

**THE EFFECTS OF INTEGRATING
BIOFEEDBACK IN PERIODIZED TRAINING
PROGRAM ON PSYCHOPHYSIOLOGICAL,
PHYSICAL FITNESS AND SHOOTING
PERFORMANCE AMONG JUNIOR ARCHERS**

by

MON REDEE SUT TXI

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LIST OF ABBRIATIONS

ANOVA	Analysis of Variance
GSR	Galvanic Skin Response
HR	Heart Rate
VO ₂ max	Maximal Oxygen Consumption
CSAI-2R	Competitive State Anxiety Inventory – 2 Revised
SPA – R	Sport Psychology Attitudes – Revised
RST	Resistance Training
BFT	Biofeedback Training
PT	Physical Training



KESAN INTEGRASI BIOFEEDBACK DALAM PROGRAM LATIHAN PERIODISASI TERHADAP PSIKOFISIOLOGIKAL, KECERGASAN FIZIKAL DAN PRESTASI PANAHAH DIKALANGAN PEMANAH REMAJA

ABSTRAK

Tujuan kajian ini dijalankan adalah untuk mengkaji kesan integrasi biofeedback dalam program latihan periodisasi terhadap hasil psikofisiologikal, kecergasan fizikal dan prestasi memanah di kalangan pemanah remaja. Kajian ini melibatkan reka bentuk pra dan pasca eksperimen dengan kumpulan kawalan dan dua kumpulan eksperimen. Seramai dua puluh satu pemanah remaja (purata umur=15.0±1.7 tahun) telah menyelesaikan keseluruhan protokol kajian. Peserta dipadankan mengikut jumlah mata panahan dan dibahagikan kepada tiga kumpulan; kumpulan latihan *biofeedback* (BFT), kumpulan latihan fizikal (PT) dan kumpulan kawalan. Kedua-dua kumpulan eksperimen menjalani program latihan periodisasi yang disediakan oleh pengkaji selama tiga bulan, sementara kumpulan kawalan meneruskan program latihan periodisasi yang disediakan oleh jurulatih mereka untuk tempoh yang sama. Semua parameter diukur sebelum intervensi, selepas intervensi kedua, selepas intervensi ketiga dan selepas intervensi keempat. Set soalan *Competitive State Anxiety-2 Revised* (CSAI-2R) telah digunakan untuk mengukur *competitive state anxiety*. *Skin Conductance sensor* (SC-Flex/Pro) digunakan untuk mengukur *galvanic skin response* (GSR), *BioGraph Infiniti version 5.1* (Montreal, Canada) dan *polar heart rate monitor* (S710i, Polar Electro Oy, Finland) digunakan untuk mengukur pembolehubah fisiologi dan *Sport Psychology Attitudes-Revised* (SPA-R) untuk menilai sikap atlet terhadap psikologi sukan. Hasil analisis variance



(ANOVA) menunjukkan terdapat interaksi yang signifikan antara kumpulan eksperimen ($p < 0.05$) dengan kumpulan kawalan sepanjang pengukuran untuk pembolehubah *galvanic skin response* (GSR), ujian *core strength*, ujian *bow arm holding*, ujian *multi-stage fitness* and ujian *maximal oxygen uptake* (VO_2 max). Tiada perbezaan yang signifikan diantara kumpulan eksperimen dan kawalan bagi kadar nadi, keseimbangan kompetitif seketika, tekan tubi, dirian bangau dan prestasi memanah. Selain itu, sikap semasa sesi pengukuran untuk semua ujian menunjukkan bahawa kebanyakan atlet bagi kumpulan BFT dan PT dilihat menunjukkan sikap positif terhadap perundingan psikologi sukan dan hasil prestasi dalam kebanyakan parameter. Dapat disimpulkan bahawa program integrasi *biofeedback* dan program latihan periodisasi yang disediakan oleh penyelidik berkesan dalam meningkatkan psikologikal dan kecergasan fizikal dikalangan pemanah remaja.



