

Changes in physical fitness performance of firefighters and paramedics after eight weeks of training with the READY app

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1 Introduction

1.1 Context and initial situation

Health can be influenced by a series of factors: by geographical location, by social, environmental and health status, by the physiological characteristics of individuals and by lifestyle. These factors determine the life expectancy of individuals.

According to the Swiss Federal Office for Sports (OFSP), on a global level, sedentary lifestyle is the fourth risk factor for early mortality. In the industrialized countries sedentariness is one of the major cause of death, the OFSP recommend for the adults at least 1.5 hour of high intensity physical activity per week to have a good health condition. A regular physical activity helps to prevent different types of disease (overweight, hypertension, cardiovascular diseases, type II diabetes, osteoporosis, colon and breast cancer and neurodegenerative diseases) [1].

By respecting this type of behavior in terms of physical activity and associating it with a healthy lifestyle with the assumptions that this entails, the risk of widespread diseases and ailments that are today the cause of a high percentage of mortality would decrease, increasing the health of individuals.

For this study, a sample of firefighters and paramedics was selected: for these people, physical performance and the fitness level is not a predominant requirement, but given the responsibility, type and physical demand that these jobs entail, it is important to be in good health and physically prepared.

The primary focus of this study is to analyze the level of physical preparation and fitness status of firefighters and paramedics and to demonstrate whether an improvement in physical performance is found with a series of training sessions.

Secondly, promoting health and an active lifestyle by carrying out at least 1.5 hours of intense physical activity per week, seeking to increase physical well-being and prevent the risk of diseases caused by inactivity.

Paramedics and Firefighters are part of first aid rescue team, and for this reason they must be ready to intervene first on the requested location. Their timeliness and their technical and tactical training are essential for the good success of the operation and in certain circumstances for the live and the death of many people. The operations are very different, they can be easy and quick, but they can also be much more complicated and physically strength, because each scenario is always different and unpredictable. For this reason in the face of some emergency also a good physical preparation can be essential to deal with these emergencies in the best way.

The Firefighters, according to the statistics of the “Federazione Cantonale Ticinese Corpo Pompeieri “ [2], in 2018, 3013 interventions have been carried out, 25% of these operations have been carried out because of spillage of polluted liquids, 19% because of fire, 18% because of flooding and damage of the nature, 7% because of rescue of people and animals, 2% because of car crashes and 27% because of alarm systems malfunctioning or false alarms (Figure 1).

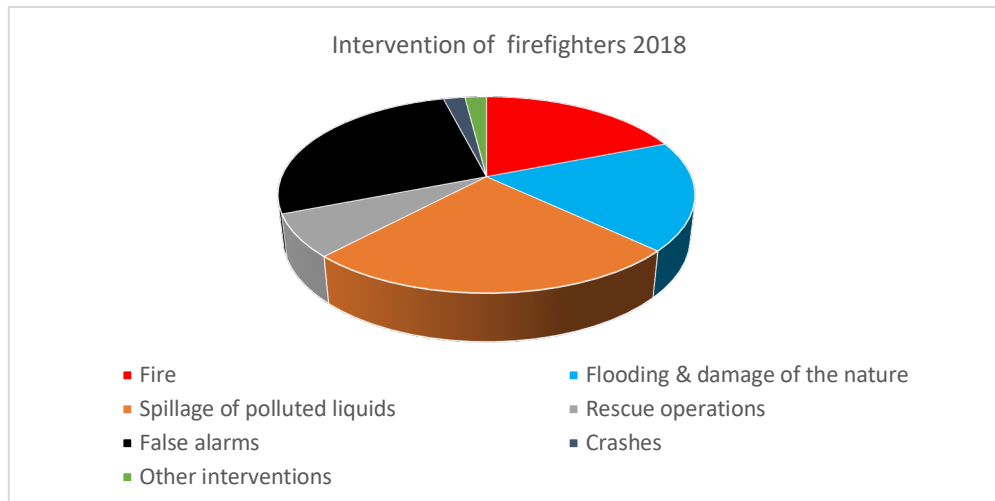


Figure 1: Numbers of intervention done by the firefighters of Canton Ticino in 2018. On a total of 3013 intervention, 52% were connected with dangerous substance and false alarms, 18% were because of fire and 19% caused by flooding. Less than 10% of the operations were for rescues and car crashes.

In the event of fire, firefighters must intervene equipped with helmets, complete fireproof suit, self-contained breathing apparatus, with extra weight of 27 kg, without calculating the weight of fire extinguishers, fire hoses, tools to free people or material.

To carry out the rescue operations with this load, the body is stressed in an important way, physical and muscular fatigue can expose the fireman to a greater risk of injuries, if not physically well prepared.

As described in [3], firefighters are 3.5 times more likely to suffer an injury at work and 3.8 times more likely to suffer a musculoskeletal disorder (MSD) at work than other workers.

On average for a fireman the days of absence from work after an MSD are 1.8 times greater while this ratio is only 1.25 for other sectors workers.

Firefighters over 55 are more at risk, 10.4 times more likely to suffer from MSD than other workers and take four times more to return to work.

The daily interventions for a firefighter require physically high-risk and demanding operational tasks.

The main activity of paramedics is to immediate rescue and transport the patient to the nearest hospital for the medical care of the most serious patient like people who are in life threatening. According to the statistics of 2018 done by the “Federazione Cantonale Servizi Ticinesi Ambulanze”[4], on average, paramedics in the Canton of Ticino rescue a person every two hours, ensuring an immediate departure after two minutes of receiving the alarm. Thanks to this quickness they guarantee that the injured person is reached within 15 minutes in 90% of the cases. The average duration of a paramedic rescue is less than 60 minutes.

For every emergency they must always be equipped with a first aid medical backpack and first aid monitor with extra weight of 16 kg, without calculating the weight of the stretcher and the patient who must be handled, moved and transported. Having to carry out operations in often uncomfortable places and as quickly as possible to ensure patient care, can increase the risk of injuries to the rescuers.

Paramedics have the risk of developing MSD and injury, almost six times higher than other workers moreover, the probability of MSD for paramedics is 34.6%, compared to 5.8% probability for workers operating in other sectors [5].

These data let us understand well, how physically hard the work of firefighters and paramedics is and the kind of high injuries risk they face. Spending periods of time of the day, even relatively long, in a sedentary way, where office work or small maintenance is carried out, in the event of an alarm, the first aid rescue must go to the intervention site without notice, often finding themselves confronted with operating without having warmed up muscles. This circumstance increases even more the risk of injuries or stretching of muscles or ligaments.

During the rescue operations, they have to run, jump, climb, pull, lift and lower weights, for example, carrying stretchers with a person, objects and intervention materials, carrying out the work and the tasks, in often uncomfortable positions, such as on the knees, crouched or bent in unnatural positions for the body.

The fact of working in uncomfortable positions, performing movements that require physical demanding, moving loads and transporting equipment, make interventions even harder for the body. Having to perform a wide range of movements, support, transport and move weights, physically the most involved parts of the body are the legs, the back and the core. During the operations, the muscles of the upper limbs are often stressed too, such as the arms, for example for a cardiopulmonary resuscitation (CPR) or for the handle of a high-pressure fire hose.

As described in [6,7], a good core stability, that is the ability of the lumbopelvic hip complex to prevent buckling and to return to equilibrium after perturbation, can provide numerous benefits to the musculoskeletal system, such as maintaining the health of the lumbar area and preventing injuries to the ligaments of knees and chronic low back pain, moreover a good core

stability, allows to transfer more effectively the strength of the body from the upper part to the lower limbs, as a result it also leads to a better distribution of loads, significantly reducing the risk of injuries.

A good physical preparation is very important for firefighters and paramedics: first of all, they can be more performant during the emergency, cope with workloads optimally and carry out interventions effectively. Secondly, physical preparation plays an important role in the prevention of injuries.

1.2 Goal and specific question

The primary purpose of this work is to check whether firefighters and paramedics have changes in physical fitness performance after eight weeks of training with the READY application or with a personalized training program.

More precisely, to what extent a training of 30-45 minutes, carried out with a frequency of three times a week, for the duration of eight weeks, improves the level of the physical fitness performance and which of the two types of training has a better response of physiological adaptation.

Secondly, the aim of this work is to reach the minimum threshold of weekly healthy activity recommended by the OFSPO, of one hour and thirty minutes of high physical activity. This can promote health and well-being in the departments of first aid rescue.

2 Method

This work was carried out on a group of firefighters and paramedics currently active and operating in Canton Ticino.

The first aid agencies, were selected according to a geographical location respectively located north of the Canton Ticino and according to their availability.

This made it possible to group the candidates as easily as possible during the days of the physical tests.

After conducting an oral presentation with the Director of the Bellinzona firefighters, the Director of the Locarno and Bellinzona ambulance service, during which the project was presented, all them showed a lot of interest and they joined this project.

A second presentation of the project was made to all the people involved, leaving the faculty to choose candidates whether or not to join this project.

The candidates made themselves available for this project according to their personal motivation, without being obliged to take part in it.

2.1 Investigation group

The total sample was composed by 27 paramedics and 45 firefighters, the age of the participants was between 20-60 (Figure2).

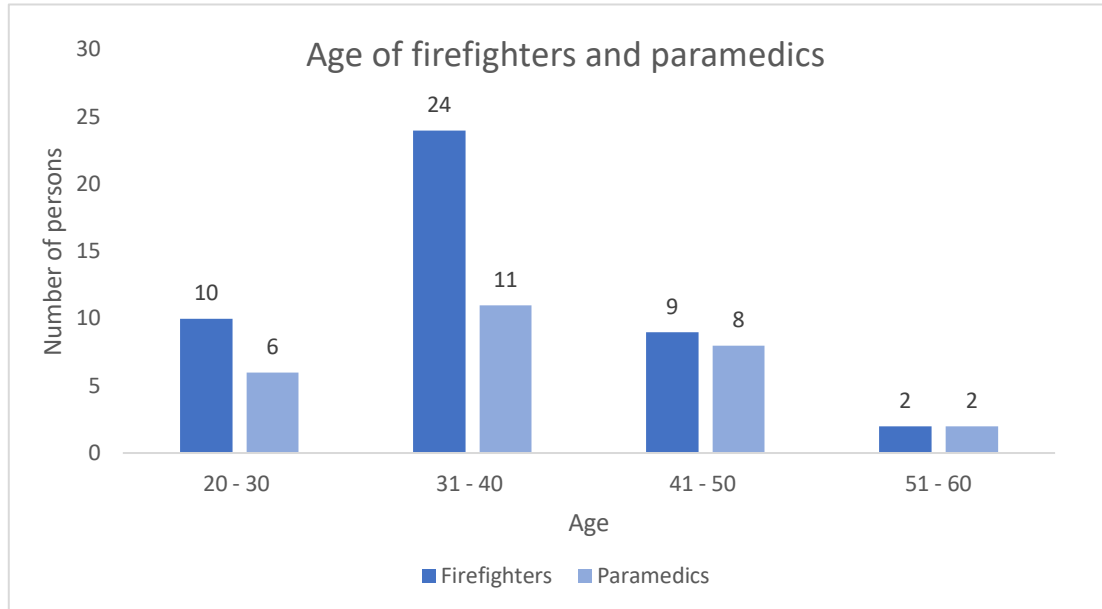


Figure 2: Age of firefighters ($n = 45$) and paramedics ($n = 27$) binned every 10 years.

Within the sample there were people of different ages, sex, fitness, and lifestyles. They were very sporty and active people, moderately active and sedentary or overweight people.

To obtain a general fitness assessment of the reference sample, the body mass index (BMI) of the candidates was calculated. BMI is a mortality predictor but it is also used as a parameter to evaluate body weight and have a first impression of physical health. This relates the height and the weight of the subject. For this study the BMI was calculated using this formula:

$$BMI = \frac{w}{h^2}$$

In this formula w represents the weight in [Kg] and h the height in [m].

The result of this formula classifies subjects in a weight range that can be considered normal, underweight, overweight or obese.

According to the Table 1, a BMI between 18.5-25 is considered normal.

A normal parameter leads to a lower mortality and a lower risk of pathologies influenced by overweight problems, such as cardiovascular diseases, diabetes, hypertension [8].

The BMI of the candidates was represented stratified by professions (Figure 3).

Table 1

Reference values of Body Mass Index

Category	From	To
Very severely underweight		15
Severely underweight	15	16
Underweight	16	18.5
Normal (healthy weight)	18.5	25
Overweight	25	30
Obese Class I (Moderately obese)	30	35
Obese Class II (Severely obese)	35	40
Obese Class III (Very severely obese)	40	

Clarification: The table classifies the Body Mass Index of subjects with ranges that reflect body mass [kg / m²]. For the values in the table "The Global Database on Body Mass Index, World Health Organization 2006" was used as a reference.

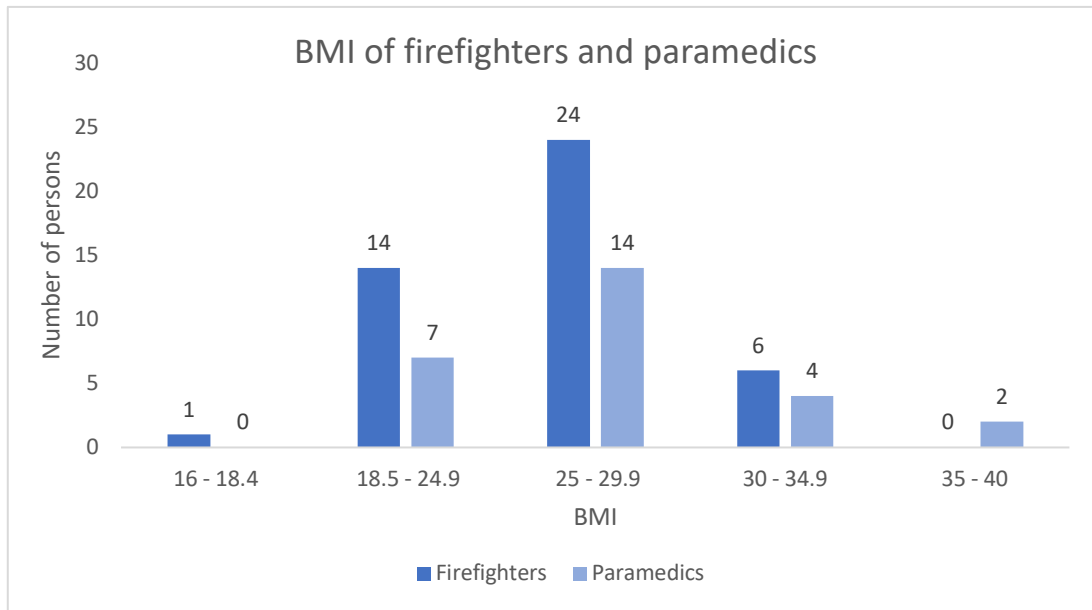


Figure 3: Body mass index of firefighters ($n = 45$) and paramedics ($n = 27$) is represented in the range “underweight, normal weight, overweight, moderately obese and severely obese”.

As the BMI does not differentiate among the fat body mass, the lean body mass and the musculature, even after removing the adipose tissue, a subject could have a high BMI but thanks to the lean body mass and the muscle mass.

For this reason, waist to height ratio (WtHR) was also calculated to have a second indicator relating to the health of the candidates. WtHR indicates the circumference of the waist in relation to the height and indicates the abdominal fat, with a scale that classifies the subject with ranges from "healthy" to, "obese" (Table 2). Like BMI, WtHR is also a mortality predictor; high adipose tissue implies a higher risk of mortality and risks of heart and cardiovascular diseases [9]. A person with a WtHR value greater than 0.51 is considered as a "person at risk", while a person with a WtHR equal to or less than 0.5 is considered healthy [10].

The WtHR was represented, stratified by professions (Figure 4). For this study the WtHR was calculated using this formula:

$$\text{WtHR} = \frac{w}{h}$$

In this formula formula w represents the waist in [cm] e h the height in [cm].

