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# Using a Strain Gauge Load Cell for Analysis of Round Punch

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**Abstract**

This article is focused on the using a strain gauge load cell in a professional defense. In the described experiment, we measured a round punch. The round punch is one of the striking techniques that is used in a professional defense. The professional defense is a very important part of physical security and safety. Nowadays, it is necessary to protect our life and property. We can see many robberies, thefts, murders, vandalism, rapes and many others criminals. The physical security and safety give us effectively possibilities to protect us. In this article, we will describe one of the striking techniques - the round punch (also called a slap). We measured a force during our experiments with the help of a strain gauge load cell L6E-C3-300kg. A total of 194 people took part in our experiment. Then we found dependences on input parameters - a body mass, body height and gender. In previous experiments, we measured a direct punch with the help of the same device. We presented the results in previous articles.

*Keywords***:** Professional defense, strain gauge load cell, round punch

## 1 Introduction

The professional defense [**1, 2**] is a necessary part of physical security and safety. When we want to protect our life, our health, and our property, we can pay professional defenders. For them, it is important to know how to use defensive techniques and how to use offensive techniques.

We can learn from many martial arts, combat sports, and combat systems. There are many differences among techniques, movement, and quality of instructors. However, many of them have one common part - the striking techniques. This part is the base of all.

In our experiments, we are focused on the basic striking techniques - the direct punch, the round punch, a direct kick and a round kick. The results of the measurement of the direct punch were presented in previous articles [**1-7**]. In this work, we focus on the round punch. We used the same measuring device - the strain gauge load cell L6E-C3-300kg. For this reason, we present only a brief description of the measurement in this paper. A detailed description of the measurement is provided in the previous work. In this paper, we present a new striking technique, which we analyzed - the round punch.

## 2 Round Punch

The round punch is one of the striking techniques that is taught during training, especially in the training of women. However, some schools of martial arts [**8**], combat sports, and combat systems teach this strike also the men. It is a very effective technique. It can seem that the slap is not a professional strike, but it is not true.

The round punch (Figs. **1** and **2**) is made with an open hand and in round line to the target [**9**]. The critical part is a movement of the elbow. The elbow must move along the arc.

**Fig. 1.** Round punch - view from the right

**Fig. 2.** Round punch - view from the left

During the round punch, there are several important parts. The first is the movement of hips. It is the first part of our body that must move. The motion is much faster with the help of hips. The other problematic part is the height of the hand. For maximum force, it is necessary to have the hand higher than shoulders and in ideal situation higher than the head.

In professional defense, we use the round punch for the destabilization of an attacker. This technique is natural for us, especially for women. The result is a shock to the attacker's body. Another advantage is the possibility to hit the attacker's ears. The results are pain and a longer time period of a shock for the attacker.

## 3 Measurement of Force

We used the strain gauge load cell L6E-C3-300kg for the measurement of the force. In detail, we described the whole experiment in previous articles [**2-4, 7**]. Therefore, the measurement is mention here in short.

The measurement station (Fig. 3) consists of a punching bag, a construction of its suspension and from the strain gauge load cell [**2**]. We used the punching bag for protection of the hand during the punch.


**Fig. 3.** Process of the slap

We used the strain gauge load cell for measurement of the force of the slap (Fig. **4**). The principle is that the sensor changes electrical resistance depending on the deformation of the sensor. The sensor consists of four metal film strain gauges in a Wheatstone bridge configuration that are placed in places with the thinnest wall. For this reason, we can measure the deformation of these several metal film strain gauges very precisely. In the next step, we can calculate the force. This sensor was made in VTS Zlín company, which also calibrated the sensor.

