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Research article

Effect of Mindfulness Training on Fatigue and Recovery in Elite Volleyball Athletes: A Randomized Controlled Follow-Up Study

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Abstract

Volleyball is a team sport with high physical and perceptual-cognitive demand, hence, increasing the perception of physical and mental fatigue during a competition. To alleviate fatigue (physical and mental), mindfulness and music have been proposed. The aim of this study was to analyze the effect of mindfulness-based mental versus music training on mental fatigue, physical fatigue, and recovery in elite competitive female volleyball athletes using a randomized two-controlled study with follow-up. Participants were 30 elite female Brazilian volleyball athletes. Athletes were randomly assigned to the following groups: 1) mindfulness-based mental training group (MBMT); 2) music-based training group (MBT); or 3) control group (CG). Three variables were evaluated as follows: 1) recovery based on total quality recovery; 2) mental fatigue visual analog scale; and 3) physical fatigue visual analog scale. Regarding recovery, there was no difference between the MBMT, MBT, and CG groups ($p > 0.05$). A difference in mental fatigue was noted between MBT and CG at follow-up [$F(2,26) = 5.71$, $p = 0.009$; large]. Regarding physical fatigue, there was no difference between the MBMT, MBT, and CG groups ($p > 0.05$). The mindfulness intervention effectively attenuated the mental fatigue caused by competition in volleyball athletes. These results will assist coaches and staff in providing fatigue management and reinforce the applicability of mental training in sports.

Key words: Mental fatigue; mental training; team sports; sport psychology.

Introduction

Volleyball is characterized by intermittent stimuli of short duration and high intensity interspersed by short recovery periods that occur successively during a training session or a match. The sport requires capacity to repeatedly perform efforts that require strength, power, and agility, induce in high physical fatigue after training (Horta et al. 2017; Mroczek et al., 2013; Timoteo et al., 2017). Volleyball also need psychomotor and perceptual cognitive skills, such as coordination, decision making, and reaction time, collective and individual tactical actions of the team, and emotional control (Andrade et al., 2016; Mroczek et al., 2013). Additionally, volleyball is open-skill sports with degree of unpredictability, in which athletes have to react in continuously changing situations and an externally-paced environment, required higher cognitive demands in planning and strategy, leading to increased mental fatigue (Krenn et al., 2018).

Mental fatigue is a psychobiological state characterized by a combination of subjective, behavioral, and physiological manifestations; feelings of fatigue and a lack of energy are caused by prolonged periods of cognitive demands (Van Cutsem et al., 2017). The framework proposed suggest that team sports have different stimulus that impair cognitive demand, like response inhibition, sustained vigilance, increase perception of effort, impaired executive function, decrease accuracy, attention, and action. These mechanisms leave to a decrease technical and tactical performance, decision-making skills, and match performance (Smith et al., 2018). Additionally, the specifics of training, successive games, trips, and level opponent level (Kelly and Coutts, 2017) lead to a high physical and mental demand in collective modalities during the competitive period. High load and worse recovery during competition in the season are found in volleyball players (Timoteo et al., 2017), emphasizing the need to monitor mental and physical fatigue and recovery of athletes throughout the competitive period.

Recent studies investigating elite competitive volleyball have verified a high training load in the preparatory and competitive periods during which the mental requirement also increases (Andrade et al., 2016; Timoteo et al., 2017). Consequently, there is a greater need for strategies that promote sufficient recovery of athletes (Poppendieck et al., 2016). In this sense, relaxation techniques have been recommended (Dupuy et al., 2018; Jithendra and Shahin, 2014), among which mindfulness has been gaining prominence (MacDonald and Minahan, 2018; Palmi and Solé, 2016; Sappington and Longshore, 2015).

Mindfulness is a process of openly engaging with one's uncritically conscious awareness of the present experience in the present moment (Bühlmayer et al., 2017; Creswell, 2017; MacDonald and Minahan, 2018). Mindfulness-based mental training (MBMT) involves the application of techniques, strategies, and procedures, including attention to one's own bodily sensations, emotional reactions, mental images, self-talk, and perceptual experiences of external stimuli, such as sounds and tastes as they arise (Bühlmayer et al., 2017; MacDonald and Minahan, 2018; Sappington and Longshore, 2015). MBMT currently aims to provide an individual with autonomy and self-regulation in the management of attention through the learning of self-applied or autogenic techniques (MacDonald and Minahan, 2018).

