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THE EFFECT OF VOCAL AND INSTRUMENTAL MUSIC ON CARDIO RESPIRATORY VARIABLES, ENERGY EXPENDITURE AND EXERTION LEVELS DURING SUB MAXIMAL TREADMILL EXERCISE

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Abstract : The purpose of the study was to investigate the effect of vocal and instrumental music on various physiological parameters during sub-maximal exercise. Each subject underwent three sessions of exercise protocol – without music, with vocal music, and instrumental versions of same piece of music. The protocol consisted of 10 min treadmill exercise at 70% HR_{max} and 20 min of recovery. Minute to minute heart rate and breath by breath recording of respiratory parameters, rate of energy expenditure and perceived exertion levels were measured. Music, irrespective of the presence or absence of lyrics, enabled the subjects to exercise at a significantly lower heart rate and oxygen consumption, reduced the metabolic cost and perceived exertion levels of exercise ($P<0.05$). There was faster recovery of systolic and diastolic blood pressures and exertion levels during the post exercise period. Music having a relaxant effect could have probably increased the parasympathetic activation leading to these effects.

Key words : vocal music; instrumental music; heart rate; oxygen consumption; energy expenditure; perceived exertion

INTRODUCTION

The beneficial effects of listening to music have been reported in a variety of applied settings. Music is known to reduce pain, anxiety and fear in several stressful conditions (1, 2). The potential physiological and psychological properties of music have become an area of increased interest in exercise physiology. Music motivates exercisers to sustain the effort and at the same time distracts them from the sensation of fatigue from their bodies (3, 4). There are two issues that need to be addressed in this area. The first issue is the effect of music *per se* on the cardio respiratory parameters

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and energy expenditure depending on whether the participants perform exercise in the presence of music or in silence. The second issue is the effect of different components of music such as tempo, rhythm, loudness and lyrics on the above parameters. It has been shown that the various features of music, namely rhythm, tempo, genre and loudness of music, enhance exertion tolerance through the diversion of attention from the exertive and uncomfortable physical sensations during exercise. Thus, the effect of each of these features becomes important while the subject is exercising with music. Several studies have shown that exercising while listening to music decreased the perceived exertion levels and improved the exercise performance when compared to exercising in silence during low and moderate intensity exercises (5, 6). However, there seems to be no difference in the exertion felt during high intensity exercise (7). Various studies have demonstrated conflicting results with respect to the heart rate changes in response to exercise. The heart rate and plasma lactate measures were lower in the music group than in the 'no music' group in a study with submaximal treadmill exercise (8). On the contrary, in yet another study, music did not alter the exercise performance and there were no significant changes in heart rate, oxygen consumption and minute ventilation (9). Further, the different components of music (tempo, rhythm, loudness) seem to influence the heart rate differently. Several studies have explored the interaction of tempo and loudness. One such study showed that soft and slow music decreased the heart rate when compared to loud and fast music during sub-maximal exercise (10). However, other studies have shown that exercising with fast music had greater arousal effect and greater work accomplishment without proportional change in heart rate (4).

In a recent study using self – selected music, heart rate, oxygen uptake and minute ventilation increased while the participants experienced greater enjoyment and lower perceptions of exertion in the music condition (11). In yet another study which used a steady-state exercise protocol using a treadmill, fast music increased several indices relating to heart and lung function, namely, minute ventilation, respiration rate and cardiac output when compared to the other two conditions (12).

At this juncture, it seems that a breath-to-breath measurement of the rate of energy expenditure and cardio respiratory variables could add on to the clarity of our understanding of the effect of music on exercise. Thus, our first objective was to measure the rating of perceived exertion, rate of energy expenditure, cardiac and breath by breath respiratory variables during a short bout of sub maximal treadmill exercise with and without music.

