

# Temporal analysis of the ergogenic effect of asynchronous music on exercise

## *Análise temporal do efeito ergogênico da música assíncrona em exercício*

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**Abstract** – Several studies show that motivational asynchronous music can exert an ergogenic effect on submaximal intensity exercise. However, to date, no study has investigated whether motivation would continue after chronic exposure to this factor. The objective of this study was to examine the continuity of the ergogenic effect of asynchronous music on endurance running performance (time limit to exhaustion, Tlim) before and after a 4-week period of exposure to motivational music (musical saturation). Twenty-four subjects susceptible to motivational music were randomly divided into control (CG, n=12) and experimental (EG, n=12) groups. Both groups were subjected to endurance running for 4 weeks. Before and after this period, Tlim was measured with and without the use of motivational music in both groups. EG was exposed to musical saturation during the exercise sessions. The results confirmed the acute ergogenic effect of motivational asynchronous music; however, this effect did not continue after the saturation period. It can be concluded that, although motivational music exerts an acute positive effect on endurance exercise performance, a 4-week chronic exposure to this music appears to suppress its ergogenic effect.

**Key words:** Motivation; Music; Physical activity; Time to exhaustion.

**Resumo** – Diversas pesquisas demonstram que a música motivacional assíncrona pode exercer efeito ergogênico em exercícios realizados em intensidade submáxima. Entretanto, não foram encontrados até o momento, estudos que tenham analisado a continuidade da motivação frente à exposição crônica a este fator. O objetivo do estudo foi verificar a continuidade do efeito ergogênico da música assíncrona sobre o desempenho em corrida de longa duração (tempo limite para exaustão - Tlim) antes e depois de um período de quatro semanas de exposição à música motivacional (saturação musical). Foram envolvidos vinte e quatro sujeitos suscetíveis à música motivacional foram randomicamente divididos em 2 grupos: controle (GC=12) e experimental (GE=12), sendo ambos submetidos a corrida de endurance por quatro semanas. O GE foi exposto durante as sessões de exercício à saturação musical. Antes e depois deste período foi mensurado o Tlim com e sem a utilização da música motivacional em ambos os grupos. Os resultados sugerem que o efeito ergogênico agudo da música motivacional assíncrona foi ratificado, não observando todavia continuidade deste efeito após o período de saturação. Pode concluir que apesar da música motivacional exercer agudamente efeito positivo sobre o desempenho em exercício de endurance, a exposição crônica por quatro semanas parece suprimir seu efeito ergogênico.

**Palavras-chave:** Atividade física; Motivação; Música; Tempo limite de exaustão.

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## INTRODUCTION

Among the various attributes required for athletic performance, motivation is an important predictor of the success of exhaustive exercise and an essential part of any training program<sup>1-3</sup>. As the product of a set of social, environmental and personal variables, motivation determines one's choice of sport and the intensity of one's practice, and is thus closely linked to performance<sup>4,5</sup>.

Although motivation is broadly intrinsic in nature<sup>6</sup>, it also depends on external factors such as motivational music, which has been extensively characterized from a neuropsychological standpoint<sup>7</sup>. As music does not require linguistic coding, it has direct access to affect limbic areas that control impulses, emotions, and motivation. It also appears to be able to activate tertiary areas of the brain, located in the frontal lobe, that are responsible for motor sequencing functions<sup>7</sup>.

In this context, Teel et al.<sup>8</sup> note that music plays a significant role in the success of exercise sessions; therefore, it is relevant that practitioners choose background music that contribute to the pleasure of the exercise environment and boosts motivation. Musical accompaniment during physical activity can reinforce a sense of dissociation or disconnect<sup>9</sup> or a "state of flow"<sup>10,11</sup>, in which the practitioner would be intrinsically motivated for and fully involved and absorbed in the activity. According to Csikszentmihalyi<sup>10</sup>, the experience of "flow" would be accompanied by a narrowing of perception, an increase in self-awareness, and a sense of oneness with the activity and the environment, thus heightening positive and pleasurable feelings.

The conceptual framework of studies on music and its influence during physical activity has been divided into two broad modalities: synchronous music (SM) and asynchronous music (AM)<sup>12</sup>. SM is music whose rhythm is proportionally tied to the repetitive movements made by the athlete, such as steps, strokes, or pedal spins; the motivation provided by SM is of predominantly external origin. Conversely, AM seeks to motivate the practitioner by means of internal stimuli, without any direct connection between repetitive motion and the rhythm of the music played (e.g. music associated with a motivational situation that occurred in the past)<sup>13</sup>.

