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Entraining music and power output on two different submaximal loads in bench press

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Preface:

I would like to thank my supervisors professor Rolf Petter Ingvaldsen and associate professor Hans Jørgen Støp for their help and guidance through the process with this master thesis. I want to thank all the participants who took time off their schedule to attend this study. To Knut Lyng Hansen and Magne Johan Steiro, thank you for the helpful comments and guidance during the last few days. And a special thanks to my co-students Line Ringseth, Kathrine Forfang and Veronika Myran Wee for helping in the everyday struggles and all the laughter and joy you provided during this period.

Entraining music and power output on two different submaximal loads in bench press

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Abstract

Research has in several studies shown the effects music has on training, but less work has been done in resistance training. The purpose of this study was to assess the potential advantages and disadvantages of following a specific tempo during bench press. It was hypothesized that using personalized music tempo could increase power output in bench press, by entraining subjects to a higher tempo. Four male and female participants (Mean age = 25.2 yr., SD=4.6; M height = 174, SD = 9.7; M body mass = 76.5 kg, SD = 8.6) were tested in power output during bench press. They were tested in one repetition maximum (1RM) bench press, and 6 sets on 30 % 1RM and 6 sets on 60 % 1RM. The Musclelab^{TM} system was used to measure power output, through a linear encoder. All participants listened to music prior and during music conditions. The personalized music tempo was increased on two occasions. Statistical analysis showed that there was a significant increase in power output, supporting the hypothesis that personalized music tempo can entrain subjects to enhance power in bench press. No statistical significance was found within the increased music conditions on 60 % 1RM, but a small significance was found on 30 % 1RM. This indicates that higher music tempo has a greater influence on lower loads. However, due to the small number of subject no final conclusion could be made from this study. This study is, nonetheless, a promising start for further research in this area.

Entraining av musikk og power på to forskjellige submaksimale belastninger i benkpress

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Forskning ved flere studier vist effekten musikk har på trening, men mindre studier har blitt gjennomført innen styrketrening. Hensikten med denne studien var å se på de potensielle fordelene og ulempene av å følge et spesifikt tempo under benk press. Hypotesen i dette studiet var at personalisert musikktempo kan øke power i benkpress, ved å entraine forsøkspersoner til et høyere tempo. Fire menn og kvinner (gjennomsnitt alder = 25.2 år, SD=4.6; G høyde = 174, SD = 9.7; G kroppsvekt = 76.5 kg, SD = 8.6) ble testet i power under benkpress. Alle forsøkspersoner ble testet i en repetisjon maksimum (1RM) benkpress, og 6 sett med 30 % av 1RM og 6 sett med 60 % 1RM. Musclelab^{TM} systemet ble brukt for å måle power, gjennom en lineær enkoder. Alle forsøkspersonene hørte på musikk før og under alle musikkbetingelsene. Det personaliserte musikktempoet ble økt ved to anledninger. Statistiske analyser viste en signifikant økning i power i benkpress. Ingen statistisk signifikant forskjell ble funnet mellom musikkbetingelsene på 60 % av 1RM, men en liten signifikans ble funnet på 30 % av 1RM. Dette indikerer at høyere musikktempo har større påvirkning på lavere vekt. På grunn av det lille antallet forsøkspersoner kunne det imidlertid ikke konkluderes med noe i studiet. Dette studiet er likevel en lovende start for videre forskning på området.

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1.0 Introduction

Music has since time immemorable been an integral part of people's everyday life. All through human history it has been a need to sing or create music, either to sing children to sleep, entice livestock, to prepare for war or to create work songs during hard labour. An archaeological dig found a flute made from bone believed to be some 50,000 years old, indicating that humans used music instruments in prehistoric times (Karageorghis C. I., 2016). Traditional folk songs were transferred from generation to generation. A known example is the traditional folk song "the Volga Boatmen", which was a Russian work song, sung by the working men (Fuld, 2000). Songs could have more than a single meaning, like the songs sung by Native American women who sang while grinding corn, not only to make their labour less exhausting, but also used it as a prayer to ensure their supply of corn continued (Gioia, 2006). In ancient Greece, the balance between music and gymnastics was important in education, and the rhythm of the movement for the athletes was important (Gardiner, 2002). In the education system, they learned the movements and combinations of different exercises (like throwing the discus and the javelin, power-based exercises) as a musical drill, since the time in the exercises was usually given by a flute-player (Gardiner, 2002).

Given the history of music and exercise, there is no wonder there has been interest in the benefits of the combination of music and exercise. The potential benefits of combining music and exercise has been on a rise in later years, but the interest is not new. The combination between the two fields has been of interest for 150 years (Karageorghis & Priest, 2012), and has been in active research for more than 50 years (Nelson, 1963; Coutts, 1961). Clapping and drumming were used to create rhythm in Olympic Games (Karageorghis C. I., 2016), and flutes were used to synchronize movements in the games (Finley & Pleket, 1976). This shows the influence the use of rhythm and music has on exercise, and that it's been a part of human life for a long time.

The benefits of using music in exercise is highly agreed on in the field (Atan, 2013; Pearce, 1981; Pujol & Langenfeld, 1999; Brooks & Brooks, 2012; Loizou & Karageorghis, 2015; Eliakim, Meckel, Nemet, & Eliakim, 2007; Jarraya, et al., 2012; Copeland & Franks, 1991; Almeida, et al., 2016; Brownley, McMurray, & Hackney, 1995) Music is something humans have enjoyed and loved throughout history, and has been found to be used even from prehistoric times, like pipes from the Upper Palaeolithic era (Morley, 2013). Music is hard to explain due to its almost magical nature. Music is difficult to determine because of its impact on humans and their individual emotions. Music theory uses concepts within the music genre to analyse pieces of music, and are concepts used by both musicians and laymen. Melody is often characterized as the coherent structure or the tune of the music, while harmony is what gives music its atmosphere or distinctive flavour. Beat is the steady number of units in a rhythm, while rhythm is the repetition of a beat, accent or occurrence of strong or weak beats in time. When you are synchronizing your movements to the music (like tapping or clapping), you are following the beat. Tempo is the speed of the music, and is referred to as bpm; beats per minute. Bmp refers to the speed in how often the beats are repeated. Tempo, in this study, refers either to the speed of the music as mentioned over, or as the pattern of work in exercise. Research within music and exercise must try to understand and use the terms correctly. Researchers have studied a variety of different ways to use music, examples as background music (Copeland & Franks, 1991; Terry, Karageorghis, Saha, & Auria, 2011) or with individual headphones (Atan, 2013; Pujol & Langenfeld, 1999), with self-selected (Crust, 2004; Biagini, et al., 2012) or pre-chosen music (Almeida, et al., 2016; Pearce, 1981), during or prior to exercise (Jarraya, et al., 2012; Eliakim, Meckel, Nemet, & Eliakim, 2007), with motivating or sedative music (Pearce, 1981; Karageorghis, Drew, & Terry, 1996; Brownley, McMurray, & Hackney, 1995).

