

**SUPERVISED PATTERN RECOGNITION OF ARCHERS' RELATIVE  
PSYCHOLOGICAL COPING SKILLS AS A COMPONENT FOR A BETTER  
ARCHERY PERFORMANCE**

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**ABSTRACT**

The current study explores the most significant psychological skills needed for the accomplishment of high archery scores and determines the discriminating psychological coping skills needed for archery performance. 32 archers completed psychological coping skills inventory before their shooting tests. Multivariate techniques of principal component analysis, hierarchical agglomerative cluster analysis and discriminant analysis were applied. The rotated PCA indicates 3 parameters containing 6 and 3 principal components (Pcs). The first Pcs reveal high loadings from three psychological skills. The second Pcs disclose high loadings from two skills, while the third Pcs demonstrate a high loading from only one skill. HACA classified the archers into two classes viz. High-performance group and low-performance group. DA discriminates the classes with an excellent accuracy of 93.55%.

**Keywords:** archery; pattern recognition; psychological coping skills; multivariate analysis.

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## 1. INTRODUCTION

In the sport of archery, several skills are necessary to direct arrows to the target. The shooting process is the core quota of the archery skill. Mental concentration couple with visual focus plays a key role in its successful performance. It has been documented that archery performance is linked with motivation, mental concentration, stress and anxiety management, self-confidence and emotion control [1]. Moreover, previous researchers inferred that there are many types of attention associated with archery namely visual attention, mental attention and selective attention [2]. Visual attention and mental attention are involved in the normal shooting process. In competition, since there are several noises, tensions and anxiety, selective attention in shooting becomes significant. In the shooting process, the emotional focus may be involved first but visual attention will play a meaningful role in the later part of the shooting process. Therefore, shooting training should consider this transition of attentions to building the archer's confidence to overcome such challenges during real competition.

Numerous researchers have attempted to offer insights on the effects of psychological skills to the improvement of athlete's performance in various sports. Some researchers investigated the roles of psychological factors on the performance of elite soccer players and concluded that although psychological factors alone could not predict the performance of elite soccer players, they a significant role in enhancing athletic performance [3]. Likewise, research has indicated that those psychological elements such as stress and worry could be a major factor in hindering athlete's performance [4-5]. They further stressed that athletes who are unable to cope with stress and adversity effectively might likely suffer from performance declining and general psychological well-being issues. It has been reported that the sport of archery, shooting involves several important phases such as stance, holding the bow, raising and pulling back, aiming, releasing and observing [6-7]. These phases are vital for archery performance. Therefore, considerably essential for an archer to execute them efficiently and to do so, some psychological as well as physiological factors play a major role in the process [8].

Many of these theoretical and investigational work concerning psychological factors in the sport of archery have concentrated on anxiety, mainly pre-competition anxiety. This is due to

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the obvious physiological variations related to anxiety and because of investigation proposing extreme performance and health effects connected with anxiety and stress. There has also been substantial interest paid to more expectant “flow state” emotions [9], which are more psychologically based in nature such as feelings of joy, fun, competence, control and peacefulness which are occasionally accredited with positively influencing performance.

Numerous scientific scales have been developed for application in attempting to measure psychological factors in sports. The Competitive State Anxiety Inventory, the Sports Anxiety Scale, The Sports Competition Anxiety Test and Smith’s Sports Performance Anxiety Scale are but a little of the many such tests which measure anxiety states. Anxiety is not the only limited to emotion which has stimulated the advancement of several emotional evaluation scales. Moreover, Anger, hostility and aggression are also commonly evaluated applying an assortment of scales like the Buss-Durkee Hostility Inventory (BDHI), the Buss-Perry Aggression Questionnaire (BPAQ), the Anger Inventory (AI) and the Anger Expression Suppression Scale (AX) to mention just a few. There is also the availability of anger, hostility and aggression measures usually utilized in sport comprising the Aggressive Tendencies in Basketball Questionnaire (ATBQ), the Bredemeier Athletic Aggression Inventory (BAAGI), the Rise Reactive Aggression Measure for Baseball (RRAMB) 144 and the Sports Aggression Questionnaire (SAQ) and so on. The depth of improvement of instruments to evaluate several hypotheses connected to psychological components such as anger, attention, personality, relaxation, cognitive ability, aggression, anxiety and stress are not surprising when one reflects the pressures stroked by athletes and coaches to optimize athletic performance, especially in a sport like archery. However, another authors revealed that psychological components are one of the fundamental reason for failure and success in sporting activity [10]. They inferred that this explanation could be comprehended by reflecting that most athletes with higher physical and technical abilities and less sound psychological preparation in their domain are unable to produce a good result.

