ISSN 1816-6075 (Print), 1818-0523 (Online)
Journal of System and Management Sciences
Vol. 8 (2018) No. 1, pp. 23-44

Education in Professional Defense – Possibilities of Classification of Training Level with the Help of Impulse

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(*Received Oct 2017, accepted Apr 2018*)

Abstract. This article is focused on education in a professional defense. The professional defense is a necessary part of a physical protection of property and people. Army, police and commercial security industry need knowledge about the defense for the quality protection of client's interests against an attack. The main goal of our research is to find possibilities for classification of a training level. Previous research was focused on classification with the help of a velocity. In this research, we measured the force of chosen striking techniques. Then we tried to find the classification of the training level with the help of an impulse.

Keywords: Professional Defense, Force, Classification of training, Direct punch, Round punch, Direct kick

1. Introduction

The education is an essential part of our life. We can obtain knowledge about many areas. One of these areas is the professional defense. Nowadays, there are many clubs, where the people are taught combat sports, martial arts or combat systems. The problem is that these clubs are focused on self-defense. The professional defense is different (Fig. 1).

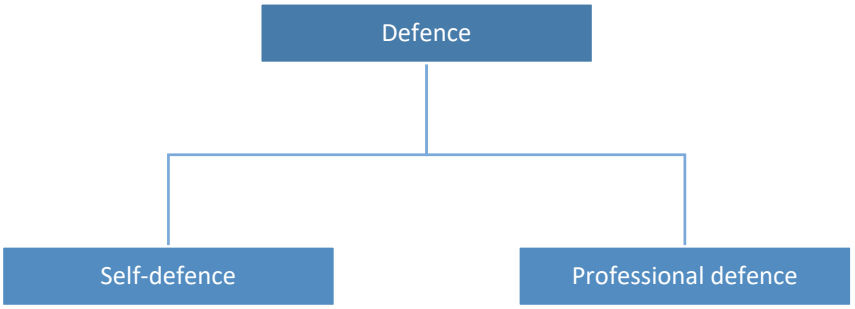

Fig. 1. Self-defense and professional defense.

The aim is the protection of client's interests against the attack. These people have a salary, and a content of their job is the protection and nothing else. A conflict situation must be solved quickly and efficiently. Another problem is that many uninterested people are in a conflict situation. Nowadays, with many modern technologies, is usually that somebody does photos or videos. The result is that the professional defense must be in high level and effective.

The goal of our research is to improve a training of the professional defense. The training must be effective and as quick as possible. It is necessary to have an employee who is ready for work in the short time period.

We have two main goals in this experiment. The first is to measure a force of chosen striking techniques. The second is applying a classification of the training level with the help of the impulse to a larger sample of data.

In the previous article, we described a measurement of a direct punch and the classification of the training level with the help of the impulse. In this article, we will present the measurement of other striking techniques – a round punch and a direct kick. Then the classification of the training level with the help of the impulse was extended by these two new striking techniques.

2. Striking techniques

We chose three of striking techniques for this research. In the previous article

(Lapková et al., 2017) , we presented only a direct punch. For this article, we added the round punch and a direct kick (Fig. 2). The striking techniques are the base of the majority of combat sport, martial arts or combat systems (Lapková et al., 2017; Lapkovaet al.,2016). We can generally say that the striking techniques are used for stopping an attacker and for keeping the attacker at a distance for a defender.

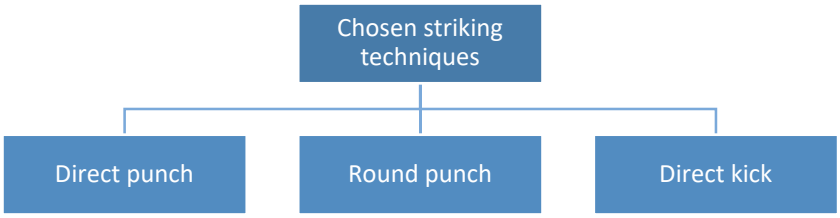

Fig. 2. Chosen striking techniques.

Each of striking techniques has a different process. The direct punch (Fig. 3) is made in the direct line to a target. A hit area is a closed fist (Lapkovaet al.,2016; Reguli, 2011; Lapková et al., 2015).

. The important part of the direct punch is a movement of hips and an elbow. The elbow must also move in direct line. An often mistake is that the elbow moves along the arc.

