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Effect of Music Therapy on Heart Rate Variability: A Reliable Marker to Pre-competition Stress in Sports Performance

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As evidence-based Music Therapy (MT) turns its attention to physiological responses; it will need outcome measures that are grounded in an understanding of mechanisms which drive physiological activity. Despite strong indications for the involvement of the Autonomic Nervous System (ANS) in health and disease, very few studies have systematically explored the therapeutic or interventional effects of music on ANS function. The purpose of the current study was to estimate the contribution of MT on Heart Rate Variability (HRV) in reducing Pre-competition Stress (PCS) and its effect on Sports Performance (SP). A sample of 110 male elite Shooters, with mean age of 29.5±4.5 years were examined as in MT and control groups (n = 55). The total duration of the study was for 5 weeks, 4 weeks of interventional and followed by 1 week to determine the follow-up effect. Pre, post and follow-up data of quantitative phenotypic markers of ANS activity and PCS were analyzed by HRV and SP, respectively. Study results showed that MT group has shown significant result in post-intervention ($p<0.001$) and follow-up ($p<0.001$) in time and frequency domains of HRV and SP, indicates the reduction of PCS level and increase in SP, whereas the control group showed non-significant result. It is concluded that relaxation therapies such as MT may decrease PCS and therefore enhance SP. It is concluded that four weeks of MT has an effect on ANS by altering changes in time and frequency components of HRV and can be consider as a reliable physiological marker of PCS.

Key words: Music, ANS, HRV, pre-competition stress, shooting

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INTRODUCTION

Listening to music for the purpose of a therapeutic benefit were reported date to the writings of the ancient Greeks; most notably, Pythagoras, Aristotle and Plato; lengthier discussions of the healing power of music listening emerged in the Middle Ages, beginning with Boethius, Wigram *et al*. (2002). In modern times popular methods like therapeutic schools like, traditional oriental music therapy. Tucek (2006) employ a wide repertoire of the so-called receptive methods like, relaxation to music, reminiscence of lifetime events Grocke and Wigram (2007), wherein the client simply listens to music.

The current generation usage of music is virtually kept as a personal secret by the athletes. Recently Rendi *et al*. (2010) investigated on fast and slow-temp of music in sports performance and observed that both interventions are effective than non-music group. A number of studies have also reported that listening to sedative music ie, slow tempo, legato phrasing and minimal dynamic contrasts can lead to decreased HR, respiration rate and blood pressure. Notably, however, these effects are inconsistent (Hodges, 2009). In addition to numerous psychotherapeutic applications, music finds great acceptance in physical medicine, especially in perioperative, for its anxiolytics and analgesic effects (Nilsson, 2008; Evans, 2002). Review of studies have reported that listening to sedative music (i.e., slow tempo, legato phrasing, minimal dynamic contrasts) can lead to decreased HR, respiration rate and blood pressure. Notably, however, these effects are inconsistent, (Ellis *et al*., 2012).

The literature on the effect of music on healthy and diseased participants have been done in quite large; however, most of the studies are often investigated changes in physiological activity like heart rate, blood pressure, electrodermal activity (Hodges, 1980, 2009). The literature on how music affects sports individuals with pre-competition stress, especially within the context of Autonomic Nervous System (ANS) is less developed.

With respect to non-invasive and non-exhaustive measures of assessing fitness, wellness (e.g., stress, fatigue), recovery status and physical performance, submaximal exercise and post-exercise cardiac autonomic activity as inferred from Heart Rate Variability (HRV) measures have recently received increased interest (Borresen and Lambert, 2008).

These results are most likely no surprise to our readership. Our interventions are increasingly observing the impact of music entrainment on physiological function. But are our athletes missing out on an aspect of resilience and incentive that could enhance their performance? Would a consultant or coach add a component of physiological function that would improve performance? Should this be an area that is investigated with greater focus?

In current times, it is novel for us to observe modern athletes using different types of music to prepare for the ultimate performance, but is important for gaining a better understanding of the potential benefits of music in sports. Little is published about the functional applications of music or the physiological changes of music on athletes. In the present study, we therefore report results from a study focusing on elite athletes' physiological uses of music in sports and its capacities in performance enhancement.

