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MONITORING HEART RATE VARIABILITY DURING COMPETITION PREPARATION IN A NATIONAL LEVEL POWERLIFTER WITH CEREBRAL PALSY: A CASE REPORT

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ABSTRACT

Heart rate variability (HRV) monitoring has been shown to be effective for guiding programming and evaluating individual training adaptation in endurance athletes. However considerably less attention has been given to strength and power athletes, particularly in disabled populations. It is currently unclear how HRV responds throughout a longitudinal resistance training program and how it may relate to fatigue and performance. The purpose of this case study was to observe the HRV trend of a high level powerlifter with cerebral palsy throughout a 4-week competition preparatory period in response to varying training load. Details of the training program, training load, daily and weekly HRV changes and performance are described.

Keywords: training, parasympathetic, cardiac-autonomic, performance

INTRODUCTION

Heart rate variability (HRV) is a non-invasive measure of cardiovascular-autonomic control and reflects sympathetic and parasympathetic influence of the heart. HRV is becoming a popular monitoring variable among sports programs for objectively assessing fatigue and training status in athletes (1). The evolution of one's HRV trend over time may be useful for evaluating individual training adaptation (2). The return of HRV to baseline following exercise is effected by lactate concentrations, plasma catecholamine, metabolite build-up, fluid balance and body temperature changes (3). Therefore, HRV can be considered a general marker of recovery status and may be useful for guiding training and preventing excess fatigue accumulation.

There is ample research supporting the utility of HRV monitoring among endurance athletes (3, 4), however considerably less attention has been given to strength and power athletes, particularly in disabled populations. For example, recent research has suggested that HRV monitoring may be effective for guiding training during competition preparation in elite para-athlete swimmers (5). The effectiveness of HRV monitoring in a strength/power para-athlete is currently unknown. In able-bodied elite level weightlifters, HRV and 1 repetition maximum (1RM) strength demonstrate acute reductions for 48 hours in response to an intense resistance training bout while returning to baseline concurrently at 72 hours (6). Thus, one may hypothesize that HRV monitoring may be useful in strength/power athletes throughout training.

The purpose of this case study was to observe the HRV trend of a high level powerlifter with cerebral palsy throughout a 4-week competition preparatory period in response to varying training load.

METHODS

Subject

The subject of this case study was an African-American male powerlifter with cerebral palsy (age = 22; height = 158.75 cm; weight = 55.2 kg; body fat via dual energy x-ray absorptiometry = 12.2%).

HRV data collection

Daily HRV was self-measured by the subject on his smart phone with a validated application and accompanying chest strap transmitter and portable electrocardiograph receiver (7). Daily HRV measures were performed following waking and bladder emptying in a back-supported, seated position. The smart phone application utilizes a 55-second recording period for determining ultra-short (i.e., 55-second) log transformed root mean square of successive R-R intervals (lnRMSSD). This HRV parameter is vagally mediated and is the preferred index for athlete monitoring in field settings (1). For user-friendly interpretation, the manufacturer of the application multiplies the lnRMSSD value by twenty (lnRMSSD*20), providing the user a figure on a ~100 point scale (7).

Training Load and Structure

The subject's disability only allows him to compete in one powerlifting event; the bench press. Therefore, the training program was designed and implemented by the researchers to maximize bench press strength. Training sessions occurred on Monday, Wednesday and Friday at 9:30 am through weeks 1-3. During week 4, training was reduced for a taper with training sessions taking place only on Monday and Wednesday with the competition held on that Saturday. Daily undulating periodization was used for the bench press where training intensity and volume was modulated each session. Training intensity on Monday's were considered moderate, Wednesday's considered heavy and Friday's considered light. Progressive overload was used on all assistance exercises where 2.5-5lb increments in weight were added each week if the subject demonstrated sufficient execution of the exercise in the prescribed repetition range. A linear increase in % of 1 repetition maximum (%1RM) was used across weeks 1-3 while week 4 served as a deload week. Table 1 provides training program details for the 4-week training cycle. Subtle changes in load may have been made based on exercise technique and athlete feedback.

Table 1. The 4-week competition preparation training program.

