dba University of cooperative education
Deutsche Berufsakademie Sport und Gesundheit

Bachelor thesis

To obtain the academic degree of Bachelor of Arts (B.A.)

Testing of improved regeneration and increased strength through High Tone therapy

submitted by

Finn Schmetzer

First reviewer: Prof. Dr. Kuno Hottenrott

Second reviewer: Dr. Laura Hottenrott

Submitted on: 01.08.2023

Abstract

Regeneration is an essential part of sport. It is crucial for achieving regular progress and avoiding subsequent complaints such as fatigue, a drop in performance or susceptibility to infection. It is therefore very important to understand how regeneration can be influenced by suitable means.

The aim of this bachelor thesis is to investigate the influence that the targeted application of HighTone Therapy can have on regeneration and the associated increase in strength. This results in the following hypotheses:

H1: Bilateral strength training of the biceps brachii muscle leads to an increase in the maximum strength of the treated arm (in relation to the one-repetition maximum) when High Tone therapy is applied unilaterally.

H2: Bilateral strength training of the biceps brachii muscle leads to an increase in strength endurance of the treated arm (in relation to the maximum repetitions) when using High Tone Power therapy unilaterally.

In order to answer these research questions, a study was conducted on the influence of High Tone training on the increase in strength. The one-repetition maximum and the repetition maximum of both arms were tested at around 70% of maximum strength capacity. This was followed by a six-week training intervention paired with the targeted use of High Tone therapy on the weaker of the arms tested. The initial test was repeated and evaluated after three and six weeks. An ANOVA was used to evaluate the results.

The results showed that both arms improved significantly at both the one-repetition maximum and the repetition maximum, $p=<0.001$. However, no significant difference was found between the therapy and control arm groups, $p=0.992$ and $p=0.566$. No significant difference was found between the arms in their development at the one-repetition maximum either, $p=0.107$. At the repetition maximum, however, there was a significant difference between the arms in their development over the intervention period, $p=0.002$.

However, further studies over a longer intervention period would be necessary in order to be able to make valid statements about the benefits of High Tone therapy.

Table of contents

List of abbreviations

ANOVA	Analysis of variance
TENS	Transcutaneous electrical nerve stimulation
HiToP	High Tone Power Therapy
SimulFAM	Simultaneous frequency and amplitude modulation
Kg	Kilogram
Rep.	Repetitions

List of illustrations

List of tables

1 Introduction

1.1 Initial situation

Sport is becoming increasingly important in our society. Over the last few decades, awareness of the importance of sport and physical activity and its effects on health has grown continuously in various areas. Physical activity not only offers physical benefits such as weight control, improving fitness and performance, strengthening the cardiovascular system, and reducing the risk of cardiovascular disease, diabetes, obesity, and other health problems, but also has positive effects on mental health. Numerous scientific studies have shown that regular physical activity has positive effects on emotional well-being, reduces stress, relieves anxiety, and can improve overall mood. Sport can boost self-confidence and self-esteem and reduce depression ("Just 1 hour of sport per week helps against depression", 2018).

In addition, sport provides a platform for interaction, cohesion, and integration. The World Health Organization (WHO), for example, recommends at least 150 minutes of moderate or 75 minutes of intense physical activity per week in combination with muscle strengthening sessions to maintain and promote one's health (Activity, 2020). It is important to emphasize that physical activity is not just for athletes or sports enthusiasts but can have positive effects for people of all ages and fitness levels. It is never too late to start regular physical activity and reap the health benefits.

Physical activity undoubtedly has many positive effects on health. Nevertheless, negative consequences can occur if too much sport is practiced without adequate recovery. Recovery is an essential part of sport, but one that is often not given enough attention. It is of paramount importance that coaches, professional and recreational athletes recognize the importance of regeneration in competitive and recreational sport and integrate it appropriately into their training plan. Adequate recovery forms the basis for continuous progress and the avoidance of secondary complaints. Insufficient regeneration can cause a variety of symptoms in the long term, including headaches, fatigue, exhaustion, sleep disorders such as problems falling asleep and sleeping through the night, loss of performance in sport, work and everyday life, altered psyche with inner restlessness and irritability, as well as an increased risk of infection and injury. According to Ziegler (2009), every excessive stress stimulus triggers a biological response in the organism, which is referred to as regeneration in the context of endogenously induced and temporally structured processes

These transformation processes do not take place during the sport itself, but in the early or late post-exercise phase (Ziegler, 2009). For this reason, it is crucial to plan sufficient rest periods and to support regeneration through various measures such as adequate sleep, nutrition, foam rolling, cold therapy, active recovery and relaxation techniques.

In recent years, the demands on competitive sport and athletes have increased enormously, not only due to training itself and participation in regular competitions, but also due to additional stresses such as travel, sponsorship commitments, press appointments, social media appearances and other time-consuming activities (Schurr, 2012). As a result, it is becoming increasingly difficult for many athletes to implement the optimal training regimen between the intensive stress phases and to find the right balance. Overtraining and even burnout with far-reaching health consequences are a danger for modern competitive athletes. To avoid this, some competitive athletes are currently using so-called High Tone therapy, which can be carried out individually immediately after training or from the comfort of your own home.

1.2 Objective

The aim of this bachelor thesis is to investigate the possible influence of high tone therapy on regeneration and performance enhancement in sport. It is expected that sport will continue to play an important role in health, recovery, social integration, and personal development in the future. The social significance of sport will continue to increase and more and more people will take part in sporting activities. As a result, regeneration will also play an increasingly important role. In addition, the growing demand on the performance of professional athletes makes targeted recovery essential.

However, technological progress, social changes and new trends will also change the way in which sport, exercise and appropriate regeneration are organized and experienced. High Tone therapy could be one such step forward.

1.3 Structure of the work

In the following, the theoretical foundations and the current state of research are presented. The questions and hypotheses are then explained and the methodology used is presented in detail. The data is then evaluated and analyzed in a critical discussion. Finally, practice-relevant conclusions and recommendations for action are derived and the bachelor thesis is summarized in a short summary.

2 Theoretical background and state of research

2.1 High tone therapy

High-tone therapy, also known as a further development of conventional electrotherapy or stimulation current therapy, was patented by the German psychiatrist and neurologist Hans-Ulrich May and included in the national care guidelines in 2008 (Hochton-therapie - Ein Überblick - HiToP® PNP, 2020). This form of therapy is currently offered in around 400 practices, clinics and institutes and is classified as a physical therapy (Nonnenmacher, n.d.). High tone therapy involves electrical muscle stimulation with electrical oscillations at very high frequencies between 4096 and 32768 Hertz. The current intensity and frequencies can be modulated simultaneously and individually and are not audible to the human ear. The aim of these frequencies is to optimally activate the cells and vitalize the body. Another aim is to generate resonances that cause the cells and tissue structures to vibrate in order to stimulate the metabolism and accelerate the body's own processes. These mechanisms distribute minerals, nutrients, vitamins, waste products, pain and inflammation mediators more efficiently, which in turn helps to supply the cells more quickly, activate their functions and normalize certain functions in the body (Nonnenmacher, n.d.).

One of the aims of high tone therapy is to improve regeneration and cell metabolism. It is mainly used to treat polyneuropathy, a nerve disorder that often occurs in diabetics and alcoholics and can cause severe pain. High Tone therapy can be used either as a substitute or as a supplement to conventional drug therapy, especially if the drugs are not sufficiently effective or are associated with side effects (High Tone therapy - An overview - HiToP® PNP, 2020).

2.2 Current state of research

It should be noted that High Tone therapy has not yet been widely accepted in conventional medicine, as no double-blind studies on the treatment of polyneuropathy have yet been presented that are required for it to be recognized in conventional medicine. Nevertheless, the number of studies on polyneuropathy is impressive, with around 13 studies published in scientific journals. These studies come from various universities and specialist clinics in different countries and include a total of over 700 study participants (clinical studies - HiToP® PNP, 2020).

The study published by L. Reichstein in 2005, in which the effect of High Tone therapy was investigated in comparison with transcutaneous electrical nerve stimulation (TENS) in the treatment of diabetic polyneuropathy, serves as the basic building block. A total of 41 patients were recruited, 20 of whom were treated with tweeter therapy and 21 with TENS. The primary aim of the study was to investigate and summarize the improvement of disease symptoms, including pain, numbness and paresthesia in the lower extremities. The treatment consisted of 30-minute sessions on three consecutive days, followed by an observation period of two days.