Studies that investigated the use of music for recovery immediately after exercise. The results suggest that listening to motivational music during non-structured recovery leads to reduced perception of effort and maybe used by athletes to enhance recovery activity (Eliakim et

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al., 2012). In the same way Karageorghis et al., (2017), found that slow and sedative music can increase the recovery process immediately after strenuous exercise. However, they investigated acute effect in young active students (men and women). In sport setting, Ghaderi et al. (2015) observed a decreased response of lactate and cortisol during a circuit of resistance exercise with handball players, which might be one of underlying mechanisms of fatigue reduction after training. However, no study investigated the effect of music post training or competition in sport context.

In a recent meta-analysis, Bühlmayer et al. (2017) found a significant effect of mindfulness on physiological performance compared to control and on performance in precision sports. However, only a moderate effect was seen on psychological performance, pointing to the need for more studies investigating psychological aspects with more samples and the application of more detailed and homogeneous protocols using MBMT. Goodman et al. (2014) found a greater goal-directed energy and less perceived stress following an intervention with mindfulness and yoga with 13 NCAA division I athletic team. In the same way, Scott-Hamilton et al. (2016) found in a randomized controlled trial with 47 cyclists a positive effect on flow, and pessimism with 15’ in class mindfulness practice plus 20’ home-guided meditation.

To date, no study has specifically investigated the effect of MBMT on physical and mental fatigue and recovery. In fact, interventions such as immersion in cold water, active recovery, and compression garments have been the main approaches to the recovery and restoration of physical fatigue induced by training (Dupuy et al. 2018). In contrast, psychological strategies and mental training techniques are most commonly recommended for the recovery of mental fatigue and emotional exhaustion induced by training and competition (Kellmann et al., 2018).

Furthermore, studies with better methodological quality evaluating the effects of MBMT on psychological outcomes are recommended (Bühlmayer et al., 2017) as is the need for follow-up studies to verify the lasting effect of interventions of this nature. Although these results demonstrate that MBMT and music training produce positive effects in athletes, little is known about the effects of this application during a competitive period on the mental fatigue, physical fatigue, and recovery of volleyball athletes. It is important to understand how MBMT or music training can help mitigate these outcomes in high performance sports during a competitive period. Furthermore, to our knowledge, no study to date has compared these two interventions during a competitive period or verified the enduring effects for a follow-up period after the intervention.

Thus, the aim of the present study was to analyze the effect of mindfulness-based mental training versus music training on mental fatigue, physical fatigue, and recovery in elite competitive female volleyball athletes using a randomized two-group controlled study with follow-up. It also aimed to analyze the relationship between these parameters after MBMT. Based on previous studies, we hypothesized that MBMT and music training affect the attenuation of mental fatigue and physical fatigue and improve the recovery of athletes during the competitive period.

Methods

Study design

This study was a three-arm randomized controlled blinded trial with follow-up. Female athletes as members of a volleyball team were randomized to the following groups: 1) Group MBMT; 2) Group MBT; or 3) Control Group. This study was registered with the Brazilian Registry of Clinical Trials (RBR-32gwpm -REBEC).

Subjects and eligibility criteria

A team with three categories (U-16, U-14, and U-13) of competitions during the season was selected. The inclusion criteria were federated athletes with no injuries or health problems that might interfered in study. Exclusion criteria were absence from more than half of the training sessions or interventions, injuries, or health problems.

The power of the sample size was calculated based on the difference between the control and treatment groups (MBMT or MBT) after the intervention based on the *mean* effect size of $d = 0.5$ (Cohen, 1988) on a single-tailed test with $\alpha = 0.05$ and a $1\text{-}\beta$ error probability of 0.8 for the outcome variable using G*Power (Faul et al., 2007).

