The effect of resistance band and dumbbell swing training and hand-eye coordination moderation on petanque athletes' shooting results

El efecto del entrenamiento con bandas elásticas y mancuernas y la moderación de la coordinación mano-ojo en los resultados de tiro de los atletas de petanca

Authors

Boby Helmi [1]
Rinaldi Aditya [2]
Andi Nur Abady [3]
Ahmad Al Munawar [4]
Mutiara Syabilla [5]
Syahruddin [6]

[1, 2, 3, 4, 5] STOK Bina Guna (Indonesia)
[6] Universitas Negeri Makasar (Indonesia)

Corresponding author:
Boby Helmi
sibobhelmi@gmail.com

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Abstract

Introduction: The issue of inconsistent shooting accuracy is the basis for the importance of developing exercises that are in line with the physical abilities and coordination of athletes
Objective: This study aims to analyze the effect of Resistance Bands and Dumbbell Swing exercises and hand-eye coordination on the shooting results of petanque athletes.
Methodology: The issue of inconsistent shooting accuracy is the basis for the importance of developing exercises that are in line with the physical abilities and coordination of athletes. This study used a 2×2 factorial experimental design with grouping based on the type of exercise and level of hand-eye coordination. The instruments used included hand-eye coordination and shooting outcome tests, while data analysis was performed through normality, homogeneity, and 2×2 factorial ANOVA tests.
Results: The results showed that the type of exercise had a significant effect on shooting outcomes ($p = 0.008$), with Dumbbell Swing providing greater improvement than Resistance Bands. Hand-eye coordination also had a significant effect ($p = 0.012$), with athletes with high coordination achieving better shooting results. In addition, there was a significant interaction between the type of exercise and hand-eye coordination ($p = 0.037$), indicating that the effectiveness of the exercise differed in each coordination category.
Discussion: These findings emphasize the importance of designing training programs tailored to individual motor characteristics to optimize shooting performance improvement.
Conclusions: In conclusion, Dumbbell Swing is more effective for athletes with high coordination, while Resistance Bands are more suitable for athletes with low coordination

Keywords

Dumbbell swing, resistance bands, hand-eye coordination, shooting, petanque.

Resumen

Introducción: El problema de la falta de precisión en los lanzamientos es la base de la importancia de desarrollar ejercicios que se ajusten a las capacidades físicas y la coordinación de los atletas.
Objetivo: El objetivo de este estudio es analizar el efecto de los ejercicios con bandas de resistencia y mancuernas, así como la coordinación mano-ojo, en los resultados de los lanzamientos de los atletas de petanca.
Metodología: La cuestión de la falta de precisión en los lanzamientos es la base de la importancia de desarrollar ejercicios que se ajusten a las capacidades físicas y la coordinación de los atletas. Este estudio utilizó un diseño experimental factorial 2×2 con agrupación basada en el tipo de ejercicio y el nivel de coordinación mano-ojo. Los instrumentos utilizados incluyeron pruebas de coordinación mano-ojo y de resultados de lanzamiento, mientras que el análisis de datos se realizó mediante pruebas de normalidad, homogeneidad y ANOVA factorial 2×2.
Resultados: Los resultados mostraron que el tipo de ejercicio tenía un efecto significativo en los resultados de los lanzamientos ($p = 0{,}008$), siendo el Dumbbell Swing el que proporcionaba una mayor mejora que las bandas de resistencia. La coordinación mano-ojo también tuvo un efecto significativo ($p = 0{,}012$), ya que los atletas con una alta coordinación obtuvieron mejores resultados en los lanzamientos. Además, hubo una interacción significativa entre el tipo de ejercicio y la coordinación mano-ojo ($p = 0{,}037$), lo que indica que la eficacia del ejercicio difería en cada categoría de coordinación.
Discusión: Estos hallazgos enfatizan la importancia de diseñar programas de entrenamiento adaptados a las características motoras individuales para optimizar la mejora del rendimiento en el tiro.
Conclusiones: En conclusión, el swing con mancuernas es más eficaz para los atletas con alta coordinación, mientras que las bandas de resistencia son más adecuadas para los atletas con baja coordinación.

Palabras clave

Balanceo con mancuernas, bandas de resistencia, coordinación ojo-mano, tiro, petanca.

