



The effects of music on mechanical work and psychophysical performance in physical activity

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Abstract

Background: Music is increasingly recognized as a legal and effective ergogenic aid in the field of sports and exercise. However, a comprehensive understanding of the underlying mechanisms and the moderating factors of its efficacy remains fragmented.

Objectives: This review aims to systematically analyze and synthesize scientific evidence to elucidate the key causal relationships between psychophysical effects (mediating psychological and psychophysical mechanisms) and ergogenic effects (measurable performance outcomes).

Methods: This study employs a narrative review approach, analyzing and synthesizing data from foundational theoretical models, meta-analyses, and empirical studies published in reputable scientific databases (e.g., PubMed, Scopus, Google Scholar).

Results: The analysis reveals that music operates through a causal chain, initiating from psychophysical mechanisms (e.g., a ~10% reduction in Rating of Perceived Exertion [RPE], promotion of flow state, and arousal regulation) to yield measurable ergogenic outcomes (e.g., enhanced endurance and prolonged time to exhaustion). This effect is most pronounced and consistent in endurance sports. However, findings remain equivocal for strength and power-based activities. The efficacy of music is strongly moderated by factors such as personal preference, tempo (BPM), synchronous application, and exercise intensity (as explained by the Load-dependent Hypothesis).

Conclusion: Music serves as a potent psychophysical aid when applied scientifically and intentionally. The personalization and selection of music based on specific goals, exercise phases, and individual characteristics can significantly optimize both performance and the training experience.

Keywords: Music, sports performance, ergogenic, psychophysical, rating of perceived exertion (RPE), synchronization, load-dependent hypothesis, sports science

Introduction

Music is a nearly ubiquitous presence in sports and exercise settings, ranging from bustling fitness gyms to elite competitive arenas. Beyond its role as mere entertainment, music is increasingly recognized by the scientific community as an ergogenic aid—a safe, legal, and non-pharmacological method capable of enhancing both the physical and psychological performance of athletes. In the context of elite sports performance, which is often decided by minute margins, the search for legal and effective support methods is a top priority, and music emerges as a compelling and accessible option.

However, to fully understand and optimally apply the role of music, it is academically crucial to distinguish between two core concepts: ergogenic effects and psychophysical effects.

As defined in sports science, an ergogenic effect refers to any external factor that enhances the capacity to perform physical work, improves performance, or delays the onset of fatigue. In this context, the ergogenic effects of music refer to measurable outcomes such as increased endurance, improved maximal power output, or faster sprint times.

Conversely, psychophysical effects refer to the psychological, psychophysical, and psychophysiological mechanisms through which ergogenic benefits are generated. These effects include the regulation of mood, motivation, arousal levels, and the perception of effort.

This distinction is pivotal, as these two concepts are not parallel outcomes but rather a causal chain. Scientific evidence suggests that the interplay between psychological

and physiological mechanisms (psychophysical effects) is the primary cause responsible for the ultimate ergogenic outcomes. In other words, music functions as an "emotional stimulus" (a psychophysical effect) to drive and sustain physical activity (leading to an ergogenic effect).

The inconsistency in early findings within this field, or the "knowledge gap" pointed out by recent studies, is largely attributed to the arbitrary selection of music, a lack of theoretical basis, and the failure to clearly distinguish the psychophysical-ergogenic causal chain. Therefore, to understand how music enhances performance, we must first analyze the psychophysical mechanisms it activates.

This narrative review aims to systematically synthesize and analyze current scientific evidence regarding the impact of music on sports activities. Specifically, this paper will address the following objectives: Analyze the foundational theoretical frameworks explaining the relationship between music and performance; Elucidate the key psychophysical mechanisms (cause); Evaluate evidence on measurable ergogenic outcomes (consequence) across different types of performance; and Analyze the role of key moderating factors, thereby proposing a practical application framework for athletes and coaches.

Research Methodology

This article is conducted as a narrative review. This method was selected as it allows for the synthesis and in-depth analysis of findings from a diverse range of study types, including randomized controlled trials (RCTs), laboratory and field-based empirical studies, systematic reviews, and meta-analyses.