The study found that 80% of patients in the intervention group who received high tone therapy experienced a significant improvement in symptoms. In comparison, only 33% of patients in the control group were treated with TENS. The difference between the two groups was statistically significant (IGeL Mo-nitor - High Tone Therapy, n.d.).

Furthermore, there are additional recent studies that point to potential benefits of High Tone therapy in various areas of application.

In a randomized controlled study, 35 men aged between 21 and 50 years who had undergone anterior cruciate ligament reconstruction were examined. The tests were carried out before the operation and 6 months after the reconstruction. The patients were randomly divided into an experimental group (17 patients) who received high-tone therapy during rehabilitation and a control group (18 patients) without high-tone power therapy.

The analysis after the application of high tone therapy showed a statistically significant improvement in muscle torque ($p = 0.041$, $Es = 3.71$), knee circumference ($p = 0.039$, $Es = 1.65$), thigh circumference ($p = 0.049$, $Es = 1.26$) and knee extension ($p < 0.001$, $Es = 2.20$) in the experimental group compared to the control group (Ogrodzka-Ciechanowicz et al., 2021).

There are also other studies investigating the possible applications of High Tone therapy. One particularly recent study, for example, investigated the effectiveness of High Tone therapy in the treatment of soldiers with post-traumatic stress disorder and traumatic brain injuries. This study also delivered significant results, which may be extremely promising (Babov et al., 2022).

2.3 Indications and contraindications

All indications and contraindications that may be of great importance are listed below.

- Degenerative joint diseases such as arthrosis
- Polyneuropathie
- Nerve diseases
- Pain in the musculoskeletal system
- Migraine, headache
- Promotion of wound healing
- Promoting the healing of fractures
- Treatment of edema
- Thrombosis prevention
- Bronchial asthma
- Sleep disorders, states of exhaustion
- Tinnitus

Contra indicators

- Wearers of pacemakers
- Wearers of metal implants
- Acute febrile infections
- Pregnancy
- Local infections in the treatment area
- Sensory disorders

2.4 Muscle regeneration and performance development

Improved regeneration could lead to more efficient protein biosynthesis, which in turn could lead to faster muscle recovery and readiness for action. According to Hottenrott and Neumann (2009), training with excessive fatigue leads to increased biological effort, which leads to a catabolic metabolic state and to a restriction of protein synthesis and thus to delayed adaptation in the organism. A training load requires regular, appropriate relief so that the organism can adapt in a targeted manner within the scope of its regulatory possibilities. Exertion and relief in the form of regeneration are indispensable interrelated complexes of effects for improving performance in sport.

If regeneration is impaired, this prevents the muscles from growing. Targeted use of high tone therapy to increase regeneration could therefore promote muscle growth and open up new applications in performance, leisure and fitness sports. Among other things, this therapy could help to compensate for muscular imbalances caused by sport and everyday life, shorten the healing process of muscle injuries and support rehabilitation measures. Athletes could resume their training earlier after an injury. Competitive athletes, strength athletes and professional bodybuilders could potentially benefit from a shortened recovery time, which would allow them to train more frequently, improve their performance or build muscle mass faster without resorting to the use of widely used doping agents. Optimal recovery enables a higher training frequency and intensity, which allows the athlete to improve their performance faster.

3 Hypotheses and research question

High tone therapy has been established as an effective treatment method in medical practice for many years and is gaining increasing recognition. A steadily growing number of publications document the potential benefits of this form of therapy. However, the areas of application of the therapy are currently limited exclusively to medical purposes. But what are the benefits of High Tone therapy for sport? What influence could it have on improving performance? Does it influence muscle growth when used in a targeted manner? Despite the growing body of data that provides increasing evidence to address this issue, all these questions remain unanswered.

The aim of this bachelor thesis is to investigate whether the targeted application of high-tone therapy can have an influence on muscle growth and performance enhancement. This results in the following hypotheses:

H1: Bilateral strength training of the biceps brachii muscle leads to an increase in the maximum strength of the treated arm (in relation to the one-repetition maximum) when High Tone therapy is applied unilaterally.

H2: Bilateral strength training of the biceps brachii muscle leads to an increase in strength endurance of the treated arm (in relation to the maximum repetitions) when using High Tone therapy unilaterally.

4 Methods

4.1 Test subjects

The sample consisted of members of the BGM health studio, or more precisely, members of the associated Halle13 in Henstedt-Ulzburg. A total of 8 members took part in the study voluntarily and without compensation. Of these, 6 participants successfully completed the study over the entire intervention period of six weeks. However, two participants injured themselves in their free time before the intermediate test could be completed.

Each participant started the study with different basic requirements and training levels. Information on each individual participant is listed below:

- Test subject no. 1: A 22-year-old man who has been strength training once or twice a week for about five years and four to five times a week for two years. He also takes part in a dance class once a week.

- Test subject no. 2: A 17-year-old trans man who has been doing strength training two to three times a week for about a year and a half.

- Test subject no. 3: A 25-year-old man who has been active in sport since childhood and has been a professional mixed martial arts competitor since 2018. He has been doing weight training four times a week for around three years. He also takes part in martial arts training at least twice a week.

- Test subject no. 4: A 25-year-old woman who has been doing weight training no more than once a week and figure skating about twice a week for a year.

- Test subject no. 5: A 59-year-old woman who has been active in sports since childhood and regularly goes jogging. She has been strength training three times a week for about a year.

- Test subject no. 6: A 26-year-old man who has been strength training four to five times a week for about a year and has also been active in sport since childhood.

This diverse group of participants with different genders, ages, sporting experience and backgrounds allows the effects of high tone therapy to be studied on a wide range of individuals.

4.2 Study design

In order to investigate the influence of High Tone therapy on regeneration and muscle growth, the therapy is applied in the form of a cross-sectional study over a test period of six weeks. At the beginning of the intervention period, two initial measurements are carried out. The one-repetition maximum (1RM) and the repetition maximum (RM) are tested at around 70% of maximum strength capacity. The initial test is repeated after 3 weeks and after 6 weeks, whereby the initial weight at 70% remains the same as in the initial and intermediate tests.

High tone therapy is applied as an intervention over a period of six weeks. The therapy is applied five times a week for 60 minutes each time, exclusively on the weaker arm of the test subjects.

In addition, they supplemented their training with three predetermined units of biceps training each week. It is important to emphasize that high tone therapy is used in this study as a complementary measure to the prescribed biceps training program. The subjects continued their own training, with the exception of unilateral strength exercises, and supplemented it with the prescribed sessions of high tone therapy.

The main aim of this targeted approach is to investigate the specific influence of High Tone therapy on the weaker arm. Regular and intensive stimulation of this arm is aimed at achieving faster regeneration. The aim is to achieve a targeted improvement in muscular performance and muscle growth in this area. Choosing the weaker arm as the target also offers the opportunity to compensate for any asymmetries or imbalances in muscle strength, or even to surpass the strength capabilities of the stronger arm.

This study design makes it possible to investigate the specific influence of High Tone therapy on muscular performance, muscle growth and the compensation of asymmetries as part of a controlled and structured intervention program. Regular tests make it possible to record changes in strength levels and repetition performance. In order to obtain meaningful results, it is important to conduct the study under controlled conditions. The test subjects should not make any further changes to their training and lifestyle during the test period to minimize possible influencing factors.

4.3 Force measurement

Before starting the strength measurements, the participants received detailed instructions from the study director. The strength measurements were performed in an identical and standardized manner for all subjects and supervised by the study director. In order to determine the one-repetition maximum, the biceps curl was performed both on the cable pulley and with dumbbells in the preacher curl variant in a seated position. It was crucial that the buttocks remained firmly on the seat and that the armpit of the arm to be tested was in close contact with the pad. This is intended to minimize the influence of the body and reduce the force used on the performing arm. The weight was then lifted from the extended arm position until an angle of 90 degrees was reached. The aim was to determine the maximum weight that could be voluntarily contracted once. Subsequently, approximately 70% of this maximum weight was used to test the maximum repetitions, whereby the execution remained identical. The strength measurements were carried out on two consecutive days to ensure reproducibility and to exclude possible influencing factors such as stress, fatigue and lack of strength. The dumbbell variant was selected for the presentation of the results. This is explained in more detail in the discussion section under point 6.3.1.

4.4 Strength training plan

To optimize the strength qualities of the participants holistically, the strength training plan was divided into three categories. The first category is maximum strength training or intramuscular coordination training, which aims to increase the greatest possible strength that the neuromuscular system can realize voluntarily against resistance. The second category is muscle-building training, also known as hypertrophy training, which is designed to increase muscle mass. The third category is strength endurance training, which aims to improve fatigue resistance during prolonged exercise.