Table 2

Reference value of Waist to Height Ratio

Men	Women	Category
≤ 0.34	≤ 0.34	Extremely Slim
0.35 to 0.42	0.35 to 0.41	Slim
0.43 to 0.52	0.42 to 0.48	Healthy
0.53 to 0.57	0.49 to 0.53	Overweight
0.58 to 0.62	0.54 to 0.57	Very Overweight
0.63 \Rightarrow	0.58 \Rightarrow	Obese

Clarification The table classifies the WtHR of subjects with ranges that reflect body mass As reference for the table was used the studies [11,12].

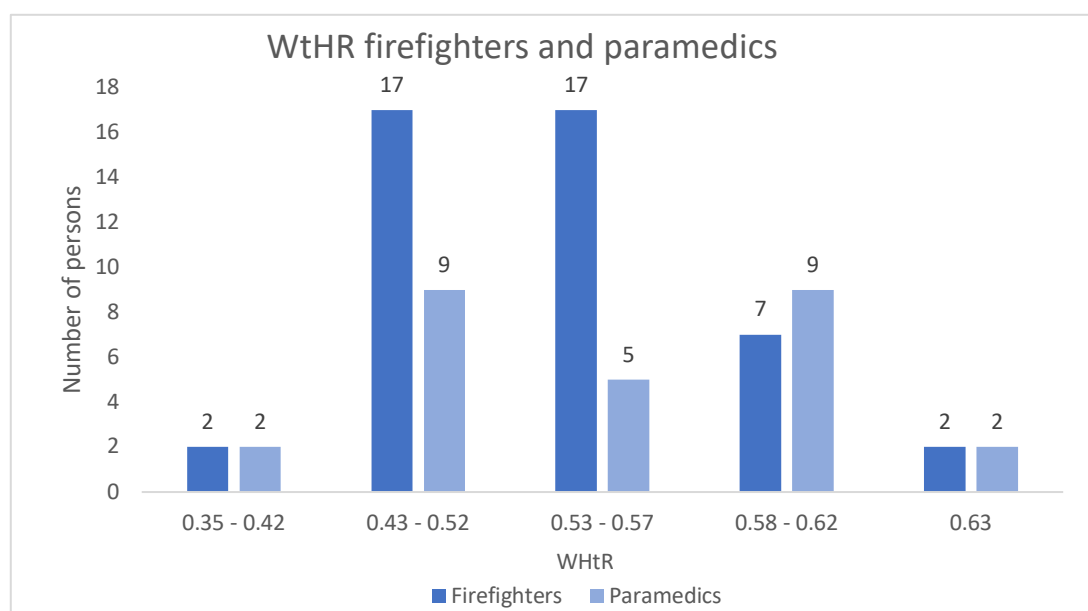


Figure 4: Waist to height ratio from firefighters ($n = 45$) and paramedic ($n = 27$) divided by the ranges “slim, healthy, overweight, very overweight, obese”.

Table 3 :

Mean age, gender, BMI, WtHR of firefighters and paramedics

	FIREFIGHTERS	PARAMEDICS
AGE	35.44 ±8.6	38.5 ±7.9
GENDER		
Male	40	20
Female	5	7
BMI		
Underweight (16 - 18.4)	1	0
Normal (18.5 - 24.9)	14	7
Overweight (25 - 29.9)	24	14
Obese Class I (30 - 34.4)	6	4
Obese Class II (35 - 40)	0	2
WtHR		
Slim (0.35 - 0.42)	2	2
Healthy (0.43 - 0.52)	17	9
Overweight (0.53 - 0.57)	17	5
Very Overweight (0.58 - 0.62)	7	9
Obese (0.63)	2	2

Clarification: The age values were expressed on average, ± indicated the standard deviation. Gender expresses the total numbers of the samples ($n = 72$) divided into males and females. BMI and WtHR were represented in different health categories.

2.2 Study design

This work began with the selection of candidates, and with the initial physical FTRD test (Supplementary material, FTRD test) which included strength, balance resistance and mobility tests. The FTRD test was designed recently and it is now used as a test for the evaluation of the physical foramen by the Ambulances of Canton Bern.

The test took place over seven days, from 9:00 am to 8:00 pm and the 10 stations were set up in the fire station. For each candidate, an hour of maximum time was reserved for completing the test which was carried out individually in order of position from 1 to 10.

The measurements (height, weight, waist) and the results of the physical performance, were acquired at each position based on exercises and according to the test evaluation criteria.

Subsequently the candidates trained for an eight-week period, three times a week.

Strength, endurance and balance training lasted from 30 to 45 minutes.

To allow candidates to perform the exercises directly at their working place or at home, the training sessions were carried out with their body weight.

A sample of 49 people carried out the training period following the READY smartphone application. This application has been designed to prepare the recruits of the Swiss army for the physical recruitment test and offers several training sessions with a frequency of three times a week and a volume of 30-45 minutes per session.

This sample had to do the READY app. test, a second physical test presets in the application, to fix the fitness level and to allow the application to program a workout adapted to the physical fitness of each candidate. According to the READY app. test scores, the application assigned a percentage of physical fitness.

This test was composed of four exercises and included: an exercise to evaluate balance, the candidate had to remain in balance on one leg for as long as possible as required by the FTRD test, an exercise to evaluate the explosiveness of the limbs, with the countermovement jump the application calculated the candidate's milliseconds of flight time, a five-minute run to evaluate endurance, the candidate had to complete as many meters as possible and an exercise to evaluate the strength of the core, the candidate had to remain in the plank position for as long as possible, alternating the movement of the legs dictated by the metronome as in the FTRD test.

A second sample of 23 people carried out the workouts without the application, but with a personalized training program, similar in exercises and identical in duration and frequency to the training provided by the READY application. These people expressly requested not to follow the application for health reasons, convenience in understanding the exercises and personal needs.

After the intervention, the candidates should have repeated the FTRD test with the same initial conditions: evaluation, place, material, order and duration of the test, to assess whether the eight weeks of training influenced and to what extent, the physical fitness performance.

For external reasons it was not possible to take the FTRD test after the eight weeks of training scheduled. For this reason, a part of the sample of firefighter and paramedics of 12 people repeated the READY app. test, after performing the eight weeks of training with the application.

2.3 Instruments

In Table 4 the instruments used and the units of measure were listed, according to the provisions of the FTRD test.

Table 4

Instrument used for the FTRD test

TEST	MEASURE	INSTRUMENTS
STEPPER TEST	Time in minute and seconds and Heart rate	Garmin 920 XT with cardio with cardio band, 15kg backpack, Step 30.5cm, Stopwatch, Metronome
BALANCE TEST	Time in seconds	Stopwatch, Circle Ø70cm
SORENSEN TEST	Time in seconds	Table, T-Bar, Stopwatch
CPR TEST	Exceeded/ Failed	Resuscitation dummy, Stopwatch
SQUAT TEST	Number of repetitions	20kg barbell, 40kg disc, Counter
CORE STABILITY TEST	Time in seconds	T-Bar, Stopwatch
HAND FORCE TEST	Force in kilograms	Hand dynamometer, Stopwatch, Chair
PUSH UP TEST	Number of repetition	Metronome, Counter
WEIGHT DETECTION	Weight in kilograms	Weight scale
WAISTLINE DETECTION	Waist in centimeters	Measuring meter
HEIGHT DETECTION	Height in centimeters	Stadiometer
SIT&REACH TEST	Stretch in centimeters	Sit&Reach Box

Clarification: Instruments used and units of measure, for testing the candidates according to the provisions of the FTRD test. The material was taken from school gyms, fitness centers, medical centers or was self-built.

During the eight weeks of training, the candidates performed the exercises without specific equipment. The exercises were carried out body weight, following the training instructions.

2.4 Data analysis

For the data analysis we used the standard library of the program Microsoft Excel, version 16.36 for Macintosh.

First the results of the FTRD test were transcribed in a table (Supplementary Material, Table 1) and plotted as box plot stratified by profession, on the same way the results from each singular exercise of the test.

The maximal oxygen consumption (VO₂max), was calculated with the results of the monitoring of heart rate of "stepper test" in the FTRD test.

The formula used for computing the VO₂max is:

$$VO_{2max} [ml/min/kg] = 84.687 - 0.722 \cdot HR_{post} [bpm] - 0.383 \cdot age [y]$$

where HR_{post} is the sum of heart frequency after 30 [s] and after 60 [s] after the end of the stepper test exercise and age is the age of the subject in years.

After that the results obtained by each candidate were transformed into percentile and represented in a table (Supplementary Material, Table 2), according to the percentile results of paramedics and firefighters of Canton Bern (Supplementary Material Table 3).

The BMI and WtHR were calculated with the measurements of height, weight and waist circumference and plotted as histogram (Figure 3,4).

The results of the READY app test before and after the intervention period were transcribed in a table and plotted as box plot. On the same way the results from each singular exercise of the test were plotted. A tables of the READY app. test before and after the intervention and with the percentage of each candidate's fitness level, set by the READY app. was represented.

The Pearson correlation coefficient (PCC) between the READY app. test and FTRD test has been computed using the function PEARSON of EXCEL and written inside the scatter plots. According to [13] we can reject the null hypothesis (no correlation) with a p-value of 0.05 only for correlations larger than 0.576 in absolute values.

3. Results

In Figure 5 were presented the results of the FTRD test, stratified by profession and the results of each post were represented in Figure 6 to 13.

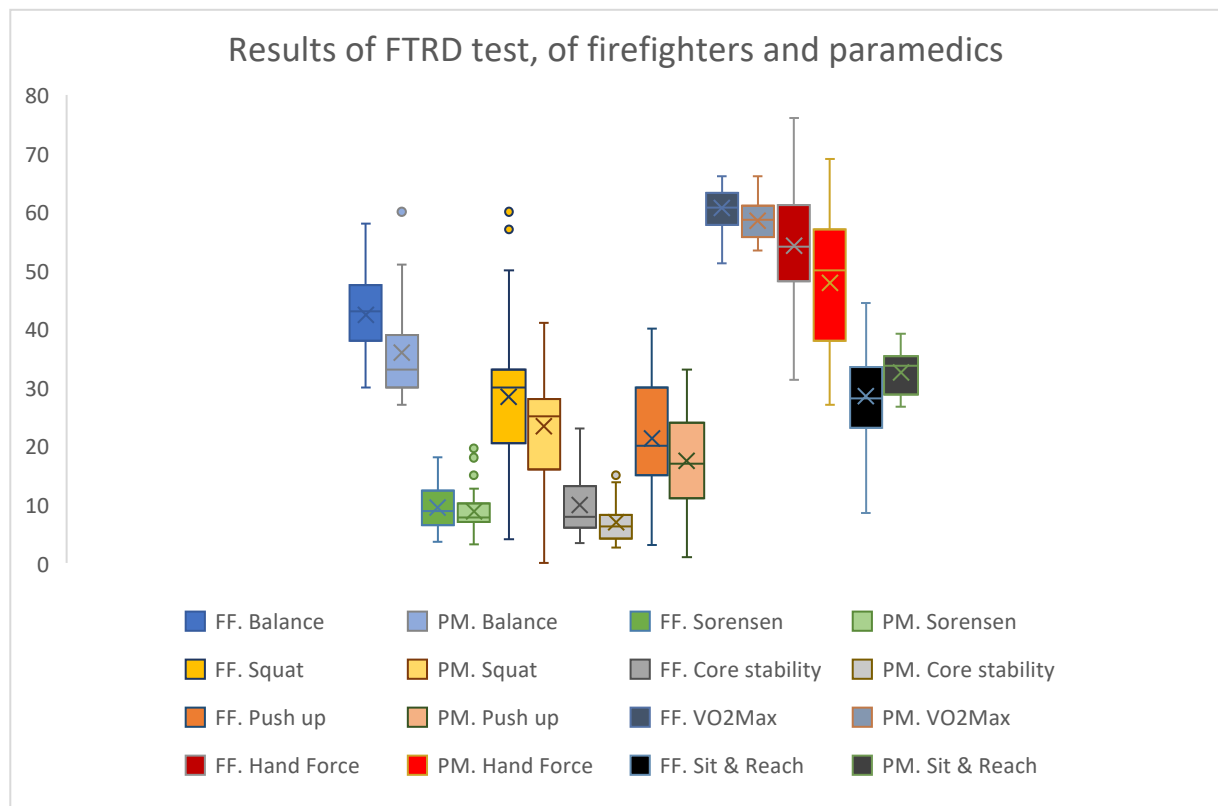


Figure 5: FF.= Firefighters ($n = 45$), PM.= Paramedics ($n = 27$). The results of FTRD test were expressed in different units of measure. The balance tests, the sorensen test and the core stability test were expressed in seconds. The push up and the squat tests were expressed in number of repetitions. The Hand force tests were expressed in kilograms, the sit & reach tests in centimeters and the VO2 Max in [ml/min/kg]. The results of the hand force test and sit & reach test were expressed on average of the four attempts.

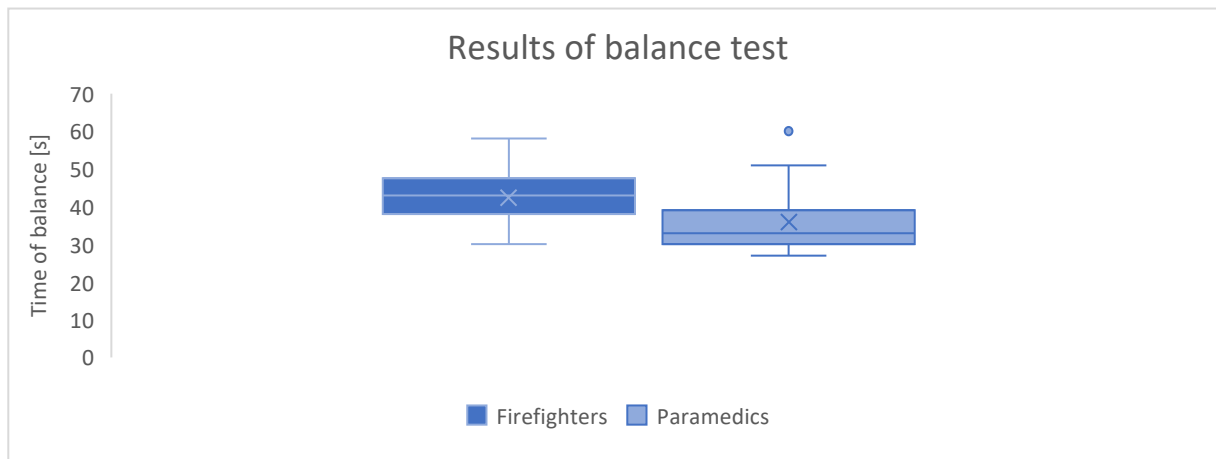


Figure 6: Results of FTRD balance test of firefighter ($n = 45$) and paramedics ($n = 27$) expressed in seconds. The results include the time of balance on the right leg added to the time of balance on the left leg.

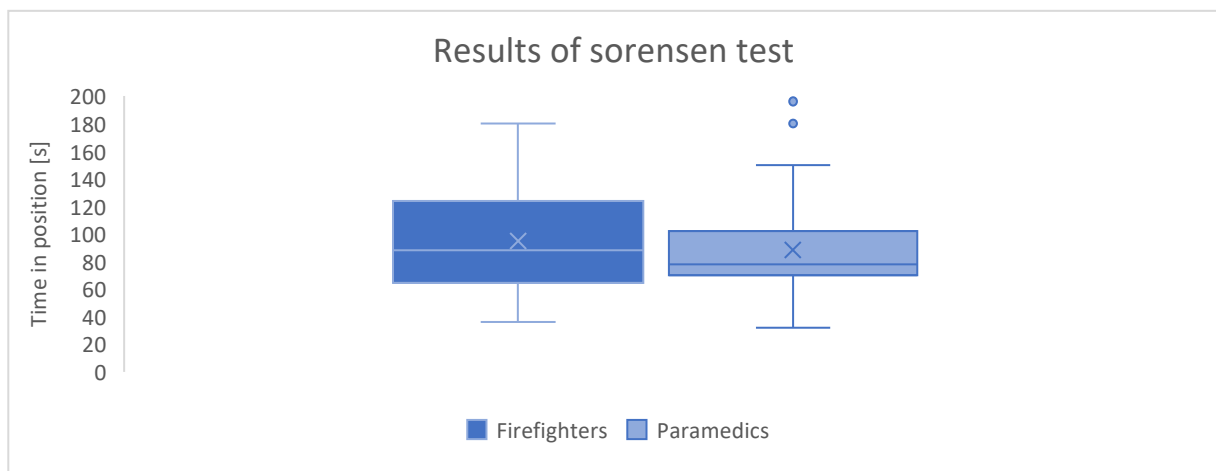


Figure 7: Results of FTRD sorensen test of firefighters ($n = 45$) and paramedics ($n = 27$) expressed in seconds.