In this sphere, one of the less explored components of music is the effect of lyrics. That is, whether vocal music have different effects than instrumental music on either, or both objective and subjective measures. In the vocal version, apart from the instrumental background, the lyrics might have an additional effect of language, the meaning it conveys and the thoughts and feelings it generates with its wordings. In the instrumental version, the effect is mainly through the tone, type and the melody of the instrumental notes. Better adherence to exercise regimen was found with instrumental and with certain motivational vocal music in a study done in elderly people (13). A study of exercise with vocal and instrumental music in Alzheimer's patients showed that the participation in exercise with instrumental music was significantly greater than exercise with vocal music (14). Our second objective was to compare the difference in the effects of same piece of music with and without lyrics (vocal and instrumental forms) on healthy young subjects. We also recorded the post exercise recovery times of heart rate, exertion levels and blood pressure. With regards to performance, a couple of studies have shown that fast loud music has greater arousal effect and better exercise performance than slow quiet music (15, 16). Therefore, we chose to play vocal and instrumental forms of a fast tempo track.

METHODS

Participants

A total of 44 healthy male volunteers, between the ages of 18 and 25 years, participated in the study. Participants were recruited using a sign-up sheet. They were students of St. John's Medical College, Bangalore. Subjects suffering from diagnosed cardiovascular diseases, respiratory diseases, anxiety disorders, hypertensives, smokers, obese, physically handicapped and subjects with hearing disorders were excluded from the study.

Procedure

The experiment was conducted in the Respiratory Physiology Research lab of St John's Medical College, Karnataka, India. The study was approved by the institutional ethics committee. Participants were asked to take part in the study one at a time. A consent form handed to the participants stated that the participants were free to withdraw from the study at any time; participation was purely voluntary and assured confidentiality. All participants were requested to read and sign the consent form. Concise instructions were read to participants. They were informed of the experimental procedure, the equipment and its functions. Adequate time was given to each of the participants to clear their doubts, if any. The subjects were made to run on the treadmill a couple of times before the actual test sessions so as to overcome their initial anxiety.

The laboratory was air conditioned and temperature was maintained constant at 25 degree Celsius. The experiment consisted of three sessions. All the exercises were performed on a cardio pulmonary exercise testing treadmill instrument (BSA American Motion Fitness, USA). All subjects were instructed to refrain from eating or consuming caffeine for 4 hours prior to testing and to abstain from exercising for 24 hours prior to testing (12). Subjects were requested to follow identical patterns of activity and diet and not to engage in any other vigorous physical activity prior to the trial on each of the test days. Also, they were requested to refrain from eating a meal within 2 hours prior to a trial (6). Each testing session took place at approximately the same time of day (10 AM) for each subject and sessions were separated by at least 48 hours (12).

One control (without music) and two

experimental conditions (vocal and instrumental forms of same piece of music) were randomly applied on three days, 48 hours apart at the same time of the day for each subject. The investigator recorded the age, height, weight and calculated the body mass index of each subject at the first visit. Heart rate was monitored with a pulse oxymeter (Welch Allyn Tycos Instruments Inc., Arden, USA). Before each exercise session the pulse oxymeter was attached to the participant's index finger and after a 5min rest period the pulse rate was recorded by the examiner (on a score sheet) as a baseline measure. Maximum heart rate (HR_{max}) of each subject was calculated using Karvonen's formula (17). Each session consisted of warm up period (to bring the heart rate to 70% HR max), 10 minutes of exercise period and 20 minutes of recovery period. The subject started to run at a speed of 6 km/h at zero inclination and the inclination was gradually increased by 2° every 30s until the heart rate increased to 70% of the HR_{max} for that subject. The warm-up time was noted using a stop watch during the first session and same warm up time was applied for that particular subject during his next two sessions. It was observed that the subjects consistently reached almost the same heart rate, that is, comparison of the heart rates during the three sessions for each subject at the end of warm up time (0 min) of exercise were not significantly different. (Mean HR at 0 min was 129±6 bpm). The subjects continued to run at that inclination for next 10 minutes which was the actual test session. Music was introduced in a manner intended to be inconspicuous, at the end of warm up period, that is, at the beginning of the 10 min exercise period and the music was played throughout the 10 minute exercise session. The music was played from iPod (Apple® iPod® nano) through personal headphones in two of the experimental conditions (vocal and instrumental music) with the other being a no-music condition where headphones were worn but no music was played. Music of fast tempo (more than 120 beats/min) was selected. The vocal and the Instrumental versions of music stimulus of the song 'Waka Waka' (Shakira – Song: Waka Waka, Album: This Time for Africa, The Official 2010 FIFA World Cup Song) was played during the two experimental conditions. Both the vocal and instrumental forms of the songs were recorded several times sequentially, in order to last through each of the exercise periods. The music was played at loudness of approximately 80 dB. During the exercise the subject was made to breathe through a mouth piece into a tube connected to a computer with a V_{max} software which recorded the breath by breath oxygen consumption (VO_2), Carbon dioxide expired (VCO_2), Respiratory quotient (RQ), Respiratory rate (RR), Minute ventilation (VE), end tidal volume CO_2 expired ($PetCO_2$), Metabolic equivalents (METS) and rate of energy expenditure (REE). A subjective scale, the RPE scale (18), was displayed throughout each trial and participants' verbal ratings were recorded at the 0 min, 5^{th} min and 10^{th} min exercise. The RPE scale denotes exertion levels from rest to maximum effort (0 to 10). Heart rate was recorded every minute and Rating of Perceived Exertion (RPE Scale) was recorded at the end of 0 min, 5^{th} min and 10^{th} min. During the post exercise recovery period, the heart rate, RPE, systolic and diastolic blood pressures were recorded at every 5 min interval until they returned to the resting values.

