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Original Research

The Influence of Relaxing and Self-Selected Stimulating Music on Vertical Jump Performance in Male Volleyball Players

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ABSTRACT

International Journal of Exercise Science 15(6): 15-24, 2022. Most research concerning the effects of music on physical performance was conducted using endurance parameters. This study investigated the effects of relaxing (RLX) vs. self-selected stimulating music (SM) vs. no music (NM) on jump height (JH), jump power (PWR), and average rest period between jumps (RP) in 13 athletes (age: 25.5 ± 2.6 years). After a warm-up and listening to music (1 min) or NM, participants completed five squat jumps on a force plate. Psychological ratings of mood were assessed using a questionnaire before warm-up and after jumping. A one-way ANOVA was conducted to compare effects of music on JH, PWR, and RP. A Friedman test with Wilcoxon signed-rank test was used to detect changes in mood. There were no significant effects of music on JH (p = 0.162) and PWR (p = 0.162). A trend towards longer RP in RLX when compared to SM was detected (+2.72 s, +22%, p = 0.059, d = 0.35). Participants felt more "relaxed" (+3 ranks) and more "powerful" after listening to SM (+2 ranks). Following NM and RLX, athletes felt more "energetic" (each +3 ranks) but less energetic (-3 ranks) after SM. In conclusion, this study did not find any performance-enhancing effects of self-selected SM on jump performance. The influences of music on psychological ratings were inconclusive. For this reason, no evidence-based guidelines for the practical application of music in elite jumping athletes can be made, and more studies are warranted.

KEY WORDS: Squat jump, jump height, mood, power

INTRODUCTION

More than 100 studies have addressed how music can influence human performance, many showing a variety of effects of music on physical, physiological, and psychological processes (e.g., altered affective valence and reduced rates of perceived exertion [RPE] (28)). While the vast majority of this research has been conducted on endurance performance (16, 17), showing increased performance, reduced perceived exertion, and improved oxygen consumption (see Terry et al. (28) for review), this study begs the question of whether other forms of human physical output can also be affected by music. This question is further reinforced by the fact that altered affective states might potentially affect a wide range of physical performances (8, 23).

Current evidence suggests that high physical outputs over short periods can also be influenced by music (10). Bartolomei et al. (3) investigated the effects of music (stimulating music [SM] vs. no music [NM]) on local strength endurance. More bench press repetitions were performed at 60% of one-repetition maximum (1-RM) while participants listened to music. Replicating this study, Ballmann et al. (2) also found a higher number of bench press repetitions at 75% of 1-RM when participants listened to SM (preferred music genre) compared to non-SM music (nonpreferred music genre). In contrast, Biagini et al. (7) found bench press strength endurance to be unaffected by music.

One question that arises at this point is whether music can also enhance maximal short-term physical outputs. Testing the effect of music (SM vs. relaxing music [RLX] vs. NM) on a relatively simple motor task Pearce (25) found lower maximal grip force during RLX compared to NM. Conversely, no difference in grip force was found when comparing SM to NM. Using a similar procedure (SM vs. RLX vs. white noise), a later study found higher levels of grip strength for SM compared to both RLX and to white noise (15). Moving towards music's effects on larger effectors, Bartolomei et al. (3) found no effect of music on maximal bench press force output. Further investigating music's impact on power and velocity parameters, Ballmann et al. (2) found a higher mean velocity, mean relative power, peak velocity, and peak absolute power during bench pressing under conditions of SM compared to non-SM. Assessing the effect of music (self-selected music vs. NM) on squat jump performance, executed with an additional load of 30% of squat 1-RM, Biagini et al. (7) discovered ground reaction force and jump height to be unaffected by music variations. However, when analyzing takeoff velocity, rate of force development, and velocity development, all these parameters were higher in the music condition than NM. Taken together, SM appears to hold some potential to act as an ergogenic aid while performing short-term, high intensity physical output. Although the results are to some extent inconsistent, stimulating music has been shown to positively affect strength endurance, maximal force output, and explosive physical outputs in some studies. Importantly, it appears that the choice of music may play an essential role in the efficacy of music's effects on physical performance. All studies cited above have used SM as auditory stimuli. Furthermore, all studies on more complex movements have used self-selected SM (2, 3, 7). In conclusion, self-selected SM may be particularly appropriate when investigating the effects of music on high physical outputs.