A single error in shooting might lead to significant impacts on the performance outcome and psychological states of the archer. The frequent search for effective psychological strategies potentially contributing to the improvement of performance in the various sports has long

been documented. The uniqueness of each sport places a special demand on the athlete participating in it. It is necessary consequently to apply different approaches to psychological skills related with expertise in each sport in order to specifically identify the psychological skills needed in the particular sport. However, to date, there seems to be limited research to systematically identify the most essential psychological skills necessary for the achievement of greater archery scores through the application of supervised pattern recognition. Hence, the current study endeavour to determine the relationship or psychological coping skills and a successful performance of archery as well as to discover the most significant psychological skills that contribute to the achievement of high archery scores

## **2. METHODOLOGY**

### **2.1. Participants**

A total number of 32 archers were recruited to participate in this study. The participants were 24 male and 8 female youth archers between the ages range of 13-24 with a mean and standard deviation of  $(17.0 \pm 3.4)$  drawn from Terengganu sports council, Malaysia. The archers are under a development program for training both at university and the state level and subsequently, targeted to be promoted to state and national archers respectively. The coaches and the stakeholders of the council were informed about the purpose of the research. Written approval was obtained, and all the archers signed consent forms. All the procedures, protocol and apparatus for this study were permitted by the Research Ethics Board of the Terengganu Sports Institute (ISNT) with a reference number 04-04/T-01/Jid 2.

### **2.2. Psychological Inventory Assessment**

#### **2.2.1. The Athletic Coping Skills Inventory (ACSI)**

A measure of an athlete's psychological skills established by the preceding researchers was adopted [11]. This instrument is perceived appropriate for assessing the psychological skills of the archers in this study because of it relevant to the nature of archery game as an individual sport rather than a team sport. The ACSI has been reported to be valid and reliable for assessing the psychological coping skills of athletes [12-13]. The instrument measured seven basic psychological constructs namely Coping with Adversity which determined

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whether an athlete remains active and enthusiastic even when things are going badly, remains calm and controlled and can rapidly rebound back from mistakes and setbacks.

### **2.2.2. Coachability**

It evaluates if an athlete is exposed to and learns from coaching, and accepts constructive criticism without taking it personally and becoming upset.

### **2.2.3. Concentration**

This subscale reveals whether an athlete becomes easily distracted and can center on the activity at hand in both training and game situations, even when adverse or unexpected circumstances occur.

### **2.2.4. Confidence and Achievement Motivation**

It assesses if an athlete is assertive and confidently motivated, constantly gives 100% during training and games, and works hard to develop his or her skills.

### **2.2.5. Goal Setting and Mental Preparation**

It measures whether an athlete sets and works toward precise performance goals, plans and emotionally prepares for games, and undoubtedly has a game plan for performing well.

### **2.2.6. Peaking Under Pressure**

It evaluates if an athlete is challenged rather than threatened by stress situations and executes well under pressure.

### **2.2.7. Freedom from Worry**

Measures whether an athlete puts pressure on him- or herself by worrying about playing poorly or creating mistakes; worries about what others will think if he or she performs poorly. The instrument was distributed to the archers prior to the shooting test and their responses were collected and analyzed. Although, the inventory was previously validated, but the inventory was again pretested and validated for the subjects under study. The items from the inventory demonstrated acceptable values with a range between 0.67 to 0.82, which further indicated that the inventory possessed a good internal consistency and reliability.