This approach is particularly suitable for constructing a comprehensive and coherent landscape of a multifaceted topic such as music and sports, where foundational theoretical frameworks, mechanisms of action, and influencing factors are diverse and interactive. The literature analyzed in this review was primarily sourced from reputable electronic scientific databases such as PubMed, Scopus, and Google Scholar, focusing on peer-reviewed literature, meta-analyses, and foundational theoretical models.

Data from the selected studies were subsequently extracted, synthesized, and analyzed according to a thematic structure, adhering to academic logic. This structure progresses from establishing foundational theoretical frameworks, to analyzing mediating mechanisms (psychophysical), followed by an evaluation of performance outcomes (ergogenic), and finally, an analysis of key moderating factors and the proposal of a practical application framework.

Results

This section analyzes the evidence regarding the phenomenon of music's impact, commencing with the theoretical foundations, delving into psychological and physiological mechanisms (causes), and finally evaluating measurable ergogenic outcomes (consequences).

1. Foundational Theoretical Frameworks in Music-Sport Research

The scientific application of music in sport has been underpinned by the maturation of theoretical models, primarily pioneered by Karageorghis and colleagues. Understanding these models is essential to interpreting the mechanisms and results presented in subsequent sections.

The Pioneer Conceptual Model (Karageorghis *et al.*, 1999) [1, 21]:

The modern theoretical foundation for this field was established by Karageorghis, Terry, and Lane (1999). This represented the first scientific attempt to predict the effects of music in sport and exercise, although it was initially limited to the use of asynchronous music (i.e., background music where the practitioner does not attempt to synchronize movement).

This model identifies four key factors contributing to the "motivational quality" of a piece of music, arranged in a hierarchical structure:

Rhythm Response: The most critical factor, referring to the rhythmic elements of music, particularly tempo (speed, measured in beats per minute - BPM).

Musicality: Refers to pitch-related elements such as melody and harmony.

Cultural Impact: Refers to the pervasiveness of music within the individual's socio-cultural context.

Association: The least critical factor, referring to extra-musical associations evoked by the piece (e.g., associations with a movie or a personal event).

This hierarchy (Rhythm Response > Association) carries a profound practical implication: selecting a piece of music with a physiologically appropriate tempo (e.g., matching the desired heart rate or stride rate) is likely to yield greater ergogenic benefits than simply choosing a "favorite" song (high Association) that possesses an unsuitable tempo.

The Brunel Music Rating Inventory (BMRI)

To operationalize the 1999 theoretical model, a psychometric instrument was developed: the Brunel Music Rating Inventory (BMRI). The BMRI, and its successor BMRI-2, provide a valid and reliable method for researchers, coaches, and athletes to assess and select motivational music scientifically, addressing the issue of "arbitrary" music selection that hindered early research.

The New Theoretical Model (Karageorghis, c. 2016)

Karageorghis's research continued to evolve, leading to the proposal of a more comprehensive "new theoretical model" around 2016. This model reflects the maturation of the field: it shifts the focus from music selection (1999 Model: "What makes music motivational?") to application and outcomes (2016 Model: "How can we use music systematically to achieve specific results?").

This approach is more prescriptive and interventional, expanding the scope of benefits and predicted outcomes. The new model encompasses not only mood improvement and RPE reduction but also emphasizes specific applications such as enhancing skill acquisition and increasing the prevalence of the flow state.

Table 1: Comparison of Theoretical Frameworks on Music in Sport

Feature	Conceptual Model (Karageorghis <i>et al.</i> , 1999) [1, 21]	New Theoretical Model (Karageorghis, c. 2016)
Primary Focus	Predicting "motivational quality"	Scientific application of music for specific outcomes
Factors / Antecedents	Four hierarchical factors: Rhythm Response, Musicality, Cultural Impact, Association	Music-structural factors (e.g., tempo) and interpretative factors (e.g., preference)
Predicted Outcomes	Arousal control, reduced RPE, mood enhancement	Expanded to include: mood, activation/sedation, reduced RPE, increased work output/duration, skill acquisition, flow state, dissociation
Scope of Application	Primarily asynchronous (background) music selection	Integration of synchronous and asynchronous applications for pre-task, in-task, and post-task purposes

2. Core Psychophysical Mechanisms (Causes)

This section delves into the psychophysical mechanisms—the psychological and psychophysical "causes" situated within the causal chain leading to performance enhancement.

