CASE STUDY

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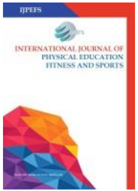

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The effect of osteopathic manipulative treatment on heart rate variability: A case study in a female World Championship medaling open-water swimmer

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Abstract: To examine the effect of osteopathic manipulative treatment (OMT) on heart rate variability (HRV) indices in an elite open-water swimmer. A female open-water swimmer (age =28 years, height = 172 cm, body mass = 60 kg) participated in this study. The swimmer performed a daily supine HRV test routine 12 days before the 2019 open-water World Championships. OMT was administered when parasympathetic activity (based on HRV indices) was considered below normal values. The swimmer won a bronze medal in the 25 km event and placed fourth in the 10 km event, which qualified her for the 2020 Tokyo Olympics. Parasympathetic falls occurred three times during the taper period. After OMT, we observed a rebound of parasympathetic activity with a moderate to strong increase for High Frequency (HF) values compared with the average baseline from 10 to 150% increase of Ln HF values. OMT appeared to allow a parasympathetic rebound and increase the quality of recovery in an elite open-water swimmer who performed well during the World Championships. This case report illustrates the potential effects of OMT on autonomous nervous system activity, highlighting the possibilities to improve the quality of recovery in world-class athletes. It also shows the necessity to implement individualized training in the context of elite sports.

Keywords: Performance, Recovery, Autonomic Nervous System, Prevention, Case report.

About the Authors

Dr. Robin Pla is the Head of Sports Sciences of the French Swimming Federation, working with the french national team. He dedicated his research work to swimming monitoring, mainly focused on recovery, altitude training, tools monitoring and race analysis.

Ms. Marion Bril is the osteopath of the French open water team since 2018. She works with many elite athletes. She is also a consultant in the analysis of motor preferences.

1. Introduction

Ultra-endurance sports training elicits severe changes in the autonomous nervous system (ANS) and has the potential to alter the quality of recovery [1]. Researchers have underlined the importance of monitoring athletes' adaptive responses to these high training loads to prevent 1) fatigue; 2) entering a non-functional overreaching state; 3) illness and injuries; and to improve physiological adaptations [2-4]. For that reason, some researchers use heart rate variability (HRV) analysis, which consists of the analysis of the time interval measurement between two heartbeats, with intending to make inferences on the functioning of the sympathetic and parasympathetic branches of the nervous system [5, 6]. Some indices allow to estimate modulation of parasympathetic influence of the heart, while others reflect the influence of sympathetic modulation [5, 6]. Finally, heart rate will represent an index of vagal tone. In elite endurance athletes, Plews et al. suggested that increased parasympathetic activity was associated with performance improvements [7]. In swimming, after 3 weeks of reduced training load, Atlaoui et al. noted a positive correlation between parasympathetic indices and performance, and a negative correlation for sympathetic indices [8]. However, various authors reported a shift towards sympathetic predominance during the taper period, associated with a high pre-competition anxiety level [9, 10]. It is possible that the decreased training volume and the stress caused by the importance of competition led to a fall in parasympathetic activity.

Training is not the only factor that impacts HRV changes. Many techniques can enhance parasympathetic activity, such as immersion in cold water, whole-body cryotherapy, bio resonance therapy, self-regulation factors, yoga etc [11-15]. Research has demonstrated that training prescription could be improved for endurance athletes when guided by HRV analysis compared to a predetermined training plan [16,17]. Within this context, a daily HRV analysis could provide clarity on the ANS balance and the necessity to adopt an appropriate strategy for recovery.

Osteopathy is a health care sector that has been gaining popularity for several years. However, osteopathic manipulative treatment (OMT) is less widely understood than traditional medicine and is often a subject of debate, especially with the current preference towards evidence-based medicine.[18] Athletes are becoming more interested in OMT and many now use OMT in order to prevent or recover from injuries and to improve performance before competition [18]. Researchers have demonstrated that OMT prior to competitions could improve football players' performance [19]. Others authors have highlighted that OMT before competition can reduce stress in cross-country athletes [20]. Further, a recent systematic review concluded that OMT might have an impact on ANS changes after treatment of suboccipital regions [21]. Henley et al. have also demonstrated that cervical myofascial release could increase vagal response using HRV analysis [22]. Other studies showed that OMT could influence autonomic nervous system functions [23,24]. They argued that OMT was associated with some physiological mechanisms that can lead to changes in ANS reactivity as: reduced cytokine production, decreased heart rate and blood pressure (trophotropic effect), changes in skin-conductance [25].