The RPE scale presents a 10 - point scale ranging from 'nothing at all' (RPE 0) to 'very very hard' (RPE 10).

Statistical analysis

The study was a three condition randomized cross over study. A sample size of 44 ensured a power of 80% with 95% confidence. Participants carried out the exercise in each of the three experimental conditions: vocal and instrumental forms and control (no music). The anthropometric measures namely age, height, weight, and BMI, and the other parameters such as the resting heart rate, predicted maximal heart rate, target heart rate, resting systolic and diastolic blood pressures were tabulated as descriptive data as mean values with standard deviations. The mean values of heart rate, VO_2, VCO_2, RQ, VE, RR, $PetCO_2$, METS, REE and the recovery times of heart rate, blood pressure were subjected to single factor Repeated Measure ANOVA with the three conditions as the time in repeated measures. Since the RPE data was not normally distributed Friedman's test was applied to compare the three time points (0, 5^{th}, 10^{th} min) within each condition. Mixed linear model was used to compare the recovery times of the heart rate and the RPE using the 10^{th} min heart rate and the RPE values as the co-variate.

RESULTS

Forty six healthy male volunteers were recruited for the study. Two subjects discontinued; 44 subjects completed the study. Most of the subjects were familiar with the treadmill. For those who were new to it, trial runs were conducted 1 to 2 days prior so that the anxiety of the subject reduced and the subject became familiar with the exercise pattern. The general characteristics namely age, body weight, BMI, pre exercise basal values of resting heart rate, maximal heart rate (estimated using Karvonen's prediction equation), the target heart rate (mean value of 70% of maximal heart rate) and the resting systolic and diastolic blood pressures of the study volunteers are depicted in Table I.

TABLE I : Descriptive characteristics of the study subjects.

Parameters	*Subjects**
Age (years)	18.95±1.0
Body weight (kg)	64.84±9.2
Height (cm)	173±4.6
BMI (kg/m^2)	21.7±2.9
Max HR (beats/min)	201.0±0.8
Basal HR (beats/min)	73.4±9.9
Target HR (beats/min)	130.6±0.5
Systolic BP (mmHg)	111.7±9.34
Diastolic BP (mmHg)	68.3±6.9

*Results are in mean±S.D.

Heart rate :

Figure I shows the minute-to-minute recording of the heart rate during the exercise periods. Repeated Measures ANOVA showed that the heart rate attained at 0 min were not significantly different during the three sessions for each subject. Thus each subject was exerted to the same duration and to the same extent at the beginning of the three sessions. The mean heart rates achieved with both the vocal form and instrumental form of music were significantly lower when compared to no music condition. However, there was no significant difference in the heart rates achieved between vocal and instrumental conditions (Table II).

Rating of perceived exertion :

The subjective feeling of exertion measured using the Borg Scale at 0min (beginning of exercise period) showed that RPE was not significantly different at 0min. Thus, the subjective feeling of exertion at the beginning of the exercise session at the end of warm up was the same during all three sessions for each subject. The comparison of RPE during 5th min and 10th min revealed that the exertion levels were significantly lower with both forms of music than without music as shown in Table II and Figure II. Again there was no significant difference in the exertion levels between the two forms of music.

