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Validity and Reliability of Table Tennis Performance Measuring Eye-Hand Coordination

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Abstract The ability of eye-hand coordination is needed in table tennis performance. Therefore, measuring the eye-hand coordination of table tennis performance is necessary. This study aimed to develop a measuring instrument for table tennis eye coordination and test its validity and reliability. This study uses mixed methods—data collection using the Delphi technique and test-retest. The participants were three academic experts, four table tennis professional experts, and fourteen table tennis athletes. This research instrument uses a questionnaire with a rating scale of one to four, namely very relevant, relevant, less relevant, and irrelevant. It uses a measuring instrument for hand-eye coordination. Data analysis used Aiken's formula, Intraclass Correlation Coefficients (ICC), and Cronbach Alpha. The results of this study that measuring eye-hand coordination of table tennis performance show the first aspect: the suitability of the coordination concept has a value of V = 0.952, the second aspect: the suitability of the number of stimuli has a value of V = 0.857, the third aspect: the suitability of distance has a value of V = 0.952, the fourth aspect: the suitability of the movement has a value of V = 0.857, the fifth aspect: the suitability of the test procedure has a value of V = 0.857. The Intraclass Correlation Coefficients (ICC) test has a value of 0.875. The reliability test has a value of 0.891. Based on these results, the eye-hand coordination measuring instrument has content validity and high reliability. Therefore, the eye-hand coordination measuring instrument can be used to measure table tennis performance.

Keywords Table Tennis, Eye-Hand Coordination, Instrument

1. Introduction

Eye-hand coordination is the ability to combine the visual system in receiving stimuli and hand movements in carrying out tasks such as throwing, catching, and hitting the ball [1]. Eye-hand coordination is the most important element in table tennis because table tennis performance requires eye-hand coordination, which is quite difficult and complex with the changing environmental conditions under high time pressure [2]–[4]. In other words, eye-hand coordination plays a role when athletes hit a backhand, forehand, and serve in positioning the ball in the area where they are playing [5]–[8].

Previous research explained that the effect of eye-hand coordination exercises could increase Forehand Topspin Accuracy, forehand smash accuracy, and forehand drive strokes [5]–[7]. In addition, further research showed that eye-hand coordination could increase the accuracy of the backhand spin service [9] with training in the suitability of the form of coordination exercise, as well as the ability of the athlete's service accuracy level [8], [10].

Based on this explanation, table tennis athletes' eye-hand coordination is the main factor in improving table tennis performance. Therefore, a measuring instrument is needed to measure eye-hand coordination ability because

measurement and exercise cannot be separated. Although eye-hand coordination measuring tools already exist [5], [11], the trainers are not fully satisfied with the existing hand-eye coordination measuring tools.

The research by Vandorpe et al. [12] showed that eye-hand coordination was strongly correlated with the competition results in elite gymnasts. Although the research was conducted on gymnasts, the concept of this research is believed to be less suitable for table tennis performance because these gymnasts require coordination, whose movements are different from the main performance movements of table tennis. Eye-hand coordination in table tennis performance is required for more appropriate ball control, speed, anticipation, accuracy, and changing environments. In addition, Feber et al. [11] have shown the results of research measuring the eye and hand coordination as one of the test items in identifying talent in the net game sports group.

Previous research by Mahendra et al. [5] used a measuring instrument for hand-eye coordination in the form of throwing tennis balls. In addition, Faber et al. [11] research showed the benefit of measuring hand-eye coordination in identifying children's talents in net game sports. The results of this study state that measuring instruments with a distance of 1 meter have a good level of validity. The measuring instrument [5] used is different from the performance characteristics of table tennis because the ball and the way of throwing it do not approach the table tennis stroke. The results of research by Faber et al. [11] that this measuring instrument approaches the performance characteristics of table tennis with a distance of 1 meter has good validity, but from observations made, this measuring instrument still has less practicality because the table used must be lifted on the table. This explains that a good measuring instrument must-have criteria not only about validity and reliability, but also elements, relevance, purpose, and practicality [13], [14].

Based on the facts above, the purpose of this study was to test the content validity and reliability of the table tennis performance measuring instrument for eye-hand coordination.

2. Materials and Methods

This study used a mixed method of qualitative and quantitative methods. There are five stages in this research, which are as follows: A first stage is a qualitative approach with the method of literature reviews of articles, journals, and textbooks [15], which is related to the existing table tennis performance measuring eye-hand coordination tool, to develop a conceptual definition and operational measuring instrument eye-hand coordination of table tennis performance. The second stage is to test the instrument's content validity by collecting data using the Delphi technique [16]–[18]. The Delphi technique is that every expert judgment does not meet in assessing the construction design of a beginner table tennis eye-hand coordination measuring instrument, used to reach expert opinions on a particular subject in a gradual and iterative process [19]. The third stage, followed by qualitative analysis, namely as input from expert judgment, with the results being analyzed afterward to be revised until the construction of the eye-hand coordination measuring instrument was accepted without further improvement [20] by giving a value. The fourth stage of the results of the expert's assessment is carried out by testing ICC (Intraclass Correlation Coefficients). ICC is a reliability index widely used in test-retest, intra-rater, and inter-rater reliability analysis [21]. In the fifth stage, fourteen table tennis athletes conducted a trial using eye-hand coordination measuring instrument that had been developed to test the reliability of a table tennis performance measuring instrument for eye-hand coordination.