This study was approved by the Research Ethics Committee of the local university (opinion no.: 2,609,693). The parents of athletes (all under 18 years of age) provided written informed consent for their participation.

Randomization and allocation process: Figure 1 shows an overview of study flowchart and protocol randomization procedure (parallel group design). After the first contact with the team and screening for the inclusion and exclusion criteria, the athletes were randomized and assigned by team to groups and informed about the conditions of the experiment. Measurements were assessed at time 1 (baseline), time 2 (post-intervention and competition), and follow-up (approximately 2 weeks after the end of the competition).

Protocol

Mindfulness-based mental training: The study methodology was developed according to the protocol suggested by Elliott et al., (2011) an audio containing the Body Scan mindfulness technique (MacDonald and Minahan, 2018; Scott-Hamilton et al., 2016). Body scan is a classical technique of meditation and consciousness is a central element of mindfulness-based relaxation. The step-by-step sequence of the audio content containing the Body Scan technique is shown in Table 1.

Music-based training: The protocol involving music training was developed with the intention of inducing relaxation (Elliott et al., 2011). The athletes were instructed to listen self-selected music that induced relaxation.

Intervention: For the present study, the protocols were adapted to the team’s competitive period (2 weeks). The intervention occurred in two moments: 1) After the training session, in a comfortable environment near the training area without important visual or sound stimuli; and 2) Before bedtime, when the athletes were instructed to follow the protocol. The equipment used for the intervention included a smartphone.