Introduction

Petanque is a precision sport that requires high accuracy in throwing the ball (shooting) at a specific target(Abdurrahman et al., 2024; Helmi et al., 2024a; Santosa et al., 2024). Good shooting skills are crucial to the outcome of a game because they serve to clear the opponent's ball or strategically place the ball around the jack(Badaru et al., 2021). Therefore, shooting accuracy is the main indicator of skill in the game of petanque.

However, improving shooting ability depends not only on throwing technique, but also on arm muscle endurance and hand-eye coordination, two interrelated biomotor components that control the power and direction of the throw(Awang et al., 2019; F. A. Irawan et al., 2022). Planned and targeted physical training for these two aspects is key to developing stable and precise athletic performance.

In petanque, shooting ability is a determining factor in victory because this technique is used to knock down or remove the opponent's ball with high accuracy(Iskandar et al., 2023). However, observations and interviews with petanque coaches show that most athletes still experience inconsistency in their shooting results, especially when facing competitive situations or muscle fatigue.

Various empirical findings show that the shooting performance of petanque athletes still faces fundamental interrelated obstacles. One of the main problems is suboptimal arm muscle endurance, which is reflected in decreased strength and stability of throws when athletes perform repetitive movements during long training sessions(Isknadar, 2019; Wulandari & Jariono, 2023). This condition indicates that even though basic strength has been trained, the ability of the arm muscles to maintain consistent contraction quality is still low, even though muscle endurance and control are important prerequisites for producing stable and accurate throws(Nurhasan et al., 2023). In line with this, eye-hand coordination is also a determining factor that has not been developed to its full potential. Athletes with low visual-motor coordination tend to experience a lack of synchronization between visual focus and arm movement control, making it difficult to control the direction and strength of the throw with precision(Luo et al., 2025). A number of studies on precision sports confirm that eye-hand coordination contributes significantly to reaction speed and movement accuracy, including in the context of petanque (Grenha et al., 2021; Saparia et al., 2020). This problem is further exacerbated by the implementation of training programs that are still general and non-specific in nature, where strength training tends to be monotonous and does not adequately represent the characteristics of shooting movements that require dynamic strength, stability, and simultaneous neuromotor integration. As a result, arm muscle adaptation is slow and does not fully support shooting performance needs. This condition indicates the need for a more specific and integrated training approach that simultaneously develops arm muscle endurance and hand-eye coordination as the main foundation for improving the shooting accuracy of petanque athletes. According to research, training using resistance bands provides effective elastic load stimulation to increase functional muscle strength without burdening the joints. (Flandez et al., 2020; Lee et al., 2024; Vargas-Molina et al., 2023). Meanwhile, other studies show that dumbbell swing exercises can improve muscle endurance and movement coordination simultaneously through a combination of strength and momentum(Arandjelovic, 2013; Lü et al., 2016).

This fact shows that the shooting performance of petanque athletes can still be improved through a more specific training approach based on the principles of dynamic strength and motor coordination. However, to date, there have been few studies comparing the effectiveness of resistance band and dumbbell swing exercises on shooting results, taking into account the factor of hand-eye coordination as a moderator.

Based on the results of previous studies and findings, it is known that most studies on improving the performance of petanque athletes still focus on the technical and biomechanical aspects of shooting, such as body position, throwing angle, or game strategy. In fact, shooting ability is not only determined by technical factors, but also by specific physical conditions, especially arm muscle endurance and hand-eye coordination, which play a major role in maintaining accuracy and stability of movement.

Research (Isknadar, 2019; Wulandari & Jariono, 2023) has indeed proven that arm muscle strength training can improve shooting results, but both studies only used one type of exercise, without comparing the effectiveness of two different forms of exercise. Meanwhile,(Flandez et al., 2020) demonstrated the effectiveness of resistance band exercises on muscle strength, and (Alif et al., 2024) highlighted the

benefits of dumbbell swings for improving endurance, but no studies have directly compared the two in the context of petanque.

Based on these conditions, there are two main research gaps, namely: (1) there has been no comparative study that tests the differences in the effects of resistance band training and dumbbell swings on the shooting results of petanque athletes, and (2) the role of eye-hand coordination as a moderating variable in determining the effectiveness of these two forms of training has not been revealed. These gaps are the main reasons why this research is necessary. This study is expected to provide new empirical evidence (novelty) regarding the most effective form of training to improve shooting results, as well as explain how eye-hand coordination moderates the effects of training on the performance of petanque athletes.