Participants

The participants in this study were seven experts and fourteen table tennis athletes. The seven experts have qualifications: three academic experts, four professional table tennis experts, and fourteen table tennis athletes with criteria aged 10-12 years who have practiced for two years or at least twice and have participated in regional-level competitions.

Table 1. Athlete Anthropometry

Variable	Participant (n=14)		
	Min	Max	Mean & S.D
Age	10	12	11 ±0.784
Height (cm)	131.5	154.9	143.6 ±7.56
Body Mass (kg)	28.3	54.2	43.1 ±8.60
Sitting Height	67.5	81.3	73.9 ±3.79
Arm Span (cm)	131	162	146.14 ±9.96

Table 2. Training Experience

Week	Meeting	Training Items	Training Frequency
1-2	1-6	a Coordination with ball b Squat Jump c Shuttle run with a ball d Side step e Side jump f Shadow and side step	Frequency: 3 Intensity: Medium Set: 5 Time: 30 seconds Rest Interval: 30 seconds Rest between circuits 3 minutes
3-4	7-12	a Coordination with ball b Squat Jump c Shuttle run with a ball d Side step e Side jump f Shadow and side step	Frequency: 3 Intensity: Medium Set: 6 Time: 30 seconds Rest Interval: 30 seconds Rest between circuits 4 minutes

Procedure Instrument Coordination Hand-Eye Table Tennis

Test Place Measurement Distance

1. The distance limit of participants standing with a wall as far as 2 meters,

2. The distance of the target limit from the floor to the lower limit of the target is as high as 91.25 cm,

3. The distance between the throwing target and the test taker's standing limit is 1.83 meters, providing a rising boundary line on the right and left sides of the throwing target as high as 50 cm.

Test Equipment

1. Three table tennis balls
2. Scoring and stationery rubrics
3. Stopwatch
4. Meter and Insulation

Number of Examiners and Position of Examiners

1. The number of testers or test supervisors is 4 people.

2. One counter for accurate throws and catches, one scorer, and one-timer.

3. The counter and recorder of the results stand in a straight line position where the participant stands behind the test taker, approximately two meters from the standing test taker.

4. Timer clerk is more flexible. It is recommended to be next to the counter clerk.

Test Procedure

1. The standing position is cultivated in the most effective ready condition, which is relaxed and leaning slightly forward.
2. The position of the legs and feet, try always to be close to the boundary line, stand with both feet shoulder-width apart and slightly bent, one foot slightly forward and one slightly behind, and adjust to the technique or type of throw.
3. Arms and hands as body parts for throwing. Try to get the most appropriate angle and position and follow the characteristics of the stroke in table tennis.
4. Testimonies are allowed to choose to throw with forehand or backhand technique according to the conditions of the game.
5. The result of the throw-in this case, must be just above the target line.
6. The hand's position when catching, try to be in a position to welcome the ball or direct the palm used for throwing and catching toward the front or towards the target wall.
7. Score one if the test result is correct, namely according to the existing technical provisions, standing behind the line, throwing with an active hand, and being caught with the same hand, both forehand and backhand, the result of the throw enters the target. A score of zero if the test is wrong is a violation of the test rules.
8. The results recorded are the number of correct test results within 30 seconds.
9. Implementation of the test twice.

Research Instruments

The instrument used to collect data in this study was a questionnaire. In this study, the data collection technique that will be carried out is giving an instrument in the form of a questionnaire to the assessment, namely an expert judgment. The questionnaire used in this research and development is structured with a rating scale of 1 to 4. The research instrument is a material expert assessment sheet and sports evaluation expert. The expert assessment sheet is used to determine how relevant the conceptual and operational definitions are, the stimulus for the respondent, (1) the concept, (2) the appropriateness of the amount of stimulus, (3) distance, and (4) movement, and (5) measuring instrument procedures. The instrument tested the reliability using the developed eye-hand coordination measuring instrument.