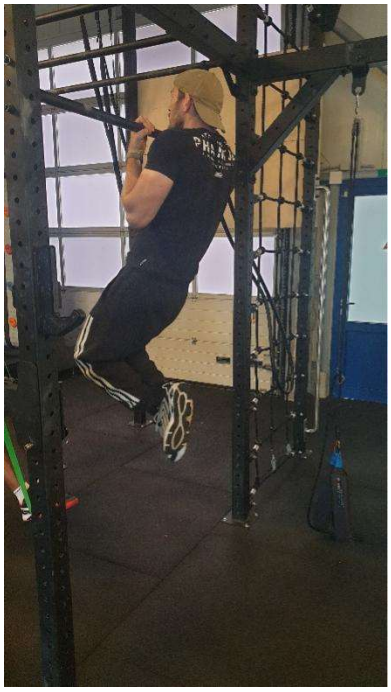
The training plan only includes bilateral exercises to ensure that the weaker arm is not trained more intensively than the stronger arm. This is because unilateral exercises can be used to compensate for imbalances and correct weaknesses. Including unilateral exercises would therefore make the influence of high tone therapy unmanageable. It would be difficult to determine how much the high tone therapy contributed to the equalization of the imbalances, or whether the respective sides merely adapted as a result of the unilateral training.

The following exercises make up the bicep training plan:

Figure 1a and 1b: Performing preacher curls with the barbell in a seated position

- Preacher curls with the barbell: 3 sets, 4-6 repetitions, 80-90% of maximum strength capacity

Figure 2a and 2b: Execution of pull-ups with supinated grip



- Pull-ups in supinated grip (chin-up): 3-4 sets, 8-12 repetitions, 70-80% of maximum strength capacity, if necessary regression with Theraband support.

Figure 3a and 3b: Performing barbell curls in a standing position

- Barbell curls, standing: 3-4 sets, 15-25 repetitions, 50-60% of maximum strength.

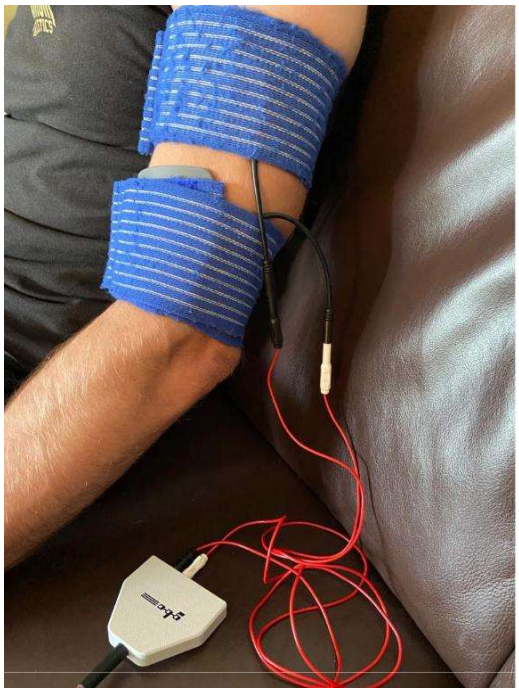
The weight for each person was calculated individually before the start of the intervention period. The weight was then increased based on personal perception. The aim was to adjust the weight so that the number of repetitions was within the specified range and no further repetitions were possible in the respective set. The bicep training was carried out independently of the personal training either before or after the training session or, if possible, on separate days.

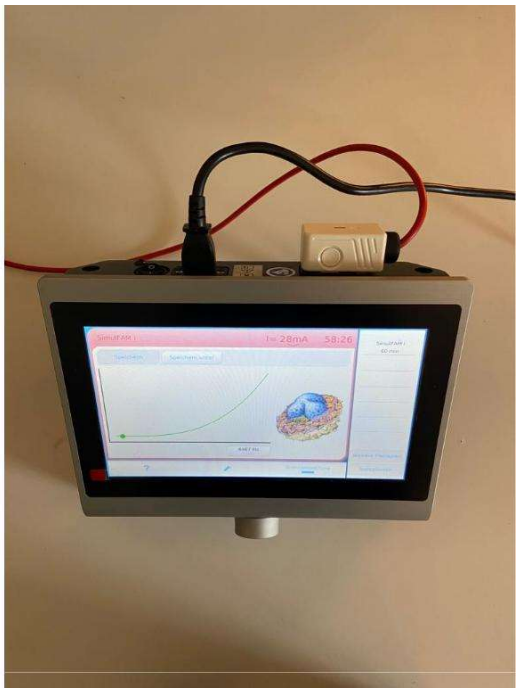
It took place three times a week, so that all participants completed around 18 bicep training sessions in Halle13 over the six weeks. In total, around 27-33 sets per week were added to the training, which represents a very high training volume and makes the influence of regeneration even more decisive.

4.5 Intervention with High Tone therapy

The test subjects were treated with the HiToP® 1touch device after training or on training-free days in Halle13. The device operates in a frequency range between 4,096 and 32,768 Hertz. The SimulFAMi program was used, which causes the cells to vibrate and is intended to promote regeneration through targeted metabolic facilitation.

Figure 4a and 4b: Illustration of the treatment with the High Tone therapy device





As can be seen in Figures 4a and 4b, two electrodes are attached to the biceps of the corresponding arm one above the other and secured with bandages. Before the start of the treatment, the study leader then regulates the maximum tolerable intensity at the lower corner frequency of 4,096 Hertz and at the middle frequency of 16,384 Hertz. The test subjects should feel a slight tingling sensation. The tingling should be perceived as pleasant and not cause any muscular contractions. After setting the intensity, the treatment begins, during which the HiToP® 1touch device automatically oscillates between the frequency ranges of 4,096 and 32,768 Hertz. The treatment lasted 60 minutes and was carried out a total of five times over the course of a week under the supervision of the study leader.

4.6 Statistical evaluation

For statistical evaluation, the results were recorded in a table and their location parameters, e.g. mean values and scattering parameters such as variance and standard deviation, were calculated. These were used to create dependent T-tests between the measurements for an initial assessment of the results. In order to compare the two arms, therapy arm and control arm, over the three measurement points of the initial test, intermediate test and baseline test, the two-factor analysis of variance with repeated measures was calculated and the results evaluated and interpreted in the following chapter 5. In addition, tables and graphs were created using the data to illustrate the results below.

5 Results

5.1 Evaluation of the one-repeat maximum

Table 1: Evaluation of the single-repetition maximum with tweeter therapy

Test subjects	Entrance test (Specification in kilograms)	Intermediate test (Specification in kilograms)	Exit test (Specification in kilograms)	Difference (Specification in percent)
A	16 kg	18.5 kg	18 kg	12,5 %
B	11 kg	12.5 kg	13 kg	18,2 %
C	17 kg	20.5 kg	22 kg	29,4 %
D	7.5 kg	8 kg	8.5 kg	13,3 %
E	8 kg	9.5 kg	10 kg	25 %
F	12.5 kg	14 kg	15 kg	20 %

Table 1 shows the progress of the arm treated with High Tone therapy between the initial, intermediate and final tests. It can be seen that all subjects increased their maximum strength over the intervention period of six weeks. The treated arm of the test subjects improved by at least 12.5%. The maximum increase in the one-repetition maximum was around 29.4%.

Table 2: Evaluation of the single-repetition maximum without high tone therapy

Test subjects	Entrance test (Specification in kilograms)	Intermediate test (Specification in kilograms)	Exit test (Specification in kilograms)	Difference (Specification in percent)
A	17.5 kg	19 kg	18.5 kg	5,7 %
B	11 kg	12.5 kg	12.5 kg	13,6 %
C	18.5 kg	20 kg	21 kg	13,5 %
D	8 kg	8 kg	8.5 kg	6,3 %
E	8 kg	9 kg	9 kg	12,5 %
F	12.5 kg	13.5 kg	14 kg	12 %

Table 2 illustrates the progress of the untreated arm between the initial, intermediate and baseline tests. Here, too, it can be clearly seen that the untreated arm of each subject improved without exception over the six-week intervention period. The strength gains in the one-repetition maximum of the control arm were between 5.7% and a maximum of 13.6%.

The largest differences between the entrance and exit test occurred in the arm treated with the High Tone therapy. Tables 1 and 2 show that the single-repetition maximum of the arm treated with High Tone therapy improved significantly more than that of the control arm. A detailed illustration of the exact comparison of the individual test subjects is presented in Figure 5.