Fig. 3. Direct punch.

The round punch (Fig. 4) is made with an open hand and in round line to the target. The important part is a movement of the elbow. The elbow must move along the arc.

Fig. 4. Round punch.

The direct kick (Fig. 5) is also made in a direct line to the target. The hit area is the foot.

Fig. 5. Direct kick.

3. Experiment

We created a new device at the beginning of our experiment - Measuring station for a measurement of dynamic features of striking techniques (Fig. 6). This station consists of a punching bag and a construction of its suspension (Lapkovaet al.,2016).

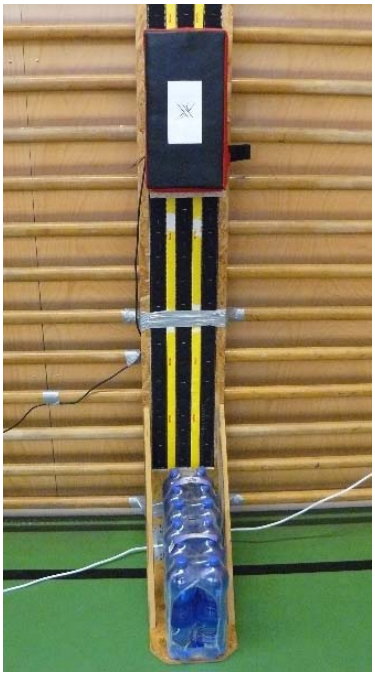

Fig. 6. Measuring station.

The punching bag covers the strain gauge sensor (Fig. 8) because is it necessary to protect the hand or foot during striking techniques.

For measurement of force, we used a strain gauge sensor L6E-C3-300kg (Fig. 7). The principle is that the sensor works as unilaterally cantilever bending beam. Metal film strain gauges are inside the sensor. It changes their electrical resistance depending on deformation. This deformation is caused by force, which is delivered by punching techniques. The most significant deformation is in places with the thinnest walls of the sensor. It is possible to convert the difference of resistance to an electrical signal because strain gauges are switched on Wheatstone bridge (Lapková et al., 2017).

Fig. 7. Strain gauge sensor L6E-C3-300kg. (Lapková et al., 2017; Lapkovaet al.,2016)

Fig. 8. Measuring station with sensor, computer and camera.

The strain gauge sensor is connected to the computer for data storage. The speed of measurement is averaged around 600 measurements per second (Lapkovaet al.,2016; Pospíšilík et al., 2012).

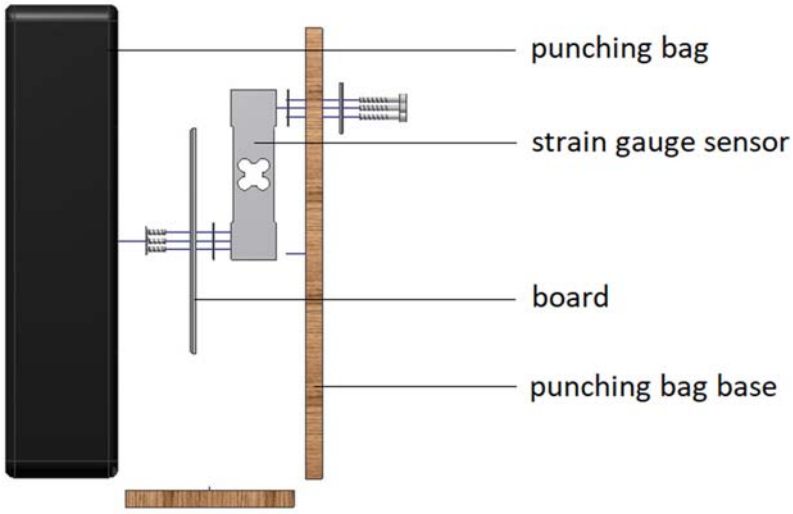

Fig. 9. Measuring station – schematic. (Lapková et al., 2017; Lapkovaet al.,2016)

We used students of Tomas Bata University in Zlín and people from Karate Kyokushin Club for the experiment. A total of the number was 220 participants - 192 men and 28 women who were at age 19 - 25 years. Each of them performed ten strikes.