Data Analysis

The expert judgment assessment was analyzed using Aiken's formula [21], where aspects were calculated using Aiken's formula as follows:

$$V=\frac{\sum(r_i-l_0)}{n(c-1)}$$

$S = r - lo$

Lo = lowest rating score

C = highest rating score

R = number given by rater

Figure 1. Formula Aiken's

Analysis of reliability test data between raters uses Intraclass Correlation Coefficients (ICC) with SPSS (IBM SPSS statistics version 25.0). The results of the ICC calculation use four categories according to Fleiss [22] as follows: an ICC value of 0.40 or lower can be interpreted as a low level of agreement, an ICC value of 0.41-0.75 as a good level of agreement, and a high level of agreement ICC 0.76-1.00.

Empirical reliability data analysis measuring instrument eye-hand coordination of table tennis performance was analyzed using Cronbach alpha, with Cronbach alpha reliability criteria as follows: > 0.9 Excellent, > 0.8 Good, > 0.7 Acceptable, > 0.6 Questionable, > 0.5 Poor, < 0.5 Unacceptable [23].

3. Results

The results of the Literature Review of the Eye-Hand Coordination Instrument found research results that were worthy of study as Table 3 as follows.

Table 3. Relevant Research

Name	Title	Method	Result
I. R. Faber et al. [11]	Does an eye-hand coordination test have added value as part of talent identification in table tennis? A validity and reproducibility study	Experimental method, sample Forty-three table tennis players (7-12 years)	The results of this study resulted in table tennis eye-hand coordination instruments having good validity with a distance of 1 meter.
Mahendra et al. [5]	Wrist flexibility and hand eye coordination in table tennis forehands	The experimental method, the instrument used is throwing tennis balls. The sample is 30.	The results of this study explain that eye-hand coordination has a significant contribution to the forehand hitting ability of table tennis.
Liskustyawati et al. [24]	Physical Tests for 13-15 Year Old Table Tennis Players	Experimental method, sample 61 players (34 men players and 27 women players.	The results of this study resulted in 6 test items including arm span, hand reaction speed, tennis ball throwing and catching tests, shuttle runs, and 20 meters, for the table tennis athlete test.

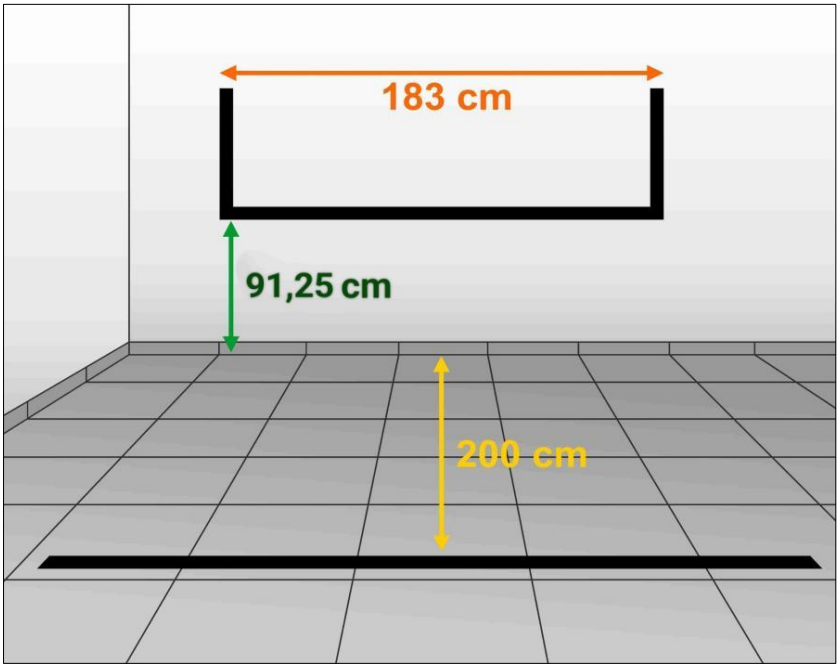

Figure 2. Eye-Hand Coordination Test Table Tennis Performance

From the results of the analysis of literature reviews, it is found that the definition of hand-eye coordination is for beginner table tennis athletes. Eye-hand coordination is the visual system's ability that is received by the eyes and transmitted by the hands in movements or performances. Eye-hand coordination is very important for table tennis because, in a game or competition, athletes are required to make fast movements accompanied by hitting accurately and on target [25]. In addition, an eye-hand coordination test was constructed for novice table tennis athletes. The construction of the test can be seen in Figure 2.

After the table tennis eye-hand coordination measuring instrument was produced without revision from the expert, it was continued to test the validity of the content.

Aiken's Validity Test Results

Aspects of eye-hand coordination instruments specifically for novice table tennis athletes are assessed by expert judgment, including (1) the suitability aspect of the eye-hand coordination concept, (2) the aspect of the suitability of the amount of stimulus, (3) aspects of distance suitability, (4) aspects of movement suitability, (5) aspects of the suitability of test procedures. The expert's assessment uses a range of 1 to 4. If the assessment is close to a scale of 1, then the assessment criteria are close to irrelevant. While the assessment is close to a scale of 4, the more relevant the assessment criteria. Then the data from the expert assessment was analyzed quantitatively with Aiken's formula.

