South African Journal for Research in Sport, Physical Education and Recreation, 2015, 37(2): 33-45.
Suid-Afrikaanse Tydskrif vir Navorsing in Sport, Liggaamlike Opvoedkunde en Ontspanning, 2015, 37(2): 33-45.
ISBN: 0379-9069

LISTENING TO MOTIVATIONAL MUSIC: LACTATE AND CORTISOL RESPONSE TO A SINGLE CIRCUIT RESISTANCE EXERCISE FOR YOUNG MALE ATHLETES

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ABSTRACT

The aim of this study was to investigate the listening to motivational music and lactate and cortisol response to a single circuit resistance exercise (CRE) in male handball players. Sixteen handball players were randomly assigned to two equal groups of eight participants that trained with the intensities of 60% (G60) and 80% (G80) of their 1RM. G60 and G80 performed the exercise with (G60-M and G80-M) and without (G60-nM and G80-nM) music. Serum cortisol, epinephrine, norepinephrine, growth hormone (GH) and lactate levels were measured before (BE), immediately (IAE) and two hours after the exercise (2AE). In all groups, GH and lactate increased from BE to IAE and decreased from IAE to 2AE ($p \leq 0.05$). Serum cortisol levels decreased from BE to IAE and BE to 2AE in the group G60-M ($p \leq 0.05$). Listening to motivational music during CRE had no effect on GH, epinephrine and norepinephrine, yet decreased responses of lactate and cortisol were observed, which might be one of underlying mechanisms of fatigue reduction. More studies are needed to understand the exact mechanisms about the hormonal responses to music listening during exercise.

Key words: Music; Circuit resistance exercise; Growth hormone; Catecholamine; Lactate; Cortisol.

INTRODUCTION

Resistance exercise has been shown to elicit significant acute hormonal responses (Kraemer & Ratamess, 2005). In peripheral tissues, cortisol stimulates gluconeogenesis in the liver and lipolysis in adipose cells. At the same time, increased protein degradation and decreased protein synthesis in the muscles cells result in greater release of lipids and amino acids into the blood circulation (Koelsch *et al*., 2011; Yamasaki *et al*., 2012). Epinephrine (EN or adrenaline) and norepinephrine (NE or noradrenaline) are derived hormones from phenylalanine secreted from adrenal medulla (Guyton & Hall, 2006). After these hormones bind to membrane receptors α or β, epinephrine and norepinephrine stimulate glycogenolysis, gluconeogenesis and lipolysis in the liver and muscle cells (Bottaro *et al*., 2009).

Growth hormone (GH), also known as somatotropin or somatropin, is a peptide hormone that stimulates growth, cell division and regeneration. Its metabolic effects include lipolysis stimulation and proteolysis suppression (Bottaro *et al*., 2009). During muscular exercise involving high power output, including resistance exercise, in which the energy demand is high, glucose is degraded to pyruvate, and lactate is produced from the pyruvate faster than its removal from the tissues, so blood lactate concentration increases (Guyton & Hall, 2006).

Nowadays, the study of using music while exercising is a rapidly growing field (Chtourou, 2013). Music has been shown to have a variety of positive influences on health, such as stress reduction, relaxation, pain management, neural cognition, cardiac function, amongst other effects (Chtourou *et al.*, 2014). However, increasing interest has been centred on understanding the physiological mechanisms underlying the effects of listening to music and, more recently, the suggested role of music in modulating the metabolic responses of humans (Yamasaki *et al*., 2012). Research has established that music influences the hypothalamic-pituitary-adrenal (HPA) axis, the sympathetic nervous system (SNS) and the immune system, which have key functions in the regulation of metabolism and energy balance (Yamasaki *et al*., 2012).

During exercise, music is commonly used for motivational purposes, to counterbalance emotional and physical fatigue, and improve performance (Chtourou *et al*., 2012a; Chtourou *et al*., 2012b; Jarraya *et al*., 2012). Recent studies have highlighted the role of music regarding physiological mechanisms by increasing exercise performance, including improving the blood lipid profile and facilitating post-exercise recovery (Costa *et al.*, 2011). Brownley *et al*. (1995) found that after intensive training, serum cortisol levels were higher following concurrent motivational music listening compared with relaxation music or no music at all (Brownley *et al*., 1995).

