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Slingshot Accuracy in Traditional Games: What is The Ideal Grip in Shooting?
Precisión del tirachinas en juegos tradicionales: cuál es el agarre ideal al disparar?

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Abstract. The purpose of this study was to analyze the biomechanics of the ideal grip on the traditional game of slingshots. This study used quantitative methods that were described in detail using descriptive analytics with a one-shot case study design. The sample in this study consisted of 10 people who were activists of the traditional slingshot game in Semarang Regency and filled out complete consent information as a willingness to participate in the research to completion. The data in this study is in the form of kinematic data obtained from the results of video analysis using Kinovea software version 0.9.5. The quantitative data in this study is in the form of a recap of kinematic data consisting of 3 phases, namely the preparation phase; the release phase; and the follow-through phase. The results of this study found that the preparatory phase had an average grip angle of 99.08 ± 5,995 degrees. Grip angle data at release phase 99.66 ± 4.977 degrees. This study found the conclusion that the ideal grip is a straight hand position parallel to the pull of the arm until an angle of approximately 90 degrees is formed with the slingshot position slightly tilted, this position can provide enough space for the other hand to pull the slingshot rubber back. So that the pull carried out can be maximized and can be adjusted to the intended target distance. It is expected that further research can discuss the analysis of pull length and shot accuracy.
Keywords: biomechanics analysis; traditional games, slingshot; grip

Resumen. El propósito de este estudio fue analizar la biomecánica del agarre ideal en el tradicional juego de tirachinas. Este estudio utilizó métodos cuantitativos que se describieron en detalle mediante análisis descriptivos con un diseño de estudio de caso único. La muestra de este estudio estuvo formada por 10 personas que eran activistas del tradicional juego de tirachinas en Semarang Regency y completaron la información de consentimiento completa como muestra de voluntad de participar en la investigación hasta su finalización. Los datos de este estudio se encuentran en forma de datos cinemáticos obtenidos de los resultados del análisis de video utilizando la versión 0.9.5 del software Kinovea. Los datos cuantitativos de este estudio se presentan en forma de un resumen de datos cinemáticos que consta de 3 fases, a saber, la fase de preparación; la fase de liberación; y la fase de seguimiento. Los resultados de este estudio encontraron que la fase preparatoria tenía un ángulo de agarre promedio de 99,08 ± 5995 grados. Datos del ángulo de agarre en la fase de liberación 99,66 ± 4,977 grados. Este estudio encontró la conclusión de que el agarre ideal es una posición de la mano recta paralela al tirón del brazo hasta formar un ángulo de aproximadamente 90 grados con la posición de tirachinas ligeramente inclinada, esta posición puede proporcionar suficiente espacio para que la otra mano pueda tire de la goma del tirachinas hacia atrás. Para que la tracción realizada se pueda maximizar y ajustar a la distancia objetivo deseada. Se espera que futuras investigaciones puedan discutir el análisis de la longitud del tiro y la precisión del tiro.
Palabras clave: análisis biomecánico; juegos tradicionales, tirachinas; agarre

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Introduction

Traditional games are one of the cultural evidences of ancestral heritage in Indonesia that has inherent cultural characteristics, and is a form of games and sports activities that grow from the habits of certain populations (Handoko & Gumantan, 2021). Traditional games are closely related to the cultural heritage of a society because they teach life values in social life (Irawan, Junaidi, et al., 2023). This culture can train children's skills in socializing in society, and no less important in socializing with their peers (Puspitasari, 2022). Traditional games are very necessary to be maintained and preserved. Through traditional games, the culture and identity of a society can be preserved and passed on from generation to generation.

Traditional games that exist in each region have different rules and concepts according to the origin of the region and also the times. Some may have undergone changes in the rules or equipment used. According to Asmawi et al., (2022) traditional games have positive values that give attractiveness such as teaching about how the value of unity, mutual cooperation, tolerance, fairness, honesty, sportsmanship, and discipline when playing. In addition to these values, traditional games also have benefits such as training the physical condition of the players indirectly including accuracy, endurance, speed, accuracy, agility, and many more (Ishak, 2014). Of the many types of traditional games that people know today, there are many contribute to having a positive impact on the players, one of which is the traditional slingshot game (Irawan & Permana, 2019). Slingshot is a traditional game that involves gross motor skills because it performs activities using its large muscles (Saputri & Purwadi, 2015). Gross motor skills are very important and must be possessed by children as a basis for mastering further, more complex movements. Motor skills that work properly will make children do activities (Nurhasan et al., 2024; Yudanto et al., 2024) by moving their hands and feet without feeling stiff and will become agile (Santoso & Setiabudi, 2020).

