

Heart Rate Profiling in Formula 1 race: A Real-Time Case

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Summary

Aim: To assess the HR responses of an F1 driver during an official driving session and an entire Gran Prix race (GP).

Materials and Methods: One professional driver (24 years old, height: 176 cm; weight: 64 kg) was recruited for this study during the Gran Prix of Albert Park Melbourne Australia 2013 season of the F1 World Championship. The participant was monitored for HR values throughout qualification and race. The HR was recorded in the interval: 45-min-before through 30-min-after the qualification/race period.

Results: During the qualification period, the HR was ~ 77% of the HRmax (154±29 bpm). In particular, HR peaked around 94-99% of HRmax.

During the race, the HR was constantly between 74% and 82% of HRmax (from 148 to 163 bpm), peaking around 92% of HRmax. Our data could pave the way to increase knowledge about HR trends during specific phases of an official F1 competition. The ultimate goal would be to customize training periodicity, which is critical for sports scientists and coaches.

Sommaire

Objectif : évaluer les réponses RH d'un pilote de F1 lors d'une séance de pilotage officielle et d'une course de Grand Prix (GP) entière.

Matériels et méthodes : Un pilote professionnel (24 ans, taille : 176 cm ; poids : 64 kg) a été recruté pour cette étude lors de la saison 2013 du Grand Prix d'Albert Park Melbourne Australie du Championnat du Monde de F1. Le participant a été surveillé pour les valeurs de RH tout au long de la qualification et de la course. La FC a été enregistrée dans l'intervalle : 45 minutes avant jusqu'à 30 minutes après la période de qualification/course.

Résultats : Pendant la période de qualification, la FC était d'environ 77 % de la FCmax (154 ± 29 bpm). En particulier, la FC a culminé à environ 94-99% de la FCmax.

Pendant la course, la FC était constamment comprise entre 74 % et 82 % de la FCmax (de 148 à 163 bpm), culminant autour de 92 % de la FCmax. Nos données pourraient ouvrir la voie à une meilleure connaissance des tendances RH lors de phases spécifiques d'une compétition officielle de F1. Le but ultime serait de personnaliser la périodicité des entraînements, ce qui est essentiel pour les scientifiques du sport et les entraîneurs.

Keywords

F1 racing, motorsport physiology, heart rate trend, hearth rate profiling, F1 qualifying, F1 official race.

Mots clés

Course de F1, physiologie du sport automobile, tendance de la fréquence cardiaque, profil de fréquence cardiaque, qualifications F1, course officielle F1.

1. Introduction

Formula-one (F1) is the most popular motorsport in the world. During the competition, drivers have to sustain high levels of concentration and physical stress [1–4] continuously throughout the entire duration of the race (~ 120 minutes; [5]). The main competition, called Gran-Prix, consists of approximately 300-km long races with a number of laps depending on the various track lengths (on average, 1 lap equals to ~ 5 km; www.fia). Current regulations provide two free practice sessions on Friday, a morning practice session and an afternoon qualifying session held on Saturday, which defines the order of drivers at the official starting grid. The F1 World Championship gathers millions of fans in multiple countries, however scientific approaches to evaluate racers' physiological responses are complex, and data acquisition is difficult to obtain during the race. Schwabergger (1987) [6] studied different hormonal/metabolic (i.e. lactate, glucose, free fatty acids, insulin, human growth hormone) and heart rate responses in twenty race-car drivers during the World Touring Car Cup and demonstrated that the greater the level of physical fitness the higher the mental fatigue tolerance [6]. During a single race, Brearley & Finn (2007) described the physiological parameters (such as core temperature, hydration and heart rate) and the perceived effort [7] in V8 drivers [8]. Thermal discomfort [9] and heart rate (mean values: 160-170 bpm) were also evaluated. Further, Turner & Richards (2015) [3] monitored HR profiles in rally race drivers whereas McKnight et al. [5] evaluated VO_2 peak, body composition and neck strength in F1, Indy car, Nascar and IMSA GTD pilots, finding that F1 pilots outperformed the other drivers in all the investigated outcomes. In a very recent study, during six laps of the same circuit, professional drivers ($n = 2$) showed higher HR than amateurs ($n = 2$) in pit stops (+17 bpm) and during caution racing conditions (+19 bpm) [10]. Also, Matsumura et al. (2011) monitored HR in three kart pilots during an real-time race (170 bpm) and a qualification session (140 bpm) [11]. Despite an increasing interest in the physiological responses of car race pilots, to the best of our knowledge, no study assessed F1 drivers' HR responses during an official World Championship race [3]. In fact, only a French case study, forty years ago, described HR trends in free driving practice and during official races (i.e. Pironi) [4]. Thus, this case-report aimed to assess the HR responses of an F1 driver during an official driving session and an entire Gran Prix race (GP).

2. Material and methods

2.1 Participant

One professional driver was freely recruited for this study during the season 2011 of the F1 World Championship. The driver was 24 years old (height: 176 cm; weight: 64 Kg), with three years of experience as a professional pilot in F1. Written informed consent was provided and signed out by the study participant. Furthermore, the general team manager agreed to collect and analyse the participant's data during qualification and GP.

