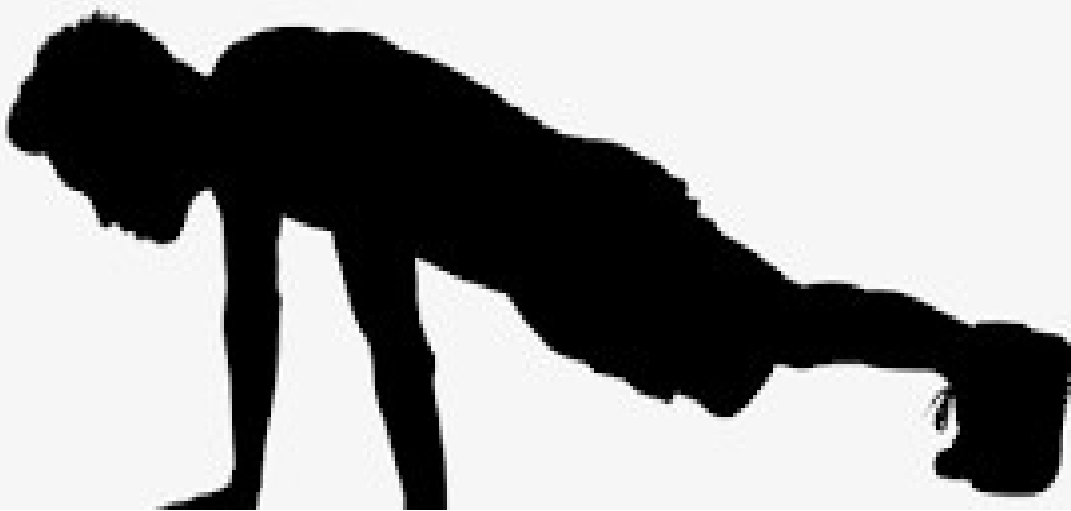


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Determinant Factors For The Performance In Two Calisthenic Exercises



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ABSTRACT

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Keywords: Calisthenics, Body weight, Strength Training, Relative strength, Absolute Strength, Fitness Testing, Body Composition.

The aim of this study was to identify the most determinant factors for the performance in the pull-up and push-up exercises and the relationship among Lat pull down and Bench press exercises.

Fifteen males with sport background were evaluated for different fitness tests which included: maximum number of repetitions in pull-up, maximum number of push-ups, one-repetition maximum Lat pull (1RM Lat pull), one-repetition maximum Bench press (1RM Bench press), Lat pull repetitions at a load equivalent to body mass (Lat pull at BM-load), Bench press repetitions at a load equivalent to the mean weight obtained from the push-up position all the way up and down which was scaled for each participant and different anthropometric variables.

Maximum number of pull-ups were significantly correlated with maximum number of push-ups ($r=0.80$, $P<0.01$) and with Lat pull at BM-load ($r=0.72$), but not with 1RM Lat pull ($r=-0.07$) nor 1RM Bench press ($r=0.08$). About body composition, pull-ups showed a significant negative correlation ($P<0.01$) with Body fat percentage ($r=-0.75$) and Fat mass ($r=-0.71$), while Body weight showed ($r=-0.61$, $P<0.05$) negative correlation.

These findings suggest that pull-up and push-up exercises have common elements when performing maximum repetitions. In addition, the anthropometric dimensions seem to influence differently on both exercises.

ACKNOWLEDGMENT

My thesis has been a very good opportunity to learn and get more experience in the field of coaching and fitness testing. My goal is to study a MSc in coaching and fitness testing, so this thesis has been a great practice for me.

I would like to thank all the volunteers who participated in my fitness testing since without them I would not have been able to do my research study.

In addition, I would like to thank all the teachers and staff from Kajaani University of Applied Sciences who helped me for my learning during my studies, in particular my tutor and thesis supervisor Kari Partanen.

On the other hand, I have to thank my supporter Fernando Pareja Blanco, from my Commissioning party Pablo de Olavide University, who helped me and encouraged me to do this thesis.

CONTENTS

1	INTRODUCTION	1
2	PURPOSE OF STUDY.....	3
	2.1 Aim of investigation	3
	2.2 Literature review.....	5
3	CALISTHENICS AND STRENGTH TRAINING.....	6
	3.1 Pull-up Vs Lat pull-down	9
	3.2 Push-up Vs Bench press	10
	3.3 How strength training affects the muscles	11
	3.4 Muscle strength	12
4	METHODS	14
	4.1 Body composition analysis and anthropometric assessment.....	15
	4.2 Fitness testing	16
	4.3 Statistical analysis	17
5	RESULTS	18
6	DISCUSSION	29
	6.1 Ethicality and Reliability	30
7	CONCLUSION	33
8	REFERENCES.....	34

1 INTRODUCTION

Calisthenics is a sport discipline which is becoming popular around the world. It has also got even more popularity during this pandemic we are going through, since so many people from different countries had to stay at home because the lockdown and they were not able to go out. That is one of the reasons why people started to train from home, so bodyweight training and calisthenics have started to become more popular. There have been different blogs and websites like “School of calisthenics”, which have offered calisthenics training programs or online trainings for free in order to make people active while staying at home (Jackson, 2020).

Calisthenics is a form of exercise in which athletes use their own bodyweight for training. It is designed to improve strength, flexibility, agility, balance, coordination, and aerobic conditioning (Mazzo, 2019).

One of the most important features of this sport is that it is made for everyone where people can decide the level where they are and it is very flexible and easy to develop since any fancy equipment is needed and it is possible to train wherever, so that makes this sport to be one of the cheapest ones.

In addition, calisthenics is also considered a competitive sport since there are different competitions such as “Street workout” and weighted calisthenics and street lifting which is the combination of Powerlifting and Calisthenics.

Back to my thesis topic, since calisthenics has become more important for me in the last few years, I wanted to make a study research about two common calisthenic exercises which are the pull-up and push-up. The main reason and objective for my research is to identify what are the most determinant factors for the performance in those exercises. There have not been done yet many studies about these calisthenic exercises, so that is one of reasons too why I wanted to make this research.

A total of fifteen male volunteers with some sport background, have participated in my study research. The different fitness tests were split in three different days with 48/72h of recovery between them. The tests included endurance performance for the calisthenic exercises, pull-up and push-up and strength performance for the bench press and Lat pull-down exercises. The reason why these exercises were chosen was because a comparative between them may allow coaches to know how to train or improve them. Moreover, different anthropometric measurements have been done to all the subjects and InBody Composition Analyzer 720 Bio-electrical Impedance (BIA) to analyze different body composition variables.

The commissioning party for my research was Pablo de Olavide University, located in Seville, and especially my thesis supporter Fernando Pareja Blanco, have helped me a lot in order to make this study.

A quantitative research will be used for this research, since different fitness tests, anthropometric measurements, and body composition variables have been planned for 15 trained subjects. All the data and results have been analyzed from PSCP Statistics program; Pearson's correlation coefficients and Linear Regression methods will be used.

2 PURPOSE OF STUDY

This study research is done to identify different variables for the performance in two calisthenic exercises: pull-up and push-up. Different measurement methods for data collection in fitness testing were used. Endurance and strength exercises have been used in the fitness tests.

This research has been conducted in order to get more experience and knowledge from the author in the coaching and fitness testing field.

In this study research, it has been studied important fields such as statistics: PSPP Statistics Program, fitness testing, calisthenics, and strength training.

The commissioning party of this research, Pablo de Olavide University and the author's mentor Fernando Pareja suggested to the author to do this research since not many studies have been done for the performance in the pull-up and especially in the push-up exercise.

2.1 Aim of investigation

The commissioning party Pablo de Olavide University has accepted the author's interest to work on this study and benefit from it. The investigation was mainly focused on the following:

Different fitness testing of some calisthenics and strength exercises which somehow are strongly related in order to find out possible correlations when analyzing the data. Secondly, some anthropometric measurements were done to the fifteen subjects, measuring mainly the biceps, chest and wingspan perimeter.

And lastly, body composition assessment done by “InBody Composition Analyzer 720” Bio-electrical Impedance measuring mainly the bodyweight, body fat percentage, fat mass, lean body mass and muscle mass.