## **2.3. Archery Shooting Score Test**

A simulated shooting competition area was set up and all the archers' shoot six arrows (one end) over a distance of 50 meters. All the archers were given trials of four arrows shot before

recording the final six arrows scores.

#### **2.4. Data Analysis**

The strongest pattern recognition [28] method that is generally combined with HACA is the principal component analysis (PCA). PCA was used in the study in order to give insights into the most essential variables due to the differences of relative performance variables that explain the whole data set and as such by lessening huge variables with a considerably limited loss of the original data [14-15]. Hierarchical agglomerative cluster analysis (HACA) was applied to isolate the classes of the relevant performance variables measured. Discriminant analysis (DA) was employed using the standard, forward stepwise and backward stepwise methods. These methods were used to construct degree of freedoms (DFs) to evaluate relative performance variations in the psychological coping skills and the archery shooting performance. The relative performances of the archers were the accumulated (dependent) variables whereas all the assessed components constitute the independent variables. Similarly, in the forward stepwise mode, the variables were counted step by step beginning with the highest significant variable until no significant changes were obtained. In the backward stepwise mode, variables were eliminated step by step starting with the less important variable until no significant changes were obtained. Before application of the statistics on the data obtained, normality test was conducted using Shapiro-Wilk and the archers were found to be homogeneously distributed. All the statistical analysis was performed at  $p \leq 0.05$  alpha level of confidence using XLSTAT 2014 add-in software.

### **3. RESULTS AND DISCUSSION**

Table 1 demonstrates the descriptive statistics of the parameters evaluated. The number of the participants, the minimum, maximum scores, mean as well as the standard deviation of each parameter is shown.

Table 2 shows the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy. This test was implemented to determine the adequacy of the sampling to quantify as well as to make a reasonable interpretation based on the data gathered [16-17]. Similarly, the test was conducted to ensure that the variables are not related to each other. The KMO value from the table shows

0.60, which indicated that the number of the participants are adequate to make a realistic interpretation as suggested by the previous researchers [18]. Therefore, based on this result it is apparent that there is no multicollinearity observed among the original variables and that enabled us to proceed further with the PCA analysis having satisfied the measure of the sampling adequacy.

**Table 1.** Descriptive statistics of the evaluated parameters

Variable	N	Min	Max	M	SD
Coping With Adversity	32	4.00	10.00	7.00	1.83
Coachability	32	2.00	8.00	5.16	1.30
Concentration	32	2.00	9.00	5.84	1.55
Confidence and Achievement Motivation	32	3.00	11.00	7.41	1.68
Goal Setting and Mental Preparation	32	3.00	11.00	6.97	1.89
Peaking Under Pressure	32	4.00	8.00	5.44	1.22
Freedom From Worry	32	2.00	10.00	5.88	1.81
Archery Shooting Scores	32	17.00	57.00	45.19	10.42

**Table 2.** Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy

Variables	Values
Coping With Adversity	0.61
Coachability	0.60
Concentration	0.68
Confidence and Achievement Motivation	0.62
Goal Setting and Mental Preparation	0.69
Peaking Under Pressure	0.21
Freedom From Worry	0.34
KMO	0.60

Fig. 1 displays the scree plot of the eigenvalue for the initial PCA. From the figure, it can be observed that the PCA identified three components as the most essential due to their higher eigenvalues greater than 1 ( $> 1$ ). These components were retained and used as an input

variable for further analysis.