Rate of energy expenditure (REE) and Metabolic equivalents (METS) :

The energy expenditure and METS were significantly lower with both the music conditions than no music condition (Table II).

Respiratory parameters :

Oxygen consumption and Carbon dioxide expired were both significantly lower with both the forms of music groups than the no music group. There was no significant difference in the Minute ventilation, respiratory rate, end tidal volume CO_2 and respiratory quotient in all three conditions (Table II).

Recovery periods :

The heart rate recovery during the post exercise period was significantly more rapid in both the vocal and instrumental forms of music as compared to no music group. The exertion levels returned to baseline faster with instrumental music when compared to vocal and no music. The results were obtained after adjusting for the 10th minute

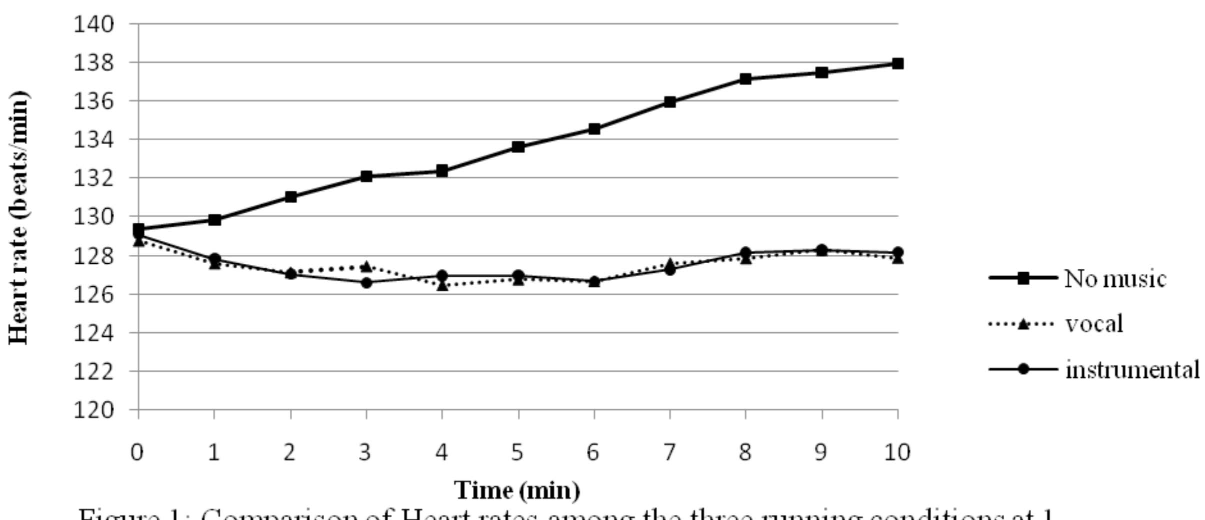

Figure 1: Comparison of Heart rates among the three running conditions at 1 min interval during the 10 min run.

TABLE II : Effects of vocal and instrumental music on heart rate, Rating of Perceived Exertion (RPE), respiratory parameters and energy expenditure during sub maximal treadmill exercise and post exercise recovery times.