THE EFFECTS OF INTEGRATING BIOFEEDBACK IN PERIODIZED TRAINING PROGRAM ON PSYCHOPHYSIOLOGICAL, PHYSICAL FITNESS AND SHOOTING PERFORMANCE AMONG JUNIOR ARCHERS

ABSTRACT

The aim of this study was to investigate the effects of integrating biofeedback training into a periodized training program on psychophysiological, physical fitness and shooting performance outcomes among junior archers. This study involves a pre and post experimental design with a control group and two experimental groups. Twenty-one junior archers (Mean age=15.0±1.7 years) completed the whole study protocol. Participants were matched according to their shooting scores and they were assigned into either three groups; biofeedback training group (BFT), physical training group (PT) and control group. Both experimental groups underwent three months of periodized training program provided by the researcher, while the control group continued their training program provided by their coach until the end of the study period. All parameters were measured at pre-intervention, after one month of intervention, after two months of intervention, and after three months of intervention. The revised Competitive State Anxiety-2 (CSAI-2R) was used to measure competitive state anxiety. Skin Conductance sensor (SC-Flex/Pro) was used to measure galvanic skin response (GSR). BioGraph Infiniti version 5.1 (Montreal, Canada) and polar heart rate monitor (S710i, Polar Electro Oy, Finland) were used to measure the physiological variables and Sport Psychology Attitudes-Revised (SPA-R) to evaluated athletes' attitudes toward sport psychology. The results of Mixed Factorial Analysis of Variance (ANOVA) revealed significant interactions between





experimental groups across the measurement sessions ($p < 0.05$) compared to the control group for galvanic skin response (GSR), core strength test, bow arm holding test, multi-stage fitness test, and maximal oxygen uptake (VO_2 max) test. No significant interaction between the experimental group across measurement session for heart rate, competitive state anxiety, stork stand, push up and archer performance. Furthermore, the positive attitude and negative attitude across the measurement sessions for all the tests showed that most of the athletes in BFT and PT groups were positive toward sport psychology consulting and performance outcome in most of the parameters. It can be concluded that the biofeedback and periodized training program are effective in improving the psychophysiological and physical fitness among junior archers.





CHAPTER 1

INTRODUCTION

1.1 Background and Scope of the Study

Archery is one of the oldest professional games which has been established by The International Archery Federation (FITA) since 4th September 1931 and is now known as the World Archery (WA) Federation. It is contested in the Olympic Games with various rules and format of the competition (Lee and Benner, 2009). It is also one of the sports that is contested at the Olympic Games since the 1972 Olympics in Munich. Since then, participation for this sport has become increasingly popular in many countries including Malaysia. This is due to medal potential in world-class competitions including the Olympic Games. The Malaysian national archer first qualified for the individual event in the 2004 Olympic Games and has since been a regular contender in 2008, 2012 and 2016 Olympic Games.

It is generally acknowledged that a periodised training programme contributes to the improvement in performance of a wide range of sports including archery. According to David (2000), periodised training programmes are built with an organised design that comprises training, physical and other aspects required in that sport. The objective is to achieve the optimum level of performance in a competition that has been set during that year (Arnd Krüger, 1973). Preparation, competition, and transitions are three main phases proposed by Bompa (1990) in periodisation programmes. The main goal of periodisation training is to help athletes in various aspects and it involves preparation and planning in short, moderate and long seasonal. According to Bompa (1999), high, and low to moderate volume of training intensity





must be given attention during the preparation phase. During this phase, athletes will perform more on low-intensity exercises and also repetitions.

A mental training programme periodisation training should also be an integral part of the athletic preparation. Therefore, the mental training techniques which should be in a training programme include techniques such as relaxation, concentration, meditation, imagery and biofeedback training, so that the athlete will be better prepared for the practice and competition. Behncke (2004) stated that high performing athletes need to have strong mentality levels, high skill performance and also physical capabilities. A strong mentality can help athletes in handling and managing themselves in terms of anxiety, self-confidence and in controlling emotion during training or competition (Young and Pain, 1999). According to Gandelsman and Smirnov (1970), it has been proposed that an annual training programme must meet

the specific demands of sports such as archery. They proposed that:

- All voluntary sports activity is performed in coordination with complicated muscle contractions in a static and dynamic state.
- Archery and shooting have the characteristics of less vigorous muscle contraction action.
- Archery and shooting demand the coordination of fine muscles and are mainly related to stress regulation and the control of the mental state and endurance during the competition.
- Archery shooting skill is a self-paced or closed skill.
- Archers must have mental and psychological skills for the success of the competition.

Stuart (1990) has reported that each level of athlete (expert or beginner) uses similar types/quality of equipment, thus what distinguishes their achievements is their





self-control actions. In archery, in order to shoot the arrows consistently into the center of the target, specific routines and the same repetitions have to be implemented. However, to perform these routines with the desired result, the physical and mental components must be in balance. Many researchers agreed that archery is mostly a mentally oriented sport (Acikada et al. 2004; Caterini, 1993; Cizmek, 2011; Filho et al. 2008; Frangilli, 2005; and Lee et al. 2005), but strong evidence and the result of the study on specific mental training are still limited.

