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Kinematic Movement Differences Between Petanque Pointing and Shooting Technique in Children
Diferencias de movimiento cinemático entre la técnica de puntería y tiro de petanca en niños

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Abstract. This study aimed to evaluate children's kinematic movement in petanque pointing and shooting techniques. There were 16 male beginner petanque athletes (aged 11.37 ± 1.36 years old, weight 42.37 ± 4.36 Kg, and height 151.37 ± 7.36 cm) who were selected using the purposive sampling method. The successful throwing was observed in the sagittal plane and measured by kinematic analysis in Kinovea 0.9.4 Software. There were pointing and shooting kinematic data, categorized into four phases, i.e., back swing, zero position, release, and follow throw position. As a result, there were significantly different in several variables of each phase between pointing and shooting techniques. There was a significant difference in the back swing phase at shoulder extension and ball height ($\alpha < .05$). The shooting technique showed greater velocity (10.94 ± 13.34 m/s) than pointing (5.290 ± 0.44 m/s). In the release phase, every variable was significantly different ($\alpha < .05$). The ball height in pointing was higher (92.53 ± 9.69 m) than in shooting (80.19 ± 10.74 m). Ball velocity at pointing was slower (6.46 ± 0.43 m/s) than shooting (16.09 ± 5.18 m/s). The release elevation angle at pointing was wider (42.38 ± 5.85 °) than shooting (35.31 ± 7.26 °). There were significant differences in trunk flexion, knee flexion, maximum ball height, and ball velocity at the follow-throw phase ($\alpha < .05$). Ball velocity at pointing was slower (4.90 ± 2.35 m/s) than shooting (13.01 ± 5.36 m/s). In conclusion, the specific technique in shooting and pointing could be adapted in the training method for children to advance the result and successful possibility. Further study could be conducted in different age groups and gender to gain more information about the petanque throwing technique.
Key Words: biomechanics, gait analysis, manipulative skill, training evaluation

Resumen. Este estudio tuvo como objetivo evaluar el movimiento cinemático de los niños en las técnicas de puntería y tiro de petanca. Fueron 16 atletas principiantes de petanca (edad 11,37 ± 1,36 años, peso 42,37 ± 4,36 Kg y altura 151,37 ± 7,36 cm) que fueron seleccionados mediante el método de muestreo intencional. El lanzamiento exitoso se observó en el plano sagital y se midió mediante análisis cinemático en el software Kinovea 0.9.4. Había datos cinemáticos de apuntar y disparar, clasificados en cuatro fases, es decir, swing hacia atrás, posición cero, liberación y posición de seguimiento de lanzamiento. Como resultado, hubo diferencias significativas en varias variables de cada fase entre las técnicas de apuntar y disparar. Hubo una diferencia significativa en la fase de balanceo hacia atrás en la extensión del hombro y la altura de la bola ($\alpha < .05$). La técnica de tiro mostró mayor velocidad (10,94 ± 13,34 m/s) que la de apuntar (5,290 ± 0,44 m/s). En la fase de liberación, cada variable fue significativamente diferente ($\alpha < .05$). La altura del bola en puntería fue mayor (92,53 ± 9,69 m) que en tiro (80,19 ± 10,74 m). La velocidad de la bola al apuntar fue más lenta (6,46 ± 0,43 m/s) que al disparar (16,09 ± 5,18 m/s). El ángulo de elevación de lanzamiento al apuntar fue más amplio (42,38 ± 5,85 o) que al disparar (35,31 ± 7,26 o). Hubo diferencias significativas en la flexión del tronco, la flexión de la rodilla, la altura máxima del bola y la velocidad del bola en la fase de seguimiento del lanzamiento ($\alpha < 0,05$). La velocidad de la bola al señalar fue más lenta (4,90 ± 2,35 m/s) que al disparar (13,01 ± 5,36 m/s). En conclusión, la técnica específica en tiro y puntería podría adaptarse en el método de entrenamiento para niños para avanzar en el resultado y posibilidad de éxito. Se podrían realizar más estudios en diferentes grupos de edad y sexo para obtener más información sobre la técnica de lanzamiento de petanca.
Palabras Clave: Biomecánica, Análisis de la Marcha, Habilidad Manipulativa, Evaluación del Entrenamiento

Fecha recepción: 13-11-22. Fecha de aceptación: 24-11-23
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Introduction

Sport plays a vital role in improving quality of life (Maria et al., 2023). Sport improves health, restores organ function, and maintains physical fitness, also physiological functions (Kanaan et al., 2023). It is important in supporting children's motoric development (Patiño et al., 2023). Sport and physical activity are recommended for the elderly to maintain their physical fitness and motoric capability (Posso-Pacheco et al., 2022). As a result, various kinds of sports became a need in society (Maulana et al., 2020). One of the new sports which is getting more popular at any age is petanque (Nasution & Daulay, 2021). Petanque is a sports game that originated in France and is currently played in Indonesia (Loser et al., 2011). Petanque is a new sport in Indonesia (Laksana et al., 2017). However, the game's characteristics and the simple tools allow various groups of people could play it (Okilanda, 2018). Petanque requires 4 x 15 meters field (Sudiadharma & Rahman, 2017). Furthermore, petanque can be used as an option for people to maintain fitness and body immunity because this sport is straightforward and safe to play for all ages, which only requires bosi, Boka, circle, and small fields (Prayoga, 2020).

The rules of the petanque are pretty simple; each player brings an iron ball or bosi close to a wooden ball or boka as a target to score points (Kristanto, 2020), with both feet in a circle (Sinaga & Ibrahim, 2019). The basic technique in throwing is divided into two, namely pointing and shooting. There are three throwing for pointing techniques in Petanque, namely: (a) Roll (Throw by rolling the ball to the ground), (b) Soft-Lob (Mid-Throw Parabolic), and (c) High-Lob (High Throw Parabolic) (Nurhasan, 2020). Pointing in petanque is a technique of delivering an iron ball close to the target, namely a wooden ball (Kharim & Nurkholis, 2018). In pointing, the best score is counted based on the distance of the iron ball to the ball (Kharim & Nurkholis, 2018). This technique involves a high accuracy to place the bosi at the right point (Pelana, 2020).

The shooting technique requires power in directing the iron ball to the opposing party's iron ball so it stays away from the jack or boka target (Lubis, 2019). In addition, shooting in petanque aims to keep the target ball away to reduce the opponent's points and add points to the team (Cahyono & Nurkholis, 2018). The best position in shooting is standing, so athletes can estimate the part of the iron ball (Nurhasan, 2020). The shooting technique is important in the game of petanque in all the competed numbers (Agustina & Priambodo, 2017). Furthermore, shooting is also one of the numbers contested in petanque (Badaru et al., 2021). Accuracy is an essential part of petanque, however power is also needed in shooting accuracy numbers, so it is necessary to have a mental and physical training process that can contribute to the athlete's ability to improve accuracy and power (Rizal et al., 2021).