The experiment is focused on the possibilities of the classification of training level. For this reason, we divided participants into following categories according to their previous experience with combat sports, martial arts, and combat systems at the beginning (Table 1).

Table 1. Groups of people (Lapková et al., 2017; Lapkovaet al.,2016; Lapková et al., 2015; Lapková and Milan, 2015)

Categories	**Previous experience**	**Length of training** (in years)	**Special physical training course**	**Other combat sports, martial arts or combat systems**	**Noted**
Untrained	NO	0	NO	NO	UTM (for men) UTW (for women)

Mid-trained	YES	0,5 – 2	YES	NO	MTM (for men) MTW (for women)
Trained	YES	2 and more	YES	YES	TM (for men) TW (for women)
Self-trained	YES	0,5 - 2	NO	YES	STM (for men) STW (for women)

Two categories are very similar – mid-trained and self-trained people. The difference is that mid-trained people did attend the Special physical training course. We teach this course at Tomas Bata University in Zlín, so we know the content of the training. Self-trained people did practice some combat sports, martial arts or combat systems. There is no guarantee of the quality of the training, and we do not know the content.

4. Results of experiment

We used Microsoft Excel and MINITAB for data analysis. These two pieces of software are used for statistical data analysis. We have measured the force of the striking techniques with the help of the strain gauge sensor. The maximum forces and standard deviations of maximum for each category according to the training level are in Table 2 for the direct punch, in Table 3 for the round punch and in Table 4 for the direct kick.

Table 2. Maximum force and standard deviation of maximum for direct punch (Lapková et al., 2017)

Direct punch	**Maximum [N]**	**Standard Deviation of Maximum [N]**
Untrained man	230	80
Mid-trained man	260	120

Self-trained man	280	120
Trained man	610	200
Untrained woman	170	40
Mid-trained woman	190	30
Self-trained woman	200	40
Trained woman	410	220

Table 3. Maximum force and standard deviation of maximum for round punch

Round punch	**Maximum [N]**	**Standard Deviation of Maximum [N]**
Untrained man	260	90
Mid-trained man	250	90
Self-trained man	270	110
Trained man	530	300
Untrained woman	160	40
Mid-trained woman	220	30
Self-trained woman	160	20
Trained woman	360	210

Table 4. Maximum force and standard deviation of maximum for direct kick

Direct kick	**Maximum [N]**	**Standard Deviation of Maximum [N]**
Untrained man	520	270
Mid-trained man	580	250
Self-trained man	520	250
Trained man	590	220
Untrained woman	270	90
Mid-trained woman	400	190
Self-trained woman	300	90
Trained woman	460	110

In previous tables, we can see some interesting data. In the case of the direct punch, we can see significant differences among categories. On the other hand, there are also high standard deviations. For the round punch, there are significant differences between the trained people and the rest categories. There are no significant differences among the untrained people, the mid-trained and the self-trained people. The data of the direct kick are very similar.

5. Classification of training level

Based on these data we cannot clearly find out borders among categories. This is

the reason why another quantity was chosen – impulse.

Impulse:

$$I = \int_{t_1}^{t_2} F\, dt \tag{1}$$

I: impulse

F: force

t1: time at the beginning

t2: time at the end

In the beginning, we chose five samples from each striking technique and each category according to the training level. We used a simplification by triangulation for the calculation (Fig. 10 and Fig. 11).