Studies have found that archery is a sport with less movement and requires high concentration. The mental training programme has proven to be a great advantage and has helped athletes to improve their performance. Blumenstein, Lidor and Tenenbaum (2005) have explained that psychological skills' training is aimed to help athletes and teams to overcome their psychological barriers in achieving their objective.

Psychological skills can be practiced with various methods including self-talk, meditation, relaxation technique, progressive muscle relaxation, biofeedback and imagery (Murphy and Tammien, 1998). A review on sports psychology literature reveals that several of these methods and approaches to mental training were applied with athletes (Sachs, 1991). Among the approaches, biofeedback is often used to improve an athlete's performance (Zaichkowsky and Fuchs, 1988, 1989).

Given the heavy demand on mental orientation for archery performance, biofeedback is an appropriate technique to regulate muscle tension and to improve mental skill. A growing number of evidence has indicated the effectiveness of biofeedback in psychological related sport performances domains. According to Durand, Vincent, Barlow and David (2009), many physiological functions can be obtained from biofeedback. It can help in the process of gaining awareness to regulate them according to our needs or purpose. Various types of human physiology can be





controlled (deCharms, Maeda, Glover; et al. December 2005) such as heart rate, skin conduction and many more by using biofeedback together with other materials (video and audio) to obtain high-quality outcomes (Davis et al., 2005).

Biofeedback provides great benefits to the sport of psychophysiology to help athletes achieve better results. Landers (1988) and Petruzzello, Landers, and Salazar (1991) stated that biofeedback has been used with some physiological sensors in gaining high performance in many sports disciplines via psycho-regulation. Lately, closed-skilled sports have earned the attention from biofeedback researches to identify the athlete's psychological states with better performance (Collins, 1995), notably, the application of biofeedback has also been applied in archery (Filho, Moraes, and Tenenbaum, 2008; Salazar et al., 1990).

Caterini (1993) investigated seven archers using electrocardiogram, electromyography and electroencephalogram (EEG) data during shooting. The results showed that the heart rate decreased before shooting and during concentration.

Maman et al. (2012) studied the effects of sensorimotor rhythm (SMR) neurofeedback on the psychophysiological, EEG measure and performance among twenty-four university archers. The findings showed a statistical significant change in the experimental group as compared to the control group. Neurofeedback training was beneficial for the athletes for archery performance and in lowering the HR values. Landers et al., 1991 and Boutcher and Zinsser (1990) have reported that heart rate deceleration is associated with sports that require high accuracy among experienced athletes such as archery.

Psychological training is one of the important factors to be successful in archery which needs to be given attention during training and competition; other aspects include physical, physiological, mental, tactic, technique, types of equipment





used, and the surrounding condition. To date, few studies have investigated the effects of biofeedback training in a periodised training programme on psychophysiological, physical fitness and shooting performance among junior archers. Therefore, the present study investigates the beneficial effects of integrating biofeedback in a periodised training programme on the psychophysiological, physical fitness and shooting performance among junior archers. The results from this study will add new findings into applied sports psychology and archery.

1.2 Terms and Definitions

The terminologies of this study are conceptualised and operationalised as follows:

(a) Biofeedback training

Biofeedback is about increasing the awareness of the body physiological functions using devices to provide information on the activity of the internal body system, in order to manipulate them at will (Durand, Vincent, Barlow, and David, 2009).

Biofeedback training in this study has been measured using the skin conductance sensor to measure galvanic skin response using the BioGraph Infiniti software version 5.1, which transmits signals to the host computer via the microprocessor-controlled ProComp Infiniti encoder unit, while a Polar Heart Rate Monitor (S710i, Polar Electro Oy, Finland) is used to measure the heart rate. The transmitter belt is fitted on the participants' chest wall before the beginning of the data recording.

(b) Periodisation training

Periodisation training is systematic athletic or physical training planning. (Rowbottom, David, 2000).





In this study, both experimental groups followed the 12 weeks periodised training programme that had been provided by the researcher throughout the study. For the biofeedback training group, the participants had followed the training programme with biofeedback training. For the physical training group, the participants had followed the same training programme, but without biofeedback training. However, for the control group, they followed a standard training programme that had been provided by their coach.

