THE EFFECTS OF INTERNAL AND EXTERNAL IMAGERY, AND BADMINTON SKILLS EXECUTION ON MUSE MEASURE AMONG NOVICE UNIVERSITY BADMINTON PLAYERS

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by

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LIST OF ABBREVIATIONS

EEG	Electroencephalogram
PAR-Q	Physical Activity Readiness Questionnaire
SIAM	Sport Imagery Ability Measure
USMKK	Universiti Sains Malaysia Kampus Kesihatan

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KESAN IMGAERI DALAMAN DAN LUARAN, DAN PELAKSANAAN PUKULAN BADMINTON ATAS *MUSE MEASURE* DALAM KALANGAN PEMAIN BADMINTON BARU UNIVERSITI

ABSTRAK

Kajian ini bertujuan untuk membezakan aktiviti gelombang otak antara imageri dalaman, imageri luaran dan pelaksanaan pukulan badminton. Sejumlah N = 8 peserta direkrut dalam kajian ini dan diagihkan kepada a) kumpulan imageri dalaman (n = 4) dan b) kumpulan imageri luaran (n = 4) secara rawak, sementara semua peserta melakukan pelaksanaan pukulan badminton. Semua peserta memperolehi skor sederhana hingga tinggi dalam ujian *Sport Imagery Ability Measure* dan berada dalam keadaan sihat seperti yang diukur dengan *Physical Activity Readiness Questionnaire*. Peserta diminta memakai *Muse headband* semasa melakukan pukulan badminton dan semasa melakukan imageri pukulan badminton. Aktiviti gelombang otak direkodkan dan dianalisis. Keputusan kajian ini menunjukkan bahawa gelombang delta adalah tertinggi semasa melakukan imageri dalaman manakala gelombang theta, alpha, beta, dan gamma adalah tertinggi semasa pelaksanaan pukulan badminton. Walau bagaimanapun, keputusan ini tidak signifikan oleh sebab jumlah peserta yang kurang.

THE EFFECTS OF INTERNAL AND EXTERNAL IMAGERY, AND BADMINTON SKILLS EXECUTION ON MUSE MEASURE AMONG NOVICE UNIVERSITY BADMINTON PLAYERS

ABSTRACT

This study aimed to differentiate the brain wave activity between internal imagery and external imagery of badminton shots, and execution of badminton shots. A total of 8 participants (N = 8) were recruited in this study. They were randomly assigned into two groups: a) internal imagery group (*n* = 4) and b) external imagery group (*n* = 4), in which all of the participants performed the badminton skills execution. All participants obtained moderate to high scores in the Sport Imagery Ability Measure SIAM) and are in good health as measured by the Physical Activity Readiness Questionnaire. Participants wore the Muse headband while performing the badminton shots and while performing imagery of the badminton shots. The brainwaves activity was recorded and analysed. Results showed that internal imagery induced the highest delta wave, whereas the execution of badminton shots induced the highest theta, alpha, beta and gamma waves. However, the result was not statistically significant due to the small sample size.

CHAPTER 1

INTRODUCTION

1.1 Introduction

Badminton is a fast-paced racquet sport that is popular among Malaysians. Various achievements have been made by Malaysia's badminton players such as in SEA Games, Olympic Games, Thomas and Uber Cup, Commonwealth Games. Badminton can be played as recreational or competitive and it is played in either single with two opposing players or doubles with two opposing pairs. Originally, badminton was created by British military officers stationed in British India in mid-1800s (Badminton - an overview and history of the sport - Badminton - factfile - GCSE Physical Education Revision - Edexcel, no date). It underwent a significant change when the British army officers in India introduced the net and court. It was brought back to England when the officers were retired. Badminton has then been listed in the Olympic games since 1992. The lightness of the badminton racquet and the shape of the shuttlecock are the reason why badminton is fast-paced and speed-demanding. There are seven basic badminton shots: clear/lob, drop, smash, net shot, net kill, net lift, and drive (Tong & Hong, 2000; Yuksel, 2019).

