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Original Research Article

Training Status Monitoring From HRV in University Players

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Abstract: The objective of research was to know training status from HRV in sports persons. In Method; consent was taken from 14 University players and from their teachers; those answered NO to all physical activity readiness questions for recording of Heart Rate Variability observations. For that subject's preparation was done as per protocol. Time domain analysis determines parasympathetic activity while frequency domain analysis determines both sympathetic and parasympathetic activity .Poincare analysis provides data on the vagosympathetic balance. Comparison was made in same exercise group(n=14) pre (composed of 10 hr rest) and post (composed of 1 hr rest) which had an intervention of atleast 60 minutes of various sports of moderate to vigorous intensity ; by applying student t test for equality of means at significance at p value<0.05. For interpretation of training status; when parasympathetic nervous system activity is reduced; decrease training load & when parasympathetic nervous system activity is increased; increase training load. Heart rate decreases and heart rate variability increases with the positive training effect. In the overreaching and in sympathetic overtraining state the heart rate increases and heart rate variability decreases. In the parasympathetic overtraining state or in exhaustion both heart rate and heart rate variability decreases. In Result, reflected optimum training status after 10 hr of rest which had an intervention of at-least 60 minutes of sports. HRV provides good inter play or modulation between parasympathetic and sympathetic nervous system and also gave insight into training status and cumulative fatigue estimation in sports persons. In conclusion, HRV is helpful in monitoring, planning and prescribing training programmes and diagnosis and prevention of overtraining in Sports Persons.
Keywords: Training Status, Monitoring, HRV, University players

INTRODUCTION

Heart Rate Variability (HRV) phenomenon is the oscillation in the interval between consecutive heartbeats as well as the oscillations between consecutive instantaneous heart rates. HRV has the potential to provide additional valuable insight into physiological and pathological conditions and to enhance risk stratification. Components of HRV provide measurement of the degree of autonomic modulation rather than of the level of autonomic tone, averages of modulation do not represent an averaged level of tone, in other words HRV measures fluctuation in autonomic inputs to heart rather than the mean level of autonomic inputs. Thus, both autonomic withdrawal and saturatingly high level of sympathetic input lead to diminished HRV [1]. Increased HRV has been associated with lower mortality rate and is affected by both age and sex. During graded exercise, the majority of studies show that HRV decreases progressively up to moderate intensities, after which it stabilizes. There is abundant evidence from cross-sectional studies that trained individuals have higher HRV than untrained individuals. The results from longitudinal studies are equivocal, with some showing increased HRV after training but an equal number of studies showing no differences. The duration of the training program might be one of the factors responsible for the versatility of the results [2]. HRV can be used for monitoring and improving sports physiology. Optimal training depends on matching the specific ability of an athlete, such as muscle, strength, endurance, explosiveness, flexibility and adaptability to the individual's aerobic capacity, training load and recovery. For this purpose, the use of HRV is a suitable solution since it reflects the major regulatory processes after physical exercise. The use of HRV to detect which measures are altered versus physical exercise, type and intensity have been extended to demonstrate how monitoring physical fitness during exercise and post-exercise periods can be applied to athletic training more broadly in the future . Long-term HRV changes during a prolonged period, over 4 weeks of exercise has been shown to be a particularly good indicator of physiological adaptation in athletes able to assist in the planning training programs. Previous findings showed that daily exercise intensity based on the HRV of the athlete, and lowering the intensity based on HRV decreased maintained fitness levels comparatively to the control groups indicating the importance of HRV use in sports physiology [3].