In a recent literature review, Botelho et al. determined that OMT appeared to have a beneficial effect on sports performance. However, the authors stated that there were a limited number of studies on the topic and the current literature needed more rigorous methodology [26]. In our study, we investigated the effects of OMT on a world-class athlete. Therefore, this study aimed to estimate the impact of OMT on HRV for a World Championship open-water medalist who was attempting to qualify for the 2020 Tokyo Olympics Games.

2. Materials and Methods

2.1 Case description

This study describes the physiological monitoring of a female open-water swimmer (age =28 years, height = 172 cm, body mass = 60 kg) during the taper phase of the 2019 open-water world championships. She had 13 years of competitive swimming experience and she had already participated twice in the Olympic Games in swimming. The swimmer also participated in the 2017 open-water world championships and the open-water European championships 2018, winning a bronze medal in the 25 km race. The objective of the swimmer was to qualify for the Tokyo 2020 Olympic Games and therefore, she needed to place in the top 10 for the10-km event at the 2019 World Championships in South Korea. The swimmer won the bronze for the 25 km and put 4th place for the 10 km, which allowed her to qualify for the 2020 Tokyo Olympic Games. These were the best results of her career.

Open-water swimming is an ultra-endurance sport, which requires a high training load to achieve world-class performance. This training load is still important during the taper period, so swimmers are prone to overtraining. In that sense, these swimmers still need a high level of recovery during taper and have various options to quantify this level of fatigue and recovery.

No OMT based on falls of parasympathetic activity was administered during the year before the tapering period.

2.2 HRV measurements

To quantify the quality of recovery, the swimmer performed a daily HRV test for 12 days prior to the World Championships [27]. The HRV protocol was conducted in the morning, just after awakening. The same routine was used for every test recording. The test lasted 5 minutes in the supine position. RR intervals were recorded with a heart rate belt (Polar H10, Polar Electro Oy, Finland) and transmitted by Bluetooth using a smartphone application. The last 4 minutes of the recording were used in the analysis. Breathing frequency was not guided. All RR recordings were visually inspected for stationarity and corrected for artifact and ectopic beats via Kubios's built-in piecewise cubic spline interpolation (v2.0, University of Kuopio, Finland). The same sports scientist always inspected data. Two time-domain indices were used for the HRV analysis: heart rate and root of the mean square of sequential deviations (rMSSD). Low- (LF: 0.04-0.15 Hz) and high-frequency (HF: 0.15-0.4 Hz) were obtained using power spectral analysis with fast Fourier transform (FFT). Then, we used the sum of LF+HF and the ratio LF/HF for further analysis. The rMSSD and HF indices reflect the modulation of the parasympathetic influence of the heart, while LF mainly demonstrates the modulation of the sympathetic influence of heart rate (Schmitt et al). After each data inspection, the sports scientist reported the results to the swimmer's support staff, including the osteopath. The objective was to inform the osteopath when a fall of parasympathetic activity was observed. Indeed, throughout the season, various falls of parasympathetic indices occurred and were related to a high level of fatigue perceived by the swimmer, implying difficulty in recovering well. The goal of the OMT was to help the rebound of parasympathetic activity.

2.3 Osteopathic Manipulative Treatment

OMT was administrated three times during the 12-day monitoring period: on the 3rd day, 7th day and 10th day of the training camp (two days before the 10 km event) due to a reduction in vagal tone. The OMT consisted of performing parasympathetic stimulation in response to the decrease in vagal tone (when HF values were falling down) and to the request by the swimmer (when she felt tired). The treatment was not applied as a protocol. The swimmer was only informed that this stimulation could help her improve recovery quality. She had already tested it in the past and she appreciated it with a feeling of reduced fatigue after that. This stimulation was based on the anatomical localization of the emergence of parasympathetic fibers. The preganglionic fibers of the parasympathetic system exit the spinal cord at S2, S3 and S4 and the brain stem with the 3rd, 7th, 9th and 10th cranial nerves. The vagus nerve (10th) contains about 75% of all parasympathetic fibers [McCorry]. So, in our case, manipulating cranial nerves was the best way to stimulate parasympathetic activity.