$$I = \frac{F_{max}(t_2 - t_1)}{2} \tag{2}$$

I: impulse

Fmax: maximum force

t2: time with the maximum force

t1: time at the beginning of the punch

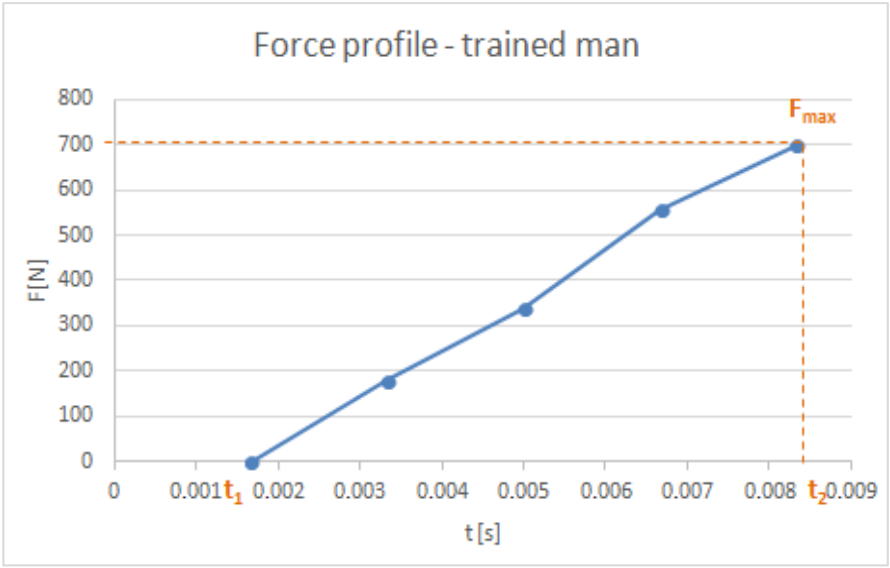

Fig. 10. Force profile (trained man) – part 1. (Lapková et al., 2017)

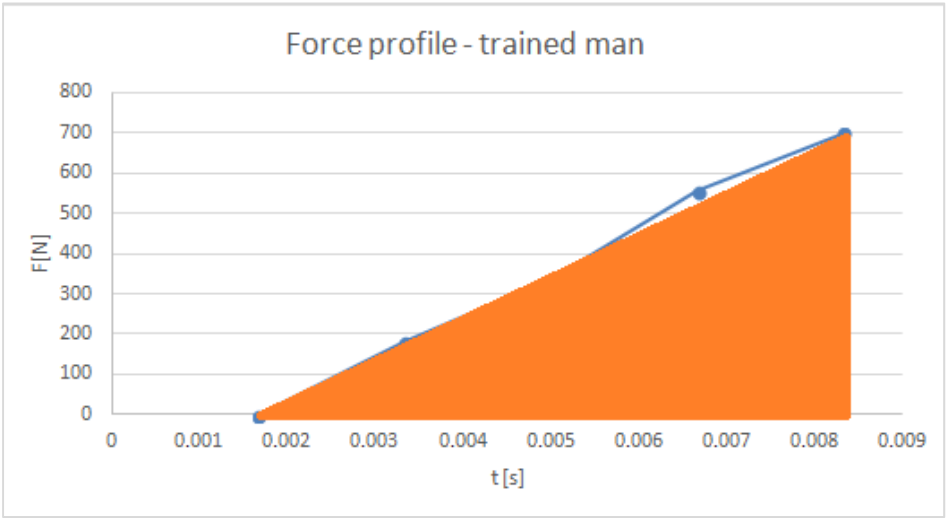

Fig. 11. Force profile (trained man) – part 2. (Lapková et al., 2017)

In Table 5, there are results for the direct punch, together with the mean and the standard deviation of the mean.

Table 5. Impulse – data for direct punch (Lapková et al., 2017)

Sample	**I_{UTM} [N s]**	**I_{MTM} [N s]**	**I_{STM} [N s]**	**I_{TM} [N s]**
1	2.4	4.9	2.6	2.4
2	2.5	2.5	2.7	2.0
3	1.4	2.7	4.7	3.0
4	2.7	0.9	2.3	1.8
5	1.8	6.2	3.9	2.2
Mean	2.1	3.5	3.2	2.3
Standard deviation of mean	0.5	1.9	0.9	0.4
Sample	**I_{UTW} [N s]**	**I_{MTW} [N s]**	**I_{STW} [N s]**	**I_{TW} [N s]**
1	6.9	2.4	4.2	3.6
2	1.9	2.1	3.4	1.7
3	1.6	2.9	3.5	1.6
4	0.7	0.6	0.6	1.1
5	2.5	1.0	0.6	0.7
Mean	2.7	1.8	2.5	1.7
Standard deviation of mean	2.2	0.9	1.5	1.0

When we compared the data from Table 5, we have not found any trend for

sorting people according to their training level. The results (Mean) are very similar, and there are not significant borders among categories. We can see wrong results in some categories. For example, we can see lower impulses in the group of trained people than in the group of untrained men in some cases.

In the other step of our experiment, we analyzed a force profile. We tried to find out why the impulse seems to be a wrong choice. We compared two punches from opposite categories – untrained men (Fig. 12) and trained man (Fig. 13). We compared their force profiles.