Traditional slingshot games are also known as slingshot games and have been played for centuries in various cultures around the world (Kurniaziz et al., 2022). Based on

(Rahesti et al., 2023) in playing slingshot, it is not just shooting until the bullet reaches the target, but there are several things that need to be considered such as playing techniques ranging from body position, amo installation, how to hold the frame, rope pulling (drawing), anchoring, aiming techniques (aiming), bullet release techniques (release), and the last one namely the continued motion until the bullet hits the target (follow through). Traditional slingshot games are included in the accuracy branch where calmness, balance, and accuracy are needed in order to aim the target correctly (Irawan et al., 2022). The speed of the bullet will not be straight with the target if the shooter stands unsteadily. Therefore, each of these complex stages must be studied one by one in detail and supported by science and technology.

In traditional games, biomechanical motion analysis is very necessary for both coaches and teachers. This is very necessary to know the movements and muscles that can improve the ability and perfect movements (Wibisona et al., 2019). According to Safitri & Irawan, (2022) biomechanics is a special science that studies motion in living things. In the field of sports, biomechanics has a role in providing evaluation in every movement that is considered to achieve the process of improving athlete performance. Playing slingshots is very beneficial for knowledge and psychomotor skills, apart from the academic benefits of being able to provide information regarding the effectiveness of movements in shooting targets accurately and quickly to the community and traditional game enthusiasts. The importance of studying the traditional slingshot game is not only about knowledge and learning, but also about how to preserve traditional games in the modern era. In addition, sports biomechanics can be useful in preventing injuries. Biomechanical analysis in sports can prevent injuries to athletes while providing recommendations for effective and efficient movements (Irawan & Long-Ren, 2019). With the advancement of technology that continues to grow, biomechanical analysis can be done easily to analyze movements through videos or images and then will be processed in video analyze software. Kinovea video analyze application is one of the video analyze applications (Irawan, Permana, Nurrahmad, et al., 2023) that is often used to analyze a valid movement.

Researchers observed that 60% of the activists' slingshot shooting techniques were still incorrect, including ineffective grip positions. These findings came from observations made during the 2022 Semarang Regency Elementary Level Folk Games Festival, which took place on November 17, 2022 at Bung Karno Ungaran Square. The poor success rate of firing reaching the target indicates this. Inaccuracies in shooting can occur due to grip and pull techniques that do not comply with physiological and biomotor concepts or body instability in the series of movements performed. So, these factors need to be looked at more fully to find out what factors are causing the slingshot shots to be inaccurate. Based on Safitri & Irawan, (2022) earlier research on how the body's biomechanical characteristics impact movement outcomes, his study demonstrated the application of kinematic data in the analysis of each body segment's movements. This made researchers interested in analyzing the ideal grip in traditional slingshot games. The purpose of this study was to analyze the biomechanical grip on traditional slingshot games. Researchers also hope that this research can be used as a reference for further studies.

Method

Descriptive analytics is used in this study to provide a comprehensive explanation of the quantitative research findings (Purnomo & Irawan, 2021). Information from research projects using the one-shot case study (Rumiati et al., 2021). In order to solve current concerns, Sugiyono, (2019) state that the descriptive study's main focus is on analyzing the sling shoot grips that occur in the field. The study's population consisted of ten activists of traditional slingshot sports in the Semarang Regency and at least two years involved in traditional games. The limited sample that took part in this research was because only a few activists mastered the slingshot game. Each sample provided fully informed consent, indicating that they intended to participate in the study until its completion. The primary focus of the analysis was the angle of the grasp, the distance of the foot in the stance, and the duration of performing a series of slingshot motions (Irawan et al., 2021). Kinematic data represented the three phases of the study's quantitative data: the preparation, release, and follow through phases. In this study there are several tools that support this research, including 1) digital camera type Nikon D5200, 2) camera tripod, 3) stationery, 4) laptop with Kinovea application version 0.9.5. This study also was approved by the Health Research Ethics Committee of Universitas Negeri Semarang, Indonesia

Data collection techniques in this study used survey methods, observation, and analysis in the form of videos analysis from which kinematic data was taken including time, distance, and angle. The study was conducted using the following procedures: (1) the subject was given an explanation of the test before it was conducted; (2) the equipment, including cameras, tripods, and stationery, was set up; (3) the camera was positioned perpendicular to the sample and began recording as soon as the subject began using the slingshot; and (4) the research subject fired a predetermined number of shots using the slingshot.

