Fontys
University of Applied Sciences

Fontys Paramedic University of Applied Sciences

Physiotherapy, English Stream

Bachelor Thesis

Is there a correlation between the result of a Forced Vital Capacity (FVC) test and a Maximum Hand Grip Strength (MHGS) test in young adults?

- an observational cross-sectional study.

Preface

This observational cross-sectional study was performed in order to investigate the relationship between forced vital capacity and maximal hand grip strength. To date, no studies have been conducted with the aim to find a correlation between these two parameters in healthy young adults. This is what inspired me to conduct further research into the field. The investigation was done in healthy second year physiotherapy students. The start was made in February 2015 and the finished product was handed in in June 2015.

This project was part of a greater study where multiple data was collected to calculate risk factors for chronical diseases; Screening Adolescents, Young Adults for Risk Factors for Chronic Diseases. All testing was done together with three fourth years fellow students, Ivo van Knippenberg, Miriam Myrsten and Niels van Hoof. I would like to thank all of them as it was a great team to work with. They were all determined and involved in order to complete this study in time. Thanks also to my thesis supervisor, Steven Onkelinx for a great guidance, and for always being available for feedback and questions.

Furthermore, I would like to thank Miriam Myrsten, and Cas Fuchs for their peer reviewing of this research product.

This thesis is part of my final project to conclude my 4 years of studying physiotherapy at the University of Applied Sciences, Eindhoven. A number of friends and family have supported me and guided me through this study, I owe my gratitude to you.

Andréa Gustafsson, 29 May 2015

Author: Andrea Gustafsson
Department of Physiotherapy, English Stream, Fontys University of Applied Sciences, Eindhoven, The Netherlands. Student number: 259704.
E-mail:a.gustafsson@student.fontys.nl Tel: +31-657109123.

Supervisor:
Steven Onkelinx, E-mail:Steven.onkelinx@fontys.nl, Tel: +316222948396

General thesis supervisor:
Anke Lahije. E-mail: a.lahaije@fontys.nl, Tel: + 31620935802.

Abstract

Introduction: Strength training is a part of the physical therapy for COPD patients, in particular to keep the lungs functioning optimally and to retain the strength of skeletal muscle tissue. It would be interesting to see whether there is a relation between overall body strength and lung capacity. Therefore, we aim to investigate whether there is a correlation between a FVC test and a MHGS test in healthy young adults.

Method: 137 physiotherapy students were invited to participate in this research project. FVC was measured by a spirometer (Spirobank G) and MHGS was measured by a hand dynamometer (Nurytec). Pearson's Correlation Coefficient was used to calculate the correlation.

Results: 86 subjects completed this study. The participants were between the age of 18 and 26. Thirty nine (45,3%) of the participants were males, forty seven (54,7%) were females. A significant correlation (p: <0,0001) was found when paralleling the outcomes of both tests in the total group. Pearson's correlation coefficient between FVC and MHGS was found to be moderate to strong (r= 0.677) when comparing the results of the total group.

Discussion and conclusion: The results from the total group indicate that there is a high likelihood that individuals which perform a high FVC will also perform a high MHGS test. The correlation between the tests was also calculated when splitting the group into males and females. However, then the correlation transformed into a weak correlation (Males r:0,303, Females r:0,326).

Context

Introduction

The burden of chronical diseases is increasing in our society on a daily basis. Nowadays, the third leading cause of death in the world is the lung condition; Chronical obstructive pulmonary disease (COPD), making this disease one of the major health challenges in the future. In addition, it represents a huge rising economic and social burden (1). Yet there is limited data available on its natural history in young adults (2).

COPD is defined as an airway limitation, which causes a slow and protracted exhalation, involving structural changes in the lungs. This term includes all known lung diseases caused by chronic narrowing of the airways. It is generally accepted that smoking is the leading risk factor for COPD, although there are other aetiologies of COPD present (3). Other factors that may cause COPD are heredity, air pollution, hypersensitivity to certain substances, infections, occupational exposure to irritants or reduced lung development (1). Apart from being one of the most common chronical diseases, there is also a correlation between COPD and other chronical diseases; lung cancer and other cancers, diabetes, obstructive sleep apnoea syndrome, asthma, hypertension, cardiovascular disease, metabolic syndrome, dysfunctional skeletal myopathies, osteoporosis and mental disorders (4).

Patients with airway limitations share physical inactivity as a characteristic risk factor for their health condition. Physical inactivity is the main reason for a reduced endurance capacity and decrease in skeletal muscle strength. Strength training is an essential aspect of the physical therapy of COPD/asthmatic patients, in particular to keep the skeletal muscles strong and to prevent atrophy (5). Throughout the years studies have been done in relation to elderly with COPD as well as long term smokers with COPD. However, limited studies have been performed regarding COPD and other lung restrictions in healthy young adults.

There are numerous ways to test if the lungs are working optimally. The most often used method in the healthcare is the spirometer. The spirometer is used to measure lung function and to detect obstructive lung diseases. With the outcome of the test one can determine whether there is a suspicion or if a participant is obstructive (or restrictive) (1). Lung function is often assessed by measuring Forced Expiratory Volume (FEV) and Forced Volume Capacity (FVC)(6). A low FEV/FVC is often related to all-cause mortality and cardiovascular mortality (7).