The main objectives of this study are the following ones:

- To assess whether body composition variables taken to the subjects affect somehow to the performance of the calisthenics exercises: pull-up and push-up.
- To assess how important the biceps, chest perimeter and wingspan measure are for the performance of the calisthenics exercises.
- To find out correlations between both calisthenics exercises and two other strength exercises related in the same movement pattern as the bench press and the Lat pull-down.

Once everything has been tested, all the data from the fitness tests and the body composition variables of all the fifteen subjects will be analyzed using a statistics software program called PSPP; a program for statistical analysis of sampled data. It is the free version of SPSS program which is very similar but with few exceptions which did not affect to the author.

To be able to achieve the goals in this thesis process, all the important key points will need to be studied by the author since they are important for the research. Topics such as calisthenics, strength training, relative strength, absolute strength, and body composition variables which body fat, muscle mass, fat percentage, bodyweight, lean body mass, biceps and chest perimeter and strength, and middle body strength will be the most relevant ones for this study.

2.2 Literature review

To get support for the thesis process, few interesting scientific articles from the author's commissionary party have been provided to the author to get familiar and knowledge to his study research, which included fitness testing and body composition variables assessment too. Also, online information mainly from scientific journals and academic articles have been searched since they were very reliable and related to the thesis (The Journal of Strength and Conditioning Research, s.f.).

The theoretical background needed to support the study research included Calisthenics and strength training as the main topics, body composition, fitness testing, and PSPP Statistics program. In addition, the author's background about calisthenics and strength training were also an important value for the research as well as his personal development and learning in sport studies.

3 CALISTHENICS AND STRENGTH TRAINING

If we go back to history, the term of Calisthenics comes from Greek, “Kàlos” that means beauty and “Sthénos” that means strength. Over the years, this term has been updating to a set of bodyweight skills aiming to improve health and fitness (Thomas et al., 2017). It is designed to improve strength, flexibility, agility, balance, coordination, and aerobic conditioning. Calisthenics is a form of exercise in which athletes use their own bodyweight for training (Mazzo, 2019). These exercises have been used in different environments such as medical, military and schools. Nowadays the aim of this discipline is to increase strength in a variety of its expressions, such as performing the maximum number of repetitions of pull-ups, push-ups or parallel bar dips with and without an external overload, for strength endurance, or to lift the maximum possible weight in the previous mentioned exercises, for maximal strength (Thomas et al., 2017).

Calisthenics was a term used to define a generic set of body weight exercises. Such term is now used to define a worldwide spread discipline based on body weight and gymnastics exercises such as pull-up, push-up, muscle up, handstands and any other exercise which body weight is involved (Thomas et al., 2017).

According to the journal “The effects of a calisthenics training intervention on posture, strength and body composition”, Calisthenics training is a feasible and effective training solution to improve posture, strength, and body composition without the use any major training equipment. Therefore, calisthenics due to its low costs of practice, being this mainly practiced in public parks and basically everywhere since not fancy equipment is needed.

There is a private organization known as World Street Workout and Calisthenics Federation (WSWCF), where the main office is located in Riga, Latvia. This organization promotes different competitions such as local and international ones. But there are some other private organizations which organize competitions too (World Street Workout and Calisthenics Federation, 2020).

On the other hand, strength training, also known as weight or resistance training, “is physical activity designed to improve muscular fitness by exercising a specific muscle or muscle group against external resistance, including free weights, machines or your own body weight” according to the American Heart Association. Muscular strength is a fundamental component of physical fitness and a primary consideration for evaluating performance and prescribing exercise (J.L. Mayhew et al., 1991). Therefore, the main difference between calisthenics and strength training is the way how you train. As it was mentioned earlier, with calisthenics uses the bodyweight and involves compound exercises, on the other hand, strength training, use external weights like dumbbells and it involves isolated exercises.

The benefits of strength training include:

- Involves isolated exercises, so it increases the muscle mass.
- Resistance training and strength building
- Improves the absolute strength
- Protects bone health and muscle mass
- Develops better body mechanics, balance, coordination, and posture
- Helps with chronic disease management

One popular method very used in the strength training is the One-Repetition Maximum (1RM). This method is used to measure the current performance of the athlete before to start a training program. The 1RM is how much weight one is capable of lifting for just one repetition in one exercise, bench press or Lat pull-down for instance, the ones which I will use for my fitness testing (Robson, 2019).

When studying calisthenics and strength training exercises, it is important to mention and to differentiate the terms “Relative strength and Absolute strength”. Relative strength is how capable you are at moving your own bodyweight and Absolute strength is the maximum force that is produced when executing a resistance exercise (Vadnal, 2017). For instance, pull-up and push-up, both are a good measure of weight-relative strength, and Lat pull-down and bench press are good exercises to increase more your strength and it

is easier to progress. One example for absolute strength is the One-Repetition Maximum (1RM). Let's assume that one subject A bodyweight 65kg and lifted 90kg in an exercise and other subject B BW 90kg lifted 105kg; according to the numbers, subject B has greater strength in absolute strength, but talking about strength in relative values, the subject A was the one with greatest relative strength; $BW\ 65kg/90kg\ load = 1.38$ for subject A and $BW\ 80kg/105kg = 1.31$ for subject B (Vadnal, 2017).

For this study research, two different training methods will be used, strength and endurance training. As it was mentioned previously, the 1RM method was used for the bench press and Lat pull-down exercises.

On the other hand, for endurance, maximum repetitions in pull-ups and push-ups have been used, and maximum reps with bodyweight load for Lat pull-down and for bench press exercises.

When studying muscular endurance, is typically characterized by either the number of possible exercise repetitions until failure, or by the time one can maintain a prescribed pace of lifts or a posture. Strength training is difficult to combine with endurance types of activity. When strength and endurance training are done concurrently, it is difficult for an organism to adapt simultaneously to the conflicting demands. The solution is to conduct sequential strength and endurance programs. Focus first on strength training and afterward on endurance (Kraemer, 2006). That is why all the different tests have been split in three different days to have some recovery time for the individuals.

All athletes need strength - even endurance athletes like marathon runners. Keeping track of it by using regular strength tests like a grip test or a chin up test is an essential part for tracking the progress and performance of the athlete or the subject being tested.

Strength can either be tested by measuring the ultimate performance of an athlete for example, are they running any faster or by specific tests which are going to be my methods used for this thesis. These are useful for breaking down the components of that performance and measuring them more individually. But there are other ways why we use fitness tests, in this study, fitness testing has been used to make a study research, since

the author's goal was to find out correlations and variables which might affect for the performance in the calisthenic exercises.

3.1 Pull-up Vs Lat pull-down

The pull-up and latissimus dorsi pull (Lat pull) are two exercises commonly used to increase upper-body muscular pulling strength (Sánchez M. et al., 2016).

The pull-up is a calisthenic, multi-joint upper-body exercise, which is considered a valid measure of weight-relative muscular strength. In the pull-up, the individual grips a stationary bar overhead and pulls the body mass (BM) upward to the bar. The individual is typically limited to the use of BM as resistance, although external load can be added via a weighted vest or belt to achieve greater resistance. The pull-up has traditionally been used to test upper-body strength to BM ratio in children, adolescents, and men and women attending the U.S. military service academies (Sánchez M. et al., 2016). This exercise takes a certain amount of strength and is excellent for developing the latissimus dorsi and teres major muscles, and when the shoulder blades come together at the top, the rhomboids and middle and lower portion of the trapezius. For secondary muscles, it also works the biceps brachii, brachialis, and brachioradialis (Delavier, 2006).

The Lat pull-down exercise is a resistance exercise consisting of a shoulder adduction and an elbow flexion. A specially designed machine allows the subject to sit with support across the thighs to stabilize the lower body while pulling a horizontal bar downward from an extended overhead arm position, allowing the addition of external load to achieve the desired degree of resistance loading. Pull-up and Lat pull-down exercises appear to involve the same muscles performing similar motions, and they might be considered interchangeable in a training program (Sánchez M. et al., 2016). This exercise develops the bulk of the back. It mainly works the upper and central fibers of the latissimus dorsi, the middle and lower portions of the trapezius, the rhomboids, the biceps brachii, the brachialis, and, to a lesser extent, the pectorals also contract (Delavier, 2006).