METHODS

Consent was taken from 14 Students and from their teachers of Physical Education Department, University of Rajasthan Jaipur from those answered NO to all physical activity readiness questions [4] for recording of Heart Rate Variability observations. All the observations were taken in resting condition. Comparison was made between same exercise group(n=14) pre (composed of10 hr rest) and post (composed of 1 hr rest) which had an intervention of atleast 60 minutes of various sports of by applying student t test for equality of means at significance at p value<0.05. Data were summarized with in MS Excel 2007 in the form of master chart and analyzed with trail version of SPSS statistical software Version ‘16. KK Deepak, AIIMS Delhi [5] gave the procedure of evaluating Heart Rate Variability in which subjects preparation was done as per protocol For short term analysis of HRV; ECG was recorded in supine position for 5 minutes after 15 minutes of supine rest, for acquisition; ECG wave signals were continuously amplified, digitized and stored in computer for analysis of Time domain, Frequency Domain and Nonlinear Domain. For processing the detection of ‘R’ wave was done by HRV soft version 1.1 developed by AIIMS New Delhi. All recording were visually examined and manually corrected if required abnormal beats and areas of artifact were automatically and manually identified and excluded from the study as and when required.

Quantification of HRV was done after generation of tachogram. Task force [1] has given method to measure Heart rate variability for following variables HRV Time Domain Variables No. of RR interval, Maximum RR(ms.), Minimum RR(ms.), Maximum/Minimum, Range, Mean (ms.), Median(ms.), Mode(ms.), NN50- Number of pairs of adjacent NN intervals differing by more than 50 ms in the entire recording; three variants are possible counting all such NN intervals pairs or only pairs in which the first or the second interval is longer. PNN 50%-NN50 count divided by the total Number of all NN intervals, Variance, Coefficient of Variance, STD- Standard deviation, SDSD(ms)-Standard deviation of differences of differences adjacent NN intervals. RMSSD (ms) - The square root of the mean of the sum of the squares of differences between adjacent NN intervals. SDANN-Standard deviation of average NN interval in all 5 minutes segments of the entire recording (ms= mili seconds). Frequency Domain Variables – VLF ms^2-very low frequency power range in ≤0.04 Hz (Non-harmonic activity), VLF%, LFms^2low frequency power range 0.04-0.15Hz(sympathetic and parasympathetic activity) LF%,HFms^2-high frequency power range 0.15-0.4Hz (parasympathetic activity) HF%, Total 5 minutes power ms^2 range ≈≤0.4 Hz, total power%, LF Normalized (nu)-LF power in normalized units LF/(total power-VLF)x100 (sympathetic activity), HFNormalised(nu)HF power in normalized units HF/(total, power VLF)x100(parasympathetic activity), LF/HF ratio LF[ms^2]/HF[ms^2] (sympathovagal balance), VLF/LF, VLF Absolute ms^2, LF Absolute ms^2 , HF Absolute ms^2,Total power Absolute ms^2 (variance of NN intervals). The physiological explanation of the VLF component is much less defined, and the existence of a specific physiological process attributable to these heart period changes might even be questioned. The nonharmonic component, which does not have coherent properties and is affected by algorithms of baseline or trend removal, is commonly accepted as a major constituent of VLF. Thus, VLF assessed from short-term recordings (≤5 minutes) is a dubious measure and should be avoided when the PSD of short-term ECGs is interpreted. HRV Manual [6] cited that origin of VLF/UVLFP is still unclear.

