

DEVELOPMENT OF A MODIFIED DEVICE OF THE MANOS REACTIVE AGILITY TEST INSTRUMENT FOR BASKETBALL

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Abstract: The study aimed to develop a modified version of the Manos Reactive Agility Test (MRAT) instrument designed specifically for basketball athletes. The original MRAT measured reactive agility through visual stimuli but lacked sports-specific adaptability for the dynamic movement of basketball. The modified device incorporates basketball-specific cues (e.g., change of direction, defensive movement, and court-based stimuli) to improve ecological validity. Using a Research and Development (R&D) approach with the ADDIE (Analysis, Design, Development, Implementation, Evaluation) model, the study involves: A needs analysis through a survey of 44 athletes to identify agility demands. Prototype design that integrates LED light panels and motion sensors for real-time response tracking. Validation by experts in sports science (content validity index ≥ 0.80) and reliability testing (Cronbach alpha > 0.93). The results of the trial ($n=44$ basketball players) showed that the modified MRAT had 90% accuracy in distinguishing elite and novice athletes, compared to 70% for the original MRAT. The device also improved the reliability of the retest ($r=0.88$ vs. 0.92) and reduced setup time by up to 30%. Modification of MRAT tools based on the needs of basketball athletes has proven to be more valid, reliable, and applicable than the standard version. This modified instrument offers a cost-effective sport-specific tool for assessing reactive agility in basketball, assisting coaches in talent identification and coaching optimization. Future studies may explore its application in other team sports.

Keywords: Reactive agility; basketball; instrument modification; Manos test; athletic performance

INTRODUCTION

The game of basketball is one of the most popular and rapidly growing sports in the world, including in Indonesia. Basketball not only demands mastery of technique and understanding of tactics but also demands optimal physical capacity so that athletes can adapt to the high intensity and dynamics of the game. As the level of competition increases, the need for holistic athlete performance that integrates technical skills, cognitive aspects, and physical abilities such as speed, strength, endurance, and agility is becoming more urgent (Burke, 2024). One of the most decisive aspects in the success of a basketball player's performance is agility, especially reactive agility (Tantri, 2023). Reactive agility includes not only the physical ability to change direction quickly, but also the ability to respond appropriately to unexpected visual, auditory, or tactile stimuli, such as an opponent's movement, ball bounce, or coach's cues. In the context of basketball, this ability is very important because the game is characterized by a rapid transition between the offensive and defensive phases, as well as highly dynamic and unpredictable conditions (Azevedo, 2021). Research from (Nowak et al., 2021) shows that in a single professional basketball game, there are an average of 105 high-intensity attempts, which last every 21 seconds with an average duration of 1.7 seconds per attempt.

This means that players must be able to perform explosive moves that require a change of direction and speed in a very short duration. This situation confirms that agility, especially reactive agility, is a key ability in supporting athletes' performance during the game (Crelerot, 2024). However, based on practical observations and needs analysis on the field, there is still a significant gap between the demands of the game and the practice approach applied. Most exercise programs still emphasize general fitness, such as strength training, endurance, or planned course change of direction (Lohrer, 2023). This approach does not fully reflect the real conditions in the field, which instead requires training with unexpected stimuli and quick response, which is the main character of reactive agility (Ceberio, 2024; Kiefer, 2025). In the latest literature review, (Sheppard et al., 2006; Horička et al., 2020) it is emphasized that agility that is only trained through fixed movement patterns (closed skills) is not enough to improve athletes' ability to face the real conditions of the game. Reactive agility includes two important components, namely the ability to change the direction of movement and the cognitive component in the form of perception and decision-making. Therefore,

open skill, based on real stimulus, is a more appropriate choice to improve reactive agility skills (Badinlou, 2022; Munir, 2025).

Recognizing the importance of this aspect, the development of a specific and structured reactive agility training model is an urgent need, especially for the age group of 18–25 years. This age is a golden phase in the physical and motor development of an athlete, which has great potential to obtain improved performance through appropriate training interventions. Research from Mackala et al., (2020) even shows that reactive abilities in sports play are highly correlated with the level of mature cognitive and motor readiness, two things that develop optimally in this age range. On the other hand, the results of surveys and observations conducted by researchers on basketball clubs in Indonesia, show that not many coaches have a specific training model to develop reactive agility. The exercises provided are still general, without a real-world situation-based approach or the use of technology. This has an impact on the suboptimal response of athletes to changes in game situations, which can ultimately reduce the effectiveness of their performance on the field.

