HOSTED BY
ELSEVIER
CrossMark
Available online at www.sciencedirect.com
ScienceDirect
Journal of Sport and Health Science 4 (2015) 371–376
www.jshs.org.cn

Original article

Daily heart rate variability of Paralympic gold medallist swimmers: A 17-week investigation

Rohan Edmonds [a], Anthony Leicht [b], Mark McKean [a], Brendan Burkett [a,*]

[a] School of Health and Sport Sciences, University of the Sunshine Coast, Sunshine Coast 4556, Australia
[b] College of Healthcare Sciences, James Cook University, Townsville 4811, Australia

Received 17 March 2014; revised 2 July 2014; accepted 13 August 2014
Available online 8 November 2014

Abstract

Objectives: Heart rate variability (HRV) can be a simple, non-invasive method of gauging cardiac autonomic nervous system fluctuations across periodised training workloads and taper in elite athlete populations. The purpose of these three case studies was to examine daily cardiac autonomic variations in Paralympic athletes leading in to the Paralympic games.
Methods: Three Paralympic gold medallist swimmers were monitored daily for their resting HRV over a 17-week monitoring period leading up to the Paralympic games. Specific time- and frequency-domain measures, along with non-linear indices of HRV were calculated for all analyses. All HRV data were analysed individually using daily values, weekly average values, and average values for rest and training phases.
Results: A significant difference in HRV was seen for all variables between athlete 1 and athletes 2 and 3 (amputee disabilities) during the entire monitoring period.
Conclusion: Despite minimal long-term changes, both swimming classification and disability type significantly influence HRV during athlete monitoring. An increased understanding of individual responses to training, travel, and other outside influences affecting Paralympic athletes could potentially lead to improved management and monitoring of training workloads for enhanced performance.

Keywords: Autonomic nervous system; Cardiac modulation; Disability; Elite athlete; Periodised training; Testing

1. Introduction

Periodised training programs of elite athletes are most often comprised of a balance between phases of high training loads and active recovery or rest.[1,2] Establishing the right balance between these aspects for athletes, in particular understanding when to rest, can often be quite difficult to achieve.[3] Despite the potential value and importance of monitoring an athlete's state of recovery, there are few adequate or convenient tools for monitoring daily recovery.[4] Though most training induced adaptations occur while at rest, recovery is one of the most under-researched components of the stress–recovery cycle.[5] The ability for sport scientists to identify inadequate recovery and the potential for overtraining has generated much debate over the past few decades.[6,7]

Heart rate variability (HRV) has been examined as a simple non-invasive indicator of cardiac control and a useful tool in assessing autonomic nervous system activity across a range of populations.[8–11] Further, fluctuations in cardiac autonomic regulation and HRV have been shown to decrease with periods of intense training and competition[9] and increase during taper in elite athletes.[12–14] Garet and colleagues[13] reported a negative correlation between cardiac parasympathetic indices of HRV and swimming performance during intensive training, coupled with an increase in HRV and performance during taper, in seven regional level adolescent swimmers. Subsequently, HRV has been suggested as a simple, non-invasive method of gauging cardiac autonomic nervous system fluctuations.

Although HRV has been examined within specific training phases, there has been minimal longitudinal assessment of daily variations in HRV throughout a periodised training program.[3] Recently, Plews and colleagues[3] observed daily HRV responses over a 10-week period in two elite triathletes. While recent studies have highlighted the prospective use of HRV for able-bodied athletes, minimal research has focussed on elite athletes with a disability competing in the Paralympics. It has been shown that Olympic and Paralympic swimmers follow similar periodised training programs.[15] However, despite the similar

* Corresponding author.
E-mail address: bburkett@usc.edu.au (B. Burkett)
Peer review under responsibility of Shanghai University of Sport.

http://dx.doi.org/10.1016/j.jshs.2014.08.002
2095-2546/© 2014 Production and hosting by Elsevier B.V. on behalf of Shanghai University of Sport.

training characteristics, it is unknown whether Paralympic swimmers exhibit a similar cardiac autonomic profile comparable to athletes competing at the Olympic level.