Parameters	*No music*	*Vocal music*	*Instrumental music*	*P value*
HR (beats/min)	$134 \pm 7.4^{*\#}$	127±8.6**	$128 \pm 9.8^{\#\#}$	0.000
RPE scores				
0 min	$1.36 \pm 1.28^{*\#}$	0.93±0.95*	$1.09 \pm 0.96^{\#}$	0.06
5 min	$2.91 \pm 1.0^{*\#}$	2.11±0.99**	$2.14 \pm 1.1^{\#\#}$	0.000
10 min	$3.80 \pm 1.23^{*\#}$	2.95±1.30**	$3.05 \pm 1.36^{\#\#}$	0.000
$V0_2$ (L/min)	$1.21 \pm 0.23^{*\#}$	1.14±0.20**	$1.14 \pm 0.20^{\#\#}$	0.003
VCO_2 (L/min)	$1.08 \pm 0.21^{*\#}$	1.03±0.18*	$1.01 \pm 0.18^{\#}$	0.05
REE (kcal/day)	$8554 \pm 1.61^{*\#}$	8101±1.39**	$8040 \pm 1.43^{\#\#}$	0.004
METS	$5.32 \pm 0.85^{*\#}$	5.04±0.74**	$5.0 \pm 0.67^{\#\#}$	0.006
RQ	$0.88 \pm 0.01^{*\#}$	0.9±0.01*	$0.88 \pm 0.01^{\#}$	0.065
VE (L/min)	$38.8 \pm 0.94^{*\#}$	37.91±0.83**	$37.18 \pm 0.84^{\#\#}$	0.03
RR (breaths/min)	$32 \pm 6.74^{*\#}$	34±5.8**	$33 \pm 5.21^{\#\#}$	0.002
Pet CO_2	$39.84 \pm 3.86^{*\#}$	39.67±4.26*	$39.16 \pm 3.42^{\#}$	0.487
Recovery Times				
HR (min)	$20.68 \pm 0.5^{*\#}$	12.39±6.9**	$12.73 \pm 7.3^{\#\#}$	0.000
SBP (min)	$17.39 \pm 5.86^{*\#}$	12.39±5.0**	$14.66 \pm 6.23^{\#\#}$	0.000
DBP (min)	$13.64 \pm 4.98^{*\#}$	11.02±5.45**	$11.7 \pm 5.28^{\#\#}$	0.04
RPE (min)	$11.14 \pm 6.09^{*\#}$	8.98±5.56**	$8.41 \pm 3.37^{\#\#}$	0.004

Data presented are Mean±S.D. Analysis of data was done by single factor Repeated Measure ANOVA. Friedman's test for RPE and Mixed linear model for recovery times. The * depicts comparison with vocal group. The $^{\#}$ depicts comparison with instrumental group. All post hoc comparisons were done using Bonferonni corrections and considered statistically significant with $P<0.05$. **$P<0.05$, $^{\#\#}P<0.05$. HR = heart rate, RPE = rate of energy expenditure, $V0_2$ = rate of oxygen consumption, VCO2 = rate of carbondioxide expired, REE = Rate of Energy expenditure, METS = Metabolic equivalents, RQ = respiratory quotient, VE = Minute ventilation, RR = Respiratory rate, Pet CO_2 = end tidal volume CO_2 expired, SBP = systolic blood pressure, DBP= diastolic blood pressure.

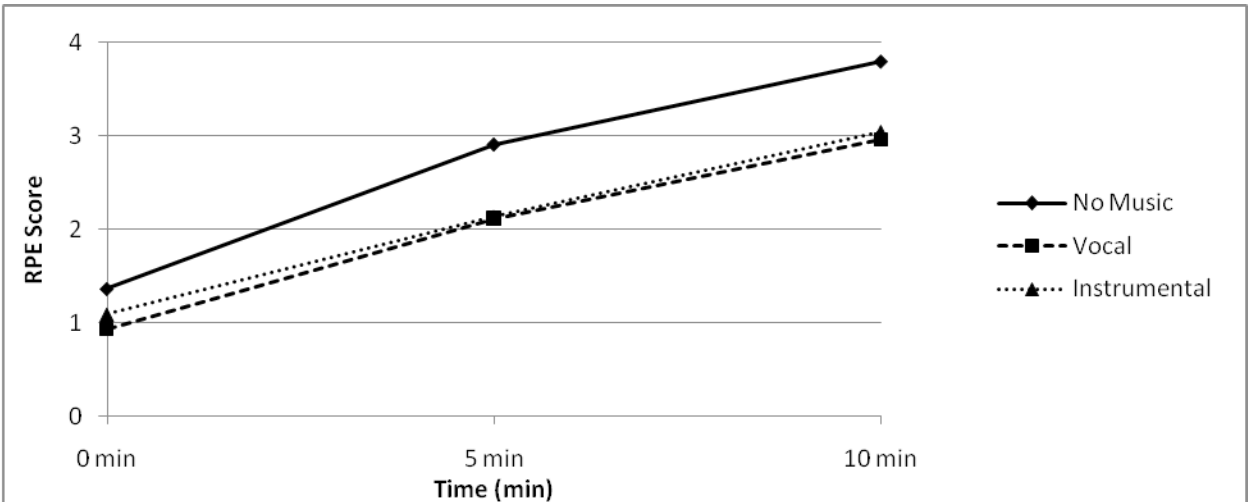

Figure 2: Comparison of Rating of Perceived exertion among the three running conditions at 0, 5th and10th min intervals during the 10 min run

heart rate and exertion levels as co-variate. The systolic and diastolic blood pressures and RPE also returned to the resting values significantly faster in both the music conditions as compared to 'no music' condition as shown in Table II.