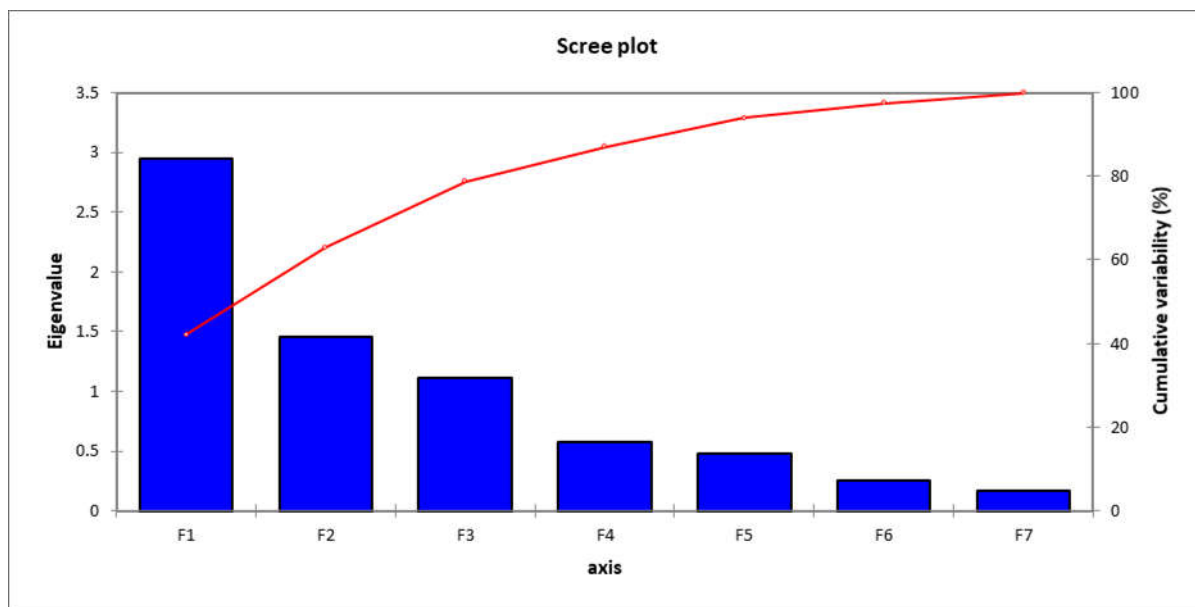


Fig.1. Scree plot for PCA

Table 3 discloses the PCA after varimax rotation. It can be seen from the table that from VF1 three parameters fulfilled the 0.70-factor loading threshold. The VF2 identified two parameters while the VF3 revealed only one parameter. Fig. 2 projects the most significant parameters after varimax rotation likewise, the contribution of each varifactor within the components as well their variability is shown. It can be observed from the figure that VF1 and VF2 contributed to about 62.75% of the total data set and the variability of 38.74% and 24.02 % respectively.

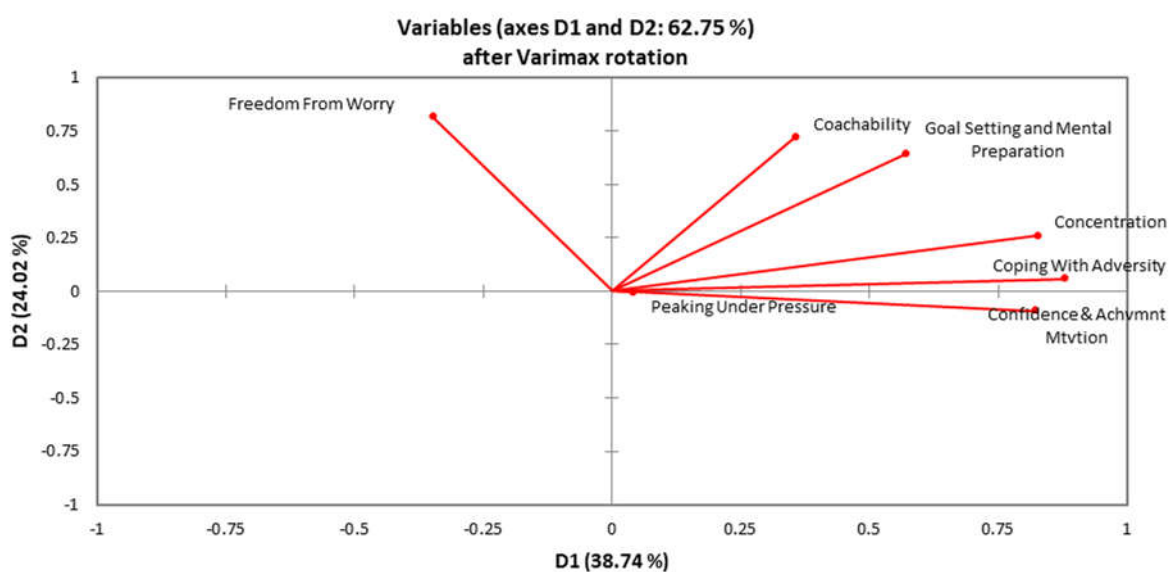
Table 3. PCA Factor loading after varimax rotation