Therefore, we carried out OMT at the base of the skull between the occiput and the Atlas (Figure 1) while the swimmer was in the supine position (sub-occipital manipulation only). For the OMT, the practitioner held the swimmer's occiput in their hands, with their fingertips on the sub-occipital area. The pressure applied was deep and bilateral, with the swimmer's head balanced over the palms of the practitioner's hands. The pressure of the practitioner's fingers was at 90° to the swimmer's cervical axis. The weight of the swimmer's head caused the tissues of the sub-occipital region to relax until a balance of tensions was felt. The swimmer's head was gradually placed in the palms of the practitioner's hands. The treatment duration lasted between 30 and 45 minutes. The swimmer did not receive any other intervention during the taper period.

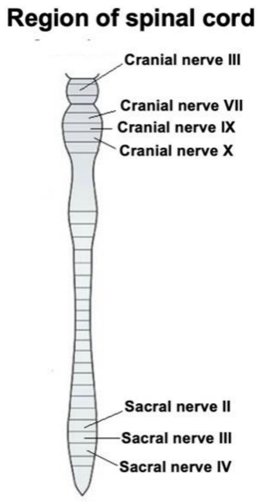

Figure 1. Osteopathic manipulative treatment (OMT) protocol.

2.4 Statistics

Data were expressed as mean ± standard deviation for rMSSD, LF, HF and LF+HF for both groups: with OMT or without OMT. All data were log transformed before analysis to reduce bias arising from non-uniformity of error. Due to the small sample sizes, we only reported effect sizes to consider the magnitude of changes between OMT and without OMT. The magnitude of difference between groups (OMT vs without-OMT) was assessed by Cohen's d in order to measure the strength of relationships between the variables. The magnitude of the difference was considered either trivial (<0.20), small (0.20 to 0.49), moderate (0.50 to 0.79), or large (0.80

and more). Calculations were made with Statistica (StatSoft, Tulsa, United States of America).

3. Results and Discussion

The mean ± SD for each HRV parameter with or without OMT are presented in Table 1. Effects sizes (Cohen's d) show that all HRV parameters were higher with OMT than without OMT.

The daily HF changes during taper are presented in Figure 2. Various changes were observed during this taper, including some drops of parasympathetic modulation (HF decrease). After each OMT, we observed a rebound of parasympathetic modulation (from 10 to 150% increase of Ln HF values).

This case report describes the potential impact of OMT on HRV changes during the final taper of an elite open-water swimmer during her preparation for the 2019 World Aquatic Championships. Three OMT sessions over 10 days were associated with an increase in parasympathetic indices.

Previous studies have demonstrated the influence of OMT on the activation of the parasympathetic system in different populations [22,23,29]. Manipulation of certain nerves in the spinal cord stimulates vagal activity, which promotes better recovery [30-32].

In this case, OMT led to a rebound in parasympathetic activity after a previous fall. It is possible that the swimmer maintained a high level of vagal activity, which led to a decreased risk of injury and/or illness [33].

Table 1. Mean ± SD for each HRV parameter with or without OMT during taper.

	Absolute mean ± SD				**Changes with previous day ± SD (%)**			
	RMSSD (ms)	LF (ms^2)	HF (ms^2)	LF+HF (ms^2)	RMSSD (ms)	LF (ms^2)	HF (ms^2)	LF+HF (ms^2)
With OMT	4.24 ± 0.16	7.79 ± 0.48	7.06 ± 0.15	8.20 ± 0.36	11.72 ± 8.84	21.45 ± 16.67	28.85 ± 19.40	21.38 ± 15.21
Without OMT	4.01 ± 0.28	6.96 ± 0.74	6.13 ± 0.74	7.34 ± 0.72	-4.53 ± 7.10	-6.57 ± 15.26	-8.04 ± 13.19	-6.61 ± 12.99
Cohen's d	1.01	1.33	1.74	1.51	2.03	1.75	2.22	1.98

