DETERMINATION OF WOUNDING POTENTIAL OF GUNS KNOWN FROM CHILDHOOD - BLOWPIPE AND SLINGSHOT

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Abstract: *This paper deal with the comparison of relative wounding potential of guns, which we know from childhood, specifically blowpipe and slingshot. Many people played with these guns in childhood without knowing how dangerous these guns are. Because this area has not been examined enough, this paper focuses on it. The relative wounding potential is examined through an experimental method. This method is indirect and includes shooting to the replacement material, which was gelatine with a concentration of 20 %. Using a high-speed camera, the course of missiles in the target, from penetration to stopping, is recorded. The volume of the temporary cavity is determined by image analysis, and subsequently, the relative wounding potential is calculated. Other monitored parameters are the depth of penetration of the projectile and the impact velocity of the projectile. Then, it is possible to determine the transmitted kinetic energy of the projectile. The results should help to assess the dangers of these "children's" weapons and alert society to their risks. They can also serve to experts in the field of ballistics and forensic expertise.*

Key words: *blowpipe, slingshot, relative wounding potential, substitute material, 20% gelatine.*

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1. Introduction

Possibly every boy had a weapon, blowpipe, slingshot, bow, airsoft gun, air rifle, etc. in his youth. Probably the most common weapons were slingshots and blowguns because they could be made of materials that could be found at home. It was enough to have a suitably shaped stick and rubber to make the slingshot. The blowpipe used to be made of a pen casing. In childhood, our parents told us to not play with these weapons because they were dangerous. To answer the question of how much and whether these weapons are dangerous, research is needed.

As far as we know, no one has ever dealt with this particular area, i.e. the wounding potential of a slingshot or a blowpipe, on a scientific basis. In general, several authors deal with wounding ballistics, such as Ludvík Juříček [1,2,3,], Beat P. Kneubuehl [4,5,6], Malcolm J Dodd [7], Steven Manners [8], Di Maio [9] or Zvi Rosenberg [10].

A related area to the researched intention is to determine the wounding potential of low-power weapons such as air rifles, expansion weapons, bows, crossbows or airsoft weapons [11,12,13,14,15,16]. However, no one has dealt directly with the area of determining the wounding potential of a blowpipe and a slingshot - the authors have not been able to find any article discussing the wounding potential of a blowpipe or a slingshot from the available databases. Hence, it is necessary to research this area in detail.

In this paper, we examine already modern and professionally made weapons, i.e. a blowpipe and a slingshot with appropriate ammunition. Our research is based on knowledge of wounding ballistics, which is generally used. We investigate the wounding potential of a slingshot and a blowpipe, and we provide their comparison. The results can serve to experts in the field of ballistics and forensic expertise.

2. Methods

The method, used in this article, is based on an experiment, which consists of shooting from a slingshot and a blowpipe into a replacement material. The depth of the shot in the replacement material was monitored, and the trajectory of the missiles through the material was recorded using a high-speed camera. Furthermore, the velocity of the missiles on impact was measured using ballistic gates.

The experimental workplace was as follows: the shooting took place at a distance of 2 m. Ballistic gates CALDWELL CHRONOGRAPH with a maximum deviation of $\pm 0.25\%$ (60 cm spacing) were placed 15 cm in front of the replacement material. The muzzle of the weapon was placed 125 cm from the ballistic gates.

Ballistic gelatine, with a concentration of 20 %, was chosen as a replacement material. Gelatin of this concentration is close to the muscles of the human body with its physical properties (see Table 1).

Material	t	ρ	K	η	v	c
	°C	[kg·m ⁻³]	[Pa ⁻¹]	[Pa·s]	[m ² ·s ⁻¹]	[m·s ⁻¹]
20% Gelatine	20	1060	$3,8 \cdot 10^{-10}$	$1,0 \cdot 10^2$	0,1	1567

Tab. 1. Properties of ballistic gelatine with a concentration of 20 %.

Where t - temperature, ρ - density, K - compressibility, η - dynamic viscosity, v - kinetic viscosity, c - speed of sound. The dynamic viscosity was measured at 30 °C as it increases strongly with decreasing temperature. A blowpipe (Fig. No. 1) and a slingshot (Fig. No. 2) were used.

Fig. 1. Blowpipe.

Fig. 2. Slingshot with a ball.

Fig. 3. Slingshot with a ball.

Each weapon was shot ten times. The results of this experiment are described in the following chapter.