DISCUSSION

This study showed that the subjects were able to exercise at lower heart rate with music compared to no music during the exercise period for the same intensity of exercise. Thus, the heart rate reserve and thus the cardiovascular efficiency would be higher while exercising with music. The finding is in par with similar study which showed a decrease in heart rate with exercise (8). Further, there was a significantly faster recovery of heart rate, systolic and diastolic components of blood pressure. These findings suggest the involvement of the parasympathetic system (5, 19). Music probably increased the parasympathetic tone and thus reduced the rise in heart rate during exercise and brought about a faster recovery of heart rate and blood pressure during the recovery period. Thus fast tempo music, both vocal and instrumental forms, showed beneficial effect on heart rate and thus on cardiac fitness. The faster recovery of diastolic blood pressure suggests that music might lower the peripheral resistance due to decrease in sympathetic tone and reduces muscle tension, thus increasing blood flow and consequently having a psychobiological impact on exercise (20, 8, 21).

Perceived exertion levels were significantly lower in both types of music groups and post exercise recovery of exertion was significantly faster with instrumental music as compared to vocal and no music conditions. Our finding is in concordance with previous studies which showed that the exertion levels were lower with music suggesting a distraction effect (5, 8, 10, 22, 23).

The rate of energy expenditure was significantly lower when the subjects exercised with both the forms of music when compared to the no music condition. Thus music, irrespective of the presence or absence of lyrics, reduced the metabolic cost of exercise by promoting greater neuromuscular and/or metabolic efficiency. An ergogenic effect is evident in both the conditions since music improved exercise performance by decreased perceived exertion levels and lower energy expenditure, which is indicative of increased work capacity. Our study is potentiated by few recent studies which have shown that music has an ergogenic effect and improves metabolic efficiency (6).

The minute ventilation (VE) and respiratory rate (RR) were not significantly different in the three conditions, yet the VO_2 was significantly lower. Thus, music did not alter the respiratory exertion significantly but the oxygen consumption (VO_2) was lower with both forms of music conditions which suggest that the subjects had better respiratory efficiency with no increase in the work load on respiratory system while exercising with music. The subjects were able to exercise to the same extent with greater oxygen economy. So, physical training with music could make the subjects more aerobically fit.

The RQs are not significantly different

in the three groups confirming that the intensity of exercise has been the same in all three sessions.

The $PetCO_2$ did not significantly alter in all three exercise conditions with or without music showing that the adequacy of ventilation was not compromised in any of the conditions.

Our findings indirectly support other studies which have shown that there was greater work accomplishment with fast tempo music as compared to no music during sub maximal exercise (4, 16). Investigating the role of lyrical content of music on the psycho-physiological responses during exercise, we found that there was no significant difference in the effects of vocal when compared to instrumental form of the same piece of music on any of the parameters measured during exercise. However, the instrumental music seems to have a greater beneficial effect on the RPE recovery times, suggesting a greater relaxation effect as compared to the vocal form of music.

In the present study, we have selected a homogeneous group of subjects. In future studies, we would like to test the effect on gender and in hospital scenario. We would also wish to look at the effect on plasma epinephrine levels which would give us better insights regarding the mechanism of action of music leading to such results.

Conclusion

Music (fast tempo, stimulating) has a relaxant effect which allows the person to exert to the same extent with less calories burnt and exercise at a lower heart rate and lesser oxygen consumption, thus the cardiovascular and respiratory demand are reduced for the same amount of work accomplished with greater enjoyment. However, there seems to be no difference in the effect of the vocal and instrumental forms of the same piece of music during exercise suggesting that presence or absence of lyrics has little influence over the effect of music on exercise in young healthy adults.

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