In 1665 Huygens, a Dutch mathematician and scientist, discovered the phenomenon we today refer to as entrainment (Clayton, 2012). The term refers to independent rhythmic systems that interact with each other. As we all know, humans are rhythmic organisms and tend to synchronize their movement with musical rhythms (Gaston, 1951), giving light to entrainment in human nature. Thor Heyerdahl filmed workers in Easter Island moving giant rocks with rope, while singing, making the statues "dance" (HistoMephistix, 2011). The workers synchronized their movements to the song, just like the ancient Greek used musical rhythms in their sporting events, and how Russians synchronized their effort through song while pulling their boats. This shows us how music has been used to entrain exercise for centuries.

The tradition of music and exercise is long, but is still embossed by mixed results (Atan, 2013; Brownley, McMurray, & Hackney, 1995; Pearce, 1981; Mayfield & Moss, 1989; Eliakim, Meckel, Nemet, & Eliakim, 2007; Copeland & Franks, 1991; Almeida, et al., 2016; Cole & Maeda, 2015). Music is today an aid in exercise, and in 2007 the New York City Marathon banned all personal music, because of the possible benefits music had for the participants (Karageorghis C. I., 2016). Music research has shown that music produced psychological effects that influence mood, emotion affect, cognition, behaviour and fatigue (Copeland & Franks, 1991; Karageorghis, Drew, & Terry, 1996; Crust, 2004; Crust, 2004; Biagini, et al., 2012), along with psychophysiological effects associated with subjective perceived exertion (Borg, 1982). Others found that stimulating music could entrain brainwaves, heartbeat and breathing rate (Karageorghis C. I., 2016; Agrawal, Makhijani, & Valentini, 2013; Loizou & Karageorghis, 2015; Brownley, McMurray, & Hackney, 1995).

There is, however, a question concerning what type of exercise the entrainment to music contributes to, in a positive or negative way. As mentioned above, music and exercise research has been embossed by mixed results, where the difference is mainly between aerobic and anaerobic exercise. There is significantly higher benefits found in aerobic studies, while anaerobic studies have vastly more mixed results (Karageorghis & Priest, 2012). The field of aerobic exercise has produced more studies than in the anaerobic field (Atan, 2013), and the work in anaerobic studies are limited in their strength and power performance area, and the use of music in the studies (Pearce, 1981; Crust, 2004). Some studies considered the effects of music on smaller anaerobic tasks (Pearce, 1981; Karageorghis, Drew, & Terry, 1996; Crust, 2004; Bartolomei, Michele, & Merni, 2015; Biagini, et al., 2012). Pearce (1981) examined the effects stimulating and sedative music had on handgrip, and Karageorghis et al. (1996) replicated Pearce's study. Pearce had a control group with no music, while Karageorghis et al. used white noise[1]. The studies both found results indicating that grip strength was higher during stimulating music then sedative. While Pearce found no significant increase with music versus no music, Karageorghis et al. found a significant increase in handgrip with music, and found a gender difference where females preformed higher with music then men. Crust (2004) examined the effects of exposure to music during a short-term isometric weight-holding task, and compared listening to music the entire task instead of just part of it. Crust compared music to white noise, and found that participants had longer endurance during the task with music then without. The study also found that higher endurance while listening to music during the whole task instead of some of part of it. While all these three studies all tested anaerobic exercises, it was tested with isometric exercises and for their psychological benefits, and not for its ability to entrain with the exercise.

Biagini et al. (2012) examined the effects of self-selected music on bench press to failure and squat jump. The study found no effects of music on bench press to failure then without music, but found effect of music on jump squat for explosiveness. Bartolomei et al. (2015) examined the effects of self-selected motivational[2] music on maximal strength and endurance strength in

[1] White noise is a combination of all the different frequencies of sound, and creates static sound rain
[2] Motivational music is considered to be music with over 120 bpm

bench press, one group with music and one controll without music. The study found no difference on 1RM, but found a significant effect with music on the strength endurance test (60 % of 1RM). A clear difference between the earlier studies, from Pearce (1981) to Bartolomei et al. (2015), is the advance in details in the method chapters. Another thing to be noticed is that in most of the studies, the music works as a distraction and lets the participant dissociate from the exercise. A study by Loizou & Karageorghis (2015) showed that using video, prime[3] and music was an even greater distraction from the task than music alone. Both Biagini et al. (2012) and Bartolomei et al. (2015) used dynamic exercises, and bench press is a much more rhythmic exercise compared to the studies talked about in last paragraph. The participants have a greater opportunity to entrain with the music with dynamic tasks. However, none of the studies above have looked at the physiological benefits of entraining participant to the specific tempo of music. Some studies have looked into those benefits, but they are more common with cycle and treadmill studies (Copeland & Franks, 1991; Terry, Karageorghis, Saha, & Auria, 2011; Pujol & Langenfeld, 1999; Atan, 2013). This leads to an inadequate amount of informasjon on using entrainment to synchronize exercise movement to music tempo and rhythm in anaerobic strength training exercises.

The bench press is a well-used exercise for testing upper body strength, and is part of powerlifting. The exercise is easy to perform, and is used in both competitions and for regular exercise for the average person. As mentioned above, the bench press exercise is a dynamic rhythmic exercise. Breathing is important in all of training, since breathing patterns generally give the athlete an effective economical breathing manner (Katch, McArdle, & Katch, 2011). For people who just train for health purposes are often taught to breathe in on the eccentric contraction and out on the concentric contraction (Austin & Mann, 2012). For powerlifters however, this technique is not good enough. They are taught the Valsalva Maneuver, where there is a need for a rapid, maximum application of force for a short duration (Katch, McArdle, & Katch, 2011; Porth, Bamrah, Tristani, & Smith, 1984; Austin & Mann, 2012). The different breathing patterns gives rhythm to the exercise set, where breathing entrains the speed in which each lift is performed.