(c) **Galvanic skin response (GSR)**

Galvanic skin response (GSR), refers to the measure associated with emotional arousal (Dawson et al. 2000; Lang et al. 1993).

In this study, Skin Conductance sensor (SC-Flex/Pro) has been used to measure the galvanic skin response (GSR) parameter using the BioGraph Infiniti software version 5.1, which transmits signals to the host computer via the microprocessor-controlled ProComp Infiniti encoder unit. As sweat is produced, the ability of the skin to conduct an electrical current is improved and also increases the measured conductance. The higher reading of GSR parameter indicates the higher level of stress and anxiety.

(c) **Heart rate (HR)**

Heart rate is the speed of the heartbeat measured by the number of contractions (beats) of the heart per minute (bpm) and The American Heart Association states that the normal resting adult human heart rate is 60–100 bpm (American Heart Rate Association, 2017).

In this study, a Polar heart rate monitor (S710i, Polar Electro Oy, Finland) has been used to measure the heart rate. The transmitter belt is fitted on the participants'





chest wall before the beginning of the data recording. The higher reading of HR parameter indicates the higher the level of nervousness and anxiety.

(d) Physical fitness

Physical fitness is a general state of health and well-being and the ability to carry out aspects of sports or occupations (Tremblay et al., 2010).

In this study, the physical fitness test was assessed through a push-up test, the stork swim balance stand test, abdominal strength test, bow arm holding test and multi-stage fitness test. The measured test was based on the total time (minutes and seconds) obtained by the respondents except for the push-up test which was counted through the total number of repetitions in one minute. A longer duration of time indicates a better fitness level.

(e) Anxiety



Anxiety is defined as the negative emotional state- of nervousness, worry, and apprehension related to body activation (Weinberg et al., 2007).

In order to measure the athlete's competitive state of anxiety, the Revised Competitive State Anxiety Inventory-2 (Cox et al. 2003) has been used in this study. It is comprised of three subscales with five cognitive anxiety items, seven somatic anxiety items, and five self-confidence items. The seventeen items are attached to a Likert scale of a 4-point range from one (not at all) to four (very much so). The CSAI-2R that had been adapted in Malaysia was used to measure the competitive anxiety of the athlete. Hashim and Bagherpour (2016) established the validity and reliability of the Malaysian version of the revised Competitive State Anxiety-2. The higher point determines high level of anxiety.



**(g) Attitude**

Attitude is a psychological tendency expressed by some degree of favour or disadvantage in evaluating an entity (Eagly, Alice and Shelly, 1998).

In this study, the attitudes of the athletes were assessed using the Sport Psychology Attitudes-Revised (SPA - R; Martin et al., 2002). It consists of four subscales with 7 items pertaining to stigma tolerance, 8 items on confidence in consultant, 6 items on personal openness, and 4 items on cultural preference. The 25 items were linked to a scale of 7-point Likert from 1 (strongly disagree) to 7 (strongly agree). The athletes were asked to rate their feeling after the interventions. The adapted version that had been used by Sharifah and Hashim (2013) was used in this study. The Bahasa Malaysia translated version had shown adequate findings in terms of its internal consistency. The points were divided into upper and lower range in the data analysis. The upper range represented positive attitudes, while the lower range was negative attitudes.

(h) Recurve bow

A recurve bow is a bow with limbs that when unstrung curve away from the archer.

(i) Compound bow

A compound bow is a modern bow that bends the limbs with a lever system, usually with cables and pulleys (Paterson, 1984).

(j) Archery

Archery is a sport that during shooting the arrow will launch using a bow to hit the target (Lee, 2009).



(k) Junior Archers

Archers are divided into seniors and juniors, with juniors being those under the age of 18 (World Archery Federation).

(l) Archery shooting performance

High-performance archery shooting is described as the ability to accurately shoot an arrow at a target (Ertan, soylu and Korkusuz, 2005; Leroyer, Hoecke, and Helal, 1993; Martin et al., 1990).

In this study, archery shooting performance was assessed through the total scores of double 50 meters round for compound category and double 60 meters round for recurve category. This scoring format (double 50/60m round) refers to the standard international competition outdoor target archery junior division- age classes below 18 years old, where the athlete can participate in a Junior Class tournament until the year of his/her 18th birthday (Book 2, Chapter 4; 4.2.3) by World Archery Federation (1931) with recurve athletes shooting on targets set at 60 meters away and compound athletes shooting on targets set at 50 meters away, the higher score determines high level of shooting performance.