Figure 5: Comparison of the one-repeat maximum between treatment arm and control arm in percent

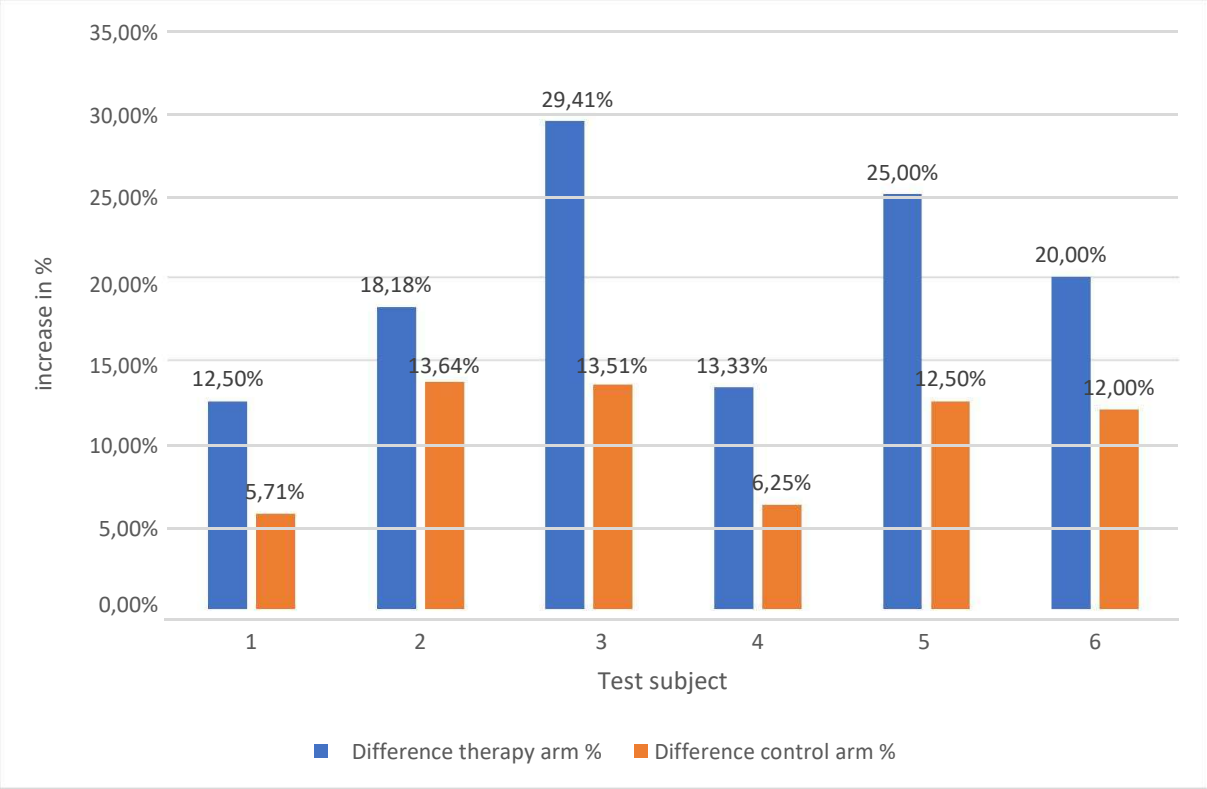


Figure 5 illustrates the percentage difference in the one-repetition maximum between the entrance test and the exit test of the individual test subjects in the form of a bar chart. It can be clearly seen that the arm treated with High Tone therapy made the most progress. During the six-week intervention period, the therapy arm was able to achieve almost twice the improvement of the control arm in the majority of subjects.

Table 3: Representation of the mean values of the one-repetition maximum in kilograms

	Entrance test	Intermediate test	Exit test	Total
Therapy	12	13,83	14,42	13,42
Control	12,58	13,67	13,92	13,39
Total	12,29	13,75	14,17	13,4

Table 3 shows the mean value of the participants between the three measurement times: initial test, intermediate test and initial test. The values of the treatment arm are compared with the values of the control arm in kilograms.

Figure 6: Comparison of the one-repetition maximum between the treatment arm and the control arm in kilograms

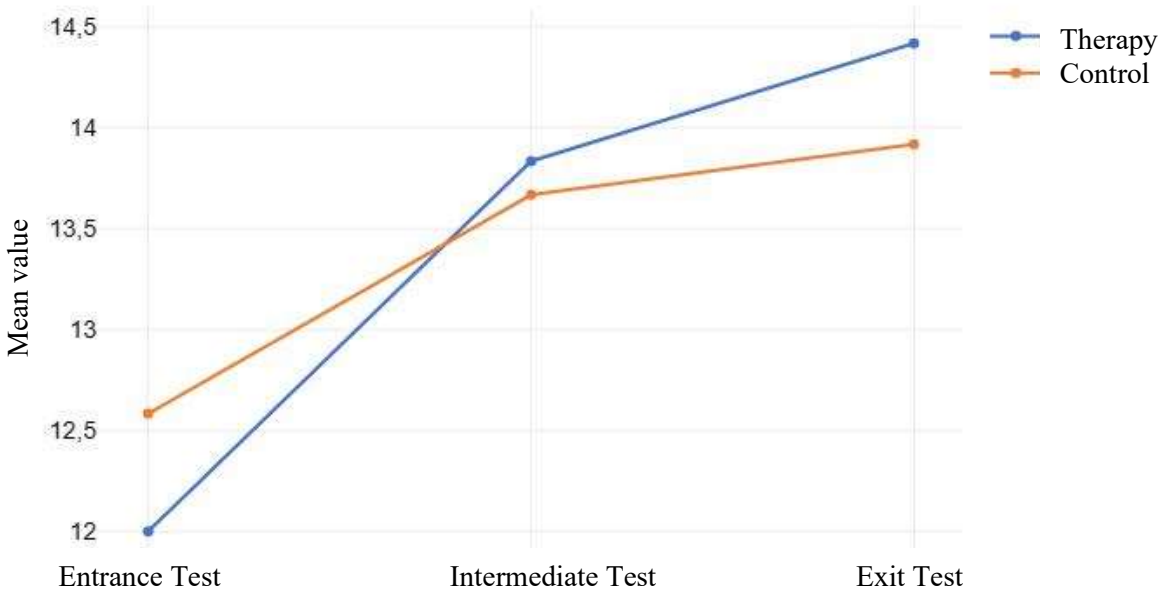


Figure 6 illustrates the comparison of the mean values between the treatment arm and control arm in kilograms. The change over time is shown between the measurement time points of the initial test, intermediate test and final test. It can be seen that the therapy arm starts with lower initial values and outperforms the control arm from the intermediate test onwards. In the exit test, the therapy arm also achieves higher values than the control arm.

A two-factor analysis of variance with repeated measures was carried out to test whether there was

- a significant difference between the groups of the first factor " entry test, intermediate test and exit test " (repeated measures) in relation to the dependent variable.
- a significant difference between the groups of the second factor therapy in relation to the dependent variable.
- an interaction between the two factors " initial test, intermediate test and initial test " and therapy in relation to the dependent variable.

Table 4: Statistical analysis of the one-repeat maximum using two-factorial variance analysis with repeated measures

	Square sum	df	Mean value of the Squares	F	p
Entrance test, intermediate test, Exit test	23,26	2	11,63	31,48	<0,001
Therapy	0,01	1	0,01	0	0,992
A x B	1,85	2	0,92	2,5	0,107
Between	673,41	11	61,22		
Within the sample	673,4	10	67,34		
Residuum	7,39	20	0,37		
Inside	32,5	24	1,35		
Total	705,91	35	20,17		

The two-factor analysis of variance with repeated measures showed that there is

- a significant difference between the groups of the first factor entry test, intermediate test and exit test in relation to the dependent variable, p=<0.001,
- no difference between the groups of the second factor therapy with regard to the dependent variable, p=0.992,
- no interaction between the two variables therapy and " initial test, Between test and baseline test " in relation to the dependent variable, p=0.107.

Results with these values indicate that there are significant differences between the three measurement points, p=<0.001, but no significant differences between the intervention groups, p=0.992, or between the intervention groups in their development over time, p=0.107.