In the GOLD guidelines for assessing a patient with COPD it is also recommended to use the Maximum Hand Grip Strength (MHGS) as a test, since it is a good indicator of total body strength and COPD patients often show diminished strength (1)(8). Muscle strength tests are suitable within many different target groups; healthy subjects, people with neurological complaints, individuals with chronical complaints and more. The advantage of a MHGS test is that one needs little attributes, the protocol is simple, the test takes little time and that the test can be performed at many different target groups (9). Grip strength is related to total muscle strength. This indicates, in the clinical setting, that muscular hand grip strength may be used as a tool to get a rapid indication of a subjects general muscle strength(10).

Clinimetrics is a vital part within the physiotherapy sector, it is a part of the diagnostics or as evaluation of a treatment. The best way to diminish the occurrence of COPD and other chronical diseases is to control the risk factors (5). But are there potential risk factors in young adults which we could decrease if we knew more about them?

The aim of this study is to evaluate if there is a correlation between lung capacity and overall body strength. This will be investigated by measuring and comparing FVC and MHGS in young healthy adults. As elderly people generally have a lower general body strength which seems related with lower

lung capacity, it might be a possible to find a correlation in an earlier state, in young healthy subjects(4). When a correlation will be found earlier it would give more time to influence and change the issue. It is very interesting to measure both vital capacity and body strength in young healthy adults in order to evaluate if there is a relation between the outcomes in these tests. If a strong correlation between the values is found one could state the importance of good overall strength, as well as strength training being strongly advised as preventive training to remain optimal lung health.

Further, the FEV/FVC spirometry tests are often used in hospitals and medical centres but not within physiotherapy practices or smaller primary care settings. If there would be a strong correlation between the FVC value and the MHGS value this would be a way to state that being physically fit is influencing our lungs performance. If a correlation is found between the values, MHGS could be used as a standard tool mainly measuring strength, but it could also be a good predictor to the FVC value of an individual. This study can also form the beginning of a long term follow-up study. With the results collected in this study, recommendations can be made for screening and monitoring of young adults with an increased risk of chronic conditions. A splitting of the total group into male and females will be done to make sure sex does not influence the outcome.

Research question:
Is there a correlation between the result of a Forced Vital Capacity (FVC) test and a Maximum Hand Grip Strength (MHGS) test in young adults?

Methods

Study design
This cross-sectional observational study took place at Fontys University of Applied Science (FUAS) in Eindhoven, The Netherlands. This project was part of a greater study where multiple data was collected to calculate risk factors for chronical diseases. In total four students were conducting tests where multiple data was collected concerning physical conditions such as body measurements, flexibility, strength, stamina and reactivity time among second year physiotherapy students at FUAS. All tests were conducted in an exercise lab located at FUAS. The great number of collected data was additionally to make it possible for calculating risk factors based on different physical aspects, creating a base for further research in the future. This particular study will focus on the FVC (ml) test and MHGS (kg) test of the participants, the results of the other tests will not be discussed.

Subjects and selection process
All second year physiotherapy students at Fontys University of Applied Science, Eindhoven, were recruited for this study. All subjects received written information, which explained the aim of the study and the testing procedure. An informed consent form (Appendix II) was signed prior to the test occasion, where confidentiality of handling data was guaranteed. Participation was voluntary and the subjects could at any time withdraw from the testing without giving a reason. Inclusion criteria were age between 18-26 years and second year physiotherapy students and the exclusion criteria was current illness or injuries to the dominant hand.

Researchers
The researchers contained four fourth years physiotherapy students from the Paramedic University of Applied Sciences in Eindhoven. Prior to the moment of testing the subjects, the researchers have practiced approximately eight hours to reassure correct use of the equipment. In order to prevent that the researcher would influence the outcome, an agreement was made that there would be no cheering on/ motivating the participants during the testing sessions.

Measurement tools and justification
A questionnaire was used to collect additional information about the subjects including age, gender, allergies, physical activity, illnesses, medicine use and smoking habits (Appendix II). Height and weight was measured. The same set of measurement tools were used for every participant.

FVC was measured, according to international guidelines using a spirometer, Spirobank G (Mir via del Maggiolino 125, Roma, Italy). Before testing the subjects were informed about the procedure. After appropriate settlement of the mouthpiece and nose clip, the subject was asked to perform a maximum forced inhalation, followed by a powerful, forced expiration test. One technically well preformed test was recorded. FVC was measured in milliliter (ml).

A study has been performed to assess the accuracy of spirometry the Spirobank (Mir via del Maggiolino 125, Roma, Italy). The spirometer performed very well compared with the Jaeger MasterScope. High correlations were found for the pulmonary function parameters (11).

The MHGS was measured with a Nurytec Thp2 (Model TF 411). These tests were adhered by protocols from the THP2 Manual made by the NURYTEC Inc. Company, founded in 1983 in Korea. This was the only hand grip measurement tool which collected the data straight into a database available in the lab of Fontys University of applied science. Unfortunately, the validity of this specific hand dynamometer remains relatively unknown and could therefore be a limitation of the study.

Prior to the testing the subjects were informed about the procedure(12). The control lever of the grip strength was adjusted, the second knuckle of the fingers was at the bottom of the grip bar. Only the dominant hand was being tested. The subjects flexed maximally during 2 trials and the maximum strength (kg) among the 2 trials was enrolled into the database. MHGS was measured in kilogram (kg).