1.3 Problem statement

Archery is one of the prospective sports in Malaysia to contribute to the Olympic Games medal. Malaysia has managed to qualify in 2004 for the first time. However, Malaysia has yet to win a medal. These are the successful national archers who have qualified for the previous Olympic Games:

- Olympic Games 2004 in Athens, Greece – Mon Redee Sut Txi (women recurve individual category).



- Olympic Games 2008 in Beijing, China - Muhammad Marbawi Sulaiman, Cheng Chu Sian and Wan Mohd Kalmizan Abdul Aziz (men recurve individual and recurve men team categories).
- Olympic Games 2012 in London, United Kingdom – Nurul Syafiqah Hashim (women recurve individual category) Haziq Kamaruddin, Khairul Anuar Mohamad and Cheng Chu Sian (recurve men individual and team categories).
- Olympic Games 2016 in Rio de Janeiro, Brazil – Haziq Kamaruddin, Khairul Anuar Mohamad and Mohd Akmal Nor Hasrin (recurve men individual and team categories).

High-performance archery shooting is defined as the ability to shoot an arrow with accuracy at a given target to achieve a higher score (Soylu, et al., 2006). Mental preparation is not less important to perform well during training and competitions.

Vanek and Cratty (1970) have stated that the difference between the best performers and the winners is the players who can overcome the game's mental pressures.

Many aspects such as mental, physical, environments and other related aspects may lead to the psychological and physiological obstacles that prevent the athletes to perform well. These include a lack of concentration, arousal and anxiety, muscle tension, and consequently shooting accuracy. According to Landers (1985) and Norris (1999) and Wilson and Gunkelman (2001), the performance improvement is multi-factorial, consisting of excitement regulation, concentration and motivation, autonomous control and the simultaneous incorporation of these aspects in competition.

Athletes, coaches, and sports scientists generally recognise the ability to produce and maintain proper skills and techniques before and during competition as one of the most important factors contributing to a successful performance.





Biofeedback is a training programme in which a person is informed about their psychophysiological processes that are usually available in order to gain conscious control and to use visual and auditory inputs in conjunction with video materials. Biofeedback is also used to facilitate positive mental imaging of high quality (Davis and Sime, 2005). With these methods, it can help the athletes to identify their psychological conditions that are associated with better performance.

Thus, the purpose of this study is to examine the effects of integrating biofeedback into a periodised training programme on psychophysiological, physical fitness and shooting performance among junior archers.

1.4 Objective of the Study

The aim of this study has been divided into general and specific objectives:

(a) General Objective



This study's general aim of this study is to investigate the effects of integrating biofeedback in a periodised training programme on psychophysiological, physical fitness and shooting performance among junior archers.

(b) Specific Objective

The specific objectives of the present study are:

- (1) To determine the effects of integrating biofeedback into a periodised training on psychophysiological, physical fitness variables and shooting performance among junior archers.
- (2) To compare the effects of integrating biofeedback training with the periodised physical training and normal routine training on psychophysiological, physical fitness variables and shooting performance among archers.





- (3) To determine the effect of different attitude on intervention outcomes.

1.5 Research Questions

For this study, the research questions are:

- (1) Is integrated biofeedback training effective in regulating psychophysiological, physical fitness and shooting performance among junior athletes?
- (2) Do different types of training programme affect the psychophysiological, physical fitness and shooting performance outcomes?
- (3) Does attitude moderate the effectiveness of integrating biofeedback and periodised training programme?



1.6 Significance of Study

The outcomes from this study are expected to provide a training guideline for athletes, coaches, and various parties involved- to know, identify and understand the benefits of an integrated biofeedback training with periodised training in the psychological, physiological, physical, attitude and shooting performance of archery. Furthermore, the findings can be useful in the design of training for athletes using biofeedback and regular training programmes to improve their performance.

In addition, previous studies have primarily focused on elite archers and have assessed the effects of biofeedback during shooting but have seldom focused on junior archers in using biofeedback as a training method to improve the archers' psychophysiological aspects. In this study, the researcher will focus on young junior athletes because they are the main sources to build future champion or to back-up the





national team in the future. Mental skills are therefore best developed during the earlier stage of sports participation to ensure that they are compatible with the training that is provided. Earlier exposure to psychological skills such as relaxation, concentration, attention, focus and other approaches may help the mental development of young athletes.

