

DISCUSSION

In this case report, we described the pacing of a 17-year-old untrained female during a 6-hour run who aimed to complete a marathon distance within 6 hours. The findings from this case report could be of interest for athletes, coaches and medical doctors facing a similar case. Of particular importance was the question of whether a marathon could cause health problems for a teenager. In general, only runners older than 18 are allowed to compete in large city marathons held in Switzerland, and therefore this young runner has chosen a 6-hour run as alternative. Even children are allowed in this specific 6-hour run if they compete in a relay of several people during the 6 hours. An age limit of 18 years for a marathon does not seem to be justified from a sports science and medical point of view. Official age records for marathons have already been recorded starting from the age of 4 years (16). In the current world top list of marathon runners by age, the American Kevin Strain ran a marathon in 1972 as the youngest marathon runner at the age of 4 years and 351 days in a time of 6:56:39 h:min:s (www.arrs.net/SA_Mara.htm). In the 1969 women's race, Mary Etta Boitano, the youngest runner at the age of 6 years and 285 days, ran a marathon at a time of 4:27:32 h:min:s. Her time was almost 2 hours faster than the record in the same age category for males by Charlie Westrip, who achieved a time of 6:39:06 h:min:s in 2017 at the age of 6 years and 67 days. It appears that very young girls were faster than boys their age over the marathon distance. However, it was found in the analysis of the age-world records that boys and girls from 5 to 15 years could achieve about the same degree of performance (16).

There seem to be differences regarding the nationality of these young runners (16). Americans were slightly more progressive in marathon running for children and teens than other nations (34). In the United States of America, children and adolescents could officially walk in the large city marathons (34). Thousands of people under the age of 18 have already completed the 'Los Angeles Marathon' and more than 300 teenage finishers participated in the 'Twin Cities Marathon' (34). The youngest runner in these marathons was 7 years old and both events failed to identify any significant medical problems among the young runners (34). Previous studies of marathons showed no harmful effects or disadvantages for runners in the age group 18 years and younger as it is assumed that children and adolescents are walking at their own pace – a pace which they can easily sustain (34). That is what our runner intuitively planned and performed, and she was even able to deliver a sprint in the final laps. Our runner covered the distance of 40.050 km in 6 hours and missed the marathon mark by about 2 km. This corresponded to a mean running speed of 6.675 km/h. During the 6 hours, running speed decreased continuously, corresponding to a positive pacing (1). A positive pacing is generally observed among age-group runners in a major city marathon such as the 'New York City Marathon' (28). Generally, a large percentage of marathon runners experienced a performance drop during the race. Classically, this is due to the depletion of the body's own glycogen reserves (37) after 30 km which is referred to as 'hitting the wall'. Due to this phenomenon, ~ 1-2% of the starters dropped out of the race after about 30 km (32).

When we looked at the last few laps, we could see that the runner was able to lower the lap times significantly during the last 6 laps, resulting in a higher running speed and corresponding to a final sprint. It is expected that the runner tried to gather her energy in a final spurt to achieve the marathon distance of 42.195 km within the 6 hours. In general, a final sprint was observed in recreational marathon runners of every age group (28). When we considered the age group runners' pacing in a large city marathon like the 'New York City

Marathon', we see a difference between younger and older runners (27, 28). In general, the older runners had a more stable running speed over the entire distance than the younger runners (28). Likewise, slower runners showed a clearer drop in running speed over the entire distance than faster runners (27). There were also differences in pacing based on sex, age and level of performance. It seemed that older runners, faster runners and women were more consistent pacers than younger runners, slower runners and men (23).

The runner paced herself using a GPS watch based on her own calculations. A problem in marathon running is energy consumption, which depends on the sex. Female runners consumed relatively more energy despite slow running (22). It is well-known that a low percentage of body fat (5) and a high running speed in training (6) are important factors in achieving a fast marathon race time. It was assumed that fast running during training resulted in a reduction in body fat percentage and skin fold thickness (5), and training might be more important than low body fat (which could be due to both habitual physical activity and diet) for marathon race time. Our runner with a BMI of 18.1 kg/m² and a body fat percentage of 11.5% certainly has very good anthropometric characteristics for a long-distance runner. However, it must be assumed that running for 10 min on the treadmill a few times per week before strength training during pre-race preparation would hardly be enough for a fast marathon time. Basically, it is not uncommon that recreational runners preparing for a marathon have a high percentage of alternative training (40).