The result from both tests were collected digitally and enrolled into a database straight after execution of the test.

Data Collection
The subjects were divided into subgroups of maximum 12 participants. Each subgroup was tested separately during one occasion in the exercise lab of Fontys University of Applied Science, Eindhoven. The test procedure took approximately one and a half hour. The test occasions were scheduled in advance and took place between 30th march and 8th April 2015. The participants in this study were enquired to complete a questionnaire, in which they were asked to fill in the most suitable answers describing themselves and their lifestyle (appendix III). The questionnaire included questions about allergies, physical activity, illnesses, medicine use and smoking habits.

The tests were divided into A,B and C stations. A stations were tested first since they had to be tested in idle state. Thereafter the participants continued to the B stations, when all B stations were completed the subjects moved on to the last station (C). The C station was completed last to prevent other tests being biased by exhaustion of the participants from the test. (Appendix IV).

A stations:
- Height, weight and fat-percentage
- Blood-pressure and heartrate
- Lung function - Forced Vital Capacity
- Cholesterol and glucose levels

B stations:
- Maximum hand grip strength
- Combined reaction time, jump force and balance test

- Sit and reach flexibility test
- Sit-up test
- Back strength
- Speed test

C station
- VO2 submaximal step test

Since this study was a part of a greater project, all additional tests stated above was performed by all subjects during the assessment (Appendix IV).

Data analysis
The main variables measured in this particular part of the study were the FVC (ml) and MHGS (kg). The secondary parameters taken into consideration were age, gender, height, weight, smoking habits and hand dominance. Age, height and weight were measures of a ratio scale. Gender was measured as a nominal scale. The secondary parameters were used to give a description of the test group, mean and standard deviation for men and females were calculated in addition to the total group calculation.

The computer program SPSS (Statistical Package for the Social Sciences) was used to analyse the data. All data from the FVC (ml), the MHGS (kg) and secondary data was entered into SPSS. Descriptive statistics was used to calculate the number of observations, mean value and standard deviation from each of the variables. Anthropometric data (sex, age, height, weight) was collected.

The measurements FVC and MHGS of the dominant hand were analysed for the total group, then for males and females separately, since it would be clinically relevant to know these differences. They were also studied to see if they were normally distributed.

If the data was normally distributed, Pearson's correlation coefficient was calculated to test the correlation between MHGS and FVC. If the data was not normally distributed (non-parametric), Spearman's rho was used to calculate the correlation. The statistical significance value (p-value) was defined as $p < 0.05$ (5%). All collected data was used to discover if there was a correlation between a high score (or low score) on the outcome from both test.

Ethical aspects
All participants were second years students studying at Fontys University of Applied Sciences. Taking part in this research project was voluntary and subjects were allowed to dropped out their participation at all times without giving any reason (Appendix I, Appendix II). All collected data was processed anonymously and stored carefully. All subjects were well informed and signed an informed consent form prior to testing. Data from participants who terminate was catalogued and included up until that point.

Results
From an initial target group of 137 physiotherapy second year students; 86 subjects met the inclusion criteria and completed the test sessions for both MHGS and FVC. The participants measured were between the age of 18 and 26. Thirty nine (45,3%) of the participants were male, forty seven (54,7%) of the participants were female. The collected descriptive data, age, height, weight, MHGS and FVC from the total test group, males and females is presented in Table 1.

Table 1 - Collected descriptive data

	N=86, 39M, 47F	Mean	SD
Age (years)	Total Males Females	20,71 20,77 20,66	±1,83 ±1,88 ±1,81
Height (cm)	Total Males Females	173,99 180,64 168,47	±8,62 ±6,64 ±5,70
Weight (kg)	Total Males Females	68,71 75,81 62,81	±11,25 ±10,30 ± 8,24
MHGS (kg)	Total Males Females	45,68 57,12 36,19	±14,00 ±12,29 ± 5,84
FVC (ml)	Total Males Females	4431,74 5240,51 3760,64	±1035,81 ± 874,13 ±580,17

SD = Standard Deviation; MHGS = Maximum hand grip strength; FVC = Forced Vital Capacity

Table 2 shows the mean values of the total group, males and females. All data was normally distributed. Pearson's correlation coefficient was used to calculate the correlation between MHGS and FVC. A visual representation of the correlation data can be seen in Table 2.