Results

Sample data information on body weight, height, BMI, leg distance and arm length is presented in table 1 below.

The results of the research data showed that the average body weight was 58.3 ± 12.54 kg, and the body height was 1.449 ± 0.213 m, while the distance between the legs was 0.264 ± 0.124 m and the length of the supporting arm was 0.485 ± 0.165 m. Body height and foot distance when shooting is ideal to help body stability with a target height of 1.5 m and a distance of 7 m. The results of this study found that the indicators consisted of height, overall movement time, standing leg distance, grip angle, pull angle, aiming angle, torque angle, and bullet speed to the target. The motion analysis for this study was carried out in three stages: preparation, release, and follow-through. The results of the motion analysis are explained in Table 2.

Table 1.
Motion Analysis Result

N=10	Mean ± SD.	Min	Max
Body Weight (Kg)	58.3±12.54	53	66
Height (m)	1,449±0,213	1,268	1,674
BMI (m/s^2)	1.952±0.89	1.65	2.01
Foot Stride (m)	0,264±0,124	0,128	0,565
Arm Length (m)	0,485±0,165	0,353	0,956

Table 2.
Motion Analysis Result

N=10		Mean ± SD	Min	Max
Preparation (m)		1,449 ± 0,119	1,268	1,674
Time (s)		4,93 ± 0,786	3,28	6,12
Stride Leg (m)		0,264 ± 0,124	0,128	0,565
Preparation Phase	Time (s)	2,17 ± 0,996	0,88	4,08
	Grip Angle (°)	99,08 ± 5,995	92,9	112,9
	Pull Angle (°)	98,11 ± 22,956	44	137,2
Release Phase	Time (s)	1,988 ± 0, 957	0,56	3,48
	Grip Angle (°)	99,66 ± 4, 977	93,1	109,9
	Pull Angle (°)	103,76 ± 26,22	33	137,1
	Shot Angle (°)	5,01 ± 1,563	2,4	7,5
	Torso angle (°)	169,8 ± 10, 316	140,9	178,8
	Arm length (m)	0,485 ± 0,165	0,353	0,956
	Pull length (m)	0,726 ± 0,362	0,515	1,788
	Speed (m/s)	30,667 ± 11,628	17,5	58,33
Followthrough Phase	Time (s)	0,512 ± 0,333	0,08	1,04

Based on Table.2, the results of kinematic data analysis of a series of slingshot movements of 10 people in Semarang district with an average total time obtained of 4.93 ± 0.786 second, with a division of time in the preparation phase with an average of 2.17 ± 0.996 second, time in the release phase 1.988 ± 0, 957 second, and time in the followthrough phase 0.512 ± 0.333 second. From the existing data in the preparation phase has an average grip angle of 99.08 ± 5.995 degree with a pull angle of 98.11 ± 22.956 degree, in the release phase has an average grip angle of 99.66 ± 4, 977 degree and a pull angle of 103.76 ± 26.22 degree. Grip and pull angle of the preparation phase can be seen in Figure 1.

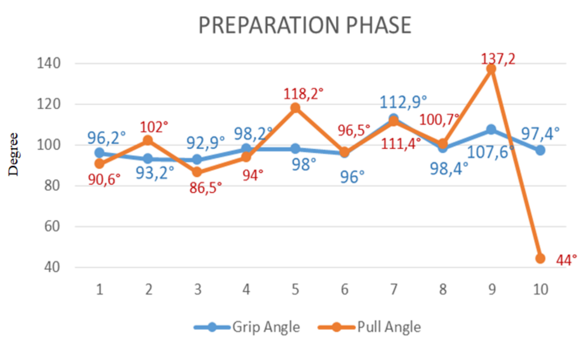

Figure 1. Grip and Pull Angle of The Preparation Phase

Data from the grip angle during the preparation phase are shown in figure 1, where sample number 3 formed the smallest angle 92.2 degrees and sample number 7 formed the largest angle 11.2 degrees in the sling shoot grip angle. Sample number 10 created the smallest pull angle, which was 44 degrees, while sample number 9 produced the largest pull angle, which was 137.2 degrees in the preparation phase. The grip arm is weak enough to sustain the pull in samples that result in grip angles that are either too big or too small. The sample produces a pull angle that is too small or less than 90 degrees because the arm is not as stretched and the body is positioned too bowed; on the other hand, the sample produces a grip angle that is greater than 90 degrees because the elbow is raised excessively.