Many research studies have investigated the effects of one session of resistance exercise on blood hormone levels (Bush *et al*., 1999; Ghaderi *et al*., 2009; Rahimi *et al*., 2010b; Chtourou *et al*. 2014). In practice, many sportspersons listen to music while they perform their resistance training sessions. However, no previous study has investigated the effects of listening to music on physiological responses during resistance training.

AIM OF STUDY

The aim of this study was to investigate the effects of motivational music listening during single circuit resistance exercise (CRE) on the levels of serum cortisol, GH, NE, EN and lactate in young sportsmen, specifically league handball players.

METHODOLOGY

Subjects

Sixteen young male handball players (age: 19.3±0.4 years; height: 182±2.5cm; weight: 77.3±2.6kg; BMI: 23.3±1.7kg/m^2), volunteered to participate in this study after receiving a detailed explanation of the experimental procedure. The players were members of a city's team, and some played in the Premier League of the Province. They normally train 4 days per week for 2-hour sessions from around 17h00 to 19h00. In addition, they played 1 game a week. The players were divided in 2 equal groups, namely a training (music) and a control (no music) group with 8 subjects in each group.

Research design

Three days before starting with the intervention the predicted maximum strength, as one repetition maximum (1RM) for the upper and lower extremities, was estimated for all of the participants according to the National Strength and Conditioning Association guidelines and calculated using the Brzycki (1993) equation ([1-RM=Weight/(1.0278 – (0.0278 × Number of repetitions)]). They completed a medical examination and a medical questionnaire to ensure that they were not taking any medication and were not using steroids. The subjects were informed of the experimental risks. They then signed an informed consent document prior to the investigation. They were requested to abstain from intense physical activity for 48 to 72 hours before the measurements. The Regional Research Ethics Committee of the Islamic Azad University, Mahabad Branch, Iran approved the study protocol and experimental procedures in accordance to the principles of the Declaration of Helsinki.

Exercise testing procedures

Prior to the intervention all participants, since they were inexperienced and not familiar with resistance training, underwent a familiarisation session of the equipment that would be utilised during the study during a control day (i.e., about 1 week before the actual measurements). In addition, they listened to motivational (fast-tempo) music during the familiarization session. Before the start of each resistance training session, a gentle aerobic warm up for 5 minutes and then 5 to 10 repetitions at 50% of the 1RM was performed.

The resistance training session consisted of 10 free-weight circuit resistance exercises: (bench press, leg press, sit-ups, leg pull, knee extension, trunk extension, seated row, back feet (leg curl), overhead press and calf-press). All subjects participated in 2 resistance training sessions. In each session, the subjects were divided randomly into 2 groups (60 and 80% of 1RM). This meant that 1 group was exposed to a lower exercise intensity (60% 1RM), with and without music, and the other group was exposed to a higher exercise intensity (80% 1RM), with and without music. Four conditions were used, but 2 groups were present (G60-nM, G80-nM, G60-M and G80-M). Demographic characteristics of the subjects of each group are shown in Table 1.

The resistance exercise sessions took place in the morning between 08h30 and 12h00 to avoid the effects of circadian rhythms on performance (Chtourou & Souissi, 2012; Chtourou *et al*., 2014). At least 48 hours, but not more than 72 hours,of recovery time was allowed between each training session.

TABLE 1. **DEMOGRAPHIC CHARACTERISTICS OF THE SUBJECTS**

Group	Age (yrs)	Height (m)	Body Mass (kg)	BMI (kg/m^2)
G60 (n=8)	18.3±0.4	185±2.7	80.5±1.3	23.5±2.2
G80 (n=8)	20.4±0.5	179±2.4	74.2±1.4	23.2±1.2

The protocols consisted of 3 rounds with 2 intensities of 60 and 80% of 1RM. For the lower exercise intensity (60% 1RM), 10-12 repetitions was considered with 60s-rest period between the sets. For the higher exercise intensity (80% 1RM), 6 to 8 repetitions were used with 90s-rest period between the sets, and 5 minutes active recovery between rounds for both protocols. Circuit RE workouts of the subjects in each group are shown in Table 2.