In this study research, it will be determined if both exercises can be interchangeable or not and why, which variables are affecting for the performance in those exercises, and if there is any correlation between these exercises when talking about maximal repetitions in bodyweight load.

3.2 Push-up Vs Bench press

The bench press and the push-up are 2 classic push exercises for strengthening the upper body also used to assess maximal muscular strength or muscular endurance, respectively. In addition, the biomechanical similarities between these exercises have been established several years ago (Calatayud, 2015).

The push-up is a calisthenic, multi-joint upper body exercise. Push-ups have also been evaluated as an upper body strength test like the pull-ups. They are commonly performed, easy to execute that do not require expensive equipment. Thus, they can be readily included in a fitness program. In fact, push-ups have been recommended by a popular consumer publication as one of the best practical upper body exercises that can be used to enhance fitness. Push-ups can be used to measure upper body strength and power, but they can also be used to evaluate muscular endurance (William Ebben et al., 2011). Maximum push-up performance has been proposed as a “low-tech” method of measuring shoulder girdle and chest strength. The push-up is a simple exercise and relatively easily standardized. If the push-up test had a high relationship with 1RM bench strength, it might be a viable alternative for upper body strength testing. However, the load imposed by the push-up is not great, and the high repetitions achieved would indicate it may be more a test of muscular endurance than strength (J.L. Mayhew et al., 1991).

The push-up exercise is excellent for the pectoralis major and the triceps brachii. There are other muscles involved like the anterior deltoid and the anconeus (Delavier, 2006).

The bench press is an upper-body resistance exercise, since it builds the muscles of the chest as well as the triceps and the front deltoid shoulder muscles. This exercise can be done using a barbell or dumbbells (Rogers, 2020; The Journal of Strength and

Conditioning Research, s.f.). The bench press is one of the most popular exercises in a resistance training program and is used by novice and advanced weight trainers alike. The exercise requires the lifter to lower a barbell from a straight arm position and return it to full arms' length while lying supine on a bench. It is relatively easy to master and is often used as a central exercise in a resistance training program. In addition, when using the 1RM procedure, the bench press is one of the primary tests used for evaluating muscle strength (Mayhew, 1992).

The bench press engages the complete pectoralis major muscle, pectoralis minor, anterior deltoid, serratus anterior, coracobrachialis, and the triceps brachii (Delavier, 2006).

3.3 How strength training affects the muscles

Strength training can help people build muscle, both from myofibrillar and sarcoplasmic hypertrophy. This involves training against resistance that gradually increases over time. The strain this place on muscles causes damage to muscle fibers, which the body repairs. Repeatedly challenging the muscles in this way causes them to adapt by growing in size and strength. People can train to promote muscle growth by focusing on strength training, doing a variety of exercises, and getting good quality sleep (Kandola, 2020).

Strength training is an important way of building muscle size and strength. The goal of strength training is to induce muscle hypertrophy from straining the muscles to cause damage.

Strength training typically includes performing movements against resistance, including:

- Lifting weights,
- using resistance bands,
- performing bodyweight exercises, such as pushups,

- using weight machines.

Different types of strength training are suitable for different fitness goals, and people can choose to focus on specific muscle groups.

For example, bodybuilders who train for muscle size typically perform moderate intensity exercises with short rest intervals. On the other hand, powerlifters training for strength perform high intensity exercises with longer rests between sets (Kandola, 2020)

For general fitness levels, the following table shows the general standards for different types of strength training:

Table 1 – General standards sets and repetitions for strength training.

Training Zone	Fitness goal	Resistance
1 – 3 RM	Muscular Power	Very Heavy
3 – 7 RM	Muscular Strength	Heavy
8 – 12 RM	Muscular strength and Endurance	Moderate
13 – 25 RM	Muscular Endurance	Light

(Jennis, 2018)

3.4 Muscle strength

Muscular strength refers to the amount of force a muscle can produce with a single maximal effort. The size of your muscle fibers and the ability of nerves to activate muscle fibers are related to muscle strength. It is measured during muscular contraction. Building muscle strength helps with body alignment, makes performing everyday actions easier, and increases metabolism (Scott, 2021).

According to the American Council on Exercise (ACE), muscular strength is the ability to generate the maximal amount of muscle force while performing a particular exercise. But there are other factors that affect how strong you are and how much strength you have to complete daily chores or exercises. ACE provides definitions for these terms that are related to muscular strength:

- Muscular endurance: The ability to produce and sustain muscle force over a certain period of time.
- Muscular power: The ability to generate enough force to move weight in the shortest amount of time possible.

For example, the number of pushups you can do in one minute depends on your muscular strength, but also on your muscular power and muscular endurance.

What happens in your body to produce the effect of strength relies on several factors. The size of the muscle and the ratio of fast-twitch and slow-twitch fibers in that muscle is one component. Then the neural connection is key, as the motor neurons must be coordinated in their firing in order to signal the muscle fibers to contract at the same time. Strength also relies on the muscle having good support for the movement of the joint, including the health of the joints, bones, ligaments, and tendons (Scott, 2021).

One of the most common methods to measure muscle strength is the one-repetition maximum (1RM), as it was mentioned earlier at the beginning of this chapter.

4 METHODS

Quantitative research is the process of collecting and analyzing numerical data. It can be used to find patterns and averages, make predictions, test causal relationships, and generalize results to wider populations. Quantitative research is widely used in the natural and social sciences such as biology, chemistry, psychology, economics, sociology, and marketing (Bhandari, 2020).

This study used a quantitative research method for collecting the data through “In Body Composition Analyzer 720” Bio-electrical Impedance where many body composition variables have been analyzed as well as some anthropometric measurements to each individual and fitness testing. For analyzing all the data from the fitness tests as well as body composition assessment, descriptive statistics was used. Descriptive statistics are used to describe the basic features of the data in a study. They provide simple summaries about the sample and the measures. Together with simple graphics analysis, they form the basis of virtually every quantitative analysis of data (Trochim, 2020).

Another statistical method used for the thesis was Pearson’s correlation coefficient. This method measures the statistical relationship, or association, between two continuous variables. It is known as the best method of measuring the association between variables of interest because it is based on the method of covariance. It gives information about the magnitude of the association, or correlation, as well as the direction of the relationship. A Pearson correlation is a number between -1 and +1 that indicates to which extent 2 variables are linearly related (Berg, 2021).

The research problems from this study are the following ones:

- To assess whether body composition variables taken to the subjects affect somehow to the performance of the calisthenic exercises: pull-up and push-up.
- To find out correlations between both calisthenic exercises and two other strength exercises related in the same movement pattern as the bench press and the Lat pull.

- To assess how important the biceps, chest perimeter and wingspan dimensions are for the performance of the calisthenic exercises.

4.1 Body composition analysis and anthropometric assessment

Each participant who participated in the fitness testing has been tested to analyze their body composition with “In Body Composition Analyzer 720” Bio-electrical Impedance. Every participant was tested during the morning and fasting to get the best and most reliable results.

The InBody test provides a comprehensive view of body composition balance analyzing body water, proteins, minerals and body fat, which are the components of the human body closely relate to the status of our health. Using the method of quantitative analysis, these elements of body composition and body composition analysis provide basic information required for assessing the status of the body (InBody, 2014).

The most important variables to analyze for this study research are the body fat, muscle mass, lean body mass, body weight, arms lean body mass, body fat % and trunk lean body mass.

On the other hand, anthropometric assessment are a series of quantitative measurements of the muscle, bone, and adipose tissue used to assess the composition of the body. The core elements of anthropometry are height, weight, body mass index (BMI), body circumferences (waist, hip, and limbs), and skinfold thickness. These measurements are important because they represent diagnostic criteria for obesity, which significantly increases the risk for conditions such as cardiovascular disease, hypertension, diabetes mellitus, and many more. There is further utility as a measure of nutritional status in children and pregnant women. Additionally, anthropometric measurements can be used as a baseline for physical fitness and to measure the progress of fitness (Casadei & Kiel, 2020).