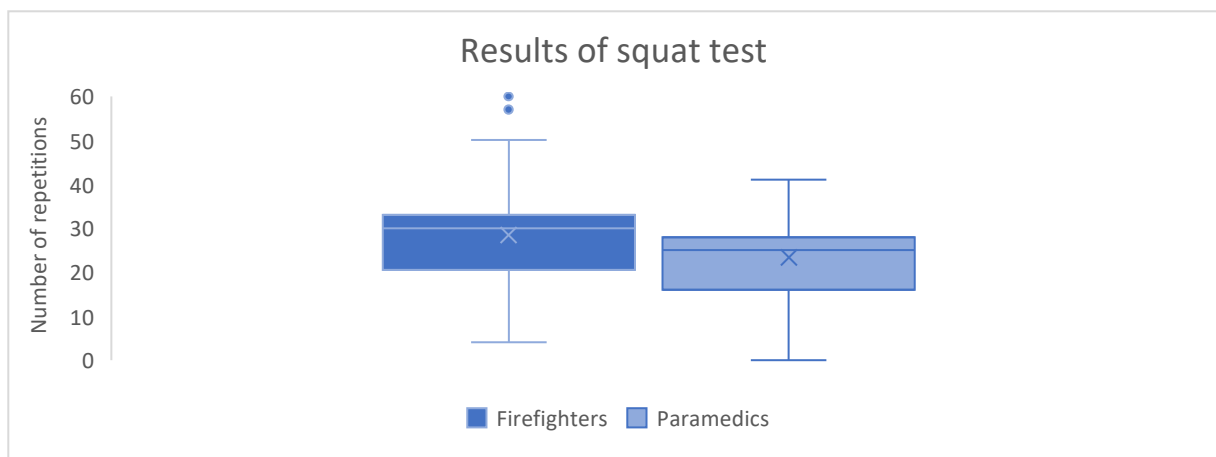


Figure 8: Results of FTRD Squat test of firefighters ($n = 45$) and paramedics ($n = 27$) expressed in number of repetitions.

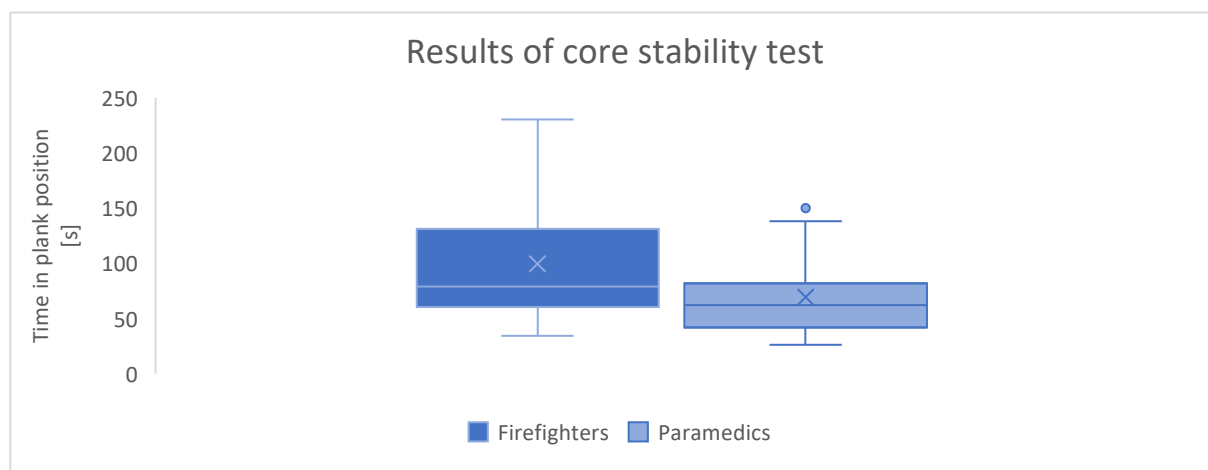


Figure 9: Results of FTRD core stability test of firefighters ($n = 45$) and paramedics ($n = 27$) expressed in seconds.

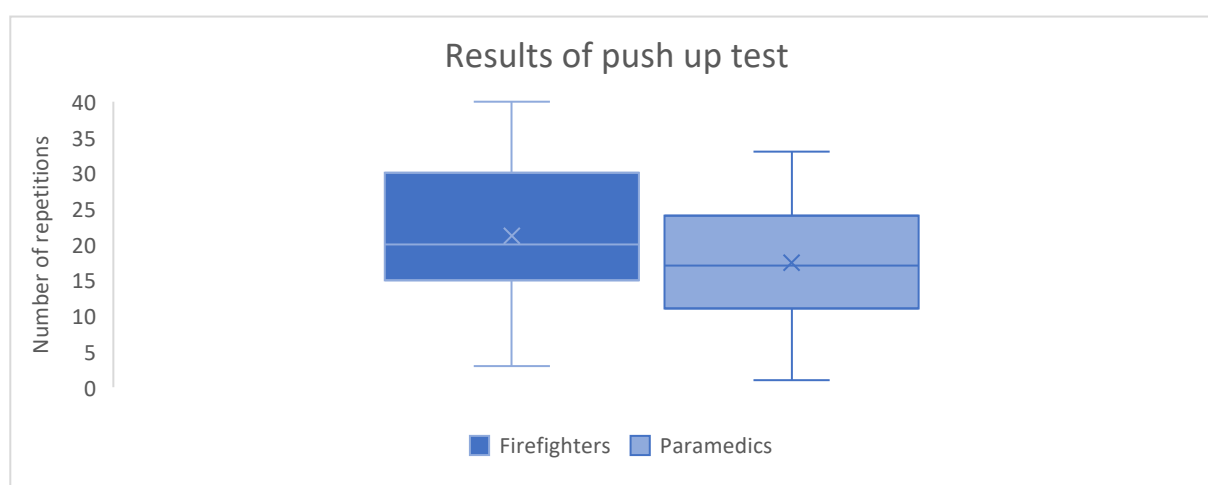


Figure 10: Results of FTRD push up test of firefighters ($n = 45$) and paramedics ($n = 27$) expressed in number of repetitions.

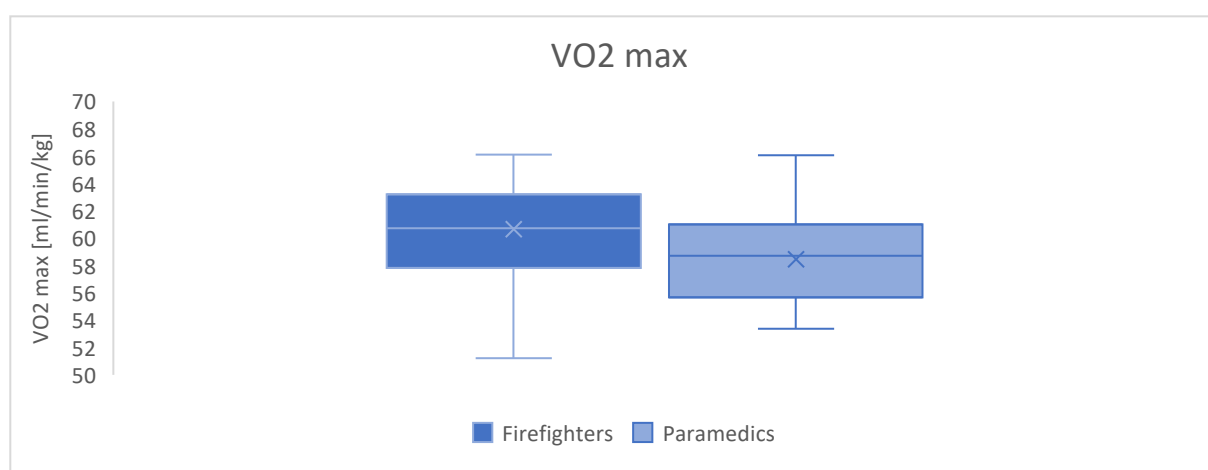


Figure 11: The results of FTRD stepper test were transformed in the VO2 Max of firefighters ($n = 45$) and paramedics ($n = 27$) and expressed in [ml/min/kg].

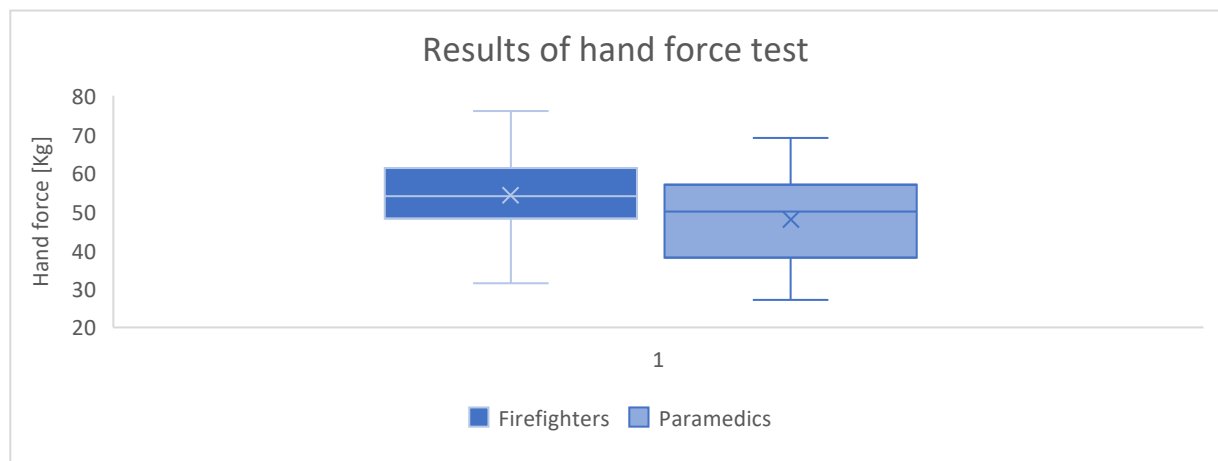


Figure 12: The results of FTRD hand force of firefighters ($n = 45$) and paramedics ($n = 27$) expressed in Kilograms. The results are the average of the four attempts.

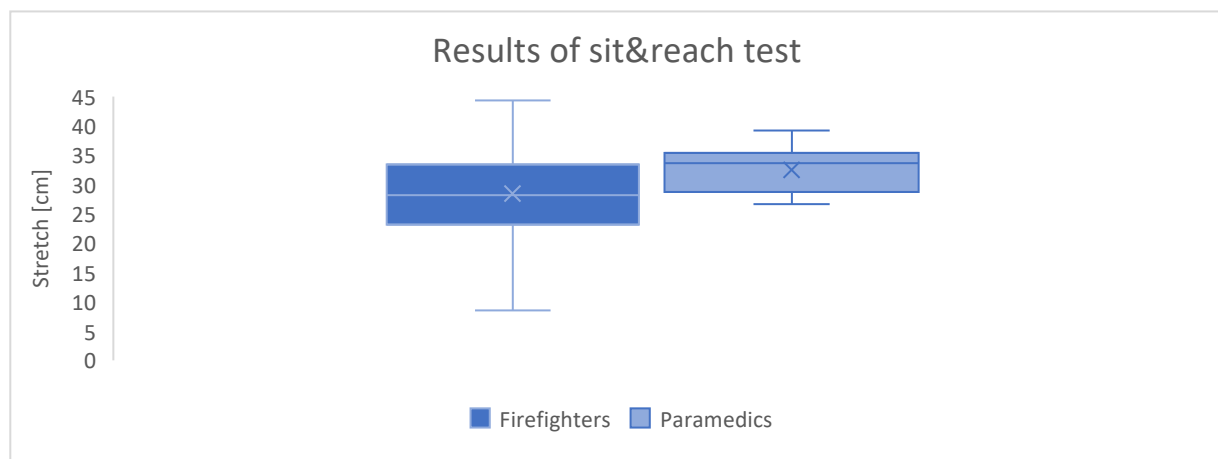


Figure 13: The results of FTRD sit & reach test of fighters ($n = 45$) and paramedics ($n = 27$) expressed in centimeters. The results are the average of the four attempts

In Figure 14 were presented the results of the REDAY app. test, carried out by the same people, before and after the intervention. The results of each post of the test were represented in Figures 15 to 18.

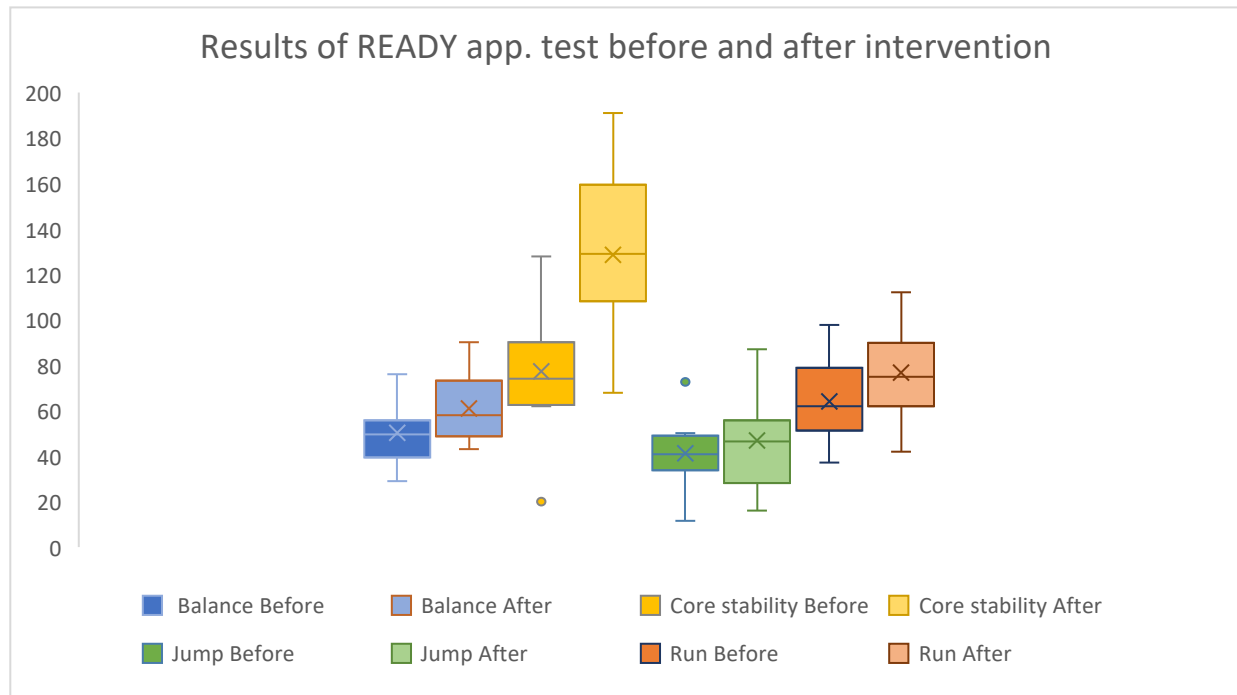


Figure 14: The Results of the REDAY app. test ($n = 12$) before and after 8 weeks of training with the REDAY app. The results were expressed in different units of measurement. The balance test and the core stability test were expressed in seconds, The results of the jump and the run were transformed into decimals and are expressed in milliseconds for the jump and meters for the run.