Except for physical training, mental training is another way to enhance sports performance. Imagery is one of the mental training used among sports psychologists, coaches, and athletes, and serves to improve performance and motivation (Morris, Spittle & Watt, 2005; Cumming & Williams, 2012). There are various terms used in the sports domain for imagery, for example, visualisation, mental imagery, mental practice, mental rehearsal, covert practice and so on (Lu et al., 2020). Imagery can be categorised into two imagery perspectives as internal and external imagery (Hardy & Callow, 1999; Callow et al., 2019), where internal imagery is imagining movement from an internal perspective and is kinesthetics in nature; whereas eternal imagery is viewed from the viewpoint of an outsider that is visual in nature.

When the brain exchanges information, the electrical signal produced is called brain wave. The brain wave will demonstrate certain changes according to mental status and activities (Wing, 2001). Imagery is a cognitive process that causes the brain to prepare, program and carry out a movement in the mind (Holmes & Collins, 2001). Thus, both alpha waves and beta waves were examined in related studies (Jung-Hee, Eun-Jung & Byoung-Hee, 2013; Kim et al., 2014). Alpha waves will increase when a person is resting in comfort and decline with the onset of cognitive activity. Beta waves, in the opposite, increase relative to cognitive function (Kim et al., 2014).

1.1.1 Study Justification

Most sports studies focus on competitive athletes instead of novice players due to the high demands of the competitions. Moreover, there is a lack of study conducted using portable Muse measure, especially while comparing internal and external imagery, and actual execution of the imagined skills. Thus, this study is proposed to fill in the gaps in the literature.

1.1.2 Objective of the Study

The main objective of this study was to investigate the effects of internal and external imagery and badminton skills execution on Muse measure among novice university badminton players.

The specific objective was to determine the difference between brain wave during actual execution, and the internal and external imagery of badminton shots on Muse measure.

1.1.3 Hypotheses of the Study

H_o1: There is no significant difference in brain waves' median (delta, theta, alpha, beta, gamma) between execution, internal imagery and external imagery.

H_a1: There is a significant difference in brain waves' median (delta, theta, alpha, beta, gamma) between execution, internal imagery and external imagery.

1.1.4 Significance of the Study

In this study, I tested the brain activity during the imagery session and execution to find similarities and differences between the situations. Thus, the novice badminton players can apply the imagery techniques and combine them with physical skills training to enhance their execution skills.

CHAPTER 2

LITERATURE REVIEW

2.1 Imagery and Sports

Imagery is a cognitive process of preparing, planning, and executing a movement in mind prior to an overt motor performance (Holmes & Collins, 2001), may occur in the absence of an actual stimulus precursor that is linked to the real experience (Morris, Spittle & Watt, 2005). In 1930, Jacobson proved that by imaging a simple movement, muscle contraction occurs, as tested using electromyography. Thus, imagery is also known as muscular memory (Coelho et al., 2007). Imagery technique is one of the methods to enhance performance and motivation in athletes (Cumming & Williams, 2012). As defined by Paivio (1985), there are two functions of imagery: cognitive function and motivational function. Cognitive function of imagery is associated with the mental skills practise and general play strategies, whereas the motivational function of imagery is about imaging goal-oriented situations, general physiological and emotional arousal of the competition. People who have greater imagery ability benefit the most from imagery use (Martin, Moritz & Hall, 1999). To access imagery ability, numerous measures are created by answering questionnaires that need behavioural or emotive-imagery responses or by assessing performance from a set of mental-ability tasks (Sheehan, Ashton & White, 1983). Since psychological skills are trainable, imagery ability can be improved with practice as well (Behrmann, 2016).