Table 2 - Correlation table

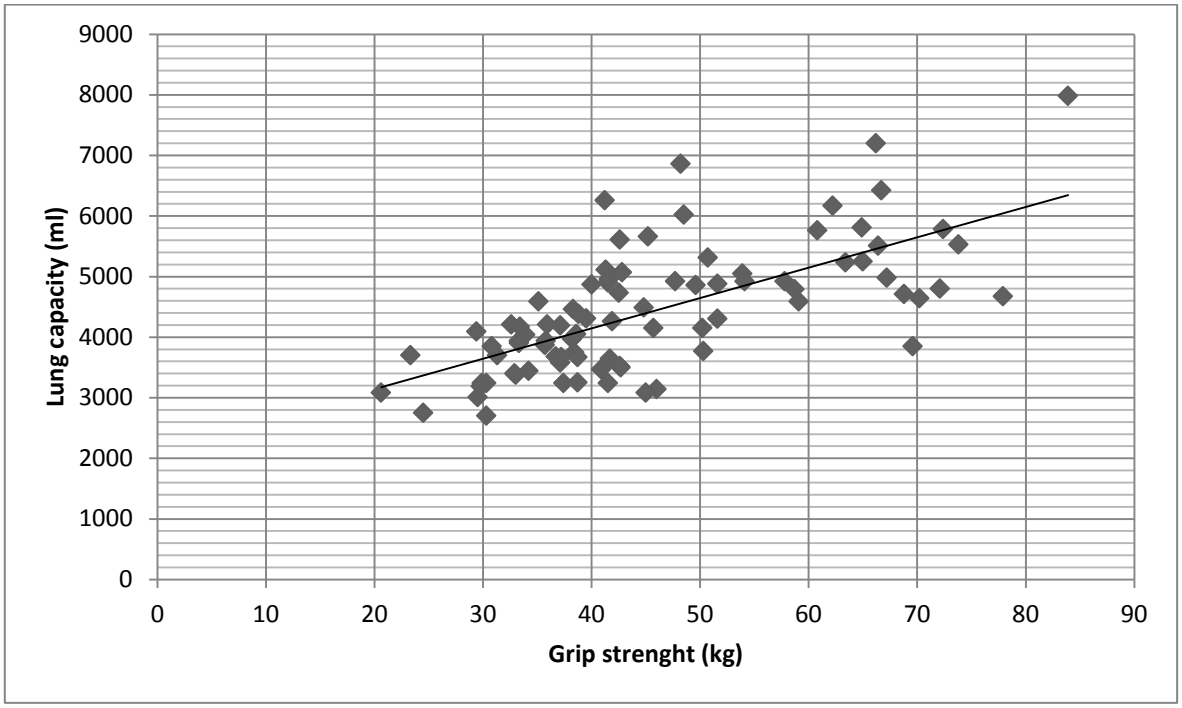
	Mean and SD	Correlation Coefficient	P- Value
Total group			
MHGS	45,68±14,00	0,677	<0,001
FVC	4431,74±1035,81		
Males			
MHGS	57,12±12,29	0,303	0,061
FVC	5240,51±874,13		
Females			
MHGS	36,19± 5,84	0,326	0,025
FVC	3760,64±580,17		

SD = Standard Deviation; MHGS = Maximum hand grip strength; FVC = Forced Vital Capacity

A significant correlation (p: <0,0001) was found when paralleling the outcomes of both test in the total group. Persons correlation coefficient between FVC and MHGS was found to moderate to strong (r= 0.677) when comparing both tests. When the group was split up the strong correlation transformed into a weak correlation (Males r:0,303, Females r:0,326). The p value for the males was no longer significant, for the females the p-value still showed a significant correlation (p0,025).

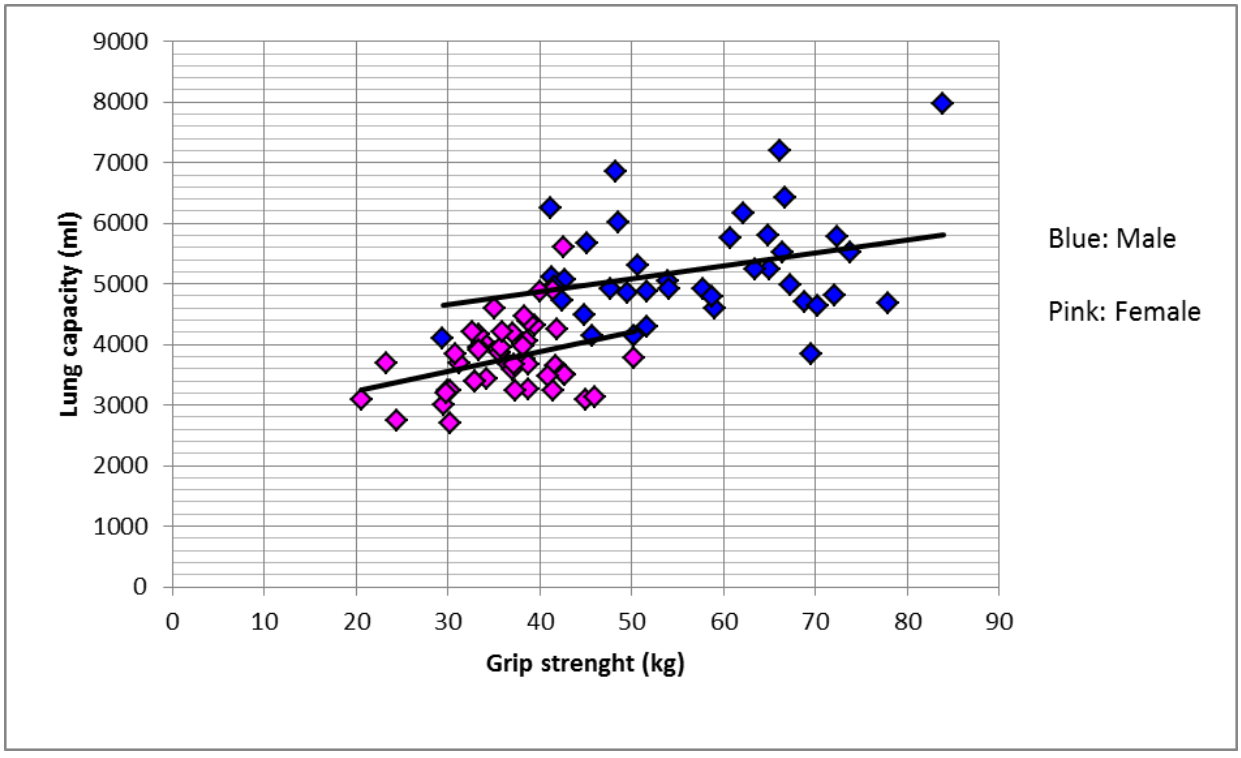
Scatter figure 1 presents a global view over the results of the total group. Two separate scatter figures when the group was split into males and females are to be found in the appendix (Appendix VI).