Variables	Pcs1	Pcs2	Pcs3
Coping With Adversity	<b>0.88</b>	0.06	0.17
Coachability	0.36	<b>0.72</b>	-0.07
Concentration	<b>0.83</b>	0.26	0.07
Confidence and Achievement Motivation	<b>0.82</b>	-0.09	-0.19
Goal Setting and Mental Preparation	0.57	0.65	-0.27
Peaking Under Pressure	0.04	-0.01	<b>0.98</b>
Freedom From Worry	-0.35	<b>0.81</b>	0.17
Eigenvalue	2.95	1.45	1.11



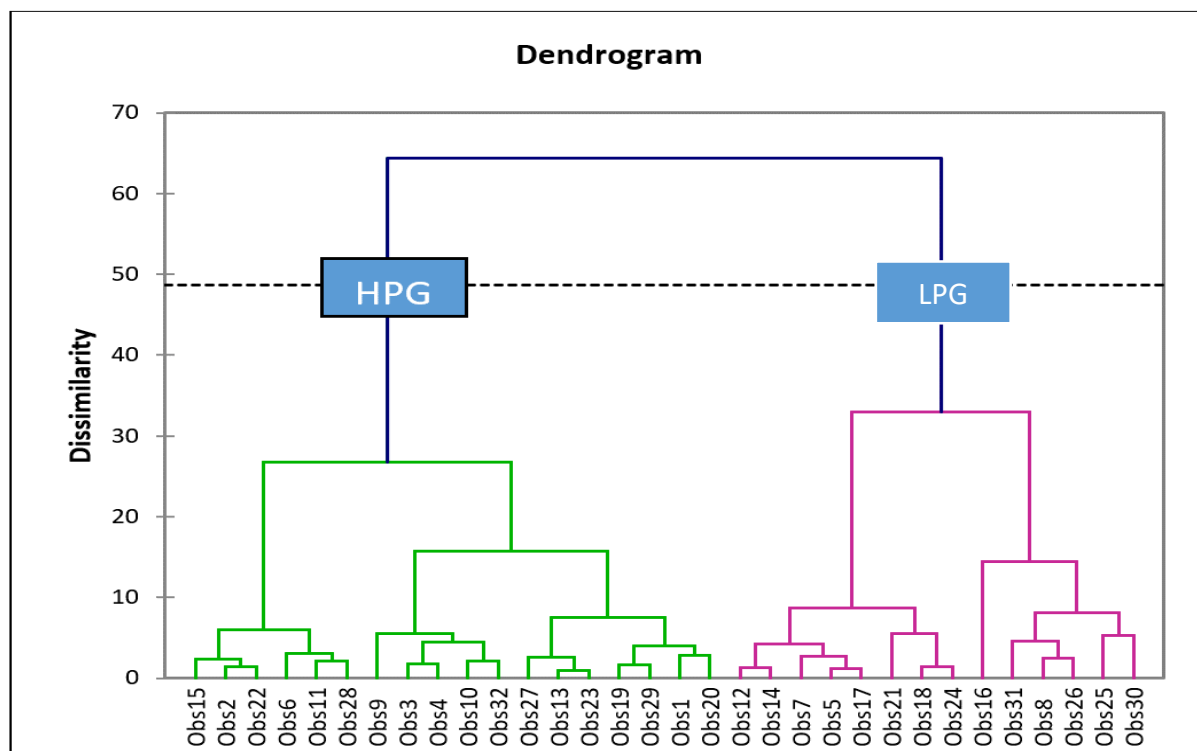
Variability (%)	42.18	20.77	15.89
Cumulative %	42.18	62.95	78.84

Fig. 3 displays the grouping of the archers in relation to their performance classes determined by HACA, which is based on the similarity level of the relative performance variables evaluated. It can be observed from the figure that two classes are defined by HACA namely high-performance group (HPG) and low-performance group (LPG), which is based on their scores on the evaluated parameters and the corresponding observations are given under each cluster.