However, the above-cited studies only addressed the acute motivational effect of music, with no analysis of the effect of chronic exposure to these strategies. Therefore, the present study sought to analyze the continuity of the ergogenic effect of asynchronous music on prolonged exercise performance after a period of chronic exposure (four weeks).

## METHODS

### Sample

The initial study sample comprised 31 male volunteers, all of whom were active-duty conscripts stationed at a unit of the Brazilian Army in the municipality of Caxias do Sul, Rio Grande do Sul (age  $19 \pm 0.37$  years, body mass

69.90±2.36 kg, height 171.4±2.06 cm, body fat percentage 10.98±1.88%), physically active, and considered healthy on a prior medical examination. Subjects deemed unsusceptible to the ergogenic effect of asynchronous music were automatically excluded from the study. This randomized crossover trial was approved by the Fundação Universidade de Caxias do Sul research ethics committee with judgment number 037/2009.

### Experimental design

After providing written informed consent, subjects went to the study laboratory for clinical and kinanthropometric assessment to determine their eligibility for study participation and morphological characteristics. Subjects then took part in a 12-minute self-paced run on a standard running track. Mean velocity ( $V_{12min}$ ) was used as the continuous test intensity for determination of time to voluntary exhaustion ( $T_{lim}$ )<sup>14</sup>.

Seventy-two hours later, the 31 subjects initially deemed fit to take part in the study and previously familiarized with treadmill running took part in two continuous-velocity ( $V_{12min}$ ) runs for determination of  $T_{lim}$ . Sessions were held 72 hours apart, with and without motivational background music, as decided individually prior to the start of each run. Twenty-four subjects exhibited greater increases in  $T_{lim}$  with the use of motivational music, and were randomly allocated into two groups (n=12): experimental (EG) and control (CG).

Both groups then underwent a 4-week running training program consisting of three weekly sessions. Throughout the exercise period, EG participants listened to the same playlist used in the pre-saturation phase. CG participants took part in the same exercise program, but had no background music. At the end of the 4-week period, post-saturation  $T_{lim}$  was measured in the exact same conditions of the first and second  $T_{lim}$  measurements as noted above.  $T_{lim}$  values were compared between the music (EG) and non-music (CG) scenarios and temporally (comparison of the pre- to post-saturation change).

### Measurement of body mass, height, and body fat percentage

Body mass and height were measured with Filizola® scales (100 g resolution) and an Invicta® stadiometer (5 mm resolution) respectively. For measurement of body mass, subjects stood fully erect, wearing only shorts and a T-shirt. For measurement of height, subjects stood with their backs to the stadiometer, with the head oriented in the Frankfurt plane; height was measured as the distance between the floor surface and the cranial vertex. Total body fat percentage was estimated with the doubly indirect method of determining body density through quantification of skinfold thickness at three anatomical landmarks (chest, abdomen, thigh), using the equation proposed by Jackson and Pollock<sup>14</sup>. Measurements were obtained with a Harpenden Skinfold Caliper® (constant pressure 10g/mm<sup>2</sup>, resolution 0.1 mm), and body density was then converted to body fat percentage using the Siri equation<sup>15</sup>.

### Measurement of mean velocity during 12-minute time trial ( $V_{12\text{min}}$ )

Mean velocity during a 12-minute time trial ( $V_{12\text{min}}$ ) was measured on a 400 m synthetic track<sup>15</sup>. Before the trial, all subjects took part in a 10-minute free warm-up period and were then directed to the starting line. A sound was used to signal the start and end of the trial. All 31 subjects performed a Cooper test (12-minute run)<sup>14</sup> on a single day and time. Mean running velocity was calculated using the following equation:

$$V_{12\text{min}} = [\text{distance (meters)} \times 5] / 1000$$

### Individual selection of motivational asynchronous music

The *Brunel Music Rating Inventory-2* (BRMI-2), proposed by Karageorghis<sup>12</sup>, was used for identification of individually motivating pieces of asynchronous music. The protocol consisted of asking subjects to assign a score of 0 to 10 pontos (0 being the lowest score and 10 being the top score) to a selection of 30 tracks of various musical genres, initially heard by subjects as 1-minute samples. The criteria for assessment were intrinsic motivation and flow. The five tracks rated most highly by each subject were compiled as individually labeled playlists and set aside to be played during the  $T_{\text{lim}}$  test.