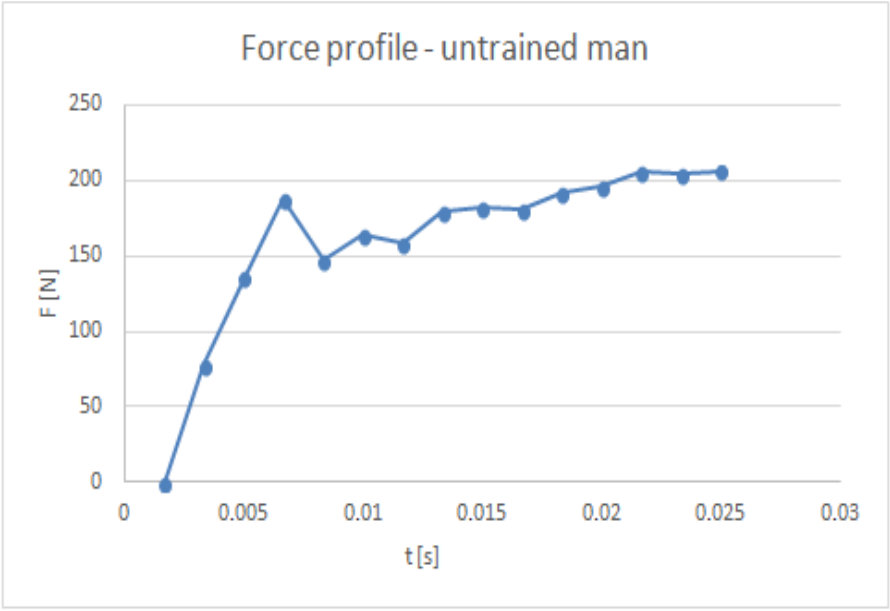

Fig. 12. Force profile - untrained man. (Lapková et al., 2017)

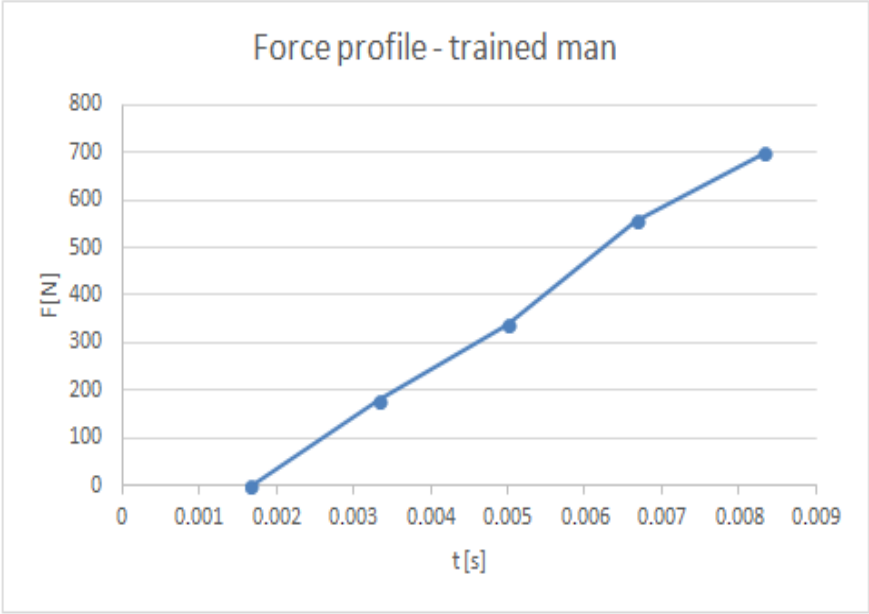

Fig. 13. Force profile - trained man. (Lapková et al., 2017)

At the beginning of the impulse calculation, we worked with the whole force profile from the beginning to the maximum force (Fig. 11). As the results of impulse show, this is the wrong choice. When the force profile for the untrained man (Fig. 12) and the trained man (Fig. 13) were compared, we can see two very important parameters – the maximum force and the time period when the punch acts. The maximum force is significantly higher for a trained person. The time period is very short. For untrained person - the maximum force is lower; the time period is longer. The result is that the impulses are very similar for both people.

The other step was that we divided each punch and kick into three parts.