Petanque demands physical, technical, tactical, and mental (Widodo & Hafidz, 2018). Anthropometric and psychomotor factors play an essential role in determining athletes' success (Kustiawan & Perkasa, 2020). Physical factors that support the best performance include height, arm length, arm muscle strength, wrist flexibility, balance, and eye-hand coordination (Amalia et al., 2019; Hanief & Purnomo, 2019a). Long arms play an essential role in desired long distances, as longer levers will be advantageous in throwing(Kunvar Singh & Ratnesh Singh, 2015). Hand muscle strength training, muscle endurance, and balance are used as training media to help athletes improve shooting accuracy (Sukawi et al., 2021). The persistence of the arm muscles is also related to the accuracy of pointing in the petanque (Setiakarnawijaya et al., 2021). Mental factors also have an essential role in supporting the performance of petanque athletes (Rony et al., 2021). The arm muscle strength can affect shooting in petanque sports (Wahyudhi et al., 2021). The training model for arm muscle strength is easy and exciting to improve abilities (Rihatno & Tobing, 2019). Muscle strength could be tested by using expanded dynamometer (Aryana, 2013; Haryanto & I Ketut Yoda, 2017; Putri & Cahyani, 2019).

Balance is the ability to maintain the center of the body's attention on the ground while standing, sitting, transiting, and walking (Munawwarah & Rahmani, 2015). Balance is the interaction of three elements: physical ability regarding the musculoskeletal system and the range of joint motion, activity environment, and workload (Romero Naranjo et al., 2023). Balance plays an essential role in maintaining body posture to carry out movement activities properly (Eustace et al., 2023). One way of measuring balance is using the ankle carpet game, which is suitable for children aged 4-5 years and is reliable for measuring static and dynamic balance abilities (Fitri & Imansari, 2020). Then one way to measure balance is with a single-leg stand or standing on one leg (Wick et al., 2021). Leg muscle strength is a relatively independent predictor of decreased mobility in a person's (Buchman et al., 2007). Balance is at the center of gravity of the body's position on the gastrocnemius muscle, which is used to bend the knee (Bustomi et al., 2020). The imbalance of leg muscle strength will have the potential to affect athlete performance (Cheung et al., 2012). Measurement of leg muscle strength was carried out using a leg dynamometer (Ayubi et al., 2022).

There are many training models used to develop shooting skills and improve accuracy (Hanief & Purnomo, 2019b). Sutrisna et al., (2018) claimed that improving the shooting ability of athletes is the primary goal. The training model should be carried out systematically, and repeatedly, with additional training loads and intensity (Pelana et al., 2021). In addition, athletes can develop their shooting skills through independent exercises which planned to increase body strength (Chan, 2012). However, there was limited quantitative data about the difference between shooting and pointing techniques in children. Fundamental movement skills and student growth are essential factors in training programs for children (Al Ardha et al., 2021). This study aimed to evaluate kinematic movement in petanque pointing and shooting techniques in children. The kinematic movement of pointing and shooting techniques were evaluated in the comprehensive methods to get a better understanding of children's movement analysis.

Materials & Methods

This research was conducted in a comparative design by using a quantitative approach. This study involved 16 male beginner petanque athletes (aged 11.37 ± 1.36 years old, weight 42.37 ± 4.36 Kg, and height 151.37 ± 7.36 cm) who were selected using the purposive sampling method. All of the samples were in the normal body mass index (BMI) and in a healthy condition. The research samples who participated in this study had experienced more than two time regional or national championships levels in the Under 12 years old. Furthermore, informed concern about participating in this study was filled by the parents of each athlete. Manipulative movement in throwing was observed in the sagittal plane and measured by kinematic analysis in Kinovea 0.9.4 Software. There were pointing and shooting kinematic data, categorized in four phases on movement (Table 4). The first phase was the backswing phase; it was the position where the right arm was in the maximum shoulder extension. A zero-position phase was indicated when the right arm closed with the vertical line. The release phase was the position when the ball was released. The follow-throw position was measured when the arm was in the maximum shoulder flexion position.

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Test Protocol and Data Analysis

The test was conducted in the outdoor gravel field at 38° Celsius, with Precipitation of 3%, Humidity of 77%, and Wind of 8 km/h. The OBUT Petanque ball with a diameter of 72 cm and 800 grams boule was used in the test. Pointing and shooting tests were conducted in a designed field that has 7 meters distance from the target (Figure 1). Before the test, all participants were explained and demonstrated the procedure of the test. Target has two zones based on the distance from the target. Each sample performed five times pointing and shooting with 30 minutes of rest between tests. The best shooting and pointing techniques were chosen based on the scores and the videos were analyzed further using the kinematic approach. The data were analyzed by using the normality test one-sample Kolmogorov Smirnov Test. The data with normal distribution were analyzed using paired sample test to inquire about the significant difference between pointing and shooting in each athlete. On the other hand, the data which were not in normal distribution were analyzed in a non-parametric test using paired Wilcoxon test. In testing the hypothesis, the significantly different were decided by sig. value < 0.05.

Based on the data analysis by Kolmogorov-Smirnov Test for normality, there were several variables of pointing techniques in the standard data distribution (table 1). However, shoulder extension, knee flexion, ball height in zero position, and ball velocity in the release phase were not normal distribution ($\alpha < .05$). In the back swing and release phase, all of the data in all variables were in the standard distribution ($\alpha > .05$). The parametric test was conducted to further evaluate the data with normal distribution. A non-parametric test was implemented to assess the abnormal data distribution. Furthermore, the homogeneity test was conducted by using Levene's Test. As a result, the data has an equality of variance ($\alpha < .05$) which indicates the homogeneity of the subject.