MATERIALS AND METHODS

Subjects: Totally 110 healthy male elite level shooters aged (29.5±4 years) were participated in the current study and randomly allocated into two groups; Music Therapy (MT) and Control by multiple blocked random sampling, n = 55 in each group, after the dropout in MT (n = 52) and Control (n = 47) subjects could complete the study. Subjects were voluntarily recruited from national shooting team; permission was obtained from the officials. Questionnaires administered prior to the experiment were indicated that no volunteers are included as per exclusion criteria such as any physical or mental illness, hearing impairment and have been undergoing music therapies for last 3 months. All subjects were non-smokers, medication free and not habitual drinkers. All the protocols were approved by research ethical committee of Punjabi University. The aims of the present study, the procedures involved and potential risks of the study were explained to each subject and the written consent was obtained prior to the study.

Intervention trial was conducted to the experimental subjects one week prior to the study. Concerning impediments to effective practice, subjects were monitored by the researcher and MT experts during the interventions. The intervention was provided over the course of four weeks and one week follow-up, group sessions with a maximum of 8 participants each, 20 min session per day, 6 days a week and one day was off per week. Participants were asked not to consume caffeine or alcoholic beverages for 12 h and not to exercise for 12 h prior to the experiment especially during testing.

Procedure: The all participants of each batch reported to the laboratory at 08:00 a.m., each session conducted in the morning (between 8 and 10 a.m.) and the subject changed into loose fitting clothing and shoes removed then the participants were instructed to lie in the supine position on the floor mat in a quiet, light-attenuated electrically shielded room with the temperature between 24 and 28°C with their eyes closed.

Interventions

Music therapy (MT): CD of 30-40 music of 'Raga Darbari' based Hindi songs given to the experimental subjects one week prior to the study and asked them to select 5-10 songs according to their choice from the songs given, after selection of individual choice of music made separate folder for each subjects. The music was delivered on Sony™ MP3 player by headphone with volume of 60-70 dB, 60-70 beats per minute.

The MT group was encouraged to assume a comfortable position in supine position on a floor mat during delivery of the music intervention, Advised subjects to clear their minds and allow their muscles to relax throughout the training session. The participants left the room after 20 min of session. The MT group underwent music therapy along with the routine sports specific training and whereas, control group only with the routine sports specific training.

Testing: The testing sessions were conducted between 8 and 12 a.m. and the same researcher tested all subjects. Measurement day scheduled one day prior to beginning the 0 day, 29th day and 36th day, subjects were assessed for pretest, post-test and follow-up data, respectively, except Performance Test, in a quiet controlled room with ambient temperature (24-28°C). The performance score calculated by pre-scheduled competition in a internationally standard shooting range on one day prior to beginning the 1st week and on 29th day, subjects were assessed for pre-test, post-test Performance score, respectively.

All the participants were instructed to avoid consuming stimulant beverages, tea and coffee; exercising, in the 12 h previous to the examination. All the participants of each batch reported to the laboratory at 08:00 a.m., HRV measurement procedure started between 09:00 a.m. and 11:00 a.m., to control as much as possible for time of day, to avoid circadian variations. Prior to testing, Participants attended a detailed briefing session where they received full verbal instructions regarding the procedures of the study. All subjects were tested individually.