The parts are:

- "punching part" - there is the fastest increase of force (Fig. 15).
- "pressing part" - the increase of force is significantly slower. We can sometimes see a decrease of force during this part of force profile for a short time period. Then the force started to increase again until the maximum force was reached.

- "decreasing parts" - the punch is finished, and person's hand moves back. This part was not important for us, so we do not analyze it.

The other part of our research was that we preprocessed the force profile of each punch and kick. The results were reducing punching parts (Fig. 15).

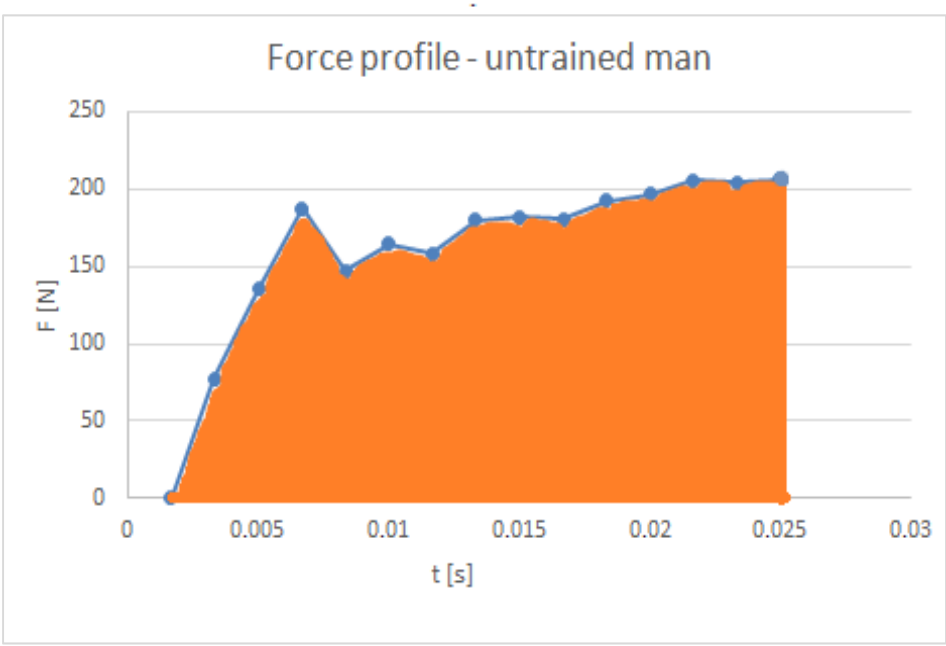

Fig. 14. Impulse (untrained man) – from the beginning to the maximum. (Lapková et al., 2017)

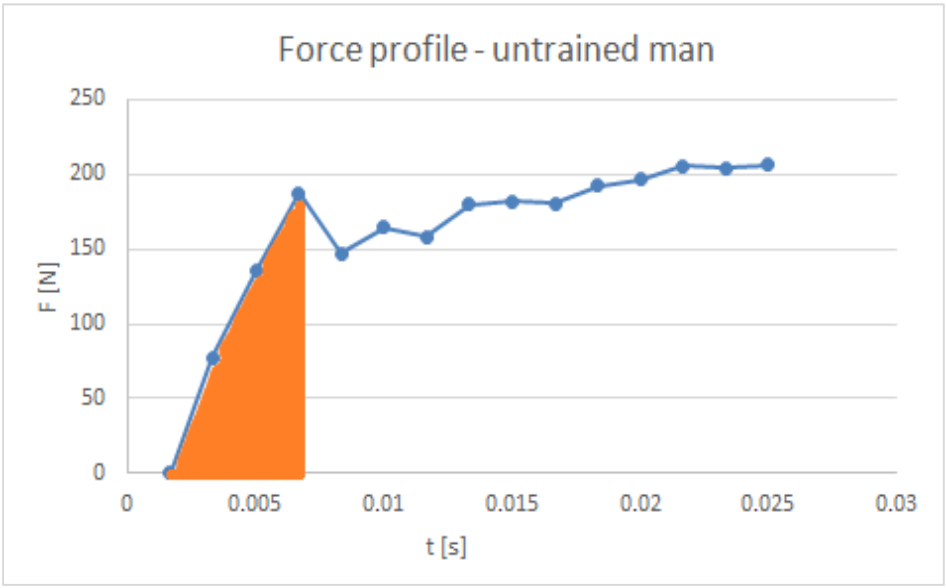

Fig. 15. Impulse – punching part. (Lapková et al., 2017)

We calculated new impulses only from the punching part of the direct punch. Another part (pressing part), we eliminated from our calculation. The results can be seen in Table 6.