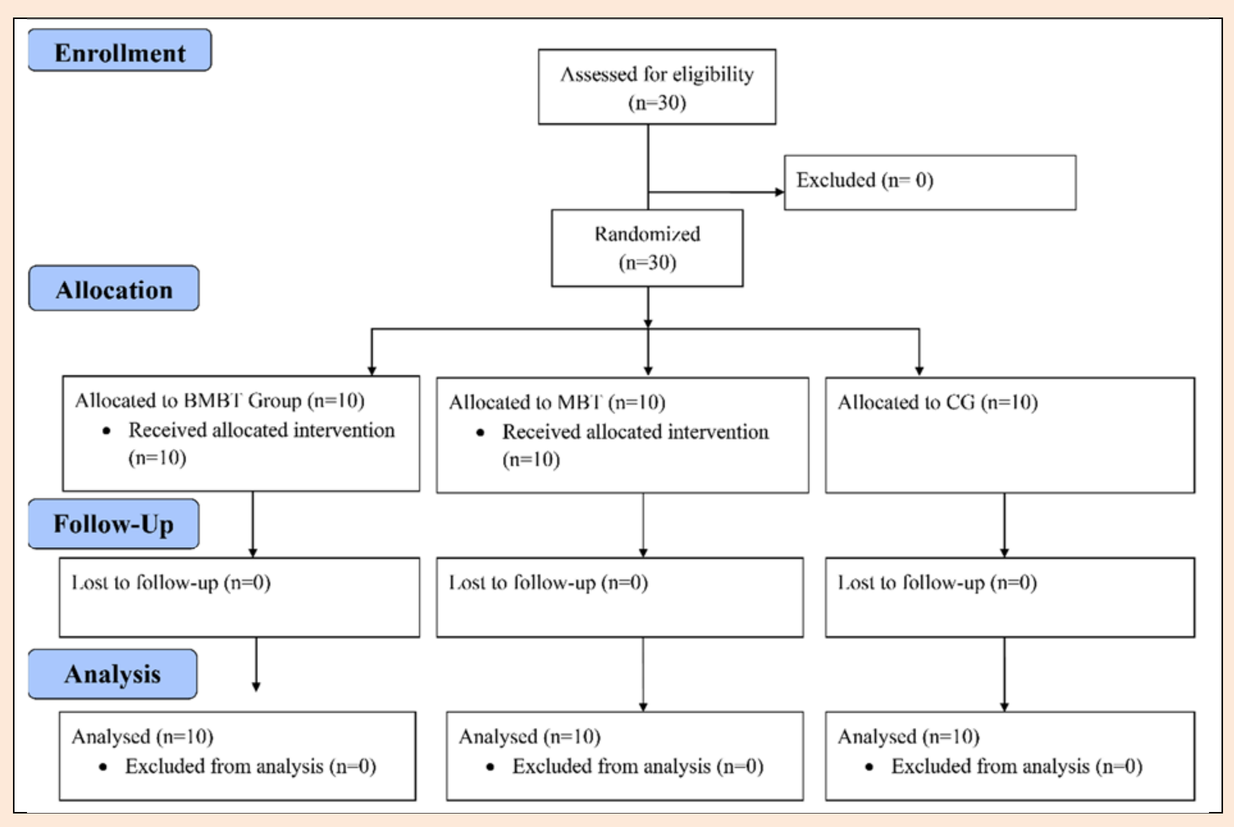

Figure 1. Participant recruitment and flowchart of the study. MBMT: Brief Mindfulness-Based Training; MBT: Music-Based Training; CG: Control Group.

Table 1. Audio transcription containing the Body Scan technique.

Time	Orientations
00:00 – 00:21	Introduction
00:22 – 01:38	Directions for location, posture and sensations
01:39 – 02:36	Attention to the sensations in the feet and ankles
02:37 – 02:46	Attention the sensations of the shins and ankles
02:47 – 03:10	Attention to the sensations of the knees and thighs
03:11 – 03:19	Attention the sensations of the pelvis and hips
03:20 – 03:28	Pay attention to the sensations of the lower back and the abdomen.
03:29 – 03:39	Attention to the sensations of the thorax and Coasts
03:40 – 04:07	Attention the sensations of the shoulder
04:08 – 04:30	Attention the sensations of the left and right arm
04:31 – 04:47	Attention to the sensations of the neck, face and head
04:48 – 05:29	Pay attention to the sensations of the body as a whole, as they are. Without control.
05:30 – 05:43	Attention to the center of the body, in the abdomen, while breathing.
05:44 – 06:00	Watch for physical reactions on the spot. Feel it rise and fall.
06:01 – 06:12	Mindfulness of breathing reactions. During each inhalation and exhalation.
06:13 – 06:30	Attention to let the breath occur naturally. Without control.
06:31 – 06:59	Be careful if the mind wanders, record the wandering and return to the breath.

The delivered intervention was supervised by a researcher and a member of the team's staff. The intervention before bed was self-applied. The randomization was performed using a drawn paired by team category. A total of 14 sessions of MBMT or MBT were performed. The sessions consisted of an audio of approximately 10 min and was performed three times a week during training week and in competition after game and before bedtime in competitive. A frequency control worksheet was used to verify the number of sessions each athlete was self-completed. The equipment used for the intervention included a smartphone and a headphone.

Control group: The control group included athletes from the other category of the same team. Athletes performed the same training routine (3–4 times per week for 2 hours each) with no competition on the calendar at the time of collection. The follow-up duration was the same as the groups receiving treatment.

Instruments

Before the start of the training session, all athletes answered the question: "How do you feel about your recovery?" The measurement was based on the Total Quality Recovery (Kenttä and Hassmén, 1998) scale (scores, which range from 6 (no recovery at all) to 20 (maximal recovery).

Mental fatigue was evaluated through the mental fatigue visual analog scale (Badin et al., 2016). The athletes answered the following question before the training session: "What is your level of mental fatigue at this time?" The answer was provided as a score ranging from 0 (none at all) to 10 (maximal).

Physical fatigue was evaluated through the physical fatigue visual analog scale (Badin et al., 2016). The athletes answered the following question before the training session: "What is your level of physical fatigue at this time?" The answer was provided as a score ranging from 0 (none at all) to 10 (maximal). Figure 2 shows the graphic of protocol delivered design.

Statistical analysis

An exploratory analysis was performed to verify the distribution of the data using the Shapiro-Wilk test, and values are expressed as median and standard deviation and 95% confidence interval. According to the normality of the data, to verify the differences among groups and moments, two-way analysis of variance (group × time) of repeated measures was applied, followed by Holm-Sidak post-hoc analysis. An α of 95% was used to define statistical significance.