5.2 Evaluation of the maximum repetitions

Table 5: Evaluation of the maximum repetitions with High Tone therapy

Test subjects	Entrance test (Specified in how-of the recalls)	Intermediate test (Specified in how-of the recalls)	Exit test (Specified in how-of the recalls)	Difference (Indication in percent)
A	14 rep.	17 Wdh.	17 Wdh.	21,4 %
B	14 rep.	15 reps.	16 reps.	14,3 %
C	14 rep.	20 reps.	23 Rep.	64,3 %
D	11 rep.	16 reps.	18 Wdh.	63,6 %
E	14 rep.	20 reps.	21 Wdh.	50 %
F	16 reps.	20 reps.	24 reps.	50 %

Table 5 shows the change in maximum repetitions between the initial, intermediate and final test. Each of the subjects treated with High Tone therapy was able to increase the number of maximum repetitions by at least 14.3%. The maximum increase in repetitions was approximately 64.6%.

Table 6: Evaluation of the maximum repetitions without tweeter therapy

Test subjects	Entrance test (Specified in how-of the recalls)	Intermediate test (Specified in how-of the recalls)	Exit test (Specified in how-of the recalls)	Difference (Indication in percent)
A	18 Wdh.	19 Wdh.	14 rep.	-22,2 %
B	14 rep.	14 rep.	14 rep.	0 %
C	18 Wdh.	20 reps.	20 reps.	11,1 %
D	17 Wdh.	19 Wdh.	21 Wdh.	23,5 %
E	19 Wdh.	19 Wdh.	20 reps.	5,3 %
F	18 Wdh.	19 Wdh.	20 reps.	11,1 %

As can be seen in Table 6, not all of the participants were able to increase their maximum repetitions over the entire six weeks. While the majority of subjects were able to increase their repetitions, subjects A and B did not manage to improve their performance. Subject A even deteriorated by around 22.2% in the exit test compared to the entry test. In contrast, the maximum increase in the control group was 23.5%.

A comparison of the maximum repetitions also shows that the therapy arm achieved a significantly better result than the control arm. This comparison of the two groups is illustrated in Figure 7.

Figure 7: Comparison of maximum repetitions between treatment arm and control arm in percent

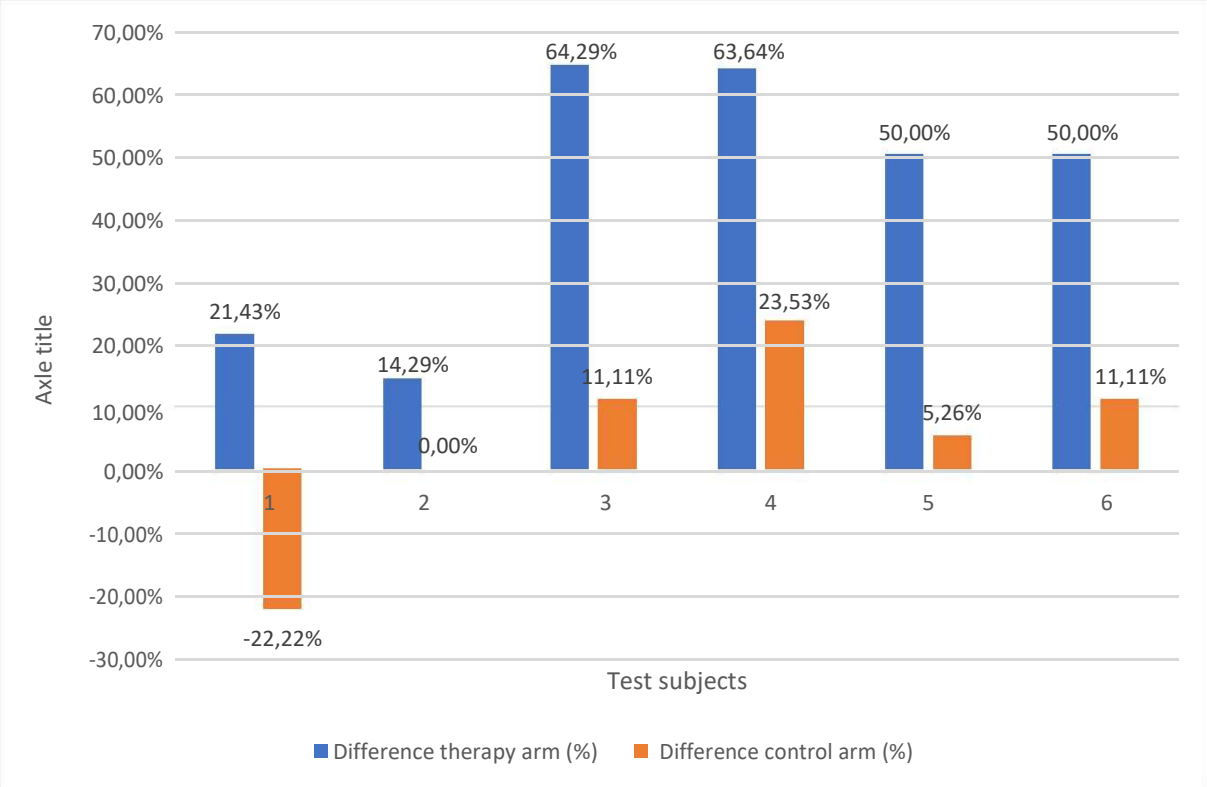


Figure 7 shows the difference in the maximum number of repetitions between the input and output test measurement times in the form of a bar chart in percent. It can be seen that the arm treated with High Tone therapy was able to increase its performance many times over compared to the control arm.

Table 7: Representation of the mean values of the maximum repetitions in repetitions

	Entrance test	Intermediate test	Exit test	Total
Therapy	13,83	18	19,83	17,22
Control	17,33	18,33	18,17	17,94
Total	15,58	18,17	19	17,58

Table 7 shows the mean value of the participants between the three measurement times of the initial test, intermediate test and baseline test. The values of the treatment arm are compared with the values of the control arm in repetitions.

Figure 8: Comparison of maximum repetitions between treatment arm and control arm in repetitions

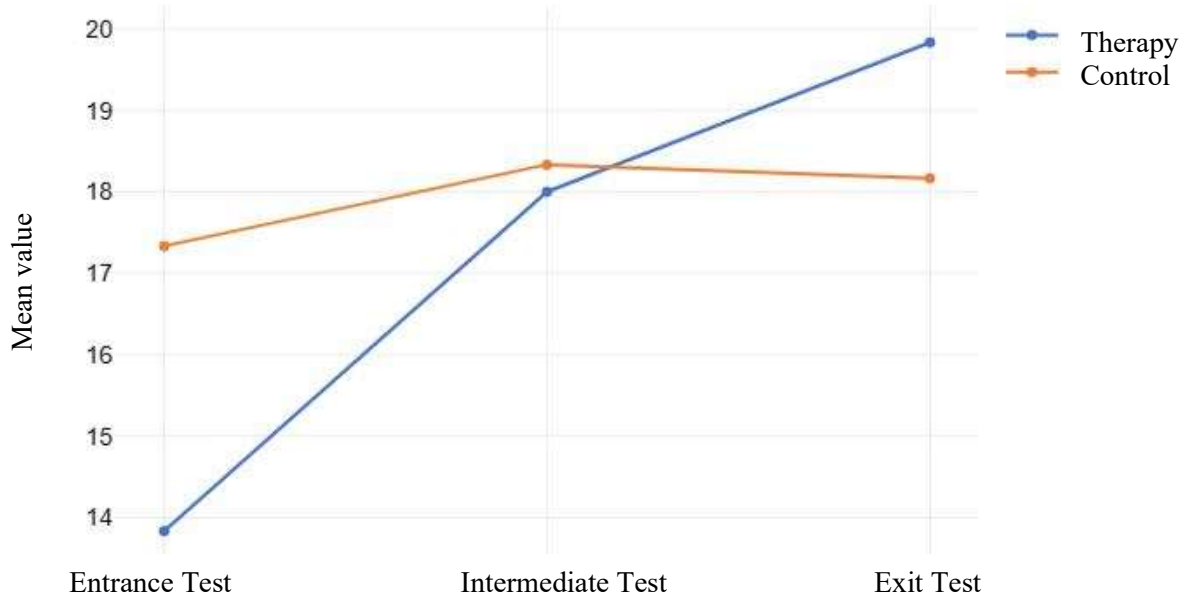


Figure 8 illustrates the comparison of the mean values between the treatment arm and control arm in repetitions. The change over time between the measurement times of the initial test, intermediate test and final test is shown. It can be seen that the therapy arm starts with lower input values but achieves higher values in the output test than the control arm.