Psychological Effects (Emotional State and Motivation)

One of the most potent and consistent effects of music is its

capacity for mood regulation. Appropriately selected music can enhance positive aspects of mood, such as vigor, excitement, and happiness, while reducing negative aspects like depression, tension, and fatigue. This effect is directly linked to motivation. Several theorists have proposed a model based on "psychological hedonism," positing that humans are fundamentally driven to seek pleasure and avoid discomfort. In this context, music renders the exercise

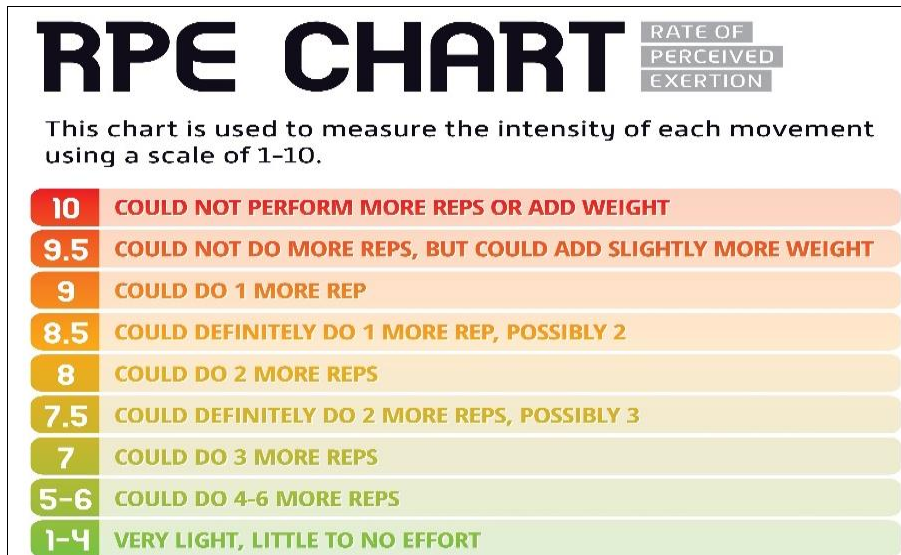
experience (which can be inherently unpleasant and monotonous) more enjoyable, thereby boosting immediate motivation and, crucially, long-term adherence to training.

Psychophysical Effects (Dissociation and RPE Reduction)

This is one of the most widely cited mechanisms. The psychophysical mechanism refers to how music influences the body's perception of effort. Music functions as an

effective dissociative strategy, allowing practitioners to divert their attention away from sensations of fatigue, pain, and internal physiological cues associated with exertion.

The direct result of this dissociative mechanism is a significant reduction in the Rating of Perceived Exertion (RPE). Specific data indicates that this reduction can reach approximately 10%; however, this effect is most pronounced at low-to-moderate exercise intensities.



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Attentional Effects (Flow State)

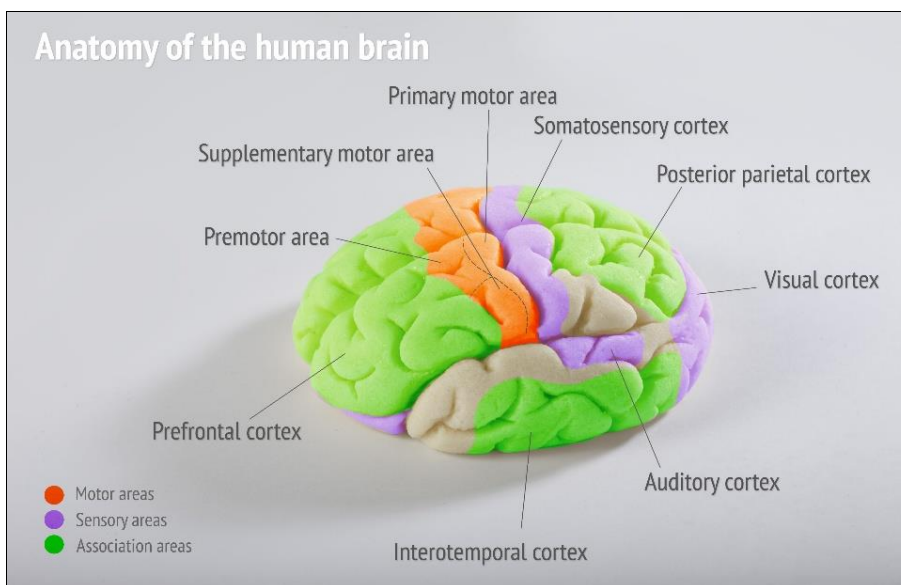
The inclusion of the "flow state" in the New Theoretical Model (2016) represents a significant advancement. It is necessary to clearly distinguish between "dissociation" and "flow state." While "dissociation" is a relatively passive process (i.e., ignoring fatigue), the "flow state" is an active process of total immersion. Flow is defined as an optimal psychological state characterized by the "fusion of action and awareness," where the individual is completely absorbed in the task and performs automatically—often