To evaluate the magnitude of the significant differences among the moments and groups, the effect size Hedges (g) $(\bar{x}1 - \bar{x}2/DP\ pooled)$ was calculated. The magnitudes of effect size were interpreted as follows: <0.2, trivial; 0.2–0.6, small; 0.6–1.2, moderate; 1.2–2.0, large; 2.0–4.0, very large; and >4.0, perfect (Hopkins et al., 2009). To represent the effect of the intervention, the delta (Δ) of the analyzed variables was calculated [$\Delta = (\bar{x}pós - \bar{x}pré)$)]. Finally, practical inference based on magnitudes was calculated. The change was assessed qualitatively as follows: <1%, almost certainly not; 1–5%, very unlikely; 5–25%, unlikely; 25–75%, possible; 75–95%, probable; 95–99%, very likely; and >99%, almost certainly yes. If the negative and positive values presented results >10%, the inference was considered inconclusive.

For the descriptive analyzes and inferential tests, SPSS (IBM, USA) was used. The effect size magnitude and practice-based magnitude calculations were performed using Microsoft Excel worksheets (Microsoft® Office, USA) available on the Sportscience website (http://www.sportsci.org/).

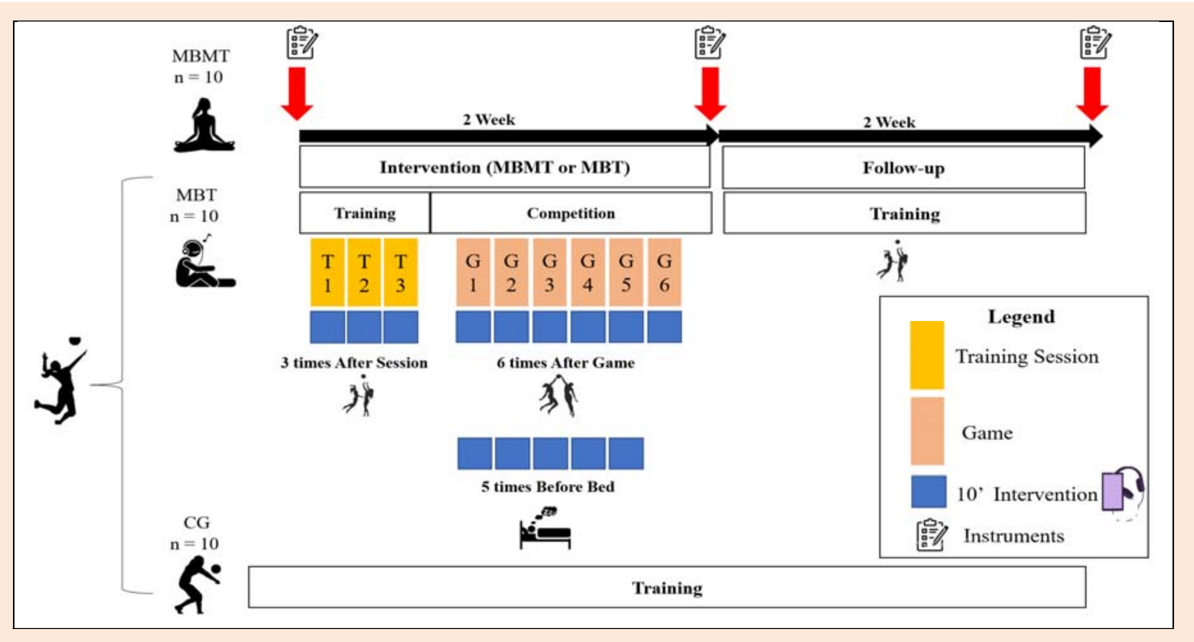

Figure 2. Graphic of protocol delivered design. MBMT: Brief Mindfulness-Based Training; MBT: Music-Based Training; CG: Control Group.