This gap is the primary reason why this research is necessary. It is hoped that this study will provide new empirical evidence regarding the most effective training methods for improving shooting performance, as well as explain how eye-hand coordination moderates the effects of training on petanque athlete performance.

This study aims to comprehensively examine the effects of arm muscle endurance and hand-eye coordination on the shooting results of petanque athletes through the implementation of a specific and functional training program. Specifically, this study is directed at comparing the effectiveness of resistance band training and dumbbell swings in improving shooting accuracy, while also analyzing the role of hand-eye coordination as a factor that influences and moderates the success of both forms of training. Through a factorial experimental approach, this study is expected to be able to explain the interactive relationship between training characteristics and athletes' neuromotor abilities, thereby producing a strong scientific basis in the formulation of petanque training programs that are more adaptive, effective, and tailored to the needs of individual athletes.

Method

Design

This study used an experimental method with a 2×2 factorial design. The first factor was the type of arm muscle endurance exercise, which consisted of two forms of exercise, namely Resistance Bands (A_1) and Dumbbell Swing (A_2). The second factor was hand-eye coordination, which was divided into two levels, namely high (B_1) and low (B_2). The dependent variable in this study was the shooting results of petanque athletes. The 2×2 factorial design produced four treatment groups as shown in the following table:

Table 1. Treatment Group Distribution

Type of Exercise	High Coordination (B_1)	Low Coordination (B_2)
Resistance Bands (A_1)	A_1B_1	A_1B_2
Dumbbell Swing (A_2)	A_2B_1	A_2B_2

Each group received treatment according to the type of exercise that had been determined. The exercise program was carried out over a certain period of time with the same duration, intensity, and frequency for each group so that the research results could be compared objectively.

This design allows researchers to test:

- The main influence of exercise type on shooting results.
- The main influence of hand-eye coordination on shooting results.

The interaction between exercise type and hand-eye coordination on the shooting results of petanque athletes.

Participants

The subjects in this study were petanque athletes who were members of regional training programs. Subjects were selected using purposive sampling with the following criteria:

- Active athletes who have participated in a regular training program for at least the past six months.
- Aged between 17 and 25 years old.
- In good physical condition and not currently injured.
- Willing to participate in the entire series of training sessions and research tests.

The total number of subjects was 32 athletes, who were then divided into four treatment groups, each consisting of 8 people:

- Group A_1B_1: Resistance Band training with high coordination.
- Group A_1B_2: Resistance Band training with low coordination.
- Group A_2B_1: Dumbbell Swing training with high coordination.
- Group A_2B_2: Dumbbell Swing training with low coordination.

The sample size of 32 athletes was determined based on population availability and the need for a 2×2 factorial design with balanced group division. Although this number was considered adequate for analyzing treatment effects and interactions, this study acknowledges the limitations of the sample size, so the findings should be generalized with caution.

Grouping was based on the results of an initial hand-eye coordination test (pretest), in which athletes with above-average scores were categorized as having high coordination, while those below average were categorized as having low coordination.

Procedure

This study was conducted in several stages, including preparation, implementation, and evaluation. In the initial stage, the researchers coordinated with the coaches and administrators of the petanque sports branch to determine the schedule and prepare the training facilities. Before the treatment was given, all athletes underwent a pretest consisting of hand-eye coordination and shooting tests to determine high and low coordination categories.

Next, each group received treatment according to a 2×2 factorial design for eight weeks with a frequency of three training sessions per week. The resistance band training group used elastic bands with light to moderate resistance levels, which were adjusted to the athletes' initial abilities and progressively increased by adding band tension as they adapted to the training. Meanwhile, the dumbbell swing training group used light weights with a relative weight range adjusted to the individual capacity of the athletes, which was around 30–40% of their maximum capacity, with a focus on swing continuity and movement control. The entire training program was carried out with equivalent duration, intensity, and intervals between groups to ensure training load equivalence and minimize treatment bias.

After the treatment was completed, a posttest was conducted to assess the improvement in shooting results. The data obtained were then analyzed using a 2×2 factorial ANOVA statistical test after meeting the requirements of normality and homogeneity tests.

Instrument

The instruments used in this study consisted of two types, namely instruments to measure hand-eye coordination and instruments to measure petanque shooting results. These two instruments were chosen because they were relevant to the variables being studied and had undergone a validation process by experts in the field of sports training and sports performance measurement.