TABLE 2. **PROGRAMME OF CIRCUIT RESISTANCE EXERCISE (CRE)**

Row	Exercise	60% of 1RM	80% of 1RM
1	Chest press	3:W-10-12	3:W-6-8
2	Foot press	3:W-10-12	3:W-6-8
3	Sit-ups	3:35	3:25
4	Leg pull	3:W-10-12	3:W-6-8
5	Front hip	3:W-10-12	3:W-6-8
6	Trunk extension	3:35	3:25
7	Seated row	3:W-10-12	3:W-6-8
8	Knee extension	3:W-10-12	3:W-6-8
9	Overhead press	3:W-10-12	3:W-6-8
10	Calf	3:W-15-20	3:W-15

W: Sets 3:35= 3 sets of 35 repetitions

Music selection

Considering the nature of the study, the music used was of a motivational nature. The motivational music was selected according to the tempo (>120bpm), which has been reported to increase energy expenditure and reduce tension (Karageorghis *et al*., 2006; Karageorghis *et al*., 2009; Chtourou *et al*., 2012b). The identification and selection of the applicable music, based on the number of beats per minute, was carried out under the supervision of a music expert. Music was played using DVD player model no. 7600 (SAMSUNG, Japan), and an audio amplifier instrument (Faratel Co model no. 180, Iran). The music was played continuously from the start to the end of the exercise session. Table 3 provides the details of the experimental music tracks.

TABLE 3. **MUSIC SELECTIONS FOR EXPERIMENTAL CONDITIONS**

Artist	Track title	Album title	Year
Modern Talking	You're my heart	Back for good	1998
Modern Talking	Brother Louie	Back for good	1998
Modern Talking	Cheri cheri lady	Back for good	1998
Modern Talking	You can win if you want	Back for good	1998
Modern Talking	Atlantis is calling	Back for good	1998
Modern Talking	Geronimo’s Cadillac	Back for good	1998
Modern Talking	In 100 years	Back for good	1998
Modern Talking	Love is for ever	Year of the dragon	2000
Modern Talking	China in her eyes (Bonus)	Year of the dragon	2000
Modern Talking	Don’t take away my heart	Year of the dragon	2000
Modern Talking	When the sky rained fire	Victory	2002

Blood collection and analysis procedures

At the exercise sessions, blood samples (5ml) were drawn from an antecubital vein into 10ml serum vacationer tubes 10 minutes before warm-up (Pre), 5 minutes after exercise (Post) and again two hours after exercise (2Post) for the purpose of measuring serum growth hormone (GH), cortisol, epinephrine and norepinephrine, and blood lactate concentrations, while the subjects were in a sitting position. The blood samples were transferred to the laboratory according to validated procedures.

All of the collected samples were stored at -20°C until the assay. Moreover, to avoid any disturbing effect, the blood sampling was conducted in the same conditions for all participants. Serum epinephrine (EN) and norepinephrine (NE) were measured using a kit (EIA, IBL International GmbH, Flughafenstr. 52A, D-22335 Hamburg, Germany, Sensitivity 0.002ng/mL), by Hyperion system. Serum cortisol concentrations were determined using enzyme immuno-assay (RADIM SpA-Via del Mare, 125-00040 Pomezia [Roma] Italia). The GH serum concentration was determined by ELISA kit (Diagnostic Biochem Canada Inc., London, Ontario, Canada, Sensitivity 2ng/mL). Lactate concentration was measured by an automated ultraviolet (UV) enzymatic method (Hitachi instrument, model 717, Germany). To eliminate inter-assay variance, all samples for a particular assay were thawed once and thereafter analysed in the same assay run. All samples of each subject were analysed on the same day.

Statistical analysis

Data are displayed as the Mean±SD. Data normality was assessed through the Kolmogorov-Smirnov test and all variables showed normal distributions. Once the assumption of normality was confirmed, parametric tests were performed. While between-group comparisons were analysed using one-way ANOVA. The LSD post-hoc test was used for pair wise comparisons. When ANOVAs revealed a significant difference, post-hoc multiple comparisons using the LSD test were conducted. Statistical significance was accepted at p<0.05.