**Fig.2.** Factor loading plot after varimax rotation

Table 4 illustrates the discriminant analysis conducted for the further analysis. The DA was applied on clusters defined by HACA in order to view through variation of relative performance. The clusters act as the dependent variable, while the psychological coping skills variables and the archery shooting scores were treated as independent variables. Standard, backward stepwise and forward stepwise mode methods were selected to perform the DA. The precision of classification using standard, backward stepwise and forward stepwise was excellent 93.55% with eight independent variables across all the methods. Similarly, we found that 18 archers are classified to HPG while 13 archers into LPG. However, one archer did not fit into any of the defined classes and therefore was automatically eliminated from the classification.



**Fig.3.** Dendrogram of the two classes assigned by the Cluster Analysis

**Table 4.** Classification Matrix of the Discriminant Analysis on the two classes in relation to their performances on the variables measured

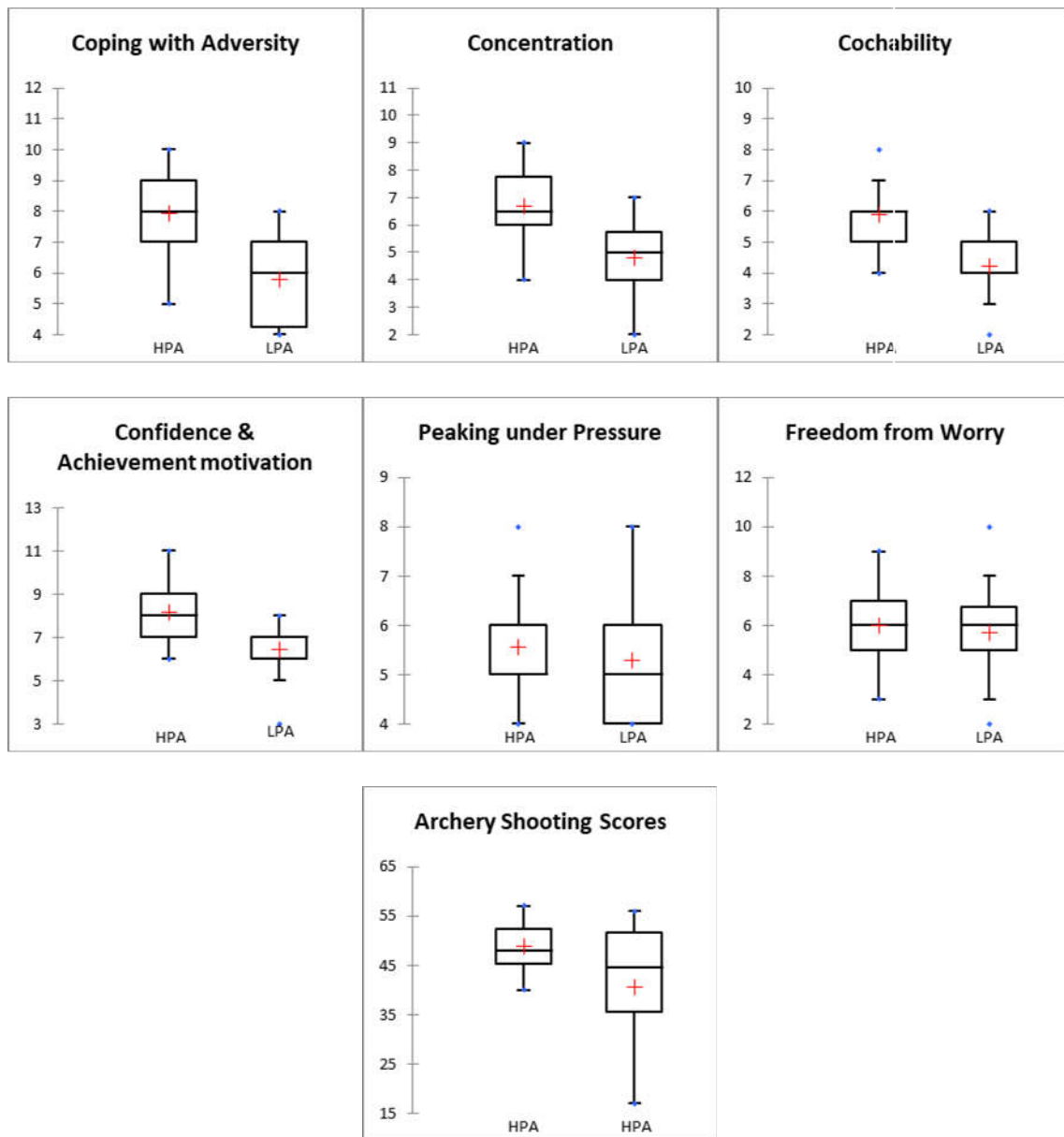
Assigned Classes	% Correct	Classification Matrix Assigned by DA	
		HPG	LPG
Standard mode (7 independent variables)			
HPG	88.89%	16	0
LPG	100.00%	2	13
Total	93.55%	18	13
Backward stepwise (7 independent variables)			
HPG	88.89%	16	0
LPG	100.00%	2	13
Total	93.55%	18	13
Forward stepwise (7 independent variables)			
HPG	88.89%	2	13
LPG	100.00%	16	0