- Eye-Hand Coordination Instrument

The hand-eye coordination test is used to determine the level of coordination ability of each athlete. This test is conducted using a standard procedure that measures visual response ability to hand movements in simple motor activities, such as catching and throwing a ball at a specific target within a specified time. The score is explicitly obtained from the number of successful catches or throws. Athletes who

obtain a score above the group average are classified as having high hand-eye coordination, while athletes with scores below the group average are classified as having low hand-eye coordination.

This test was chosen because it is able to describe the visual-motor skills relevant to shooting techniques in petanque, where athletes must be able to coordinate their gaze and hand movements accurately towards the target. The validity and reliability of the instrument were tested using Pearson's product-moment correlation test, with a reliability coefficient of r = 0.86, (R. Irawan et al., 2024)indicating that this instrument is suitable for use. The hand-eye coordination test instrument used refers to measurement procedures that have been used and validated in previous studies, thus providing an adequate empirical basis to support external validity in the context of this study.

- Shooting Results Instrument

The shooting test is used to assess the accuracy of petanque ball throws toward the target. Each athlete performs a number of shooting attempts in accordance with the standards of the International Petanque Sports Federation (FIPJP). The assessment is based on the number of balls that hit the target or the position of the ball closest to the target. The final score is the average of all attempts. This test is conducted twice, before the treatment (pretest) and after the treatment (posttest), to see the improvement in training results.

This instrument has high content validity because it reflects the actual skills performed in petanque competitions. Measurements are carried out objectively by three judges to avoid bias, and the results show inter-rater reliability of r = 0.91, which means it is reliable.

Data analysis

The research data were analyzed using parametric statistics with the help of SPSS version 25. Before the main analysis was conducted, the data were first tested for normality (Shapiro–Wilk) to determine the data distribution and homogeneity (Levene's Test) to ensure the similarity of variances between groups.

After the data met the analysis prerequisites, a 2×2 factorial Analysis of Variance (ANOVA) was performed to determine:

- The main influence of exercise type on shooting results.
- The main influence of hand-eye coordination on shooting results.
- The interaction between exercise type and hand-eye coordination on the shooting results of petanque athletes.

If significant differences are found, proceed with further testing (Post Hoc Test) to determine which group has the greatest difference.

Results

Before performing the main analysis, the data were first subjected to prerequisite tests and found to meet the assumptions of normality and homogeneity. Next, hypothesis testing was performed using analysis of variance (ANOVA) to evaluate the effect of training type, hand-eye coordination, and the interaction between the two on the shooting results of petanque athletes.

Table 2. Average Shooting Results per Group

Exercise Type	High Coordination (B1)	Low Coordination (B2)	Average Total
Resistance Bands (A1)	55.00	60.25	57.63
Dumbbell Swing (A2)	61.50	66.75	64.13
Total Average	58.25	63.50	60.88

Initial Interpretation

The average shows a tendency that:Athletes who practiced Dumbbell Swing achieved higher shooting results than those who practiced Resistance Bands.

- Athletes with high hand-eye coordination also showed better results than those with low coordination.
- There appears to be a potential interaction between the type of exercise and hand-eye coordination.

Table 3. Normality Test (Shapiro–Wilk)

Group	Statistic W	Sig. (p)	Description
A1C1	0.940	0.613	Normal
A2C2	0.962	0.783	Normal

Interpretation:

Significance value (p) > 0.05 → data in each group is normally distributed.

Table 4. Homogeneity Test (Levene's Test)

Levene Statistic	df1	df2	Sig.
2.134	1	14	0.165

Interpretation:

Sig. value = 0.165 > 0.05 → variance between groups is homogeneous

Table 5. Conclusions of the Analysis Prerequisites

Test Type	Results	Conclusion
Normality	p > 0.05	Data distributed normally
Homogeneity	p > 0.05	Homogeneous variance
Requirements for 2x2 ANOVA	✓Fulfilled	Analysis can proceed to factorial ANOVA

Table 6. Results of Factorial ANOVA (Two-Way ANOVA)

Sources of Variation	JK	df	RJK	F	Sig. (p)	Description
Type of Exercise (A)	345.78	1	345.78	9.52	0.008	Significant
Hand-Eye Coordination (B)	284.06	1	284.06	7.82	0.012	Significant
Interaction (A×B)	196.44	1	196.44	5.11	0.037	Significant
Galat (Error)	544.00	15	36.27	—	—	—
Total	1370.28	18	—	—	—	—