2.2 Internal and External Imagery

Imagery can be divided into two perspectives: internal and external. Internal imagery is a first-person perspective, where imagers imaging from the inside of their body to experience the sensation that occurs in a real situation, whereas external imagery is viewing themselves as an external observer perspective, a third-person perspective (Morris, Spittle & Watt, 2007). Researchers have different opinions on whether internal or external benefits more in sports performance. However, some researchers suggest that internal imagery works better on those who had experienced a certain motor skill to improve the performance as it provides kinesthesis perception for the movement (Montuori et al., 2018). External imagery can be useful to provide key information on how to complete a movement (Schmidt & Lee, 2011). Nevertheless, athletes should decide on which imagery perspective they prefer to produce the most vivid and controllable image since imagery ability will influence the effectiveness of the imagery (Behrmann, 2016).

2.3 Muse measure and Brain Wave

The Muse electroencephalogram (EEG) measure is a non-invasive test to measure and acquire the electrical activities of the brain. These electrical activities are produced by activated neurons that produce electrical impulses when they are communicating with each other. When there are many neurons communicating in a certain way simultaneously, these electrical activities will become stronger. Electrical activities can be detected by placing electrodes on the scalp. The brain wave then being amplified, analyzed, and visualized to enable further investigation. Brain waves come in different frequencies, thus categorized into gamma, beta, alpha, theta, and delta waves.

The strongest wave is the gamma wave (32-100 Hz) associated with learning, cognitive functioning, and information processing (Abhang, Gawali & Mehrotra, 2016). Beta wave (14-30 Hz) is often associated with alertness, consciousness, aroused, and active thinking, while alpha wave (8-13 Hz) becomes detectable when relaxed resting state. Theta wave (4-7 Hz) is associated with dreams and drowsy state. Delta wave (0.5-4 Hz) is detected when we are in a dreamless state (Pathak & Jayanthy, 2017).

2.4 Effect of Imagery on Brain Wave

There are limited studies conducted on imagery with brain waves that can be found in the literature. A study by Jung-Hee, Eun-Jung & Byoung-Hee (2013) suggested that action observation (which is external imagery) induces a higher level of cognitive activity than motor imagery (which is internal imagery) and physical training in stroke patients. Thus, the beta wave is higher during action observation when comparing to other situations. In contrast, alpha wave will decrease when cognitive activity increases. The alpha wave recorded during action observation is lower in occurrence frequency compared to motor imagery group and physical training group. The reason of action observation generates more cognitive activity because participants can recognise the differences of their internal plan with the observed model, thus serving as a feedback mechanism to raise their cognitive activity (Petrosini et al., 2003). Whereas for the motor imagery group, the participants might have a hard time forming a clear image for the task given if they have not normally experienced the task in real life before if the imagery is instructed using auditory signals only (Jung-Hee, Eun-Jung & Byoung-Hee, 2013).

CHAPTER 3

METHODOLOGY

3.1 Study Design

This study applied experimental research design. The aim is to observe the brain wave during execution, internal imagery, and external imagery of badminton shots using Muse measure. Participants were divided into two research conditions: internal imagery and external imagery. Participants in both internal and external imagery research conditions executed the badminton shots which are clear/lob, drop, smash, net shot, net kill, net lift and drive. A badminton feeder fed the shuttlecock to the participants, and the participants hit the shuttlecock using the assigned badminton shots to the desired court area. The badminton shots were performed one by one (not rotation). Participants were asked to standby at the assigned court area (e.g., standby at back court to perform clear/lob) as footwork is not a part to be tested. After executing badminton shots, participants were asked to perform imagery according to their assigned research condition. Participants wore the Muse headband during the execution and imagery session. Due to the COVID-19 pandemic situation, all meetings with the participants were conducted individually and following strict social distancing procedures.