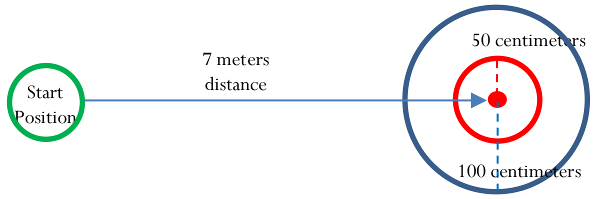

Figure 1. Pointing and shooting test procedure

Results

Table 1.
Descriptive Data and Normality of Pointing

No	Variable	Mean ± SD	Min	Max	Sign.
	Back Swing Phase				
1	Shoulder Extension (°)	88.89 ± 17.87	60	136	.146*
2	Trunk flexion (°)	146.57 ± 14.82	119.30	116.20	.200*
3	Knee Flexion (°)	153.96 ± 19.28	104.60	173.20	.092*
4	Ball Height (cm)	116.67 ± 13.92	93.33	139.97	.093*
5	Ball Velocity (m/s)	-	-	-	
	Zero Position Phase				
1	Shoulder Extension (°)	9.89 ± 8.34	4.40	30.20	.000
2	Trunk flexion (°)	160.41 ± 9.47	144.80	176.20	.181*
3	Knee Flexion (°)	169.19 ± 42.90	37.22	196.50	.001
4	Ball Height (cm)	62.56 ± 22.87	41.60	118.20	.000
5	Ball Velocity (m/s)	5.290 ± 0.44	4.48	6.30	.200*
	Release Phase				
1	Shoulder Flexion (°)	85.12 ± 11.08	64.80	103.50	.200*
2	Trunk flexion (°)	162.92 ± 9.79	148.20	176.10	.071*
3	Knee Flexion (°)	164.59 ± 10.29	147.60	177.30	.200*
4	Ball Height (cm)	92.53 ± 9.69	80.36	115.18	.200*
5	Ball Velocity (m/s)	6.46 ± 0.43	5.48	7.15	.200*
6	Release Elevation Angle (°)	42.38 ± 5.85	28.30	55.10	.187*
	Follow Throw Phase				
1	Shoulder Flexion (°)	136.57 ± 12.67	113.60	163.60	.200*
2	Trunk flexion (°)	167.71 ± 10.86	148.30	182.40	.200*
3	Knee Flexion (°)	169.47 ± 7.59	153.00	178.90	.200*
4	Ball Maximum Height (cm)	199.49 ± 27.05	139.39	250.46	.200*
5	Ball Velocity (m/s)	4.90 ± 2.35	0.47	7.15	.002

Notes:
SD : Standard Deviation
° : Degree
* : Significant different in parametric test

Kolmogorov-Smirnov test was conducted to evaluate shooting variables' data distribution (table 2). Most variables were in the normal distribution, particularly in the back swing, zero position, and release phase ($\alpha > .05$).

However, knee flexion in the release phase was not normal ($\alpha < .05$). The parametric test was conducted to further evaluate the data with normal distribution. A non-parametric test was implemented to assess the unnormal data distribution.

Table 2.
Descriptive Data of Shooting

No	Variable	Mean ± SD	Min	Max	Sign.
	Back Swing Phase				
1	Shoulder Extension (º)	107.00 ± 17.40	81.00	150.00	.200*
2	Trunk flexion (º)	139.28 ± 19.03	96.00	164.00	.079*
3	Knee Flexion (º)	158.50 ± 17.48	131.00	180.00	.200*
4	Ball Height (cm)	132.85 ± 14.27	109.84	160.88	.200*
5	Ball Velocity (m/s)	-	-	-	
	Zero Position Phase				
1	Shoulder Extension (º)	21.12 ± 14.45	4.00	51.00	.200*
2	Trunk flexion (º)	137.44 ± 16.71	106.00	171.00	.200*
3	Knee Flexion (º)	143.56 ± 14.20	123.00	175.00	.200*
4	Ball Height (cm)	49.92 ± 8.32	34.66	64.10	.200*
5	Ball Velocity (m/s)	10.94 ± 13.34	3.25	20.31	.200*
	Release Phase				
1	Shoulder Flexion (º)	94.37 ± 13.34	64.00	119.00	.200*
2	Trunk flexion (º)	139.37 ± 12.28	117.00	165.00	.200*
3	Knee Flexion (º)	151.19 ± 14.69	123.00	175.00	.200*
4	Ball Height (cm)	80.19 ± 10.74	57.97	97.32	.200*
5	Ball Velocity (m/s)	16.09 ± 5.18	7.33	25.97	.200*
6	Release Elevation Angle (º)	35.31 ± 7.26	25.00	56.00	.052*
	Follow Throw Phase				
1	Shoulder Flexion (º)	139.62 ± 11.93	117.00	160.00	.200*
2	Trunk flexion (º)	149.37 ± 9.93	132.00	165.00	.200*
3	Knee Flexion (º)	159.25 ± 12.44	143.00	180.00	.037
4	Ball Maximum Height (cm)	170.08 ± 22.51	130.06	215.05	.200*
5	Ball Velocity (m/s)	13.01 ± 5.36	5.75	25.97	.200*

Notes:
SD : Standard Deviation
º : Degree
* : Significant different in parametric test

Table 3.
Paired Test between Pointing and Shooting

No	Variable	t Value	df	Sig. (2-tailed)
	Back Swing Phase			
1	Shoulder Extension	-3.851	15	.002*
2	Trunk flexion	1.974	15	.067
3	Knee Flexion	-1.365	15	.192
4	Ball Height	-6.277	15	.000*
5	Ball Velocity	-	-	-
	Zero Position Phase			
1	Shoulder Extension	-3.793	15	.002**
2	Trunk flexion	6.342	15	.000*
3	Knee Flexion	-.413	15	.685
4	Ball Height	1.879	15	.080
5	Ball Velocity	-4.497	15	.000*
	Release Phase			
1	Shoulder Flexion	-2.947	15	.010*
2	Trunk flexion	8.974	15	.000*
3	Knee Flexion	4.220	15	.001*
4	Ball Height	3.708	15	.002*
5	Ball Velocity	-7.463	15	.000*
6	Release Elevation Angle	2.841	15	.012*
	Follow Throw Phase			
1	Shoulder Flexion	-.770	15	.453
2	Trunk flexion	6.844	15	.000*
3	Knee Flexion	4.031	15	.001*
4	Ball Maximum Height	2.957	15	.010*
5	Ball Velocity	-5.359	15	.000**

Notes:
df : Degree of freedom
* : Significant different in parametric test
** : Significant different in non-parametric test

A comparative analysis was conducted in parametric tests for most variable based on data normality distribution (Table 3). However, non-parametric test was conducted to evaluate shoulder extension, knee flexion, and ball height in the zero-position phase, also ball velocity in the follow through phase (Table 3). The back swing phase showed significant differences in shoulder extension and ball height ($\alpha < .05$). There were also significantly different in shoulder extension, trunk flexion, and ball velocity in the zero position phase ($\alpha < .05$). There were significant differences in all release phase variables ($\alpha < .05$). Lastly, there were significantly different in trunk flexion, knee flexion, and ball velocity in the follow-through phase ($\alpha < .05$).

Based on the data analysis on a comparative test, there were significant differences in each phase. There were significantly different in the back swing phase at shoulder extension and ball height ($\alpha < .05$). Athletes took more considerable shoulder extension on the shooting (107.00 ± 17.4 º) than pointing (88.89 ± 17.87 º). Furthermore, the significantly different shoulder extension angle influenced the ball height in the backswing position. The ball height in the shooting position (132.85 ± 14.27 º) is substantially higher than the pointing position (116.67 ± 13.92 º). The height difference caused significant velocity of the ball due to the influence of gravity and larger trajectory in the back swing position. However, more extensive muscle coordination and flexibility are required to create excessive ROM, particularly on the maximum shoulder extension. Shooting techniques indicated more complex movement and larger ROM. A larger trajectory required more joint coordination at the shoulder (Dounskaia & Shimansky, 2016). The limited shoulder ROM could lead the restricted and compensated movement (Lagueny et al., 2002). Furthermore, repeated compensated movement could lead to pain and injury (Almeida et al., 2013). Maximum shoulder extension could be compensated by trunk flexion. As a result, there was smaller trunk flexion angle in shooting than pointing to support the full shoulder extension.