2.2 Procedure

Before the beginning of the 2011 World Championship season, the subject undertook an aerobic running test according to OBLA threshold calculation [12]. In brief, during the incremental steps on the treadmill (1 km/h per 4min), the trainer recorded HR continuously until exhaustion. The maximum HR (HR_{max}) was defined as previously described in the literature [13]. The HR monitoring was conducted during the two-day Gran Prix of Albert Park Melbourne Australia. During the two afternoons (H 05:00 pm), there was partly sunny weather with a 16-18 °C. The driver wore an HR (beat to beat) belt (Polar Sport Performance; Sweden) with no influence with radio team transmission and ensuring free movement for all kinds of technical manoeuvres in the passage car. The HR was recorded from 45 min before the qualification/race to 30 min after (sampling rate every 5 sec). Fifteen minutes after the end of the competition, the HR belt was connected to the software for downloading the HR profiles. It took the driver approximately 100 min to complete the official race. Data are reported using descriptive statistics (mean \pm standard deviation, range, peak and percentage of HR maximum).

3 Results

The HRmax achieved during the incremental test was 200 bpm, corresponding to the theoretical maximum HR (i.e. 199 bpm). HR trends are shown in figures 1 and 2.

3.1 Qualification laps

During qualification laps, the HR was 154 ± 29 bpm (min = 123; max = 198 bpm), corresponding to about 77% of the HRmax. Some HR peaks were registered during seven specific attempts performed to gain the best time (Fig. 1). During these laps, the HR was at 94-99% of HRmax. In particular, the HR decreased in the 4th attempt (around min 80) as the driver decided to withdraw the fastest lap. The 5th was used as a launch lap.

PLEASE INSERT FIGURE 1

3.2 Official race

During the GP, the mean HR (comprising practice laps, test drive lap, starting phases and pit stops) was 146 ± 25 bpm, corresponding to 73% of HRmax. In particular, after the pre-start phase (41 min) an initial cardiac rhythm acceleration can be observed, which corresponded to the "green light" (51-52 min): the HR arose to 173 bpm in a few seconds (Fig. 2). During the race (53-143 min), the HR revealed a constant trend between 148 and 163 bpm (74% and 82% of HRmax). Some HR peaks reached 92% of the HRmax. When the pilot left the circuit (164 min), the HR was 142 bpm, whereas 15 min upon completion of the race, the HR remained, on average, at 147 bpm. In Fig. 2, a point labelled "Autonomic System shift" (161 min) shows a specific time when the driver got out of the car: this action looked like a significant HR peak.

PLEASE INSERT FIGURE 2

4 Discussion

F1 is one of the fastest car ring-race in the World and is characterized by tremendous physical and cognitive stress [1–3].

This concept is in line with the HR trends provided by one pilot during an entire GP1 official event. Per data referred to V8 race6 (160-170 bpm) and closed-wheel or closed-cockpit sports car (80-90% of HRmax) [14], in the short qualification event of our pilot, his HR reached peaks ranging from 80% to 99% of HRmax. These peaks were probably due to increased blood pressure, concentration and effort caused by specific period challenges. This is a useful start point to plan individualized loads, time and rest during physical training, as suggested by McKnight et al., 2019 [5].

During the official race, in accordance with other authors (Brearley & Finn, 2007; Potkanowicz, 2015; Ferguson, 2019), we reported a mean HR of about 75% HRmax for at least 120 minutes [2,8,15]. During specific periods such as "safety-car" and pit-stop, we noticed a decrease in HR with a plateau probably due to a stress reduction [1]. In particular, this decrement was less than the 38 beats reported by Barthel et al., 2020 in professional sports car drivers (no F1 pilots) [10]. The HR during the final phase (at the end of the challenge) was close to 140 bpm, very similar to the values found in kart drivers during solo driving (no-competitive) [11].

Moreover, a sudden change in the HR profile (Fig. 2) is appreciable when the pilot abandoned the vehicle. In the absence of other specific assessments, the authors postulate an adaptation of the autonomic nervous system because of the effort made while immediately changing position (i.e. from sitting to standing in one second).

Unfortunately, we are not able to provide data about the pilot thermoregulation discomfort and perception, muscle stress and mental stress [8,16].