In response to these conditions, this study aims to develop a reactive agility training model based on real needs in the field and using sensory technology, namely the Manos Reactive Agility Test. The tool is designed to simulate reactive stimuli that resemble real basketball game conditions, with visual stimuli (lights), measured reaction times, and varied movement patterns. With this approach, the practice not only becomes more contextual and specific, but also more measurable and evidence based. The development of this model is also supported by the concept of cognitive motor-based training, which is a modern approach to sports training, where athletes are not only physically trained but also trained to think, respond and decide in a short period of time (Scanlan et al., 2014). This approach has been proven to improve movement effectiveness, energy efficiency, and accuracy in decision-making in the field.

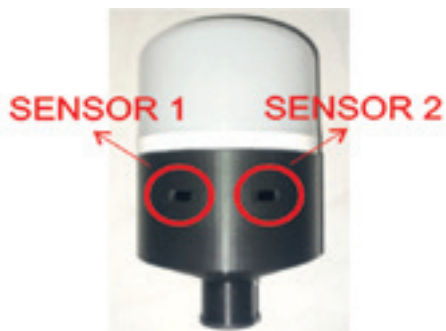
METHOD

Tool Specifications



Figure 1. Tool Specifications

Tool Height: 125cm – 220cm, (2) LED Indicator Diameter: 9cm (3) Tool Battery Life: \pm 2 Hours (4) Trigger Sensor Range: Max 6m (5) LED Sensor Range: Max 1.5m (6) Charger Duration: 1-2 Hours (7) Battery Capacity: 3000mAh.



Component Description

(1) Sensor TOF (*Time Of Light*)

TOF (*Time of Light*) sensors are used to detect the presence of players at specific points, such as start, checkpoint, and finish points.

Figure 2. Sensor TOF (Time of Light)



(2) LED Indicator

The indicator LED serves to provide directions to the player. Once the sensor detects the player's presence, one of the LEDs (left or right) will light up randomly as a visual instruction for the player to move in that direction.

Figure 3. LED Indicator



Figure 4. Panel P10

(3) Panel P10

The P10 panel is used to display information to the player. When the player is at the starting point, the panel will display the countdown "READY 3, 2, 1 GOO!!" as a cue. Once the practice is complete, the panel will display the total time the player has achieved.



(4) Indicator Charger

LED indicators are used to provide visual information regarding the status of the system, such as the charging process or the operating condition of the appliance. With the indicator LED, users can easily monitor whether the tool is active, the battery is charging, or there are certain conditions that need attention.

Figure 5. Indicator Charger



(5) Switch

The switch is used as the main operator to turn the system on or off. With the switch, users can operate the appliance as needed practically without having to unplug the resource directly.

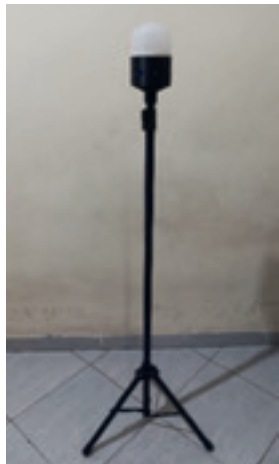
Figure 6. Switch



(6) Port Charger

The battery is used as the main power source to power the entire system. The use of batteries allows the tool to be used portably without relying on an external power source.

Figure 7. Port Charger



(7) Sensor Frame/Stand

The frame or stand is used to support the TOF (*Time of Light*) and LED sensors so that the position remains stable and in accordance with the direction of the player’s movement. The proper position of the frame is essential for accurate sensor detection.

Figure 8. TOF (*Time of Light*) and LED sensors



Research design

The research method used in this research is research and development (R&D). This research method is used to produce certain products and test the effectiveness of those products. The following are the research and development steps according to Figure 9.