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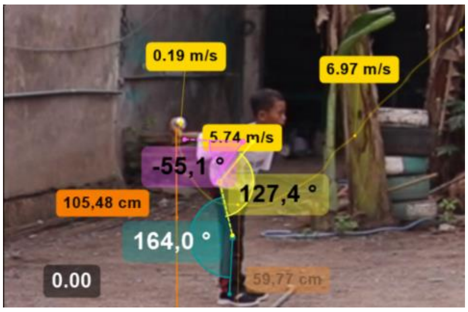
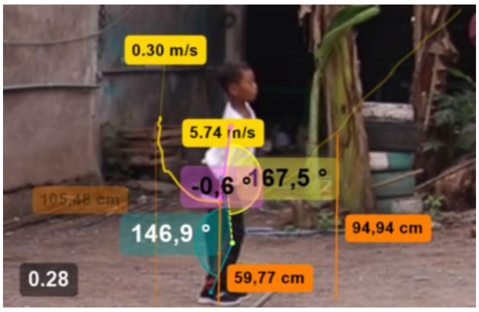
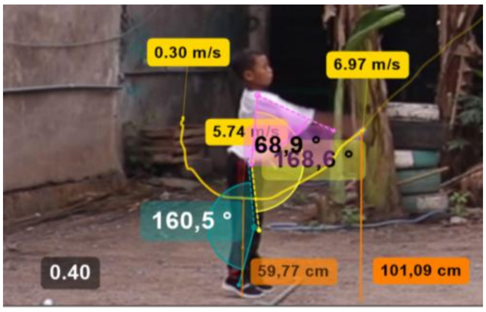
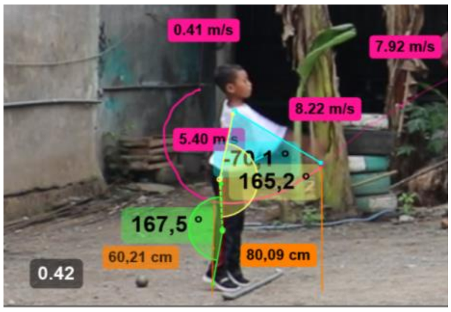
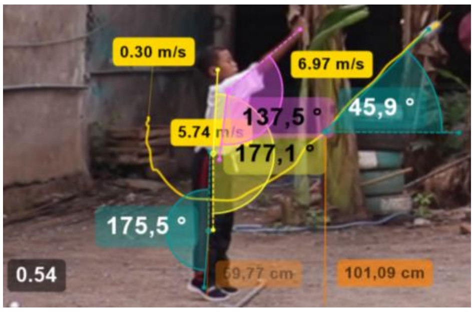
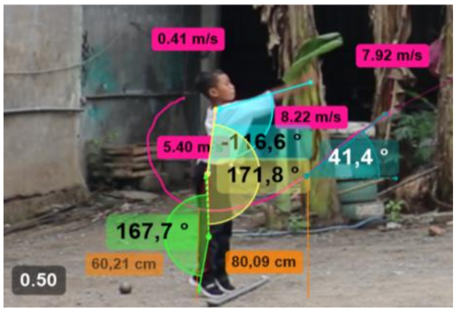
Table 4.
Kinematic Movement Differences between Pointing and Shooting

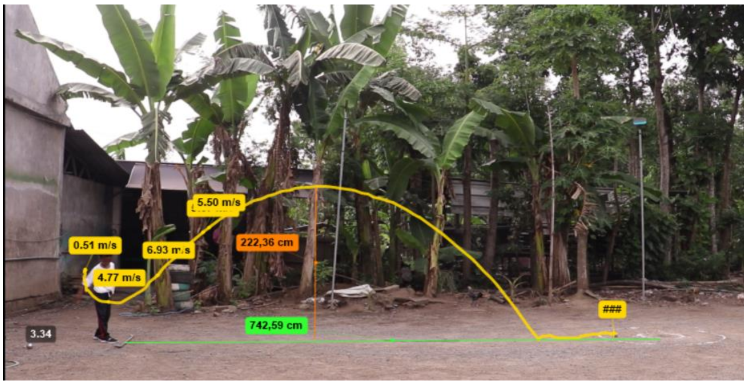
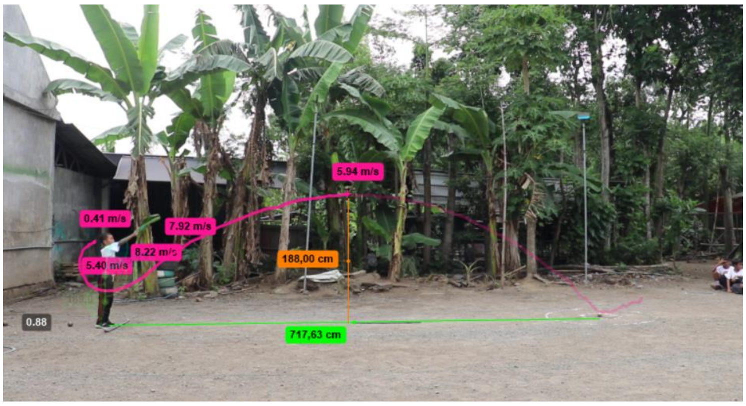
	Pointing	Shooting
Back Swing		
Zero Position		
Release		
Follow Throw		

There were significant differences in shoulder extension, trunk flexion, and ball velocity in the zero-position phase. The shooting technique showed larger ROM (21.12 ± 14.45 º) than pointing (9.89 ± 8.34 º) in shoulder extension. The trunk flexion position influenced the large ROM on shooting technique. The shooting technique showed narrower trunk flexion (137.44 ± 16.71 º) than pointing (160.41 ± 9.47 º). The shooting technique showed faster velocity (10.94 ± 13.34 m/s) than pointing (5.290 ± 0.44 m/s). Arm velocities are reflected by the function of neurological function (Elgendi et al., 2014). The muscle strength of each component in the arm contributed to developing the velocity (Hoffmann & Hui, 2010). Arm movements contributed to the posture balance (Shafeie et al., 2012). Trunk flexion influenced hip and knee movement(Arenas-Sánchez et al., 2021). There was no significant difference at knee flexion during zero position in the gait analysis.