A two-factor analysis of variance with repeated measures was carried out to test whether there was

- a significant difference between the groups of the first factor "initial test, intermediate test and initial test" (repeated measurement) in relation to the dependent variable.
- a significant difference between the groups of the second factor therapy in relation to the dependent variable.
- an interaction between the two factors "initial test, intermediate test and initial test" and therapy in relation to the dependent variable.

Table 8: Statistical analysis of the maximum replicates using the two-factor analysis of variance with measurement replicates

	Square sum	df	Mean value of the Squares	F	p
Entrance test, intermediate test, Exit test	76,17	2	38,08	16,17	<0,001
Therapy	4,69	1	4,69	0,34	0,566
A x B	40,72	2	20,36	8,64	0,002
Between	142,75	11	12,98		
Within the sample	138,06	10	13,81		
Residuum	47,11	20	2,36		
Inside	164	24	6,83		
Total	306,75	35	8,76		

The two-factor analysis of variance with repeated measures showed that there is

- a significant difference between the groups of the first factor entry test, intermediate test and exit test in relation to the dependent variable, p=<0.001,
- no difference between the groups of the second factor therapy with regard to the dependent variable, p=0.566,
- an interaction between the two variables therapy and "initial test, intermediate test and initial test" in relation to the dependent variable, p=0.002.

Results with these values indicate that there is a significant difference between the three measurement times, p=<0.001, but no significant difference between the intervention groups, p=0.566. However, there is a significant difference between the intervention groups in their development over time, p=0.002.

6 Discussion

The following section contains a critical discussion of the test results of the one-repetition maximum and the testing of the maximum repetitions. The limitations of the study are then presented.

6.1 Discussion of the results of the one-repeat maximum

Within the six-week intervention period, both arms were able to achieve significant differences compared to the initial test, p=<0.001. A closer look at the one-recovery maximum in percent reveals that the arm treated with High Tone therapy improved significantly more intensively over the intervention period of six weeks than the control arm.

Figure 9: Box-plot diagram of the one-repetition maximum of treatment arm and control arm in percent

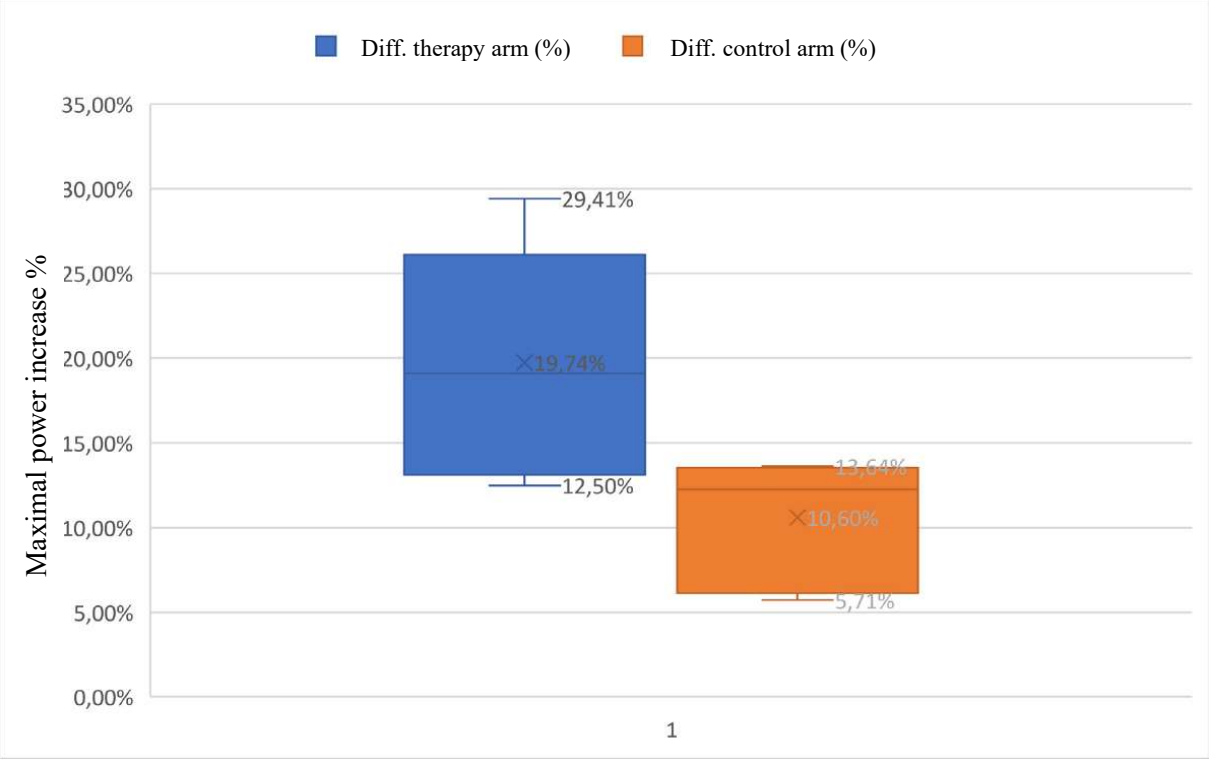
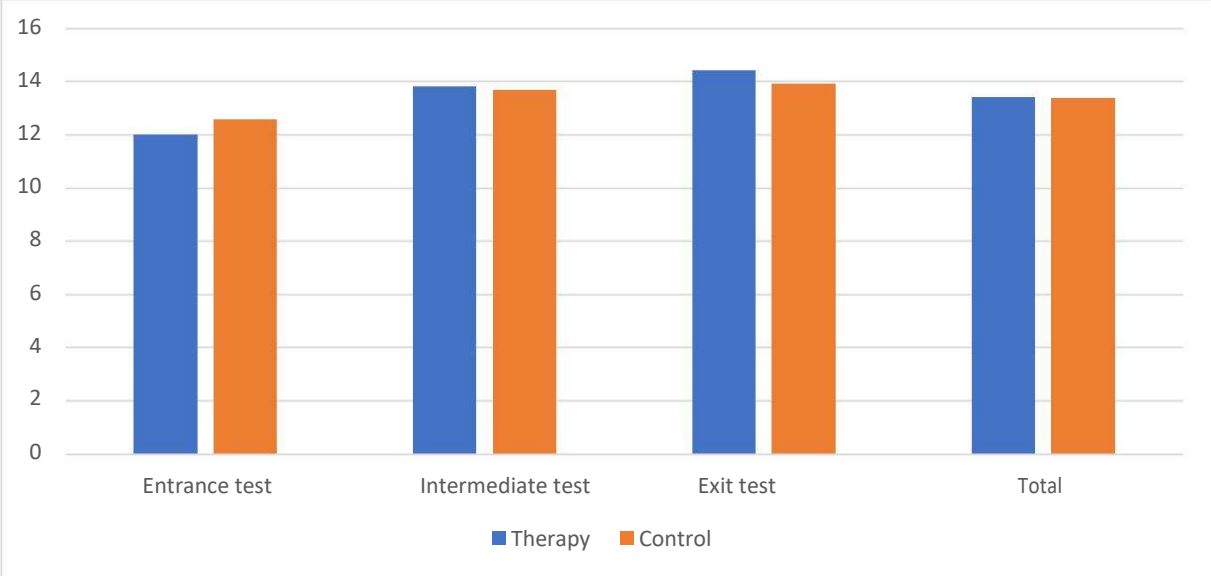


Figure 9 shows the differences in the one-repetition maximum between the therapy arm and the control arm in the form of a box plot diagram. During the six-week intervention period, the treatment arm improved on average by around 19.7%, while the control arm only improved by 10.6%. This means that the therapy arm showed about twice as much improvement as the control arm.

This difference can be attributed, among other things, to the fact that the weaker of the two arms was selected for the therapy. At the beginning of the intervention period, the two arms therefore had different initial values. During the course of the intervention, the therapy arm managed to outperform the control arm despite its lower initial value. However, the values at the respective measurement times were so close that, despite the percentage differences, no significant differences between the intervention groups, p=0.992, or the intervention groups in their development over time, p=0.107, could be determined. Although the treatment arm did not show statistically significant results, the differences achieved were noticeable for most participants and persisted over several weeks.

Figure 10: Differences in the mean values of the one-repetition maximum in kilograms



The bar chart in Figure 10 illustrates the differences in the mean value at the three measurement times: Entry test, intermediate test and exit test. It can be seen that despite an increase in the treatment arm compared to the control arm, no significant differences were found at the respective measurement times.