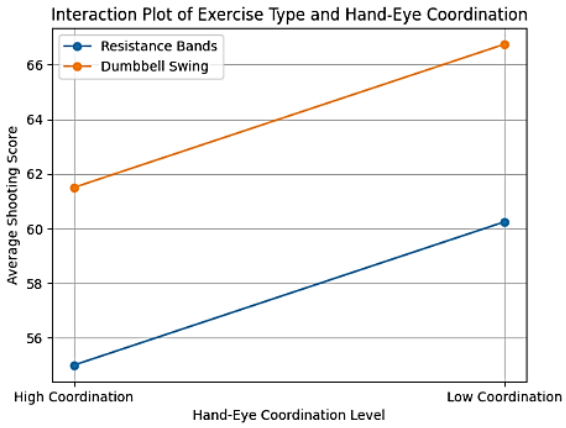
Table 7. Conclusions of Factorial ANOVA Analysis

Aspect Tested	F Calculation	Sig. (p)	Decision
Types of Exercises (A)	9.52	0.008	Significant
Hand-Eye Coordination (B)	7.82	0.012	Significant
Interaction (A×B)	5.11	0.037	Significant

Interpretation:

- The type of exercise has a significant effect on the shooting results of petanque athletes, with dumbbell swing exercises being more effective than resistance bands.
- Hand-eye coordination has a significant effect on shooting accuracy, with athletes with high coordination showing better performance.
- There is an interaction between the type of exercise and hand-eye coordination, which shows that the effectiveness of the training method depends on the neuromotor characteristics of the athlete.

Figure 1. interaction graph diagram



Discussion

The results of this study confirm that improvements in the shooting performance of petanque athletes are significantly influenced by the type of training and hand-eye coordination, both independently and through the interaction of the two. These findings indicate that shooting skills are not only determined by technical aspects, but also by the quality of the athlete's physical condition and motor coordination abilities. Dumbbell swing training has been proven to be more effective than resistance bands due to the dynamic nature of the load, which resembles the demands of petanque shooting movements. Free weight swing patterns provide greater stimulation to the arm, shoulder, and core muscles, thereby improving stability, momentum control, and movement consistency when releasing the ball(Jakobsen et al., 2013; Tabark Mohammed Salman, 2024). These results align with previous research indicating that dynamic load-based training is superior in enhancing explosive strength, muscle endurance, and movement accuracy in precision sports(Clanet & Maillet, 2025; Hermassi et al., 2010). Conversely, other studies reveal that while resistance bands still provide benefits in muscle strengthening and stabilization, the relatively stable elastic stimulus is less optimal for developing the dynamic strength required in petanque shooting(Bergquist et al., 2018; Saeterbakken et al., 2024; Silahudin et al., 2021)

Eye-hand coordination also plays a crucial role in determining shooting success. Athletes with high visual-motor coordination are better able to integrate visual information with arm movement control, enabling them to regulate the direction, strength, and timing of their throws with greater precision (Helmi et al., 2024b; Jaafar, 2024). These findings are consistent with research results in various target-based sports that emphasize the role of eye-hand coordination in improving movement accuracy and stability(Guo et al., 2024). The main contribution of this study lies in testing eye-hand coordination not only as an independent factor but also as a factor that influences athletes' responses to training methods.

Another important finding is the significant interaction between exercise type and eye-hand coordination, indicating that exercise effectiveness is conditional and depends on athletes' neuromotor characteristics. Athletes with high coordination are better able to utilize the complex demands of the dumbbell swing exercise, while athletes with low coordination tend to be more adaptive to resistance band exercises that offer more stable and easily controlled loads (Sanyal et al., 2005). This confirms that the selection of training methods needs to be tailored to the athlete's coordination level for optimal training adaptation (Fuentes et al., 2019). Using a 2×2 factorial design, this study provides a more comprehensive understanding of how training type and hand-eye coordination interact to influence the shooting performance of petanque athletes.