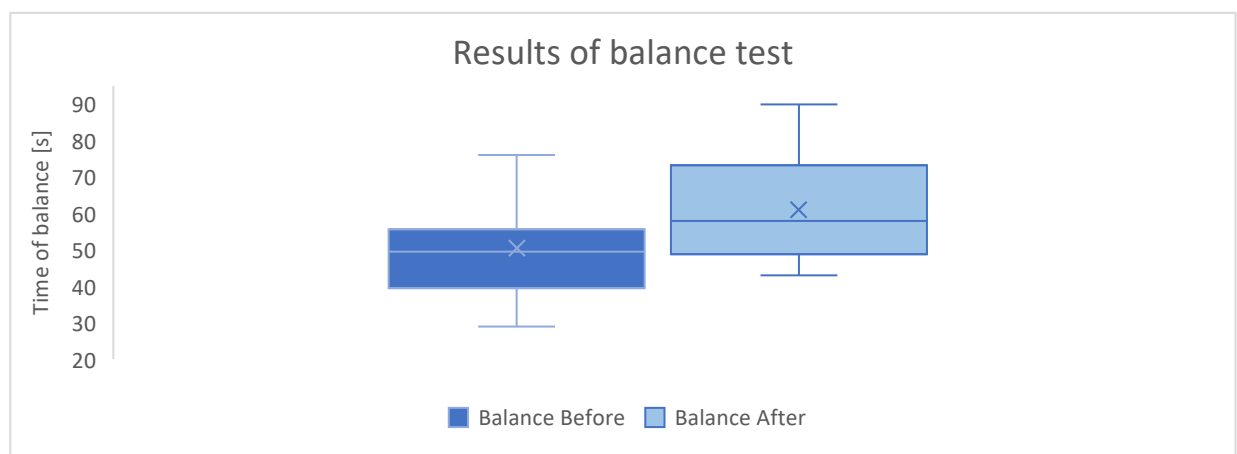


Figure 15: Results of the REDAY app. balance test ($n = 12$) expressed in seconds before and after the intervention. The results include the time of balance on the right leg added to the time of balance on the left leg.

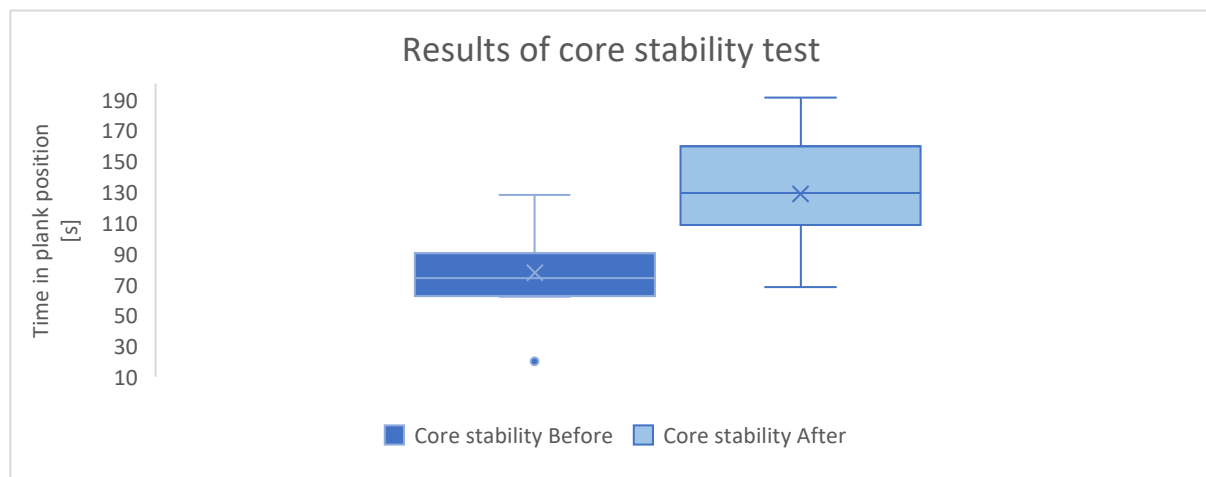


Figure 16: Results of REDY app. core stability test ($n = 12$) expressed in seconds before and after the intervention.

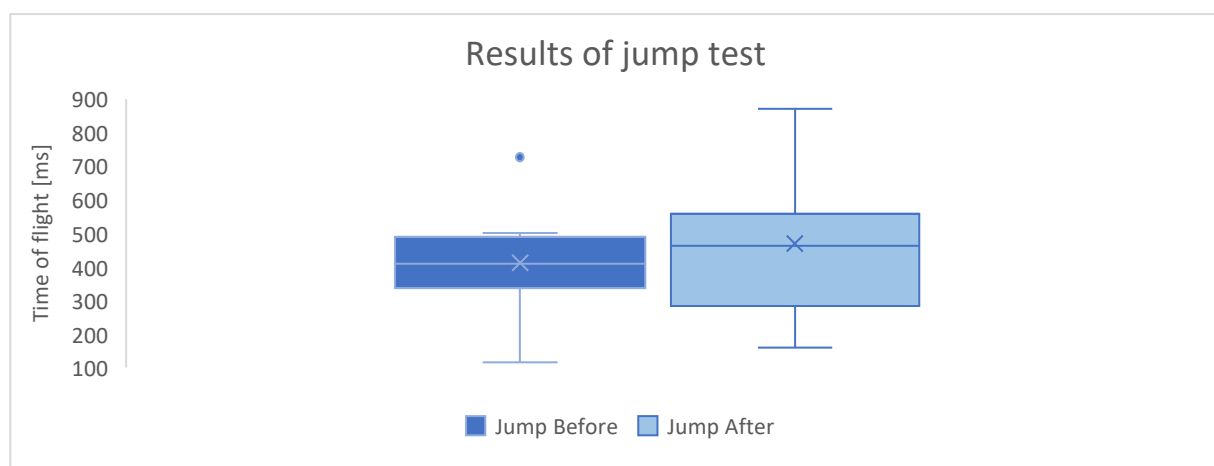


Figure 17: The results of time of flight of the REDY app. jump test ($n = 12$) expressed in milliseconds before and after the intervention.

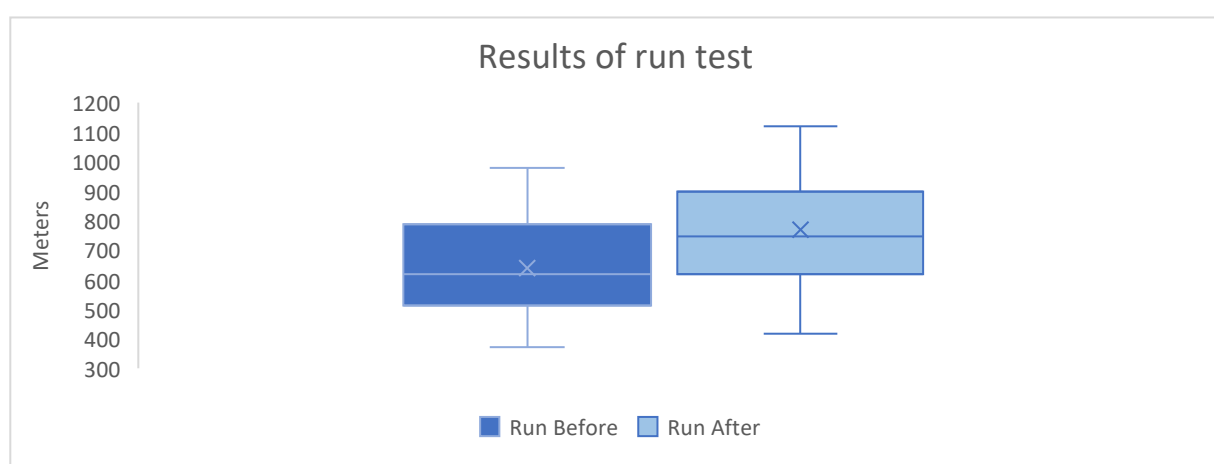


Figure 18: Results of the REDY app. 5 minutes run test ($n = 12$) expressed in meters before and after the intervention.

The results of the READY app. test before and after the intervention, were represented in Table 4 as a percentage of the subject's general physical fitness. This value has been automatically assigned by the READY app. on the test results.

Table 4

Fitness level of each candidate and mean fitness level before and after eight training weeks.

	FITNESS LEVEL ASSIGNED BY READYAPP. BEFORE INTERVENTION	FITNESS LEVEL ASSIGNED BY READY APP. AFTER INTERVENTION
SUBJECT 1	19%	26%
SUBJECT 2	21%	32%
SUBJECT 3	34%	53%
SUBJECT 4	33%	73%
SUBJECT 5	47%	67%
SUBJECT 6	39%	51%
SUBJECT 7	31%	37%
SUBJECT 8	31%	44%
SUBJECT 9	13%	27%
SUBJECT 10	47%	60%
SUBJECT 11	41%	57%
SUBJECT 12	24%	37%
AVARAGE FITNESS LEVEL OF CANDIDATES	32%	47%

Clarification: Results of the READY app. test ($n = 12$) expressed as a percentage of the general physical level of the subject before and after intervention. The value is automatically assigned by the READY app. based on the test results.

In Table 5 were represented the average results of each exercise of the READY app. test, before and after the intervention.

Table 5

Results of READY app. test before and after intervention

	Balance Before	Balance After	Core stability Before	Core stability After	Jump Before	Jump After	Run Before	Run After
Average results	50± 13.6	61 ± 14.6	77 ± 27.8	129 ± 35.8	413 ± 148	470 ± 215	641 ±186	769 ± 207

Clarification: Results of the candidates ($n = 12$) of READY app. test before and after intervention were expressed on average, \pm indicated the standard deviation. The unit of measure of the balance and the core stability were expressed in seconds, the jump in milliseconds and the run in meters.

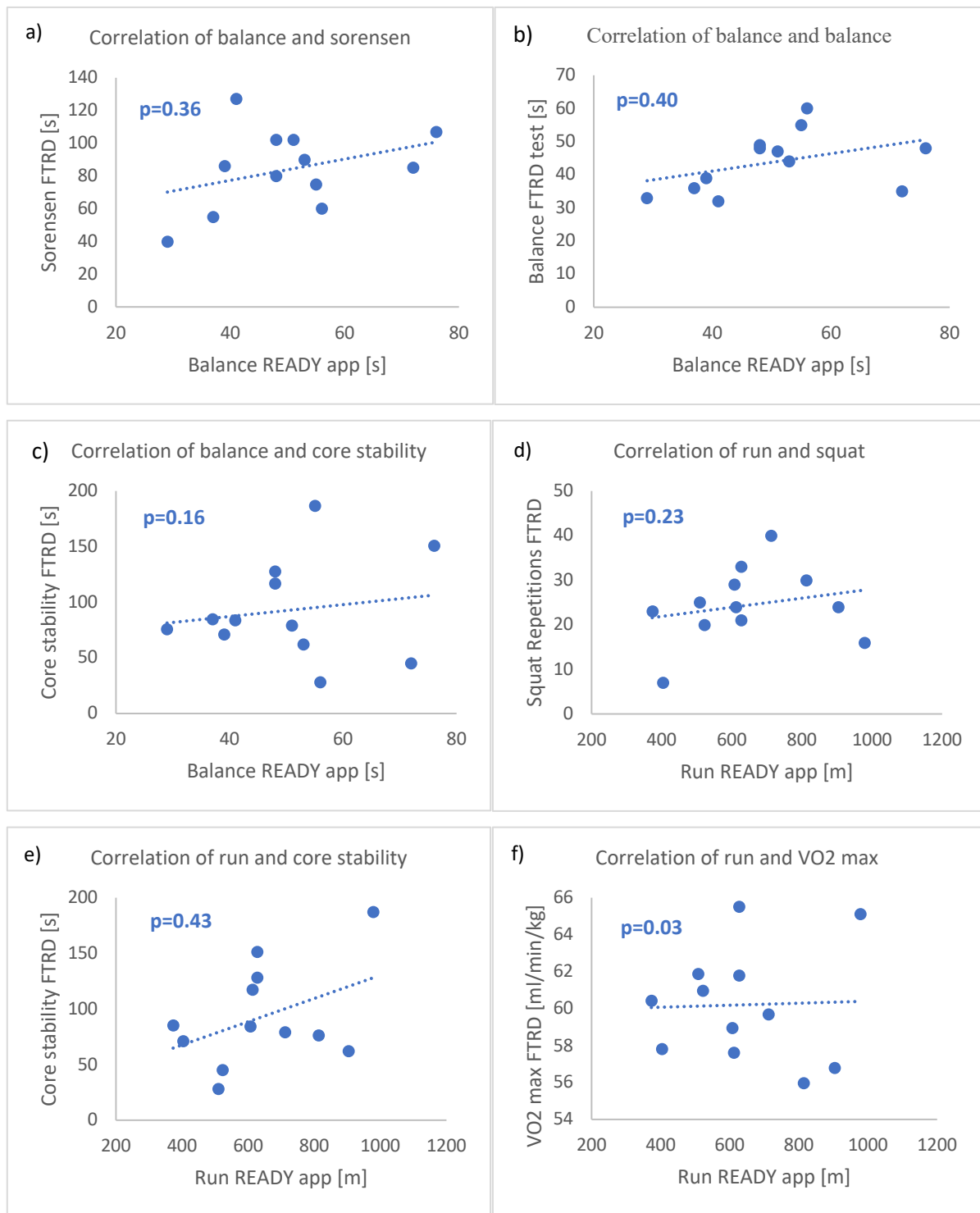


Figure 18: Scatter plot between READY app. tests before the intervention and FTRD tests ($n = 12$). Pearson correlation coefficient (p) is reported in the images. The dotted line represents a linear fit of the data.

Panel a) correlation between balance in the READY app. and sorensen in the FTRD both expressed in seconds, panel b) correlation between balance in the READY app. and balance in the FTRD both expressed in seconds, panel c) correlation between balance in the READY app. and core stability in the FTRD both expressed in seconds, panel d) correlation between run in the READY app. expressed in meters and squat in the FTRD expressed in number of repetition, panel e) correlation between run in the READY app. expressed in meters and core stability in the FTRD expressed in seconds, panel f) correlation between run in the READY app. expressed in meters and VO2 max in the FTRD, expressed in [ml/min/kg].

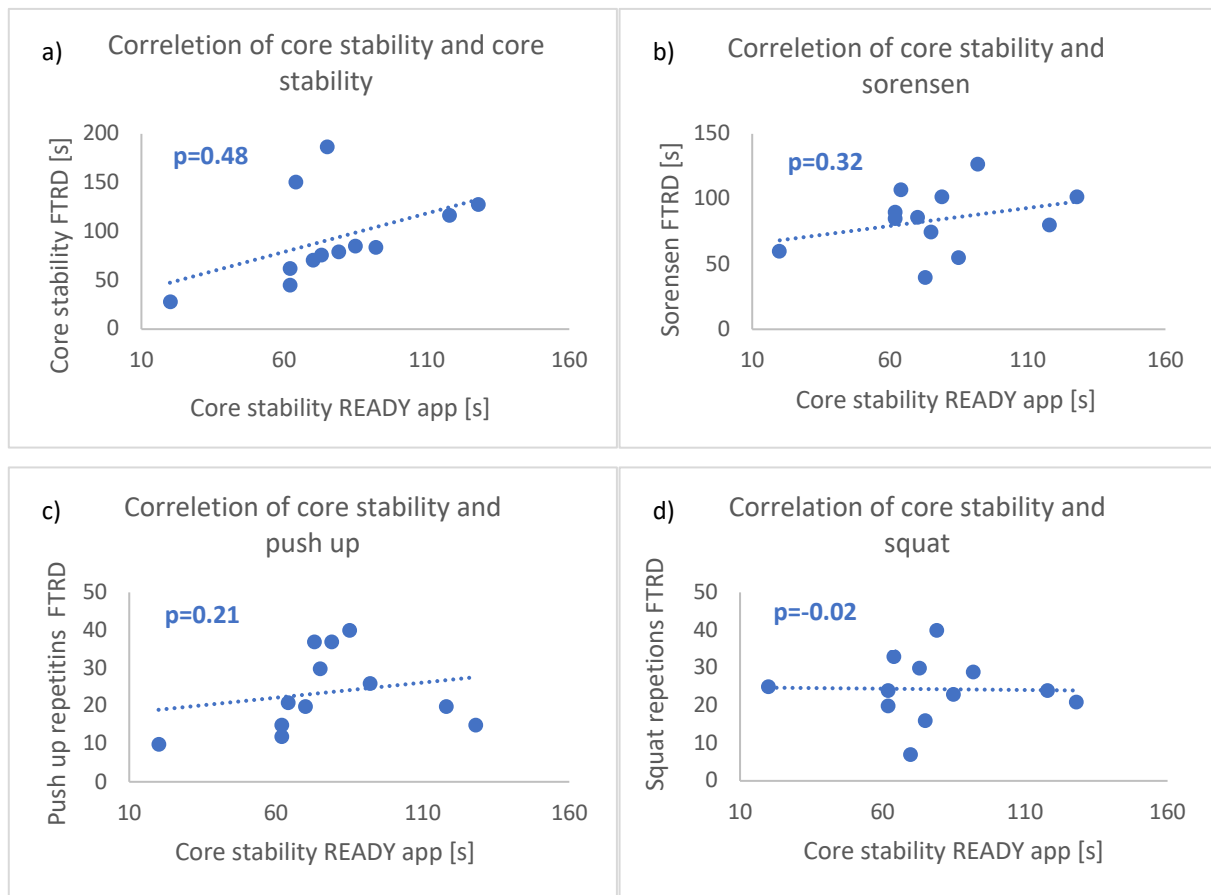


Figure 19: Scatter plot between READY app. tests before the intervention and FTRD tests ($n = 12$). Pearson correlation coefficient (p) is reported in the images. The dotted line represents a linear fit of the data.