RESULTS

The statistical analysis revealed that in the ***G60-nM*** condition, serum concentration levels of *GH* and *lactate* were significantly higher from BE to IAE (p=0.002, p=0.000). However, there was a significant decrease from IAE to 2AE (p=0.002, p=0.000) (Figure 1 to Figure 5). There were no significant changes in serum *cortisol* levels from BE to IAE (p=0.40) and IAE to 2AE (p=0.50) (Figure 2), and no significant differences in the levels of *norepinephrine* and *epinephrine* from BE to IAE (p=0.77, p=0.30), and IAE to 2AE (p=0.80, p=0.99) (Figure 3 to Figure 4). In the ***G80-nM*** condition, levels of *GH* and *lactate* increased significantly from BE to IAE (p=0.004, p=0.000), however, there was a significant decrease from IAE to 2AE (p=0.007, p=0.000) (Figure 1 to Figure 5). No significant differences were observed in serum *cortisol* levels from BE to IAE (p=0.50) and BE to 2AE (p=0.6) (Figure 2), as well as in the case of levels of *norepinephrine* and *epinephrine* from BE to IAE (p=0.2, p=0.8) and IAE to 2AE (p=0.5, P=0.39) (Figure 3 to Figure 4).

In ***G60-M*** condition, levels of *GH* and *lactate* were significantly increased from BE to IAE (p=0.000, p=0.009). However, there was a significant decrease from IAE to 2AE (p=0.000, p=0.028) (Figure 1 to Figure 5). Serum *cortisol* concentration decreased significantly from BE to IAE and BE to 2AE (p=0.009, p=0.008), but the changes were not significant from IAE to 2AE (p=0.8) (Figure 2). In the case of *norepinephrine* and *epinephrine* levels, no significant differences were found from BE to IAE (p=0.67, p=0.94) and IAE to 2AE (p=0.68, p=0.33) (Figure 3 to Figure 4).

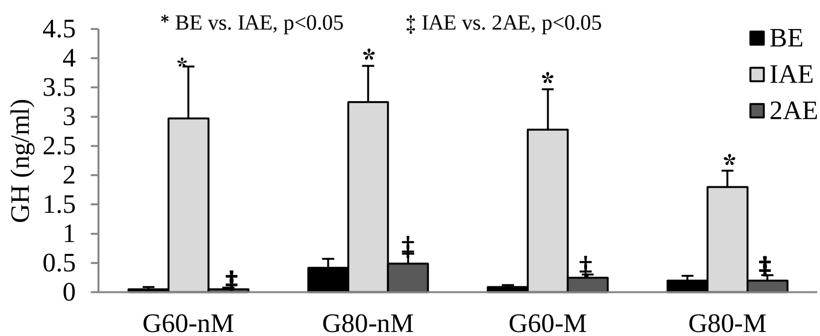

FIGURE 1. **GH LEVELS (MEAN±SD) BEFORE (BE), IMMEDIATELY (IAE) AND 2 HOURS AFTER EXERCISE (2AE)**

In the ***G80-M*** condition, levels of *GH* and *lactate* were significantly higher from BE to IAE (p=0.013, p=0.000) and significantly lower from IAE to 2AE (p=0.013, p=0.000) (Figure 1 to Figure 5). Serum *cortisol* concentration decreased from BE to IAE (p=0.15) and BE to 2AE (p=0.12) (Figure 2), but these changes were not significant. *Norepinephrine* and *epinephrine* did not increase significantly from BE to IAE (p=0.23, p=0.58) nor did they decrease significantly from IAE to 2AE (p=0.30, p=0.87) (Figure 3 to Figure 4).