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Total	93.55%	18	13
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Fig. 4 displays the performance differences of the archers based on the seven performance parameters discriminated by DA. It can be observed from the box plots that the mean performances of HPG are greater than LPG across all the parameters (Coping with Adversity, Concentration, Coachability, Confidence and Achievement Motivation, Peaking Under Pressure, Freedom from Worry, Archery shooting scores). These parameters are therefore considered the vital attributes that distinguished HPG from LPG.



**Fig.4.** Box plots of the two classes in relation to the performances differences on the measured variables highlighted by the DA across all the modes

#### 4. DISCUSSION

The aims of the current study were to determine the relationship of psychological coping skills and a successful performance of the archery sport and to discover the most significant psychological coping skills that contribute to the achievement of high archery scores. To achieve the aims of this study, we employed 32 archers from different archery programmes in Terengganu Malaysia. We assessed the archer's psychological coping skills through an inventory questionnaire primarily developed by the previous researchers to evaluate the coping skills possess by athletes. The archers shooting scores were recorded prior to the psychological assessments. We utilised PCA, HACA as well as DA statistical analysis to ascertain the most essential psychological coping skills parameters contributing to the achievement of high archery shooting scores, determine the clusters of the archers and identify the distinguishing features of the clusters. HACA has indicated clusters of the performance groups (Fig. 3) and DA has discriminated the clusters based on their performances in the predicted variables (see Table 3 and Fig. 4). However, in the current study, Pcs with absolute values greater than 0.70 for the PCA were standardised as the selection threshold due to the fact that these values are considerably solid and stable, which indicates moderate to strong loadings on the extracted factors. It demonstrated that 6 psychological parameters satisfied the 0.70-factor loading threshold (Table 4 and Fig. 5). These parameters are then classified as the necessary psychological coping skills parameters contributing to higher archery shooting scores. Nevertheless, each of these variables contained varifactors associated to it.

