

## Mini Review

# Ergogenic Effect of Music during Running Performance

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## Abstract

In running competitions portable music players and headphones are often banned. In some cases, runners have been disqualified after using such devices during competition. In this paper, it is discussed whether, aside from possible safety reasons, such competition regulations make sense and whether music can have an ergogenic effect on performance. Although a definitive conclusion on the regulation matter is not of our concern here, we review evidence of the fact that music is capable of enhancing performance in running and a range of different sports, predominantly for short duration exercise with low-to-medium intensity. The use of music players can be beneficial for training. However, it is reasonable to avoid these devices and headphones in case of championships for professional athletes.

## ABBREVIATIONS

USATF: U.S. Track & Field; SPM: Steps Per Minute; BPM: Beats Per Minute

## INTRODUCTION

In May 2016, 48 runners were disqualified after running the Beverley 10K race in Hull, England, since they were using portable music players and wearing headphones during the race [1]. This disqualification is not an isolated case and the use of headphones is officially banned in many races. In the US for instance, the USATF (the national governing body for the sports of track and field) has banned the possession or use of video, audio, or communication devices in the competition area for athletes competing in Championships for awards, medals, or prize money [2]. Previously, the USATF had even prohibited the employment of headphones by all runners. However, since it became an issue at several races its policy now leaves it up to the decision of the race director in other affiliated races. But what if you were having your medal or prize money seized because you were listening to music while running? And aside from safety reasons, does it make sense to implement such strong regulations for the use of music players? Could music impact running behavior (or the execution of other sports activities) to the extent that it might boost performance?

In the last decade, scientific research came up with plenty of evidence regarding the effect of music on sport and exercise behavior. Music listening during sports activities is believed to capture attention [3], distract from fatigue and discomfort [4], prompt and alter mood states [5,6], increase arousal [7], relieve stress, and evoke a sense of power and produce power-related cognition and behavior [8]. The results of these studies apply

to a range of disciplines, such as rowing, cycling, and running [9]. When considering the above-mentioned effects, it is clear that music listening can impact runners in a positive manner. However, besides music there are many other items that cannot be controlled and that might cause similar cognitive-emotional effects on attention, distraction, mood, arousal, stress, and empowerment. One can hardly prohibit the consumption of, for instance, energy drinks or caffeine; prevent exercisers from wearing their favorite sneakers or practicing mindfulness. Given that context, the main question is whether music is really capable of enhancing performance. If this ergogenic effect of music is real, moreover in combination with the earlier mentioned cognitive-emotional effects, the view of Karageorgis and Terry (2010) on music as “a legal drug for athletes” [10] might be reasonable and the rationale behind the headphone ban in running competition may be supported. But how could specific musical properties manage to affect performance and to what extent do they do so?

## Entrainment with musical tempo

A first musical feature that has been shown to successfully impact performance is tempo. A famous example is the long-distance track and road running athlete Haile Gebrselassie, who broke the 10,000m world record in 1998 while running to the beat of the 1995 hit song Scatman by Scatman John. Gebrselassie ran many records with the song and declared: “If you watch back some of my world records you can hear Scatman in the background. The rhythm was perfect for running” [11]. In scientific research, cyclists’ covered distance, power, and pedal cadence could be increased by introducing music with faster tempi (while slower tempi were shown to lead to decreases in these measures) [12]. In rowing research, similar effects were uncovered; shorter time to completion and more strokes per minute were observed with

faster tempi [13]. Results of studies on running behavior are well in line with these observations, revealing a positive impact of musical tempo boosts on work output (speed and cadence), but also a negative influence in case of tempo decrease [14,15]. Thus, music with a fast tempo tends to act as an external psyching-up stimulus in repetitive endurance activities, while the opposite effect is obtained through the use of slow tempi. It also seems that the disposition to entrain running behavior with a musical tempo is a natural or spontaneous one [16]. However, the level of SPM/BPM entrainment is limited and can only be obtained up to a certain degree, often referred to as the *entrainment basin* [17]. According to this basin, runners proved to be incapable of adapting beyond 2.00% of their original cadence. In addition, the level of entrainment seems to diminish for tempo increases/decreases of more than 2.50-3.00% [15]. Besides the ergogenic effect of tempo increases, synchronous music was also shown to provide benefits in running performance when compared to asynchronous stimuli [18,19], as it may reduce the energy cost of performance by improving neuromuscular metabolic efficiency [20].

### Entrainment with musical expression

Some studies demonstrated that expressive musical properties might impact performance as well. Edworthy and Waring (2006) revealed that boosts in the loudness of the stimuli enhance running speed [14]. Research on walking behavior suggested that differences in stride length and walking velocity could be linked to specific expressive sound characteristics in the music [21-23]. Examples of such characteristics are energy and pitch related features, but also the way in which these features recur over time [22,23]. These studies revealed that binary emphases in the musical rhythm, stressing each alternating beat, tend to increase walking velocity and stride length, while ternary emphases lead to decreases. In addition, the absence of tonal diversity tends to stimulate walking performance, while a negative effect was observed when introducing increases in the level of complexity of the rhythmic structure. Running performance can also be enhanced through the use of music reported by the exercisers to be motivational [24]. Generally, motivational music has been shown to be rather fast and consisting of catchy melodies and inspiring lyrics, an association with sporting endeavor, and a bright, uplifting harmonic structure [25].

### Intensity of the exercise

Research indicated that the ergogenic effect of music depends on the intensity of the exercise. Enhancement effects seem to decrease with increasing intensity levels. At high intensity levels, physiological cues seem to dominate the exerciser's processing capacity, while at the more moderate levels; both musical and physiological cues can be processed in parallel. When the workload becomes too high, the exerciser's attention is typically shifted towards the painful or fatiguing effects of the exercise and music tends to lose its power to influence work output [26-30].

Given the fact that intensities in competition are generally high, and that professional athletes tend to neglect external stimuli more than recreational exercisers, it may be the case that music is less influential at the top level [30,31]. However, the case of Gebrselassie provides a counter example and current trends

in research suggest that music tools become more intelligent and adaptive so that they might also impact performance during competition [32,33].

### Development of multimodal music interfaces

With the appearance of a new generation of smart music players [32,33], it becomes possible to personalize real-time manipulations of musical parameters in view of an optimized ergogenic effect. D-Jogger, for example, is an application that uses the accelerometer of a mobile media player to analyze body movement in order to dynamically select music and adapt its tempo and phase to the user's pace in order to enhance performance [33]. Besides, an entire range of commercial music-to-movement alignment apps aiming to impact performance (often to a limited extent based on research findings) is available. In combination with the already existing devices for monitoring, such as body area networks that capture heart rate, temperature, and other physiological parameters, it is clear that smart music players become powerful multimodal interfaces for sports and exercise activities. Their effectiveness for training has a huge potential, while their use during competition can be questioned.

### DISCUSSION & CONCLUSION

Music can have ergogenic effects on running performance, at least up to a certain limit. In the light of new developments in the field of smart multimodal music interfaces, the effects of music may even be enhanced so that music becomes a sort of a "personalized, legal drug". In order to obtain such effects, the right musical excerpts should be selected and particular manipulations may be needed to fully optimize the effect for a particular athlete. Seen from the viewpoint of organizers of sports events, it may be impossible to fully comprehend the power of the music playlist used by an individual runner during a race, and it will become even more difficult when considering this new highly technological variety of music players. Although further studies are needed on the matter, it is not unreasonable to circumvent the use of portable audio devices and headphones in case of championships for professional athletes.

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