referred to as being "in the zone." Music, particularly tracks with a fast tempo and high preference, helps eliminate distractions and fosters a positive emotional environment, thereby facilitating the athlete's attainment of this state of heightened focus.

3. Neural and Motor Mechanisms

Parallel to the psychological effects, music also activates direct neural and motor mechanisms.

Neurobiological Foundations



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Listening to music activates an extensive brain network, including the motor cortex (responsible for movement

preparation) and the limbic system (responsible for emotional processing). Notably, studies indicate that preferred music has the capacity to activate the brain's

dopamine reward system. The release of dopamine generates sensations of pleasure and reinforces behavior. This is a pivotal neurobiological mechanism, providing a scientific explanation for why the factor of "personal preference" (to be discussed in Section 4) is so critical; it is not merely a psychological issue but possesses a biochemical basis, reinforcing long-term training motivation.

Auditory-Motor Synchronization

This is a direct and potent physiological mechanism, distinct from the psychological mechanisms outlined in Section 3.2. When music is applied synchronously, it functions as an auditory metronome, promoting auditory-motor synchronization. The consequence of this is a marked improvement in movement efficiency. Empirical data is compelling: a study demonstrated that cyclists riding to the beat of music required 7% less oxygen to perform the same workload compared to a no-music group. This represents a direct ergogenic benefit, rather than a merely psychological one.

4. Ergogenic Effects on Physical Performance (Outcomes)

Once the psychophysical mechanisms (Section 3.2) and neural-motor mechanisms (Section 3.3) are activated, they converge to produce measurable ergogenic outcomes—a tangible improvement in physical performance.

Endurance Performance

This is the domain where evidence for the ergogenic effects of music is most clear and consistent. Meta-analyses have confirmed that music "unequivocally" provides ergogenic benefits in endurance tasks. Studies involving tasks to exhaustion (e.g., running, cycling) consistently show that athletes can endure longer, cover greater distances, and maintain higher speeds when listening to music.

This consistency can be logically explained: endurance tasks are typically prolonged and performed at submaximal intensity, rendering them highly sensitive to psychological factors such as mood, motivation, and especially RPE. The

psychophysical mechanisms (such as dissociation and RPE reduction) discussed in Section 3.2 are the very factors that directly address and delay the performance-limiting factors of endurance sports.

Strength and Explosive Power Performance

Unlike endurance, evidence regarding the effects of music on maximal strength and anaerobic power (e.g., short, explosive efforts) is complex and remains equivocal.

Supporting Evidence: Some studies have reported improvements in strength endurance (e.g., increased repetitions at low-to-moderate intensity), isometric strength, Rate of Force Development (RFD), and Peak Power in Wingate tests.

Contradictory Evidence: Many other studies, particularly those involving complex dynamic explosive activities, have found no significant effects. For instance, music often fails to show improvement in vertical jump height.

This apparent contradiction can be explained by two mechanistic hypotheses

Internal Signal Interference Hypothesis: Explosive skills requiring complex techniques (such as jumping) demand that the athlete maintain a high level of associative focus on the body's internal feedback cues (proprioception) to execute the movement optimally. In this scenario, a strong external stimulus like music may act as a distractor, disrupting the necessary focus on internal signals, and thus failing to improve performance.