The results of Aiken's validity test are shown in Table 4. The results showed that all aspects got a value of V. The first aspect was the suitability of the coordination concept V= 0.952. The second aspect was the suitability of the amount of stimulus V=0.952. The third aspect was the suitability of the distance V=0.952. The fourth aspect was the suitability of the movement V= 0.857. The fifth aspect was the suitability of the test procedure V= 0.857.

Reliability Test Results between Raters

Based on Table 5, the average agreement between raters is 0.875. The results of the ICC value classified by Fleiss [22] show that the agreement between raters is good.

Table 4. Result of Aiken Validity

	Score Evaluator							**Rater Scale**							**∑ S**	**V**
Aspect 1	4	3	4	4	4	4	4	3	2	3	3	3	3	3	20	0,952
Aspect 2	4	3	4	4	4	4	4	3	2	3	3	3	3	2	20	0,952
Aspect 3	4	3	4	4	4	4	4	3	2	3	3	3	3	3	20	0,952
Aspect 4	4	3	4	3	3	4	4	3	2	3	2	2	3	3	18	0,857
Aspect 5	4	3	4	3	3	4	4	3	2	3	2	2	3	3	18	0,857

Table 5. ICC Results

	Intraclass Correlation[b]	95% Confidence Interval		F Test with True Value 0			
		Lower Bound	Upper Bound	Value	df1	df2	Sig
Single Measures	,167[a]	-,043	,735	2,400	4	24	,078
Average Measures	,583[c]	-,408	,951	2,400	4	24	,078

Reliability Test Results

Table 6. Reliability Results

Cronbach's Alpha	N of Items
.943	2

4. Discussion

This study aimed to test the content validity and reliability of the table tennis performance eye-hand coordination measuring instrument. This study found that the table tennis eye-hand coordination measuring instrument has good content validity and can be used to measure the eye-hand coordination of table tennis athletes. The results of this study follow the results of research by Nugroho et al. [26]. The results of the expert assessment instrument get a value of > 0.76, so it can be said that the aspect has good content validity. Likewise, this study's results follow Hendryadi [27], which states that a coefficient of 0.857 can be considered adequate content validity. In addition, Tomoliyus & Sunardianta's research [28] states that a good measuring instrument can measure precisely and accurately what is to be measured or can be said to have a high level of validity. This result is in line with the research by Pueo et al. [29], which stated that a measuring instrument can be used to measure the ability of a group or a person must have good validity and reliability. The eye-hand coordination test is useful in measuring the eye-hand coordination ability of table tennis athletes who have implemented an exercise program so that they can find out the results of the training program to achieve peak performance [30].

The results of the Intraclass Correlation Coefficients (ICC) reliability get an agreed value between raters of 0.875. From these results, according to Fleiss [31], the agreement value between raters has a good level of reliability. This result is in line with the research [28] that the reliability of interclass or between raters is> 0.5, which means that the reactive agility measuring instrument has good reliability. The Intraclass Correlation Coefficient is very important in assessment measurement and has been widely used to evaluate inter-rater, test-retest, and intra-rater reliability [21].

The test-retest reliability correlation coefficient in this study gave good results. Heale et al. [32], state that Cronbach's Alpha value > 0.7 is said to have high reliability. Further research also states that a measuring instrument that has high validity and reliability can be recommended as a good measuring instrument [33]. Many sports need to develop test reliability. This is a major problem [34]. Rozan et al's research resulted in the reliability of the eye-hand coordination test of rugby players (KIHECT). Research related to table tennis eye-hand coordination measuring instrument [11] the results of this study have good measuring instrument reliability. However, it can be underlined that this study has advantages. Namely, the measuring instrument used has a height, width, and distance that adhere to the table's height and width and movements that use forehand or backhand movements.

Based on this research, the measuring instrument for eye-hand coordination of table tennis performance has high content validity and empirical reliability. The limitation of this study is the use of too few experimental participants—recommendations for further research to add more trial samples. Furthermore, further research is needed to test the empirical validity and examine the norms of table tennis eye-hand coordination measuring instruments to find a standard correlation of measuring instruments that can be used as a standard reference for table tennis athletes' eye-hand coordination norms.

5. Conclusions

Based on the discussion of the research results above, the results of this study can be concluded that the construction of the eye-hand coordination measuring instrument for table tennis performances is as follows: (1) the eye-hand coordination measuring instrument has high content validity, and (2) the eye-hand coordination measuring instrument has high reliability. In other words, the eye-hand coordination measuring instrument can be used to measure the eye-hand coordination of table tennis performance. Studies should be continued to measure empirical validity and assess the norms of justice. In addition, the limitation of this study is that the number of trial participants is too small, so further research is needed that uses more trial participants.

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