Some anthropometric measurements were done to each participant. The biceps perimeter in relaxation and muscle contraction was measured as well as the chest perimeter and the wingspan dimension. Everything was measured with a tape measure. The reason why these specific measurements have been taken, was to find out if it affected for the performance in the calisthenic exercises.

4.2 Fitness testing

Fifteen male students with sports experience were tested, some participants were more experienced with pull-up and push-up exercises than others, so it might have affected slightly the results obtained.

There were a total of six different fitness tests which were split in three testing sessions separated by 24-48 hours, and it was conducted in the following order: **1)** pull-up testing maximum repetitions followed by push-up maximum repetitions, there was between 10-20 minutes recovery time between tests, as long as the participant felt ready to start the next one. The pull-up and push-up exercises were performed in a strict form, chin over the bar, all the way up and all the way down with full range of motion, and without breaks. It was measured the grip length for each participant in both exercises, with a tape measure, which have been utilized for the next tests. **2)** One repetition maximum Lat pull down (1RM Lat Pull) followed by Lat pull maximum repetitions to muscular failure at a load equivalent to body mass (Lat Pull at BM-load). The one repetition maximum test (1RM) was conducted following the same protocols for every participant; a warm-up set was performed with 5-10 reps with a weight each participant could make, 1 minute recovery. Then the weight was increased about 5-10% and between 3-5 repetitions, 2-3 minutes recovery. Once again weight was increased 5-10% and just 1 repetition, if it was well enough performed, 2-3 minutes recovery and weight was increased 5-10% again. When the subject could not perform the repetition anymore, weight was decreased 2,5-5% and 2-3 minutes recovery and another attempt with the new weight. After 10-15 minutes recovery the second test was performed, Lat pull repetitions at a load equivalent to body mass; same protocols than pull-ups, full range of motion and without breaks, when the

subject stopped for 1 second test was over. **3)** One repetition maximum bench press (1RM Bench Press); same protocols than 1RM Lat pull. After 10-15 minutes recovery, repetitions to muscle failure with the mean weight obtained from the push-up position all the way up and down which was scaled for each participant. Same criteria than other tests, all the way up and down and without breaks.

4.3 Statistical analysis

Descriptive statistics has been used to analyze all the data obtained from the different fitness tests and anthropometric assessment for each individual. Correlations were also used to find relationships between variables. The correlation is one of the most common and most useful statistics (Trochim, 2020).

The symbol (r) is used to stand for the correlation. It turns out that (r) will always be between -1.0 and +1.0. If the correlation is negative, we have a negative relationship; if it is positive, the relationship is positive (Trochim, 2020). If the correlation is near to 0, that means there is no correlation.

Another statistical method used for the thesis was Pearson's correlation coefficient. This method measures the statistical relationship, or association, between two continuous variables. It is known as the best method of measuring the association between variables of interest because it is based on the method of covariance. It gives information about the magnitude of the association, or correlation, as well as the direction of the relationship. A Pearson correlation is a number between -1 and +1 that indicates to which extent 2 variables are linearly related (Berg, 2021).

5 RESULTS

Before to start analyzing the correlations found it, it is important to mention what was the mean and the SD (Standard Deviation) for each fitness test for the 15 participants. Standard Deviation is a measure of dispersion in statistics. Dispersion tells how much the data is spread out around the mean or average (Glen, 2021).

In the maximal repetitions in Pull-up (A), the Mean was 15.3 and the SD 4.99. Maximal repetitions in Push-up (B), the Mean was 41.3 and the SD 10.27.

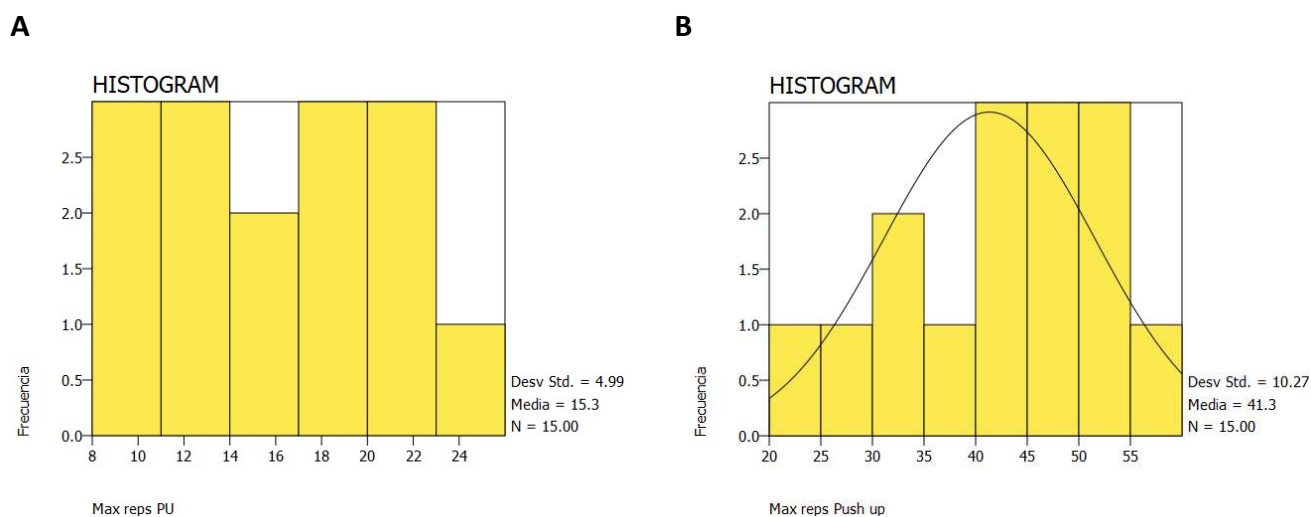


Figure 1 - Relationship between the mean and SD in Max reps PU and Max reps in Push-ups.

In the 1RM Bench press (C), the Mean was 92.3kg and the SD was 20.69. In the 1RM Lat pull down (D), the Mean was 93.6kg and the SD 15.96.

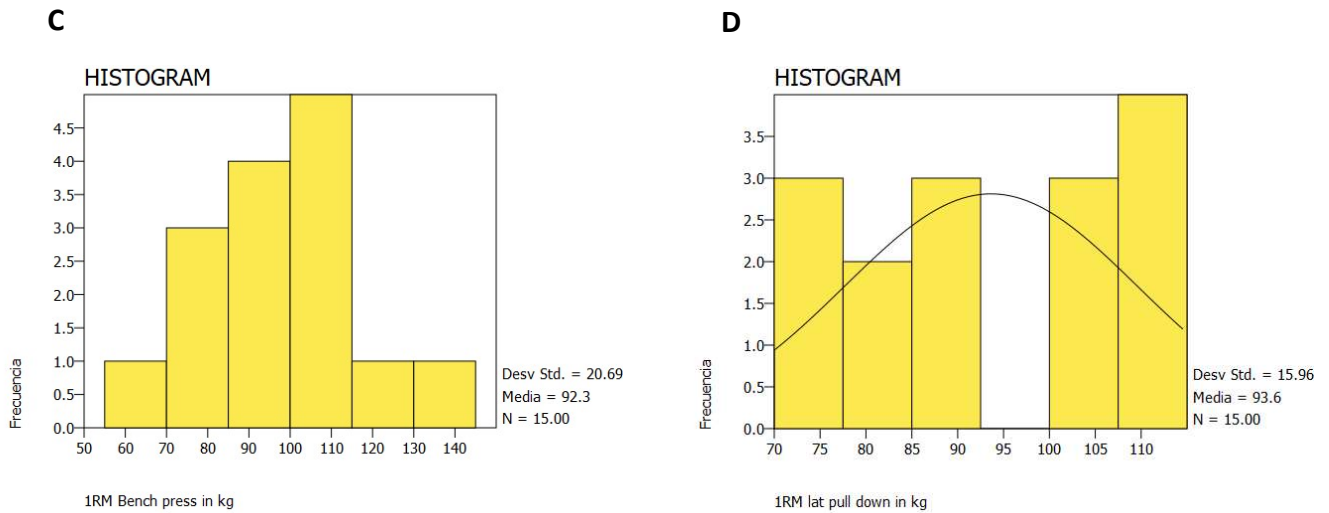


Figure 1 - Relationship between the mean and SD in 1RM bench press and 1RM Lat pull down

In the maximal repetitions Bench press (E), the mean was 23.2 and the SD 7.97. In the maximal repetitions Lat pull down (F), the mean was 11.4 and the SD 5.46.