"Pre-Task" Intervention Hypothesis: For maximal efforts lasting only a few seconds (e.g., a 1RM lift), distraction *during* execution may be irrelevant. The limiting factor here is maximal neuromuscular activation. Instead, the primary psychophysical effect of music occurs pre-task. Meta-analyses focusing on pre-task music have found that it improves psychological responses. Music is utilized as a "priming" tool to optimize the psychological state, arousal, and motivation immediately prior to the effort, setting the stage for the ergogenic outcome of higher power output.

Table 2: Summary of the Effects of Music on Sports Performance Metrics

Activity Type	Performance Metric	Direction of Effect
Endurance (Running, Cycling)	Time to Exhaustion (TTE), Distance, Speed	Increase (+)
	Rating of Perceived Exertion (RPE)	Decrease (-)
	Oxygen Efficiency	Increase (+)
Strength	Repetitions (Low-to-Moderate Intensity)	Increase (+)
	Repetitions (High Intensity)	No Effect (0)
Explosive Power	Vertical Jump Height	No Effect (0)
	Maximal Isometric Force	Increase (+)
	Rate of Force Development (RFD)	Increase (+)
Team Sports	Sprint Speed, Sprint Distance (RSA)	Increase (+)
	Peak Power (Wingate Test)	Increase (+)

Discussion

The analysis in Section 3 has illuminated how music operates (mechanisms) and its resultant effects (performance). However, the efficacy of music is not a constant; it is strongly governed by a range of moderating factors. This Discussion section will analyze these factors and construct a practical application framework, akin to a "preventive framework" in sports medicine, to optimize the utilization of music.

1. Key Moderating Factors

Personal Preference

This is regarded as the most critical factor. Self-selected music almost invariably yields the greatest ergogenic and psychophysical effects. This finding poses an interesting challenge to the 1999 Model (which positioned "Association"—a factor intrinsically linked to personal preference—at the lowest tier).

The reason for the primacy of personal preference likely lies in the neurobiological basis mentioned in Section 3.3: preferred music has a superior capacity to activate the dopamine reward system. This activation is key to generating a positive emotional experience and reinforcing motivation, rendering it a decisive moderating factor.

Musical Characteristics (Tempo - BPM, Volume)

Tempo (BPM): Plays a pivotal role, aligning with the primacy of "Rhythm Response" in the 1999 model. Tempo is particularly crucial in endurance activities for movement synchronization. Studies confirm that fast-tempo music generates greater performance effects and the most positive psychological outcomes. There is a clear linear relationship between exercise heart rate and preferred music tempo; as heart rate increases, practitioners prefer faster music.

Volume: An interesting behavioral observation is that athletes tend to actively increase music volume as exercise intensity rises. This is not arbitrary behavior but a manifestation of a complex psychophysical mechanism explained in Section 4.3.

2. Synchronous and Asynchronous Application

This is one of the most powerful intervention-based moderating factors, clearly distinguishing two strategies for music use.

Asynchronous: Music is used as background, with no conscious effort to match movement to rhythm. Its benefits are primarily psychophysical: mood improvement, increased motivation, and reduced RPE (via dissociation).

Synchronous: The individual actively synchronizes repetitive movements (e.g., stride rate, pedaling cadence) with the rhythm (BPM) of the music.

Direct comparative studies have consistently found that the ergogenic effects of synchronous music are superior to asynchronous music. The reason is that synchronous music adds a direct physiological mechanism (as seen in Section 3.3) alongside psychophysical benefits. It creates a dual pathway of effect: (1) The Psychological Pathway (improved mood/RPE) and (2) The Physiological/Motor Pathway (increased movement efficiency, e.g., a 7% reduction in \$VO_2\$ consumption).

3. Exercise Intensity and the Load-dependent Hypothesis

This section explains the empirical observation that the psychophysical effects of music (specifically the capacity for dissociation and RPE reduction) are not infinite. This effect is strongly moderated by exercise intensity, a concept best explained by Rejeski's Parallel Processing Model (1985) [8].

This model posits that human attention is a limited resource. During exercise, there is continuous competition between internal attentional cues (e.g., sensations from muscles, heart rate, breathing rate, pain) and external cues (e.g., music, environmental surroundings).