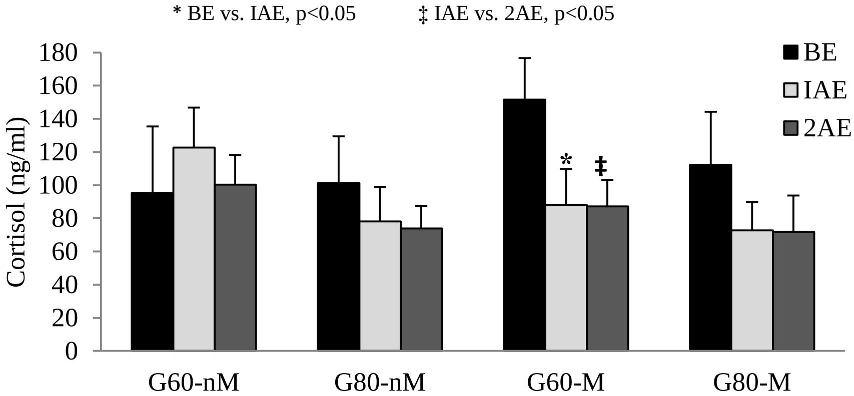

FIGURE 2. **CORTISOL LEVELS (MEAN±SD) BEFORE (BE), IMMEDIATELY (IAE) AND 2 HOURS AFTER EXERCISE (2AE) WITH G60-nM,**

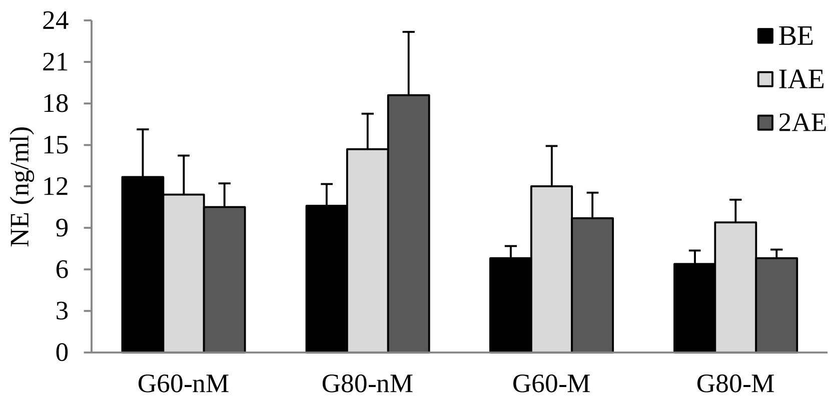

FIGURE 3. **NOREPINEPHRINE LEVELS (MEAN±SD) BEFORE (BE), IMMEDIATELY (IAE) AND 2 HOURS AFTER EXERCISE (2AE)**

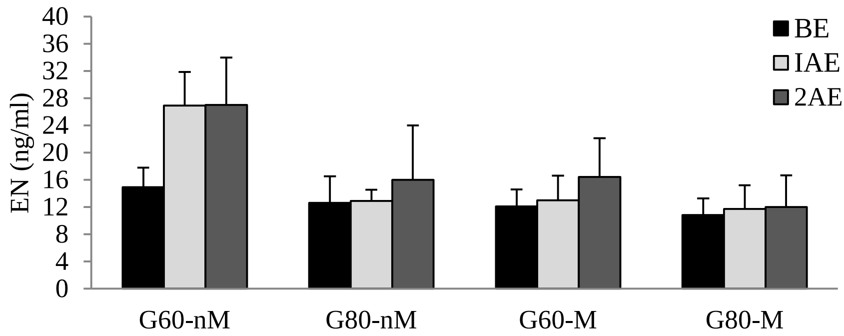

FIGURE 4. **EPINEPHRINE LEVELS (MEAN±SD) BEFORE (BE), IMMEDIATELY (IAE) AND 2 HOURS AFTER EXERCISE (2AE)**

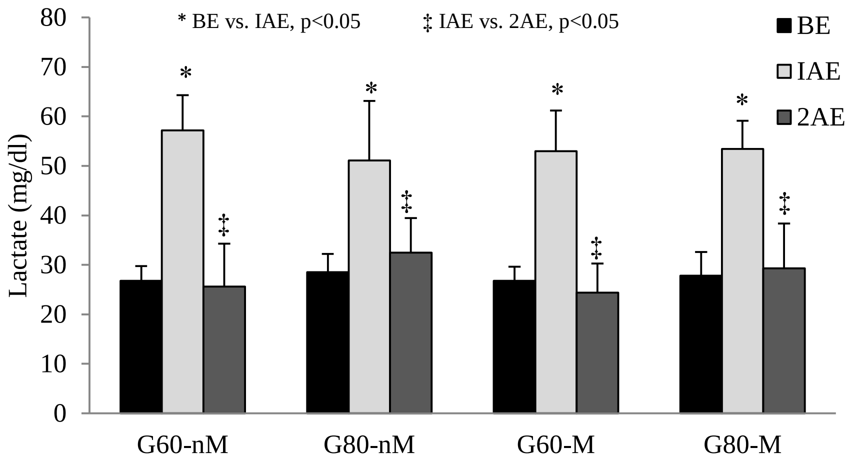

FIGURE 5. **BLOOD LACTATE LEVELS (MEAN±SD) BEFORE (BE), IMMEDIATELY (IAE) AND 2 HOURS AFTER EXERCISE (2AE)**

DISCUSSION

This is the first study that has investigated the effects of listening to motivational music on hormonal responses to a single bout of circuit resistance exercise (CRE) in young sportspersons. In all conditions, GH levels increased significantly from BE (before exercise) to IAE (immediately after exercise) and decreased significantly two hours later. In all conditions, changes of serum lactate were similar to the GH changes during the study. In the case of G60-M, serum cortisol concentration levels decreased significantly from BE to IAE and from BE to 2AE (two hours after exercise). EN and NE levels did not change in any of the conditions.

Sadegi-Boroujerdi and Rahimi (2008) showed significant elevation of GH after a single bout of resistance exercise (5 sets of 10 RM bench press and squat). A similar response of GH was observed in another study (Bottaro *et al*., 2009). Rahimi *et al*. (2010a) reported a significant increase in GH levels after one session of resistance exercise at an intensity of 85% of 1RM. Hymer *et al*. (2001) reported meaningful elevation of GH after six sets of 10 repetitions with an intensity of 75% of 1RM. These findings indicate that resistance exercise with intensity above 60% of 1RM induces an elevation of GH. This increase in GH is metabolically potentially beneficial, because GH plays an important role in the stimulation of lipolysis, glycolysis, and glycogenolysis, as well as muscle hypertrophy (Guyton & Hall, 2006). According to the results of the present study, the GH response is higher in protocols that produce higher lactate levels, and thus are relying more on glycolysis (Kraemer *et al*., 2003). Hypoglycaemia, hypoxia, protein catabolism and acid-base shifts are other factors affecting GH levels (Kraemer & Ratamess, 2005).