Following up on the study of Biagini et al. (7), one might note that the participants were not expert jumpers, but, instead, resistance-trained collegiate-aged men. Consequently, it remains unknown if their findings apply to a population with a more extensive jumping background. Jump performance in expert athletes may provide lower intertrial variance compared to less experienced athletes. Therefore, research using a jump-trained population might, on one hand, provide more robust empirical findings. On the other hand, this procedure would help establish evidence-based guidelines for the practical application of music in elite jumping athletes. The latter seems to be of critical importance, as a recent survey has demonstrated the widespread use of music as an ergogenic aid for exercise enhancement in elite athletes (21). Therefore, this study is aimed at investigating the effects of RLX and self-selected SM on vertical jump performance and psychological ratings in expert jumping athletes. The primary hypothesis was that SM would have a stronger positive effect on jump performance than RLX and NM.

METHODS

Participants

Prior to the investigation, ethical approval was obtained from the universities' ethics committee according to the Declaration of Helsinki. This study was conducted in accordance with the ethical standards of the International Journal of Exercise Science (24). For this study, volunteers were recruited at the university campus (N = 16). All participants had to be male, aged between 18 and 35 years, with no medical restrictions, and currently playing volleyball in the German first, second, or third division. Thirteen players agreed to participate in the study (first division N = 4; second division N = 6; third division N = 3). All participants were informed about the methods, and experimental procedures used and gave written informed consent prior to the intervention. Descriptive data for the subjects completing the study are presented in Table 1.

Table 1. Subjects age, height and weight (N = 13).

Age (years)	25.5 ± 2.63
Height (cm)	187.3 ± 7.47
Mass (kg)	83.9 ± 8.36

Protocol

The participants completed three testing sessions in counterbalanced order. Subjects were instructed to refrain from any strenuous physical activity 48 hours prior to each session. All sessions were held in a quiet room and every subject was tested at the same time of the day and on the same day of three consecutive weeks. Prior to warm-up, a 16-item questionnaire with eight sub-dimensions was used to assess mood (ordinal rating scale from 0-5; mean internal consistency 90.4; goodness of fit index 0.78) (19). The eight sub-dimensions were relaxation, positive mood, calmness, recovery, self-confidence, willingness to seek contact, social acceptance, and readiness to strain. Subsequently, a standardized warm-up procedure was conducted, including five minutes of low-intensity jogging and eight total-body dynamic mobility exercises. Three squat jumps, with hands on hips, approx. 90° starting knee angle, were then executed as a specific warm-up and to ensure correct jumping technique. Afterward, participants stood still on a force plate (Type 9290AD, Kistler Instrumente GmbH, Sindelfingen, Germany) with their eyes closed and listened for one minute to either no music (NM), self-chosen stimulating music (SM), or relaxing music (RLX). Due to the lack of research and recommendations regarding when and how much music must be played to have an effect, a time interval of one minute before jumping was chosen. In SM not just the song but also the exact portion was chosen by the participants. The only requirement was that the portion of the song was at least two minutes in length. RLX was selected according to the recommendations by de Witte et al. (30) (slow tempo instrumental meditative music at 60-80 bpm) as this type of music is considered particularly suitable for the purpose of relaxation (6, 9, 13, 30). Participants wore noise-cancelling headphones (SHO5300BK/00 YNTHT O'Neill Headband Drop, Philips, Amsterdam, Nederlands) connected to an MP3 player (MPaxx 900, Grundig, Fürth, Germany), even when no music was playing. Subsequently, five squat jumps were performed as described above. Except for NM, music was playing during the jumps as well. The subjects were instructed to choose an individual rest interval between jumps. The average jump height (JH), and power (PWR) of the jumps were recorded and analyzed by the force plate software at 500 Hz (Quattro Jump Software Version 2822A-01-0, Kistler Instrumente GmbH, Sindelfingen, Germany). The rest period (RP) between the five jumps was documented. Following the jumps, the above-described questionnaire was filled out again. After the intervention, only the speed (beats per minute, BPM) of the played part of self-chosen SM and RLX music was determined using the free software Audacity (Version 2.0.5).