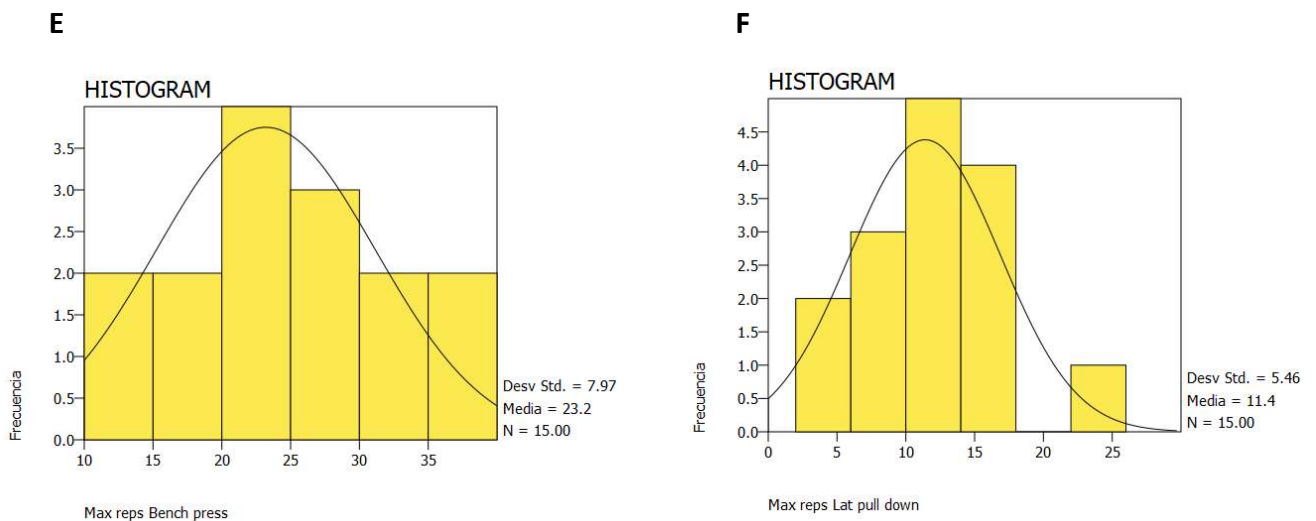


Figure 2 – Relationship between the mean and SD in maximal repetitions Bench press and maximal repetitions in Lat pull down

The results have been divided in three different groups. Table I shows the relationship in the performance analysis in all the fitness tests. Pull-ups showed some significant relationships ($P < 0.01$) between maximal repetitions in Push-up ($r = 0.80$), maximal repetitions Lat pull at BM-load ($r = 0.72$), Relative strength Lat pull ($r = 0.59$), and Relative strength Bench press ($r = 0.60$). Push-ups showed some correlations as well between Relative strength Lat pull ($r = 0.52$), Relative strength Bench press ($r = 0.63$), Maximal repetitions in Lat pull at BM-load ($r = 0.62$) and maximal repetitions in Bench press ($r = 0.52$). No significant relationships were observed between maximal repetitions Pull-up and 1RM Lat pull ($r = -0.7$), maximal repetitions Pull-up and 1RM Bench press ($r = 0.08$), maximal repetitions in Pull-up and maximal repetitions Bench press ($r = 0.44$), maximal repetitions Push-up and 1RM Lat pull ($r = 0.21$) and maximal repetitions Push-up and 1RM Bench press ($r = 0.37$).

Table I – The relationship in the performance analysis in the fitness tests.

PERFORMANCE ANALYSIS		Max reps PU	Max reps Push up	1RM Bench press	Max reps Bench press	1RM Lat pull	Max reps Lat pull	Relative Strength-Bench	Relative Strength-LatPull
Max reps PU	Pearson Correlation	1.00	.80***	.08	.44	-.07	.72**	.60*	.59*
Max reps Push up	Pearson Correlation	.80***	1.00	.37	.52*	.21	.62*	.63*	.52*

* Indicates p-values lower than 0,05, ** indicates p-values lower than 0,01; *** indicates p-values lower than 0,001

Table II shows the relationship in the technique used for the participants during the performance, but no significant relationships were observed. Maximal repetitions Pull-up and grip pull-up in cm ($r=-0.15$), maximal repetitions Pull-up and grip push-up in cm ($r=-0.8$), maximal repetitions in Push-up and grip push-up in cm ($r=-0.12$), and maximal repetitions Push-up and grip pull-up in cm ($r=-0.23$).

Table II – The relationship in the technique analysis.

TECHNIQUE ANALYSIS		Grip push up in cm	Grip pull up in cm
Max reps PU	Pearson Correlation	-.08	-.15
Max reps Push up	Pearson Correlation	-.12	-.23

Table III shows the relationship in the anthropometric analysis made with the InBody Test. Few significant relationships ($P<0.01$) were observed between maximal repetitions in pull-up and Body mass in Kg ($r=-0.61$), Fat percentage ($r=-0.75$), and Fat Mass in Kg ($r=-0.71$). No significant relationships were observed in maximal repetitions push-up with any anthropometric variable.

Table III – The relationship in the anthropometric analysis and the body composition assessment.

ANTHROPOMETRIC ANALYSIS		Age	Height in cm	Biceps perimeter in cm	Biceps contraction cm	Chest perimeter cm	Wing-span perimeter cm	Body-weight in kg
Max reps PU	Pearson Correlation	-.03	-.29	-.39	-.37	-.27	-.05	-.61*
Max reps Push up	Pearson Correlation	.01	-.30	.01	.07	-.04	.11	-.23

ANTHROPOMETRIC ANALYSIS		Body Fat %	Fat mass in kg	Muscle mass in kg	Middle body in kg	Arms in kg	Legs in kg	Lean body mass in kg
Max reps PU	Pearson Correlation	-.75**	-.71**	-.40	-.33	-.30	-.44	-.42
Max reps Push up	Pearson Correlation	-.49	-.42	.02	.03	.08	-.11	.00

*Indicates p-values lower than 0,05, ** indicates p-values lower than 0,01; *** indicates p-values lower than 0,001

About the correlations found and analyzed in the pull-ups, the graph shows the relationship between the maximal repetitions in pull-ups and the maximal repetitions in push-ups meaning that the subjects who performed more reps in push-ups were the ones who performed more repetitions in pull-ups. So, it was a positive correlation.

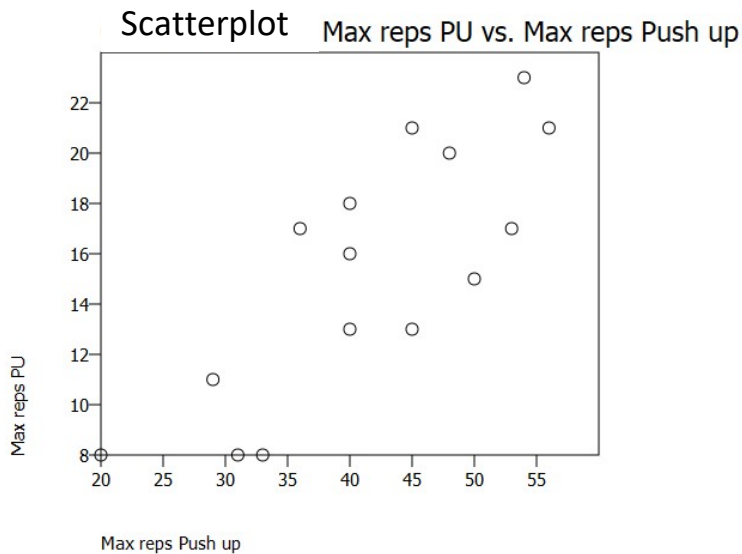


Figure 1 – The relationship between the maximal repetitions in pull-ups and the maximal repetitions in push-ups.