Panel a) correlation between core stability in the READY app. and core stability in the FTRD both expressed in seconds, panel b) correlation between core stability in the READY app. and sorenson in the FTRD both expressed in seconds, panel c) correlation between core stability in the READY app. expressed in seconds and push up in the FTRD expressed in number of repetitions, panel d) correlation between core stability in the READY app. expressed in seconds and squat in the FTRD expressed in number of repetitions.

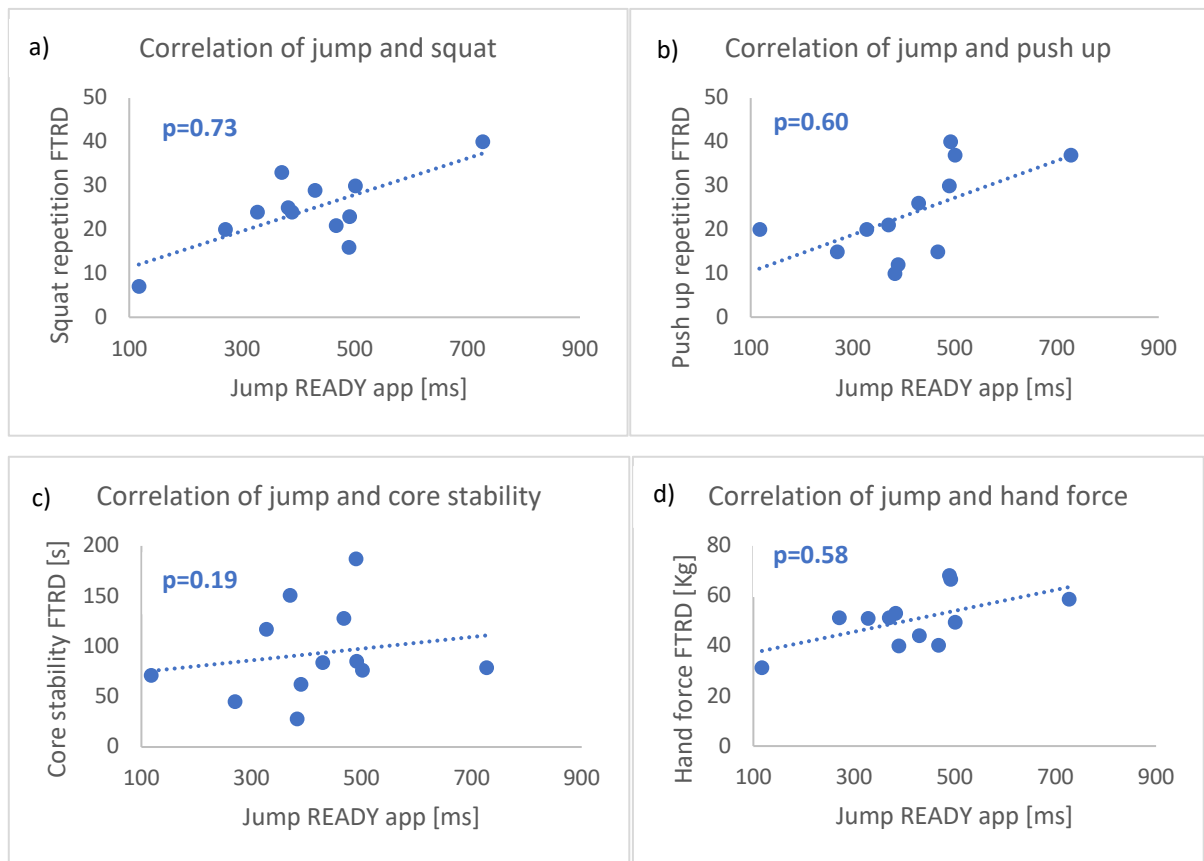


Figure 20: Scatter plot between READY app. tests before the intervention and FTRD tests ($n = 12$). Pearson correlation coefficient (p) is reported in the images. The dotted line represents a linear fit of the data.

Panel a) correlation between jump in the READY app. expressed in milliseconds and squat in the FTRD expressed in number of repetitions, panel b) correlation between jump in the READY app. expressed in milliseconds and push up in the FTRD expressed in number of repetitions, panel c) correlation between jump in the READY app expressed in milliseconds and core stability in the FTRD expressed in seconds, panel d) correlation between jump in the READY app expressed in milliseconds and hand force in the FTRD expressed in kilograms.

4 Discussion

This project has undergone changes due to the Covid-19 virus and its spread has forced the Swiss population to submit to a series of rules issued by the Swiss Federal Council.

Under these conditions for the health of the population and the law passed, it was not possible to carry out the re-test after the eight weeks of training. In the study there are no results and data interpretation after the intervention period, in relation to the FTRD test.

These missing data are essential to answer questions and to achieve the purpose of this project. Unfortunately it is not possible to check, in reference to the FTRD test, if eight weeks of training have influenced and to what extent the physical performance of firefighters and paramedics and which of the two types of training (the READY app. or the personalized program) have a better response of physiological adaptation.

The Corona Lockdown also had a negative impact on the secondary purpose of this project, because the sample did not regularly train during this period. Without this continuity, the aim of promoting physical activity, an active lifestyle with the consequent prevention of diseases caused by inactivity, has only partially occurred.

However, a small part of the sample of 12 persons, who trained following the READY app., still respected the deadlines set by the study, carrying out the training sessions of 30-45 minutes, with the frequency of three times a week for the whole period of the intervention. These people did the READY app. test before the intervention period. To follow up the study and be able to answer the questions of this project, even if in a less complete way, they carried out the same test after eight weeks of training.

From the data that were presented in the part of the results (Figures 14 to 18), based on the READY app. test, the sample who met the training criteria, achieved improvements in physical performance after the intervention period.

As represented in Table 5, the balance, evaluated with the balance test, on average improved by 11 seconds, the muscles strength of the core area of the subjects, evaluated with the core stability test, increased on average by 52 seconds. The strength of the lower part of the body expressed with the time of flight in the jump improved on average by 57 milliseconds. An increase of the endurance and the speed was also noticed, in fact in the five minutes run, on average the subjects ran 128 meters more. The mean "running pace", ie how long it takes to run one km, has decreased by about 60 seconds.

The general physical fitness assigned to each candidate by the READY app., after the intervention period, improved in mean by 15%, with a 40% peak in "subject 4" (Table 4).

A study showed [14] that eight weeks of bodyweight training consisting of pull up, push up and squat, with a frequency of three weekly sessions of 60 minutes per session, led to an improvement in performance between 18% and 30%.

Comparing period, type, frequency and volume of the workouts and the results obtained from the study [14] with the expected workouts and the fitness values assigned by the READY app., it can be seen that there is a similarity of the results and therefore the values assigned by the READY app. in terms of physical fitness, seems to be reliable.

The READY app. test includes fewer specific exercises especially for the upper body and includes less analysis on the physical and body state of the subject (such as height, weight and waist measurements) compared to the FTRD test. In order to assess the reliability of the READY app. test for describing the physical performance of firefighters and paramedics, we correlate several measurements done in the two respective tests. A strong correlation between the two tests would suggest that observations done after the intervention using the READY app. would potentially also be observed in the FTRD test after the intervention if this would have been done. As described in the methods, only correlations bigger than 0.567 can be considered significant for a sample of 12 subjects, which in our case consists of the correlation between (Jump-Squat), (Jump-Hand force), (Jump-Push up). Whereas the correlation between jump and squats may seem obvious, the others are less trivial but may just be due to the general conditions of the candidates. Note that other more expected correlations e.g. VO₂max vs Run or Plank vs Plank are not significant enough to reject the null hypothesis and so we cannot accept them. This is probably due to the relatively small sample we have analyzed and should be solved when collecting more data.

With the results of the READY app. test, we can answer, even if not completely, the question of whether eight weeks of training, with sessions of 30-45 minutes and with a frequency of three times a week, improve the level of the physical performance. This intervention period led to improvements in the physical performance of the tested subjects, especially in strength, stamina and balance. However, it is not possible to establish whether the period of intervention also improved the body composition of the candidates.

A training program with the goal of increasing lean body mass and strength for a duration of eight weeks, leads people to an increase in anaerobic capacity, endurance and muscle strength but without making significant changes on the sit & reach test, moreover eight weeks is a sufficient period to have a positive effect on body composition and physical fitness, with a decrease in fat body mass and the respective increase in lean body mass and bone density [15].

As demonstrated in the study [15], with eight weeks of training, the subjects studied also achieved a series of improvements in body composition and physical fitness. It can be assumed that the sample of firefighters and paramedics, who carried out the training, also had improvements in the body composition with the consequent decrease in fat body mass and the increase in lean mass by positively changing the values of the BMI and WtHR.

Analyzing the BMI data (Figure 3, Table 3), it emerges that 33% of firefighters are considered normal weight, 53% overweight and 13% obese class I. Paramedics have a percentage of people in normal weight of 26%, overweight 52%, obese class I 15% and obese class II 7%.

Analyzing WHtR data (Figure 4, Table 3), 42% of firefighters are considered healthy, 37% overweight, 15% very overweight and 4% obese. In paramedics, 40% are considered healthy, 18% overweight, 33% very overweight and 7% obese.

BMI and WtHR are considered to be two predictors of cardiovascular risk and mortality but although the sample analyzed is the same, the results that classify firefighters and paramedics into categories of health status are very different from each other. If based on BMI, 30.5% of the total sample is considered healthy and 69.5% has a higher risk of mortality.

The WtHR results show that 41.5% of the total sample is healthy and 58.5% have a higher risk of mortality.

As described in [11] WtHR has been considered more reliable than BMI and therefore a better predictor of mortality and cardiovascular disease.

Based on the WtHR results, it is noted that more than half of firefighters and paramedics are above the ideal weight threshold, exposing these people to a greater risk of mortality caused by cardiovascular diseases, heart attacks or type II diabetes.

Performing high intensity physical activity for the total duration of 1.5 hour per week would not only have an impact on physical performance, but would also reduce the risk of health problems caused by being overweight or inactive [1].

As shown in the results, the intervention period with READY app., has led to improvements in performance in all four exercises tested (balance, core stability, jump, run), the most significant increase emerged in core stability, with an improvement average of 37%.

Considering the physical demand of the job and the high risk of injuries with which firefighters and paramedics are confronted [3][5], having a good physical condition and a good core strength would reduce the risk of MSD and injuries [6][7]. Although difficult, it would be important for firefighters and paramedics to integrate these short training sessions directly into the workplace during periods of inactivity, following the READY application. This would not

only bring the benefits listed in this study, but would guarantee to be warmed up at the moment they must leave for the emergency, further decreasing the risk of injuries.

4.1 Weaknesses of the study

The greatest difficulty of this study was the lack of FTRD test results after the intervention period. Without these data it was not possible to carry out a complete and in-depth analysis of the performance and physical state of the candidates and to compare the efficiency of the two types of training.

In order to have data on which to discuss, and overall maintain the purpose of this project, performance analysis was done on the results of the READY app. tests.

The autonomous tests, adapted to the situation, solved the problem of social distances due to the Corona Lockdown, however allowing to have concrete results on which to carry out an analysis.

Unfortunately, due to the extraordinary situation, the sample that reacted to the various requests was only of 12 subjects. The restricted sample, the independent tests, the evaluation criteria and the detection of the performance (for running and jumping, automatically generated by the smartphone based on the GPS), may have influenced the inaccuracy of some data from READY app. tests.

Considering the extraordinary nature of this situation and what it entailed, in such a future project, it would be desirable that all the candidates taking part in the study, countersigned a declaration of commitment.

Furthermore, for this study it would have been interesting to make an initial questionnaire on the sample's habits including lifestyle, perceived health status and the amount of weekly physical activity, being able in this way to deepen the health issue of the candidates.

Lastly, we could have insisted more on the redaction of a training diary by the candidates, noting how they felt before and after each training session, and how they perceived the effort (e.g. using the Borg scale as a reference). This would have allowed the candidates to be more aware of the physiological change of their body, motivating them to a continuity in physical activity.

5. Conclusion

In conclusion the type of workouts with your own body weight, as well as simple to apply for those who know the family of movements, can be efficient in improving muscle strength and endurance of the whole body. This study evidenced an improvement of the physical performance with a load of three times a week for eight week of training using the READY app. that is based on body weight trainings.

Firefighters and paramedics are recommended to carry out regular training sessions to increase physical performance, decrease the risk of injures and mortality caused by cardiovascular diseases, diabetes, and hypertension.

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Giacomo Righetti



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Supplementary material

FTRD TEST

1 3-Minuten Step-Test mit Einsatzrucksack

Material	Stepper (30.5 cm), Einsatzrucksack (15 kg), Pulsuhr, Brustgurt, Stoppuhr, Metronom
Versuche	1
Ausgangsstellung	<ul style="list-style-type: none">✓ Der Teilnehmende trägt den Einsatzrucksack auf dem Rücken.✓ Aufrechtstehende Position vor dem Stepper.✓ Der Brustgurt wird unterhalb des M.pectoralis möglichst auf Herzhöhe direkt auf der Haut angezogen. Eine leicht feuchte Oberfläche verbessert das Signal.✓ Die Uhr wird am Handgelenk der dominanten Hand getragen (bei Rechtshändlern rechts, bei Linkshändlern links)✓ Die Verbindung von Brustgurt und Pulsuhr wird vom Testleitenden überprüft.✓ Der Testleitende stellt das Metronom auf 96 Schläge pro Minute und die Stoppuhr auf 3 Minuten.✓ Der Testleitende zeigt dem Teilnehmenden das vorgegebene Schrittmuster bei laufendem Metronom: bei jedem Ton wird ein Schritt gemacht, d.h. beim ersten Ton steht man mit einem Fuss komplett auf den Stepper, beim zweiten Ton kommt der zweite Fuss dazu (korrekte aufrechte Position auf Stepper, siehe Abbildung 1 rechts). Mit dem dritten Ton wird der erste Fuss wieder auf den Boden gestellt, beim vierten Ton steht der Teilnehmende wieder aufrecht vor dem Stepper.✓ Der Teilnehmende darf den Rhythmus kurz ausprobieren. Wenn der Teilnehmende während dem Test aus dem Rhythmus fällt, darf dieser wieder in die Ausgangsposition aufrechtstehend vor dem Stepper gehen und von vorne beginnen.
Durchführung	<p>Die Kommunikation des Testleitenden ist sehr wichtig!</p> <p>Auf das Kommando «Start» startet der Testleitende die Stoppuhr. In den ersten 3 Minuten soll der Teilnehmende das Schrittmuster möglichst im Rhythmus des Metronoms in einer Endlosschleife wiederholen. Exakt nach Ablauf der 3 Minuten gibt der Testleitende das Kommando «Stopp», worauf der Teilnehmende sich sofort auf den Stepper setzt, mit dem Einsatzrucksack noch auf dem Rücken, und seinen Radialispuls mit der dominanten Hand am nicht-dominanten Handgelenk sucht. Der Testleitende schaltet das Metronom aus. Bei 3:05 teilt der Testleitende laut das Kommando «Pulsmessung» mit, der Teilnehmende beginnt, seine Pulsschläge eine komplette Minute mitzuzählen. Bei 3:05 liest der Testleitende den angezeigten Pulswert auf der Pulsuhr ab und notiert diese. Ebenfalls bei 3:35 und bei 4:05 wird der Pulsuhrwert notiert. Das Kommando «Pulsmessung fertig» bei Zeit 4:05 beendet das Auszählen der Minute Radialispuls und der Teilnehmende teilt dem Testleitenden seinen gemessenen Pulswert mit.</p>
Messung	Die Pulswerte werden mittels Pulsuhr zu den Zeiten 3:05, 3:35 und 4:05 erhoben. Das komplette Auszählen der Minute 3:05 bis 4:05

	erfolgt durch den Teilnehmenden selber und soll möglichst ungestört möglich sein.
Kontrolle durch Testleitenden	Schrittmuster beobachten, ggf. zum Neustart auf dem Boden auffordern. Möglichst immer mit dem gesamten Fuss auf den Stepper stehen. Störfaktoren ausschalten beim Auszählen des Radialispulses.