Statistical Analysis

Statistical analysis was performed using SPSS (version 24; IBM Corp, Chicago, USA). Data are presented as mean ± standard deviation. Statistical significance was a priori defined as $p \leq 0.05$. Data were tested for normal distribution by a Kolmogorow-Smirnow-Test and for homogeneity of variance using Levene's test. One-way repeated-measures analysis of variance (ANOVA) was conducted to compare the effect of music on JH, PWR, and RP. Where necessary, Bonferroni post-hoc analysis was performed. Effect sizes were calculated according to Cohen. Effect sizes of Cohen's $d \leq 0.2$, $d \leq 0.5$, $d \leq 0.8$ and $d > 0.8$ were considered trivial, small, moderate, and large, respectively (12). A Friedman test for ordinal variables with Wilcoxon signed-rank test with Bonferroni adjustment was used to detect varying moods between the three sessions, pre- and post, listening to either no music, relaxing music, or self-chosen stimulating music. An independent T-test was used to analyze differences between BPM of SM and RLX music.

RESULTS

The independent T-test revealed faster tempo in the self-selected SM at 124.7 ± 19.4 BPM than in preselected RLX with 76 ± 0 BPM ($p \leq 0.001$). One-way ANOVA showed that the effects of music on JH (NM: 52.7 ± 5.71 cm, RLX: 53.92 ± 5.64 cm, SM: 53.84 ± 5.85 cm, $p = 0.162$) and PWR (NM: 28.8 ± 5.02 W/kg, RLX: 29.86 ± 4.59 W/kg, SM: 30.20 ± 4.10 W/kg, $p = 0.183$) were not significant. Post-hoc analysis showed that there were no significant differences in RP between conditions (NM: 13.76 ± 8.05 s; RLX: 14.99 ± 8.20 s; SM: 12.27 ± 7.32; NM-RLX $p = 0.377$, $d = 0.15$; NM-SM, $p = 0.19$ $d = 0.19$; RLX-SM $p = 0.059$, $d = 0.35$) (Figure 1).