The lack of a cockpit temperature value is a limitation of this study because, as demonstrated many years ago by Mostardi et al. [17], exercise raises the body temperature with a consequent increase in HR (about 17 bpm). This increase also occurs in quiet position (20bpm) in a heat environment using wet bulb globe temperature (as an index of heat stress) [18]. Despite this physiological evidence, it is reported in other studies with higher external temperature conditions that in open cockpit the value of HR is about 170-180 bpm [15] while other authors did not find the

cabin temperature as a significant independent contributing factor for average HR [20]. Beside these controversial results, we have calculated the HRmax value with an incremental test and this allows us to suggest a training plan based on real HRmax percentages. Further research is needed to clarify and define simultaneous sense-perceptive responses and HR during and after a GP race. For example, the acceleration and deceleration increased the HR [21] as a consequence of g-force remaining, in any case, in a range between 160 and 180 bpm as demonstrated in the pre-attack and attack phases by Saijo et al [22]. Furthermore, as stated by Saijo et al. [22], the increase of HR, during a race, has a positive valence since it is associated with better performance reflect the state of an enhanced arousal related to driving performance. Surely an analysis of the HR before decelerations and accelerations (also considering the length of these with the help of a GPS) will be the objective of future studies. Another limitation of this study is the late (8 years) reporting of the results. This delay was due to the F1 team that kept the dataset secret and gave permission to disclose it only after the sponsor, team manager, and drivers changed. The dataset was accessed after these changes by the team's medical doctor. However, this delay did not prevent us from focusing on our ultimate goal: to personalize the periodicity of training, which is crucial for sport scientists and trainers. In fact, within these limits (variability of the number of accelerations depending on the type of circuit and cockpit temperature), the present study suggests to athletic trainers that, even in the F1 race, the physiological domain of HR is between 170 and 180 bpm [15 , 19,22]. Finally, this case-report data could pave the way to increase knowledge about HR trends during specific phases of an official F1 competition.

Disclosure of interest

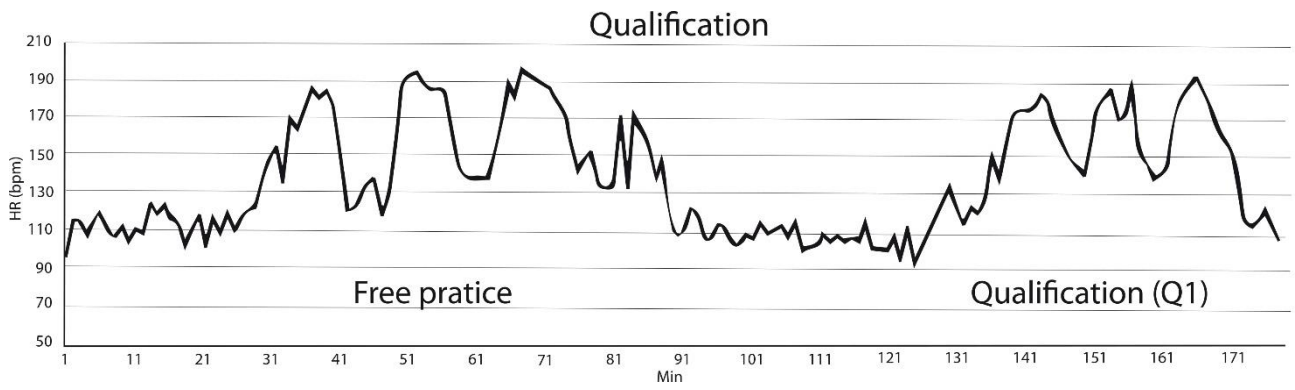
The authors declare that they have no competing interest.

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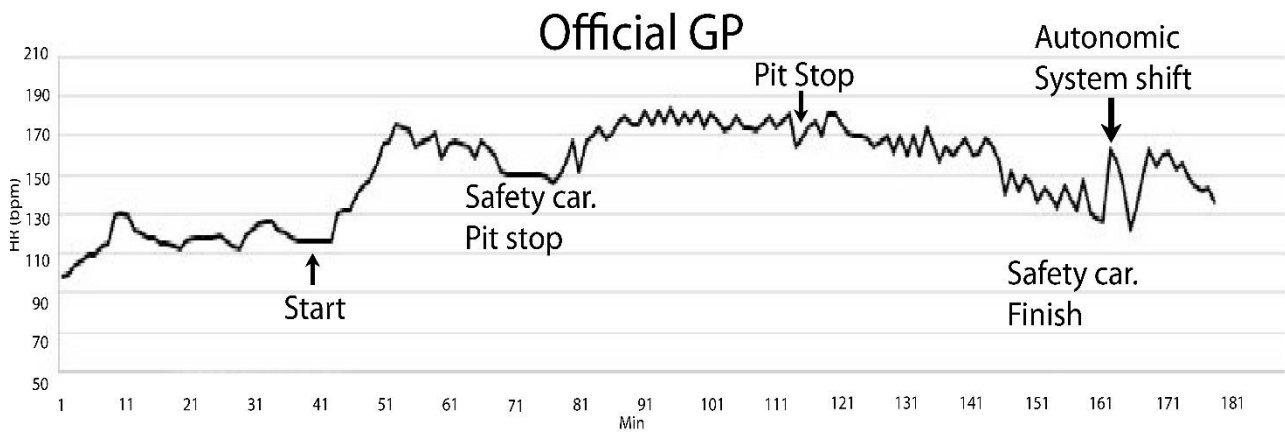
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Fig 1. HR along the qualification laps



HR trend during free practice and Q1 session.

Fig 2. HR along the official GP



HR trend during the peculiar periods of the race