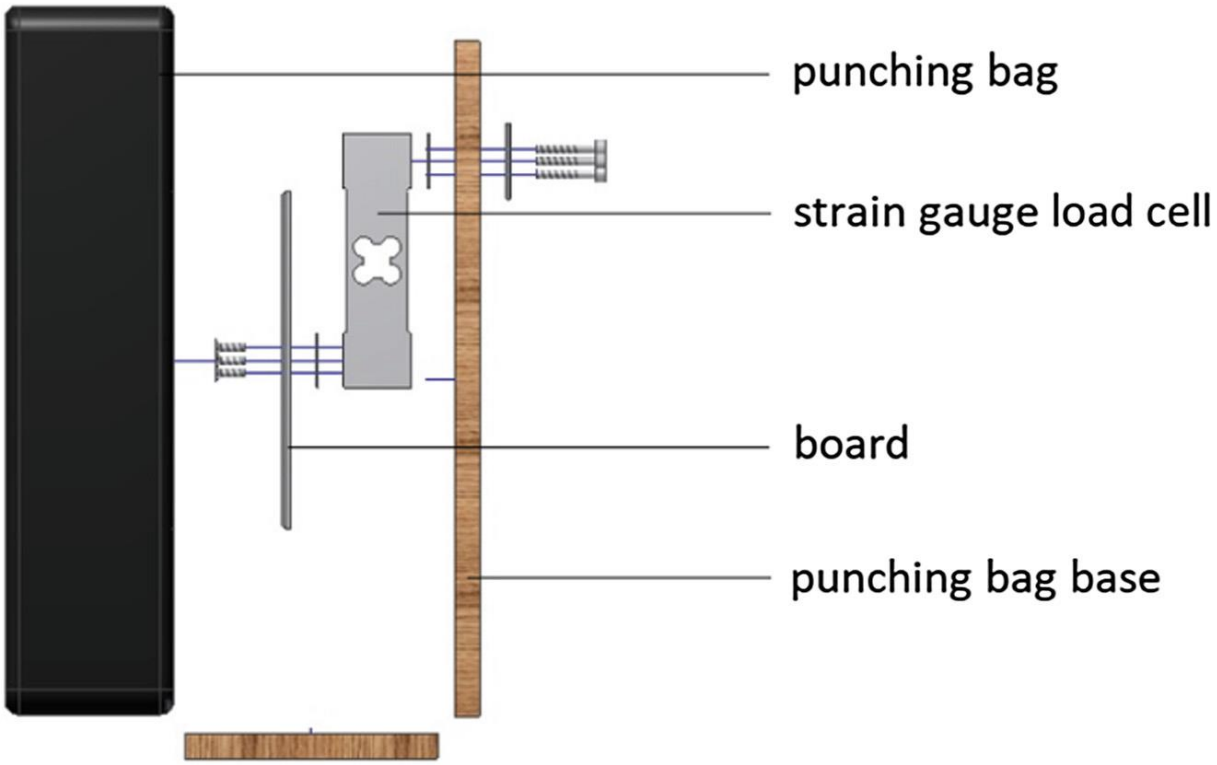


**Fig. 4.** Measuring station [**2, 3**]

We have 194 people participating in our measurement (Table **1**). They are in age from 19 to 25 years. All of them performed from one to ten punches. It is very important that the target is positioned in such manner that the centre of the strain gauge load cell was in height that is the same as the height of a person's shoulder. The round punch has the maximum force for this position.

On the base of previous knowledge and training, we divided the participants into eight categories. In the beginning, we separated men and women, because we want to compare these two groups. In Table **1**, you can see these categories.

**Table 1.** Participant categories

| Categories | Previous experience | Length of training (in years) | Special physical training course | Other combat sports, martial arts or combat systems | Noted | Number of people |
|---|---|---|---|---|---|---|
| Untrained | NO | 0 | NO | NO | UTM (for men)<br>UTW (for women) | 73<br>11 |
| Mid-trained | YES | 0.5–2 | YES | NO | MTM (for men)<br>MTW (for women) | 55<br>4 |
| Trained | YES | 2 and more | YES | YES | TM (for men)<br>TW (for women) | 9<br>6 |
| Self-trained | YES | 0.5–2 | NO | YES | STM (for men)<br>STW (for women) | 34<br>2 |

## 4 Results

Our goal was the measurement of the force of the round punch. We used the strain gauge load cell. In the other step, we analyzed the data. For this, we used Microsoft Excel and MINITAB. These two pieces of software are analytical tools. We tried to find out the dependences on input parameters - gender, body mass, and height. Limitation of the results is the vibration of the measurement station.

In previous articles [**2-4, 7**], we presented the same procedure, but we analyzed the direct punch. We can compare these two techniques, and we can evaluate which of them is better for training. This comparison will be published in the following article.