Figure 1 - Scatter figure, Correlation total group:



Scatter figure 2 presents a global view over the results when males and females are marked with different colours.

Figure 2 – Scatter figure, correlation males and females.



Discussion

The goal of this study was to determine whether there is any correlation between the outcomes of a FVC test and a MHGS test. From a total of 86 voluntary, second year administered physiotherapy students at FUAS, Eindhoven, a statistically significant correlation (p: <0,0001) was found when paralleling the outcomes of both tests in the total group. When calculating with Pearson's correlation coefficient a moderate to strong correlation coefficient was found (r= 0.677) when comparing both tests. The correlation between the FVC and the MHGS was furthermore calculated when the total group was split into males and females. When the group was split up the strong correlation transformed into a weak correlation (Males r:0,303, Females r:0,326), in which the p value for the males was no longer significant.

Since the outcome of the total group shows a strong correlation between the two tests, it supports the hypothesis of this study. Hence, if an individual has performed a high FVC, there is a strong likelihood that this subject will perform a high MHGS test. Still it is important to mention that when the subject is a male, the level of a correlation will be much lower or not exist at all. The FVC outcome does not appear to have as large correlation with a MHGS as first believed. However there are external factors that were not taken into consideration, which could have had influenced the outcome of this research. Potential external factors could be smoking, sport intensity, living environment and others. In a study made on young adults by Roberto de Marco in 2011 all participants who ever had asthma excludes from the research since it could influence a FEV/FVC outcome(13). This was not done in this study thus it might have affected the outcome.

The choice of measurement tool to measure the overall strength was the MHGS. Muscle strength tests are suitable within many different target groups; healthy subjects, people with neurological complaints, individuals with chronical complaints and more. Moreover, data from the literature tend to support the fact that MHGS may be a good predictor of body mass (1,8,9,10). The advantage of a muscle strength test is that one needs little attributes and the protocol is simple (9). All tested subjects completed the MHGS test twice, and the majority (>98%) scored highest on the first trial. This might state that there is not an advantage for subjects who already performed a MHGS test in the past. It also suggest that it would be sufficient to let the subjects perform one correctly executed test if the research would be repeated in the future. In addition, since the isometric contraction of the subjects forearm fatigues the intricate muscles, significantly lowered contractile forces might be found when performing a second or third test. Another positive aspect to the MHGS test is the short amount of time it takes to perform a valid test, as there was a total of 86 participants to test over a short experimental window. Still there are factors that can influence the outcome from a MHGS test. It is important to realise that gender has a major impact when measuring MHGS. A MHGS study was done in Greece by Charalabos et al in 2013 on young healthy subjects, when assessing similar ages, males presented higher strength than females. Next to gender, someone with a high MHGS result could have a strong dominant arm but would not always score high on other body strength tests. Which means a subject can have a very high strength only in the dominant arm, this might be due to physical work or specific sports (arm wrestling or bowling) for example. This could potentially have affected the outcomes of some MHGS tests. The MHGS in this study was measured with a Nurytec Thp2 (Model TF 411), Unfortunately, the validity of this specific hand dynamometer remains relatively unknown and could therefore be a limitation of the research.

All participating subjects in this study were studying physiotherapy at FUAS. It is of importance to mention that the majority of the physiotherapy students had some sort of involvement in different kinds of sports multiple times a week. This might have influenced the results of both FVC and MHGS test. The majority of the tested participants, both males and females performed above or even high above the norms considered average in the MHGS test compared to two other studies made on young healthy adults (12,14). The average score for a male between 20-25 years of age was tested on 2000

subjects in the study made by Lafayette et al(appendix V), the result was 37,5 kg for a female in the same age group 21,8 kg. Another study was made on 360 healthy subjects in Greece in 2013 by Charalabos et al, in the ages 18-22, the results showed the mean outcomes for males 48.7± 8.1 and for females 25.8± 5.5. The mean score for the MHGS in this study was; male 57,12 kg±12,29kg and for females 36,19 kg ± 5,84kg. Which is higher both in the total group and split into gender. Therefore it would be very interesting to repeat the study on a group more representative of the general population, with two test groups, one group of subjects who sports on regular basis and one group of individuals who does not participate in any sport.