	Week					**Week**					**Week**			
	1	**2**	**3**	**4**		**1**	**2**	**3**	**4**		**1**	**2**	**3**	**4**
MON	**82%**	**85%**	**87%**	**93.5%**	**WED**	**90%**	**95%**	**97%**	**77%**	**FRI**	**75%**	**77%**	**80%**	**Off**
Bench Press	4x3	4x2	3x2	2x1	**Bench Press**	4x1	4x1	3x1	2x1	**Bench Press**	4x5	4x5	3x5	Rest
Row	4x8	4x8	4x8	3x8	**Lat. Pull**	4x8	4x8	3x8	3x8	**1-Arm Row**	4x8	4x8	3x8	Rest
DB Press	3x6	3x6	2x6	2x6	**DB Bench**	3x6	3x6	2x6	2x6	**Incline Bench**	3x6	3x6	2x6	Rest
Face Pull	3x12	3x12	3x12	2x12	**Pull Apart**	3x12	3x12	3x12	2x12	**R. Delt Fly**	3x12	3x12	3x12	Rest
Hip Ext.	3x8	3x8	3x8	2x10	**Leg Curl**	3x8	3x8	3x8	2x10	**Leg Press**	3x8	3x8	3x8	Rest

MON = Moday; WED = Wednesday; FRI = Friday;
DB = dumbbell; Ext = Extension; Lat. = Latissimus Dorsi; R. = Rear; Delt = Deltoid

RESULTS

Weekly mean values for lnRMSSD*20 (HRVmean), %1RM utilized for the bench press and total tonnage (i.e., weight*sets*repetitions) are displayed in Table 2. HRVmean values displayed with tonnage and mean training intensity for the bench press (i.e., %1RM) can be viewed in Figures 1 and 2, respectively. Daily HRV plotted with the smallest worthwhile change (SWC, SWC = 0.5 of the coefficient of variation) (8, 9) is displayed in Figure 3. Note that HRVmean from week 4 does not include Saturday and Sunday (i.e., the day of and day following competition) so that these did not obscure the effect of the taper on HRV. The subject had a successful competition setting an 11.3 kg personal competition record pressing 2.05 times his bodyweight.

Table 2. Total tonnage, weekly mean percent of 1RM utilized for the bench press and weekly mean HRV.

	Tonnage (kg)	%1RM	HRVmean
Week 1	12964	82.3	83.8
Week 2	13449	85.2	88.9
Week 3	11923	88	86.3
Week 4*	4868	85.3	89.3

Asterisk denotes that Week 4 does not include the day of and day after competition (i.e., Saturday and Sunday).

Figure 1. Comparison of HRVmean and tonnage across the 4-week period.

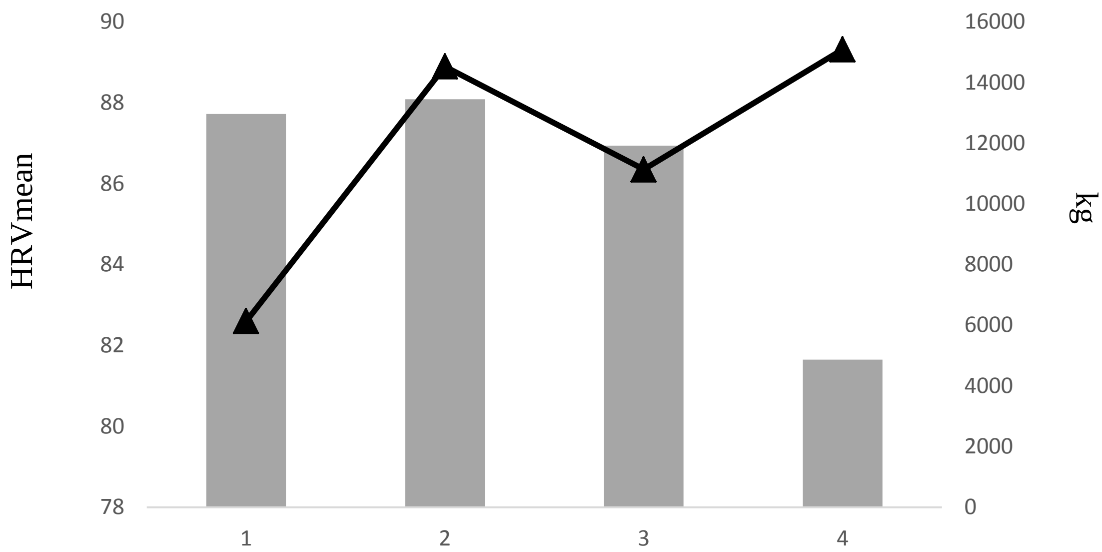


Figure 2. Comparison of HRVmean and mean bench press %1RM across the 4-week period.