There seems to be an evolving connection between rhythm in powerlifting exercises, going from the rhythmic clapping during sporting events in ancient Olympic games, to breathing patterns in athletes today. It should be noted that there is a difference between athletes and

[3] Prime is specific words used in the study, consisted of three word: Push, Drive, Go

novice trainers in how they employ tactics in exercise. Powerlifters, for instance, have learned how to breath to maximise the performance in the lift, showing how athletes can be more unresponsive to music, because of their higher ability to entrain themselves to an internal rhythm, where music can be more distracting than an aid. Brownley et al. (1995) tested trained and untrained runners, and found that music effected trained runners more negatively then untrained runners. Performance level is important to distinguish when selecting participants, since music can affect them differently. Untrained participants have the possibility for a fast learning curve that effects the result in a study. Music has become an active part of society, and has evolved with humans to become a product of the times. From prehistoric flutes to modern age with Walkman, giving people the opportunity to exercise while listening to their own music. The potential use of music to enhance performance is of growing interest, and can be used as an aid both for novices and athletes. However, there should be a focus on the training experience of the participants to distinguish between trained and untrained.

Many of the studies in this area is embossed by mixed results (Brownley, McMurray, & Hackney, 1995; Crust, 2004; Jarraya, et al., 2012; Pujol & Langenfeld, 1999; Bartolomei, Michele, & Merni, 2015; Pearce, 1981), and, in addition, most of the studies use pre-existing music, often with a powerful lyrical component. The use of music is often as a distraction from fatigue or make time pass in the exercise, and in some studies, it was being used to motivate the participants. The goal is often to stimulate the participant to perform on a higher level. Music can possibly entrain participants to follow the tempo of the music, and for this study, the possibility of entraining to a specific rhythm in bench press.

The purpose of this study was to investigate the effect music had on power in bench press, and see if the effects varied on different submaximal loads. *Hypothesis:* If music is set to each subject personalized tempo, we expect music to entrain subjects to the tempo in the lift, which could affect power output in bench press. There is also expected to be differences of the two submaximal weights, with a higher entrainment effect on heavier weights (60 % 1RM), than lighter weights (30 % 1RM).

2.0 Method

2.1 Subjects

Four healthy subjects (one male and three female) at the age of 20-32 were recruited for the study. The subjects recruited had previous knowledge to strength training, and all were familiar with the bench press exercise. Participants were instructed to refrain from any resistance training on upper body 48 hours prior to testing. The subjects had no history of injury or illness that might affect the lifting performance. All participants were informed of testing procedures and possible health risks, and a signed consent form with necessary information was obtained prior to testing.

Table 1: Characteristics of participants

	Min	***Max***	***Mean***	***SD***
Age (years)	*20*	*32*	*25,25*	*4,66*
Bodyweight (kg)	*64*	*86*	*76,5*	*8,67*
Height (cm)	*164*	*189*	*174*	*9,72*
1RM (kg)	*42,5*	*105*	*66,88*	*23,14*
30 % of 1RM (kg)	*12,5*	*32,5*	*21,25*	*7,18*
60 % of 1RM (kg)	*25*	*62,5*	*39,38*	*13,96*

All the participant n = 4 completed the study.

2.2 Procedure

2.2.1 First day of experiment

Subjects was asked to report to the laboratory on two occasions for experimental testing, one for 1RM and pre-test, and one for tests with music conditions. Upon arrival on each day of testing, the subjects completed a warm-up section. The warm-up protocol was as follows: 10 repetitions (reps) with push ups, 10 reps with push ups (wide arm stance), 10 reps with barbell, two sets of 5 reps with sub-maximal load on barbell. After warm-up period, the testing began. The subjects performed a one repetition maximum (1RM) test the first day of testing. The 1RM test consisted of the subjects estimating their 1RM, and then to reach it within 5 tries, to avoid muscle fatigue. A minimum of 2 minutes' rest between each lift was required. When 1RM was found, a longer period of rest, 3-4 minutes, was given.

The subjects then performed 5 bench press repetitions with submaximal loads of 30 and 60 % of their 1RM. The execution of the lifts required the subjects to follow lifting procedure and testing protocol, discussed in chapter 2.2.3. Subjects were instructed to follow their own preferred tempo when accomplishing the submaximal loads. Their preferred tempo were recorded and used for later analysis.

2.2.2 Second day of experiment

Second experimental test was a week after first test. The warm-up protocol was completed prior to testing. The subjects performed submaximal bench press on 30 and 60 % of 1RM, 10 sets in total, 5 sets on 30 and 5 sets on 60 %, in their preferred tempo. After each set, a 2 minutes' rest period was required.

After the first set, the subjects were exposed to music for minimum 1 minute (MT1). All music selections were set to each subject's preferred tempo set during pre-test. In the music conditions the music was increased in bmp on two occasions (MT2 and MT3), after the fourth and sixth set. The subjects listened to the music 1 minute before each set. The music was played continuously from the end of A2 (see table 2) until the music was stopped at the end of set D2. The subjects listened to the music through speakers placed behind the bench press station. Volume was controlled by researcher. Table 2 shows the order in which the subjects performed all 10 sets.

Table 2: Order for each condition during testing, yellow means subjects listened to music, and plus sign (+) shows where the increase in bmp was in the music conditions

Preferred tempo		Preferred tempo with music			Music tempo +			Music tempo ++			Preferred tempo	
Baseline 30 %	Baseline 60 %		MT1 30 %	MT1 60 %	+	MT2 30 %	MT2 60 %	++	MT3 30 %	MT3 60 %	Post-test 30%	Post-test 60%
A1	A2		B1	B2		C1	C2		D1	D2	A1	A2

2.2.3 Lifting protocol

The subjects were instructed on body position in the bench press exercise prior to testing. The execution of the lift was set with regulations by the International Powerlifting Federation (IPF). All subjects had their head, shoulders and buttocks in contact with the bench, back arced and feet fixed to the ground (International Powerlifting Federation, 2016). The subjects were allowed to find the position they found comfortable, if it did not break with any of the regulations. For all the lifts, the subjects were instructed to lower the barbell to their chest for a touch, without bouncing the barbell on their chest. The bench press holder was fitted to each subject's personal arm length, and the bench was placed to align with the exercise.