Also, in the next graph, you can observe a positive correlation between the maximal repetitions in Pull-ups and maximal repetitions in Lat pull at BM-load. The ones who performed more repetitions in pull-ups were the ones who did more repetitions in the Lat pull at BM-load.

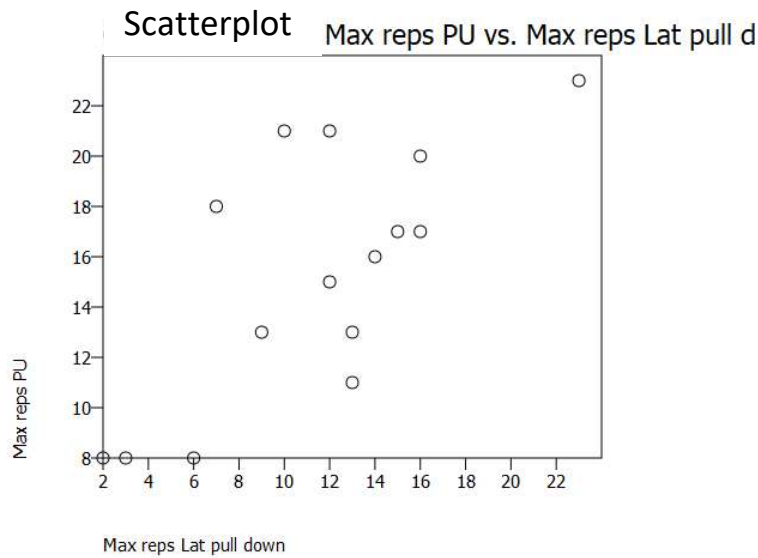


Figure 2 – The relationship between the maximal repetitions in pull-ups and maximal repetitions in Lat pull at BM-load.

Another correlation found it was the relationship between maximal repetitions pull-up and the relative strength in bench press. The ones who performed more repetitions in pull-ups were the ones with a higher relative strength in bench press.

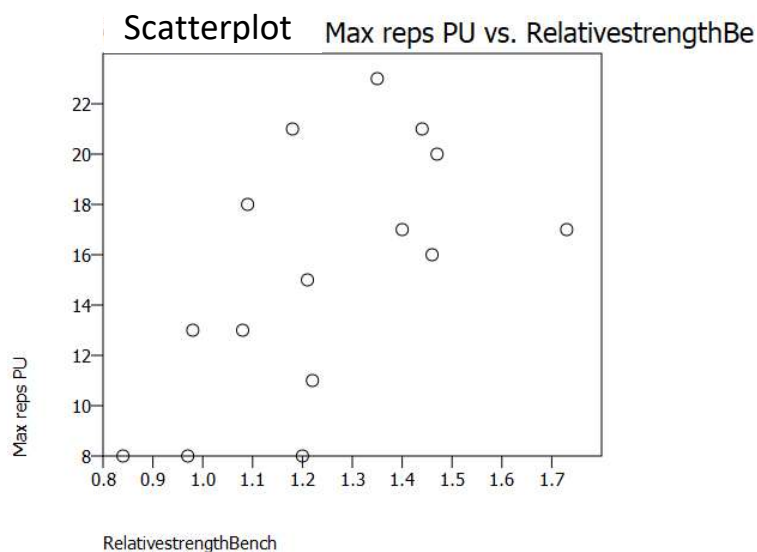


Figure 3 – The relationship between maximal repetitions pull-up and the relative strength bench press.

Also, the relationship between maximal repetitions pull-ups and relative strength in Lat pull was a positive correlation. The subjects who performed more repetitions in pull-ups were the ones with a higher relative strength in Lat pull down.

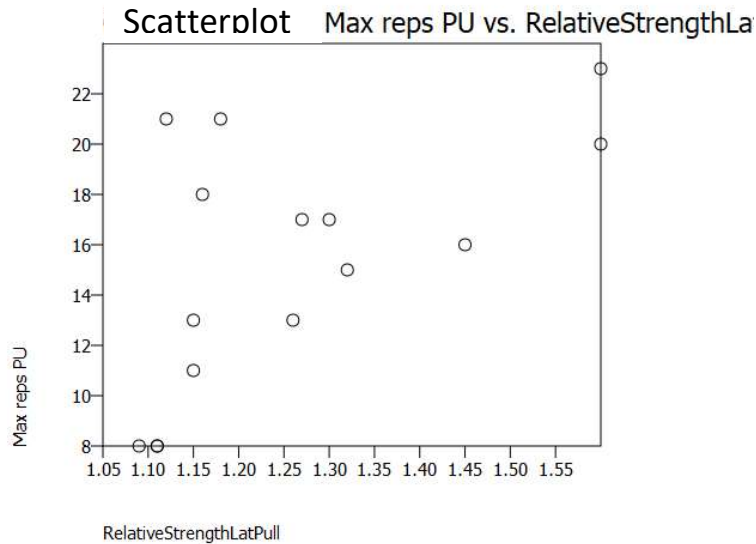


Figure 4 – The relationship between maximal repetitions pull-ups and relative strength in Lat pull.

In this case, comparing the subjects' bodyweight with the maximal repetitions in pull-ups, we can observe that the heavier ones were the ones who did less repetitions in pull-ups and the lighter ones performed more repetitions. It was a negative correlation.

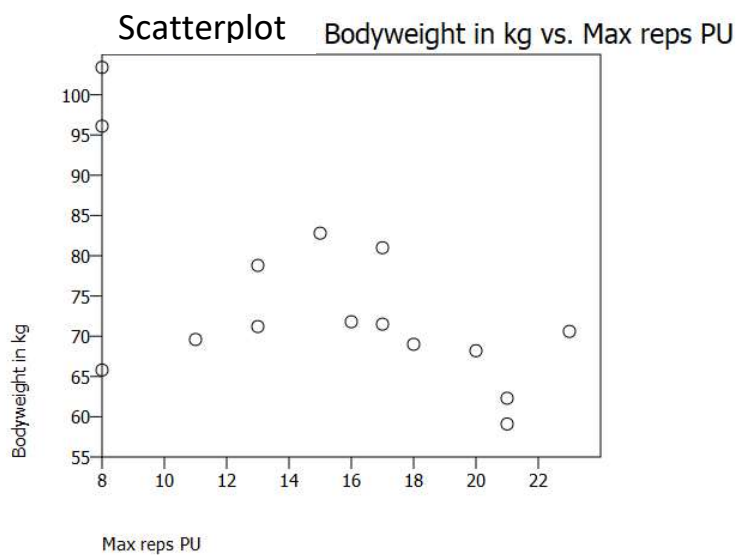


Figure 5 – The relationship between bodyweight and maximal repetitions in pull-ups.

Another negative correlation was the ones with higher body fat percentage were the ones who performed less repetitions in pull-ups comparing with the ones with lower body fat percentage.

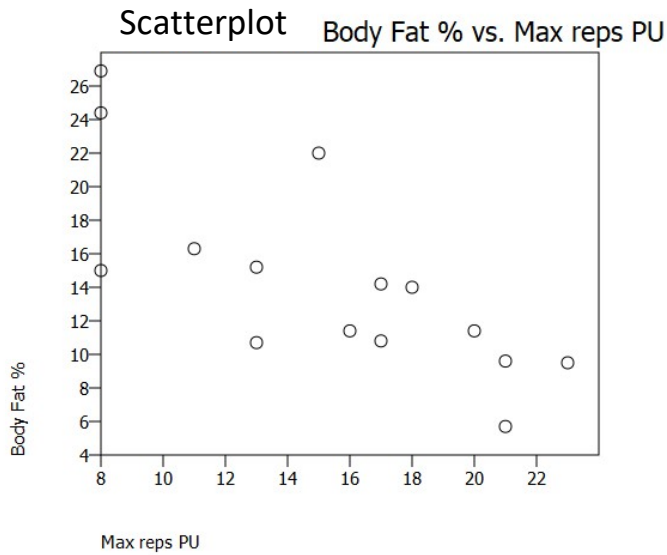


Figure 6 – The relationship between body fat % and maximal repetitions in pull-ups.

And last negative correlation was the subjects with higher fat mass were the ones who performed less reps in pull-ups comparing with the subjects with lower fat mass.