Heart rate variability (HRV): For HRV testing, after fixation of equipments, subjects were then instructed to lie down on the lounge for 5 min as an adaptation period, then the partici-pants were instructed to lie in the supine position on the floor mat with their eyes closed and the subjects were asked to remain awake and relaxed, but the depth and rate of breathing were not controlled. A continuous 5 min resting data were collected and saved for HRV analysis. HRV data were obtained using a cardio-recorder (i.e., Polar RS 800 CX® Polar electro Oy, Kempele, Finland). For the Polar monitor, the series were automatically recorded by a receptor belt and captured and stored by a wrist sensor unit and this individual files containing normal HRV data were transferred and saved to the computer via Infra Red port. Stored data processed on a computer to calculate the following time and frequency domain indices of HRV according to the recommendations of the Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology (Malik, 1996); by dedicated software analyzed with the polar HRV software (Polar Precision Performance™ Software). Heart rate variability was assessed in two ways: (1) Time domain analysis and (2) Frequency domain analysis, the power was divided into two components: Low Frequency (LF, 0.04 Hz-0.15 Hz) and high frequency (HF, 0.15-0.40 Hz). In time domain analysis Standard Deviation of all R-R Intervals (SDNNi) was obtained. In frequency domain analysis, HF (is a marker of solely parasympathetic activity) and LF (is mainly a measure of sympathetic activity with some influence from the parasympathetic nervous system) were obtained. All these components were expressed in ms^2 and then converted to normalized units (n.u) (i.e., nHF, nLF), as recommended by the Task Force of European Society of Cardiology (Malik, 1996).

Sports performance (SP) score: Measure of shooting accuracy, shooting score was calculated from the standard shooting scoring board and the final result of competition obtained from the chief coach after the completion of competition, in order to test shooting performance.

RESULTS

The descriptive statistics of outcome variables (SDNNi, nHF, nLF and SP) measured in MT (n = 52) and Control (n = 47) groups. The general characteristics of participated subjects in both groups were age = 29.5±4 years, BMI = 24±1 kg cm^{-2} HR = 70±4 bpm, RR = 15.5±2 rpm, BP = 120/80±4 Hg of mg. The comparison of mean values of SDNNi, nHF, nLF at the baseline (pre-test), 29th day (post-test) and at 36th day (follow-up) was done using one-way analysis of variance

Table 1: Descriptive statistics of variables of subjects between study groups

Dependent variables	Music therapy (n = 52)	Control (n = 47)	t-value	p-value	95% Confidence Interval of the difference of mean Lower	Upper
SDNNi-0	50.33±1.58	50.25±2.36	0.185	0.854	-0.73	0.870
SDNNi-29	54.49±0.59	48.06±0.90	42.240	<0.0001	6.12	6.720
SDNNi-36	53.87±0.58	48.23±0.77	41.090	<0.0001	5.36	5.910
nHF-0	36.72±0.60	36.66±0.21	0.590	0.558	-0.13	0.240
nHF-29	43.42±0.34	32.99±0.25	173.440	<0.0001	10.31	10.540
nHF-36	41.56±0.34	33.95±0.05	150.880	<0.0001	7.51	7.710
nLF-0	63.44±0.26	63.34±0.21	2.060	0.042	0.004	0.195
nLF-29	56.58±0.34	67.01±0.25	-173.440	<0.0001	-10.54	-10.310
nLF-36	58.44±0.34	66.05±0.05	-150.880	<0.0001	-7.71	-7.510
Perf.Score-0	529.00±29	524.00±32	0.730	0.468	-7.68	16.590
Perf.Score-29	544.00±31	5190.00±29	4.310	<0.0001	13.92	37.720

Table 2: Descriptive statistics of dependent variables of subjects within MT group

Variables	Pre (0-day)	Post (29th-day)	FU (36th-day)	F	Sig.
SDNNi	50.33±1.58	54.49±.59	53.87±.58	246.39	<0.0001*
nHF	36.72±.600	43.42±.34	41.56±.34	3151.01	<0.0001*
nLF	63.44±.260	56.58±.34	58.44±.34	6555.66	<0.0001**

*Multiple comparisons shows SDNNi and nHF are higher in MT group at Post-test and FU than Pre test, **Multiple comparisons shows nLF is lower in MT group at Post-test and FU than Pre test

Table 3: Descriptive statistics of variables of subjects within Control group

Variables	Pre (0-day)	Post (29th-day)	FU (36th-day)	F	Sig.
SDNNi	50.25±2.36	48.06±.90	48.23±.77	29.88	<0.0001*
nHF	36.72±.60	32.99±.25	33.95±.05	4639.61	<0.0001*
nLF	63.34±.21	67.01±.25	66.05±.05	4639.61	<0.0001**

*Multiple comparisons shows SDNNi and nHF are lower in Control group at Post-test and FU than Pre test, **Multiple comparisons shows nLF is higher in Control group at Post-test and FU than Pre test

followed by Tukey's *post hoc* multiple comparison tests and the sports performance score (SP) was compared before and after intervention by using student's t-test for paired samples. The 95% confidence intervals were calculated for difference of mean of all outcome variables. Both groups, showed a non-significant difference at the base line (pre-test) values of HRV components such as SDNNi ($p = 0.86$), nHF ($p = 0.54$), nLF ($p = 0.04$) and SP ($p = 0.47$) (Table 1).