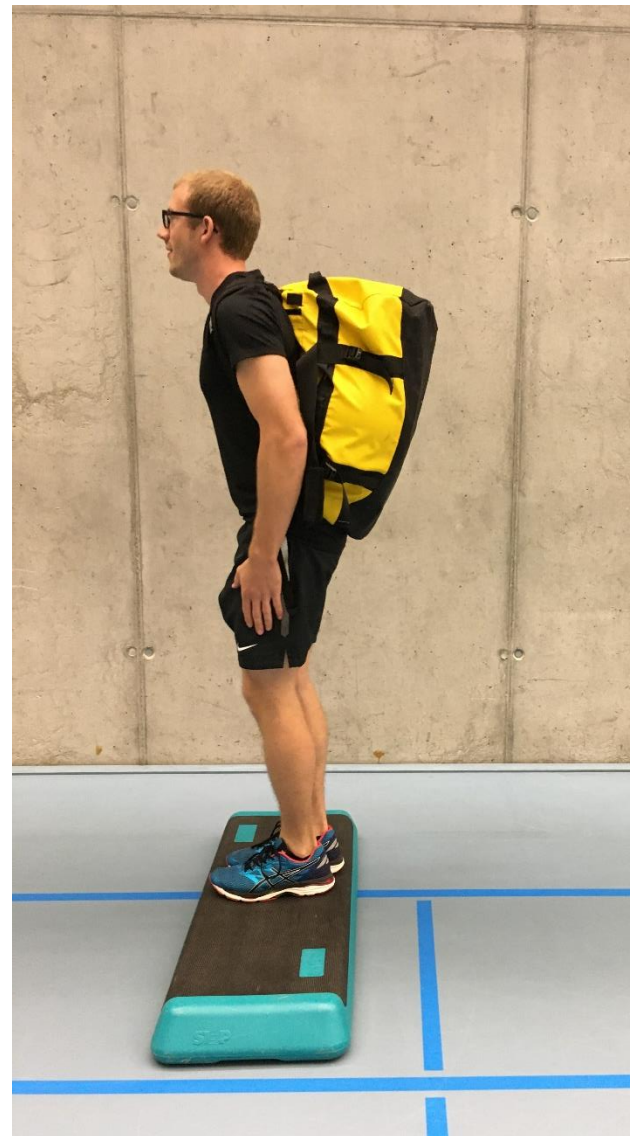


Abbildung 1 Aufrechte Startposition, Blick nach vorne. Immer mit dem gesamten Fuss auf den Stepper stehen, nicht nur Fussballen.

2 Einbeinstand

Material	Gymnastikreifen Ø 70 cm, Stoppuhr
Versuche	1 pro Bein
Ausgangsstellung	<ul style="list-style-type: none"> ✓ Den Gymnastikreifen auf geradem Boden platzieren. ✓ Der Teilnehmende begibt sich in die Mitte des Reifens. ✓ Hände hinter dem Rücken verschränken.
Durchführung	<p>Den Fuss in die Mitte des Reifens platzieren. Die Hände hinter dem Rücken zusammenhalten. Den zweiten Fuss an die Kniekehle des Standbeines halten. Der Oberkörper ist aufrecht, das Standbein gestreckt. Der Teilnehmende nimmt diese Position auf das Startsignal «Bereit, Start» ein. Dann startet die Zeitmessung. Nach 10 Sekunden erfolgt das Kommando «Augen schliessen», worauf der Teilnehmende die Augen schliessen muss. Nach weiteren 10 Sekunden erfolgt ein weiteres Kommando «Kopf mit geschlossenen Augen in den Nacken». Der Teilnehmende muss den Kopf mit geschlossenen Augen so weit wie möglich nach hinten in den Nacken legen. Die Zeit wird gestoppt, sobald</p> <ul style="list-style-type: none"> • ein anderes Körperteil als der Standfuss den Boden berührt. • der zweite Fuss die Kniekehle nicht mehr berührt. • die Hände sich loslassen. • der Standfuss den Boden verlässt (nur leichte Verschiebungen mit ständigem Bodenkontakt sind erlaubt, hüpfen ist nicht erlaubt). • die Augen geöffnet werden. • der Standfuss den Reifen berührt. <p>Nach 60 Sekunden wird die Messung abgebrochen und die Maximalzeit von 60 Sekunden eingetragen. Zuerst das linke und dann das rechte Bein messen. Die wartenden Teilnehmenden dürfen nicht üben.</p>
Messung	Die Zeit wird auf die Sekunde genau notiert.
Kontrolle durch Testleitenden	Der Testleitende sorgt für Ruhe und Konzentration und weist vorgängig ausdrücklich auf alle Abbruchkriterien hin. Er steht ca. 3m vom Teilnehmenden entfernt, um alle Abbruchkriterien überwachen zu können. Der Testleitende stoppt die Zeit, kontrolliert die Ausführung und gibt die Kommandos «Augen schliessen» nach 10 Sekunden und «Kopf mit geschlossenen Augen in den Nacken» nach 20 Sekunden.



Abbildung 2 Hände hinter dem Rücken, Fuss in der Kniekehle, Positon 1 Blick nach vorne, Position 2 Augen schliessen, Position 3 Kopf so weit wie möglich in den Nacken.



Abbildung 3 Blick auf korrekte Startposition von der Seite.

3 Sorensen Test

Material	Tisch, Stuhl, Stoppuhr, hohen T-Bar
Versuche	1
Ausgangsstellung	<ul style="list-style-type: none"> ✓ Der Teilnehmende liegt mit dem unteren Teil des Körpers bis zur Hüfte auf dem Tisch. Der grosse vordere Darmbeinstachel (Spina iliaca ventralis) kommt dabei als Referenz möglichst auf der äussersten Kante zu liegen. Der Teilnehmende darf sich dabei mit den Händen vor sich abstützen. ✓ Ein weiterer Teilnehmender kniet sich hinter den zu Testenden, und fasst ihn fest um die Knöchel. Eine verlässliche Fixierung ist wichtig, damit der zu Testende eine hohe Körperspannung aufbauen kann. ✓ Die Arme werden vor der Brust gekreuzt (Hände auf Schultern oder Clavicula berühren). ✓ Der Oberkörper wird horizontal gehalten, sodass der gesamte Körper eine gerade Linie bildet. Der Testleitende kann mit dem Inclinometer die Geradheit überprüfen (ein Ende auf Lumbalwirbel, anderes Ende über Halswirbel und gesenkten Kopf nach vorne). Der Inclinometer soll 0° anzeigen ✓ Der Testleitende stellt den T-Bar so ein, dass der Positionsständer den unteren Teil der Brustwirbelsäule des Teilnehmenden leicht berührt. ✓ Bevor der Test startet darf sich der Teilnehmende nochmals mit dem Armen auf dem Stuhl abstützen und sich entspannen.
Durchführung	Auf das Startsignal hin hält der Teilnehmende seinen Oberkörper so lange wie möglich in der horizontalen geraden Position. Die Hände dürfen nicht gelöst werden. Sobald der Kontakt zum T-Bar abbricht, wird die Zeit gestoppt und notiert.
Messung	Die Zeit wird auf die Sekunde genau gemessen.
Kontrolle durch Testleitenden	Haltung und Kontakt mit Positionsständer genau kontrollieren.

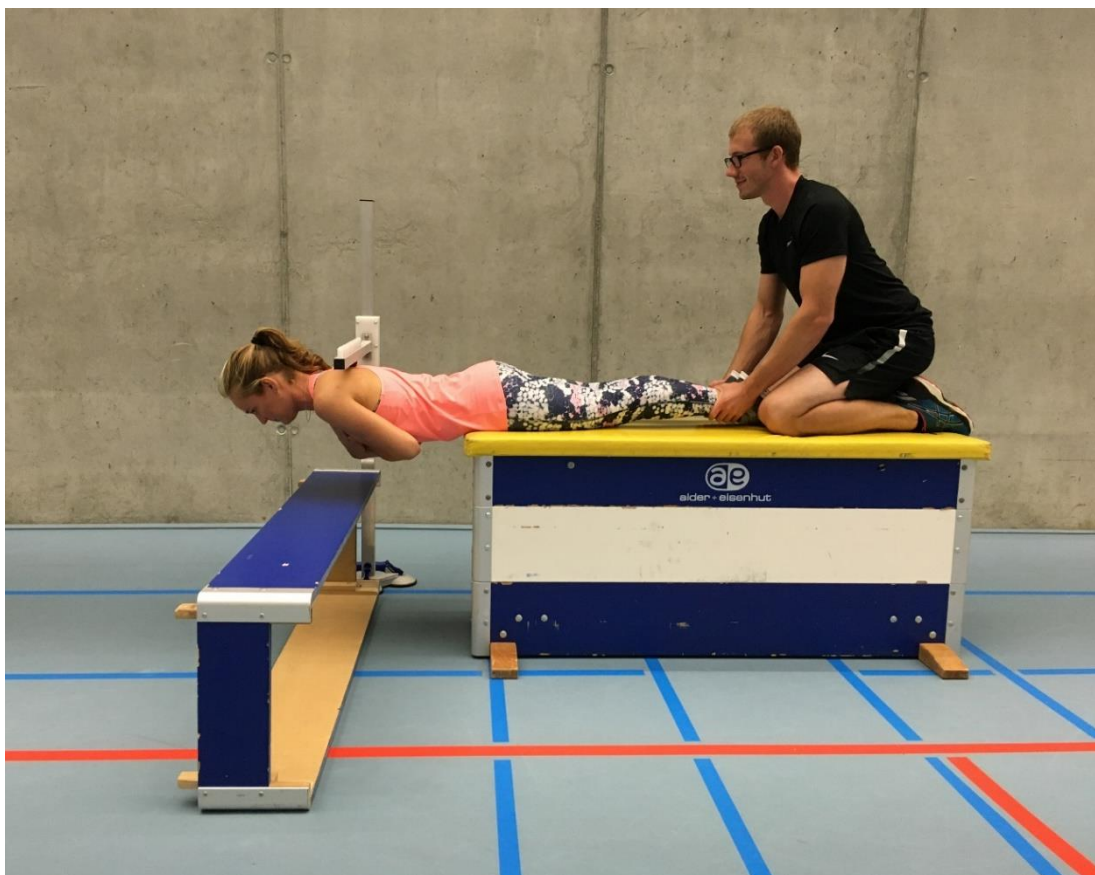


Abbildung 4 Hände auf den Schultern, Oberkörper in der geraden Linie halten, Kopf in Verlängerung des Rückens.

4 CPR (HerzKreislaufreanimation ohne Beatmung)

Material	Stoppuhr, Reanimationstorso
Versuche	1
Ausgangsstellung	<ul style="list-style-type: none"> ✓ Der Teilnehmende nimmt eine kniende Position auf einer Seite der Puppe ein. ✓ Die Hände werden auf Höhe der Mamillen über dem Brustbein übereinandergelegt (links auf rechts oder rechts auf links). ✓ Die Arme bleiben während der gesamten Reanimation gestreckt.
Durchführung	Auf das Kommando «Start» beginnt der Testleitende zwei Minuten zu stoppen. Der Teilnehmende führt zwei Minuten lang eine CPR ohne Beatmung durch (durchgehende Zyklen). Nach zwei Minuten wird die CPR abgebrochen.
Messung	«Bestanden» oder «nicht bestanden» der zwei Minuten kniender Tätigkeit ohne Unterbruch.
Kontrolle durch Testleitenden	Für ein Bestehen dieses Tests darf der Teilnehmende innerhalb dieser zwei Minuten die kniende Position nicht verlassen. Die Tiefe und Qualität der CPR wird nicht bewertet.

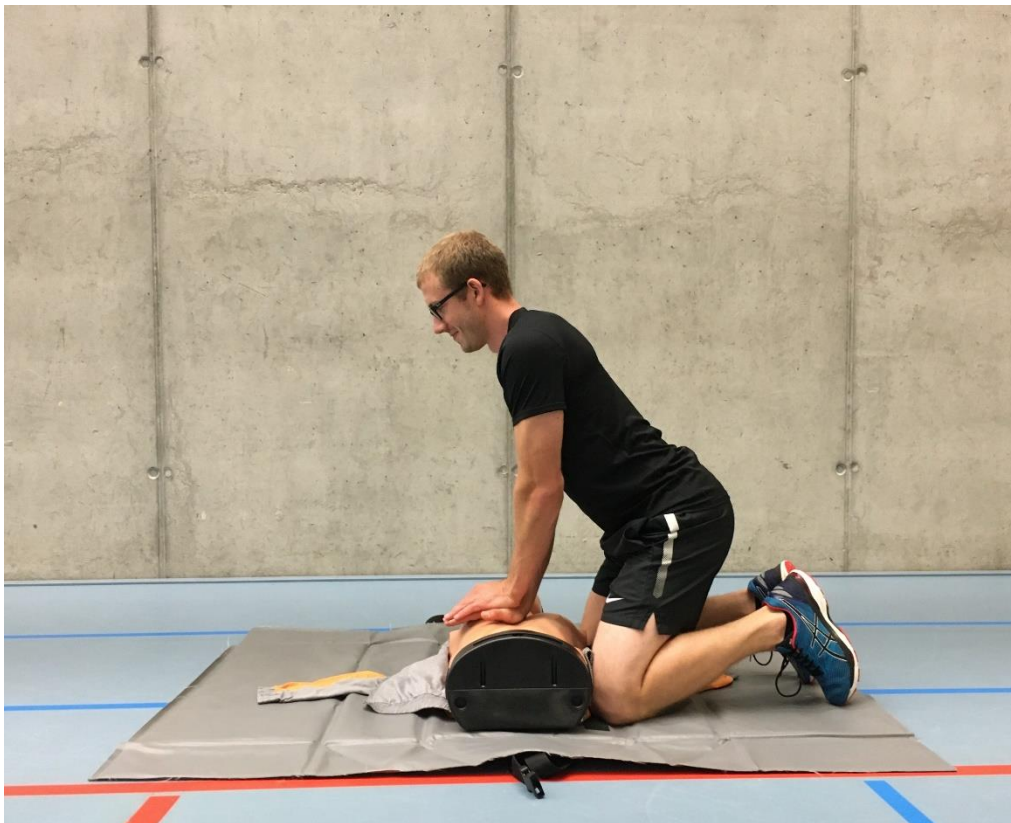


Abbildung 5 Kniende Position nahe an der Puppe, mit gestreckten Armen CPR ausführen.