There was a clear correlation between high aerobic capacity and number of training years with marathon performance, with anthropometric aspects not corresponding to performance (9). For example, when analysing anthropometric aspects such as body fat and skin fold thickness and aspects of training, the number of weekly training units and years spent as a runner were the main performance-influencing variables for women's marathon time (4). Overall, regular training is essential to be able to run a fast marathon.

An increase in CK is always detectable after a longer run such as a marathon (3) even if the running speed was submaximal. In general, CK was highest for male runners 24 hours after the marathon, occasionally increased to 15 times of the resting value, and returned to resting values about one week after the race (19). The value of around 1,200 U/l on the day after the run was relatively low, with an approximately 10-fold increase in the resting value. CK values up to 3,000 U/l were detected in male marathon runners (3). A possible explanation for the relatively small increase in CK could be the sex, but could also be the low running speed and the low fat mass of the runner. For women, CK-values were significantly lower after a marathon than for men and increased to ~1,000 U/l (35). We attributed the increased CK before the run to the strength training of the young runner who trained regularly in the weight room. An increase in CK was also demonstrated after both endurance and strength training (7).

As expected, the CRP did not increase before the race and increased significantly after the race. However, the value normalized quickly. An increased CRP indicated an inflammatory component in the course of muscle damage due to the race (26), which was documented with the increased CK after the run. Similarly, the leukocytes can increase after a half-marathon (21) and a marathon (33), but this was not the case for our runner.

Occasionally, pronounced muscle damage after a marathon leads to rhabdomyolysis, which then results in pronounced kidney damage (10). The eccentric stress of running causes skeletal muscle damage with the release of myoglobin into the bloodstream. Under certain conditions, such as high heat with dehydration, myoglobin may precipitate in the kidney and impair kidney function and even lead to kidney failure (10). However, kidney failure after a marathon is extremely rare and only occurs when the 'perfect storm' happens: all factors such as high heat, dehydration, pre-existing muscle damage, ingestion of NSAIDs, and a viral or bacterial infection come together (10).

In the current case, there was a moderate increase in CK and the creatinine always remained within the normal range during the recovery phase. This was most likely due to the low running pace. Generally, increased renal function values after a race returned to normal values after 2-6 days (25). Whether a marathon could lead to a kidney problem in adolescents was recently investigated. There were mild and transient renal impairments in 30 male and 20 female teenagers between the ages of 13 and 17 who completed a marathon with a mean time of 4:47 h:min (39). Moreover, after the run, there was a drop in hemoglobin and hematocrit and an increase in body water. These changes indicate an expansion of the plasma volume. This phenomenon is commonly observed during prolonged endurance exercise such as a marathon (39) and is explained by a protein shift into the intravascular space and by renal sodium retention (31).

Fortunately, there was no exercise-associated hyponatraemia (EAH), which is more common in slow marathoners with a race time of just under 6 hours (2). The prevalence of EAH was 0% at the 'Christchurch Marathon' in New Zealand (36), 0.6% at the 'Boston Marathon' in the USA (2), 3% at the 'Zurich Marathon' in Switzerland (24), 12.5% in the 'London Marathon' in England (15), and up to 22% in the 'Houston Marathon' in the USA (8). In most cases, EAH is detectable by laboratory tests, but is without symptoms. Risk factors for EAH include low body weight, excessive fluid intake (13), long competition time (8) and the female sex (11). Despite the increased risk for our runner (*e.g.* low running speed, female sex) there was no EAH. Whether a marathon leads to EAH in adolescents has recently been studied. For 47 teenagers between the ages of 13 and 17 years who completed a marathon in a time of 4:57 h:min, no hyper- and hyponatraemia occurred in any case (39).

A limitation of the present study was that its design was a case study, and therefore, the findings should be considered as preliminary. Further research using larger samples would be needed to confirm our results. On the other hand, the strength was its novelty, as this study is the first to examine this topic. Considering the increased number of marathons and participants during the last several years, knowledge about pacing of young and novice runners, and acute physiological adaptations to endurance exercise is of great practical importance for practitioners working with them.

Running a marathon as a teenager has no negative influence on physical health especially when the teenager runs at her own pace. Laboratory parameters during running showed similar changes to what has been reported for teenagers and adults running a marathon. Increased values returned to base line within a few days. In summary, a female teenager at the age of 17 years without specific running preparation is able to achieve nearly a marathon distance during 6 hours of continuous running without harmful effects on health and is even able to perform a final end spurt.

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