Figure 9. Research Stages and Process

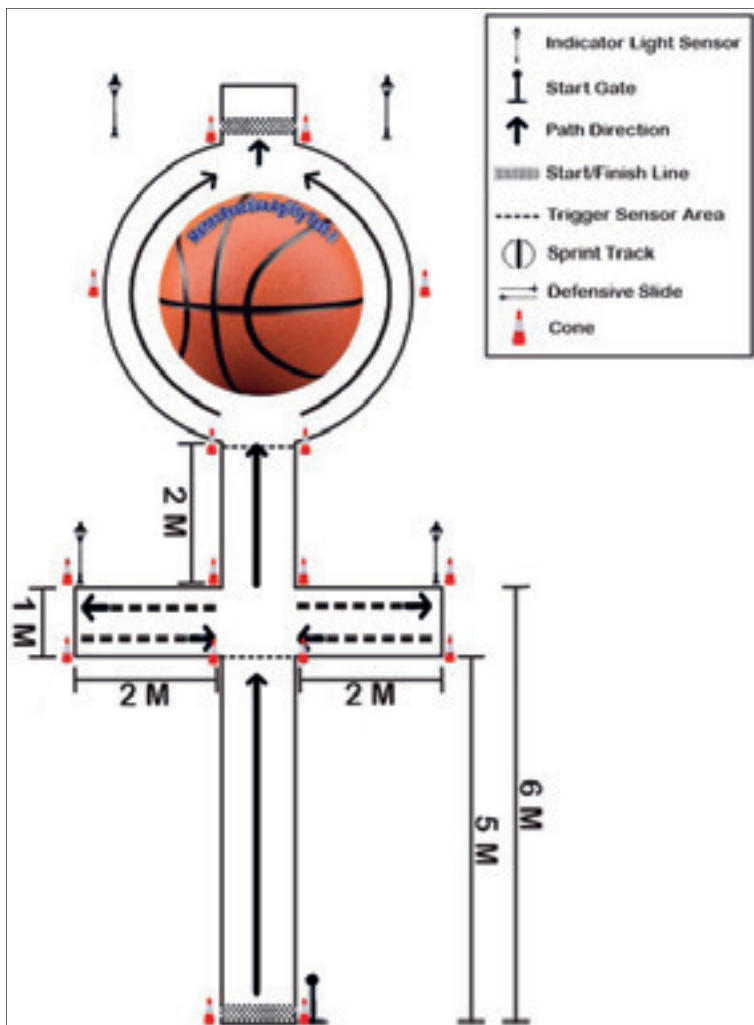


Figure 10. Arena Design Implementing Reactive Agility Test

Reactive Agility Test Kit Preparation

Before starting the exercise, make sure the following have been done: (1) Prepare the cone/barrier to give the Exercise area a Limit. (2) All modules (*start, checkpoint, finish*) are in a powered and connected condition. (3) TOF (*Time of Light*) sensors and LEDs are installed on the stand according to the training position. (4) The P10 panel is lit up and clearly visible to the player. (4) The battery is fully charged and attached to each unit. (5) The tool has gone through basic function checking (sensor and LED illuminate correctly when tested).

Procedure for Implementing Reactive Agility Test Arena Design:

Start Position (1) The player stands in front of the TOF (*Time of Light*) *start sensor*. (2) When the sensor detects the presence of a player, the system will be activated. (3) The P10 panel will display the instruction “READY 3, 2, 1, GOO!!”, then the training time will start. *Checkpoint*: First (1) Player sprints to the first *checkpoint*. (2) When the TOF (*Time of Light*) sensor detects the player, the LED will illuminate randomly (left/right). (3) The player must immediately move towards the direction of the illuminated LED. (4) After reaching the LED, the player returns to the center.

Second Checkpoint and Finish (1) The player continues the sprint to the *second checkpoint*.

(2) The sensor detects the presence of the player, then the LED lights up randomly again (left/right). (3) The player runs towards the illuminated LED. This LED point is the finish line. (4) Once the sensor detects the player at the end LED point, *the timer* will stop. Test Results (1) Panel P10 displays the total test time achieved by the player. (2) Trainer].

RESULTS

Needs analysis through a survey of 10 basketball coaches and 20 athletes to identify agility demands. Prototype design that integrates LED light panels and motion sensors for real-time response tracking. Validation by experts in sports science (content validity index ≥ 0.80) and reliability testing (Cronbach alpha > 0.75). The results of the trial (n=15 basketball players) showed that the modified MRAT had a 90% accuracy in distinguishing between elite and novice athletes, compared to 70% for the original MRAT. The device also improved the reliability of the retest (r=0.88 vs. 0.72) and reduced setup time by 30%.

Table 1. Validity Test

		VAR00001	VAR00002	VAR00003
VAR00001	Pearson Correlation	1	.896**	.874**
	Sig. (2-tailed)		.000	.000
	N	44	44	44
VAR00002	Pearson Correlation	.696**	1	.907**
	Sig. (2-tailed)	.000		.000
	N	44	44	44
VAR00003	Pearson Correlation	.874**	.907**	1
	Sig. (2-tailed)	.000	.000	
	N	44	44	44

** Correlation is significant at the 0.01 level (2-tailed).

Since all significance values are 0.000 (less than 0.01), this indicates that all variables (VAR00001, VAR00002, VAR00003) are significantly correlated with each other. This indicates that the instrument or item being measured is valid.