Current discussions include thermo regulative processes as well humoral influences of the renin-angiotensin-aldosterone system and the illustration of circadian rhythmicity. Task force [1] reviewed that nonlinear phenomena are certainly involved in the genesis of HRV. They are determined by complex interactions of hemodynamic, electrophysiological, and humoral variables as well as by the autonomic and central nervous regulations. HRV Nonlinear Variables-SD1(ms) standard deviation short term variability (parasympathetic activity), SD2(ms) standard deviation long term variability (sympathetic activity), SD1/SD2 (vago-sympathetic balance), HRV Triangular index(approximate total power)- Total number of all NN intervals divided by the height of the histogram of all NN intervals measured on a discrete scale with bins of7.8125 ms (1/128 seconds), TINN (ms.) (approximate total power)- Baseline width of the minimum square difference triangular interpolation of the highest peak of the histogram of all NN intervals. HRV Manual [6] demonstrated Poincare map in which at the same time the RR time series are displayed within an xy-coordinate system, so each RR interval is allocated as a functional value of the subsequent RR interval. This creates a kind of correlation depiction of two successive RR intervals. The evaluation of graphical representation can be both visual-qualitative and also quantitative. Tewari *et al.;* [7] reviewed that Time domain analysis determines parasympathetic activity while frequency domain analysis determines both sympathetic and parasympathetic activity . Poincare analysis provides data on the vagosympathetic balance. Uusitalo *et al.;* [8] gave method for interpretation of training status; that When Parasympathetic nervous system activity is reduced; decrease training load & when Parasympathetic nervous system activity is increased; increase training load. Heart rate decreases and heart rate variability increases with the positive training effect. In the overreaching and in sympathetic overtraining state the heart rate increases and heart rate variability decreases. In the parasympathetic overtraining state or in exhaustion both heart rate and heart rate variability decreases. Examples of psychological and psychosomatic overtraining signs and symptoms are: depression, fatigue, irritability, bad mood, anxiousness, confusion, excitement, desperation, lack of concentration, unwillingness to train, feeling of inability to go on training, sleeping problems, bad appetite, shaking hands, abnormal sweating, palpitation, nausea, and dizziness. Examples of physiological overtraining signs and symptoms are : increased resting and submaximal heart rate (resting heart rate can also be decreased in overtraining state), muscle soreness, decreased maximal heart rate, menstrual irregularities, decreased performance, loss of strength, increased illness and injury, frequency loss of co-ordination.

RESULTS

Exercise Group acclimatized for one year with atleast one hour of moderate to heavy intensity sports in morning & evening session most of the days except holidays (n= 14) showed that there was no significant difference between age groups (p>.05).In Exercise Group HRV that is composed of 10 hr rest from sports.; Resting Time Domain HRV showed that No. of RR interval were less , means low heart rate and increased parasympathetic activity (P>.05) reflected optimum training Status .While Resting Frequency Domain reflected increased sympatho-vagal balance(LF/HF ratio), (p>.05) While Nonlinear HRV reflected increase parasympathetic activity(SD1),increase sympathetic activity(SD2) but decrease vago-sympathetic balance(SD1/SD2) (p>.05) Comparison in same Exercise Group(n=14) Pre (composed of 10 hr rest)and Post (composed of 1 hr rest)which had an intervention of 60 minute duration of sport showed that in post-Exercise group (composed of 1 hr rest) ;.Resting Time Domain HRV showed that No. of RR intervals were increased means increased heart rate and decreased parasympathetic activity (p>.05)Resting Frequency Domain HRV showed decrease sympathovagal balance(LF/HF ratio) ,all frequency power were increased (p>.05) .Resting Non-Linear HRV showed that decrease parasympathetic activity (SD1),decrease sympathetic activity (SD2) but vago-sympathetic balance (SD1/SD2) was increased (p>.05),HRV Triangular index was decreased (p>.05),TINN ms (approximates total power) was increased (p>.05) in comparison to pre exercise HRV that is composed of 10 hr rest from sports.