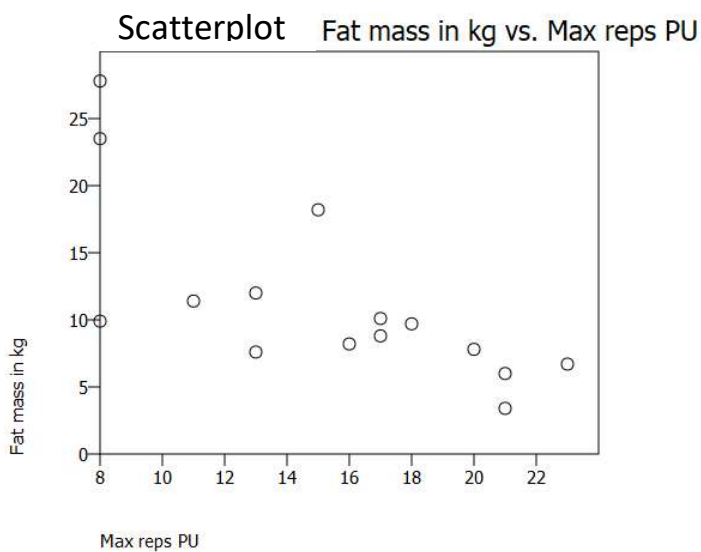


Figure 7 – The relationship between fat mass and maximal repetitions in pull-ups.

On the other hand, there were also some correlations observed in the maximal repetitions in push-ups. Like in pull-ups test, the subjects who did more repetitions in push-ups were the ones who performed more repetitions in pull-ups.

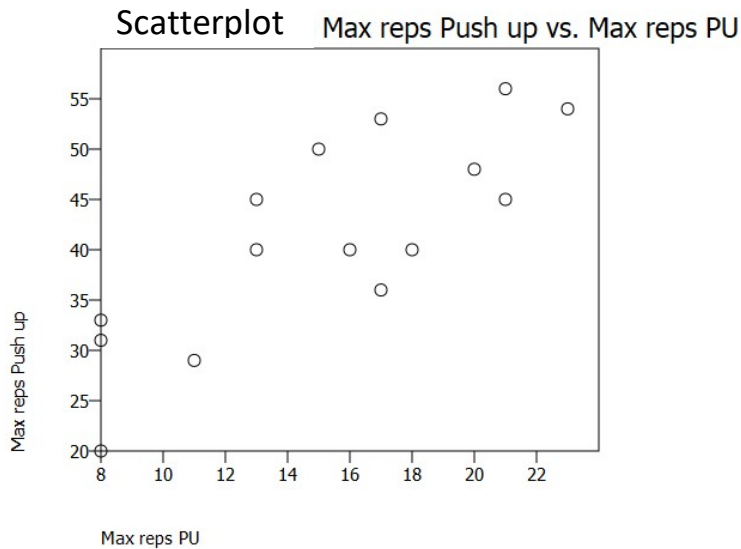


Figure 8 – The relationship between maximal repetitions push-ups and pull-ups.

Another positive correlation found was the relationship between maximal repetitions in push-ups and maximal repetitions in bench press.

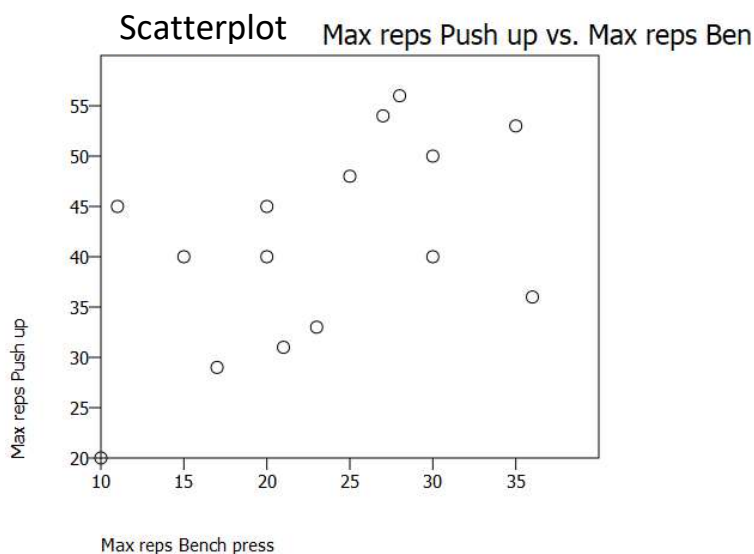


Figure 9 – The relationship between maximal repetitions push-ups and maximal repetitions bench press.

The relationship between maximal repetitions in push-ups and maximal repetitions in Lat pull down was also a positive correlation.

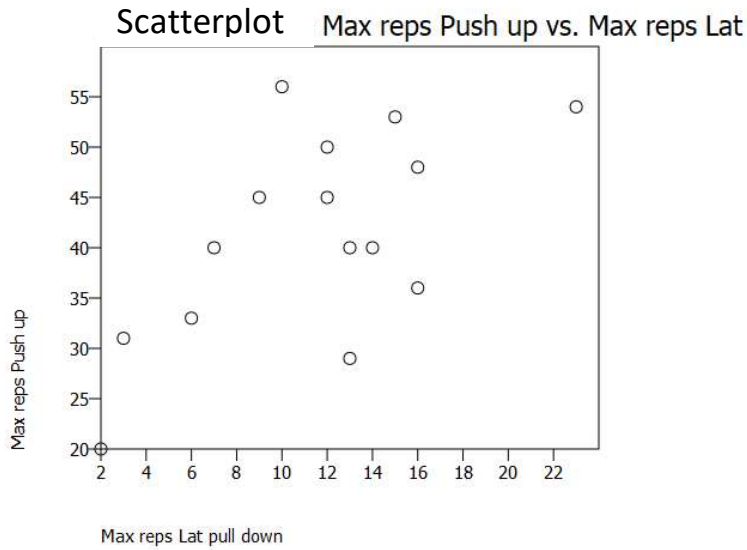


Figure 10 – The relationship between maximal repetitions push-ups and maximal repetitions Lat pull at BM-load.

The relationship between maximal repetitions in push-ups and the relative strength in bench press also showed linear dependence.

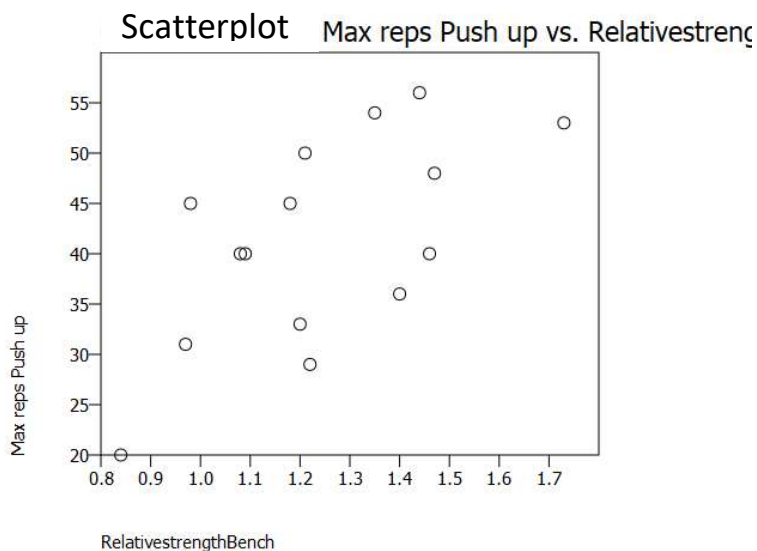


Figure 11 – The relationship between maximal repetitions push-ups and relative strength in bench press.

And lastly, it was observed another positive correlation between maximal repetitions in push-ups and the relative strength in Lat pull down exercise.