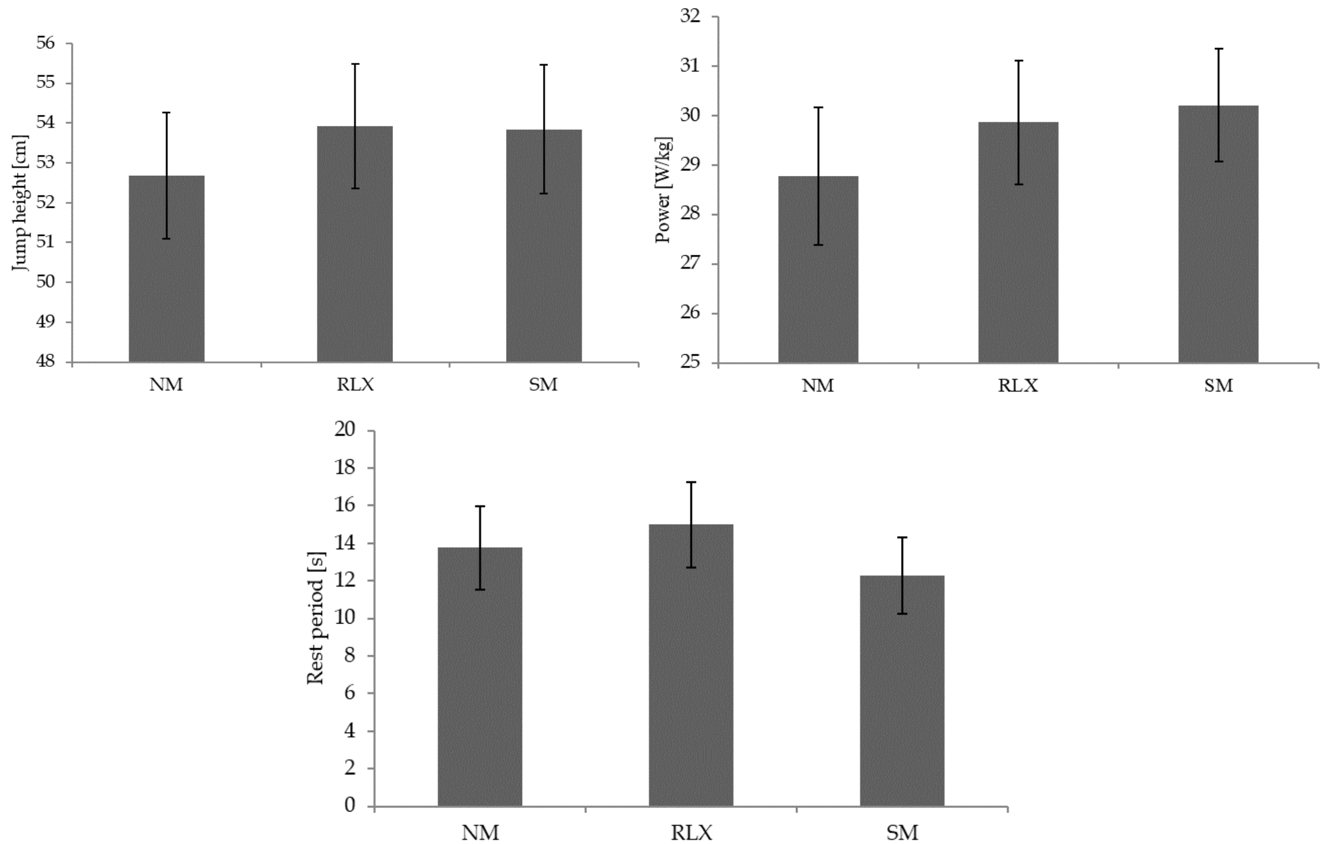

Figure 1. Mean jump height (top), power (middle), and self-selected rest period between the five squat jumps (bottom). NM = no music; RLX = relaxing music; SM = self-chosen stimulating music.

The mean ranks of the questionnaire items can be found in Table 2 The Friedman test showed no changes for the item "dull". Subjects felt "sleepier" after NM (-2 ranks), while SM and RLX music lead to no changes in self-reported drowsiness. After RLX, subjects felt more "cheerful" (+2 ranks), and less "cheerful" after SM (-2 ranks). With NM there was no meaningful change (-1 rank). There was no notable change for the "happy" item (NM no change, RLX and SM +1 rank). After NM and SM, subjects felt "calmer" (+2 ranks each), whereas RLX showed no changes in calmness score. Participants felt more "relaxed" after SM (+3 ranks), while NM and RLX had no meaningful effect (+1 rank, -1 rank, respectively). Subjects felt less "refreshed" after RLX (-2 ranks), while there was no change following NM and SM. Volunteers felt more “rested” after all three conditions (NM [+2 ranks], RLX [+2 ranks], and SM [+2 ranks]). The score of the item "confident" did not change at all. Subjects felt more "routined" after RLX (+2 ranks), while there was no meaningful change after NM (-1 rank) or SM (+1 rank). Participants felt less "communicative" following NM (-5 ranks), whereas there was no meaningful change after RLX (-1 rank) or SM (-1 rank). Subjects appeared to feel more "contact-ready" after RLX (+4 ranks), while there was a decrease after SM (-2 ranks), and no meaningful change after NM (-1 rank). There were merely slight changes (-1 rank) for the two items in the "social acceptance" category for any session. Notably, only after SM subjects felt less "accepted" (-3 ranks). Following NM (+3 ranks) and SM (+2 ranks), subjects felt more "powerful". In contrast, after RLX subjects felt less "powerful" (-2 ranks). Moreover, subjects felt more "energetic" following NM and RLX (each +3 ranks), whereas subjects felt less energetic (-3 ranks) after SM.