In MT group, the mean values of SDNNi and nHF had significantly increased from the baseline value (50.33±1.6), at 29th day (54.49±0.6) and at 36th day (53.87±0.6) which is statistically significant ($p<0.0001$). Whereas, nLF significantly decreased from the baseline value (63.44±0.3), at 29th day (56.58±0.3) and at 36th day (58.44±0.3) which is statistically significant ($p<0.0001$). The mean value of SP score has statistically significantly increased from 529±29-544±31 ($p<0.0001$) at pre and post intervention, respectively (Table 2).

Whereas, in control group, SDNNi and nHF had significantly decreased from the baseline value (50.25±2.4), at 29th day (48.06±0.9) and at 36th day (48.23±0.8) which is statistically significant ($p<0.0001$). Whereas, nLF significantly increased from the baseline value (63.44±0.2), at 29th day (67.01±0.3) and at 36th day (66.05±0.1) which is statistically significant ($p<0.0001$). The mean value of SP score has statistically significantly decreased from 524±32-519±29 ($p<0.0001$) at pre and post intervention, respectively (Table 3).

DISCUSSION

In HRV, SDNNi component value from 0-29 day (Pre and Post Intervention) and also in 29th-36th day (Follow-up) demonstrated significant difference in MT group ($F = 246.39$; $p<0.0001$). When comparing between groups, MT group has shown 7.6% increase during post interventions and a follow up increase of 6.6% whereas, control group showed 4.6% and 4.1% decrease at 29th and 36th day, respectively as compared to the baseline. Similarly nHF also demonstrated significant difference in MT group ($F = 3151.01$; $p<0.0001$). MT group has shown 15% increase during post interventions and a follow up increase of 11.6% whereas, control group showed 11.1% and 7.9% decrease at 29th and 36th day, respectively as compared to the baseline. nLF value from post intervention and follow-up showed significant difference in MT group ($F = 6555.66$; $p<0.0001$). MT group has shown 12.1% decrease during post interventions and a follow up decrease of 8.6% whereas, control group showed 5.5 and 4.1% increase at 29th and 36th day, respectively as compared to the baseline. Sports performance in comparison with MT and control groups, MT showed an increase of 2.8 and 1% decrease in control group.

In the current study, we used the HRV as a physiological marker and sports performance score as a subjective marker to assess the changes with intervention in two groups. Post-exercise cardiac autonomic activity as inferred from heart rate variability measures and the HRV parameters are very much reliable to provide true picture of changes in pre-competition anxiety or stress (Borresen and Lambert, 2008). Finally, psychological monitoring is also purported to be an effective means of assessing players' responses to training (Borresen and Lambert, 2009).

The high frequency (HF, 0.15-0.4Hz) power shows a peak centered at the respiratory frequency and predominantly reflects efferent vagal influences on HRV (Grossman and Taylor, 2007). Low frequency (LF, 0.04-0.15Hz) power is modulated by the baroreflexes with a combination of both the sympathetic and parasympathetic systems (Berntson *et al*., 1997; Kleiger *et al*., 2005). Studies have demonstrated an increased LF power with increasing sympathetic activity (Saul *et al*., 1990; Pagani *et al*., 1997) whereby the ratio between LF and HF has been considered to reflect sympathovagal balance (Malliani, 1999).