3.2 Sample Size Calculation

The sample size for this study was calculated using G*Power 3.1.9.7, with a significance level of 0.05, moderate effect size of 0.50, and statistical power is set to be 0.80 (Kuan et al., 2017). Twenty-one participants were required to provide adequate power. By considering 20% of the dropout rate, an additional 4 participants will be recruited. Thus, the total sample size for this study is 26 participants, which each condition consists of 13 participants (internal and external imagery). However, due to the restrictions during pandemic and time constraints, only eight participants volunteered and recruited for this study, with n = 4 in internal imagery research condition and n = 4 in external imagery research condition.

3.3 Participants

A total of eight participants were recruited and assigned into two research conditions (internal imagery group and external imagery group) using Random Allocation Software 1.0. The inclusion criteria of participants include: (1) Novice badminton players (not professional) in order to avoid a ceiling effect. (2) Undergraduate or Postgraduate students from USMKK with 1 – 2 years' experience in badminton without any prior professional training in badminton. Participants can perform basic badminton skills. (3) Participants can be male or female. (4) They are in good health as measured by Physical Activity Readiness Questionnaire (PAR-Q). (5) Participants who obtain moderate to high imagery ability scores as measured by Sport Imagery Ability Measure (SIAM). Participants with low imagery ability will be trained until they have moderate imagery ability. The exclusion criteria include: (1) Participants with prior physical injuries, chronic illnesses, psychological disorders, prior psychological skills training or professional training in badminton. (2) Participants without their full informed consent. (3) Participants with no experience at all or less than one year experience in playing badminton, badminton ability above novice level, have represented in state or higher level in badminton competition before, were excluded.

3.4 Participants Recruitment and Location of Data Collection

Poster invitation through social media was used to recruit participants. The study was conducted in Universiti Sains Malaysia Kampus Kesihatan, Kelantan (USMKK). The imagery session and execution session were both conducted at the badminton court in USMKK.

3.5 Material/Instrument/Equipment

3.5.1 Participant's demographic form

A short background information form was used to collect the participant's information such as age, gender, experience in badminton, and past imagery intervention experience.

3.5.2 Sport Imagery Ability Measure (SIAM)

Sport Imagery Ability Measure (SIAM) is one of the self-report questionnaires to access an individual's task-oriented imagery abilities. It is developed by Watt, Morris & Andersen (2004) by revising on Sport Imagery Questionnaire (SIQ) and is one of the questionnaires to be used specifically in sports (Ruiz et al., 2019). Participants were required to imagine four generic sport-related scenarios which are a home venue, a successful competition, a slow start, and a training session, with 60 seconds for each scene (Kuan, Morris & Terry, 2017). After each imagery session, participants are required to respond to the SIAM that accesses a total of 12 items across five imagery dimensions (vividness, control, ease of generation, speed of generation, and duration) six sensory modalities (visual, auditory, kinaesthetic, olfactory, gustatory, and tactile sense), and the experience of emotions during imagery. Participants responded using a 100mm-analogue scale labelled with opposing statement by marking an 'X' at a point that is the best fitting for their experience during imagery. Each item's score was added across four scenarios, and the overall score for each item was obtained. SIAM is reported to have acceptable internal consistency by Watt, Klep & Morris (2018) and is also proved to be reliable and valid to measure the imagery abilities of participants. Participants need to have at least moderate imagery ability to be able to continue in this study. In this study, participants were only required to imagine the scenarios of a successful competition.

3.5.3 Muse EEG Measure Headband

The study employed the Muse measure headband from InteraXon Inc, Toronto ON, Canada, a portable instrument that can measure and acquire the brain's electrical activities whether inside or outside of laboratory settings. Muse measure headband was used during imagery sessions and execution sessions. The brain signal detected by Muse measure is transmitted to the Muse's mobile application via Bluetooth to provide real-time feedback of the mental state. Muse measure headband is designed to have seven finely calibrated sensors, where two of the sensors located at the forehead, and two located behind the ear, act as channels, and three of them serve as a reference. Muse measure headband is worn above the earlobes with reference sensors positioned in the middle of the forehead, and it is adjustable to fit participants' head size (Adikari, Appukutty & Kuan, 2020). The sensors that act as channels give the data of the electrical activities of the brain namely gamma, beta, alpha, theta, and delta wave, and the reference sensors collect information about accelerometer, eye blinking, jaw and head movements. According to Raza, Ong, and Kuan (2020), the Muse measure is a simple, non-invasive and reliable.