Novelty of the Research

The novelty of this study lies in the use of a factorial experimental design that integrates exercise type and hand-eye coordination into a single analytical framework to explain the shooting performance of petanque athletes. Unlike previous studies(Zulbahri et al., 2024), which generally examined a single training method or motor factor separately, this study reveals the interaction between exercise characteristics and individual coordination abilities. By comparing the effectiveness of dumbbell swing and

resistance band training based on hand-eye coordination levels, this study presents a new, more personalized and specific approach to training program design. These findings provide practical and scientific contributions by providing an evidence-based foundation for coaches to tailor training methods to athletes' neuromotor profiles in order to optimize shooting performance.

Implications for Training

The results of this study have important implications for petanque coaches in developing more effective and targeted training programs. The finding that Dumbbell Swing training provides greater improvement in shooting results compared to Resistance Bands, as well as the fact that athletes with high hand-eye coordination show better performance, confirms that training must be tailored to individual abilities. Athletes with high coordination will benefit most from dynamic load-based exercises such as Dumbbell Swings, which have been proven to improve strength, stability, and arm swing control. Conversely, for athletes with low coordination, Resistance Band exercises are more suitable because they provide a stable and easily controlled elastic load. These results are consistent with previous research showing that exercise load characteristics influence the effectiveness of strength development and movement accuracy (Suchomel et al., 2021).

Furthermore, the significant interaction between exercise type and hand-eye coordination reinforces the need for personalized training. Coaches cannot apply the same training program to all athletes but must consider each individual's visual-motor coordination. These findings align with previous research emphasizing that exercise effectiveness increases when tailored to individual motor characteristics (Boichuk et al., 2017). Thus, integrating strength, stability, and coordination training into a single training program is the most relevant strategy for improving shooting outcomes. Hand-eye coordination training should also be a routine component, given its significant contribution to accuracy and movement control in petanque.

Limitations and Future Directions

This study has several limitations that need to be considered when interpreting the results. The relatively small sample size means that generalizations of the findings must be made with caution, especially for a population of petanque athletes with varying levels of ability. In addition, hand-eye coordination was measured using only one type of test, which does not fully describe the more complex variations in visual-motor skills. The limited duration of the training also means that this study was unable to examine the long-term effects of both forms of training on strength adaptation and shooting accuracy. Other variables that may have an effect, such as mental consistency, competition experience, or basic shooting techniques, were not analyzed in depth and may therefore be uncontrolled factors in this study.

Future research could focus on using a larger and more diverse sample to obtain a more representative picture of the effectiveness of these two types of training. Subsequent research could also include several variations of visual-motor coordination tests to obtain a more comprehensive mapping of coordination abilities. In addition, further studies could investigate longer training durations or combinations of dynamic and elastic resistance training to see the synergistic effects on shooting performance improvement. Integrating psychological variables such as focus, emotional regulation, or concentration is also an important opportunity for future research, given that petanque shooting is greatly influenced by mental factors. Thus, further research can provide a broader and deeper understanding of the design of optimal training programs for petanque athletes.

Conclusions

The results of this study indicate that the type of exercise and hand-eye coordination have a significant effect on the shooting results of petanque athletes. Dumbbell Swing exercises have been proven to be more effective than Resistance Bands in improving strength, stability, and shooting accuracy, especially in athletes with high hand-eye coordination. In addition, hand-eye coordination greatly contributes to athletes' ability to control the direction and power of their throws. The finding of an interaction between the type of exercise and hand-eye coordination confirms that the effectiveness of exercise is greatly influenced by individual motor characteristics, so that the choice of exercise cannot be generalized for all athletes.

Based on these findings, it is recommended that coaches implement personalized training programs tailored to each athlete's coordination abilities. Dumbbell Swing exercises should be given to athletes with high coordination, while Resistance Bands are more appropriate for athletes with low coordination or as an initial stage of basic technique development. Coaches are also advised to incorporate hand-eye coordination exercises regularly, given their significant contribution to shooting accuracy. For further research, it is recommended to use a larger sample size, longer training duration, and more varied coordination measurement instruments to make the research results more comprehensive and generalizable.

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Authors' and translators' details:

Boby Helmi	sibobhelmi@gmail.com	Author
Rinaldi Aditya	rinaldiaditya87@gmail.com	Author
Andi Nur Abady	andi.nurabady@gmail.com	Author
Ahmad Al Munawar	a.almunawar16@gmail.com	Author
Mutiara Syabilla	syabillamutiara@gmail.com	Translator
Syahruddin	syahruddin@unm.ac.id	Author