In the release phase, every variable was significantly different ($\alpha < .05$). Shoulder Flexion in pointing was smaller (85.12 ± 11.08 º) than shooting (94.37 ± 13.34 º). Trunk flexion in pointing was larger (162.92 ± 9.79 º) than shooting (139.37 ± 12.28 º). Trunk flexion changing would lead to lower extremity muscles activation (Preece & Alghamdi, 2021). Knee flexion in pointing was larger (164.59 ± 10.29 º) than shooting (151.19 ± 14.69 º). The ball height in pointing was higher (92.53 ± 9.69 cm) than shooting (80.19 ± 10.74 cm). Ball velocity at pointing was slower (6.46 ± 0.43 m/s) than shooting (16.09 ± 5.18 m/s). The release elevation angle at pointing was wider (42.38 ± 5.85 º) than shooting (35.31 ± 7.26 º). The release elevation angle may influence the ball trajectory result (Kartiko et al., 2019).

There were significant differences in trunk flexion, knee flexion, maximum ball height, and ball velocity at the follow throw phase ($\alpha < .05$). Trunk flexion in pointing was larger (167.71 ± 10.86 º) than shooting (149.37 ± 9.93 º). Knee flexion in pointing was larger (169.47 ± 7.59 º) than shooting (159.25 ± 12.44 º). The shooting technique showed lower ball maximum height (170.08 ± 22.51 cm) than pointing (199.49 ± 27.05 cm). In pointing and shooting techniques, a smaller release elevation angle would influence the peak height and maximum distance on the ball trajectory (Table 5). Ball velocity in pointing was slower (4.90 ± 2.35 m/s) than shooting (13.01 ± 5.36 m/s). As a result, there were significant different between pointing and shooting ball trajectory visualization (Table 5). There was a correlation movement between the lower and upper extremities (Rau et al., 2000). Both legs and arms movement were controlled by sensory feedback during locomotion (Zehr & Duysens, 2004).

Table 5.
Trajectory Differences between Pointing and Shooting

Techniques	Trajectory Visualization
Pointing Trajectory Average *Mean ± Standard Deviation* Maximum Height 199.49 ± 27.05 (cm) Ball Velocity 4.90 ± 2.35 (m/s)	
Shooting Trajectory Average *Mean ± Standard Deviation* Maximum Height 170.08 ± 22.51 (cm) Ball Velocity 13.01 ± 5.36 (m/s)	

Discussion

In the back swing phase, athletes showed a larger range of motion on shoulder extension in the shooting (107.00 ± 17.4) than pointing (88.89 ± 17.87). The significantly different shoulder extension angle also influenced the ball height in the backswing position. It requires more flexibility in the shoulder joints. The shoulder complex comprises four joints that work precisely in unison. Arm position changes require the clavicle, scapula, and humerus to shift (Levin & Piscitelli, 2022). The sternoclavicular, acromioclavicular, and glenohumeral joints, as well as the scapulothoracic gliding mechanism, all contribute to these movements (Peat, 1986). If this reversal occurs posteriorly beyond the humerus' neutral position, hyperextension occurs (Krishnan et al., 2019a). The shoulder's primary extensors are the posterior deltoid, latissimus dorsi, and teres major (McCausland et al., 2022). The deltoid is the primary mover of the arm into humeral elevation at the glenohumeral joint, supported by the supraspinatus as an accessory elevator. The rotator cuff also plays a crucial role in supporting the glenohumeral joint by compressing the humeral head medially into the glenoid and glenoid labrum. The subscapularis, infraspinatus, and teres minor all have an inferior directed line of action, which enables them to compensate for the superior translation component of deltoid muscle activity when activated (Phadke et al., 2009).

The relative humeral angle between the rest and fully flexed positions ranges between 0 and 180 degrees during flexion (Krishnan et al., 2019b). The anterior deltoid, coracobrachialis, and pectoralis major are the primary shoulder flexors. There is also a minimal role of Biceps brachii in this motion (Chang et al., 2022). The movement of the shoulder girdle (clavicle and scapula) is more important when raising the arm above the shoulder than the arm motion below the shoulder. As the arm is raised, the ratio of scapulothoracic rotation (rotation of the scapula relative to the torso) to glenohumeral rotation (rotation of humerus relative to the scapula) generally increases. Still, the ratio varies depending on the subject (Culham & Peat, 1993). If the movement of the shoulder girdle is restricted, the arm cannot be elevated above a certain posture. As a result, translation of the glenohumeral joint is required to raise the arm high (Lee et al., 2018). This could be important during release and throw because, during the high lobe, the arm will be flexed beyond the shoulder. There is significant different in shoulder flexion at the release phase where in shooting technique required larger shoulder extension motion (94.37 ± 13.34) than in pointing (85.12 ± 11.08)

Significant differences at the release phase were found in shoulder flexion, trunk flexion, knee flexion, ball height, ball velocity, and release elevation angle. The movement at the release phase movement is a combination of hip flexion, knee flexion, internal rotation, and plantar flexion. The primary hip flexors are the rectus femoris, iliacus, psoas, iliocapsularis, and sartorius muscles. Proximally, the rectus femoris muscle originates from two different heads: the direct head and the reflected head. They begin at the AIIS and the anterior acetabular rim (both located near the anterior hip capsule). The rectus femoris tendinous fibres converge distally and fuse with the rest of the quadriceps muscle in the thigh. The quadriceps comprise four separate muscles: the vastus intermedius, the vastus lateralis, the vastus medialis, and the rectus femoris. The rectus femoris is the only quadriceps muscle parallel to the hip and knee joints. Although the rectus femoris is a strong hip flexor, its influence relies mainly on the location of the knee and hip (Demir & Harput, 2023). When the knee is flexed, it is the most powerful. However, when the knee is extended, significant power is lost (Gerhardt et al., 2011).

The hamstrings, sartorius, gastrocnemius, plantaris, and popliteus are all included in the knee flexors. Interestingly, most of these knee flexors also rotate the knee internally or externally (Mansfield & Neumann, 2019). According to one study, when the knee is flexed between 30 and 90 degrees, there are approximately 45 degrees external and 25 degrees internal rotation. With an increasing extension, the rotational motion of the knee diminishes, and at 5 degrees of flexion, the knee has 23 degrees external and 10 degrees internal rotation (Zarins et al., 1983). The principal extensors anatomy of the knee, from proximal to distal, includes the quadriceps muscle, the patella, and the patellar tendon. Lower leg extension occurs due to the contraction of these muscles in unison. The patella is positioned within the femur's trochlear groove and anchors the quadriceps and patellar tendons (Deopujari & Kiel, 2022).