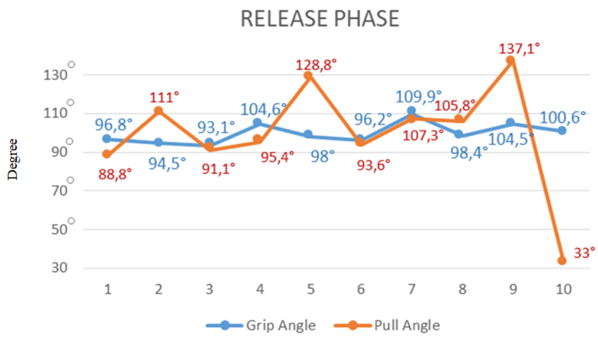

Figure 2. Grip and Pull Angle of The Release Phase

Graph 2 presents data on the relase phase of the smallest angle formed from the grip angle of 93.1 degrees produced by sample number 3 and the largest grip angle of 109.9 degrees by sample number 7. Then at the angle of pull, the smallest angle of 33 degree was produced by sample number 10 and the largest angle of pull of 137.1 degree was produced by sample number 9. The grip angle must form approximately 90 degrees, the goal is to make the grip arm straight towards the target. Then at the angle of pull to form an angle of 90 degrees by placing the right anchor point, namely on the cheekbone every time you pull the rubber slingshot.

Discussion

Based on the results of this study on the analysis of slingshot motion analysis, each subject shot using 5 bullets with 7 meters distance. The best data from each sample per indicator will be taken as data per sample. Anthropometry measurement is needed because the height of the players will affect the final result of a shot. Body height is very useful in making slingshot shots, information is conveyed because a person's height influential in helping to improve shooting abilities such as balance, eyes, elbows, and follow through abilities (Ramadhan & Irawan, 2s022). This shooting ability is the initial capital of slingshot players to support the level of accuracy, because the most important thing in playing slingshot is accuracy. Based on the data in Table 1, as many as 10 activists of the traditional slingshot game have an average height of 1.449 meters. The highest height is 1.674 meters, and the lowest height is 1.268 meters. In samples that have a height of more than 1.5 meters which is classified as tall, it will be easier to aim at the target because the height between the target and the shooter is parallel. In addition, the height of the slingshot activists allows them to have arm lengths that match their height, activists who have ideal height help increase the length of the pull and affect the speed of the shot.

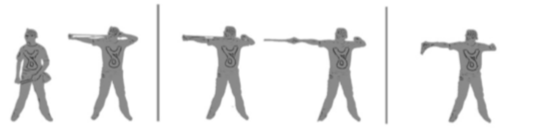

Figure 3. Slingshot Phase

The preparation phase begins when the position of the feet is already on the shooting line with an open stance with the feet shoulder-width apart, the body position is parallel to the target direction, and the position of the head turns to face the target, all parts are positioned in such a way as to achieve the correct biomechanical attitude. Balance at the time of shooting will be influenced by the standing position, especially on the distance between the two legs to support the weight of the body in the data shown from 10 samples has the smallest foot distance of 0.128 meters and the largest of 0.565 meters. The ideal leg length is shoulder-width apart, where the distance will be adjusted to the shooter's height. In the subjects in the traditional slingshot game activists in Semarang Regency have an average foot distance of 0.264 meters with a standard deviation of ± 0.124 meters. Where most of the subjects at the time of the standing position their legs were less open, the position should be standing with both feet shoulder-width apart with the aim of having a strong stance so that it is stable in aiming at the target. Anchoring movement where the rubber pulling hand that clamps the bullet is placed right on the cheekbone. After the standing position is continued with the installation of the bullet by placing it on a rubber pad and pulling the rubber after the bullet is installed. In the preparation phase, the angle in the hand grip and the angle in the arm pull will be formed, in the results of the subject data in table 1, the hand grip angle has an average of 99.08 degree with a standard deviation of ± 5.995 degree, the 10 subjects have a grip angle with the smallest angle of 92.9 degree and the smallest grip angle of 112.9 degree. The average arm pull angle value was 98.11 degree and the standard deviation was ± 22.954 degree. The total time required for the preparation phase starting from the installation of the bullet to the anchoring movement performed by the subject has an average time of 2.17 second and a standard deviation with the fastest time of ± 0.996 second and the fastest of 0.88 second. In the slingshot game anchoring is a movement to anchor the pulling hand on the cheekbone, some things that must be considered in anchoring, namely the hand pulling the rope must remain attached to the cheekbone as a benchmark.