Results

Regarding Recovery, there was no interaction effect between MBMT, MBT, and CG groups (p > 0.05) and the moments. Difference between post and baseline intervention in in MBMT was moderate effect size (g = 0.72) with Δ = - 1.1 ± 1.5 AU. The qualitative analysis of the data showed that total quality recovery presented a very likely increase from baseline (97/1/2). In MBT, the difference between post and baseline intervention in was moderate effect size (g = 0.49) with Δ = - 0.7 ± 2.6 AU. The qualitative analysis of the data showed that total quality recovery presented inconclusive difference from baseline (70/11/19).

There was interaction (group x moment) in the mental fatigue (Figure 3). In the comparison between the groups, there was a difference between MBT and CG during follow-up ($F_{2,26} = 5.71$, p = 0.009) with a large effect size (g = 1.40). There was no significant difference in mental fatigue between MBMT and MBT or CG. Additionally, there was a significant difference between the baseline and post period in MBT, with a Δ = 1.8 ± 2.2 A.U. The qualitative analysis of the data showed that the mental fatigue in the post moment presented a very likely increase in relation to the pre moment (95/4/1).

Regarding the physical fatigue, there was no interaction effect between MBMT, MBT, and GC groups (p > 0.05) and the moments (Figure 4). Difference between post and baseline intervention in in MBMT was trivial effect size (g = 0.05) with Δ =0.1 ± 2.4 AU. The qualitative analysis of the data showed that total quality recovery was inconclusive (36/37/27). In MBT, the difference between post and baseline intervention in was moderate effect size (g = 0.04) with Δ = -0.2 ± 1.6 AU. The qualitative analysis of the data showed that total quality recovery presented inconclusive difference from baseline (47/34/19).

Table 2 shows mean and SD of total quality recovery, mental fatigue, and physical fatigue of MBMT, MBT, and CG at baseline, post intervention, follow-up, and delta Post-Baseline.

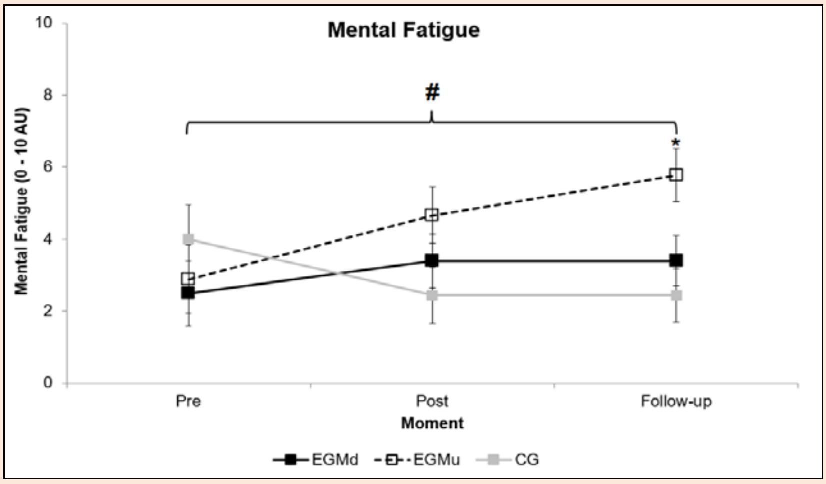

Figure 3. Effect of MBMT and MBT in Mental Fatigue of female volleyball athletes. Values in Mean ± SE; A.U.: Arbitrary Units; EGMd: Experimental Group with MBMT; EGMu: Experimental Group with MBT; CG: Control Group * Difference between EGMu and CG; # Difference between Pre and Follow-up in EGMu.