Table 6. Impulse of punching part of direct punch (Lapková et al., 2017)

Sample	**I_{UTM} [N s]**	**I_{MTM} [N s]**	**I_{STM} [N s]**	**I_{TM} [N s]**
1	0.2	0.2	0.5	2.7
2	0.1	0.3	0.3	3.4
3	0.5	0.4	0.3	2.5
4	0.4	0.5	0.4	3.7
5	0.3	0.5	0.3	2.8
Mean	0.3	0.4	0.3	3.0
Standard deviation of mean	0.1	0.1	0.1	0.5
Sample	**I_{UTW} [N s]**	**I_{MTW} [N s]**	**I_{STW} [N s]**	**I_{TW} [N s]**
1	0.04	0.35	0.65	1.79
2	0.16	0.34	0.27	1.74
3	0.21	0.20	0.41	2.24
4	0.09	0.39	0.58	1.61
5	0.05	0.20	0.42	2.17
Mean	0.11	0.30	0.47	1.91
Standard deviation of mean	0.07	0.08	0.13	0.25

The data after new calculation shows significant differences among categories of people. The other positive is that the standard deviations of the mean are also lower. The most significant differences are in categories of the trained men and women. The lowest differences are in groups of the mid-trained and the self-trained people. This result was expected because people from both categories did some martial arts, sports or systems for the same time period.

In Table 7 and 8, we have results for the round punch and the direct kick. We also used only punching parts of the force profile.

Table 7. Impulse of punching part of round punch

Sample	**I_{UTM} [N s]**	**I_{MTM} [N s]**	**I_{STM} [N s]**	**I_{TM} [N s]**
1	0.4	0.3	0.9	1.3
2	0.5	0.3	0.8	2.2
3	0.3	0.4	0.8	0.4
4	0.2	0.3	0.7	1.0
5	0.4	0.5	0.4	2.3
Mean	0.3	0.3	0.7	1.4
Standard deviation of mean	0.1	0.1	0.2	0.7
Sample	**I_{UTW} [N s]**	**I_{MTW} [N s]**	**I_{STW} [N s]**	**I_{TW} [N s]**
1	0.7	0.6	0.2	2.0
2	0.4	0.8	0.3	1.6
3	0.6	0.8	0.4	1.2
4	0.4	0.3	0.4	1.4
5	0.5	0.5	0.4	2.1
Mean	0.5	0.6	0.4	1.6
Standard deviation of mean	0.1	0.2	0.1	0.4

Table 8. Impulse of punching part of direct kick

Sample	**I_{UTM} [N s]**	**I_{MTM} [N s]**	**I_{STM} [N s]**	**I_{TM} [N s]**
1	1.5	1.4	1.2	1.4
2	2.5	5.9	0.1	1.8
3	1.2	0.6	0.4	1.3
4	0.6	1.7	0.1	6.9

5	1.9	0.5	1.1	7.7
Mean	1.6	2.0	0.6	3.8
Standard deviation of mean	0.6	2.0	0.5	2.9
Sample	**I_{UTW} [N s]**	**I_{MTW} [N s]**	**I_{STW} [N s]**	**I_{TW} [N s]**
1	0.8	1.2	0.8	1.3
2	1.0	0.9	0.7	1.3
3	0.9	0.6	0.3	1.3
4	0.6	0.4	0.5	1.0
5	0.9	0.7	0.8	1.1
Mean	0.9	0.8	0.6	1.2
Standard deviation of mean	0.1	0.3	0.2	0.1

6. Discussion about results

In the following tables (Table 9, 10 and 11), the main results are reported. There are the mean, the standard deviation and also a measurement uncertainty.