Figure **5** depicts the dependence of average force on time for all categories. The graph is shortened because the ending part is not important for us. All of the dependencies are aligned according to the maximum. This depiction is useful for comparison, especially comparison between men and women. There are significant differences between trained person and other categories.

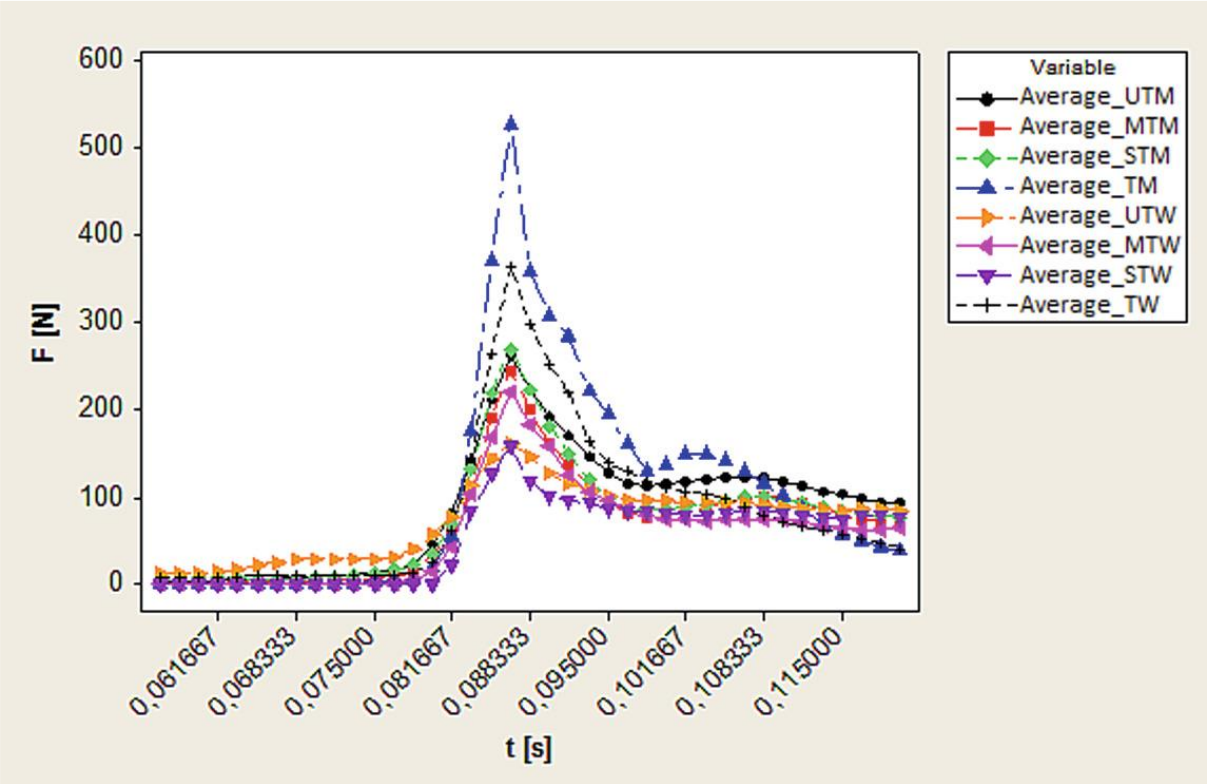


**Fig. 5.** Dependence of average force on time – shortened

Comparison of men and women categories separately is presented in Figs. **7** and **8**.

In Fig. **6**, the dependence of the average force on time for trained men are significantly higher and sharper than other categories. The interesting point is that categories of the mid-trained men, the self-trained men, and the untrained men are very similar. The differences among them are very small.