To our knowledge, no studies have examined the impact that neuromuscular disabilities, limb deficiency, or the loss of a limb(s) has on HRV. To further understand training adaptations for elite athletes, the aim of this case study was to examine cardiac autonomic variations in Paralympic swimmers as they prepared for the London 2012 Paralympic Games. These case studies were designed to explore the cardiac autonomic profiles of three elite (gold medallist) swimmers with a disability. Due to the unique nature of the study population a case study approach was employed to best analyse and compare each athlete's individual HRV responses over the 17-week monitoring period.

2. Methods

2.1. Participants and design

Three Paralympic swimmers selected for the London 2012 Paralympic Games were recruited for this study. Each swimmer had previously competed at the international level and were ranked in the top three in the world for their respective sprint distance events (<200 m). Each athlete was monitored daily for their resting HRV over 17 weeks immediately prior to the 2012 Paralympics Games. The periodised training program prescribed by the head swimming coach was individualised for each athlete and incorporated periods of speed (decreased km's and higher intensity), aerobic (higher km's and a decreased intensity), and quality (a mix of speed and aerobic, focussing on race specific pace and drills) training phases. The 17-week monitoring period encompassed international training camps, competitions and travel leading up to the London 2012 Paralympic Games. All swimmers had competed for at least 5 years and trained with an average of 28 h/week. A typical training week consisted of nine pool session of approximately 2.5 h duration each (22–23 h), two cross training sessions for fitness (2 h), two strength sessions (2.5 h), and one yoga session (1 h). Informed consent was obtained prior to participation, with university human ethics approval. Descriptive statistics for all athletes are shown in Table 1.

Short-term athlete friendly daily recordings (10 min) of heart rate (HR) were obtained by a Suunto Memory belt (Suunto Oy, Kuopio, Finland) in the supine position upon awakening.[3] An extended monitoring period (i.e., 17 weeks) was incorporated to examine in depth, the daily/weekly effect of training and other external influences on HRV, a feature lacking in studies of HRV and elite athletes.

2.2. Data and statistical analysis

Prior to the commencement of daily training, HR data were uploaded (Suunto Training Manager v2.2; Suunto Oy). From the HR recordings RR intervals were exported to Kubios HRV software (v2.1; University of Kuopio, Kuopio, Finland). Specific time (mean HR, square root of the mean squared difference of successive RR intervals, RMSSD), frequency (total power (0–0.4 Hz), high frequency expressed in normalised units, HF (nu)) and non-linear ($\alpha 1$ from detrended fluctuation analysis, $\alpha 1$) measures of HRV were analysed in the supine position as previously described.[9] Any artefact or ectopic beats were corrected via Kubios's in-built cubic spline interpolation.[16]

Data were analysed over time using a one-way analysis of variance (ANOVA) and *post hoc* pairwise comparisons with a Bonferroni correction. All HRV data were examined for each athlete using daily, weekly and training phase mean values across all variables. Data were expressed as mean (95% confidence interval) with an α level of $p < 0.05$ identified for all analyses. A straightforward crossover trial to measure raw and percentage effect statistics was also used to determine absolute and relative differences between athletes for all HRV measures over each training phase.[17]

3. Results

During the 17-week monitoring period the swimmers completed between 38 and 52 km per week leading into the Paralympic games. On average, the swimmers completed 40.5 km per week (average 5.0 km per pool session) during the speed training phase, 48.5 km per week (average 5.4 km per pool session) during the aerobic training phase, and 43 km per week (average 5.1 km per pool session) during the quality training phase (Table 2).

The highly variable nature of HRV in elite athletes supports the importance of monitoring elite athletic populations on an individual basis. As such, all HRV analyses for the current study were examined and reported at the individual level.

A significant difference in HRV was observed for athlete 1 (neuromuscular disability) during the quality training phase (Fig. 1). Mean HR (bpm) and $\alpha 1$ were significantly lower during the quality training phase when compared against the taper and speed training phases respectively (Fig. 1A and E).

Table 1
Athlete characteristics.

	Athlete (classification)[a]	Age (year)	Height (m)	Weight (kg)	Disability	Swimming background (year)[b]
Athlete 1	S10	24	1.88	85	Neuromuscular	10
Athlete 2	S8	21	1.88	84	Amputee	5
Athlete 3	SM10	26	1.70	62	Amputee	10

[a] Athletes classified according to the International Paralympic Committee Classification Code.
[b] Indicates years competing as part of the national Paralympic swim team.