Table 2. Mood assessment's sub-dimensions.

		Pre_NM mean rank	Post_NM mean rank	Pre_RLX mean rank	Post_RLX mean rank	Pre_SM mean rank	Post_SM mean rank
Relaxation	Dull	1.62	0.73	2.62	1.88	2.96	1.69
	Sleepy	5.00	4.77	4.69	4.42	4.12	3.73
Positive Mood	Cheerful	11.46	11.35	10.88	10.81	11.73	12.19
	Happy	11.73	11.88	11.42	12.12	12.15	11.38
Calmness	Calm	10.38	9.65	9.85	9.73	10.19	8.62
	Relaxed	12.58	12.15	10.81	11.46	12.65	11.23
Recovery	Refreshed	5.96	5.15	5.27	5.46	5.15	5.50
	Rested	5.88	4.42	6.38	4.50	5.62	5.23
Self-confidence	Confident	11.77	12.15	11.42	12.58	13.12	12.46
	Routined	9.04	9.77	10.35	9.73	11.15	11.08
Willingness to Seek Contact	Communicative	4.38	7.65	6.54	7.73	6.50	6.96
	Contact-ready	10.38	10.69	11.27	10.73	8.35	10.00
Social Acceptance	Liked	9.42	10.04	9.88	9.85	9.35	9.69
	Accepted	10.58	11.42	10.50	10.96	10.54	11.65
Readiness to Strain	Powerful	6.88	4.62	6.27	5.73	7.04	5.58
	Energetic	5.92	4.54	6.85	5.31	4.38	6.00
	n	13	13	13	13	13	13
	Chi^2	87.288	96.517	79.801	92.286	109.364	95.401
	p	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001

DISCUSSION

The aim of this study was to examine the effects of RLX, SM, and NM on jump performance and psychological ratings in expert jumping athletes. The most important finding of this study was that music did not affect performance. However, there was a tendency towards shorter rest periods between jumps when comparing RLX and SM.

Contrary to previous research, music did not significantly affect JH. For example, two studies by Belkhir and colleagues (4, 5) showed higher maximum and average JH during a 30-second continuous jumping task after listening to various kinds of music during warm-up, including low- and high-tempo music, as well as motivational music. On a descriptive level, an improvement of +8.10 to +22.22% in JH was previously reported (4). These results are considerably higher than those obtained in the present study, yet the results should be interpreted with caution, since a different test of JH was used. Moreover, in line with the results of the present study, data by Biagini et al. (7) found no effect of self-selected music on squat jump height with added load accounting for 30% of 1-RM compared to NM.

This study has also been unable to demonstrate an ergogenic effect of music on PWR. This is in contrast to previous studies, which have shown that PWR was improved by listening to music. A study by Centala et al. (11) with college-aged male participants demonstrated that listening to fast-tempo music (137 to 160 BPM) led to increased maximal power output. However, power output was measured using a single-leg knee-extensor ergometer, whereas the present study used a jumping task. In a different study, the effects of music on bench press performance using 75% of individual's 1-RM was investigated (2). During the first three repetitions, relative mean power and peak power were higher when subjects listened to music they preferred compared to non-preferred music. However, there was no comparison to a control situation with NM. Therefore, the available evidence of various types of music on PWR is somewhat inconclusive. Comparisons of the available data are also complicated due to different approaches in measuring PWR. Currently, it remains a matter of debate whether music has a positive effect on PWR. This research topic is an important issue for future research, especially for sports that involve jumping and other PWR-related tasks.