The release phase begins with a smooth release of the bullet cushion pull by relaxing the bullet cushion pull fingers. As soon as the bullet pad is released, the bullet will be ejected forward. Before releasing the previous pull will go through the aiming technique or aiming, the aiming technique is done by inserting the shadow of the aiming device to the target point. When aiming the body position is not expected to change, this is done so that the player is more focused on the target. Body position, slingshot grip, and arm pull, the length of the shot must be considered because it will affect the final result of the bullet shot. According to Vanagosi, (2015) from the observation of every world championship in archery on average only takes 3-4 seconds from anchoring to release. In the data results 10 existing subjects have an average time of 1.988 second with a standard deviation of ± 0, 957 second, the fastest time record is 0.56 second and the longest is 3.48 second, a total of 5 samples with a record time below 2 seconds are considered too hasty to release the bullet. Furthermore, the grip and pull technique, in the existing data from 10 sample recorded an average pull of 98.11 degree with a standard deviation of ± 22.956 degree. The pull angle value with the smallest number is 33 degrees and the largest angle is 137.1 degree. The average grip angle is 99.66 degree with a standard deviation of ±4.977 degree, in the grip angle in 10 samples has the smallest grip angle of 93.1 degree and the largest of 109.9 degree. The error that causes the grip angle to be less or more than 90 degrees is that the elbow arm does not rotate straight, and only moves the fisir which is located at the upper end of the slingshot to determine the direction of the shot. Correct elbow rotation will keep the slingshot handle straight. then the angle of pull produced in some samples is not close to 90 degrees because the anchor point is not right on the cheekbone, If the angle formed is too small it will cause the bullet to shoot far below the target, and if the angle formed is too large it will cause the bullet to shoot far above the target. Similar to archery where the angle and position of the elbow play an important role in the force at the shoulder, in slingshot games it is also influenced by both the angle of the pulling arm and the perpendicular hand holding the slingshot (Mukhtar & Rubiono, 2020). The stages of the correct grip and pull technique are, the arm holding the slingshot is at shoulder level and tilted inward so that the slingshot fire is tilted, and the pulling hand is ready to pull the slingshot rubber. At this stage there will be a shoulder abduction movement (the left arm as the slingshot holder), the pulling arm is raised to shoulder height and then positioned to touch the cheekbone. Then the neck rotates to the left or neck rotation to the left (if pulling rubber with the right hand). In the right hand there is elbow flexion and shoulder abduction of the upper arm. The last phase is followed through or continued motion after the release phase occurs. The follow through technique can affect the success of the shot and facilitate the control of the bullet release motion in the release phase to remain stable. Stones or pebbles from the ejection pad will bounce and move at a certain speed. The motion caused is a straight motion changing regularly. The speed of the ejection depends on the magnitude of the muscular force that pulls the rubber of the slingshot. The greater the muscle force, the greater the potential energy and kinetic energy produced by the slingshot. Vice versa, when the muscle force is small, the potential energy of rubber is weak and the ejection of stones or gravel becomes slow (Irawan, Permana, Hidayah, et al., 2023). The angle of attraction of the slingshot can affect the far-re near force of the bullet ejection.