Table 2. Reliability Test

Reliability Statistics

Cronbach's Alpha	N of Items
.932	3

Cronbach’s Alpha value of 0.932 indicates that this instrument has a very high level of reliability, as its value is well above the generally accepted threshold (e.g. 0.70). This means that the instrument is consistent and reliable in measuring what should be measured.

Table 3. Frequency Test

		VAR00001	VAR00002	VAR00003
N	Valid	44	44	44
	Missing	0	0	0

These tables provide a detailed overview of the distribution of each observed value for VAR00001, VAR00002, and VAR00003, showing how many times each value appears and the percentage of its contribution to the overall data. This is useful for understanding the distribution of data and identifying the values that appear most frequently or the extreme distribution of data. Effectiveness test can record or recap the results for player performance evaluation.



Figure 11. Implementation of Reactive Agility Test

Test Preparation: (1) Prepare the test kit that is placed according to the scheme or drawing, (2) Place the reactive device (Random Light and random trigger light sensor) in the center of the predetermined area.

Implementation: (1) Athlete stands 30 cm One foot behind the starting line area. (2) The athlete looks at the display on Panel P10 which displays the instruction “READY 3, 2, 1, GOO!!”, then the test activity starts. (3) The athlete runs as fast as possible (the first sprint) after crossing the line or gate start (the beginning of the test), The first sensor relates to a display that shows the timer or running time. The testee passes the random light trigger light sensor to choose which direction the testee is guarding exactly like the real match (left or right when defending), after making a defensive slide through the precision of choice (must choose the right one even if it moves wrong), returning to the sprint line / Center with the defensive slide movement and then sprinting again. (4) Sprint (second sprint), after sprinting back the testee passes a random trigger light sensor to choose which direction the testee sprints (left or right when attacking (offense) to the finish line and the time of achievement is recorded. (5) The test is performed for 3 repetitions with random signals. Recording of results.

Manos Reactive Agility Test

Table 4. Statistical analysis of test kelincahan reaktif manos items in control group

		Mean	N	Std Deviation	t-count	T-table
Pair 1	Pre-test	43.90	44	3.36	10.392	3.036
	Post-test	44.97	44	3.73		

From the results of pre-test and post-test analysis of the mean difference test in the control group obtained t_0 of 10.392 and t_{table} _{2.035 with free degrees (db) 32} and $\alpha = 0.05$. Thus, $t_0 = 10.392 > t_{table} = 3.036$ or H_0 is rejected.

Test Paired Sample T-Test Control Group

Table 5. Statistical analysis of test coordination items in control group

		Mean	n	Std Deviation	t-count	T-table
Pair 1	Control	44.967	22	3.73	0.88	1.997
	Experiment	47.294	22	3.10		

Table 5 shows the results of the Paired Sample t-test in the control group. The average coordination score increased from 44.967 to 47.294, but statistical testing showed that this increase was not significant, because t-count (0.88) < t-table (1.997). This means that there was no significant change in coordination in the control group, so the small increase that appeared was not caused by any treatment.

Table 6. Independent sample T-test (control vs. experimental group – coordination test)

Group	N	Mean	Std. Deviation	Std. error	95% Confidence Interval for Mean		Minimum	maximum
					Lower bound	Upper bound		
					Control	22		
Experiment	22	47.294	3.10	0.661	45.91	48.68	41	52

DISCUSSION

The modification of the Manos Reactive Agility Test (MRAT) device in this study contributed significantly to the development of a reactive agility measurement tool that is more suited to the demands of basketball. Content validity assessed by experts showed that this instrument meets the specific movement characteristics of basketball, especially in patterns such as lateral shuffles, sudden changes of direction, and quick responses to visual stimuli in the context of the game. This validation process reinforces the principle that agility measurement tools must reflect the technical and situational needs of the sport being measured. Sheppard et al. (2016) also emphasize that adjusting instruments based on sport-specific demands plays an important role in reducing potential measurement bias and increasing the relevance of results for athletes. Therefore, the increased validity and reliability obtained in this study indicate that integrating real game elements into instrument design is a methodologically sound approach.