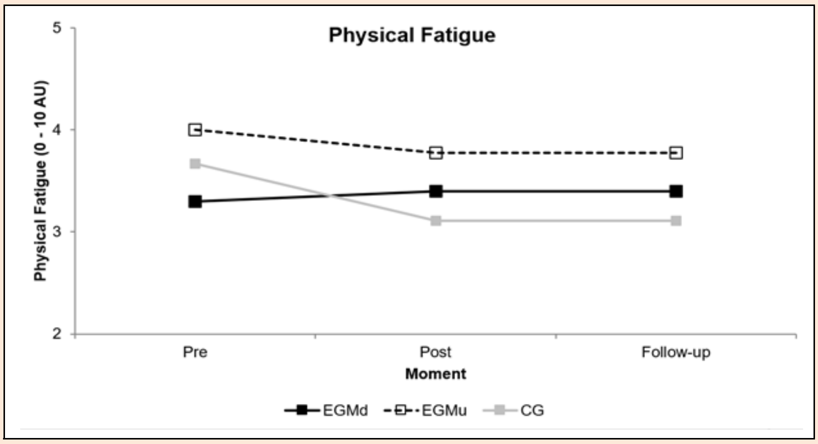

Figure 4. Effect of MBMT and MBT in Physical Fatigue of female volleyball athletes. Values in Mean; A.U.: Arbitrary Units; EGMd: Experimental Group with MBMT; EGMu: Experimental Group with MBT; CG: Control Group * Difference between EGMu and CG; # Difference between Pre and Follow-up in EGMu.

Table 2. Mean and ±SD of total quality recovery, mental fatigue, and physical fatigue of MBMT, MBT, and CG at baseline, post intervention, follow-up, and delta Pos-Baseline.

		Total Quality Recovery	Mental Fatigue	Physical Fatigue
MBMT	Baseline	15.1±1.3	2.5±2.6	3.3±2.3
	Post	14.0±1.7	3.4±1.8	3.4±1.0
	Follow-up	14.0±1.7	3.4±1.8	3.4±1.9
	Δ Pos-Baseline	-1.1±1.5	0.9±3.3	0.1±2.4
MBT	Baseline	15.4±2.3	2.9±2.0	4.0±2.5
	Post	14.5±1.3	4.8±2.4	3.9±2.7
	Follow-up	15.0±1.8	5.7±2.0	3.9±2.4
	Δ Pos-Baseline	-0.7±2.6	1.8±2.2	-0.2±1.6
CG	Baseline	15.6±2.4	3.6±3.8	3.7±2.4
	Post	15.2±2.0	2.4±2.7	3.1±2.5
	Follow-up	15.2±2.0	2.4±2.7	3.1±2.5
	Δ Pos-Baseline	-0.3±2.8	-1.6±3.8	-0.6±1.9

MBMT: Mindfulness-based mental training; MBT: Music-based training; CG: Control Group.

Discussion

The objective of the present study was to analyze the effect of mindfulness versus music training on recovery, mental fatigue and physical fatigue in female volleyball athletes using a randomized controlled follow-up study. The results support the hypothesis that the mindfulness intervention was effective at reducing mental fatigue caused by a volleyball competition, but it had no effect on physical fatigue or recovery. In contrast, the music intervention had increase in on mental fatigue with moderate effect size, and large effect size in comparation between CG in the follow-up. No difference was observed in physical fatigue, or recovery in volleyball athletes. The main results of this study are discussed below.

Mental training based on mindfulness reduce mental fatigue caused by competition

The higher physical and cognitive demands during a training or match of volleyball (Horta et al. 2017; Krenn et al., 2018; Mroczek et al., 2013) carry an increase in physical and mental fatigue, as was a reduction in recovery during the competitive period (Debien et al., 2018; Timoteo et al., 2017). In this sense, non-invasive intervention that reduce or mitigate are need. Mindfulness (Goodman et al., 2014) and music to recovery (Karageorghis et al., 2017) seem promising for this purpose. In the present study, the group that received the MBMT seemed to attenuate the mental fatigue caused by the competition. Similarly, Macdonald and Minahan (2018) found that attenuation of the increased salivary cortisol concentration associated with competition in wheelchair basketball athletes after an 8-week intervention with MBMT. Kachanathu et al., (2011) observed a reduction in cortisol concentrations immediately before the competition with the use of a 4-week MBMT program in shooters and concluded that MBMT can attenuate competition-related fatigue. However, our results did not identify significant changes in physical fatigue and recovery in any of the groups.

Palmi and Solé (2016) verified psychological effects of MBMT application in athletes. They found that the variables most investigated and with important results of mindfulness included anxiety (Thompson et al., 2011), burnout (Jouper and Gustafsson, 2013), increased self-confidence, and flow state (Sappington et al., 2015). This is the first study that investigated the effect of mindfulness on fatigue and recovery of female athletes during a volleyball competition.