A longer intervention period would be necessary for a more precise evaluation of the benefits of High Tone therapy in terms of increasing maximum strength. One of the reasons for this is that the muscles and maximum strength can only increase to a limited extent within the intervention period of six weeks. It would have been extremely interesting to observe the course of the differences between the therapy arm and the control arm over further weeks in order to determine whether there were any significant differences.

The current results do not support the H1 hypothesis: bilateral strength training of the biceps brachii muscle leads to an increase in maximum strength of the treated arm (in relation to the single-repetition maximum). The H1 hypothesis is therefore rejected in this study and further research is required in this area.

6.2 Discussion of the results of the maximum repetitions

Both arms were also able to demonstrate significant differences in the maximum repetitions over the study duration of six weeks compared to the initial test, p=<0.001. However, the extent of the increases differed widely.

Figure 11: Box plot diagram of the maximum repetitions of the treatment arm and control arm in percent

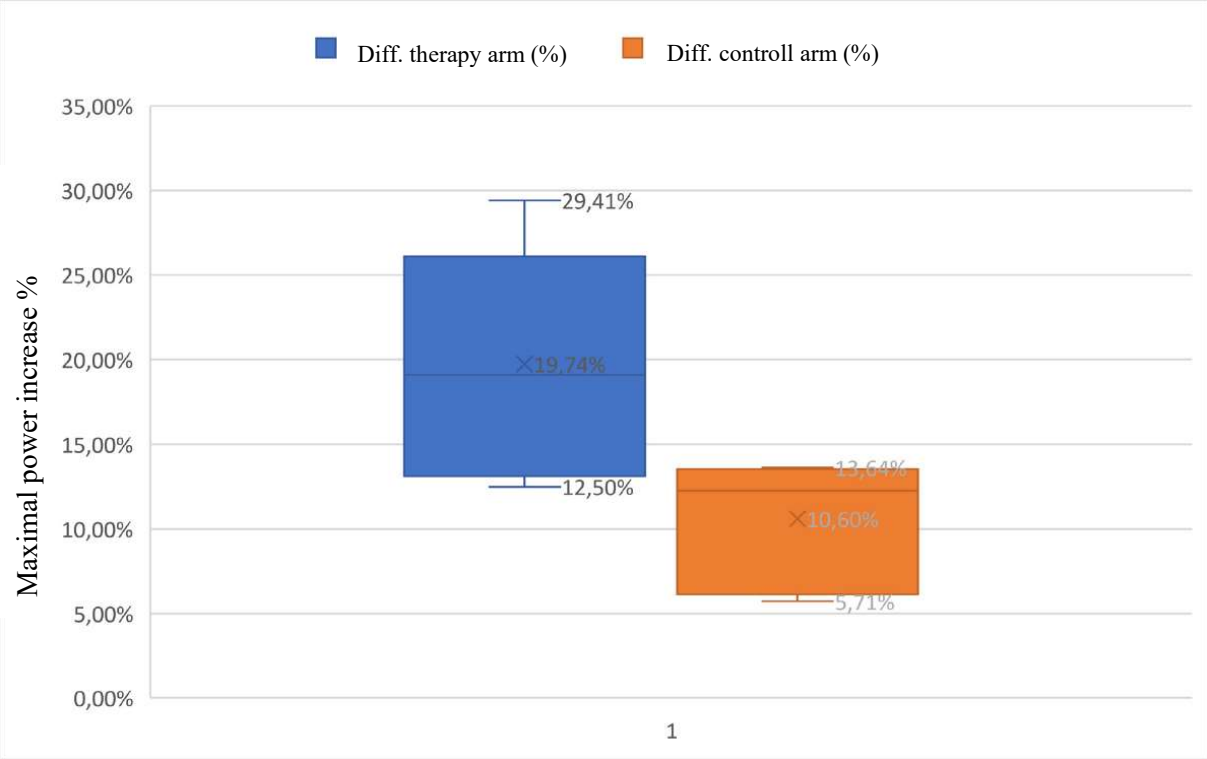
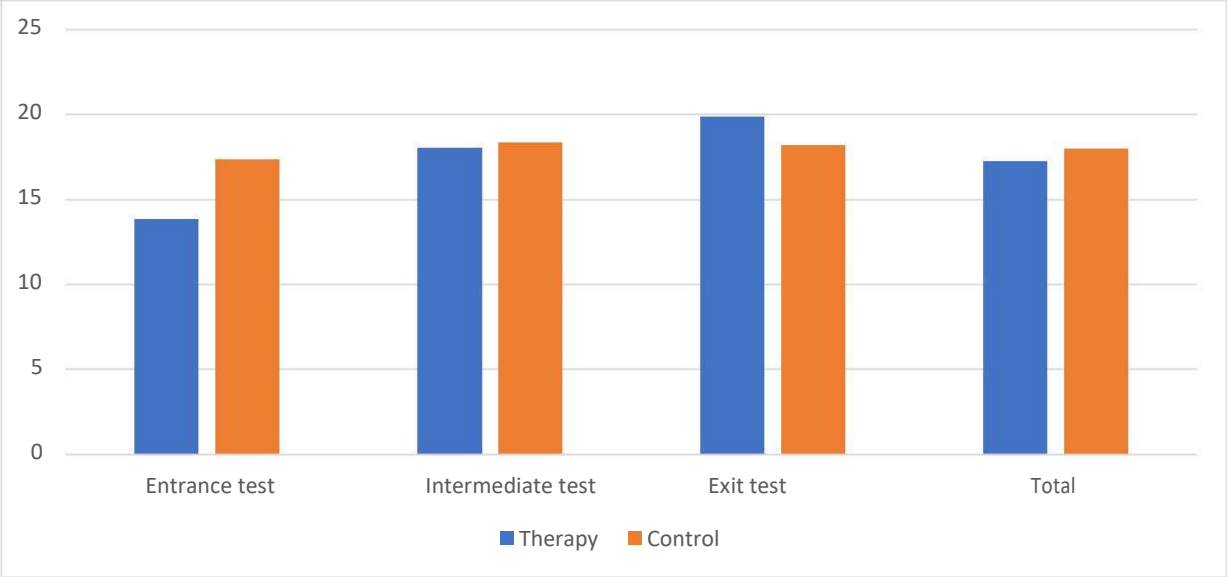


Figure 11 shows the extent of the differences between the treatment arm and the control arm in the form of a box plot diagram. While the control arm increased by an average of 4.8%, the therapy arm even managed to increase by an average of 43.9%. This represents a tenfold increase in strength endurance within the six-week study period. At the beginning, the strength endurance performance of the therapy arm was significantly lower than that of the control arm, but was able to exceed the number of repetitions of the control arm during the course of the intervention.

Here too, however, no significant difference between the arms could be determined due to the similarity of the results at the intermediate test and baseline test.

However, there was a significant difference between the poor in their development over the intervention period, p=0.002.

Figure 12: Differences in the mean values of the maximum repetitions in repetitions



The bar chart in Figure 12 illustrates the differences in the mean value at the three measurement times: Entrance test, intermediate test and exit test. It can be seen that no significant differences were found between the arms at the respective measurement times, with the exception of the initial test, p=0.005. However, the increase in the therapy arm compared to the control arm resulted in significant differences between the arms in their development, p=0.002.

For a more precise assessment of the benefits of High Tone therapy in terms of increasing strength endurance, a longer intervention period would be essential, as is the case for increasing maximum strength. This is also due to the fact that the muscles and strength endurance can only increase to a limited extent within the six-week intervention period. Here too, it would have been extremely interesting to see the progression over further weeks.

The current results partially support the H2 hypothesis: bilateral strength training of the biceps brachii muscle leads to an increase in the strength endurance of the treated arm (in relation to the maximum repetitions) when High Tone therapy is applied unilaterally. The H2 hypothesis can therefore be partially accepted in the context of this study. However, further research in this area is required in order to be able to make valid statements.

6.3 Limitations

6.3.1 Testing

In order to present the results as unbiased as possible, the plan was to test the strength measurement using a biceps curl machine. However, several problems crystallized in advance. Firstly, the unilateral execution on the biceps curl machine designed for both arms not only felt incorrect, but also caused pain in the elbow joint of some test subjects. Secondly, the difference in weight between the levels was 2.5 kg, which meant that it was not possible to make a small-step graduation of the strength of the respective arms.