The technique of movement in each phase must be done correctly to get the optimal final result, the technique that is the key to the traditional slingshot game is the grip and pull technique. In the handle in slingshot s there are four types of different ways of holding slingshot s, namely the ancient handle, the gangster handle, the hammer handle, and the finger handle. Of the four handles commonly used by slingshot activists and used in a match, namely the gangster grip. The gangster grip or side grip technique is a way of holding the slingshot vertically by turning the wrist 90 degrees inward so that it is parallel to the pulling arm. The use of the gangster grip itself aims to make it easier for slingshot players to aim at targets using the rubber tip of the upper slingshot, besides that the gangster grip is considered quite stable compared to other types of grips. The grip and pull in the traditional slingshot game must be considered, the angle formed by the shoulder as a puller and the arm that must be straight as a handle can affect the result of the shot, namely the intended target. The angle formed from the data in the grip and pull in the preparation phase to the release phase has a different amount, this is because in the release phase it has passed the aiming technique or aiming where the shooter has ensured that when the bullet is released it will hit the target correctly. The difference in angles formed in the preparation phase to the release phase should not have too much difference because it will provide many changes in movement which will ultimately disrupt the balance of the shooter. In order for the resulting angle to be stable, the shooter must perform proper grip and pull techniques starting from the preparation phase so that during the aiming technique or aiming there are not too many changes in the resulting movement. Grip and pull movements will become proportional with automation in order to produce shots with accuracy and constancy (Irfan, 2018). Automation in slingshot is carried out mainly during the pull of the slingshot rubber, precisely during the anchoring technique. When after the rubber is pulled, the arm will be anchored until the pull will be straight with the cheekbone. This anchoring process must be the same pattern and firmly attached to the cheekbone as a help point so that the pull remains in the same position, the goal is for the rubber rope to be in a straight line with the slingshot handle.

The mechanics of motion towards slingshot are the same as archery, which has two movements of shoulder attitude and the attitude of the arm holding the slingshot frame in a straight line. In playing the slingshot when the rubber starts to lift the shoulder must be kept in a low position, because in biomechanics this position is an efficient position. When pulling the rubber, the shoulder position must be low with the arm straightened to the target. The position of the shoulder in pulling the rubber needs to be considered. The elbow must be straight with the slingshot frame. According to Irfan, (2018) the technique in shooting, namely the pulling arm and the grip arm in a balanced 50/50 state. Handle and pull techniques that are done correctly will allow consistent slingshot shooting movements, so that when done continuously will get high achievement (Vanagosi, 2015). Limitations in this research include the number of samples being only 10 because the number of traditional slingshot game enthusiasts is very limited and those who have experience playing slingshots for two years are still small. The height and body weight of the samples were only an average of 58.3 ± 12.54 kg and 1.449 ± 0.213 m, where the movement stability was quite good, but if analyzed from the length of the legs and the length of the arm for the length of the slingshot, it was still not enough to get a fast and precise shot.

Not all slingshots are the same, so it is necessary to adjust the grip depending on the shape of the slingshot used. The cakuk is the main part of the slingshot shaped like a "Y", in this position some people point the cakuk upwards and some tilt it. However, any position can be used depending on the shot. But most slingshot players aim the cuckoo at a slight angle. This position may have enough room for the other hand to pull the rubber slingshot back. Thus, the realized pulling force can be maximized and adjusted according to the set target distance.

The purpose of slingshot biomechanical analysis is motion correction and how to improve performance, technique, training methods, and reduce the risk of injury. Through biomechanics, athletes will get used to doing activities or movements in an effective and efficient way. Effective and efficient means performing movements with proper coordination and timing, moving proportionally with automation. If a movement is done ineffectively and efficiently it will waste energy and excessive tension. The result of inefficiently of slingshot grip and pull would cause people to physically quickly fatigued and psychologically nervous due to instability. In addition, improper movement will make the shot off target.

Conclusion

The conclusion in this study found that the analysis of grip and pull-on slingshot traditional game activists in Semarang Regency in the preparation phase had an average grip angle of 99.08 ± 5.995 degree and a pull angle of 98.11 ± 22.956 degree. The average grip angle formed in the release phase was 99.66 ± 4.977° degrees with an average pull angle in the release phase was 03.76 ± 26.22 degree. The angle formed by the arm as a handle and shoulder as a puller can affect the final result of the shot. The ideal grip is a straight hand position so that it is parallel to the arm pull until an angle of approximately 90 is formed. As for an effective and efficient pull, it is done by anchoring the rubber pull during the anchoring technique right on the cheekbone so that the rubber pull remains consistent. The correct pulling grip technique is obtained from repeated practice so that good automation movements occur. The limitation in this study is that there is still a lack of understanding regarding shooting techniques on slingshots. It is hoped that further study can discuss related to the analysis of the length of the pull and shooting accuration.

Conflict of Interest

The author(s) declare that they have no conflict of interest.

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