Studies on competition stress have been observed to decrease HRV and alter the power spectrum by decreasing the High Frequency (HF) component, increasing the Low Frequency (LF) component (Isowa *et al*., 2006). Based on these facts if any intervention is effective to reduce competition stress then we observed the reversibility in behaviour of these markers that will get an increase in HF and decrease in LF components of HRV and increase in SDNNi component of HRV. The same phenomena observed with MT group.

Experimental studies have also shown that athletes report increased positive affect and reduced negative affect in conditions where they listen to arousing music, compared to no music, during moderate to high intensity activity (Baldari *et al*., 2010; Bishop *et al*., 2009). Further, suggesting that relative increases in sympathetic nervous system activity during stressful events (Sloan *et al*. 1994). It is also proved that there is an increase in parasympathetic activity due to interventions of this study. Malfatto *et al*. (1996) explained the results regarding elevation of SDNNi, the strongest prognostic HRV markers, have been supported with an explanation. Thus in this study SDNNi component showed elevation from their baseline values after interventions.

Acute stress may affect cardiac function by shifting autonomic cardiac regulation in favor of the sympathetic nervous system (Pacak and Palkovits 2001) thus during stress or anxiety the nLF component of HRV increases. Music affects a reduction in sympathetic nervous control and therefore a reduction in heart and respiration rates, metabolism, oxygen consumption, muscle tension (Lee *et al*., 2005). Reduced heart and respiration rates lead to less anxiety and can promote relaxation. These studies support the reduction of nLF component in groups involved with music.

McCraty *et al*. (1995) also supported that the positive emotions resulting from relaxation therapies may significantly augment the HF component of a power spectrum whereas the opposite occurs with negative emotions that happens with competition stress. Therefore, HRV analysis provides a means of assessing the rhythmical changes that occur in instantaneous heart rate (R-R intervals) in response to alterations in sympathovagal balance. By relaxing music increases in parasympathetic activity decrease heart rate and increase HRV (White, 1999). Current study also supports the increase of nHF and decrease of nLF in MT group.

Listening to classical music increases heart rate variability, whereas listening to noise or rock music decreases heart rate variability (reflecting greater stress) (Chuang *et al*., 2010). Current study also given music therapy based on classical music that might have increased HRV in groups which have under gone music interventions.

Laukka and Quick (2011) reported that the athletes most often reported listening to music during pre-event preparations, warm-up and training sessions; and the most common motives for listening to music were to increase pre-event activation, positive affect, motivation, performance levels and to experience flow.

Karageorghis and Terry (2009) also included ergogenic, or performance-enhancing, effects of music like increased work output through synchronization of movement with the tempo of the music, enhanced acquisition of motor skills when the music matches the required movement patterns and enhanced performance levels. The athletes further reported that they mainly experienced positive affective states (e.g., happiness, alertness, confidence, relaxation) in relation to music in sports.

As repeated listening to music affects people's preference for it as well as their physiological responses to it (Knight and Rickard, 2001), the HF component of HRV might be increased with repeated listening. Music appears to exert direct physiological effects through the autonomic nervous system. In the current study have given 20 min session for 4 weeks this could supports the more effect of meditation in frequency components than music.

The result of the current study indicated that there is an increase in post-intervention and follow-up values in interventional group was showing more effective, whereas the control groups it was highly insignificant result. The reason for these changes might be supported by studies on competition stress have been observed (Mellalieu *et al*., 2009), supported that, prior to competing, sport performers encounter more stressors pertinent to performance. The level of anxiety automatically narrows perception restricting the focus of attention (Ashcraft and Krause, 2007). Thus result of this study indicated that there is a decrease in control group and increase in post intervention SP in MT group; the reason for these changes might be due to decrease in PCS.

CONCLUSION

The past empirical evidence has lent support to the view that psychophysiological recordings may even provide insight into the skill related aspects of a shooter's psychomotor strategies and determinants of successful shooting performance. Current study examined whether sports capacity or performance of the shooters is related to the alteration in scaling exponents derived from short-term heart rate variability by relaxation trainings. It is concluded that MT decreases PCS and therefore enhance SP. Four weeks of MT has an effect on ANS by altering changes in time and frequency components of HRV and can be considered as a reliable physiological marker of PCS.

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