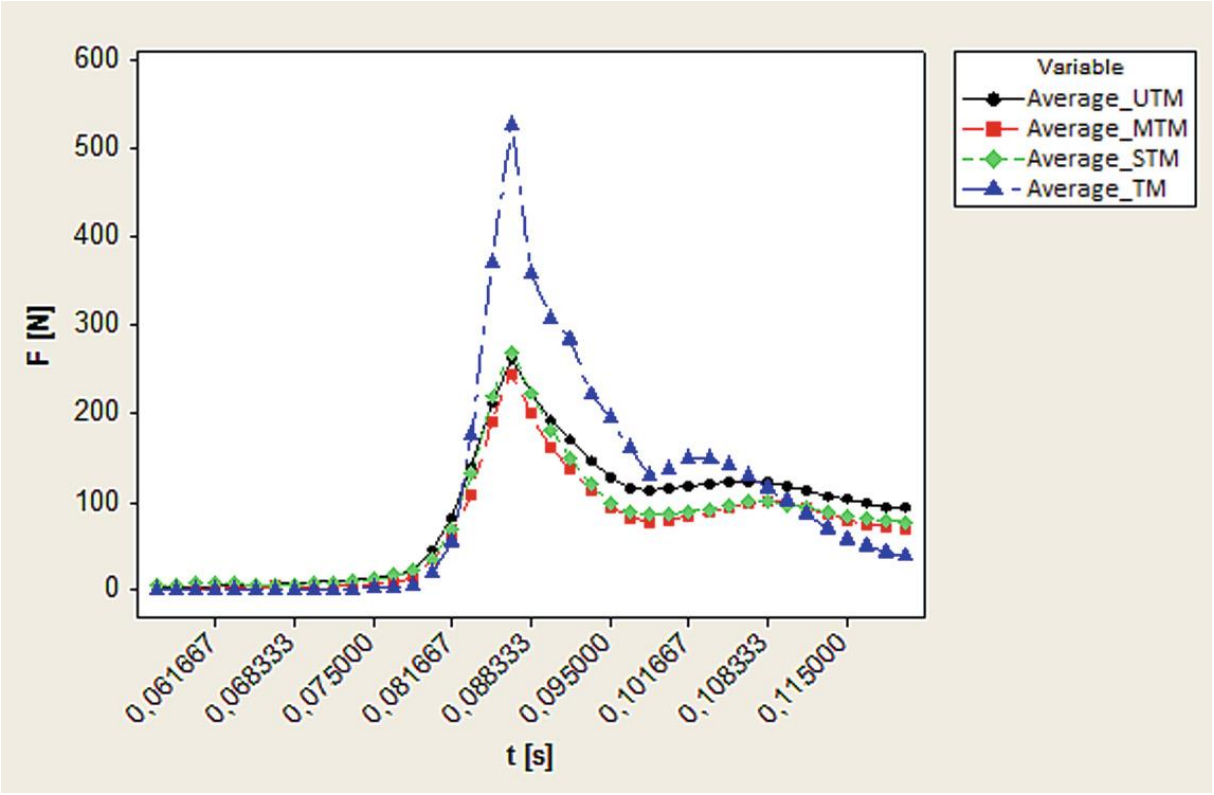


**Fig. 6.** Dependence of average force on time for men

In Fig. **7**, there is the dependence of average force on time for women. The categories of the untrained women and the self-trained women are very similar. The difference is that the untrained women have slower increase and decrease of the force. We can generally say that only few combat sports and combat systems teach the round punch. This is the reason why the category of the self-trained women is similar to the untrained women.