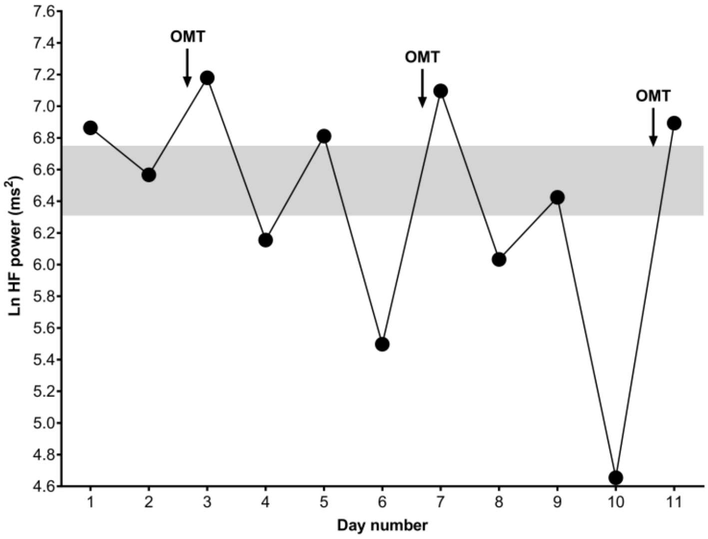

Figure 2. Relationships between HRV measurements and OMT during taper. OMT was administrated on the evening before the HRV morning test.

Maintaining parasympathetic activity also appears to be important in promoting endurance performance [7]. Otherwise, this high level of parasympathetic could allow a reduction in anxiety and stress before the competition. In this specific case, the female swimmer often experiences a lot of stress and apprehension before competitions. In this competition, she was exposed to extreme stress due to the need to finish in the top 10 to qualify for the Olympics. Maintaining her vagal activity may have helped her manage this situation better.

Additionally, considering the association between HRV and cardiorespiratory fitness [34], these changes in HRV may reflect an improvement of one or more of the components of endurance performance [7]. In a case study of an elite triathlete, Stanley et al. determined that an increase in rMSSD indicates a positive training adaptation during a training block [35]. This tendency was observed in other studies involving elite athletes and can be expected until the week prior to major competition [7,35]. Lastly, OMT could allow stimulation of parasympathetic activity to counteract the potential fall in parasympathetic modulation induced by the decrease in training volume during final taper [27,35].

In the context of elite sports management, pre-competitive spinal manipulative therapy appears to be a useful intervention strategy to enhance performance [26]. However, current evidence for enhancing sport performance still needs to be improved. Further experimental studies with more athletes are required in order to accurately evaluate the effects of OMT on recovery and its association with performance improvement. Our case report serves to improve collaborations between coaches and support staff and encourages the consideration of OMT on recovery. The monitoring of ANS activity allows an objective measurement of recovery quality.

This case report has shortcomings requiring that our results be interpreted with caution. OMT was performed on a single swimmer and only completed three times during the study period. Further, the OMT performed will be practitioner dependent. Otherwise, only the time-domain and frequency-domain were used in this study in order to assess HRV. It would also be appropriate to collect non-linear metrics to interpret HRV. It is also essential to state that some factors which influence HRV were not controlled during the study as menstrual periods, nutrition, sleep, etc.…) even if we can recall that the environment was the same during the study period (same bedroom, same training facilities and exact food location).

4. Conclusion

OMT has demonstrated potential positive effects for rebounding parasympathetic activity in an elite female open-water swimmer. This case report also highlights the possibilities to improve the quality of recovery in world-class athletes with an individualized training monitoring, requiring a good collaboration between staff support (physiologists, physiotherapists, etc…). Further studies will need to explore more in depth the potential of OMT on recovery in elite athletes.

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Ethics Approval

The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Commission Nationale de l'Informatique et des Libertés (CNIL) with the following registration number: 2218805.

Informed Consent

Prior to participation, the athlete was informed of the purpose of the study and the data collection involved.

Author's contribution & Statement

R.P. conceived the idea and collected the data. R.P. encouraged M.B. to investigate the findings of this work. R.P. took the lead on the manuscript. M.B. helped to write the methods sections. All authors accepted the final version of the manuscript. All authors have read and agreed to the published version of the manuscript.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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