The significant different of maximum ball velocity was identified at the release phase and follow throw phase (*p* value 0.000). the ball was faster in the shooting technique (13.01 ± 5.36) than Pointing (4.90 ± 2.35). Besides the result of shoulder mobility, It was also influenced by the forearm muscles controlling wrist mobility (Tekin & Agopyan, 2022). Each muscle has a body proximally positioned in the forearm and tendons that stretch distally over the wrist joint. Their activities can bring together muscles connected with the wrist joint. The muscles responsible for flexion of the wrist joint include the following: Flexor carpi radialis, flexor carpi ulnaris, flexor digitorum superficialis, and flexor digitorum profundus, as well as flexor pollicis longus and palmaris longus, to a lesser extent (Erwin & Varacallo, 2022a). Extensor carpi radialis longus, extensor carpi radialis brevis, extensor carpi ulnaris, extensor digitorum, and to a lesser extent extensor indicis are the muscles responsible for wrist extension (Erwin & Varacallo, 2022b).

Conclusions

The children's movement analysis in pointing and shooting techniques showed significant differences in every phase. In the backswing phase, significant differences were found at shoulder extension and ball height. In the zero position phase, the significant differences were found in shoulder extension, trunk flexion, and ball velocity. There are also significant differences at all variables in the release phase including shoulder flexion, trunk flexion, knee flexion, ball height, ball velocity, and release elevation angle. The last one, the significant differences in the follow-throw phase were found at trunk flexion, knee flexion, ball maximum height, and ball velocity. The movement differences between pointing and shooting would influence the coach and athletes, particularly in training methods and throwing techniques. An effective training method could be developed which specifies based on the different techniques in pointing and shooting. These specific motoric movements could be adapted to support the result and successful possibility of each technique. Further study could be conducted in different age groups and genders to gain more information of the petanque throwing technique. In addition, the study related to muscle activity during *petanque* pointing and shooting movement could be measured by electromyography (EMG).

References

Agustina, A. T., & Priambodo, A. (2017). Hubungan Antara Tingkat Konsentrasi Terhadap Hasil Ketepatan Shooting Olahraga Petanque Pada Peserta Unesa Petanque Club. *Pendidikan Olahraga Dan Kesehatan*, *5*(3).

Al Ardha, M. A., Yang, C. B., Nurhasan, Kartiko, D. C., Kuntjoro, B. F. T., Ristanto, K. O., Wijaya, A., Adhe, K. R., Putra, K. P., Irawan, F. A., Nevangga, R. P., Sasmita, N. S., & Rizki, A. Z. (2021). Biomechanics Analysis of Elementary School Students' Fundamental Movement Skill (FMS). *Advances in Social Science, Education and Humanities Research*, 471–476.

Almeida, G. P. L., Silveira, P. F., Rosseto, N. P., Barbosa, G., Ejnisman, B., & Cohen, M. (2013). Glenohumeral range of motion in handball players with and without throwing-related shoulder pain. *Journal of Shoulder and Elbow Surgery*, *22*(5), 602–607.

Amalia, B., Nurkholis, N., & Sulistyarto, S. (2019). Faktor Fisik dan Psikologis Prestasi Cabang Olahraga Petanque. *Journal Sport Area*, *4*(2).

Arenas-Sánchez, G., Martínez-Barrera, C., Hernández-Cazcarra, V., Madariaga-Flores, B., Valenzuela, C. F.-, & Espinoza-Salinas, A. (2021). Effects of The Exercise of Strength and Flexibility on the Kinetics of Muscle Oxygenation and the Range of Hip Movement in Seniors Basketball Players. *Journal of Sport and Health Research*, *13*(3), 481–492.

Aryana, G. (2013). Pengaruh Pelatihan Push-Up Terhadap Peningkatan Kekuatan Menarik Dan Mendorong Otot Lengan. *Jurnal Ilmu Keolahragaan Undiksha*, *53*(9).

Ayubi, N., Purwanto, B., Sri Rejeki, P., Kusnanik, N. W., Herawati, L., Komaini, A., Mutohir, T. C., Nurhasanah, N., Al Ardha, M. A., & Firmansyah, A. (2022). Effect of acute omega 3 supplementation reduces serum tumor necrosis factor-alpha (TNF-a) levels, pain intensity, and maintains muscle strength after high-intensity weight training. https://dialnet.unirioja.es/servlet/articulo?codigo=8557076&info=resumen&idioma=ENGBadaru, B., Rachmat Kasmad, M., Juhanis, J., & Anwar, N. I. (2021). Effect of Accuracy and Muscle Strength Training on the Result of Shooting Throws in Petanque. *Jurnal Maenpo : Jurnal Pendidikan Jasmani Kesehatan Dan Rekreasi*, *11*(1).

Buchman, A. S., Wilson, R. S., Boyle, P. A., Tang, Y., Fleischman, D. A., & Bennett, D. A. (2007). Physical activity and leg strength predict decline in mobility performance in older persons. *Journal of the American Geriatrics Society*, *55*(10).

Bustomi, A. O., Hidayah, T., Okilanda, A., & Putra, D. D. (2020). Analisis Gerak Pointing Pada Olahraga Petanque. *Journal Sport Area*, *5*(1), 65–75.

Cahyono, R. E., & Nurkholis. (2018). Analisis Backswing Dan Release Shooting Carreau Jarak 7 Meter Olahraga Petanque Pada Atlet Jawa Timur. *Jurnal Prestasi Olahraga*, *1*(1).

Chan, F. (2012). Strength Training (Latihan Kekuatan). *Cerdas Sifa*, *1*(1).

Chang, L.-R., Anand, P., & Varacallo, M. (2022). Anatomy, Shoulder and Upper Limb, Glenohumeral Joint. In *StatPearls*.

Cheung, R., Smith, A., & Wong, D. (2012). H:Q ratios and bilateral leg strength in college field and court sports players. *Journal of Human Kinetics*, *33*(1).

Culham, E., & Peat, M. (1993). Functional Anatomy of the Shoulder Complex. *Journal of Orthopaedic & Sports Physical Therapy*, *18*(1), 342–350.

Demir, C., & Harput, G. (2023). Weight-Bearing Exercises on Slideboard Increase Quadriceps and Hamstring Activation Levels and Improve Hip- and Knee-Flexion Angles in Physically Active Individuals. *Journal of Sport Rehabilitation*, *32*(6), 674–686.

Deopujari, S., & Kiel, J. (2022). Knee Extensor Mechanism Injuries. In *StatPearls*.

Dounskaia, N., & Shimansky, Y. (2016). Strategy of arm movement control is determined by minimization of neural effort for joint coordination. *Experimental Brain Research*, *234*(6), 1335–1350.

Elgendi, M., Picon, F., Magnenat-Thalmann, N., & Abbott, D. (2014). Arm movement speed assessment via a Kinect camera: a preliminary study in healthy subjects. *Biomedical Engineering Online*, *13*(1).

Erwin, J., & Varacallo, M. (2022a). Anatomy, Shoulder and Upper Limb, Wrist Joint. In *StatPearls*.

Erwin, J., & Varacallo, M. (2022b). Anatomy, Shoulder and Upper Limb, Wrist Joint. In *StatPearls*.