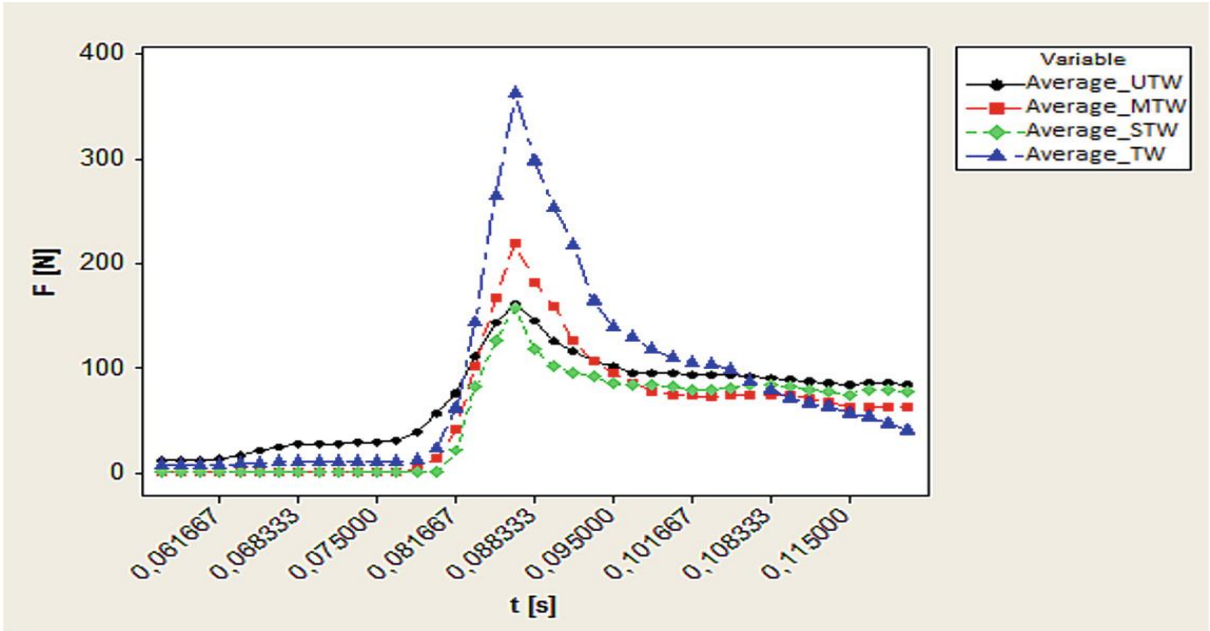


**Fig. 7.** Dependence of mean force on time for women

We used Microsoft Excel for data analysis. The average force, the standard deviation of average, the maximum and the standard deviation of maximum are important for us.

**Table 2.** Average force and maximum force for each category

| Categories | Average [N] | Standard deviation of average [N] | Maximum [N] | Standard deviation of maximum [N] |
|---|---|---|---|---|
| Untrained men | 70 | 20 | 260 | 90 |
| Mid-trained men | 40 | 20 | 250 | 90 |
| Self-trained men | 70 | 30 | 270 | 110 |
| Trained men | 50 | 30 | 530 | 300 |
| Untrained women | 60 | 20 | 160 | 40 |
| Mid-trained women | 50 | 20 | 220 | 30 |
| Self-trained women | 40 | 10 | 160 | 20 |
| Trained women | 60 | 30 | 360 | 210 |

In Table **2**, we can see the average force, the standard deviation of average, the maximum and the standard deviation of the maximum. The highest average values have the categories of the untrained men and the self-trained men. The trained people show the highest maximum force.

The interesting categories are the untrained men, the mid-trained men, and the selftrained men because the maximum force is very similar. In case of women, the same maximum force is in categories of the untrained women and the self-trained women.

In the next step, we analyzed the dependence of maximum force on the body's height and mass. The aim was to find out if the maximum force depends on body height and body mass. In the beginning, we had a premise that men with higher body height and higher body mass will have stronger the round punch.

The following graphs, we created with the help of MINITAB. This software is very useful for graphs, especially for 3D graphs. The graphs with all of three parameters (maximum of force, body height, and body mass) are very important for us. Other software can create 3D graphs, but it is a problem to turn them around for the best view. The MINITAB solves this problem. As we can see in the following figures, the graphs are clear and understandable.

Color is used to distinguish the gender - blue for men and red for women. The darker color means a higher maximum of force.