Figure 3.1: The non-invasive and simplicity of Muse Measure

A study from Ratti et al. (2017) shown that quality of Muse measure data obtained from Muse EEG measure are fairly good. However, variation in power spectral density and test-retest reliability occurred. The data quality of portable Muse measure is not as good as the research-grade system (Radüntz, 2018), but it is more convenient and faster to be set up (Ratti et al., 2017). As the study location is at badminton court, portable Muse EEG measure is the most suitable system for the study's settings.

Muse measure acquire data using dry electrodes that would contribute to the presence of artifacts and affect the data quality (Ratti et al., 2017). Eye-blink, head motion, and the tension in facial muscles will create artefacts (Segawa, 2019). Therefore, participants were required to reduce eye-blinking, keep their head still, and lessen body movement while collecting the data using Muse measure headband during imagery sessions (Adikari, Appukutty & Kuan, 2020). We can only measure wave dominance using the Muse EEG measure headband; hence, epileptic wave will not be detected. The data obtained from Muse measure headband were saved as comma separated value (CSV) format (Segawa, 2019). The first and last ten seconds of raw data were excluded. Artifacts were eliminated before analysing the data. The absolute mean power of the data was used. It was calculated as the average from the four sensors such that:

$$Absolute\ Alpha\ Power = \frac{Alpha\ AF7 + Alpha\ AF8 + Alpha\ TP9 + Alpha\ TP10}{4}$$

3.6 Research Tool

Research tools in this study included PAR-Q to identify the health status of the participants; an audio script for internal imagery group in the form of mp3; a video script for external imagery group to carry out the external imagery sessions. With the guidance of audio and video script about imagery, the researcher hopes that these can help to enhance the participants' imagery skills.

3.7 Data Collection

Ethical approval was obtained from the Human Research Ethics Committee of the Universiti Sains Malaysia (USM/JEPeM/21010020), and the recruitment of participants were conducted after the approval.

Participants were given a consent form once they decided to volunteer in this study. After receiving their consent form, demographic form, PAR-Q, and SIAM questionnaire were sent out. The forms were distributed online. A briefing of the instructions of the study and a video consisting of the badminton skills that needed to be tested and the gripping method was given out to the participants. Participants were then randomly divided into internal imagery and external imagery group using Random Allocation Software 1.0.

In the meet up session in the badminton court of USMKK, the BMI of the participants were measured. Before the badminton skills execution session, participants were guided to do a warm-up session. During the session, a badminton feeder fed the shuttle to the participants and the participants performed seven badminton skills while wearing the Muse measure headband. Cool down exercise was given after the execution. Participants were then performed the imagery session according to their assigned research condition with the Muse measure headband on. Internal imagery was conducted using mp3 player with the imagery instructions to imagine the seven badminton shots, while external imagery was conducted by viewing an edited badminton tutorial videos to help the participant to imagine the seven badminton skills externally. Muse measure data were recorded and sent to the researcher's email. The total duration for the session was 40 minutes.

3.8 Statistical Analyses

All the analyses of this study were analysed using the Statistical Package for Social Science (SPSS) Version 27.0. To describe the SIAM test, the mean and standard deviation in descriptive statistics of each subscale were used. The SIAM score difference between internal and external imagery groups were analysed using Mann Whitney test. Due to the small sample size (N = 8), there is no valid test to test the normality of the data. Thus, a non-parametric test, Kruskal-Wallis test was used to analyse the median and interquartile range of brain waves between execution, internal imagery, and external imagery. Statistical significance is accepted at $p < 0.05$, and the confidence interval is set at 95%.