This leads directly to the Load-dependent Hypothesis, which asserts

At low-to-moderate intensities (e.g., below the anaerobic threshold): Internal physiological cues are relatively weak. Therefore, a strong external signal like music can easily dominate attention, leading to effective dissociation and reduced RPE. This is when music exerts its strongest psychophysical effect.

At high intensities (e.g., exceeding the anaerobic threshold): Internal physiological cues (e.g., lactic acidosis, hyperpnea, severe muscle pain) become too potent and urgent. At this point, internal cues dominate the attentional channel, rendering distraction by external cues (like music) impossible.

This is why studies utilizing very high intensities (e.g., 90% \$VO_{2max}\$) often fail to find beneficial effects of music on RPE. The behavior of increasing music volume as intensity rises (mentioned in 4.1) is a manifestation of this hypothesis; the practitioner is attempting to amplify the intensity of the external signal to "drown out" the increasingly "noisy" internal signals.

A crucial distinction to be clarified in future research:

The Load-dependent Hypothesis primarily explains the failure of the dissociation mechanism (a psychophysical benefit of asynchronous music). The physiological (ergogenic) benefit of synchronous music acting as a metronome to maintain movement efficiency may persist even when the distraction benefit has vanished.

4. Intervention Framework and Practical Recommendations

Based on the analyzed mechanisms and moderating factors, it is evident that the haphazard use of music will yield inconsistent results. A solid scientific basis is required for the strategic use of music. The "golden rule" emerging from this analysis is personalization: music that is meaningful and preferred by the individual will always be capable of delivering the greatest benefits.

Table 3 below synthesizes practical recommendations, translating theoretical findings (e.g., "psych-up," "synchronization," "psych-down") into specific application guidelines regarding tempo (BPM) and musical characteristics for each phase of exercise.

Table 3: Music Selection Recommendations for Exercise Phases

Exercise Phase	Primary Goals (Psychophysical & Ergogenic)	Suggested Tempo (BPM)	Other Musical Characteristics
Preparation / Warm-up	Psych-up (Increase arousal), Psychological preparation, Enhance motivation	80-130 (gradually increasing)	Strong rhythm, inspirational lyrics, self-selected / preferred
Endurance (Moderate Intensity)	Enhance endurance, Reduce RPE (Dissociation), Movement synchronization (Increase efficiency)	120-140	Steady / Consistent rhythm, distinct beat (for synchronization), self-selected / preferred
High-Intensity Interval Training (HIIT)	Enhance motivation, improve affective experience (Reduce discomfort)	140-170+	Very fast tempo, high energy, explosive
Strength Training	Enhance motivation, Increase neural drive (Pre-lift psych-up)	110-150	Self-selected, matches lifting cadence, strong rhythm
Cool-down / Recovery	Psych-down (Lower arousal), Promote psychological recovery	< 100	Slow tempo, melodic, soothing, instrumental

Conclusion

The synthesis of existing scientific evidence strongly affirms that music constitutes a legal, safe, and highly effective ergogenic aid in sports and exercise. Its impact extends beyond merely creating a more enjoyable training environment; it intervenes profoundly in psychophysiological and neural processes, functioning as a potent psychophysical intervention.

This review has elucidated the causal chain: music activates psychophysical mechanisms (mood enhancement, RPE reduction, flow promotion) and physiological mechanisms (synchronization, increased movement efficiency), thereby yielding measurable ergogenic outcomes.

The benefits of music are most pronounced and consistent in endurance activities. For activities demanding strength and technique, the role of music is more complex and remains equivocal; it may operate primarily through a pre-task activation mechanism rather than in-task, and necessitates cautious application to avoid internal signal interference.

The paramount determinant of music's efficacy is personalization. Empowering athletes to use self-selected music aligned with their preferences, goals, and mental state is the key to maximizing benefits, likely attributable to the robust activation of the dopamine reward system.