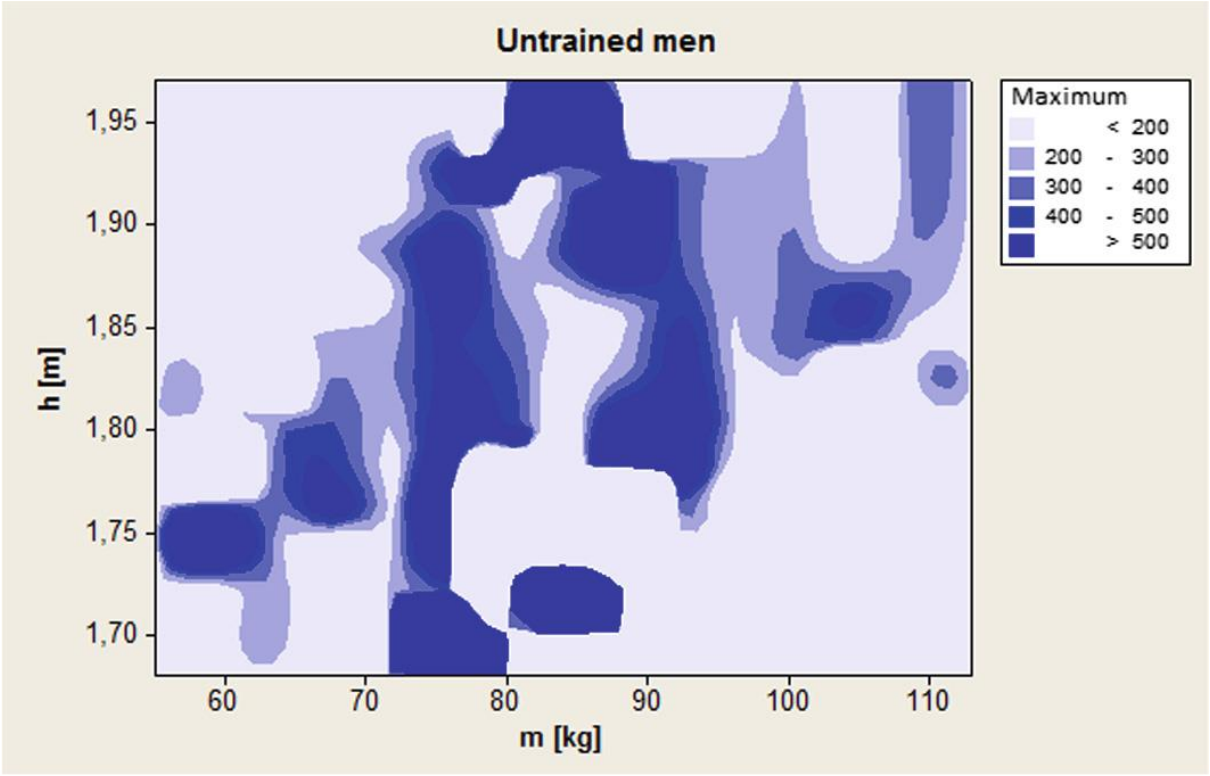


**Fig. 8.** Dependence of maximum force on body height and mass for untrained men

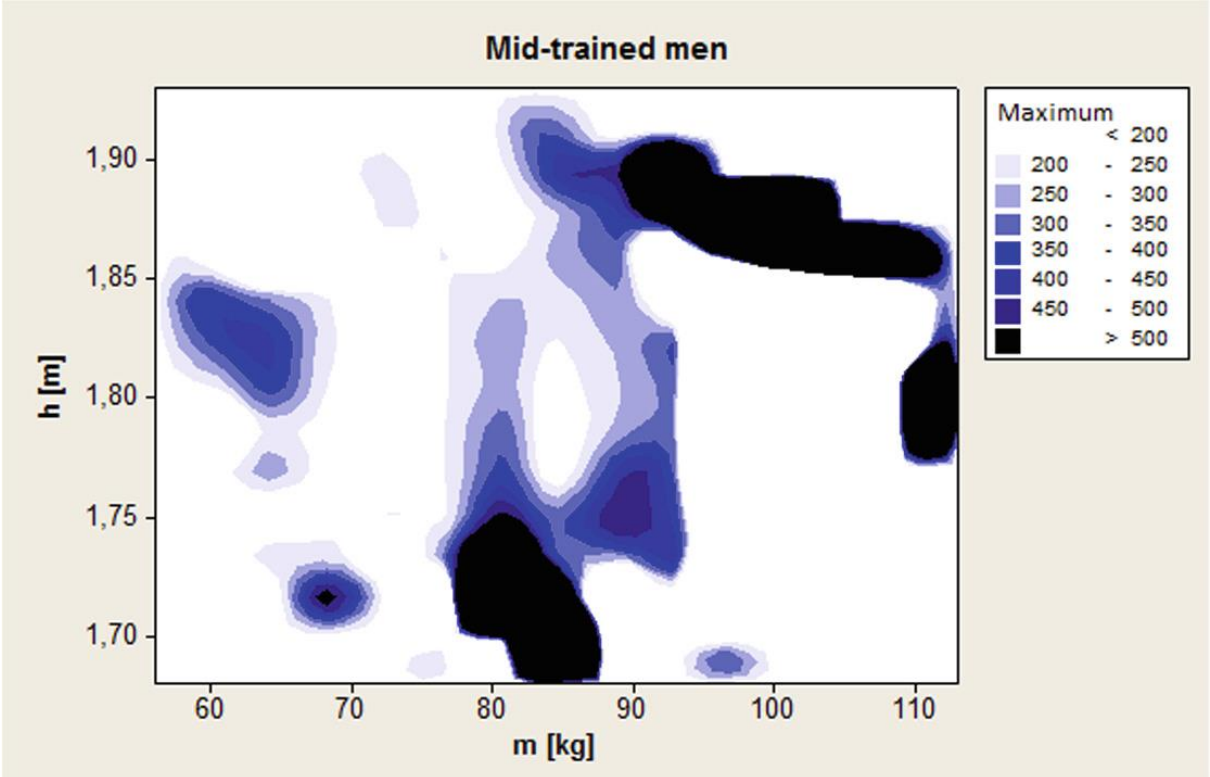


**Fig. 9.** Dependence of maximum force on body height and mass for mid-trained men

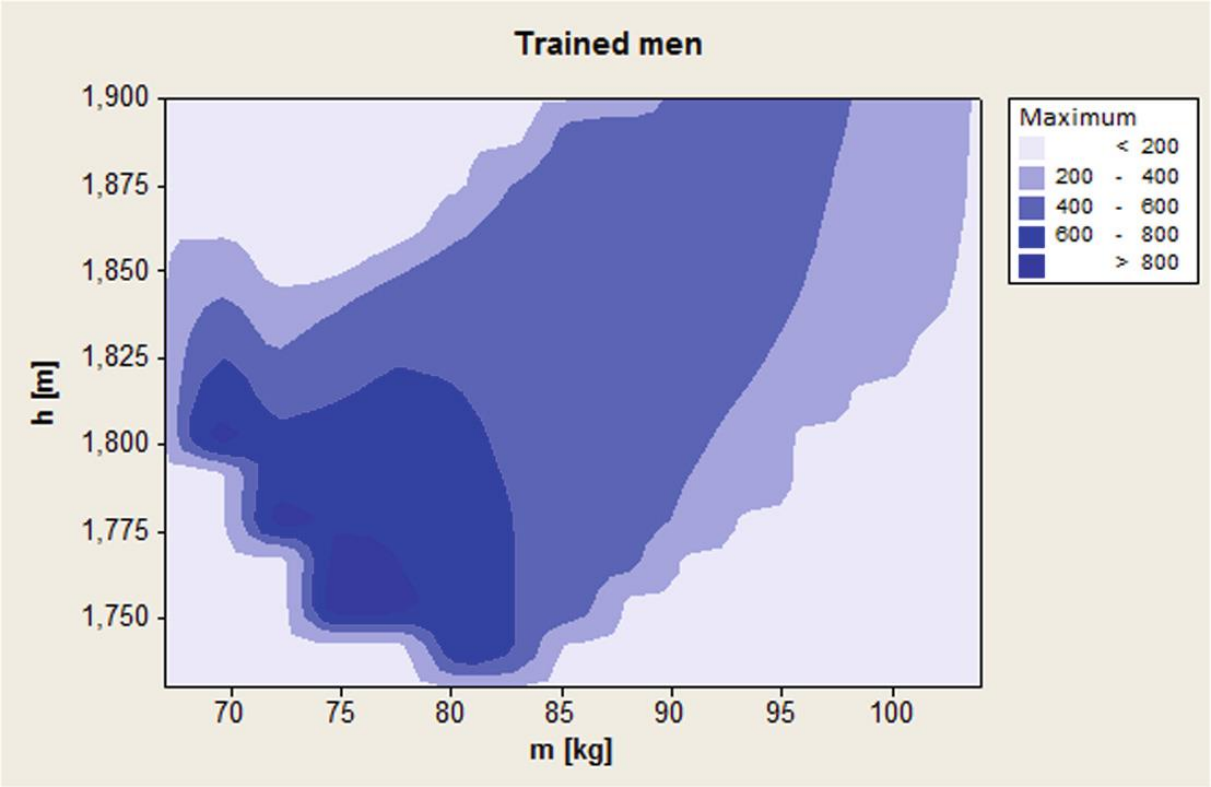


**Fig. 10.** Dependence of maximum force on body height and mass for trained men

In previously Figs. **8** and **9**, we are not able to see any trend in the dependences of maximum force on body height and mass (Fig. **10**).