Eustace, S. J., Wdowski, M., Tallis, J., & Duncan, M. (2023). The Influence of Isokinetic Trunk Flexor and Extensor Strength on Dynamic Balance in Children. *Journal of Motor Learning and Development*, *11*(2), 323–337.

Fitri, R., & Imansari, M. L. (2020). Permainan Karpet Engkle: Aktivitas Motorik untuk Meningkatkan Keseimbangan Tubuh Anak Usia Dini. *Jurnal Obsesi : Jurnal Pendidikan Anak Usia Dini*, *5*(2).

Gerhardt, M. B., Logishetty, K., Meftah, M., & Ranawat, A. S. (2011). Arthroscopic and Open Anatomy of the Hip. In *Techniques in Hip Arthroscopy and Joint Preservation Surgery* (pp. 9–22).

Hanief, Y. N., & Purnomo, A. M. I. (2019a). Petanque: Apa saja faktor fisik penentu prestasinya? *Jurnal Keolahragaan*, 7(2).

Hanief, Y. N., & Purnomo, A. M. I. (2019b). Petanque : What are the physical factors that determine performance ? *Jurnal Segar Dan Bugar*, 7(2).

Haryanto, & I Ketut Yoda. (2017). Pengaruh Pelatihan Fartlek Terhadap Volume Oksigen Maksimal dan Kecepatan. *Jurnal Ilmu Keolahragaan Undhiksa*, *5*(1).

Hoffmann, E. R., & Hui, M. C. (2010). Movement times of different arm components. *Ergonomics*, *53*(8), 979–993.

Kanaan, E. M., Ahmed, M. D., & López-Sánchez, G. F. (2023). Sport Participation, Lifestyle Habits and Determinants of Female Students from Jordan- A Qualitative Analysis. *Journal of Sport and Health Research*, *15*(2), 345–356.

Kartiko, D. C., Tuasikal, A. R. S., Al Ardha, M. A., & Yang, C. B. (2019). Biomechanical Analysis of Ball Trajectory Direction in Free Throw. *Advances in Social Science, Education and Humanities Research*, *335*, 449–453.

Kharim, M. A., & Nurkholis. (2018). Analisis Backswing dan Release Ketepatan Pointing Half Lob Jongkok pada Jarak 7 Meter Olahraga Petanque. *Prestasi Olahraga*, *1*(3).

Krishnan, R., Björsell, N., Gutierrez-Farewik, E. M., & Smith, C. (2019a). A survey of human shoulder functional kinematic representations. *Medical & Biological Engineering & Computing*, *57*(2), 339–367.

Krishnan, R., Björsell, N., Gutierrez-Farewik, E. M., & Smith, C. (2019b). A survey of human shoulder functional kinematic representations. *Medical & Biological Engineering & Computing*, *57*(2), 339–367.

Kristanto, N. (2020). Persepsi Kinestetik Terhadap Hasil Pointing Atlet Petanque Jawa Timur. *Prestasi Olahraga*, *3*(1).

Kunvar Singh, & Ratnesh Singh. (2015). Relationship of Selected Anthropometric Variables With the Throwing Distance of Cricket Ball in Cricket. *Physical Education*, *4*(8).

Kustiawan, A., & Perkasa, B. S. (2020). Analaisis Faktor Antropometri, Biomotor Dan Psikomotor Terhadap Lemparan Pointing Olahraga Petanque Atlet Porprov 2020 Kabupaten Ngawi. *Jurnal Porkes*, *3*(1).

Lagueny, A., Burbaud, P., Dubos, J. L., le Masson, G., Guelh, D., Macia, F., Debras, C., & Tison, F. (2002). Freezing of shoulder flexion impeding boule throwing: a form of task-specific focal dystonia in petanque players. *Movement Disorders : Official Journal of the Movement Disorder Society*, *17*(5), 1092–1095.

Laksana, B. G., Pramono, H., & Mukarromah, S. B. (2017). Perspektif Olahraga Petanque dalam Mendukung Prestasi Olahraga Jawa Tengah. *Journal of Physical Education and Sports*, *6*(1).

Lee, K.-S., Park, J.-H., Beom, J., & Park, H.-S. (2018). Design and Evaluation of Passive Shoulder Joint Tracking Module for Upper-Limb Rehabilitation Robots. *Frontiers in Neurorobotics*, *12*.

Levin, M. F., & Piscitelli, D. (2022). Motor Control: A Conceptual Framework for Rehabilitation. *Motor Control*, *26*(4), 497–517.

Loser, R., Piskoty, G., Al-Badri, A., Tuchschmid, M., Schmid, P., & Leemann, A. (2011). Investigation into the mechanisms leading to explosion of pétanque balls. *Engineering Failure Analysis*, *18*(2).

Lubis, M. R. (2019). Perbedaan Latihan Shooting Menggunakan Penghalang Dan Tanpa Penghalang Terhadap Peningkatan Kemampuan Shooting Game Atlet Pemula Petanque IKIP Mataram. *Proceeding National Conference: Education, Social Science, and Humaniora*, *1*(1).

Mansfield, P. J., & Neumann, D. A. (2019). Structure and Function of the Knee. In *Essentials of Kinesiology for the Physical Therapist Assistant* (pp. 278–310).

Maria, R., Jiménez, R., La, Y., Física En, C., En, A., De, R., Merino, G.-, Rodríguez-Jiménez, ;, Bustamante-Sánchez, ;, & Carmona, ; (2023). Promoting values, emotional intelligence and physical condition in socio-economically disadvantaged adolescents through basketball. *Journal of Sport and Health Research*, *15*(2), 283–300.

Maulana, M. R., Hudah, M., & Royana, I. F. (2020). Analisis Minat Dan Motivasi Pengunjung Car Free Day Di Karesidenan Pekalongan Dalam Beraktivitas Olahraga Rekreasi Tahun 2020. *Journal of Physical Activity and Sports (JPAS)*, *1*(1), 39–52.

McCausland, C., Sawyer, E., Eovaldi, B. J., & Varacallo, M. (2022). Anatomy, Shoulder and Upper Limb, Shoulder Muscles. In *StatPearls*.

Munawwarah, M., & Rahmani, N. A. (2015). Perbedaan Four Square Step Exercises Dan Single Leg Stand Balance Exercises Dalam Meningkatkan Keseimbangan Berdiri Pada Lansia 60-74 Tahun. *Fisioterapi : Jurnal Ilmiah Fisioterapi*, *15*(2).

Nasution, A. F., & Daulay, D. E. (2021). Sosialisasi Kegiatan Permaianan Rakyat Dan Olahraga Tradisional Disekolah SMP Asy Syafi'iyah Internasional Medan. *Journal Liaison Academia and Society*, *1*(1), 68–81.

Nurhasan. (2020). *Olahraga Petanque*. Unesa University Press.