The Pcs1 contributes to about 42.18% of the variation in the psychological coping skills parameters data. It has indicated high positive factor loadings from three parameters, which are coping with adversity (0.88), concentration (0.83) and confidence and achievement motivation (0.82). Considering the nature of these psychological skills parameters, they can be interpreted as confidence and self-motivational skills. The finding highlighted the need for confidence and self-motivational in the sport. Archery is an individual competitive sport that requires the archer to compete individually against another archer. For an archer to achieve a higher score, he or she must be able to have confidence and be self-motivated to contest. The

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cognitive method to the study of achievement motivation and confidence established that strivings for success are facilitated through some cognitive mechanisms. A growing body of evidence in sports, however, suggests that one's perception of ability or self-confidence is the essential element contributing to the achievement in any chosen sport [19-20]. Moreover, it has been reported that confidence and self-motivation are the indicators of a champion. They are the secret components that all great athletes appear to possess, irrespective of what level they contest since constructive mental attitude keeps an athlete working hard regardless of how many times he/she may fail or how many obstacles get thrown in his/her path [21]. Confidence and self-motivation can give an average athlete or team the courage and focus to defeat a stronger opponent. These psychological skills can inspire an athlete to attempt and accomplish the impossible. Similarly, lacking confidence and self-motivation could make athletes continually perform way below their potential. Low confidence and self-motivation can destroy an athlete's enjoyment of the sport and turn him/her into a dropout and a constant loser [22].

The Pcs2 from Table 3 accounted for about 62.95% of the variability in the psychological coping skills parameters data. It demonstrates positive higher factor loadings from coachability (0.72) and freedom from worry (0.81). The finding from this particular Pcs revealed the requirement for focus and concentration skills are an element of higher archery shooting scores. Archery competition in the major International event became more competitive. The FITA Olympic Round in which all the matches are competed face to face shooting format. This new shooting process affects archer's shooting skills as well as mental aspect. Therefore, how the archer feels and concentrate during the competitive situation is the most decisive indicator for winning. Similarly, concentration has been defined as the capability of an athlete to overlook external factors that would otherwise divert him/her from performing at the optimum level [11]. However, previous authors reported a significant positive relationship between the concentration of an athlete and his overall performance [23]. They stated further that the way the athlete concentrates directly affects his behaviour and performance outcome. Possession of positive concentration strategies can help limit distraction and boost the performance of an archer. Our finding has further revealed that

concentration is a vital factor in the performance of archery sport.

The Pcs3 contributes for about 78.84% of the variation in the psychological coping skills parameters data. It has shown high positive factor loading from peaking under pressure (0.98). The finding from this Pcs revealed the necessity for coping with pressure during archery competitions. Athletes have a number of stimuli to focus on while contending in a competition such as archery. Nonetheless, the sum of information that an athlete can process at a particular time is limited [24]. During or prior to competitions, many athletes face some pressures. For example, if athletes fear about performance assessments from coaches and parents, they tend less likely to fruitfully attend to competitive stimuli and such might hinder their optimum performance resulted in worry and stress for the athlete [5, 25]. Pressure is an element of sports competitions and consistently exist especially in an individual sport like archery where the archer has to compete independently against each other. The coping with pressure under such situation comprises of cognitive measures and behavioural activities of the archer to manage stress, and it is a key indicator that can play an essential role in the emotional adjustment of athletes and hence achieve better performance [26-27]. The present of stressful elements during competition in archery competitions such as committing physical or mental errors, experiencing soreness and discomfort, losing, observing undeniable success from an opponent, the audience noise, violating the set rule and getting criticism from the coach renders the possession of effective coping with pressure skills unavoidable in order to achieve athletic success while the incapability to deal with those aforementioned stressful factors efficiently could lead to poor performance [4]. The current result from Pcs 3 has portrayed the necessity for an archer to acquire an effective skills for coping with pressure during competition as a secret for achieving a higher archery scores.

## **5. CONCLUSION**

The present study has successfully evaluated various psychological coping skills that could play a role in the successful performance of archery. The findings demonstrated that to achieve success in a sport of archery, certain psychological skills are necessary. The most needed psychological skills in the sport are; confidence and achievement motivation,

concentration and coping with pressure during competition. Therefore, the study suggested that archery as a closed skill sport, archers must possess the aforementioned psychological skills for success in the competition. These findings may help archers and coaches recognise and develop strategies to improve the skills for better performance. Further study might be required to assess the differences of these skills among gender and level of participation as well as appropriate training approaches for improving the skills.

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