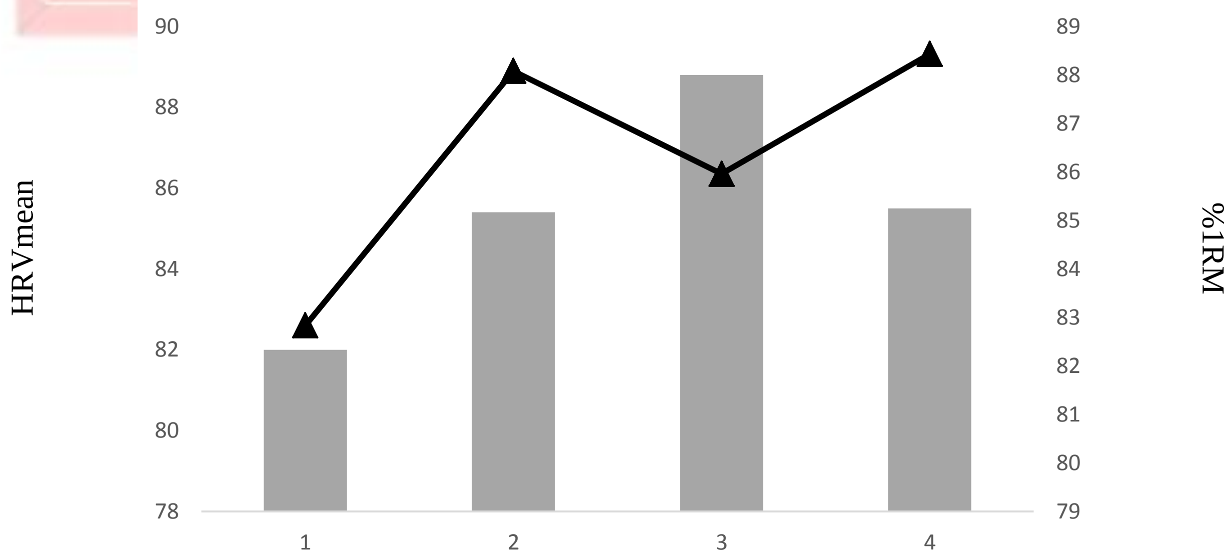
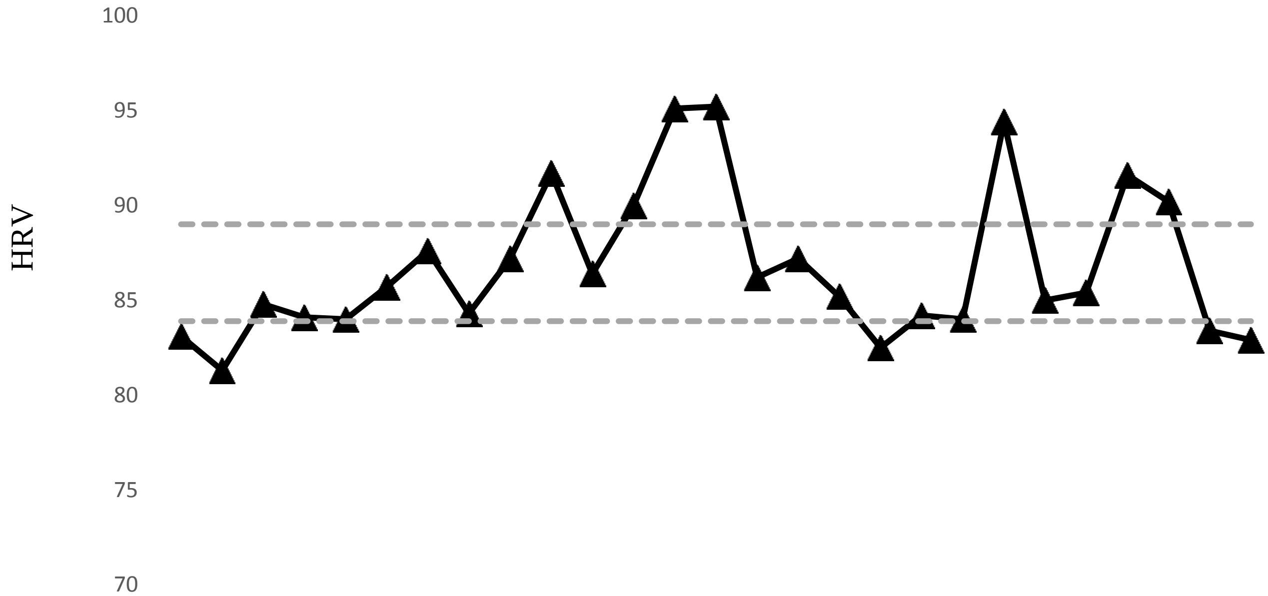