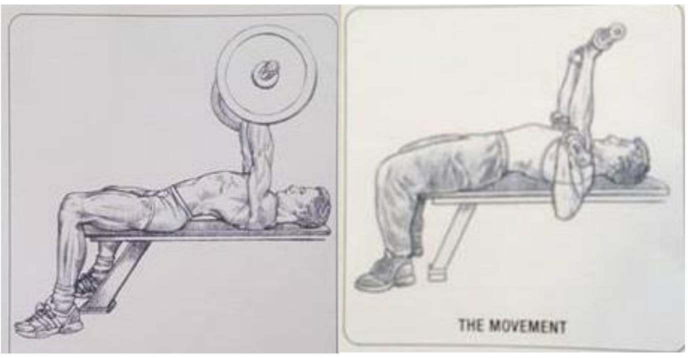

Figure 1: A demonstration of bench press with arched-back and the bench press movement (Delavier, 2010)

In the music conditions, the subjects were not told to follow the tempo of the music. Music was played in the background, individually fitted to each subject's tempo during the pre-test.

The music was played with speakers placed near the subjects. The tempo in the experimental conditions was set to each individual tempo, and the tempo was increased based on each individual preferred pre-test tempo. A total of 12 sets for each participant were collected, and used for further analysis.

2.3 Music selection

The researcher selected music that conformed to each subject's self-selected bench press tempo during pre-test. The tempo of the music was set by bpm and music was chosen based on groove. In this study, groove refers to how the rhythmic structure is experiences outside the noted metre. Each music example was played as an isolated looped part of a specific song. The drumbeats were the predominant element in the soundscape. Lyrical input was almost complete absent, and the instrumental and lyrical elements in the selected groove patterns played on the dominant drumbeats. All loops used were instrumental. Table 3 shows the tempo used during each music condition for each subject.

Table 3: The songs used for the loop in the study, and beats per minute for each of the songs for each subject

	Baseline and MT1	**MT2**	**MT3**
Subject 1	139 bpm	152 bpm	156 bpm
	Gorillaz *“Feel Good Inc”*	Fatboy Slim *“The Rockafeller Skank”*	Kings of Leon *“Sex on Fire”*
Subject 2	108 bpm	120 bpm	133 bpm
	The Weeknd *“Can't feel my Face”*	Maroon 5 *“Sugar”*	Daft Punk *“One More Time”*
Subject 3	102 bpm	108 bpm	133 bpm
	Missy Elliott *“Work it”*	The Weeknd *“Can't feel my Face”*	Daft Punk *“One More Time”*
Subject 4	139 bpm	152 bpm	161 bpm

	Gorillaz *"Feel Good Inc"*	Fatboy Slim *"The Rockafeller Skank"*	Blondie *"One Way or Another"*

The drumbeats were the predominant element in the soundscape. Lyrical input was almost completely absent, and the instruments and lyrical elements played on the dominant drumbeats. All loops used were instrumental. The music volume was set to high.

2.4 Measurement

The string of a linear encoder (MuscleLab, Porsgrunn, Norway) was connected to the barbell on the right side. The encoder was connected to the DSU (Data Synchronization Unit) which in turn was connected to the MuscleLab™ database. The encoder was placed directly under the barbell. The variables used for further analysis were: average velocity and peak velocity.

A Panasonic DMC-LX100 camera was used to record the bench press pre-test. The data were sampled for each subject, and tempo was derived from the video.

The music software used was ProTool, where songs were added to program, and put on a loop to be played for the subjects. The songs selected were based on the specific criteria of the rhythmic structure of the song. The speakers used were studio monitors Genelec 6020, placed near (proximately 1 m) the subject. The speakers were placed to give an acoustic spaciousness, enhanced by the concrete wall which gave a powerful reverberation. The individual tempo for each subject was set during pre-test, and was controlled during baseline. The tempo was set by measuring time between each lift, and divide this into 4/4 rhythms, starting when the barbell is at top position. All the songs used had emphasis on beats 2 and 4, with snare drum, 1 and 3, with bass drum, and in some cases with bass drum on all four beats.

2.5 Statistics

Standard statistical methods were used for calculating the mean and standard deviation in Microsoft Excel 2016 and IBM SPSS. All scores on 30 % and 60 % in SPSS were standardized. Standardized data was used to look at relative scores, and to counteract the major individual differences between subjects. For the statistical calculations in IBM SPSS, the 5th repetition in each set was excluded from the data. For analysis of statistical significance, a Mann-Whitney U test was used to test the hypotheses that independent variable (music) could change the dependent variable (bench press). A Mann-Whitney U test was conducted between all conditions. The significance level was set at $p \leq 0.05$. Statistical analysis was performed on the IBM SPSS Statistics 23.

2.6 Ethics

All the participants signed a consent form prior to testing. The study complied with the ethical requirements asserted for research by the Declaration of Helsinki, 1964.

3.0 Results

Across all conditions with preferred and music-entrained tempo, measures of the bench press were taken for submaximal loads of 30 and 60% of 1RM. Results shown are in the measures average velocity and peak velocity.

For all conditions the subjects were required to perform 5 repetition for each set. Previous studies have experienced that the last repetition tended to differ from the first repetitions. Based on previous studies, the 5^{th} repetition was removed from further analysis. The data presented in this study are relative scores calculated as Z-scores for each individual subject across conditions because of the large difference in absolute scores within the group tested.

3.1 Data for each subject

The results for average velocity data is presented in figure 2, 3, 4 and 5. All data were calculated as Z-scores. Most of the subjects had a varied performance between the pre-test and baseline. For example, subject 1 showed no change between the two conditions (Fig. 2), while subject 2 varied significantly between the conditions, with mean rank for the two conditions was 6.5 and 2.5, a significant decrease (p=0.009), see figure 3 for illustration. Subject 3 only had a discrepancy between conditions on 30%, while subject 4 had a discrepancy on 60% (Fig. 5). There was less difference found between baseline and MT1, where subject 1, 3 and 4 all showed no great differences between the two conditions. However, subject 2 varied much more between the conditions on 30%, as illustrated in figure 3, where mean rank between conditions were 6.5 and 2.5 showing a significant decrease between conditions (p=0.01).