In case of the trained men, we can see the trend that the men with the mass around 75 kg and with height about 1.76 m have the strongest round punch.

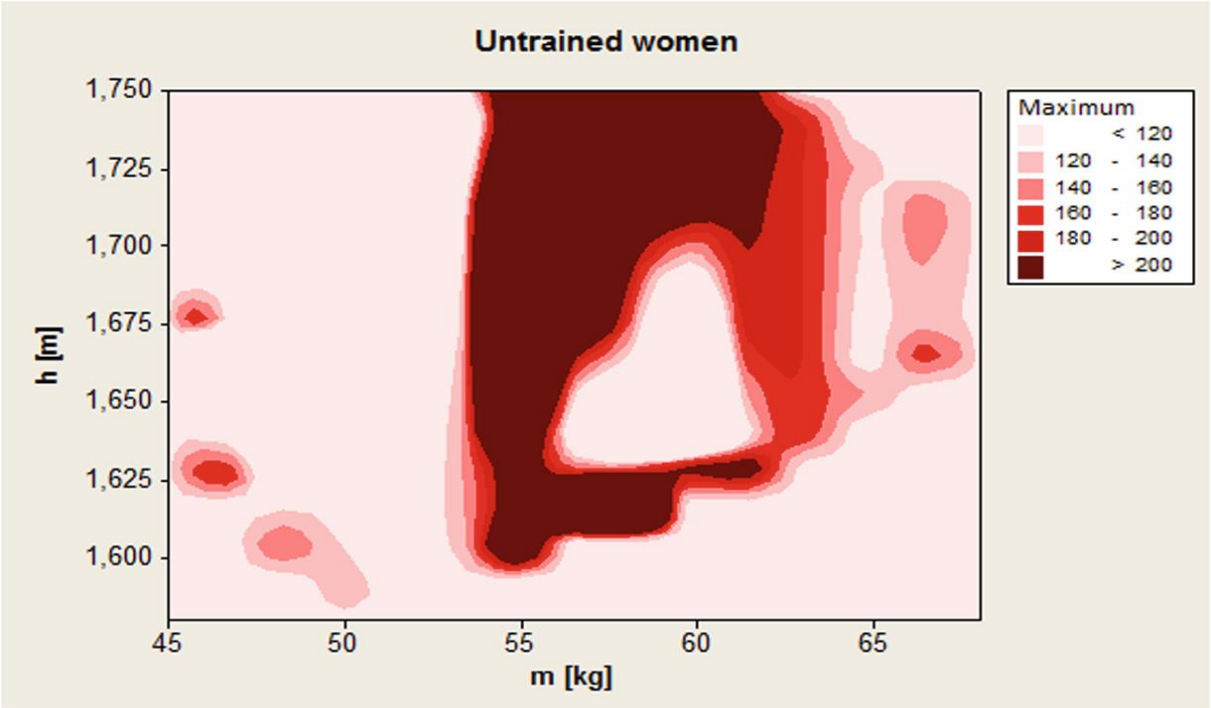


**Fig. 11.** Dependence of maximum force on body height and mass for untrained women

As we can see in Fig. **11**, in the category of the untrained women, is a very interesting trend. Important is the body mass; the ideal is between 54 and 62 kg. The unexpected result is that the maximum force is not related to body height.

## 5 Conclusion

This article was focused on the round punch that is used in the professional defense. This technique has several advantages, and the instructors of defense should show it to their students.

In this article, we described our goals, the measuring station, the experiment and the results. Our goal was analyzed the round punch with the help of force measurement by the strain gauge load cell. Total of 194 people was participating in our experiment -men and women. For data analysis, we used two pieces of software - Microsoft Excel and MINITAB.

The results have been described in the separate section. We presented the graphs with the dependences of the average force on time for all categories but also separated for men and women. In the tables, we showed the results for the average force and the maximum force. Another important part is the 3D graphs with the dependences of maximum force on body height and mass.

In the end, we can conclude that the categories of the trained people have the highest force. In other categories, the trend is not so significant. In the case of the dependences on inputs parameters - we have demonstrated the dependences on gender and in some categories the dependences on body height and mass (especially in categories of the trained men, the untrained women).

In the future, we will focus on the comparison of the round punch and the direct punch.

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