3. Results

Directly measured values were: v_I - impact velocity, s_D - shot depth. The V_{TC} – the volume of the temporary cavity and w_{TC} - the maximum width of the temporary cavity were determined by the image analysis of the recordings from the high-speed camera. Using the formula $E_k = \frac{1}{2} m v^2$, the E_I impact kinetic energy was calculated. E_I is identical to E_k . RWP - relative wounding potential is calculated based on the relationship $RWP = \frac{E_I}{V_{TC}}$ and expresses the amount of transmitted kinetic energy that the projectile needs to create 1 cm³ of the volume of the cavity of the fire channel in the replacement material. RWP is a quantity inverted to the coefficient of proportionality μ [cm³.J⁻¹], which was used by M. L. Fackler to define the resistance of soap blocks to the penetration of a projectile.

Blowpipe	Impact velocity	Shot depth	Volume of temporary cavity	Maximum width of temporary cavity	Impact kinetic energy	Relative wounding potential
	m·s ⁻¹	mm	mm ³	mm	J	J·mm ⁻³
1. missile	32,8	56	139,1	12,0	0,43	0,0031
2. missile	31,5	68	142,3	12,2	0,40	0,0028

3. missile	35,0	57	139,9	11,9	0,49	0,0035
4. missile	32,1	54	137,2	11,8	0,41	0,0030
5. missile	36,8	69	143,1	12,3	0,54	0,0038
6. missile	35,1	65	141,8	12,1	0,49	0,0035
7. missile	34,9	64	141,8	12,1	0,49	0,0034
8. missile	33,4	59	140,3	12,1	0,45	0,0032
9. missile	35,7	66	142,0	12,1	0,51	0,0036
10. missile	32,2	55	138,5	11,9	0,41	0,0030

Tab. 2. Values measured and calculated for the blowpipe.

The variance in velocity in the case of a blowpipe is affected by how powerfully we blow into it. Interestingly, the depth of the shot is considerable despite the low speed and the weight of the dart (0.8 g). The maximum width occurs at the entrance. It is caused by a plastic seal at the end of the dart. As a result, the data is so similar. As can be seen, the relative wounding potential is almost negligible.

Fig. 4. A maximal dimension of the temporary cavity.

Slingshot	Impact velocity	Shot depth	Volume of temporary cavity	Maximum width of temporary cavity	Impact kinetic energy	Relative wounding potential
	$\text{m} \cdot \text{s}^{-1}$	mm	mm^3	mm	J	$\text{J} \cdot \text{mm}^{-3}$
1. missile	28,5	13	761,8	12,1	1,42	0,0019
2. missile	29,6	14	799,6	14,6	1,53	0,0019
3. missile	38,3	29	1051,9	22,2	2,57	0,0024
4. missile	41,0	31	1072,8	26,7	2,94	0,0027
5. missile	40,6	30	1064,3	24,4	2,88	0,0027
6. missile	37,1	28	1002,5	21,9	2,41	0,0024
7. missile	31,4	20	816,0	15,3	1,73	0,0021
8. missile	30,2	19	801,7	15,7	1,60	0,0020
9. missile	29,0	19	846,2	14,5	1,47	0,0017
10. missile	33,9	23	946,7	19,0	2,01	0,0021

Tab. 3. Values measured and calculated for the slingshot.

The variance in velocities for a slingshot is affected by how much we tighten the sling rubber. The depth of the shot is proportional to the speed and weight of the bullet (3.5 g). The maximum width occurs at the entrance. As can be seen, the relative wounding potential is almost negligible; however, the data on the temporary cavity is significant. Specifically, the dimension of the temporary cavity is relatively large compared to a blowpipe. The size of the temporary cavity was more challenging to determine. As the ball passed through the block of the replacement material, two temporary cavities were created. The first one at the inlet (Fig. 5) began to close when the ball penetrated to a greater depth of the replacement material. The second one began to form at the same moment (Fig. 6), and this formation lasted until the ball stopped in the block of the replacement material (Fig. 7). The resulting size of the volume of the temporary cavity is thus the sum of the maximum volumes of these temporary cavities.

In contrast to firearms, it is complicated to provide similar values of energy or velocity of missiles with these weapons. This is because these weapons use the human force transmitted by the missiles. In the case of a blowpipe, the force of exhalation is transmitted. In the case of a slingshot, the force, with which the rubber is stretched, is transmitted. Therefore, the values are on a relatively large scale.