Although no significant change was found between baseline and MT2 on 30% for the four subjects, a small increase is apparent in the figures illustrating the change. A greater improvement is seen in 60%, where subject 1, 2 and 4 all increased their tempo, while subject 3 had a less apparent increase. Subject 1 and 3 had no improvement from baseline to MT3 on 30%, but subject 2 seemed to have a slight increase. Subject 4 improved the most on 30%, illustrated in figure 5. The subjects 1, 2 and 4 all increased their improvements on 60% from baseline to MT3, but subject 3 had no increase. Between MT2 and MT3, no improvements were found for the subjects, except for subject 4 on 30%, who had a greater increase between those conditions. Figure 2, 3, 4 and 5 suggests that music influenced the distribution of data where, especially on MT2 on 60%, the music diminish the distribution in the lifts.

In support of the music conditions having an effect, subject 1 showed a small-scale increase between baseline and post-test in 30%, but no improvement on 60%. Subject 2 had a slight improvement for both 30 and 60%, while subject 4 had a considerable improvement on 30, with mean rank 2.50 and 6.50 (p=0.01), but less improvement in 60%. Subject 3 had a slight improvement on 60%, but no improvement on 30%.

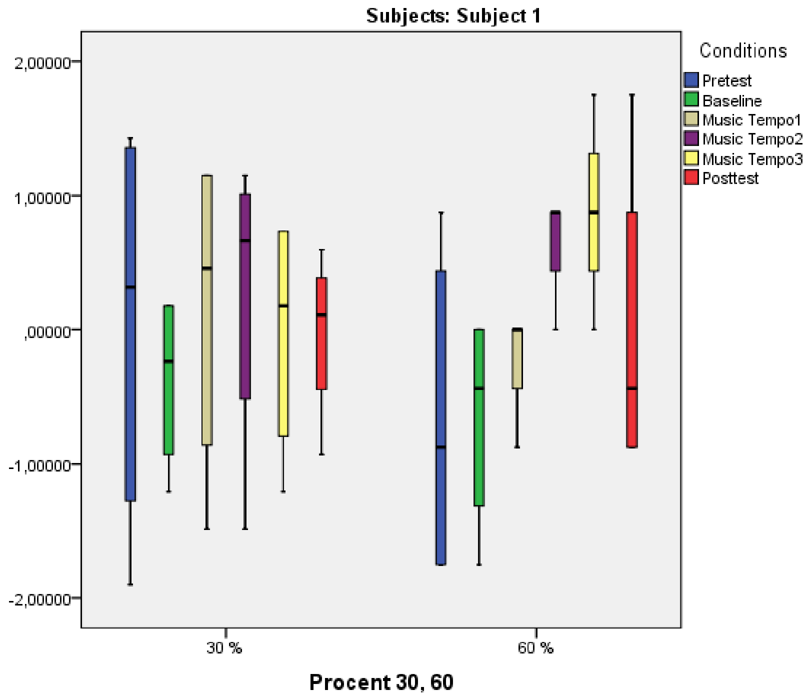

Figure 2: Shows average velocity in z-scores for subject 1 over all conditions, and is separated between the two submaximal loads 30 and 60%

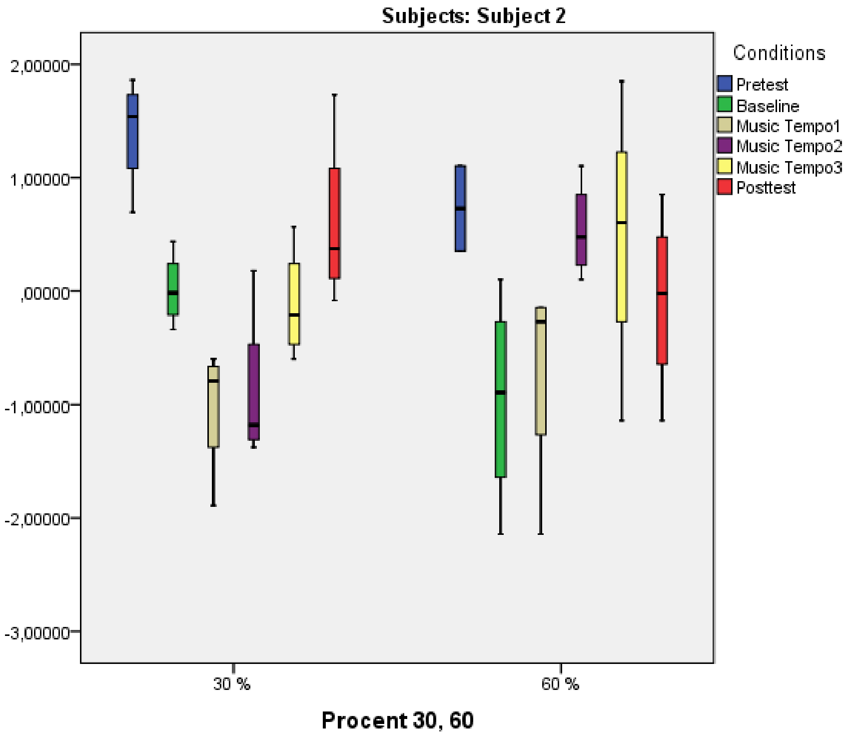

Figure 3: Shows average velocity in z-scores for subject 2 over all conditions, and is separated between the two submaximal loads 30 and 60%