Interestingly, when comparing RLX and SM, participants took shorter RP between jumps while listening to SM (RLX-SM: +2.72 s, +22%), although this difference did not reach statistical significance (p = 0.059) and only a small effect size was observed (d = 0.35). Nonetheless, it is well documented that listening to preferred or SM before or while executing performance tests can result in lower RPE (1, 4, 7, 27). For this reason, it is likely that subjects voluntarily chose shorter RP due to reduced perceived task exhaustion. In the light of this, the above-described results might be quite remarkable. Neither JH nor PWR were reduced in the SM condition compared to NM or RLX, although physiological fatigue would have been greater with shorter RP. Despite SM does not seem to improve performance, yet it may well facilitate more time-efficient training sessions - apparently without compromising performance.

Due to the conflicting results concerning jump performance, further studies regarding the effects of music on jumping performance are required. In particular, studies comparing subjects with different performance levels should are needed. It remains unclear whether acyclic movement tasks, such as repetitive jumping, can benefit from music in the same manner as repetitive or more continuous movements, such as running or cycling. For example, movement frequency, heart rate, and respiration are thought to synchronize with music, which may partially explain the performance-enhancing effects of music during continuous movements (10). However, these mechanisms are likely to have less of an effect on jumping tasks.

Among the most notable findings on the influence of SM and RLX on psychological ratings are the effects on the sub-dimension "calmness" and "readiness to strain". The first and the most surprising result was that participants felt more "relaxed" after listening to SM (+3 ranks) with 124.7 ± 19.4 BPM. This result differs from previous studies, demonstrating that primarily slow tempo music (60-80 BPM) results in relaxation (6, 9, 13). It should also be mentioned that this result was even observed after the physical activity (JH testing). One would expect the opposite outcome, as physical activity leads to tension and fatigue rather than to relaxation (26). However, it must be emphasized that this result was obtained only from a self-report questionnaire. Therefore, interpretations should be made with extreme caution. Additional physiological markers, such as heart rate or blood pressure, could provide additional information and should be considered for future studies.

Concerning the sub-dimension "readiness to strain", the current study found that subjects felt more "powerful" following SM (+2 ranks). This is in line with previous findings, showing the arousing effects of music (14, 20, 22). However, participants also felt more "powerful" after NM (+3 ranks). Moreover, participants felt more "energetic" following NM and RLX (each +3 ranks) and less energetic (-3 ranks) after SM. This raises the question of whether this effect is truly due to the music condition alone or also to the additional physical strain of performance testing. There is also the possibility that participants felt less "energetic" following the SM condition, because they chose shorter RP between jumps, as mentioned earlier. Based on the present results, no clear effects of RLX and SM on mood can be identified. All observed effects of music on mood may be a consequence of an interaction between listening to music and performing exercise. For this reason, further studies with different questionnaires focusing on the interaction of music, performance testing, and mood are needed.

Our subjects were allowed to choose the volume of the music themselves. This should be standardized in future studies, as the volume of music may have distinct effects on physical performance (18, 29). Second, it may be more appropriate to investigate RLX and SM's effects on jump performance when the RP are given, instead of letting the participants individually choose RP length between trials. Even though the design in this study led to a new finding regarding the influence of music on RP, it might as well have prevented the performance-enhancing effects of SM. Another limitation is that the RLX was pre-selected by the research team. Therefore, some subjects may have perceived RLX as unpleasant, which may have influenced the results (29). Consequently, future studies could allow subjects to self-select not only SM but also RLX. Finally, it is worth mentioning that future studies should consider higher sample sizes to increase statistical power.

Several questions remain unanswered at present. For example, the mechanisms underlying music's effects on strength performance remain poorly understood. As such, it is unknown how an auditory stimulus must be composed (e.g., timing, volume, BPM etc.) to induce maximal performance-enhancing effects. In addition, there is a general lack of studies on the influence of music on strength performance, as most studies investigate the effects of music on endurance performance (16, 17).

In conclusion, this study did not find any performance-enhancing effects of self-selected SM on jump performance. Further, the influences of music on psychological ratings were inconclusive. For this reason, no evidence-based guidelines for the practical application of music in elite jumping athletes can be made.

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