### Measurement of time to exhaustion ( $T_{\text{lim}}$ )

Each participant was given a portable media player (MP3 player, Sony, Japan) loaded with their corresponding musical selection and the volume was individually adjusted as desired. The protocol began with free stretching and warm-up exercises. Subjects then mounted a treadmill set to 6 km/h, and speed was increased stepwise to 8, 10 and 12 km/h (1 minute at each setting). At the end of this 3-minute period, subjects were considered to have completed their warm-up. Immediately after the conclusion of the 12 km/h minute, speed was adjusted to the subject's  $V_{12\text{min}}$  and, for the music scenario, a timer was started simultaneously as the subject's playlist was started. The treadmill display was hidden to prevent visualization of current speed and run time. Subjects were continuously given verbal and gestural encouragement to withstand the longest possible run time before declaring exhaustion. When voluntary exhaustion was declared, the timer was immediately stopped and speed reduced to 7 km/h for a 5-minute recovery period.

### Asynchronous music saturation protocol

Both groups were subjected to a 4-week program of 20-minute runs three times a week (12 sessions), during which they listened exclusively to the playlist used during determination of pre-saturation  $T_{\text{lim}}$  (EG) or ran without their preferred motivational background music. Subjects were instructed to run at their own pace, but continuously (with no interruptions during the 20-minute race period); all subjects ran at the same time, on the same days, and on the same track. Music volume was also set by each participant, and volume preferences were respected.

## Statistical analysis

Sample size was calculated with the PEPI 4.0 statistical software package, for a significance level of 5%, a statistical power of 80% and a correlation coefficient of 1<sup>15</sup>. Results were expressed as means and standard deviations (descriptive statistics). The Shapiro–Wilk test was used to determine the normality of sample data. The paired t-test was used for assessment of ergogenic effect and comparison of the study variable ( $T_{lim}$ ) over time, and the t-test for independent samples, for between-group comparisons. All statistical procedures were performed in the SPSS 16.0 software environment. The significance level was set at  $p < 0.05$ .

## RESULTS

The 24 participants were selected after comparison of pre-saturation  $T_{lim}$  findings (with and without music). The experimental protocol was completed by runners on whom motivational music had the greatest ergogenic effect. Results for the sample as a whole and for each group are shown in Table 1.

**Table 1.** Pre-saturation  $T_{lim}$  in minutes (mean±standard deviation).

|                  | No music  | Music       |
|------------------|-----------|-------------|
| Overall          | 7.55±0.17 | 9.91±0.23*  |
| Experiment group | 7.53±0.19 | 10.03±0.16* |
| Control group    | 7.58±0.15 | 9.97±0.19*  |

\*significant difference ( $p < 0.05$ ) as compared to the pre-saturation, no music condition

After the 4-week musical saturation phase (EG group alone), there was significant improvement in  $T_{lim}$  as compared to the no-music conditions. However, the CG exhibited a significant decline in performance with the use of music. Results are shown in Table 2.

**Table 2.** Post-saturation  $T_{lim}$  in minutes.

|                  | No music   | Music        |
|------------------|------------|--------------|
| Overall          | 10.73±0.26 | 10.42±0.23   |
| Experiment group | 10.54±0.27 | 11.37±0.25** |
| Control group    | 10.96±0.24 | 9.28±0.21**  |

\*\*significant difference ( $p < 0.05$ ) as compared to the post-saturation, no music condition

Mean percentage ( $\pm$ SD) changes in  $T_{lim}$  in the pre-saturation (Table 1) and post-saturation (Table 2) phases, in relation to the motivational music variable, in a sample comprising the subjects most susceptible to the ergogenic effect of music are shown in Table 3 below:

**Table 3.** Percentage changes in  $T_{lim}$  with music in the pre- and post-saturation phases.

|                  | Pre-saturation | Post-saturation |
|------------------|----------------|-----------------|
| Overall          | +32.33±3.85%   | + 1.57±5.01 %   |
| Experiment group | + 30.96±2.87%  | + 15.13±5.23 %  |
| Control group    | + 33.68±4.69%  | -14.68±3.66 %   |

## DISCUSSION

Analysis of pre-saturation data (shown in Table 2) suggests that the participants selected for randomization exhibited favorable conditions for the purposes of the study, as confirmed by the nonsignificant differences between the experiment and control groups and between these groups and the sample as a whole<sup>16</sup>.