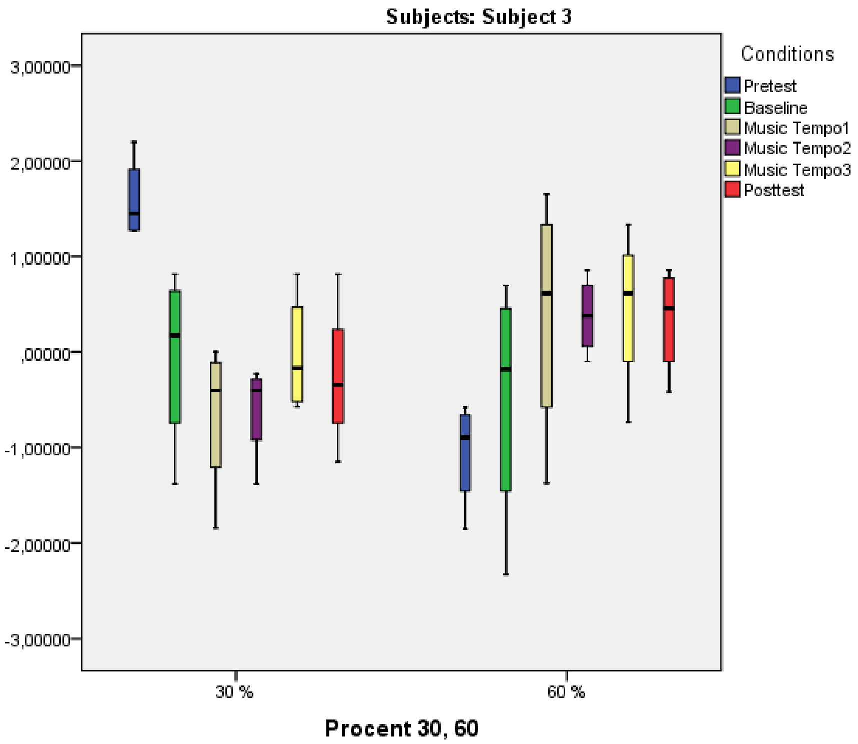

Figure 4: Shows average velocity in z-scores for subject 3 over all conditions, and is separated between the two submaximal loads 30 and 60%

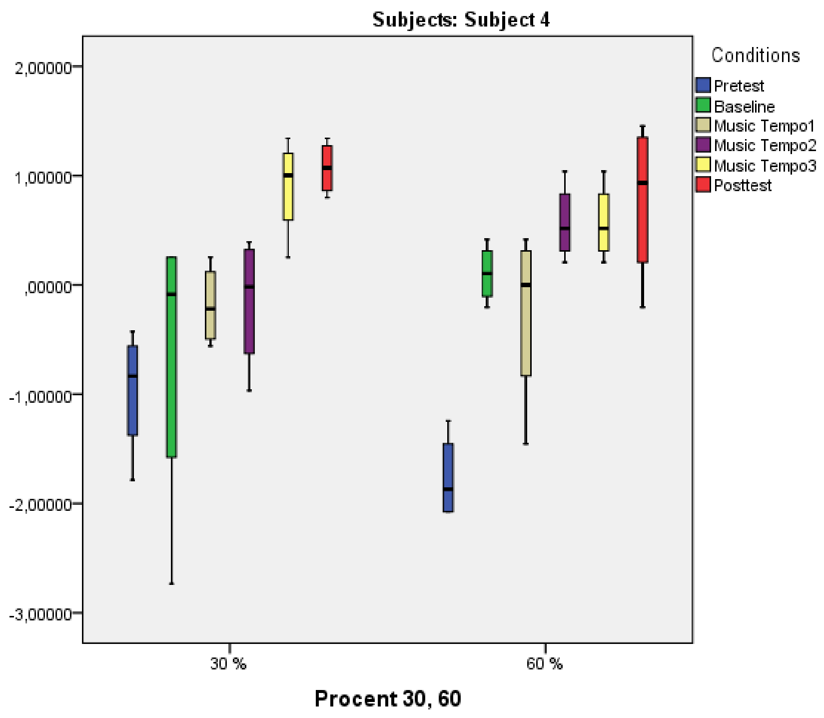

Figure 5: Shows average velocity in z-scores for subject 4 over all conditions, and is separated between the two submaximal loads 30 and 60%

3.2 Average data for all subjects on 30 % of 1RM

The data for average velocity and peak velocity for the four subjects together are illustrated in figure 6 and 7. The data indicates that the subjects significantly decreased their performance from pre-test to baseline, on both AV and PV.

The data from baseline and MT1 revealed a slight decrease on both measures, but slightly more decrease on AV (see figure 6), than PV (see figure 7). Comparing baseline and the two music conditions showed an increase, where the data show improvement from baseline to MT2 and MT3. Between the two increased music conditions there was a slight improvement between MT2 to MT3. A slightly higher improvement between the two increased music conditions on AV, than on PV. The data suggests that the subjects had a continuous improvement during the music conditions, on the measures AV and PV. This is clearly illustrated in the figures.

One of the main effects found is the improvement between baseline and post-test in AV, as shown in figure 6. A Mann-Whitney U test performed between the two tests showed a significant increase after the experimental conditions, with mean rank 13.41 and 19.59 ($p=0.03$). Although no such significant difference was found on PV, the data suggests a slight improvement for PV as well.

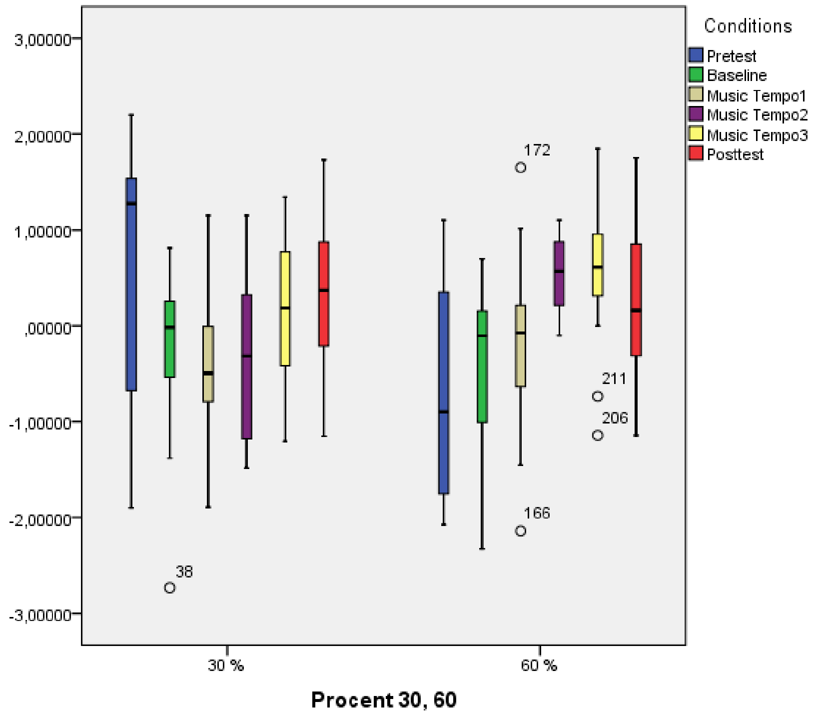

Figure 6: Shows the z-scores for all subjects in average velocity over all conditions, separated by the two submaximal loads of 30 and 60%

3.3 Average data for all subjects on 60 % of 1RM

The results of the tests on 60% are presented in figure 6 and 7. The data comparison between the pre-test and baseline suggested a slight increase. Although no significant increase was found, the data still show a tendency for increase.