5 Squats mit Gewicht

Material	Langhantelstange, 40 kg Gewichtsscheibe, Gewichtsscheibe zur Fixierung (alternativ mit einem Tuch), Handzähler
Versuche	1
Ausgangsstellung	<ul style="list-style-type: none"> ✓ Die Langhantel ist auf einer Seite mit 40 kg geladen und wird mit der ungeladenen Seite in einer Raumecke fixiert. ✓ Der Teilnehmende steht hüftbreit, beide Füße gleich belastet. ✓ Eine Knieflexion senkt das Gesäss nach hinten unten ab (Skifahrposition), dabei bleibt der Rücken gerade. Das ganze Gewicht wird folglich auf die Fersen verlagert. ✓ Mit geradem Rücken wieder aufstehen. ✓ Die Arme bleiben gestreckt.
Durchführung	Der Teilnehmende hält die Langhantelstange mit beiden Händen umfasst. Er geht mit geradem Rücken in die tiefe Hocke (Squats) bis die Gewichtsscheibe den Boden kurz berührt. Danach richtet er sich mit geradem Rücken und gestreckten Armen wieder auf. Dies wird so oft wiederholt, bis die Hantel auf dem Boden abgestellt wird. Es gibt keine Zeitlimite.
Messung	Die Anzahl korrekt ausgeführte Wiederholungen werden gezählt (wie oft der Teilnehmende sich aufrichten konnte). Wird eine Wiederholung nicht in der korrekten Haltung ausgeführt, zählt diese nicht aber der Test wird nicht abgebrochen, sondern der Teilnehmende wird korrigiert. Der Handzähler kann vom Testleitenden für ein zuverlässiges Zählen verwendet werden.
Kontrolle durch Testleitenden	Haltung genau kontrollieren und korrigieren und nur die korrekt ausgeführten Wiederholungen zählen.

Zusätzlicher Hinweis: Ein Versuch für die Bewegungsfindung und zur Gewichtseinschätzung. Obwohl 40 kg geladen, wird mit 50 kg gearbeitet (Kräfte- und Momentengleichgewicht).



Abbildung 6 Squats mit geradem Rücken, Gesäss nach hinten, Knie gehen nicht über die Zehenspitzen, Blick nach vorne. Arme bleiben gestreckt.

6 Globaler Rumpfkrafttest

Material	Stoppuhr, Metronom, T-Bar, evtl. Fitnessmatten
Versuche	1
Ausgangsstellung	<p>✓ Der Teilnehmende liegt in Bauchlage unter dem Positionsständer. Korrekte Unterarmstützposition wird vom Testleitenden instruiert:</p> <ul style="list-style-type: none"> - Die Oberarme sind vertikal, die Unterarme sind parallel und auf Schulterbreite, die Daumen sind nach oben gerichtet - Die Beine sind gestreckt, die Füße so nah wie möglich zusammen - Der Oberkörper und die Beine bilden eine Linie - Der Kontaktbalken berührt das Kreuz (direkt oberhalb des Gesässes, über den beiden Spinae iliacae posterior superior). <p>✓ Nachdem alles eingestellt ist, kann der Teilnehmende zurück in die Bauchlage.</p> <p>✓ Der Testleitende stellt das Metronom auf 60 Schläge pro Minute ein</p>
Durchführung	<p>Sobald der Teilnehmende bereit ist, geht er wieder in den Unterarmstütz (Oberarm vertikal, Unterarme parallel, Beine gestreckt und die Füße zusammen). Er hebt die Füße im Ein-Sekunden-Rhythmus (60 Schläge pro Minute) wechselseitig 2 bis 5 cm hoch. Für eine korrekte Position muss der Teilnehmende sein Kreuz während der gesamten Ausführung leicht gegen den Kontaktbalken drücken. Die Zeit wird gestoppt, sobald</p> <ul style="list-style-type: none"> • der Kontakt zwischen Kreuz und Kontaktbalken abbricht • der Teilnehmende in die Bauchlage zurückgeht • die Knie abgestellt werden • der Kopf auf die Arme gestützt werden • die Unterarmposition verändert wird (Hände zusammenpressen o.ä.) <p>Es ist nicht erlaubt, nach einem solchen Vorfall weiterzumachen. Nach dem Abbruch bleibt der Teilnehmende unter dem Messständer liegen, bis der Testleitende die Zeit und Startnummer notiert hat.</p>
Messung	Die Zeit wird auf die Sekunde genau gemessen.
Kontrolle durch Testleitenden	<p>Der Testleitende weist darauf hin, dass die Zeit nur läuft, wenn ein Kontakt zwischen dem Körper und dem Kontaktbalken besteht. Der Testleitende kontrolliert die Ausführung (Fussabheben im Sekundentakt und Körperposition). Kann der Teilnehmende den Rhythmus mangels Taktgefühls nicht einhalten, macht der Testleitende darauf aufmerksam. Da der Rhythmus nur einen geringen Einfluss auf die Leistung hat, kann der Test aber auch bei arrhythmischer Beinbewegung bewertet werden. Der Kontakt zwischen der Teilnehmenden und dem Kontaktbalken wird regelmässig überprüft. Bei drohendem Kontaktverlust weist der Testleitende den Teilnehmenden sofort an, den Kontakt wieder herzustellen (1. Verwarnung). Dies gilt solange, bis eines der Abbruchkriterien eintritt oder eine zweite Verwarnung ausgesprochen werden muss.</p>

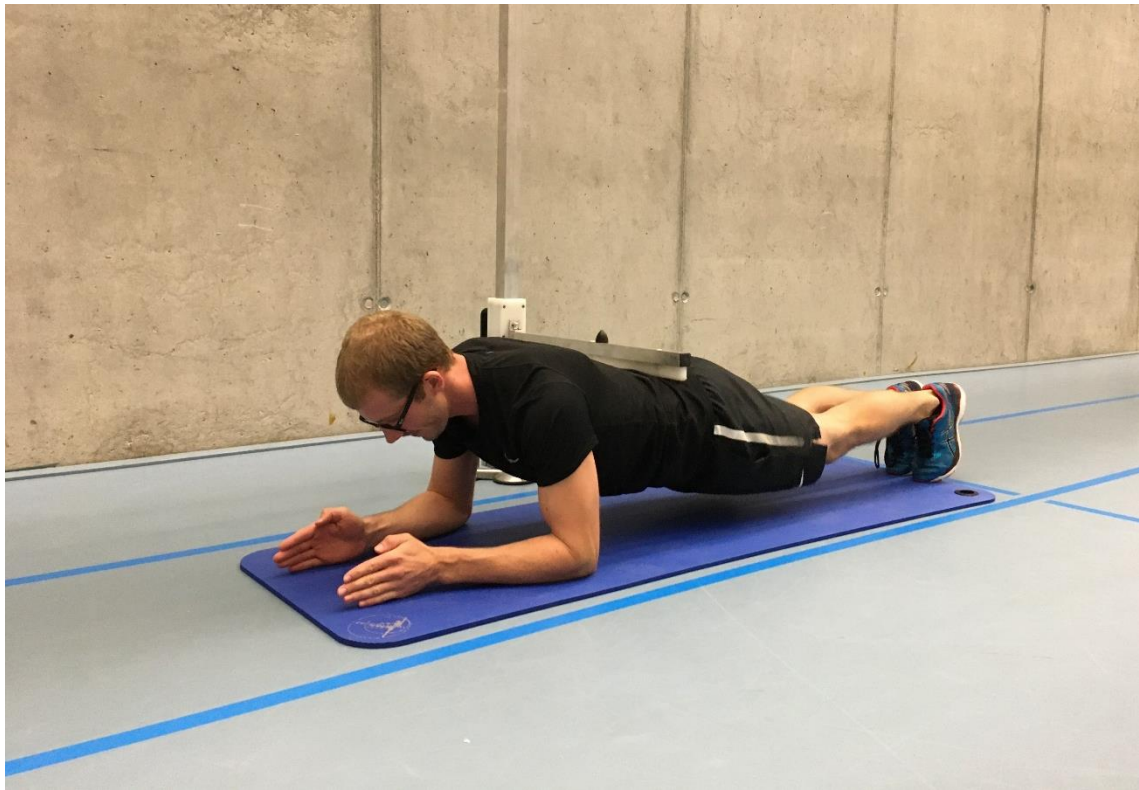


Abbildung 7 Ausgangsposition gerade Stütze, Oberarme vertikal, Unterarme parallel und auf Schulterbreite, Füße so nahe wie möglich zusammen. Mit dynamischem Beinwechsel, pro Sekunde ein Bein abwechselnd heben.

7 Handkraft

Material	Handdynamometer, Stoppuhr, Stuhl
Versuche	3
Ausgangsstellung	<ul style="list-style-type: none"> ✓ Der Teilnehmende sitzt auf dem Stuhl und hält den Dynamometer in der dominanten Hand. ✓ Die Füße sind flach auf dem Boden und die Schultern adduziert (d.h. der Oberarm berührt die Körperseite). ✓ Zwischen dem Ober- und Unterarm befindet sich ein rechter Winkel. ✓ Das Handgelenk zeigt gerade nach vorne und ist die Verlängerung des Unterarms. Keine Supination (Links-/Rechtsdrehung des Handgelenks vermeiden). ✓ Falls der Stuhl eine Lehne hat, wird diese nicht mit dem Rücken berührt.
Durchführung	<p>Der Teilnehmende umfasst den Dynamometer progressiv immer fester, bis ein persönliches Maximum erreicht wird. Der Kraftaufbau soll nicht ruckartig geschehen und die Armposition soll auch unter Maximalkraft möglichst gehalten werden (kein «Nachdrücken»). Der Testleitende liest den erhaltenen Newtonwert auf dem Handdynamometer ab.</p> <p>Der Testleitende stoppt nach dem ersten Versuch für eine Minute die Zeit, in welcher der Teilnehmende eine Pause machen darf. Es darf auch der Handdynamometer kurz aus der Hand gelegt und der Arm ausgeschüttelt werden. Nach einer Minute wird die Messung mit derselben Hand wiederholt. Nach einer weiteren Minute Pause wird die Messung ein drittes Mal wiederholt.</p>
Messung	Es wird die Anzeige auf dem Dynamometer abgelesen und notiert (in Newton, innere Skala des Handdynamometers). Bei allen drei Messungen möglichst gleiche Bedingungen schaffen.
Kontrolle durch Testleitenden	Die korrekte Haltung auch bei den wiederholten Versuchen kontrollieren. Aufpassen, dass kontinuierlich und nicht ruckartig gedrückt wird.



Abbildung 8 Sitzende Position ohne Anlehnen, Füße flach auf dem Boden aufstellen, Arm direkt am Oberkörper, rechtwinklig Oberarm nach vorne, keine Supination

8 Anthropometrische Messungen

Grösse

Material	Stadiometer
Versuche	1
Ausgangsstellung	Der Teilnehmende stellt sich ohne Schuhe auf die Platte des Stadiometer, den Rücken zum Lineal. Der Blick geht gerade aus, Jochbein und äusserer Gehörgang bilden dabei eine Linie.
Durchführung	Der Testleitende fordert den Teilnehmenden auf, einmal tief einzuatmen und den Atem kurz anzuhalten. Dabei schiebt er das verschiebbare horizontale Kopfstück so nach unten, dass dies oben auf dem Kopf ruht.
Messung	Es wird der Zentimeterwert vom Lineal notiert, die roten Pfeile zeigen präzise auf eine Zahl. Es wird auf 0.5 cm genau gerundet (.2 wird auf .0 gerundet, .3 auf .5, 7. auf .5, .8 auf 0.).
Kontrolle durch Testleitenden	Gerader Blick, keine Schuhe an, Einatmen lassen und dann erst den Wert ablesen.

Bauchumfang

Material	Massband
Versuche	1
Ausgangsstellung	Der Teilnehmende steht aufrecht, Arme entspannt auf der Seite.
Durchführung	Der Testleitende misst an der dünnsten Stelle der Taille den Bauchumfang. Das Sportshirt darf dafür anbehalten werden. Wenn die dünnste Stelle nicht einfach ausmachbar ist, kann der Bauchnabel als Referenz herangezogen werden.
Messung	Der Bauchumfang wird auf 0.5 cm genau notiert ($\leq .2$ wird auf .0 gerundet, $\geq .3$ auf .5, $\leq 7.$ auf .5, $\geq .8$ auf 0.).
Kontrolle durch Testleitenden	Der Teilnehmende soll eine neutrale Position halten, nicht den Bauch einziehen.

Gewicht

Material	Waage
Versuche	1
Ausgangsstellung	Ohne Schuhe steht der Teilnehmende mit beiden Füßen auf die Waage. Das Gewicht möglichst gleichmässig auf beide Füße verteilt, der Blick ist nach vorne gerichtet.
Durchführung	Eichung der Waage sicherstellen, der Testleitende bittet den Teilnehmenden auf die Waage und fordert ihn auf, eine ruhige stehende Position einzunehmen.
Messung	Es wird der Wert in Kilogramm notiert. Auch die Stellen nach dem Komma werden berücksichtigt.
Kontrolle durch Testleitenden	Gerader Blick, keine Schuhe an



Abbildung 9 Links: Bauchumfang an der schmalsten Stelle messen. Rechts: Stadiometer ohne Schuhe

9 Sit-and-reach Test

Material	Sit-and-Reach Box
Versuche	4
Ausgangsstellung	<ul style="list-style-type: none"> ✓ Der Teilnehmende sitzt mit gestreckten Beinen hinter der Box. Die Schuhe werden an diesem Posten ausgezogen. ✓ Die beiden Beine sind schulterbreit auseinander, die Füße sind geflext und die Fusssohlen berühren die Box. ✓ Die Beine sind komplett gestreckt. Die Knie bleiben während des gesamten Tests durchgestreckt. ✓ Die Arme sind nach vorne gestreckt und die Hände liegen übereinander.
Durchführung	<p>Der Teilnehmende lehnt den Oberkörper mit den gestreckten Armen so weit wie möglich nach vorne. Die Bewegung wird aus der Hüfte und dem unteren Rücken initiiert. Die Fingerspitzen schieben dabei den Regler nach vorne. Langsames kontrolliertes Vorbeugen mit Ausatmen wird empfohlen. Es darf drei Mal wiederholt werden, beim vierten Mal muss die maximale Position für 1s gehalten werden.</p> <p>Der Testleitende liest den erreichten Wert auf der Box ab.</p>
Messung	Der maximal erreichte Länge beim vierten Versuch wird auf 0.5 cm genau notiert ($\leq .2$ wird auf .0 gerundet, $\geq .3$ auf .5, $\leq .7$ auf .5, $\geq .8$ auf 0.).
Kontrolle durch Testleitenden	Kontrollieren, dass die Knie gestreckt bleiben. Dazu auf einer Seite des Teilnehmenden positionieren und eine Hand auf dem Knie (siehe Position roter Pfeil auf dem Bild). Soll definitiv nie bewegt werden.



Abbildung 10 Weit nach vorne greifen, Hände übereinander, mit den Fingerspitzen den Massgeber nach vorne schieben. Roter Pfeil zeigt Position für Testleiter an für Kniekontrolle, hier mit der Hand fixieren.

10 Liegestütze

Material	Metronom, Handzähler
Versuche	1
Ausgangsstellung	<ul style="list-style-type: none"> ✓ Der Teilnehmende liegt in Bauchlage ✓ Die Hände werden flach unter den Schultern auf Brusthöhe positioniert. Die Finger zeigen dabei nach vorne. ✓ Die Ellenbogen sind nach hinten angewinkelt nahe am Körper. ✓ Beine und Füße aneinander. ✓ Der ganze Körper ist und bleibt eine gerade Linie. ✓ Der Testleitende steht nahe des Teilnehmenden (ca. eine Armlänge), damit die Armposition gut beobachtet werden kann. ✓ Das Metronom wird auf 60 Schläge pro Minute eingestellt.
Durchführung	<p>Der Teilnehmende startet mit dem Kommando «Start». Mit jedem Schlag drückt sich der Teilnehmende mit beiden Armen gleichmässig aus der Ausgangsposition hoch in die gerade Stütz. Der Körper bleibt dabei eine Linie (Rücken in Verlängerung der gestreckten Beine). Wenn die Arme gestreckt und rechtwinklig zum Boden sind, wird die Bewegung umgekehrt und der Teilnehmende senkt den Körper wieder in einer Linie ab. Beim nächsten Schlag drückt er sich wieder hoch. Dies wird so oft wiederholt, bis eines der folgenden Abbruchkriterien eintritt:</p> <ul style="list-style-type: none"> • in der oberen Position mit gestreckten Armen eine Pause gemacht wird. • die Hände bzw. Füße verschoben werden. • sich der Teilnehmende nicht mehr hochdrücken kann. <p>Ist eine Wiederholung nicht korrekt, spricht der Testleitende eine Verwarnung aus und die Wiederholung zählt nicht. Bei der zweiten Verwarnung wird der Test abgebrochen.</p>
Messung	Die Anzahl korrekte Wiederholungen in der oberen Position werden gezählt. Der Handzähler kann vom Testleitenden für ein zuverlässiges Zählen verwendet werden.
Kontrolle durch Testleitenden	Die Haltung muss genau kontrolliert und korrigiert werden. Eine erste Verwarnung bei verspäteter Bewegung darf ausgesprochen werden, bei der zweiten Verwarnung wird der Test abgebrochen.