$T_{lim}$  results for the no-music, pre- and post-saturation scenarios, as shown in Tables 1 and 2, review a significant improvement ( $p < 0.05$ ) in fitness as compared to the pre-saturation condition during the 4-week training period for the sample as a whole. The effects of music appear to have had no influence on fitness gains during these 4 weeks, as shown by the absence of significant differences ( $p > 0.05$ ) between the experiment and control groups in the no-music, post-saturation scenario<sup>16</sup>.

Embora ao se comparar o declínio significativo ( $p < 0,05$ ) do desempenho do universo da amostra sob efeito da música (pré-saturação com música em relação a pós-saturação com música), conforme apresentado nas tabela 3, gives no scientific support to the hypothesis that the ergogenic effects of motivational music on submaximal exercise decline after chronic saturation (4 weeks). This was probably due to the fact that the CG exhibited a significant difference ( $p < 0.05$ ) in the post-saturation, with-music scenario as compared to the pre-saturation, with-music scenario<sup>16</sup>.

In view of the unexpected results of the control group in the post-saturation phase, we conducted an analysis of intervening variables that may have arisen during the saturation phase, in an attempt to detect any factors that could interfere significantly with the motivational status of the sample, as the results showed a significant improvement in physical fitness in both groups. Ambient temperature, diet, rest, and typical situations encountered during military life, such as military instruction, mess duty, and combat exercises, were analyzed, and we concluded that these situations were present both during and before the pre-saturation phase and that both groups had been equally exposed.

However, we did find that, during the saturation period, individually paced running replaced continuous formation runs<sup>17</sup> and their acute pre-saturation motivational effect<sup>18</sup> across the whole sample, due to the chronic adaptation of participants to formation running since the start of military service (3 months before the start of the study). Trucollo et al.<sup>18</sup> reported higher and more sustained levels of motivation in street runners who run in groups as compared to lone runners. Furthermore, the motivational vector of synchronous music<sup>13,19</sup>—represented during formation running by cadence calls—was also suppressed when formation runs were replaced by individually paced runs<sup>17</sup> during the musical saturation phase.

The significant within-group difference ( $p < 0.05$ ) in the relative performance of the experiment and control groups during the post-saturation phase<sup>16</sup> is suggestive of decreased susceptibility to discontinuation of the variable (most probably continuous formation running)<sup>17</sup> that lead to

the unexpected results of the control group in the post-saturation phase as compared to the pre-saturation phase<sup>16</sup> (Table 1). The explanation for this difference appears to lie in a chronic, gradual adaptation to the motivational mechanism of asynchronous music in the experiment group during the saturation phase<sup>19</sup>, which would suggest an acute response of superior performance as compared to that of the control group. Kandel et al.<sup>20</sup> reported that changes in motivational states are produced by changes in one's internal condition in relation to a certain set point of regulatory processes, leading to adaptation<sup>20</sup>.

Although care was taken to select participants who were susceptible to the acute motivational effect of music, a review of the literature revealed no tools for this selection process, taking into account the perspective of chronic exposure, which could affect the time required for saturation and, consequently, the results of the study.

Another limitation of this study concerns the overlap of motivational vectors on the participants. During the intervention period, subjects were fully immersed in military life (the study took place during their third month of mandatory national service), an unusual environment in that it can expose individuals to a confluence of overlapping motivational factors<sup>20</sup>, which makes it difficult to isolate and interpret the real effect of chronic exposure to motivational music.

## CONCLUSION

The results of this study corroborate an acute effect of asynchronous motivational music, which translates into an improvement in submaximal performance. Our findings do not, however, support the hypothesis of a continued ergogenic effect of asynchronous motivational music on exercise performance, in view of the abnormal results exhibited by the control group in the post-saturation phase. There is evidence that the motivational effect both of synchronous and of asynchronous music may manifest itself chronically. New studies are warranted to bridge the knowledge gaps still present in this field.

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