The data between the baseline and MT1 showed no increase in AV, but an insignificant increase in PV can be seen in figure 7. The performance significantly improved between the baseline and the two increased music conditions, MT2 and MT3, in AV. A Mann-Whitney U comparison supported the notion of the increase on both music conditions, with mean rank for MT2 was 10.44 and 22.56 ($p=0.000$), and for MT3 was 10.94 and 22.06 ($p=0.000$). This is illustrated in figure 6. The same data was not found in PV, where the increase between baseline and MT2 were insignificant, as seen in figure 7. However, the increase in PV between baseline and MT3 was higher, and showing a higher PV value with mean rank of 13.31 and 19.59 ($p=0.02$). The music condition data suggested a higher improvement in AV from baseline, but almost no change between MT2 and MT3. In PV, the data showed less change between the first music conditions, but a significant improvement between MT2 and MT3 ($p=0.05$), with mean rank of 13.81 and 19.19 ($p=0.05$), as illustrated in figure 7.

The main effects showed the improvement between baseline and post-test in AV. Unlike the data in the previous chapter, there seems to be an improvement from pre-test (p=0.01) as well as baseline (p=0.02) to post-test, showing subjects performed higher after the experimental conditions. This is illustrated in figure 6. However, no such significant change was found in PV. Figure 7 shows the baseline and post-test to be almost equal in, showing no performance improvement for PV.

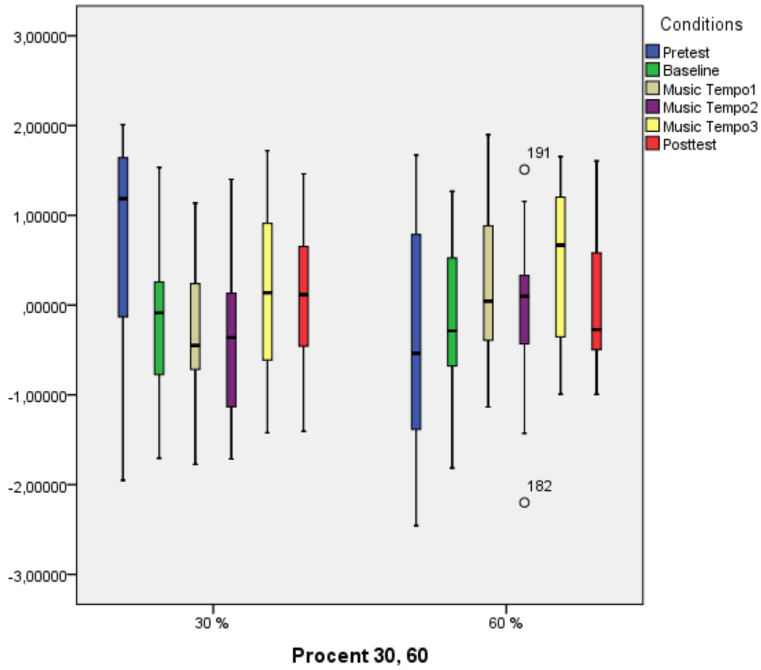

Figure 7: Shows the z-scores for all subjects in average velocity over all conditions, separated by the two submaximal loads of 30 and 60%

4.0 Discussion

The purpose of this study was to see if music can be used to increase power output in anaerobic exercises, such as bench press. It was hypothesized that music would entrain the participants to the music, and could potentially increase their tempo with the music. With the increased tempo, it was suggested an increase in power output. The results, overall, supported the hypothesis that music could improve performance in bench press.

In this study, we excluded the 5th repetition from the statistical analysis after looking at the statistics for each repetition. Fatigue often occurs or there might be a change in the mindset of the subjects that contribute to reduce output in the last repetition. Results from this study confirmed a tendency for the last rep to change significantly from the rest of the repetitions. Other studies support this notion, as they have found that the last repetition in sub-maximal lifts on bench press often differ from the rest (van den Tillaar & Sæterbakken, 2014; van den Tillaar & Sæterbakken, 2013; Duffey & Challis, 2007). The data was standardized before further analysis. The standardizing of data was done in order to make data from the subjects comparable, so the variables for the subjects could be directly comparable across conditions.

4.1 Submaximal loads of 30 versus 60 %

As hypothesized, there was a difference of the submaximal loads of 30 and 60%. One of the differences noticeable in the results, was the difference between heavy and light loads in the exercise, and the effect they had on the data distribution. During the submaximal load of 30% the subjects seemed to have a harder time keeping the music tempo, than during the submaximal loads on 60%. One of the subjects commented during testing, that they had a noticeable higher tempo than normal, because of the light load on the barbell. Research has shown that training with 30% 1RM resulted in significant strength gain (Cronin & Crewther, 2004), but the strength gain in that study was due to a higher number of repetition and large acceleration. Regular exercise with lighter loads are often accompanied by a high repetition number, but this was absent in this testing procedure. A higher amount of repetitions, could be assumed to give more time to find a stable tempo in the exercise. The low repetition count could in this case make it harder for subjects to adjust to the right tempo, during both preferred tempo conditions and experimental conditions. This could be interpreted as the 30% of 1RM demands a higher degree of control compared to the 60%, because weights with lighter loads pose less of an external constraint for subjects. It could also be reasonable to suggest that most people have less experience producing high power at smaller loads than higher loads.

The observed difference between 30 and 60% could also be caused by the set tempo during the music conditions. The same music tempo, set during the pre-testing, was used for both 30 and 60% of 1RM. In the pre-testing, it was harder to find their preferred tempo, because of a greater lack in consistency in the lifts in 30%. This caused experimenter controlling the tempo to set their preferred pre-test tempo to their individual tempo in 60%. Reasonably, the subjects might have to entrain to a lower tempo in the music conditions, because their preferred tempo in 30% does not necessary fit with their preferred tempo in 60%. In the increased experimental conditions, it could be argued that the subjects had to entrain to a lower tempo than their actual preferred tempo in the submaximal load of 30% of 1RM. This is similar to other studies that found significant differences between higher and lower submaximal loads where kinetics of the movement changed (Wilson, Elliott, & Kerr, 1989; Elliott, Wilson, & Kerr, 1989), and there was difference in muscle activation (Jenkins, et al., 2015). The data from figure 3, 4 and 5 show that those subjects had a significant increase in MT3 on 30%. It is reasonable to suppose that the higher music tempo in MT3 is closer to the preferred tempo with lower submaximal loads, and make it easier to entrain to the music.