Table 9. Results for direct punch

Category	Mean	Standard deviation of mean	Measurement uncertainty
UTM	0.3	0.1	33.3
MTM	0.4	0.1	25.0
STM	0.3	0.1	33.3
TM	3.1	0.5	16.1
UTW	0.11	0.07	61.9
MTW	0.30	0.08	26.5
STW	0.47	0.13	28.8
TW	1.91	0.25	13.1

Table 10. Results for round punch

Category	Mean	Standard deviation of mean	Uncertainty
UTM	0.3	0.1	33.3

MTM	0.3	0.1	33.3
STM	0.7	0.2	28.6
TM	1.4	0.7	50.0
UTW	0.5	0.1	20.0
MTW	0.6	0.2	33.3
STW	0.4	0.1	25.0
TW	1.6	0.4	25.0

Table 11. Results for direct kick

Category	Mean	Standard deviation of mean	Uncertainty
UTM	1.6	0.6	37.5
MTM	2	2	100.0
STM	0.6	0.5	83.3
TM	3.8	2.9	76.3
UTW	0.9	0.1	11.1
MTW	0.8	0.3	37.5
STW	0.6	0.2	33.3
TW	1.2	0.1	8.3

In the previous table, the main results are presented. We can say that there is significant trend among categories only in the case of direct punch. For the round punch, there are the most significant differences in groups of trained people. The rest of categories are similar. For the direct kick, the results are very similar, and we are not able to find border among categories. In the future, we must find a new method for kicks.

In the other step, we analyzed data from the category of direct punch. We determined borders among each category (Table 12 and 13).

Table 12. Intervals for direct punch – men (Lapková et al., 2017)

Category	Interval
UTM	0.2 - 0.4
MTM	0.3 - 0.5
STM	0.2 - 0.4
TM	2.6 - 3.6

Table 13. Intervals for direct punch – women (Lapková et al., 2017)

Category	Interval
UTW	0.04 - 0.18
MTW	0.22 - 0.38
STW	0.34 - 0.60
TW	1.66 - 2.16

The categories of the mid-trained and the self-trained people are logically very similar. The results of our experiment confirmed this hypothesis. We put these groups together, and now we have two categories instead four (for men and women). The names of the groups are "Collection of mid-trained men" (noted as CMTM) and "Collection of mid-trained women" (noted as CMTW).

Table 14. Final intervals for direct punch – men (Lapková et al., 2017)

Category	Interval
UTM	0.2 - 0.4
CMTM	0.2 - 0.5
TM	2.6 - 3.6

Table 15. Final intervals for direct punch – women (Lapková et al., 2017)

Category	Interval
UTW	0.04 - 0.18
CMTW	0.22 - 0.60
TW	1.66 - 2.16

In Table 14, we can see that the intervals of untrained men and collection of mid-trained men are overlapping. We expected this problem because the same situation was in our previous experiment when we were founding the classification of the training level of people according to a velocity. Men have very similar results in categories of untrained and mid-trained. A sharp border exists only for the group of the trained men. We hypothesize that the significant role has a genetics.

7. Conclusion

In this article, we described our experiment and our method for the classification of the people according to training level with the help of impulse. This research builds on previous work. All our experiments aim to measure the striking

techniques and to find some possibilities of classification of people.

The professional defense is very important part of our life. The reason is very simple. We want to live in safety. It is natural desire and need for people. Nowadays we have police, army and commercial security industry for our protection. It is logical that these people need training. Quality training and effective training. Moreover, the training must be in short time period. All of this is very necessary. When we chose some combat sport, martial art or combat system, we must think if the instructor is able to adapt to our requirements.

Our research has the goal to help in choosing of combat sport, martial art or combat system. It is necessary to teach our employees quickly and effectively. Our new method helps the instructor during training. He is able to check if the person improves as quickly as possible. The method helps to find mistakes during striking techniques.

During our experiment, we found out that the strain gauge sensor is the best for the measuring of force. We were able to process the data with the help of Microsoft Excel and Minitab. In the end, we presented our method for the classification of the training level with the help of the impulse. The best results and the most significant borders are at the direct punches. The other striking techniques have not so clear results.

Acknowledgment

This work was supported by the Ministry of Education, Youth and Sports of the Czech Republic within the National Sustainability Programme project No. LO1303 (MSMT-7778/2014) and also by the European Regional Development Fund under the project CEBIA-Tech No. CZ.1.05/2.1.00/03.0089 and also by the research project VI20172019073 "Identification and methods of protection of Czech soft targets against violent acts with elaboration of a warning system", supported by the Ministry of the Interior of the Czech Republic in the years 2017-2019 and also by the research project VI20172019054 "An analytical software

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