Most research studies have been carried out on the effect of music on physiological and hormonal responses, more specifically, cortisol (Hymer *et al*., 2001; Kraemer *et al*., 2003; Ghaderi *et al*., 2009; Koelsch *et al*., 2011; Yamasaki *et al*., 2012). Cortisol is one of the important stress hormones secreted in response to physical and psychological stress (Ghaderi *et al*., 2009). The data of the present study indicated that, in the case of G60-M, serum cortisol concentrations were significantly lower from BE to IAE and from BE to 2AE compared to G80-M and no-music conditions (G60-nM and G80nM). These changes of serum cortisol concentrations were not significant when compared among all the conditions. In clinical situations, listening to music reduces cortisol concentrations before, during and after surgery (Koelsch *et al*., 2011; Yamasaki *et al*., 2012). Mottahedian-Tabrizi *et al*. (2012) studied the effect of listening to music on the cortisol concentrations and blood glucose levels in patients with spinal cord injuries. They reported that listening to music prevented the increase of cortisol in these patients after the surgery.

Ghaderi *et al*. (2009) examined the effect of motivational and relaxation types of music on the endurance performance, rating perceived exertion (RPE) and salivary cortisol concentration in male athletic students. Findings indicated that five minutes after exercise, RPE and salivary cortisol concentrations with relaxation music were significantly lower compared to listening to motivational music or no music during exercise. Jurcau and Jurcau (2012) investigated the effect of listening to music on cycle ergometer performance and salivary cortisol concentrations. The test exercise was performed at a pedalling rate of 60rpm, starting with a power of 30 watts for three minutes, followed by a gradual increase of power by 30 Watts every three minutes until exhaustion. The authors reported that in the non-trained subjects, listening to music decreased salivary cortisol concentrations after the exercise.

The results of the present study showed that increased physiological stress resulted from the mix of music listening, and lower exercise intensity probably reduced the production of cortisol by the adrenal gland and increased clearance of this hormone from the blood stream. However, more studies are needed to understand the mechanisms of this response.