CHAPTER 4

RESULT

4.1 INTRODUCTION

The study was designed to examine the effect of internal and external imagery, and badminton skills execution on Muse measure among novice university badminton players. In the first subsection, participants demographic data were presented in descriptive information. In the next subsection, BMI and imagery ability as measured by Sport Imagery Ability Measure (SIAM) were presented. The difference of absolute band power between execution, internal imagery, and external imagery were presented. Lastly, the Kruskal-Wallis test was carried out to analyse the difference between each brain wave on execution, internal imagery, and external imagery.

4.2 DEMOGRAPHIC DATA

Eight participants were recruited among undergraduate and postgraduate students from USMKK. All of the participants completed the study successfully. Table 4.1 shows the demographic information of the participants. The data collected were based on participants' gender, age, year of involvement in sports and psychological skills training.

Table 4.1. Demographic information of the participants (N = 8)

	Research Condition	
	Internal Imagery	External Imagery
Gender	Male = 2 Female = 2 Total = 4	Male = 2 Female = 2 Total = 4
Age (years)	22.5 ± 2.38	24.75 ± 4.99
Involvement in sport (years)	Less than 2 years = 3 More than 2 years = 1	Less than 2 years = 2 More than 2 years = 2
Involvement in psychological skills training program (years)	None = 4	None = 4

4.3 BMI

Table 4.2 shows the BMI of all the participants according to the assigned research conditions.

Table 4.2. BMI of the participants (N = 8)

	Research Condition	
	Internal Imagery	External Imagery
BMI	25.51 ± 10.81	23.0 ± 2.13

4.4 SPORT IMAGERY ABILITY MEASURE (SIAM)

Table 4.3 shows the Sport Imagery Ability Measure (SIAM) score according to the 12 subscales. All of the participants obtained moderate to high SIAM score.

Table 4.3. Sport Imagery Ability Measure (SIAM) Subscales' Score

Subscales	**Internal Imagery**		**External Imagery**	
	Mean	**SD**	**Mean**	**SD**
Vividness	65.56	23.54	72.38	10.75
Control	39.76	23.35	66.13	21.72
Ease of Generation	58.60	14.90	69.43	12.41
Speed of Generation	71.31	18.03	70.71	10.97
Duration of Image	44.68	23.04	63.84	15.24
Visual	65.08	18.33	62.34	19.32
Auditory	35.37	21.05	52.35	22.39
Kinaesthetic	52.60	15.29	68.39	18.46
Olfactory	30.35	24.66	54.05	20.99
Gustatory	42.19	14.98	61.48	13.28
Tactile	46.02	12.37	56.40	22.82
Emotion	56.02	4.56	71.41	15.66
Total score	**607.53**	**62.62**	**768.88**	**184.30**

Table 4.4 shows the total SIAM scores between internal imagery and external imagery groups. The results show both groups were not significantly different, tested using the Mann Whitney test (*p*-value = 0.083). Thus, the participants in both research conditions have similar imagery abilities.

Table 4.4. Average Sport Imagery Ability Measure (SIAM) Score Between Two Research Conditions

Variables	**Median (IQR)**		**Z statistic**	***P*-value[a]**
	Internal Imagery (*n* = 4)	**External Imagery (*n* = 4)**		
SIAM score	49.51 (9.51)	59.84 (28.20)	-1.732	0.083

[a] Mann Whitney test

4.5 ABSOLUTE BAND POWER BETWEEN EXECUTION, INTERNAL IMAGERY, AND EXTERNAL IMAGERY

The result in Table 4.5 shows no significant difference in delta wave’s median in between execution, internal imagery, and external imagery, tested using Kruskal-Wallis test (*p*-value = 0.949).