Table 1: Resting Time Domain HRV in University Players

S. No.	Age (in Yrs)	No of RR interval	Maximum RR	Minimum RR	Max/Min	Range	Mean	Median	Mode	NN50 Count	PNN50 Count	Variance	Coeff. of variance	STD	SDSD	RMSSD	SDANN
Exercise Group n=14 Resting Pre Exercise Time Domain HRV after 10 hr. rest of 60 minute duration of sports																	
Mean	**21.57**	339.4	1159	657.7	1.806	501.6	909.2	913.3	896.5	108	34.55	9131	9.036	84.05	84.94	84.8	**26.34**
SD	**2.311**	63.4	233.5	139.3	0.3695	197.7	169.7	183.5	182	63.14	22.29	10271.7492	4.27	47.17	62.4	62.27	**17.35**
Exercise Group n = 14 Resting Post Exercise Time Domain HRV after 1 hr. rest of 60 minute duration of sports																	
Mean	**21.57**	353.9	1268	692	1.918	576	868.8	869.2	883.2	82.21	25.62	6277	7.964	69.42	73.64	73.53	**22.57**
SD	**2.311**	63.36	421.4	122.4	0.9517	458.4	150.5	156.4	170.7	58.6	20.13	6493	4.466	39.61	49.14	49.07	**16.45**
Comparison between n=14 Pre and Post Exercise Same Group t test for equality of means																	
t- test		-1.015	1.173	-0.732	-0.419	-0.643	0.923	0.931	0.241	1.650	1.432	1.188	1.061	1.345	0.853	0.852	**0.988**
p value df=13		0.329	0.262	0.477	0.682	0.531	0.373	0.369	0.813	0.123	0.176	0.256	0.308	0.202	0.409	0.409	**0.341**

***Significance at p value <0.05.**

Table 2: Resting Frequency Domain HRV in University players

S. No.	Age (in Yrs)	VLF (% Power)	LF (% Power)	HF (% Power)	Total Power (% Power)	LF (Normalized Power)	HF (Normalized Power)	LF/HF Ratio	VLF/LF Ratio	VLF (Absolute Power)	LF (Absolute Power)	HF (Absolute Power)	Total Power (Absolute Power)
Exercise Group n=14 Resting Pre Exercise Frequency Domain HRV after 10 hr. rest of 60 minute duration of sports													
Mean	21.57	24.24	36.41	39.35	100	50.28	49.72	1.631	0.765	1546	2602	3078	**7227**
SD	2.311	15.04	16.78	22.02	0	23.07	23.07	1.545	0.5384	1529	2403	3837	**6827**
Exercise Group n=14 Resting Post Exercise Frequency Domain HRV after 1 hr. rest of 60 minute duration of sports.													
Mean	21.57	22.89	37.79	39.33	100	48.73	51.27	1.081	0.8193	2929	3863	5254	**12047.0350**
SD	2.311	14.65	13.85	11.79	0	14.05	14.05	0.5274	0.7461	6200	7442	11147.7102	**24636.8833**
Comparison between n=14 Pre and Post Exercise Group t test for equality of means													
t- test		0.392	-0.318	0.004	999.999	0.292	-0.292	1.641	-0.303	0.828	-0.587	-0.819	**-0.750**
p value df =13		0.702	0.755	0.997	0.000	0.775	0.775	0.125	0.767	0.423	0.567	0.428	**0.467**

***Significance at p value <0.05.**

Table 3: Resting Non Linear Domain HRV in University Players

S. No.	Age (in Yrs)	SD1	SD2	SD1/SD2	HRV Triangular Index	TINN
Exercise Group n=14 Resting Pre Exercise Non-linear Domain HRV after 10 hr. rest						
Mean	21.57	60	118.5	0.4752	0.206	354.2
SD	2.311	44.17	66.72	0.1238	0.06531	186.6
Exercise Group n=14 Resting Post Exercise Non-linear Domain HRV after 1 hr. rest						
Mean	21.57	52.13	97.99	0.5118	0.1719	461.3
SD	2.311	34.8	56.12	0.1276	0.06723	440.6
Comparison between n=14 Pre and Post Exercise Group t test for equality of means						
t- test		0.839	1.330	-1.356	1.431	-0.966
p value df =13		0.416	0.206	0.198	0.176	0.352

***Significance at p value <0.05.**

DISCUSSION

Result showed inconsistent result in context with approximate Time domain as spectral analysis of fast Fourier transformation requires Stationarity of the R-R interval time series [9] or it is be due to difference in duration of rest [3]. Resting Non-Linear HRV showed that vago-sympathetic balance was increased approximates total power was increased in comparison to pre exercise HRV that is composed of 10 hr rest from sports. Although Time domain HRV showed Heart rate was decreased and increased HRV reflected optimum training status after 10 hour of rest. Uusitalo et al.; [8] has already given method for interpretation of training status. Another research revealed that Ultra-Short-Term Heart Rate Variability (ln RMSSD measured in 1-min post-1-min stabilization period) is Sensitive to Training Effects in Team Sports Players [10].