Hinweis: der Teilnehmende darf vor der Zeitmessung einen Versuch durchführen mit Metronom, um die Bewegungsgeschwindigkeit einzuschätzen.

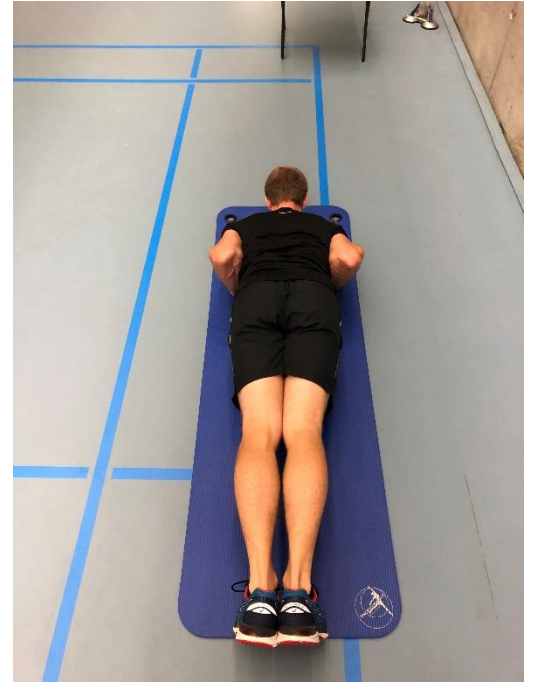


Abbildung 11 Position unten, Ellbogen nahe dem Körper, Hände auf Höhe der Brust.

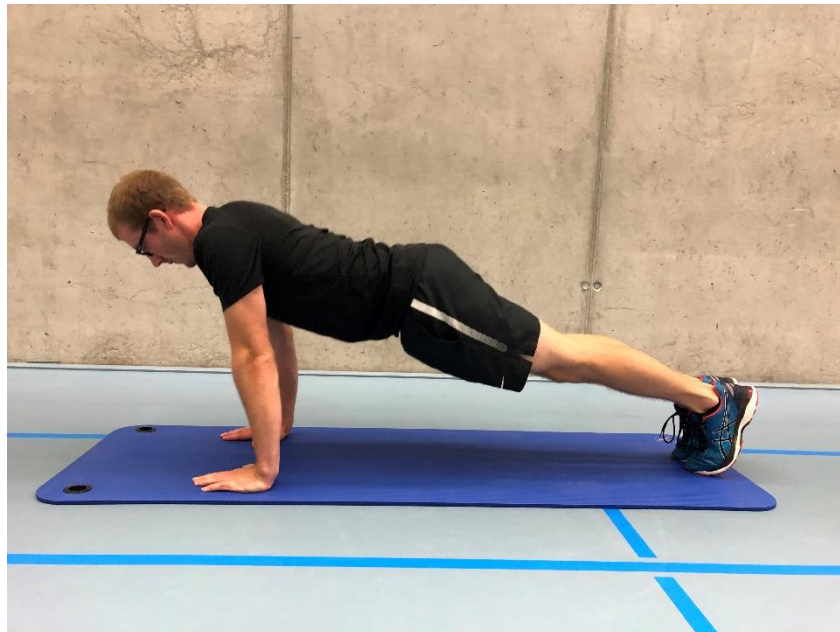


Abbildung 12 Position oben in gerader Stütz. Beine und Füße aneinander. In dieser Position zählt der Testleitende 1 korrekte Ausführung.

Table 1, Results of FTRD Test Firefighters and Paramedics

	Balance	Sorensen	Squat	Core stability	Push up	VO2Max	Hand Force	Sit & Reach	CPR
Subject 1	43	118	15	134	16	62	46	22.5	exceeded
Subject 2	47	163	31	96	37	63	54	20.0	exceeded
Subject 3	33	40	30	76	37	56	49	42.0	exceeded
Subject 4	40	73	21	72	22	62	61	36.5	exceeded
Subject 5	32	123	36	65	11	66	45	28.0	exceeded
Subject 6	35	85	20	45	15	61	51	27.5	exceeded
Subject 7	48	107	33	151	21	62	51	28.5	exceeded
Subject 8	38	105	32	74	17	62	70	33.5	exceeded
Subject 9	39	79	23	55	5	59	49	24.0	exceeded
Subject 10	40	142	32	60	21	56	66	36.0	exceeded
Subject 11	48	179	10	182	9	63	37	36.0	exceeded
Subject 12	31	80	31	94	17	65	48	22.0	exceeded
Subject 13	55	75	16	187	30	65	68	33.5	exceeded
Subject 14	51	60	30	42	7	62	56	17.5	exceeded
Subject 15	48	108	25	100	10	61	45	33.5	exceeded
Subject 16	45	103	19	185	30	58	49	25.5	exceeded
Subject 17	43	36	20	43	23	58	48	21.5	exceeded
Subject 18	49	102	21	128	15	65	40	32.5	exceeded
Subject 19	45	138	41	93	17	65	61	42.5	exceeded
Subject 20	44	98	33	217	35	58	55	24.5	exceeded
Subject 21	49	136	48	181	33	63	49	31.5	exceeded
Subject 22	35	69	50	167	19	54	47	19.0	exceeded
Subject 23	33	140	40	74	21	61	50	23.0	exceeded
Subject 24	37	92	20	61	8	55	59	20.5	exceeded

Subject 25	40	140	30	70	22	60	55	18.5	exceeded
Subject 26	47	102	40	79	37	60	59	23.5	exceeded
Subject 27	58	86	34	109	33	64	59	31.0	exceeded
Subject 28	46	88	32	34	3	66	41	34.5	exceeded
Subject 29	48	80	24	117	20	58	51	29.0	exceeded
Subject 30	45	180	60	220	28	58	63	22.0	exceeded
Subject 31	38	130	57	66	36	62	65	26.5	exceeded
Subject 32	40	72	22	52	15	64	76	26.5	exceeded
Subject 33	43	50	25	56	24	60	58	25.0	exceeded
Subject 34	41	71	22	43	10	58	49	33.5	exceeded
Subject 35	36	55	23	85	40	60	67	8.5	exceeded
Subject 36	38	40	20	92	15	51	62	33.0	exceeded
Subject 37	44	136	41	230	30	62	69	44.5	exceeded
Subject 38	47	52	33	66	24	65	61	30.0	exceeded
Subject 39	49	55	30	83	19	60	66	25.5	exceeded
Subject 40	49	51	23	69	21	61	45	34.0	exceeded
Subject 41	47	49	23	53	20	58	53	25.0	exceeded
Subject 42	41	125	30	94	31	66	47	35.5	exceeded
Subject 43	39	86	7	71	20	58	31	28.8	exceeded
Subject 44	30	56	20	54	19	59	54	34.5	exceeded
Subject 45	34	107	4	146	13	60	55	32.5	exceeded
Subject 46	33	72	25	62	19	59	46	28.5	exceeded
Subject 47	35	93	6	52	13	57	63	34.5	exceeded
Subject 48	27	50	14	46	11	61	33	27.5	exceeded
Subject 49	28	78	39	112	33	63	31	34.5	exceeded
Subject 50	29	87	16	63	20	61	54	35.5	exceeded
Subject 51	34	180	30	151	30	60	38	36.0	exceeded

Subject 52	33	107	0	30	1	63	50	29.0	exceeded
Subject 53	28	82	30	64	13	61	57	34.0	exceeded
Subject 54	51	71	27	79	24	56	69	39.0	exceeded
Subject 55	45	74	7	82	10	54	50	30.5	exceeded
Subject 56	30	66	14	62	10	53	63	33.0	exceeded
Subject 57	30	75	25	80	17	59	37	30.0	exceeded
Subject 58	47	102	23	42	8	54	43	27.5	exceeded
Subject 59	32	35	26	26	19	57	35	28.0	exceeded
Subject 60	32	127	29	84	26	59	44	34.5	exceeded
Subject 61	30	196	25	138	24	60	53	37.5	exceeded
Subject 62	36	112	39	113	28	57	38	33.5	exceeded
Subject 63	39	70	15	150	32	57	53	39.0	exceeded
Subject 64	29	89	22	40	10	62	59	33.5	exceeded
Subject 65	37	73	41	80	23	54	53	34.5	exceeded
Subject 66	30	57	27	63	17	66	57	36.5	exceeded
Subject 67	32	150	28	37	21	55	27	26.5	exceeded
Subject 68	34	32	25	47	15	58	64	35.5	exceeded
Subject 69	60	60	25	28	10	62	53	32.0	exceeded
Subject 70	51	70	20	47	14	60	37	29.0	exceeded
Subject 71	44	90	24	62	12	57	40	28.5	exceeded
Subject 72	33	90	28	28	11	54	46	28.5	exceeded

The results of FTRD test ($n = 72$) were expressed in different units of measure. The balance tests, the sorensen test and the core stability test were expressed in seconds. The push up and the squat tests were expressed in repetitions. The Hand force tests were expressed in kilograms, the sit & reach tests in centimeters and the VO2 Max in [ml/min/kg]. The results of the hand force test and sit & reach test were expressed on average of the four attempts. The evaluation of CPR was exceeded or fail.

Table 2, Results of FTRD Test in percentile

	VO2 Max	Balance	Sorensen	Core stability	Plank	Hand force	Sit&Reach	Push up
Subject 1	90	55	50	30	85	40	20	65
Subject 2	90	65	80	75	60	65	15	95
Subject 3	65	20	5	65	40	45	90	95
Subject 4	85	45	15	40	35	85	70	85
Subject 5	95	15	55	85	30	40	35	50
Subject 6	85	25	30	35	15	50	35	65
Subject 7	85	70	45	80	95	50	35	85
Subject 8	85	40	40	75	25	95	60	70
Subject 9	75	45	20	50	25	45	25	20
Subject 10	65	45	70	75	25	90	70	85
Subject 11	90	70	85	10	95	15	65	35
Subject 12	90	15	20	75	60	45	20	70
Subject 13	95	80	15	30	95	95	60	95
Subject 14	85	80	10	65	15	70	10	30
Subject 15	85	70	45	55	65	40	60	45
Subject 16	75	60	40	35	95	45	25	95
Subject 17	75	55	5	35	15	45	15	90
Subject 18	95	75	40	40	80	25	55	65
Subject 19	90	60	70	90	60	85	90	70
Subject 20	80	60	40	80	95	70	25	95
Subject 21	90	75	70	95	95	45	50	95
Subject 22	55	25	15	95	95	45	10	75
Subject 23	85	20	70	90	40	50	20	85
Subject 24	60	35	35	35	30	75	15	30

Subject 25	80	45	70	65	35	70	10	90
Subject 26	80	65	40	90	45	75	20	95
Subject 27	90	85	30	80	65	75	50	95
Subject 28	95	65	35	75	5	10	60	10
Subject 29	75	70	20	50	70	50	40	80
Subject 30	70	60	85	95	95	85	20	95
Subject 31	85	40	65	95	30	90	25	95
Subject 32	90	45	15	45	20	95	30	65
Subject 33	80	55	10	55	25	75	25	90
Subject 34	70	50	15	45	15	45	60	45
Subject 35	80	30	10	50	55	90	5	95
Subject 36	45	40	5	35	60	85	55	65
Subject 37	85	60	65	90	95	95	95	95
Subject 38	90	65	10	80	30	85	45	90
Subject 39	80	75	10	60	55	90	25	75
Subject 40	85	75	10	50	35	40	60	85
Subject 41	75	75	10	50	20	60	25	80
Subject 42	95	50	60	70	60	45	65	95
Subject 43	75	40	35	10	35	5	35	80
Subject 44	75	10	10	35	20	65	60	75
Subject 45	80	25	45	5	90	65	55	55
Subject 46	85	20	40	50	15	40	35	30
Subject 47	70	25	5	60	5	85	75	75
Subject 48	85	5	65	65	55	5	90	90
Subject 49	90	5	90	55	85	5	70	90
Subject 50	85	5	50	90	70	65	65	95
Subject 51	85	25	15	30	90	15	55	95

Subject 52	90	20	35	45	15	50	5	45
Subject 53	85	5	15	90	50	75	25	90
Subject 54	60	80	10	65	30	95	40	70
Subject 55	55	60	75	65	10	50	5	85
Subject 56	55	30	5	55	20	85	55	45
Subject 57	75	10	10	55	5	15	70	45
Subject 58	55	70	15	35	20	35	20	60
Subject 59	70	15	35	50	30	10	30	50
Subject 60	75	15	35	65	5	35	25	50
Subject 61	80	5	10	55	30	60	40	75
Subject 62	70	30	35	10	20	15	40	55
Subject 63	65	45	10	25	15	60	45	50
Subject 64	85	5	20	90	65	80	55	95
Subject 65	60	35	35	30	30	60	80	80
Subject 66	95	10	85	70	90	70	50	90
Subject 67	60	15	45	5	5	5	85	5
Subject 68	75	25	25	65	30	85	35	50
Subject 69	85	90	10	65	45	60	20	90
Subject 70	85	80	15	10	55	15	35	45
Subject 71	70	60	15	25	30	25	45	45
Subject 72	55	20	15	25	30	40	20	45

The results of FTRD test ($n = 72$) expressed in percentile for each exercises of the test.

Table 3, Reference in percentile of paramedics Canton Bern

Perzentile	3-Min Step Test [ml/min/kg]	Handkraft [kg]	Fmax [kN]	Sørensen [s]	Squats [Anzahl]	Globale Rumpfkraft [s]	Liegestütze [Anzahl]	Sit-and-reach [cm]	Einbeinstand [s]
5	36.65	33.39	0.79	46.00	5.70	33.40	1.00	16.75	28.00
10	41.09	35.23	0.84	62.60	10.00	39.40	3.00	19.75	30.00
15	42.37	38.39	0.91	77.00	11.00	46.10	4.00	21.63	31.00
20	45.09	39.67	0.98	81.00	12.80	53.80	5.40	24.00	33.00
25	45.88	40.67	1.02	84.00	14.50	60.50	6.00	26.50	34.00
30	47.39	42.35	1.14	85.60	18.40	66.00	8.00	27.50	36.00
35	48.35	43.89	1.24	94.20	20.00	73.00	9.00	28.63	37.00
40	49.83	46.87	1.30	105.60	21.00	77.00	9.80	30.00	38.00
45	50.61	49.09	1.32	114.40	22.30	79.30	10.80	31.00	39.75
50	51.61	51.22	1.34	121.00	24.00	81.00	13.00	32.00	41.00
55	52.70	52.67	1.37	123.00	25.00	91.10	13.00	33.00	43.00
60	54.76	53.00	1.40	126.20	26.00	98.00	14.20	35.00	44.00
65	55.91	54.84	1.49	135.80	30.00	112.10	16.00	36.00	46.00
70	56.71	56.50	1.54	142.40	30.00	121.80	17.00	37.00	48.00
75	57.54	59.79	1.58	152.00	32.00	123.00	19.00	39.00	49.00
80	59.30	60.78	1.67	166.80	34.00	131.00	20.00	40.50	51.00
85	60.55	63.92	1.71	183.60	37.90	142.60	21.00	41.50	56.00
90	62.42	67.50	1.86	200.20	43.20	155.60	24.80	42.50	59.00
95	65.10	70.46	2.03	216.40	52.50	190.90	30.40	45.13	62.25

Anmerkungen: Fmax = isometrische Maximalkraft, $n = 114$