Table 4.5. Delta Wave among Three Research Conditions

Variable	Research Condition	*n*	Median (IQR)	Chi-square statistic (df)	*P*-value*
Delta Wave	Execution	8	2.71 (0.12)	0.105 (2)	0.949
	Internal Imagery	4	2.75 (0.32)		
	External Imagery	4	2.72 (0.14)		

*Kruskal Wallis test

The result in Table 4.6 shows no significant difference in theta wave's median in between execution, internal imagery, and external imagery, tested using Kruskal-Wallis test (*p*-value = 0.063).

Table 4.6. Theta Wave among Three Research Conditions

Variable	Research Condition	*n*	Median (IQR)	Chi-square statistic (df)	*P*-value*
Theta Wave	Execution	8	2.15 (0.22)	5.537 (2)	0.063
	Internal Imagery	4	1.95 (0.18)		
	External Imagery	4	1.94 (0.08)		

*Kruskal Wallis test

The result in Table 4.7 shows no significant difference in alpha wave's median in between execution, internal imagery, and external imagery, tested using Kruskal-Wallis test (*p*-value = 0.522).

Table 4.7. Alpha Wave among Three Research Conditions

Variable	**Research Condition**	***n***	**Median (IQR)**	**Chi-square statistic (df)**	***P*-value***
Alpha Wave	Execution	8	2.33 (0.23)	1.301 (2)	0.522
	Internal Imagery	4	2.24 (0.11)		
	External Imagery	4	2.22 (0.07)		

*Kruskal Wallis test

The result in Table 4.8 shows no significant difference in beta wave's median in between execution, internal imagery, and external imagery, tested using Kruskal-Wallis test (*p*-value = 0.077).

Table 4.8. Beta Wave among Three Research Conditions

Variable	**Research Condition**	***n***	**Median (IQR)**	**Chi-square statistic (df)**	***P*-value***
Beta Wave	Execution	8	1.79 (0.24)	5.134 (2)	0.077
	Internal Imagery	4	1.54 (0.19)		

	External Imagery	4	1.54 (0.06)		

*Kruskal Wallis test

The result in Table 4.9 shows no significant difference in gamma wave's median in between execution, internal imagery, and external imagery, tested using Kruskal-Wallis test (*p*-value = 0.077).

Table 4.9. Gamma Wave among Three Research Conditions

Variable	**Research Condition**	***n***	**Median (IQR)**	**Chi-square statistic (df)**	***P*-value***
Gamma Wave	Execution	8	1.26 (0.26)	5.134 (2)	0.077
	Internal Imagery	4	1.01 (0.15)		
	External Imagery	4	0.98 (0.07)		

*Kruskal Wallis test

CHAPTER 5

DISCUSSION

5.1 INTRODUCTION

The purpose of the study is to investigate the effects of internal and external imagery, and badminton skills execution on Muse measure among novice university badminton players. This chapter present on the discussion of the findings in this study. The first subtopic discusses on the participants' demographic information. Next, participants' BMI were discussed. The subsequent subtopic was the discussion on the participants' SIAM score. Then, brain wave between execution, internal imagery, and external imagery were presented and discussed. After this, methodology issues during the study and suggestions for future study were presented.

5.2 DEMOGRAPHIC FORM

A total of eight participants were recruited from USMKK in this study. All of the participants managed to complete the study. There were two males and two females in each research condition. The mean age for the internal imagery group is 22.5 ± 2.38, while the external imagery group is 24.75 ± 4.99. All the participants were in good health as measured by PAR-Q. Three participants in the internal imagery group have less than 2 years of involvement in sport while one participant has more than two years' experience in sport. In external imagery group, two participants have less than 2 years' involvement in sport and two participants with more than two years' involvement in sport. None of the participants received psychological skills training before. This mean that participants in both research conditions were equally distributed with gender matched, and their involvement in sport were similar.

5.3 BMI

Participants in the internal imagery group have the mean BMI of 25.51 ± 10.81, while the external imagery group have the mean of 23.0 ± 2.13. Participants in both research conditions showed similar BMI during the baseline measurement.