The spirometer is used to measure lung function and to detect obstructive lung diseases. The GOLD standard protocol from 2015 states that spirometry is the most reproducible and objective measurement of airflow limitation available. But it is also written that patients with COPD typically shows decrease in both FEV1 and FVC, not only FVC alone(1,6). With the outcome of the two tests one can determine whether there is a suspicion or if a participant is obstructive (or restrictive) (1). For this study only FVC was measured to test the subjects lung capacity. More research needs to be done to find out more accurately how FVC can be used to predict different chronic lung diseases and which factors will influence the outcome. It would have been preferable to measure Forced expiration volume in 1 second (FEV1) and FVC instead of FVC alone, since more studies have been performed using lung capacity and not only the FVC as a standard test. In addition, FEV1 and occasionally FEV2 or FEV6 have been used in these studies (3,6,8,15). Unfortunately, there was no opportunity to measure the FEV1 during this study due to a lack of professional equipment.

All the subjects performed a correct FVC test, however some of the subjects still mentioned having difficulties with performing the FVC correctly, having the idea they could have performed better. The subjects who conducted FVC tests in the past might have had an advantage above the other subjects since they knew what to expect from the test session. Some of the participants seemed distracted from the other subjects performing different tests in the same room. It was also mentioned as feedback that it had been difficult to perform a correct test when the individual had to perform the tests around others. Therefore there would be wishful to test every student individually or at least in a more quiet setting when repeating this study in the future.

There are an restricted amount of studies to be found supporting a possibility of finding COPD already in an early age. However, A study made in 2011 by Roberto de Marco (13) involving 4,636 concludes that COPD is a considerable problem for young adults and the most important risk factor for developing COPD is cigarette smoke. It would therefore be interesting to measure the vital capacity on smoking young adults, since there are more studies done to chain smokers in relation to COPD. In this research no one of the attending individuals was smoking >15 cigarettes per week. Therefor a separate group with smokers never stood value in this particular study. The young age of our cohort may have implied a relatively low risk for already having a lung restriction. Additionally, there are just a very limited amount of articles to be found relating to lung capacity tests tested on groups of young adults, therefore a suggestion would be to include participants with a higher age when preforming a similar study in the future. Moreover, due to the relatively low amount of individuals with COPD and lung restriction in young adults, the power of this research might not have been enough to detect small effects or to be able to correlate the outcomes with the MHGS.

As written in the method section, the subjects were asked to fill in a questionnaire before taking part of the research. The importance of the filled in questionnaires was to get more information about the individuals to be able to relate the outcome of the tests to external factors. The survey contained questions about the subjects lifestyle and their health, such as; smoking habits, sport intensity, injuries, illnesses and medication use. Unfortunately less than 50% of the participants completed the survey, even after receiving a number of e-mails and mouth-to-mouth reminders. Therefore a choice was made to skip all the collected information from the questionnaires, the reason was to be able use

as many test results from the completed FVC and MHGS as possible. Still it would have been preferable to have all additional information about the participating subjects to regain more information about the individual health, which may be of importance to the outcome. Therefore it is requested to have all subjects to complete the survey if this study will be repeated in the future.

Conclusion:

It can be concluded that a statistically significant correlation (p: <0,0001) was found when paralleling the outcomes of both test in the total group. It appears that the FVC is a moderate predictor of the MHGS of the total group, but since the correlation for the split group males and females is weak, FVC cannot be used as an alternative method of estimating the MHGS of a patient. This applies for both males and females. More external factors must be taken into consideration when repeating a similar research. Also, it would be preferable to use a more widely representative group of smokers/non-smokers with diverse occupations and of a higher age. Despite the limitations of this research, the researcher is confident that the build-up and result of this study will help to pave the way for more research in this area in the future.

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Appendix I
Information letter

Dear student,
You are invited to participate in a study that concerns; screening young adults for risk factors for chronical diseases.

General information:
As a participant in this study, you will be enquired to complete a questionnaire, in which you will be asked to truthfully answer all questions. Thereafter you will be asked to participate in different tests in the exercise lab. Multiple tests will be executed to gather information about body measurements, flexibility, strength, stamina and reactivity. The testing will take approximately one and a half hour and is scheduled as a workshop (FH) in your schedule sometime between 24th march and 8th April 2015. The testing will take place in the exercise lab of Fontys University of Applied Science, Eindhoven. It is important that you as participant follow a couple of clothing prescriptions; clothes and shoes suitable for exercise. Long hair must be tied up and it is essential to remove all kinds of jewelry.

Background / Problem description:
Waist circumference and physical inactivity are risk factors for a.o. pre diabetes mellitus type 2 and cardiovascular disorders. Measuring physical activity, physical fitness and risk factors in a healthy population may increase awareness of health risks. Further, it is interesting to study which factors can be influenced and how, in trying to achieve a lasting healthier lifestyle.

Previous researches have shown that within a student population relatively many risk factors occur. The new Exercise Lab of FPH (Fontys Paramedishe Hogenscholen) offers a range of possibilities to investigate risk factors in young adults. Also, it is possible to follow students throughout their study at Fontys.

Scientific relevancies:
These studies form the beginning of a long term follow-up study. With the results of these studies recommendations can be made for screening and monitoring of young adults with an increased risk on chronic conditions.

Social relevance:
In the light of increasing prevalence of chronic diseases it is important to gain more insight in the presence of risk factors and in how we can modify them in this particular population.

Relevance for the physiotherapy program:
With the new Exercise Lab we can start to integrate clinometric better in the study program. Students will get more insight and get more experience in the use of the different measurement tools.