4.2 Preferred or entrained tempo

As mentioned earlier, the music in MT1 was set to the subjects preferred tempo during the pre-test. It was hypothesised that the tempo in pre-test, baseline and MT1 would be the same. Using the set preferred tempo, the subjects would hypothetically be automatically entrained to the tempo in MT1. Using the subjects preferred tempo, and using that as a basis for the tempo in the music condition, it could create a familiarization with the music, and make it easier to entrain in the later music condition. However, the pre-test and baseline was not in the same tempo. Two of the subject, number 2 and 3 (see figure 3 and 4), missed the preferred tempo they set during pre-test in the baseline. A plausible explanation for the change was that for some of the subjects there were occurring fatigue. The pre-test was performed after the 1RM testing, and repetitions close to maximal force can often result in rapid decrease in power output (Allen, Lamb, & Westerblad, 2008). Another possible explanation for the change can be the familiarization with the procedure, since it was the first time they had been in the laboratory. This could have been avoided with a third visit to the laboratory prior to testing, where they had a familiarization with the equipment and location. However, no significance was found between baseline and MT1. The music was changed as close to the baseline as possible, for the subjects with most discrepancy between pre-test and baseline, so the MT1 still worked as a familiarization condition. And the data does suggest that the MT1 did match the baseline, except for one significant discrepancy for subject 2 during 30%. Which discussed in previous paragraph, could be caused by the difference of lifting with lighter loads.

Listening to music in the same tempo as their preferred exercise tempo in MT1, and then entraining subjects to higher music tempo to increase the exercise tempo did seem to influence the subject's performance (see figure 6 and 7). A possible explanation lies in that the first music condition works as a familiarization, and then synchronize the subjects to the given tempo. The music provides a cue for the subject to entrain to, and by starting with entraining the music to their preferred tempo makes it more natural to entrain with increased music conditions in this study. Another noticeable change is that when the subjects had a cue to entrain to, it seemed to give a more specific rhythmic pace. The music seemed to help limit the distribution in the lifts for the subjects. The music helped the exercisers to find a pace, even in the short duration of each set. On individual subject levels, there seems to be a difference in where the pace was more evident for some of the subjects. During all the music conditions, there is a more evenly distribution of the lifts on 30% for subject 2, 3 and 4 (fig. 3, 4 and 5). This suggests it was easier to follow the tempo of these subjects, giving them a specific pace to follow, while the effect of the music cues was less evident for subject 4. During the 60% it seemed it was easier for subject 4 to find a specific lifting-pace. In general, it did seem that music helped the subjects find a more steady pace during the music conditions, as illustrated in figure 6.

4.3 Trained versus untrained athletes

An interesting question here is whether the tendency of music benefiting the subjects would occur with trained athletes. The subjects in this study were regular exercisers, with average to low performance level, and as Brownley et al. (1995) found, there was a higher benefit for novices with listening to music, but was counterproductive for the athletes. Athletes have a higher internal rhythm or entrainment, and for them, the music often is a disturbance in the performance instead of an aid. It could seem that athletes have a harder time to entrain with music because it does not follow their internal set rhythm. For novices and regular exercises music often seem to either help them perform higher as music distracts them from the task or the occurring fatigue in exercise. Athletes seem to demand a higher concentration during their performance then novices. It could be suggested that if music was set to each athlete's personalized tempo, as done in this study, there could be a higher benefit for use of music for athletes in performance. It should be noted that for athletes, music cannot be used in performance, as in team sports, powerlifting, marathons, cycle race or in athletics. In cycling Jarraya et al. (2012) found that music could be a aid in performance prior to exercise on trained athletes. However, it was still set to a generalized tempo for all participants, and a personalized tempo could potentially give a higher transfer benefit from warm-up to performance for athletes. This is a factor that should be implemented in research in the future.

4.4 Musical elements and entrainment abilities

Music in research often use music from popular culture, and categorize the songs based on bpm in the song. Often are songs with over 120 bpm said to be motivational and songs with less than 120 are sedative. There is, in these studies, often a strong lyrical component. In this study, the lyrical component was excluded from what the subjects listened to. Lyrics is an important part of popular music, and in most of the music research studies, lyrical component is present. The point should be made that the lyrical component plays a less significant role in the physical aspect of entrainment. The cue to entrain in the music is not linked to the lyric, but a specific beat in the music. However, within the instrumental music, there is a question on what specific beat assists the subjects to entrain. In this study, the focus was set to the drumbeats in the songs, with bass drum and snare as drums used in the specific songs. Historically, the drums play a significant role, and even today drums are the cue to movements in for example marching. However, no studies have considered the specific factor in the music that makes entrainment possible.

4.5 Individual differences within use of music

There is also an individual factor within music that makes research into music hard. Music is known to affect mood (Gaston, 1951), but it is hard to generalize music to a group of people. Although music has a rhythmic factor, it does affect individuals in differently. After two of the experimental music conditions with two of the subjects, they both noted different experiences with the music. One of the subjects told researchers that the music was a disturbance because the loop of the song was an annoyance. Another of the subjects noted that the music gave a more specific rhythm to follow. This study used pre-existing songs, and made them instrumental by setting them on a loop. Later studies should consider creating music from scratch with basic instrumental elements, to avoid a potential loop being an annoyance for participants. Using basic instrumental elements could also potentially give researcher information on the qualities the different instrumental elements have, and what specific beat we entrain to. This also reduces some of the individual impact, by removing the potential history the participants might have with a song. The participant's music preference could influence the motivation during exercise, so the music selection used in this study could potentially negatively affect the subjects. This should be a factor to take into consideration in later studies.

5.0 Limitations and Conclusion

Research into music seem to be a beneficial aid, but should be investigated further, in more details. More research should be done between trained and untrained subjects, as well as research into what specifically that makes us entrain within the music.

The major limitation of this study was the small number of subjects that makes it impossible to generalize to a population. Therefore, no final conclusion about the usefulness of music in strength training to increase power was made from this study. The results are, however, a promising start for further studies into this area. This study could therefore be seen as an exploratory study, and sets the basis for future research.

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