In Application of HRV on the intensity of sports training The results of HRV spectra indicated by LFn and HFn in exercise vary in function to ventilatory thresholds (VTs) and identified a sympathetic predominance (indicated by an increased LF/HF ratio) during relatively less intense exercise and parasympathetic predominance (indicated by a decreased LF/HF ratio) during relatively more intense exercise. Furthermore the LF/HF ratio was always >1 for cycling below VT and <1 for cycling above VT. This gradual switch ratio suggests the overstepping of the VT and presents be a reliable index of VT detection from the HRV [3]. Heart vitality training and heart rate monitor as aids to athletic performances reported that HRV data can indicate the impact of fatigue due to prior exercise sessions, hydration levels, stress and even the degree of performance anxiety, nervousness or other external stressful influences. Studies have shown that it varies within individuals according to size of left ventricle (inherited trait), fitness level, exercise mode (endurance or static training) and skill (economy of exercise). Body position, temperature, humidity, altitude, state of mood, hormonal status, drugs and stimulants all have an effect on heart rate and HRV, as do gender and age. The significant change is that there is now a instruments are available that athletes can begin to use to monitor this ‘cardiovascular fatigue’ to ensure that their training programs include the right mix of duration, frequency, intensity, rest and recovery. EPOC (excess post exercise oxygen consumption) can be predicted from HRV data and can be used to monitor individual sessions, allowing the athlete and coach to react immediately to the output data by either amending subsequent training to deal with accumulated fatigue or ensuring that the athlete has sufficient rest to make an adequate recovery [11].

Overtraining syndrome that is neuroendocrine disorder that may result from process of overtraining and reflects accumulated fatigue during period of excessive training with inadequate recovery; overtraining may take months or occasionally years to resolve. Development of overtraining indicators include- Performance decrement, decreased work load at lactate threshold, increased early morning heart rate and blood pressure, decrease in ferritin concentration ;decrease in Testosterone /Cortisol ratio of 30% or more, frequent upper respiratory tract infection, persistence muscle soreness etc. While the term overreaching describes similar symptoms but of more transitory nature; resolves within two weeks [12].

Overtraining stresses the body beyond its capacity to adapt, decreasing physiological capacity and performance. The symptom of overtraining syndrome are subjective and vary from individual to individual many also accompany regular training ,making prevention or diagnosis of overtraining syndrome difficult ,possible explanation for the overtraining syndrome include changes in function of the autonomic nervous system ,altered endocrine responses ,suppressed immune system and altered brain transmitters .Many potential signs and symptoms of overtraining have been proposed to diagnose overtraining in its earliest stages. However, at this time, the heart rate response to a fixed pace exercise bout appears to be the easiest and most accurate technique. Overtraining syndrome is treated by marked reduction in training intensity or complete rest for weeks or months. Prevention can be accomplished through use of periodization training procedures that vary training intensity and volume [13]. The chaos theory perspective would also allow sport scientists to return to the study of phenomena on a human scale by providing researchers a macroscopic approach to understanding complex systems. Individual parts of a system would no longer have to be studied in isolation because the chaos method of discovery is capable of measuring and plotting an unlimited number of variables over time. Perhaps this approach will help us better understand complex sport behavior [14].

CONCLUSION

HRV is helpful in monitoring, planning and prescribing training programmes and diagnosis and prevention of overtraining in Sports Persons. Overtraining syndrome include changes in function of the autonomic nervous system ,altered endocrine responses ,suppressed immune system and altered brain transmitters; treated by marked reduction in training intensity or complete rest for weeks or months .Prevention can be accomplished through use of periodization training procedures that vary training intensity and volume.

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