Testing on the cable pulley presented a similar problem. Although it was much easier to perform, the differences in weight were also quite large. The cable pulley offers weights from 5-100 kg with 5 kg increments, with a transmission ratio of 4:1 with one cable (one pulley) and 2:1 with both cables (two pulleys). However, the male test subjects exceeded the weight of 100 kg (25 kg at 4:1), which also increased the weight differences per step to 2.5 kg per step. As a result, the progress over the short intervention period was hardly separable, although there were noticeable differences.

Only in the preacher curl variation with dumbbells in a seated position 0.5 kg steps were possible, which meant that even small differences in weight and improvements were noticeable during the intervention. Close attention was paid to the execution and sitting position in order to minimize possible execution errors.

Each test was carried out with long breaks between the tests and on two consecutive days and were generally reproducible. This was to check the results achieved, as the strength slowly decreases during the maximum tests. In a few cases, however, deviations occurred due to stress, fatigue, lack of strength or impending illness. In these cases, the better result was chosen. The final test could only be carried out once for one test subject, as he fell ill the following day and was absent for almost two weeks. This was also reflected in the results; on the day of the test, he reported feeling tired and stressed due to a strenuous week at work. The final results were lower than those of the initial and intermediate tests. However, the majority of the test subjects delivered almost identical results on the two test days.

6.3.2 Test subjects

As each of the test subjects represents both the intervention group and the control group for themselves, a smaller number of participants is sufficient. Each of the test subjects only treats their weaker arm and thus offers optimal conditions for comparing and checking the measurement results of the respective arms. Differences between the groups can therefore be ruled out and external factors influence the control group and intervention group equally.

A total of eight volunteers took part in the study. Two of the test subjects ended their participation before the intermediate test due to injury. Six participants completed the study over the entire intervention period of six weeks. This results in a drop-out rate of 25%. Due to the extensive participation requirements, there were few participants who could afford to take part in the study. In order to participate in the study, it was necessary to supplement or replace their training with three units of biceps training per week. In addition, they had to complete High Tone therapy five times a week for 60 minutes each time. This places very high demands on the participants. As a result, it was very difficult to find volunteers for the study who were able and willing to fulfill these conditions. The limited opening hours of Halle13 Monday to Friday from 3pm to 10pm and Saturday from 2pm to 6pm also limited the number of participants. It was equally difficult for the participants to meet these conditions, even after they had agreed to take part. Despite the agreed dates for the training sessions and therapy sessions, the participants found it difficult to fulfill them at the planned times. Reasons for this included overtime at work, after-work traffic or free-time commitments and other private circumstances. Each participant had to plan around one hour and 15 minutes, including set-up and dismantling. Due to the circumstances explained above, there were repeated overlaps or significant delays. This meant that the study leader had to regularly work overtime or additional working days on a Sunday. This was to ensure that every participant was able to complete the study under the specified conditions.

7 Conclusions

Over the intervention period of six weeks, both the therapy arm and the control arm recorded significant improvements. These improvements relate to both the increase in the one-repetition maximum and the increase in maximum repetitions. Although no significant differences were found between the "therapy" and "control" groups, certain tendencies were nevertheless observed that indicate a benefit of High Tone therapy.

In particular, the arm that was regularly treated with High Tone therapy showed a clearer improvement than the untreated arm in a direct comparison. These improvements were perceived by the participants and even remained noticeable for some subjects for several weeks after the end of the study. With regard to the increase in maximum repetitions, there was even a significant difference between the groups in their development.

These results suggest that the use of High Tone therapy in sport may have a positive effect and could influence regeneration. However, the differences recorded were not large enough to make a meaningful recommendation. The duration of the intervention period of only six weeks was too short for this. It would be of great interest to see how the arms would have developed over the course of further weeks.

In order to be able to make valid statements, further studies would therefore be necessary that deal with the topic over a longer period of time. Further research is therefore needed in this area to enable a well-founded assessment of the benefits of High Tone therapy in sport and its long-term effects on maximum strength increase and regeneration.

8 Summary

The aim of the study was to examine whether the targeted application of Tigh Tone therapy can have an influence on regeneration and thus on the increase in strength. The parameters chosen for testing were, on the one hand, the one-repetition maximum and, on the other hand, the maximum repetitions, which could be realized at about 70% of the maximum strength capacity. In the first part of the bachelor thesis, the objective and the current state of research were presented. In the following part, the methodology was presented in detail and the final results were evaluated.

A total of eight test subjects took part in the study. Six subjects successfully completed the study. Two of the test subjects had to end the intervention prematurely due to injury. Each of the test subjects was treated with High Tone therapy on one of the two arms. The other arm served as a control. Thus, each of the test subjects was the therapy and control group in one. This procedure made it possible to exclude deviations between the groups. The arm selected for treatment was determined during the initial test. The weaker of the two arms was chosen so as not to further promote possible imbalances. The one-repetition maximum was tested as a preacher curl variation with dumbbells and on the cable pulley. The maximum repetitions were tested with 70% of the determined maximum weight using the same procedure. The dumbbell variant was chosen for the detailed presentation. Subsequently, biceps strength training was carried out over a period of six weeks. The exercises were double-arm pre-curls, followed by chin-ups and standing barbell curls. The training was carried out three times a week as multi-set training in the BGM health studio. The test subjects were allowed to continue their own training during the intervention period. Unilateral exercises were not performed in order not to falsify the results. In addition to the strength training, High Tone therapy was carried out five times a week for 60 minutes on each arm under the supervision of the study director.

Within the six-week study period, each of the test subjects managed to significantly increase their strength abilities. The arm treated with High Tone therapy achieved the greater progress. This applied both to the improvement in the one-repetition maximum and to the increase in maximum repetitions. However, the differences between the "therapy" and "control" groups were not significant. Only the increase in maximum repetitions showed a significant difference between the groups in their development. The study shows that further Studies over a longer test period are necessary in order to be able to make valid statements about the benefits of High Tone therapy in sport.

9 Bibliography

Activity, M. P. (2020). WHO guidelines on physical activity and sedentary behavior. www.who.int. https://www.who.int/publications/i/item/9789240015128

Babov, K. D., Zabolotna, I. B., Plakida, A., Volyanska, V. S., Babova, I. K., Gushcha, S. & Kolker, I. A. (2022). The effectiveness of high-tone therapy in the complex rehabilitation of servicemen with post-traumatic stress disorder complicated by traumatic brain injury. Neurological Sciences, 44(3), 1039-1048. https://doi.org/10.1007/s10072-022-06510-0

High tone therapy - An overview - HiToP® PNP. (2020, July 14). HiToP® PNP. https://hitop-therapie.de/hochtontherapie-ein-ueberblick/

Hottenrott, K. (2010). Is the supercompensation model still relevant? ResearchGate. https://www.researchgate.net/publication/278300295_Ist_das_Superkompensa-tionsmodell_noch_aktuell

IGeL Monitor - High tone therapy. (n.d.). https://www.igel-monitor.de/igel-a-z/igel/show/hoch-tontherapie.html

clinical trials - HiToP® PNP. (2020, July 12). HiToP® PNP. https://hitop-thera-pie.de/klinische_studien/

Nonnenmacher. (n.d.). High tone therapy - treatment, effects & risks. Gesundpedia.de. Retrieved May 20, 2023, from https://gesundpedia.de/Hochtontherapie#Quellen

Ogrodzka-Ciechanowicz, K., Głąb, G., Ślusarski, J. & Gądek, A. (2021). Quadriceps muscle strength recovery with the use of high tone power therapy after anterior cruciate ligament reconstruction: a randomized controlled trial. BMC Musculoskeletal Disorders, 22(1). https://doi.org/10.1186/s12891-021-04862-w

Reichstein, L. (2005). Effective treatment of symptomatic diabetic polyneuropathy by High Tone external muscle stimulation. Retrieved May 25, 2023, from https://docserv.uni-duesseldorf.de/servlets/DocumentServlet?id=3538

Just 1 hour of sport per week helps against depression. (2018). Fortschritte Der Neurologie Psy-chiatrie, 86(07), 397-398. https://doi.org/10.1055/a-0631-3648

Schurr, S. (2012). Regeneration for athletes. Google Books. Retrieved May 25, 2023, from https://books.google.de/books?hl=en&lr=&id=gXE-wAQAAQBAJ&oi=fnd&pg=PT68&dq=Regenera-tion+im+Sport&ots=8Hjr8BvanI&sig=_9uyytrtTOV-DaEysNi2SHUMpQw&re-dir_esc=y#v=onepage&q&f=false

Ziegler, R. (2009). Regeneration in sport - the forgotten discipline. Sports Orthopaedics And Traumatology. https://doi.org/10.1016/j.orthtr.2009.09.004