Figure 3. Line graph representing daily HRV throughout the 4-week period. The last two data points represent the day of and day following competition, respectively. The horizontal dashed lines represent the smallest worthwhile change.



DISCUSSION

Prior reports of longitudinal HRV data in a strength/power athlete have not been published, thus leaving trend analysis open to the authors' interpretation. The lowest HRVmean occurred during week 1. This may be due to the subject being unaccustomed to this particular training program as previously the subject only bench pressed twice per week and did not perform full body workouts, but rather split sessions into upper and lower body. The new program therefore may have been a novel training stressor causing greater homeostatic disturbance reflected in lower HRV values (3). The increase in HRVmean from week 1 to week 2 suggests that training may have been less stressful compared to the previous week despite a small increase in training volume and intensity, indicative of positive adaptation. Increases in HRVmean are generally interpreted as a positive coping response in other sports disciplines such as soccer (2, 10). A decrease in HRVmean was observed in week 3 despite a decrease in tonnage. However, the mean %1RM used in week 3 was the highest of the three weeks, which may suggest that training intensity rather than volume effected cardiac autonomic activity to a greater extent in this subject. Complete cardiac-parasympathetic recovery was unattained, reflected in suppressed HRV throughout the week. Decreases in an individual's HRV trend throughout training are often associated with increased fatigue (10) and may reflect overreaching when chronically suppressed (9).

Though 1RM performance was not evaluated each week, the subjects' ability to successfully complete prescribed repetitions based off of a previously tested 1RM may provide a reasonable indication of performance and fatigue. In weeks 1 and 2, the subject successfully completed all of the prescribed repetitions during training. On Wednesday of week 3 (i.e., heavy day), the subject only completed 1 of the 3 prescribed sets of 1 repetition at 97% of 1RM despite being given ample rest between sets. This was unexpected considering the subject successfully completed 4 sets of 1 repetition at 95% of 1 RM the week before (i.e., week 2). The suppressed HRV and inability to complete prescribed repetitions during the workout may indicate that the athlete was experiencing some fatigue. In week 4 when training load is reduced, HRVmean peaks, interpreted as a favorable response leading into competition and has been previously reported in Paralympic swimmers (5). Our interpretation is further supported by the successful performance in competition where the athlete bench pressed 104.2% of his previous (non-competition) 1RM.

The subject demonstrated an acute decrease in HRV exceeding the SWC on the day of and the day after competition (Week 4 HRVmean = 89.3; day of competition HRV = 83.4; day after competition = 82.9). The reduced HRV on the day of competition may be attributable to pre-competitive anxiety which has previously been observed in rugby players (11). Additionally, recent research suggests that anaerobic performance is inversely related with HRV on the day of competition, characterized by withdrawn cardiac-parasympathetic and elevated sympathetic activity (12). The low HRV value observed on the day after competition is likely due to fatigue from competition as has been observed in elite weightlifters following an intense bout of resistance training (6).

As no previous longitudinal HRV data has been published in a strength or power athlete (able-bodied or disabled), this case study offers unique insight regarding the responsiveness and sensitivity of cardiac-parasympathetic activity to varying resistance training loads throughout competition preparation. However, the interpretation of the HRV trend is largely speculative. It may however, encourage future research to further investigate HRV responses to strength/power training and its association with markers of performance and fatigue. It remains to be determined how useful HRV monitoring is for athletes involved in strength and power sports but the data presented in this case study shows promise.

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