Epinephrine and norepinephrine play a role in dealing with resistance training needs and are necessary for enhancing power, muscle contraction, accessing energy and several other functions including the increase of other hormones like testosterone (Kraemer & Ratamess, 2005). In the present study, listening to music produced non-significant changes in the levels of serum epinephrine and norepinephrine in all groups/conditions. Okada *et al*. (2009) suggested that music therapy in patients with cerebrovascular diseases reduce the risk of heart diseases by lowering epinephrine and norepinephrine.

In the present study and in all conditions, unlike norepinephrine, epinephrine no significant increases from pre-exercise to two hours post-exercise were found, which is a sign of the delayed effects of this hormone compared to norepinephrine during exercise and recovery stages. In general, one session of resistance training (no music) increase the levels of serum epinephrine and norepinephrine, which depend on the contractile force of muscle, the amount of contracted muscle, training volume and rest between sets (Bush *et al*., 1999). One of the mechanisms presented by research findings is the increase of GH concentrations, which reduces the need of epinephrine and norepinephrine secretion from adrenal cortex for stimulation of lipolysis, glycolysis and glycogenolysis (Koelsch *et al*., 2011). Moreover, before physical exercise, and more specifically intense efforts, the levels of epinephrine and norepinephrine increase quickly which are related to predictive/anticipative mechanisms to start the activity. This reaction is part of the psychological adjustment of the body for beginning a strenuous/stressful task (Kraemer & Ratamess, 2005). It is concluded from this study that epinephrine and norepinephrine response to CRE are not influenced by listening to music.

In all the conditions, serum lactate levels was shown to be significantly higher when measured after exercise, compared to pre-exercise conditions and lactate levels also decreased significantly two hours post-exercise compared to IAE levels. A significant difference was observed between conditions of G60-nM and G60-M and G80-nM and G80-M from BE to IAE and from IAE to 2AE. These changes were proportional to GH changes in the present study and supported the theory that one of the mechanisms of the increase of GH during exercises is the increase of H^+ due to the production of lactic acid (Hoffman, *et al*., 2003). In sportspersons, motivational music listening significantly increased the training volume and consequent lactate concentrations, while RPE was significantly lower during the first 15 minutes of recovery (Eliakim *et al*., 2012), which were similar to the findings of the present study (Ghavam-Bakhtiar *et al*., 2012). Sadegi-Borujerdi and Rahimi (2008) also reported an increase in lactate and GH levels after one session of resistance training in men. In another research study, lactate and GH levels significantly increased after resistance training at an exercise intensity of 85% of 1RM (Rahimi *et al*., 2010a).

The findings of this research indicate that listening to music reduced lactate response to exercise and this response could be considered a metabolic advantage since the increase of lactic acid production and its conversion to lactate increases H^+ concentrations, which is a notable cause of exercise-related fatigue (Guyton & Hall, 2006). Lactate secretion into the blood can be a potent stimulator of GH secretion from the pituitary gland for muscle fibre regeneration and hypertrophy. Nevertheless, the decrease of lactate observed could also result from increased blood lactate clearance that cannot be ruled out, and the present study protocol does not allow for determining if the decreased lactate observed could result from less production and/or higher clearance. In all cases, listening to music seems to have reduced the fatigue related signs, and that is in accordance with the findings of previous studies (Eliakim *et al*., 2012; Ghavam-Bakhtiar *et al*., 2012).

CONCLUSION

Despite the small size of the sample in this study, the statistical analysis showed significant results allowing for drawing preliminary conclusions with regard to the effects of listening to music on the hormonal responses to resistance training. In conclusion, listening to motivational music during CRE of moderate and high intensities, had no effect on the growth hormone, epinephrine and norepinephrine, but decreased the response of cortisol and lactate. Less secretion of cortisol by the adrenal glands and high clearance of this hormone from the blood may lead to less glucose degradation during glycolysis, resulting in less lactate production. The latter could be one of the underlying mechanisms of fatigue reduction related to listening to music during exercise. However, more studies are needed to comprehend clearly the exact mechanisms around hormonal responses to music listening during exercise. In the meantime, listening to rhythmic music when performing resistance-training exercises can be recommended.

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(Subject Editor: Prof Ernts Krüger)