Despite the increased interest, interventions using MBMT in sports remain scarce and with a low methodological quality with the absence of a control group, randomization, and follow-up, especially considering that only three were experimental and randomized trials (Palmi and Solé, 2016). Thus, the strength of the present study is its methodological quality.

Music training does not reduce mental fatigue caused by competition

At the moment post there was an increase in mental fatigue in the MBT with a moderate effect size; at follow-up, it remained higher than that in the control group (large effect size). It has been reported that music has pre-ergogenic and motivational potential during sports performances (Archana and Mukilan, 2016). However, recent studies investigated the effect of music on recovery and relaxation (Karageorghis et al., 2017), found that relaxing music promotes faster recovery after strenuous exercise. Similarly, Eliakim et al. (2012) found a greater reduction in the perception of effort after intense exercise. Alexandre et al. (2012) applied songs with different rhythms to recover several psychophysiological parameters in runners after completing three sessions of strenuous exercise. Ghaderi et al. (2015) observed a decreased response of metabolic fatigue during a circuit of resistance exercise with handball players. This evidence suggests that music is a technique with an acute effect on fatigue or recovery soon after an activity, whereas its long-term effects remain inconclusive (Eliakim et al., 2012). Possibly because the time of collection, the present study did not find a similar result in physical and mental fatigue after a volleyball competition. Additionally, the music was individualized and self-selected. The athletes were given guidance to choose music that would induce relaxation. However, we suggest that there was no effect of music training on the mental fatigue because they were already adapted to the musical sequence and the automated rhythm and time. Future studies could investigate effects of different musical sequences to minimize this learning effect in athletes.

The practical difficulty of performing objective measures of performance as well as the lack of viable specific tests emphasizes the need to develop individualized and simple measures validated for the sporting context (Saw et al., 2015), such as perceptive measures. In the present study, only validated and recommended scales for physical and mental fatigue (Smith et al., 2016) and recovery (Kenttä and Hassmen, 1998) were used. In addition, the entire experiment was conducted in a sports environment without altering the routine and during the team's main competition, enhancing the ecological validity of the study (Röthlin et al., 2016).

The fact that we found no difference in physical fatigue and recovery can also be a positive result. This was expected as an increase in physical and mental fatigue and reduced recovery due to volleyball competition.

To our knowledge, this is the first study to compare the effects of MBMT and MBT on mental and physical fatigue and recovery in volleyball athletes during a period of competition. However, it was limited by the use of self-reported scales. Despite this, the scales used in the present study have been used in research, recommended in training contexts, and applied in longitudinal and experimental studies (Saw et al., 2016). Performance measures were not investigated. Since the team that performed the MBMT and the team that performed the music training were in a competitive period and the moment after was the end of the main competition, performance measurements were unfeasible. Future studies should investigate the effect of mindfulness on athletes of other sports for a longer period during a season as well as on other recovery outcomes, such as sleep.

The mindfulness intervention effectively attenuated the mental fatigue caused by competition in volleyball athletes, whereas the music training did not. These results are important for assisting coaches and coaching staff with fatigue management. The 10 min-routine using the body scan technique encourages intervention with mindfulness in sports for the recovery and attenuation of fatigue in athletes. The results reinforce the applicability of mental training in the sports context, as well as the use of simple tools, such as visual scales that can provide individualized and immediate data about the training.

Conclusion

The results of the present study suggest that mental training based on mindfulness was more effective at reduce competition-induced mental fatigue than that music training. However, no effect of mindfulness or music effect was seen on recovery or physical fatigue.

Acknowledgements
The authors have no conflict of interest to declare. The experiments comply with the current laws of the country in which they were performed.

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Key points

- No effect of mindfulness and music on physical fatigue of female volleyball athletes after a competition.
- Mindfulness reduce mental fatigue of female volleyball athletes competition-induced.
- Music does not reduce mental fatigue of female volleyball athletes competition-induced.

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