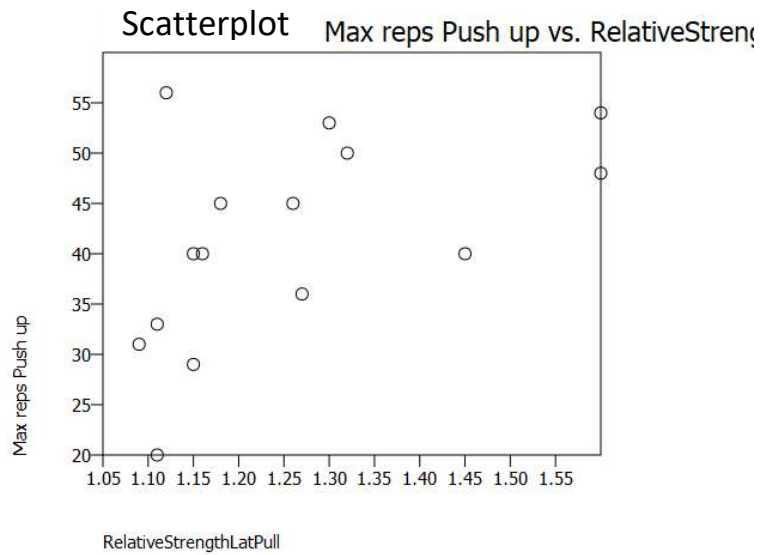


Figure 12 – The relationship between maximal repetitions push-ups and relative strength in Lat pull down.

6 DISCUSSION

The purpose of this study was to investigate the most important variables for the performance in the pull-up and push-up exercises. Also, an investigation was done to analyze if there is any relationship between these two calisthenics exercises with two strength exercises: bench press and Lat pull down.

One of the main findings in this study was that pull-up performance showed significant relationships with different strength measures in Lat pull down at BM-load ($r=0.72$), in push-up performance ($r=0.80$), in bench press relative strength ($r=0.60$) and in Lat pull down relative strength ($r=0.59$), (Table I). Relative strength means that the greater it was to BM, means that a load equivalent to BM represents a lower relative effort. Meaning that a greater number of repetitions might be performed with this load.

There was not any significant relationship taking into consideration maximal strength, in 1RM Bench press and 1RM Lat pull, and either in maximal repetitions bench press.

In addition, the relationships observed between pull-up and anthropometric variables says that there is an influence of absolute values of BM, FM and Body Fat percentage on pull-up performance, but not in push-up performance, (Table III). Therefore, there were found negative correlations when considering Body Mass, Fat Mass and Body Fat percentage, meaning that the higher these anthropometric variables were the lower the repetitions were in the pull-up performance.

On the other hand, talking about the push-up performance, no significant relationship was found when considering anthropometric variables, (Table III). It did not affect much for the performance in this exercise. However, it showed significant relationships taking into account different fitness tests like the pull-up performance ($r=0.80$), maximal repetitions bench press ($r=0.52$), maximal repetitions Lat pull ($r=0.62$), Relative strength in bench press ($r=0.63$) and Relative strength Lat pull ($r=0.52$), (Table I).

There was not any significant relationship in pull-up or push-up performance when considering the technique analysis (the grip width in pull-up and push-up) showed in the Table II.

In addition, it was observed that pull-up or push-up could not be predicted when 1RM Lat pull and 1RM Bench press was performed but could be predicted when Lat pull was combined with BM and Bench press was combined with the mean weight obtained from the push-up position all the way up and down which was scaled for each participant. The fact of greater amounts of BM, FM and Fat percentage were in detrimental to pull-up performance, and it suggests that heavier athletes might penalty for relative strength values, however, this heavier mass might suppose a benefit for absolute strength performance.

6.1 Ethicality and Reliability

When doing any kind of research work, it is important to have some ethical values as well as some reliability. The most common way of defining “ethics”: norms for conduct that distinguish between acceptable and unacceptable behavior. There are several reasons why it is important to add to ethical norms to research. First, norms promote the aims of research, such as knowledge, truth, and avoidance of error. Secondly, ethical standards promote the values that are essential to collaborative work, such as trust, accountability, mutual respect, and fairness. Thirdly, many of the ethical norms help to ensure that researchers can be held accountable to the public. Fourthly, ethical norms of research also help to build public support for research. And finally, many of the norms of research promote a variety of other important moral and social values, such as social responsibility, human rights, safety, etc. (David B. Resnik, 2020).

Firstly, it is needed to be mentioned that all the report of this study research has been accurately written and author’s citations have been made when needed as well as figures and tables have been taken from PSPS Statistics Software Program. One way of honesty is to give credit to someone when using one’s work and avoiding plagiarism. Data,

methods, results, and procedures have been presented honestly. Research results, methods and all the data obtained, have not been fabricated or falsified. All the participants for this research project have taken part voluntarily and all of them have been treated equally without any discrimination and all their important personal information has been confidential. Some pictures about the fitness tests and anthropometric measurements have been used for the research with the permission of some of the participants.

On the other hand, reliability refers to how consistently a method measure something. If the same result can be consistently achieved by using the same methods under the same circumstances, the measurement is considered reliable (Middleton, 2019). When using the research methods: body compositions analysis, anthropometric measurements, fitness tests, and PSPP Statistical Analysis Program; each participant was measured in the same circumstances. For instance, when performing the “In Body Composition Analyzer 720” Bio-electrical Impedance, each subject was measured fasting and, in the morning, so everybody was tested under the same conditions to ensure reliability. The author considers valid and accurate results given by the test through the “In Body Composition Analyzer 720” Bio-electrical Impedance.

About the fitness tests, all the individuals were informed about the process and protocols when performing each test. All the procedures were explained in the “Methods” section. How to perform each test, the recovery time, the technique applied was explained before to the participants. Some of the factors which might affected to the reliability were that some of the participants had more experience in the pull-ups and push-ups exercises than others as well as the external factors which might varied the results like the fatigue, the moods, etc. Some of the participants performed the pull-ups and push-ups test with a wrong technique even they were informed earlier how to do it; accordingly, both tests were repeated once again in a different day with the right technique to ensure reliability.

Talking about how the data was analyzed, PSPP Statistical Analysis Program was used for that purpose. PSPP is a stable and reliable application. It can perform descriptive statistics, T-tests, Anova, linear and logistic regression, measures of association, cluster analysis, reliability and factor analysis, non-parametric tests and more. Its back end is designed

to perform its analyses as fast as possible, regardless of the size of the input data (PSPP, 2021).

Another factor that adds reliability to this research is my own background in the field of sports and my experience in calisthenics and bodyweight training. I started training with calisthenics since 2017, so I got familiar with the most popular bodyweight exercises: the pull-up and the push-up. In addition, I also got some experience in maximal strength training, for instance, when performing a 1RM test which was also used in my research. With that experience and knowledge that I have had previously and the learning I have acquired during my studies at Kajaani University of Applied Sciences, I hope that all my research methods utilized for my research have been reliable and successful.

7 CONCLUSION

In conclusion, these findings suggest that pull-up and push-up have common elements when performing maximum repetitions. In addition, pull-up and Lat pull at same BM-load have common elements, but not on 1RM Lat pull. According to other studies heavier BM, even if it is mostly LBM, may invoke a certain penalty on pull-up and Lat pull at BM-load performance, but could have a positive effect on 1RM Lat pull (Sánchez M. et al., 2016).

In these findings, pull-up performance was influenced when BM, body fat percentage and FM were taken in account, but not in push-up performance. On the other hand, the anthropometric measurements done by the writer of this study did not affect for the performance in the calisthenic exercises, meaning that it did not matter how big subjects' biceps, chest perimeter or wingspan dimensions were when performing the fitness tests.

Previous authors state that pull-up and Lat pull are analogous exercises when body composition factors as BM, FM and body fat percentage are taken in account (Sánchez M. et al., 2016). On the other hand, push-up and bench press might have common elements when BM is considered. Lastly, when relative strength is considered pull-up and push-up have similarities with Lat pull and bench press exercises.

The entire study research, taking into account the few numbers of participants; it represented a great opportunity by the author to have done a real study case. The study made by the author contributed to enlarge his knowledge in the coaching and fitness testing field. Moreover, it will also reinforce his curriculum for his work career in the field of sports.

The lack of experience in fitness testing by the author was a little obstacle during the performance of the tests since it might have been easier and accurately to have had some assistant to help the author out during the fitness testing sessions. However, the author managed all the difficulties and he carried out all different events for this study as good as possible.

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