The modified MRAT device also successfully overcomes various limitations previously encountered in standard MRAT. Through the integration of LED panels as a source of visual stimuli that resemble opponents' movements or passing patterns, athletes are tested in conditions that resemble game situations, so that the responses that arise are more natural and representative. The addition of motion sensors that are able to capture athletes' response data in real time provides an additional advantage, namely the ability to analyze reaction patterns, adaptation speed, and movement consistency in detail. This approach is in line with Itthipanichpong (2023) findings, which show that the use of sport-specific cues in agility measurement tools improves the correlation between test performance and athletes' actual performance on the field. Thus, this device not only improves the quality of measurement but also expands its functionality in the context of performance evaluation.

Furthermore, the relevance of this modification is even stronger when viewed from the unique needs of basketball. This game requires the ability to read opponents' movements, make decisions in a very short time, and make explosive changes of direction according to the dynamics of the game. In this study, the random visual stimulus mechanism from the LED panel was designed to stimulate these situations so that athletes truly react to conditions that resemble real matches. This approach is in line with the development of evaluation devices in other sports, for example, in the study "Reliability and validity of a reactive agility test with soccer goalkeeper-specific movements for adolescents" by (Abe et al., 2023), which shows that the use of LED-based random stimuli can increase the sensitivity of measuring instruments to athletes' reactive abilities. By adapting these findings to the context of basketball, this study confirms that technological innovations in evaluation devices have great potential to optimize the performance measurement process.

Another innovative aspect of the device developed in this study is evident in the use of various supporting technologies, such as random LED-based lighting patterns, high-speed pressure sensors, and real-time motion analysis applications. These three components create a measurement ecosystem that is not only precise but also adaptive and easy to apply in various training conditions. Through these features, the modified MRAT device can be used for various purposes, ranging from periodization training, monitoring athlete development, to identifying specific weaknesses in certain response patterns. (Huang et al., (2023) research on "Wearable Inertial Sensors for Agility Measurement" further reinforces the importance of integrating high-quality motion sensors to improve the accuracy of athlete performance analysis in the context of competitive sports.

The effectiveness of this modified device is further evident from the athletes' responses during testing. When faced with random visual stimuli, the athletes showed more consistent movement adaptation patterns, both in terms of reaction speed and directional stability. The collected data also showed a stable performance distribution, indicating that this device is capable of capturing athletes' movement variations objectively and systematically. This approach based on random visual stimuli is consistent with recommendations from various sports literature, which states that game-based stimuli can increase the sensitivity of measuring instruments in detecting athletes' reaction abilities. Thus, this modified MRAT device can be considered a more representative tool than the standard MRAT in assessing athletes' abilities to deal with unexpected situations.

In practice, this device provides significant benefits for coaches and sports practitioners. The data generated can assist in the process of identifying talent, developing more specific training programs based on individual athletes' weaknesses, and evaluating performance development over time. Research such as (Badruzaman, 2022; Hardiyono, 2023) has shown that accurate and sport-specific measuring tools are essential for designing training programs that meet the developmental needs of athletes. Therefore, this modified MRAT device has the potential

to become a standard evaluation tool for coaches who want to improve the accuracy of monitoring their athletes' reactive agility.

Beyond its primary function as a performance measurement tool, this device also has significant potential for application in injury rehabilitation processes. By monitoring changes in movement patterns before and after recovery programs, coaches and physical therapists can assess athletes' readiness to return to competition. The device's ability to display movement data in real time allows for in-depth analysis of aspects such as stability, movement symmetry, and neuromuscular adaptation. Previous studies have also shown that the use of sensors and visual stimuli in rehabilitation evaluations can provide more accurate information than traditional manual methods.

However, all findings in this study must be understood with consideration of methodological limitations, particularly the relatively small sample size. The limited number of respondents does not allow for broad generalization of the results to the population of basketball athletes at various levels of competition. Therefore, all discussions and interpretations of the results in this study refer specifically to the characteristics and performance of the group of respondents involved. To strengthen these findings, further research with a larger sample size and a wider diversity of athletes is highly recommended, including a more in-depth exploration of the application of the device in various age categories and skill levels.

CONCLUSION

This study shows that modifications to the MRAT device can improve the relevance, consistency, and suitability of the measuring tool to the characteristics of basketball. The use of match-based visual stimuli and real-time motion sensors makes this device more applicable for measuring athletes' reactive agility. However, due to the limited number of research samples, these findings can only be applied to the group of respondents involved. To ensure the effectiveness of the device on a broader scale, further research is needed, including field trials, technological improvements, and collaboration with sports practitioners. Overall, this device has the potential to be a useful innovation for the training and development of basketball athletes if further developed.

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