References

- Karageorghis CI, Terry PC, Lane AM. Development and initial validation of an instrument to assess the motivational qualities of music in exercise and sport: The Brunel Music Rating Inventory. *J Sports Sci*,1999;17(9):713–24.
- Karageorghis CI, Jones L, Low DC. Relationship between exercise heart rate and music tempo preference. *Res Q Exerc Sport*,2006;77(2):240–50.
- Terry PC, Karageorghis CI. Effects of music in exercise and sport: A meta-analytic review. *Psychol Bull*,2020;146(2):91–117.
- Karageorghis CI, Priest DL. Music in sport and exercise: An update on research and application. *The Sport Journal*, 2008, 11(3).
- Karageorghis CI. The scientific application of music in exercise and sport: Towards a new theoretical model. In: Lane AM, editor. *Sport and Exercise Psychology*. 2nd ed. London: Routledge, 2015.
- Ballmann CG. The influence of music preference on exercise responses and performance: A review. *J Funct Morphol Kinesiol*,2021;6(2):33.
- Delleli S, Dallel M, Jarraya M, *et al*. The effects of pre-task music on exercise performance and associated psycho-physiological responses: A systematic review with multilevel meta-analysis of controlled studies. *Front Psychol*,2023;14:1293783.
- Rejeski WJ. Perceived exertion: An active or passive process? *J Sport Psychol*,1985;7(4):371–8.
- Nethery VM. Competition between internal and external sources of information during exercise: Influence on RPE and the impact of the exercise load. *J Sports Med Phys Fitness*,2002;42(2):172–8.
- Tenenbaum G, Lidor R, Lavyan N, *et al*. The effect of music type on running perseverance and physiological parameters. *J Sports Med Phys Fitness*,2004;44(3):271–8.
- Chen C, Li Y, Zhang W, *et al*. Music tempo, movement flow, and electroencephalographic characteristics during brisk walking: An experimental study. *Front Psychol*,2023;14:1255767.
- Chtourou H, Jarraya M, Aloui A, *et al*. Music as an ergogenic aid in team sports: A systematic review. *Front Sports Act Living*,2024;6:1514756.
- Ghaderi M, Ghaderi F, Belali K, *et al*. The effects of listening to music on anaerobic exercise performance and internal load in team sports. *Front Sports Act Living*,2025;7:1514756.
- Bood RJ, Nijssen M, van der Kamp J, *et al*. The effect of synchronous and asynchronous music on physiological, psychological, and psychophysical responses during exercise: A systematic review and meta-analysis. *Psychol Bull*,2023;149(3–4):192–214.
- Karageorghis CI, Terry PC. The psychophysical effects of music in sport and exercise: A review. *J Sport Behav*,1997;20(1):54–68.
- Szmedra L, Bacharach DW. Effect of music on perceived exertion, plasma lactate, norepinephrine and cardiovascular hemodynamics during steady-state exercise. *Int J Sports Med*,1998;19(1):32–7.
- Bigliassi M, Karageorghis CI, Bishop DT, *et al*. Cerebral effects of music during isometric exercise: An fNIRS study. *Int J Psychophysiol*,2018;131:37–44.
- Ballmann CG, McCullum MJ, Rogers RR, *et al*. Effects of preferred vs. nonpreferred music on resistance exercise performance. *J Strength Cond Res*,2021;35(6):1650–5.
- Hutchinson JC, Sherman T. The effect of exercise intensity on preferred music intensity. *J Sport Exerc Psychol*,2014;36(2):176–83.
- Wang J, Liu M, Li Y, *et al*. Music as an affective stimulant to physical activity (MASPA): A new theoretical model and future directions. *Front Psychol*,2023;14:1141159.
- Karageorghis CI, Terry PC, Lane AM. Development and initial validation of an instrument to assess the motivational qualities of music in exercise and sport: The Brunel Music Rating Inventory. *J Sports Sci*,1999;17(9):713–24.
- Karageorghis CI, Jones L, Low DC. Relationship between exercise heart rate and music tempo preference. *Res Q Exerc Sport*,2006;77(2):240–50.
- Karageorghis CI, Mouzourides DA, Priest DL, *et al*. Psychophysical and ergogenic effects of synchronous music during treadmill walking. *J Sport Exerc Psychol*,2009;31(1):18–36.
- Vlachopoulos SP, Karageorghis CI, Terry PC. Hierarchical confirmatory factor analysis of the Flow State Scale in exercise. *J Sports Sci*,2000;18(10):815–23.