Fig. 5. The temporary cavity at the entrance of the ball fired from the slingshot into the replacement material.

Fig. 6. Formation of the second temporary cavity and the beginning of the closure of the first one.

Fig. 7. Second temporary cavity with the maximum volume.

Fig. 8. The permanent cavity of the slingshot.

Weapon	Impact velocity	Shot depth	Volume of temporary cavity	Maximum width of temporary cavity	Impact kinetic energy	Relative wounding potential
	Arithmetic mean					
	$\text{m} \cdot \text{s}^{-1}$	mm	mm^3	mm	J	$\text{J} \cdot \text{mm}^{-3}$
Blowpipe	33,95	61,3	140,6	12,05	0,46	0,0033
Slingshot	33,96	22,6	916,35	18,64	2,06	0,0022

Tab. 4. Values measured and calculated for the slingshot.

Table 4 clearly shows the average values for measured or calculated parameters. Interestingly, the average speed is almost the same for both weapons. As might be expected, a blowpipe that shoots sharp thin darts has a far greater depth of shot than a steel ball fired from a slingshot. However, a significant difference can be observed in the case of the volume of the temporary cavity. The dart passes almost without the formation of a temporary cavity, which arises practically only at the end of the dart, where a plastic stop of the arrow strikes or partially penetrates the replacement material.

On the other hand, the ball penetrates during the entire path and causes the formation of the temporary cavity. Similarly to the dart, the maximum width of the temporary cavity is at the point of penetration. As can be seen, the transmitted kinetic energy is more than four times larger in the slingshot than in the blowpipe. The relative wounding potential of the projectiles is almost the same (the difference is nearly negligible); however, the blowpipe has a slightly higher wounding potential, which is given by the relationship of the amount of energy per unit volume.

The authors of the article would rather choose the criterion of proportionality coefficient (PC), which shows the amount of volume that arises per unit of energy with the calculation $PC = \frac{V_{TC}}{E_I} [\text{cm}^3 \cdot \text{J}^{-1}]$, where V_{TC} is the volume of the firing channel (temporary cavity) and E_I is the impact energy (in this case identical to the kinetic energy at impact). According to the authors, this criterion expresses the wounding potential of the projectile adequately and serve to compare individual weapons better.

For this criterion, PC has an average value of $307 \text{ mm}^3 \cdot \text{J}^{-1}$ for the blowpipe and $463.8 \text{ mm}^3 \cdot \text{J}^{-1}$ for the slingshot. In the case of the blowpipe, a PC of $307 \text{ mm}^3 \cdot \text{J}^{-1}$ would be generated by transmitting 1 J of kinetic energy (impact). In the case of the slingshot, a PC of $463.8 \text{ mm}^3 \cdot \text{J}^{-1}$ would be produced.

Weapon	Proportionality coefficient (PC)
	$[\text{mm}^3 \cdot \text{J}^{-1}]$
Blowpipe	307,00
Slingshot	463,80

Tab. 5. Values measured and calculated for the slingshot.

4. Conclusion

This article focused on determining the wounding potential of weapons known from childhood, namely the blowpipe and the slingshot. Data were obtained from the experiment. From these data, the wounding potential of weapons can be determined. The most important criteria are the proportionality coefficient, the volume of the temporary cavity and the impact (kinetic) energy. The slingshot has higher values in all these parameters. From this, it can be stated that the slingshot has a higher wounding potential in the muscles. Although the blowpipe penetrates deeper, it practically does not cause injuries, while the slingshot penetrates only a few centimetres of muscle, but causes more serious injuries.

It should be admitted that this paper deals with the study of the wounding potential for living tissue, namely for muscles that are replaced by physically similar material (20% gelatine). It can be assumed that if the skin cover were also presented in the experiment, the ball fired from the slingshot would not penetrate the replacement material, and there would be a vertical shot, or the muscle damage would be considerably reduced. This assumption is confirmed by the experience of authors from childhood. It can also be assumed that with the addition of a skin cover, the depth of the shot from the blowpipe would be significantly reduced; however, the dart would still penetrate the muscles. It can be stated that, in real life, these weapons do not pose a significant risk; however, the specific risk is a situation where the projectile would be aimed, for example, at the eyes. Although the title of the article states that these weapons are from childhood, it must be said that they should be placed in the hands of children only under the supervision of prudent and careful parents. The findings of this article should contribute to the education of the public; moreover, they should help experts in the field of forensic expertise or ballistics.

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