Personal relevance:
By volunteering for this study, you will learn about physical research in general and the topic of this study in particular. In addition, you will personally benefit from this research since you can get more insight about your physical status and collect your personal outcomes from the different tests. You may decide to withdraw from this study at any time by counseling one of the researchers and may do so without any penalty.

Participation:
Participation in this research study is voluntary. All information you provide is considered completely confidential; your name will not be included or in any other way associated with the data collected in the study. Data collected during this study will be retained indefinitely, only researchers associated with this study will have access to the given information. There are no known or anticipated risks

associated with participation in this study.

Thank you for your assistance in this project, we are looking forward to meet you during your participation of this research.

With kind regards
The research team

Title of Project: Screening young adults for risk factors for chronic diseases

Student Researchers:
Andrea Gustafsson, Student Physiotherapy, a.gustafsson@student.fontys.nl, +31-657109123.
Miriam Myrsten, Student Physiotherapy, m.myrsten@student.fontys.nl, +31-625181906.
Niels van Hoof, Student Physiotherapy, niels.vanhoof@student.fontys.nl, +31-643191525.
Ivo van Knippenberg, Student Physiotherapy, i.vanknippenberg@student.fontys.nl, +31-622139808.

Supervisor:
Steven Onkelinx, s.onkelinx@fontys.nl, +31-6222948396.

Institution:
Fontys University of Applied Sciences
Department of Physiotherapy
P.O. Box 347, 5600AH Eindhoven
The Netherlands

Appendix II
Consent form

I agree to participate in this study conducted by Andrea Gustafsson, Miriam Myrsten, Niels van Hoof and Ivo van Knippenberg, students of the Fontys University of Applied Sciences. I have made this decision based on the information I have read in the information letter and have had the opportunity to receive any additional details I wanted about the study. I understand that I may withdraw this consent at any time by telling one of the researchers. I am aware that all the data will be collected and used in research projects. The data may also be used in the future for follow-up studies and will at all times be handled anonymously.

Participant's Name _____

Participant's Signature _____ Date _____

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Appendix III

Questionnaire - "Screening young adults for risk factors for chronic disease"

Studentnumber:_____
Male/Female
Age:_____

Please circle the most suitable answers describing you and your lifestyle:

I am asthmatic: *Yes/No*

I was asthmatic during my childhood: *Yes/No*

I am allergic to grass/pollen: *Yes/No*

I have diabetes: *Yes/No*

I have been ill during the past 5 days: *Yes/No*

I am taking medications interfering with my respiratory function: *Yes/No*

Hand dominance: *Right handed/Left handed*

I have been injured the last 3 months and not been able to participate as I normally do in my regular sport/physical activity: *Yes/No*

Smoking habits:

Not smoking, Yes - 1-15 cigarettes a week, Yes -16-50 cigarettes/week Yes >50ciggarets/week.

Do you perform any sport or physical exercise? *Yes/No*

If Yes; which sport/activity? _____

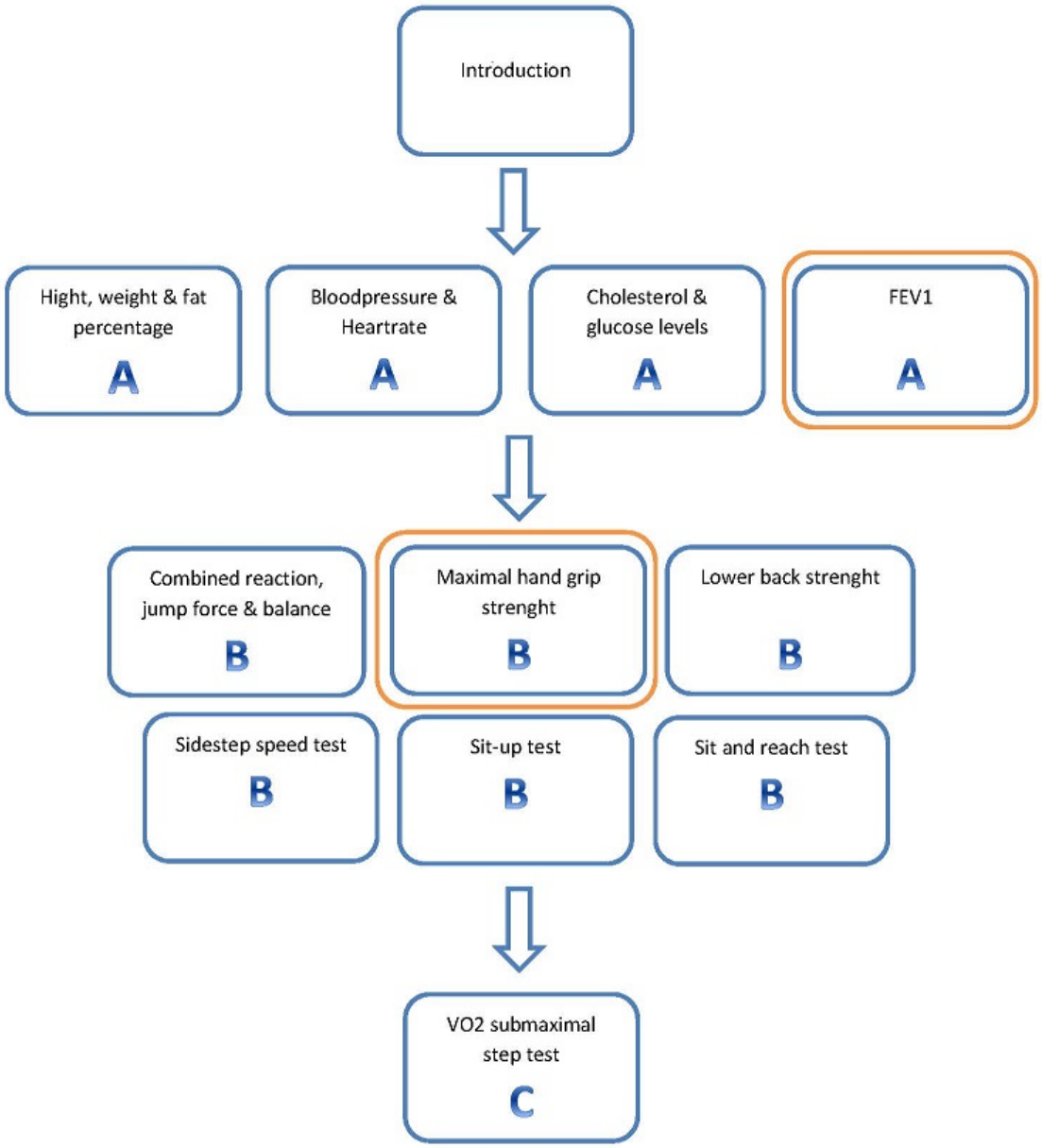
How many hours/week are you performing your sport/activity?_____