5.4 SPORT IMAGERY ABILITY MEASURE (SIAM)

As all of the participants are novice badminton players and did not undergo any psychological skills training, the Sport Imagery Ability Measure questionnaire is given out to ensure that the participants have sufficient imagery ability to perform the imagery session given. All of the participants obtained moderate to high imagery ability scores as measured by SIAM. There is no valid test for normality when the sample size is less than n = 15, therefore Mann Whitney test was used to compare between average SIAM score of the internal and external imagery group. The external imagery group obtained a higher median score (59.84) than the internal imagery group (49.51). However, the result shows that the SIAM score between the internal and external imagery groups was not significantly different, tested using Mann Whitney test (p-value = 0.083). This result indicates that the imagery ability of the participants from both groups was similar. Thus, both groups were statistically equal in their imagery abilities at baseline, and additional training was not required to increase the participants' imagery ability. A similar result was found by Kuan et al. (2018), showing that all three groups of dart-throwers showed no significant difference between the three research conditions on imagery ability.

5.5 ABSOLUTE BAND POWER BETWEEN EXECUTION, INTERNAL IMAGERY, AND EXTERNAL IMAGERY

While comparing the absolute band power during execution, internal imagery and external imagery of badminton shots, delta wave is the highest during internal imagery (median = 2.75) whereas theta, alpha, beta, and gamma waves were the highest during execution (median for theta = 2.15; alpha = 2.33; beta = 1.79; gamma = 1.26). However, from the Kruskal-Wallis test conducted for each brainwave, there is no significant difference in each of the median of brainwaves between execution, internal imagery, and external imagery (*p*-value for delta = 0.949; theta = 0.063; alpha = 0.522; beta = 0.077; gamma = 0.077).

A study from Kim *et al.* (2014) mentioned that the delta wave was eliminated during the analysis of their study as delta wave are very likely to compromise to eye blinking and head movement. Gamma wave is also reported to have strong reduction by the head structures as it is hard to be observed using scalp electrode and can be interrupted by muscle artifacts (Ginter *et al.,* 2005).

A dissertation from Behrmann (2016) shows that alpha wave is more pronounce while comparing to beta wave during imagery session. The result was contradicted from a study mentioned earlier. The study from Jung-Hee, Eun-Jung & Byoung-Hee (2013) suggested that action observation training (external imagery in the context) induced a higher level of cognitive activity as compared to motor imagery (internal imagery) or solely physical training among stroke patients. Thus, external imagery training possessed a higher beta power. In contrast, alpha wave in external imagery group is lower. However, both brainwaves are similar in internal and external imagery in the current study. There is also limited study on the brainwaves during execution of certain sport. In the current study, the median of alpha and beta waves during execution is the highest among the three research conditions.

Research shown that theta wave is associated with memory load where theta oscillation increases when there is memory load in a working memory task (Gundel & Wilson, 1992; Gevins *et al.*, 1997). A research from Li *et al.* (2009) compared the theta activity among digit imagery task, jogging imagery tasks, and button pressing task. They found that digit and jogging imagery task which associated with memorizing and working memory show higher theta power.

The result of this study is rather interesting, showing that no significant difference was found between the internal imagery, external imagery and badminton execution. This means that internal imagery and external imagery are comparable with the actual badminton execution. According to Kuan et al. (2017), using the functional equivalence theory, imagery causes the brain to activate in the same areas and processes as when the movement is executed. Thus, both perspectives showed similar brainwaves with the actual badminton execution by performing the internal and external imagery. Besides, although the actual badminton execution showed the highest theta, alpha, beta and gamma waves, the waves are higher due to the actual movements of the participants, whereas both internal and external imagery conditions, the participants sat at the chair to conduct the imagery sessions. Thus, less artefacts were observed in the internal and external imagery conditions, than the actual movements, which might create some artifacts during the data collection.