Okilanda, A. (2018). Revitalisasi Masyarakat Urban/Perkotaan Melalui Olahraga Petanque. *Halaman Olahraga Nusantara (Jurnal Ilmu Keolahragaan)*, *1*(1), 86–98.

Patiño, B. A. B., Nieto, G., Martínez, E., Riaño, S., & Dimas, D. S. (2023). Evaluation of motor coordination in 9-year-old Colombian infants postconfinement by COVID-19: gen-der related, sociodemographic context and sport. *Retos*, *48*, 6–15.

Peat, M. (1986). Functional Anatomy of the Shoulder Complex. *Physical Therapy*, *66*(12), 1855–1865.

Pelana, R. (2020). *Teknik Dasar Bermain Olahraga Petanque*.

Pelana, R., Setiakarnawijaya, Y., Anggraini, D., Sukiri, S., Safitri, I., & Antoni, R. (2021). Pointing Skills Training Model For Petanque Athletes. *Kinestetik : Jurnal Ilmiah Pendidikan Jasmani*, *5*(1).

Phadke, V., Camargo, P., & Ludewig, P. (2009). Scapular and rotator cuff muscle activity during arm elevation: a review of normal function and alterations with shoulder impingement. *Brazilian Journal of Physical Therapy*, *13*(1), 1–9.

Posso-Pacheco, R. J., Ortiz-Bravo, N. A., Paz-Viteri, B. S., Marcillo-Ñacato, J., & Arufe-Giráldez, V. (2022). Analysis of the influence of a structured physical education program on motor coordination and self-esteem in 7 and 8-year-old children. *Journal of Sport and Health Research*, *14*(1), 123–134.

Prayoga, A. S. (2020). Menjaga Kebugaran Dan Imunitas Tubuh Dengan Bermain Olahraga Petanque Di Rumah Pada Masa Pandemi Covid 19. *Jurnal Keolahragaan*.

Preece, S. J., & Alghamdi, W. (2021). The effect of increasing trunk flexion during normal walking. *Gait & Posture*, *83*, 250–255.

Putri, W. S. K., & Cahyani, O. D. (2019). ingkat Konsentrasi, Kekuatan Otot Peras Tangan, dan Kekuatan Otot Bahu Terhadap Hasil Tembakan. *Altius:*

Jurnal Ilmu Olahraga Dan Kesehatan, *8*(1).

Rau, G., Disselhorst-Klug, C., & Schmidt, R. (2000). Movement biomechanics goes upwards: from the leg to the arm. *Journal of Biomechanics*, *33*(10), 1207–1216.

Rihatno, T., & Tobing, S. R. A. L. (2019). Pengembangan Model Latihan Kekuatan Otot Lengan Pada Cabang Olahraga Softball. *Gladi : Jurnal Ilmu Keolahragaan*, *10*(1).

Rizal, R. M., Asmawi, M., & Lubis, J. (2021). Effect of self-talk on pentanque shooting accuracy. *International Journal of Human Movement and Sports Sciences*, *9*(4).

Romero Naranjo, F. J., Andreu Cabrera, E., & Arnau Mollá, A. F. (2023). Neuromotricity and body schema: Bases for the use of body percussion in the sciences of physical educa-tion and sport. *Retos: Nuevas Tendencias En Educación Física, Deporte y Recreación, ISSN 1579-1726, ISSN-e 1988-2041, Nº. 47, 2023, Pages 615-627*, *47*(47), 615–627.

Rony, M. R., Asmawi, M., & Lubis, J. (2021). Petanque: Mental Imagery and Shooting Accuracy. *Proceedings of the 4th International Conference on Sports Sciences and Health (ICSSH 2020)*, *36*.

Setiakarnawijaya, Y., Kuswahyudi, Pelana, R., Yuliasih, Oktafiranda, N. D., Ilham, M., & Mitsalina, D. (2021). Correlation study between arm muscle endurance and arm length with pointing accuracy in petanque. *Journal of Physical Education and Sport*, *21*.

Shafeie, M., Manifar, S., Milosevic, M., & McConville, K. M. V. (2012). Arm movement effect on balance. *Annual International Conference of the IEEE Engineering in Medicine and Biology Society. IEEE Engineering in Medicine and Biology Society. Annual International Conference*, *2012*, 4549–4552.

Sinaga, F. S. G., & Ibrahim, I. (2019). Analysis Biomechanics Pointing dan Shooting Petanque Pada Atlet TC PON XX PAPUA. *Sains Olahraga : Jurnal Ilmiah Ilmu Keolahragaan*, *3*(2), 66.

Sudiadharma, & Rahman, A. (2017). Pengembangan Olahraga Permainan Petanque pada Siswa SMA di Makassar. *Pengabdian Kepada Masyarakat Universitas Negeri Makassar*, *1*(1).

Sukawi, W. A. S., Maliki, O., & Widiyatmoko, F. A. (2021). Pengaruh latihan kekuatan otot tangan, daya tahan otot dan keseimbangan terhadap ketepatan shooting game petanque di UKM Petanque Upgris. *Journal of Physical Activity and Sports (JPAS)*, *2*(2).

Sutrisna, T., Asmawi, M., & Pelana, R. (2018). Model Latihan Keterampilan Shooting Olahraga Petanque Untuk Pemula. *JURNAL SEGAR*, 7(1).

Tekin, D., & Agopyan, A. (2022). Comparison of Motorcyclists' Hand Grip Strength and Reaction Time. *Journal of Sport and Health Research*, *14*(1), 97–112.

Wahyudhi, A. S. B. S. E., Ismail, Muh., & Arfah, Muh. (2021). Koordinasi Mata Tangan, Kekuatan Otot Lengan dan Kelentukan Pergelangan Tangan terhadap Keterampilan Shooting Atlet Petanque. *SPORTIVE: Journal Of Physical Education, Sport and Recreation*, *5*(1).

Wick, K., Kriemler, S., & Granacher, U. (2021). Effects of a Strength-Dominated Exercise Program on Physical Fitness and Cognitive Performance in Preschool Children. *Journal of Strength and Conditioning Research: The Research Journal of the NSCA, ISSN 1064-8011, Vol. 35, Nº. 4, 2021, Pages 983-990*, *35*(4), 983–990.

Widodo, W., & Hafidz, A. (2018). Kontribusi Panjang Lengan, Koordinasi Mata Tangan, dan Konsentrasi Terhadap Ketepatan Shooting Pada Olahraga Petanque. *Prestasi Olahraga*, *3*(1).

Zarins, B., Rowe, C. R., Harris, B. A., & Watkins, M. P. (1983). Rotational motion of the knee*. *The American Journal of Sports Medicine*, *11*(3), 152–156.

Zehr, E. P., & Duysens, J. (2004). Regulation of arm and leg movement during human locomotion. *The Neuroscientist : A Review Journal Bringing Neurobiology, Neurology and Psychiatry*, *10*(4), 347–361.