For how long have you been performing your sport/activity? *0-3 months / >3 months*

Thank you for your cooperation!

Appendix IV

Figure – Flowchart of order of station entry.



Appendix V

Adult Data for Lafayette Model 78010 Dynamometer*

Age	Male – Dominant Hand	*Male – Non Dominant Hand*	Female – Dominant Hand	*Female – Non Dominant Hand*
20	36 kg	*35 kg*	21.5 kg	*19 kg*
25	39 kg	*36 kg*	22 kg	*20 kg*
30	40.25 kg	*36 kg*	21 kg	*19 kg*
35	39 kg	*35.5 kg*	19.5 kg	*18.75 kg*
40	37.5 kg	*34 kg*	18.5 kg	*17.75 kg*
45	35.75 kg	*32.5 kg*	17.5 kg	*16.75 kg*
50	33 kg	*30.25 kg*	17.5 kg	*16.5 kg*

* From Lafayette Instrument Owner's Manual from tests on more than 2000 subjects; 1986

Appendix VI - Scatter figures males and females

Figure 3

Scatter figure - Correlation males:

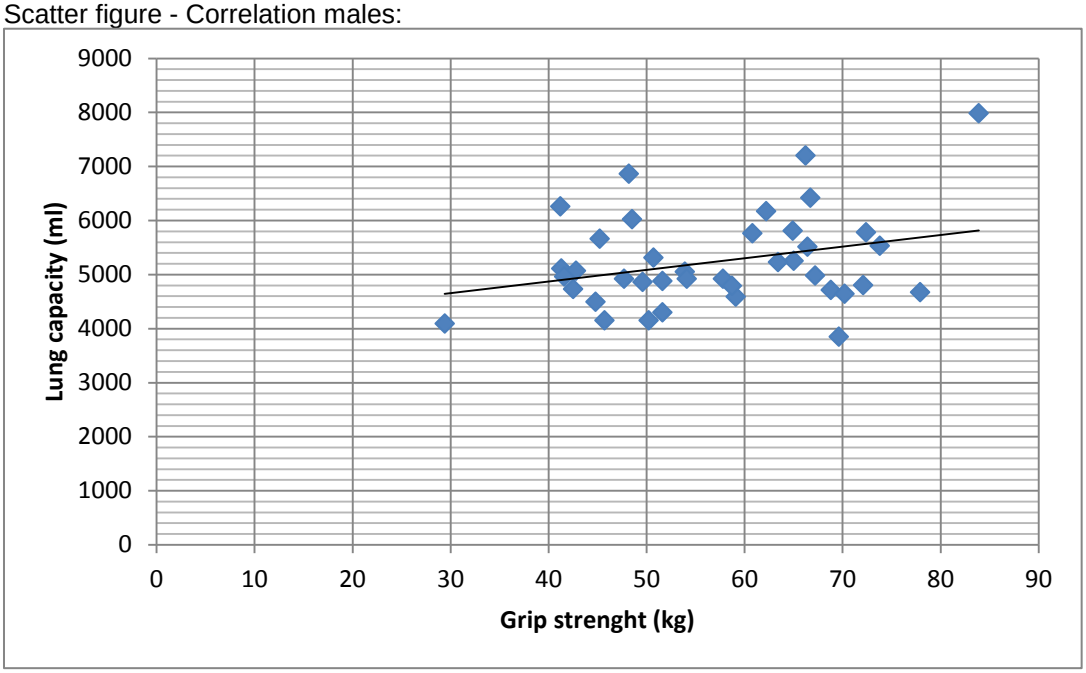


Figure 4

Scatter figure - Correlation females: