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THE EFFECTS OF PROGRESSIVE MUSCULAR RELAXATION ON NOVICE ARCHERS' STATE ANXIETY, HEART RATE AND PERFORMANCE SCORES

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ABSTRACT

Background: Studies have indicated that relaxation techniques are beneficial for athletes by enhancing their concentration, self-confidence, and reducing the levels of anxiety, stress, blood pressure and muscles stiffness. Progressive muscular relaxation (PMR) focuses on tightening and relaxing specific muscle groups of the body to achieve a state of relaxation which is a useful tool for competitive sport.

Materials and Methods: PMR was applied to novice archers to examine its effect on state anxiety, heart rate and shooting performance. A total of 11 male and 17 female participants were recruited for this study. They were randomly assigned using gender matched into two research conditions, PMR (n = 14) and control (n = 14) groups. A pre- and post-tests archery shooting performance was conducted before and after the three weeks of intervention period, which consisted of nine sessions of PMR. Participant's psychological aspects were measured using the Revised competitive state anxiety inventory-2 (CSAI-2R) questionnaires, while the physiological aspect was measured using a digital pulse oximeter to monitor heart rate. Archery shooting score were measured using ten metre distance. Repeated measure of variance (ANOVA) was used to analyse the results.

Result: There were significant changes in time effect for cognitive anxiety (p = 0.037) and archery performance (p = 0.019) but no significant difference between group (p = 0.458) and interaction effects (p = 0.110). There were also no significant results for time, group and interaction effects for somatic anxiety, self-confidence and arousal state

Conclusion: PMR training showed no significant effect on anxiety, heart rate and archery performance on novice archers. Future studies may compare the effects of PMR on trained athletes.

Keywords: Progressive muscle relaxation, novice, archers, shooting, performance

1.0 Introduction

Archery is classified as a precision sport and is widely played across the world. In the latest Olympic Games in Rio 2016, archery continues to be a popular event to watch since it first debuted during the 1900's in Paris. Performance in archery is designated based on the sum of scores of the arrows shot by an archer that hit the target (Kolayis et al., 2014). The factors that may affect an archer's performance can be categorised into external and internal factors. The external factors are environmental conditions such as wind direction, velocity and materials used that determine the behaviour of the bow and arrow; whereas, the internal factors include fatigue, stress and athlete's technique (Kolayis et al., 2014). Both factors play a vital part in determining the performance of the archers.

The goal of every archer is to decrease the group diameter of the arrows directed to the target. This means that archer's attempt to hit the target areas consistently as possible as near to each other. If the athlete is misdirecting his or her shots away from the centre or bullseye, the athlete can just re-adjust their sight to aim closer towards the centre, thus obtaining more points by hitting the inner yellow circles. Archery experts displayed higher activation in cortical areas associated with visuospatial attention and working memory, including the middle frontal cortex, supplemental motor area, and dorsolateral prefrontal cortex than that of the novices (Seo et al., 2012). In order for an athlete to maintain such cognitive demands, they must first be in a relaxed state. Studies have indicated that relaxation techniques are beneficial for athletes by enhancing concentration, self-confidence, and reducing the levels of anxiety, stress, blood pressure and muscles stiffness (Parnabas et al., 2014). One such technique to promote relaxation is Progressive Muscle Relaxation (PMR).

PMR focuses on tightening and relaxing specific muscle groups of the body to achieve a state of relaxation (Goldman, 2014). The goal of PMR is to achieve a state of relaxation by tensing and relaxing specific muscles of the body. This process would allow participants to distinguish between a relaxed muscle and a tensed one, which would usually be accompanied by anxiety and stress (Charalambous et al., 2016). Once distinguished, participants may use this simple knowledge to relax the muscles at the first signs of tension. PMR emphasises the difference in sensation between a tensed and relaxed muscle (Ranjita & Sarada, 2014). The knowledge gained from this may help participants to be aware when they stressed and thus improve their coping style, reduce stress and fatigue (Ozgundondu & Gok Metin, 2019).

PMR is well renowned in the clinical and rehabilitative field as an alternative means for reducing stress, anxiety, pain and discomfort in chronically ill patients. These illnesses include contingent negative variation (CNV) such as cancer, hypertension and cardiovascular disease as well as other chronic illnesses (Lu, Lin & Chang, 2019; Meyer et al., 2016; Zamenjani et al., 2019). PMR can also be used to improve general health (Sadeghi et al., 2018). The relaxation provided by PMR can reduce pain, stress and depression (Nasiri et al., 2018; De Paolis et al., 2019). This study attempted to investigate the effects of PMR on novice archers' anxiety, arousal and shooting performance.

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2.0 Materials and Methods

This is an experimental research design to investigate the effect of PMR on anxiety, heart rate and shooting performance. the recruited participants were undergraduate students, aged between 18-25 years. The intervention period lasted for three weeks. A familiarisation session was conducted to familiarise the participants to archery before the intervention began. Then, a simulated pre-test was conducted to measure the participants' shooting performance during the first week. The Revised Competitive State Anxiety Inventory 2 (CSAI-2R), heart rate monitors as well as handgrip and back and leg dynamometer were tested on the participants prior the shooting performance. The Figure 1 demonstrates the flow of the study procedure.

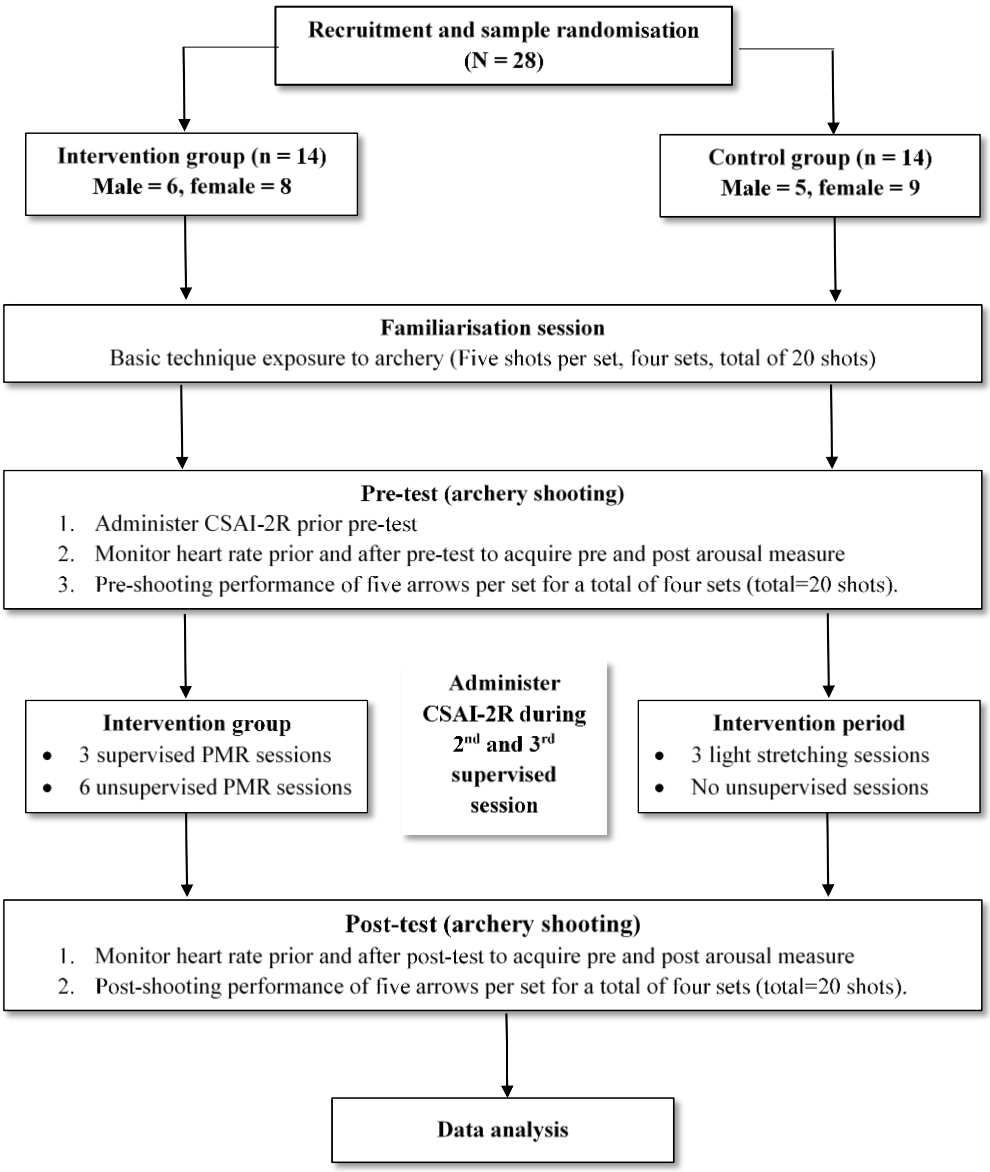

Figure 1: Flowchart of the study procedure

Following that, a total of nine sessions of PMR were conducted over a period of three weeks in the intervention group. Each session lasted for about 15 minutes. The PMR sessions were further divided into three supervised sessions and six unsupervised ones. For each week, one supervised session took place followed by two unsupervised ones. Whereas, for the control group, a weekly light stretching session was conducted with no unsupervised sessions. An adherence logbook was given to the participants of the intervention group to ensure the participant's adherence to the PMR sessions. After the three weeks of PMR intervention, simulated post-test on participants' shooting performance was conducted in which CSAI-2R and heart rate monitors were administered to the participants.

2.1 Instruments

2.1.1 Revised Competitive State Anxiety Inventory 2 (CSAI-2R)

Each participant completed the CSAI-2R questionnaire before and after each PMR intervention session. The CSAI-2R is a 17-item questionnaire that is used to measure perceived intensities of somatic anxiety (SA), cognitive anxiety (CA), and self-confidence (SC) promptly before a competition (Cox, Martens, & Russell, 2003). Therefore, the CSAI-2R measures temporal states rather than stable personality traits. The SA scale is concerned with physiological symptoms of arousal and is composed of items such as "my body feels tensed," whereas the CA scale addresses cognitive symptoms of arousal such as "I'm concerned that others will be disappointed with my performance." The SC rates perceived ability of the athletes to meet situational demands and includes statements such as "I'm confident I can meet the challenge."

Each CSAI-2R item is rated on a 4-point Likert scale ranging from 1, "not at all" to 4, "very much so". Subscale scores are calculated by summing items in each subscale, dividing by the number of items, and multiplying by 10. Higher scores indicate higher intensities of cognitive and somatic state anxiety, as well as higher levels of self-confidence. The factorial validity of the CSAI-2R was previously established by Cox et al. (2003), using confirmatory factor analysis (CFA) on data from 331 athletes. The results showed a good fit of the hypothesised measurement model (CFI = .95, NNFI = .94, RMSEA = .05) and Cronbach alpha coefficients for each subscale of the CSAI-2R showed sound internal consistency (somatic anxiety = .88, cognitive anxiety = .83, self-confidence = .85).

2.1.2 Heart rate monitor

The heart rate monitor used in this study was a digital pulse oximeter (Instant Read Finger Pulse Oximeter, Model OX250, MeasuPro, USA) which allows the simple measurement of heart rate with minimum inconvenience to the subjects (Kerr et al., 1997). Each participant inserted their right index finger in the digital pulse oximeter which measured their heart rate. The measurement was taken before and after the pre- and post-tests. Kerr et al. (1997) stated that by using the simple heart rate monitor, the possibility of provoking and deterring participant's psychological state by fitting them with unfamiliar scientific apparatus can be avoided.

2.1.3 Progressive Muscle Relaxation (PMR)

The PMR script used in this study was validated and used by Isa et al. (2013) in a previous clinical population. The progression of the alternate tensing and relaxing muscle began at the fingers and hands, followed by the elbow, arms, chin, eyebrows, eyes, jaws, teeth, tongue, lips, head, neck, shoulder, back, abdominal, buttocks, feet and finally toes. Each major muscle groups were repeated up to three times such as the arms and abdomen while the rest was only done once. Constant purposeful deep breathing was instructed throughout the session especially in between changes of muscle. Participants were seated in a comfortable position and in a cool and quiet environment. Each session lasted for approximately 15 minutes.

2.1.4 Handgrip and back/leg dynamometer

A handgrip dynamometer (Jamar hydraulic handgrip dynamometer, Jamar, Model J00105, Lafayette, USA) was used to determine the hand grip strength of each participants. Whereas, the back and leg dynamometer (Back and leg dynamometer, Lafayette, USA) was also used to determine the strength of the back and legs of each participants. The best reading of three tries was recorded. The hand grip was conducted using the right hand only. This is because only the right hand was used to draw the bow during the pre and post-tests archery shooting. The test was conducted to reduce the possibility of strength being a confounding factor in this study. Lack of strength may lead to fatigue which has a direct effect on archery performance.

2.1.5 Archery shooting performance

The participants were asked to shoot a total of 20 shots split into four sets (each set consist of five shots) based on a modified scoring system. The target board was placed ten metres from the shooting position. The bows used were 20 and 22 pounds for females and males respectively. The target board used was a standard 122-cm wide shooting performance. A familiarisation session was conducted prior the pre-test in order to familiarise the participants to archery. An experience coach taught the basic techniques. A total of 20 shots were allocated to each participant during the familiarisation session.

2.2 Data analysis

The analysis for this study was analysed using the Statistical Package for Social Science (SPSS) Version 24.0. All data were examined for normality through the Shapiro-Wilk test except for the variables that were analysed using the repeated measure analysis of variance (ANOVA) as the test is robust against normality. CSAI-2R questionnaires were scored manually and evaluated using the scoring system. CSAI-2R score, heart rate and archery score for both intervention and control groups were analysed using a repeated measure analysis of variance (ANOVA). The results for arousal state was based on the difference in gained heart rate between pre-test and post-test archery shooting. The term “gained” refers to the heart rate measure of before and after the archery performance. Statistical significance was accepted at ($p < 0.05$).

The statistical analysis used for all anxiety subscales were repeated ANOVA. However, if sphericity assumption was violated, meaning that there was a significant difference in the p-value ($p < 0.05$) in the Mauchly’s test, the multivariate tests were used instead. The Wilk’s lambda test is commonly reported by researchers, but it may not always be the best choice, so Pillai's trace is reported in this study due to its powerfulness and robustness (OriginLab, 2017). The main effects in repeated measure ANOVA test the exploratory value of a predictor in a model while post hoc tests are a priori unspecified tests (Stevens, 1999). Therefore, the significance of the post hoc tests are a subsequent comparison of the raw data. In short, the significant changes found in the multivariate tests (Pillai's trace) does not automatically mean there will be significant changes between sessions found in the subsequent post hoc test. The main effects reported in this study were time, groups and interaction (time x groups) effects.

3.0 Result

Table 1 shows the characteristics of the participants. During recruitment, 30 participants volunteered to participate in this study, however, due to study commitments, two participants dropped out. A total of 28 undergraduate students completed the study. The participants were randomly assigned based on computer generated randomisation and gender-matched into the intervention group which underwent PMR training and the control group which underwent light stretching exercise sessions.

Table 1. Demographic data and characteristics of the participants

Demographic	**Group (*N* = 28)**		
	Intervention (m = 6, f = 8) Mean (SD)/ Median	**Control (m = 5, f = 9) Mean (SD)/ Median**	***p*-value**
Age (years)	19.5[c]	19.0[c]	0.391[a]
Height (cm)	160.6[d] (8.7)	161.2[d] (7.4)	0.830[b]
Weight (kg)	61.0[d] (11.6)	55.9[d] (12.0)	0.263[b]
Muscular strength			
i) Handgrip strength (kg)	34.0[c]	31.0[c]	0.613[a]
ii) Back and leg strength (kg)	111.4[d] (50.3)	98.8[d] (38.1)	0.460[b]

Note: m = male, f = female, [a]Mann-Whitney U test, [b]Independent *t*-test, [c]Median, [d]Mean

The mean (SD) score obtained for archery shooting performance for intervention and control groups were 147.2 (17.1) and 137.8 (13.9) scores for pre-test and 150.1 (14.1) and 151.9 (19.0) scores for post-test respectively (Table 2). The results indicate a significance in terms of time effect (p = 0.019) but no significance in terms of group (p = 0.458) and interaction effects (p = 0.110). Table 3 shows the mean (SD) of all three anxiety subscales in CSAI-2R, namely; somatic state anxiety, cognitive state anxiety and self-confidence.

Table 2. Archery shooting performance score

Tests	Archery shooting performance score, mean (SD)	
	Intervention (*n* = 14)	**Control (*n* = 14)**
Pre	147.2 (17.1)	137.8 (13.9)
Post	150.1 (14.1)	151.9 (19.0)

Table 3. Descriptive mean (SD) of CSAI-2R for intervention and control groups

Week	Subscales score, mean (SD)					
	Intervention (*n* = 14)			**Control (*n* = 14)**		
	SA	**CA**	**SC**	**SA**	**CA**	**SC**
1	-1.9 (5.8)	-1.2 (3.0)	1.9 (2.4)	-3.2 (4.9)	-0.6 (3.1)	0.7 (4.0)
2	-2.9 (3.2)	-1.4 (2.4)	2.2 (2.2)	-2.8 (3.5)	-2.1 (2.9)	0.2 (1.2)
3	-0.8 (4.8)	-1.5 (2.4)	0.6 (2.1)	-2.0 (2.4)	-1.3 (1.8)	1.3 (1.6)

SA = somatic anxiety, CA = cognitive anxiety, SC = self-confidence

Based on Table 4, time, group and interaction effects were not significant ($p < 0.05$) with the exception of cognitive subscale ($p = 0.037$) for time. However further analyse was needed to see the significance between sessions. A post-hoc test was conducted to see the significance between sessions for the cognitive aspect. The results showed no significance between sessions ($p > 0.05$) for both intervention and control group.

Table 4. F-statistic on CSAI-2R (intervention and control; time, group and interaction effects)

Effects	**Subscales**	***F*-statistic (df)**	***p*-value**	***eta*^{2}**
Time	Somatic	2.641 (2,25) [a]	0.056	0.199
	Cognitive	3.368 (2,25) [a]	**0.037***	0.315
	Self-confidence	0.665 (2,25) [a]	0.582	0.083
Group	Somatic	0.055 (1,26)	0.817	0.002
	Cognitive	0.001 (1,26)	0.972	<0.001
	Self-confidence	2.845 (1,26)	0.105	0.106
Interaction	Somatic	0.784 (2,25) [a]	0.516	0.097
	Cognitive	0.288 (2,25) [a]	0.834	0.038
	Self-confidence	2.881(2,25) [a]	0.059	0.282

F-statistic[a] of Pillia's Trace is reported when assumption of Mauchly's test of Sphericity is not met

Table 5 shows the mean heart rate scores obtained before and after pre- and post-tests archery performance. During data analysis, pre-gain and post-gain heart rates were used. The mean (SD) for pre-gain and post-gain heart rates were 15.9 (10.9) and 9.7 (13.2) beats per minute for the intervention group; whereas, in the control group, pre-gain and post-gain heart rates were 15.6 (10.5) and 16.1 (15.2) beats per minute. The results for arousal showed no significance for time ($p = 0.365$), group ($p = 0.413$) and interaction ($p = 0.289$) effects.

Table 5. Mean (SD) of participants' arousal state before and after pre- and post-tests

	Heart Rate (beats.min^{-1})			
	Pre-test Shooting Performance		**Post-test Shooting Performance**	
	Intervention	**Control**	**Intervention**	**Control**
Before Shooting Performance	76.3 (13.9)	85.9 (10.3)	92.2 (9.5)	84.4 (12.6)
After Shooting Performance	83.7 (8.3)	101.4 (11.6)	93.4 (8.3)	100.4 (20.2)

4.0 Discussion

Participants from both groups have normal hearing ability. The students were able to commit to the study and were mostly able to attend all the sessions throughout the intervention period. The exceptions were two students, who were not able to participate the third session due to classes. Therefore, were excluded for further analysis. Based on the comments made in the adherence logbook, participants reported good adherence to the intervention program, thus, all participants (N = 28) were added in to the subsequent analysis.

Muscular strength is an important fitness parameter that can affect archery performance (Sureyya, 2017). In archery, arm strength to pull the bow is directly proportional to the draw weight of the bow. Thus, hand grip strength has a significant value in archery as it is one of the main factors that improve target shooting accuracy scores positively (Sureyya, 2017). In this study, recurve bow was used, the male participants were given bows with 22 pounds draw weight while the female participants were given bows with 20 pounds draw weight. It is noted that for competition, the draw weight ranges from 30 pounds (14kg) to 44 pounds (20kg) and is commonly used depending on the strength of the archers. Significant differences in arm strength and grip strength that may affect the outcome.

The results for the hand grip strength test indicate both intervention and control group have no significant different in hand grip strength (Table 1). It can be concluded that both groups have similar arm strength. Core body strength also plays an important role in archery. Back tension is the most important movement in archery, more specifically, the major and minor rhomboids which helps in the creation of back tension (Sharma et al., 2015). Studies showed that the primary muscles of the shoulders and upper back involved in archery are the rhomboids, levator scapulae, trapezius, deltoids, latissimus dorsi, and the rotator cuff muscle group, which also includes the supraspinatus, infraspinatus, and teres minor (Sharma et al., 2015). The purpose of the back and leg strength in this study was to ensure no variability in overall core body strength between the groups affecting archery performance. The results indicated there was no significant difference in back and leg strength at the baselines between intervention and control groups (Table 1). Therefore, differences in archery performance between the two groups were not interfered by back and leg muscular strength.

PMR is a physical relaxation therapy that differs from autogenic relaxation as it focuses on physiological muscle movements rather than cognitive outcomes (Hashim & Ahmad Yusof, 2011). Therefore, somatic anxiety should be reduced more than the cognitive aspect. However, in this study, the results showed that somatic anxiety has no significance for time, group and interaction effects. Whereas, cognitive anxiety showed a significant reduction for time but not for group and interactions effects. The premise of PMR is to have participants tense and relax their muscles to differentiate between tensed states and a relaxed one (Charalambous et al., 2016). Nonetheless, in one study, it was concluded that relaxation technique is an effective intervention for reducing pre-competitive state anxiety and improving self-confidence in athletes. As both progressive muscular relaxation and autogenic relaxation technique were significantly effective in reducing competitive state anxiety and improving self-confidence than the control group (Sakhare, Sharma & Syal, 2018).

Alwan et al. (2013) found that PMR training showed no changes in somatic anxiety among soccer players during its six weeks intervention period. They concluded that there was no significant effect of relaxation methods on the somatic anxiety among soccer players similar to this study. In another study, findings showed a significant increase in swimming performance in the experimental group but no significant changes in terms of cognitive and somatic anxiety subscales when compared to the control group (Pavlidou & Doganis, 2008).

In addition, many studies are also in agreement with the findings of this study as their results indicate no effect of PMR and guided imagery relaxations on athletes after a specific period of mental intervention (Vadoa, Hall & Moritz, 1997; Page, Wesley & Kelly, 1999). It should be noted that the effects of the above study were on well trained athletes and not novice archers. On the other hand, Navaneethan and Rajan (2010) also reported there was a significant effect of PMR training in reducing somatic anxiety among members of a volleyball team. However, they did not apply the PMR intervention at the pre-competitive stage.

The contradictory results of PMR effects on anxiety which may be due to the duration of the implementation of PMR techniques. An increase in the length of time and sessions conducted should be considered as the duration of many conducted studies in relation to sports are more than three weeks. However, the length of the intervention period for clinical studies of PMR on patients were only up to three weeks (Charalambous et al., 2016; Aalami, Jafarnejad & Gharavi, 2016). The difference in PMR techniques such as the abbreviated version of PMR (APMR) that were used in different studies aligned with different objective outcomes, thus leading to variability in results (Srilekha, Soumendra & Chattopadhyay, 2013).

Arousal state in this study was represented by the changes in heart rate. Heart rates were monitored using a digital pulse oximeter. The readings were taken before and after the pre- and post-tests sessions. The gained heart rate was calculated from before and after each pre- and post-tests respectively. The objective measuring the heart rate was to examine whether they were any significant differences between pre- and post-tests arousal level. Rather than directly determining the relationship between arousal and archery performance, the changes in heart rate (arousal) was measured as a subsequent effect of PMR interventional training.

Robazza, Bortoli, and Nougier (1998) also used heart rate deceleration as physiological arousal during the shooting of elite female archers, from draw to release, was associated with optimal, blind, and simulated conditions. As elite archers are well rehearsed in their skill, the use of such techniques may have a higher value as compared to novice archers, especially in competitive situations. The use of PMR training as a technique to improve arousal state in archery have not been well researched. However, in clinical settings, PMR has been shown to reduce to reduce blood pressure levels of hypertensive patients (Aalami et al., 2016).

In competitive sports, Parnabas (2015), concluded that PMR helps running athletes perform optimally by managing arousal state and reducing blood pressure. Results from other studies show that arousal state can improve sporting performance (Johnson et al., 2007). PMR has also proven to reduce heart rate which in turn improve arousal state but the results were only subjected to patients in clinical settings (Pawlow & Jones, 2002). PMR has shown no significant difference in arousal state during pre- and post-test archery performance. Direct relationships between arousal state and sporting performance regarding PMR intervention showed little findings in the literature. Thus, more study is needed in this field to measure and conclude its relationship.

The development of PMR was based on the premise of promoting relaxation and reducing anxiety by tensing and relaxing the muscles to differentiate between the two states. Some studies have used this technique to apply to patients in clinical settings as a supplementary method to reduce negative symptoms such as anxiety, depression and to enhance quality of life (Charalambous et al., 2016; Hassanpour-Dehkordi & Jalali, 2016). Basic relaxation skills are important and must be applied in the act of performance (Amanda & Collins, 2010). Arguably, the implementation of PMR should be applied directly in the scope of performance rather than being conducted separately. For example, during the archery shooting performance, participants had a total of four sets to complete. Each participant had to wait for their turn to shoot as there are only four target boards available at a given time. Since there are 14 participants taking part during the test, participants have to wait for a total of four rotations in order to shoot for their next set. During that time, participants do not practice the PMR techniques, thus the effects obtained from PMR may have subsided by then. Nonetheless, PMR may be useful to decrease state anxiety, improve well-being and social functioning in adults especially with clinically mental illness (Melo-Dias et al., 2019).

Besides that, skill acquisition in archery requires complex motor skills which takes time to develop. Even though motor skills vary widely in type and complexity, the learning process that individuals go through when acquiring various motor skills is similar (Gabriele, 2007). Gabriele (2007) further divided the learning process into three stages; cognitive, associative and autonomous stages. Participants were primarily considered to be in the cognitive stage in which considerable amounts of conscious movements were required to perform the archery skills. Because learners sometimes use both covert and sometimes overt self-talk, this stage has also been labelled the 'verbal stage' (Adams, 1971). Participants in this stage are subjected to experimental movements in which they employ different strategies to execute the skill more effectively. Therefore, more attentional capacity is used in correcting their movement rather than focusing on the outcome goal which is the archery performance. Hence, the results obtained by the analysis may not fully be in line with the study's objective, which is to see the effects of PMR on archery performance as other factors such as self-talk and strategy improvisation may have acted as the confounding factors (Gabriele, 2007).

Successful learning of a motor skill requires repetitive training and can be advanced through a number of stages (Luft & Buitrago, 2005). The first stage mentioned in Luft's study was the acquisition phase which is characterised by fast (within sessions) and slow learning (between sessions). Luft and Buitrago (2005), further added that for a short period following the initial training sessions, the skill is labile to interference by other skills and protein synthesis inhibition, indicating that consolidation process occurs during rest periods between training sessions. Participants in this study are regarded as novice archers in which they were exposed to archery during the familiarisation session which took place a week before the pre-test. However, the study argues that skill acquisition requires more than one session in order to grasp the basic skills of a sport. Therefore, longer familiarisation sessions may have been needed.

On a related note, archery performance conducted in this study was subpar to the rules and regulations of competitive archery. For example, the distance used in this study was set to 10 meters rather than the minimum 18 meters in indoor competitive archery. Olympic archery sets the distance at 70 metres range for outdoor archery (World Archery Coach's Committee, 2015). The reason for this distance was because participants were unable to hit the target board in a consistent manner for longer distances. Besides that, the recurved bow used in this study has a draw weight of 9kg (20 pounds) for females and 10kg (22 pounds) for males. The draw weight of a bow depends on the size and strength of everyone involved. However, in this study, to reduce variability, all the participants were given bows with standardised weight for males and females respectively. The number of shots taken was also changed due to consideration to time and strength of the participants. Due to their limited ability, a total of 20 shots was spread out to 4 sets to measure their archery performance. Although some studies have shown that 20 shots are suffice in measuring archery performance, the overall significance of tests conducted during data analysis well be under represented (Nishizono et al., 1987).

Future studies should take into considerations the techniques of PMR being used and to who it is being applied to. For example, abbreviated version of PMR (APMR) is more suited to be applied to direct performance such as before competition and during resting intervals as it takes less time to complete as compared to the full PMR version. In one study, APMR was also used for attentively deficient children in order to maintain attention span (Srilekha et al., 2013). Furthermore, considerations should also be placed on confounding factors such as muscle strength, skill acquisition, strategy improvisation and learning curve which may affect the significance of the results when comparing between groups. Further studies are required to examine the positive relationship between PMR and performance.

5.0 Conclusion and recommendation

PMR is used as a relaxation method to reduce psychological and physiological distress such as anxiety, stress, blood pressure and heart rate. This study was designed to extend the knowledge in the field of psychophysiological impact of PMR in the sporting field, specifically archery. The findings of this study reveal that there was no significant difference between PMR and archery performance. There was also no significant change for somatic anxiety, cognitive anxiety, self-confidence and arousal state. This means that PMR had little to no effect on anxiety and arousal state among novice archers. However, other studies show conflicting results as PMR have been proven to reduce anxiety and arousal state. Confounding factors such as skill acquisition, strategy improvisation and learning curve may have affected the significance of the archery performance results. Furthermore, variability in PMR techniques may have led to insignificant results. Therefore, more research is required to find more conclusive findings of the effects of PMR on anxiety, arousal and archery shooting performance among novice archers.

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Declaration

Authors declare that there was no conflict of interest.

Authors contribution

HR and MSH conducted the literature search, analysed and interpreted the data; GK and YCK analysed, interpreted and approved the submitted data; all authors wrote the paper.

References

Aalami, M., Jafarnejad, F., & Gharavi, M. (2016). The effects of progressive muscular relaxation and breathing control technique on blood pressure during pregnancy. *Iranian Journal of Nursing and Midwifery Research*, *21*(3), 331–336. doi:10.4103/1735-9066.180382

Adams, J. A. (1971). A closed-loop theory of motor learning. *Journal of Motor Behavior, 3*(2), 111-150. doi:10.1080/00222895.1971.10734898

Alwan, M. A., Zakaria, A. H., Rahim, A. M., Hamid, A. N., & Fuad, F. M. (2013). Comparison between two relaxation methods on competitive state anxiety among college soccer teams during pre-competition stage. *International Journal of Advanced Sport Sciences*, *1*(1), 90-104.

Amanda, M., & Collins, D. (2010). But why does what works work? A response to Fifer, Henschen, Gould, and Ravizza, 2008. *Human Kinetics Journal 24*(1), 113-116. doi:10.1123/tsp.24.1.113

Bartkowiak, J. (2014). *Secrets of The NLP Masters.* London: The McGraw-Hill Companies, Inc.

Baumeister, R. F. (1984). Choking under pressure: Self-consciousness and paradoxical effects of incentives on skillful performance. *Journal of Personality and Social Psychology 46*, 610-620. doi:10.1037/0022-3514.46.3.610

Behan, M., & Wilson, M. (2008). State anxiety and visual attention: The role of the quiet eye period in aiming to a far target. *Journal of Sport Sciences 26(*2), 207-215. doi:10.1080/02640410701446919

Charalambous, A., Giannakopouou, M., Bozas, E., Marcou, Y., Kitsiois, P., & Paikousis, L. (2016). Guided imagery and progressive muscle relaxation as a cluster of symptoms management intervention in patients receiving chemotherapy: A randomized control trial. *PLoS ONE*, *11*(6), 1-18. doi:10.1371/journal.pone.0156911

Chaudhuri, A., Ray, M., Saldanha, D., & Bandopadhyay, A. (2014). Effect of progressive muscle relaxation in female health care professionals. *Annals of Medical Health Scince Research*, *4*(5), 791-795. doi:10.4103/2141-9248.141573

Committee, W. A. (2015). *Coach's manual entry level*. Utah, United States: Issuu.

Cox, R. H., Martens, M. P., & Russell, W. D. (2003). Measuring anxiety in athletics: The revised competitive state anxiety inventory–2. *Journal of Sport and Exercise Psychology*, *25*, 519-533. doi:10.1123/jsep.25.4.519

Craft, L. L., Magyar, M., Becker, B. J., & Feltz, D. L. (2003). The relationship between the competitive state anxiety inventory-2 and sport performance: A meta-analysis. *Journal of Sport and Exercise Psychology*, *25*, 44-65. doi:10.1123/jsep.25.1.44

De Paolis, G., Naccarato, A., Cibelli, F., D'Alete, A., Mastroianni, C., Surdo, L., . . . Magnani, C. (2019). The effectiveness of progressive muscle relaxation and interactive guided imagery as a pain-reducing intervention in advanced cancer patients: A multicentre randomised controlled non-pharmacological trial. *Complementary Therapies in Clinical Practices*, *34*, 280-287.

Dennis, T., & David, E. (1980). Guided imagery: Healing through the mind’s eye. In *Imagery* (pp. 253-266). Springer US.

Ertan, H., Kentel, B., Tumer, S., & Korkusuz, F. (2003). Activation patterns in forearm muscles during archery shooting. *Human Movement Science*, *22*, 37-45. doi:10.1016/S0167-9457(02)00176-8

Gabriele, W. (2007). *Attention and motor skill learning*. Champaign, IL: Human Kinetics Ltd.

Gill, S. D., Kolt, G., & Jenny, K. (2004). Examining the multi-process theory: An investigation of the effects of two relaxation techniques on state anxiety. *Journal of Bodywork and Movement Therapies*, *8*(4), 288-296. doi:10.1016/j.jbmt.2003.11.002

Goldman, R. (2014, December 2). What is Jacobson’s relaxation technique? *Introduction*, pp. 1-2.

Hagtvet, K., & Hanin, Y. (2007). Consistency of performance-related emotions in elite athletes: Generalizability theory applied to the IZOF model. *Psychology of Sport and Exercise*, *8*(1), 47-72. doi:10.1016/j.psychsport.2005.12.002

Hanin. (2003). Performance related emotional states in sports: A qualitative analysis. *Forum: Qualitative Social Research*, *4*(1), 5. doi:10.17169/fqs-4.1.747

Hanin, Y. L. (2000). Individual zones of optimal functioning (IZOF) model: Emotions-performance relationships in sport. In Y. H. (Ed.), *Emotions in sport* (pp. 65-89). Champaign, IL: Human Kinetics.

Hanton, S., Thomas, O., & Maynard, I. (2004). Competitive anxiety responses in the week leading up to competition: The role of intensity, direction and frequency dimensions. *Psychology of Sport and Exercise*, *5*, 169–181. doi:10.1016/S1469-0292(02)00042-0

Hashim, H., & Ahmad Yusof, H. (2011). The effects of progressive muscle relaxation and autogenic relaxation on young soccer players' mood states. *Asian Journal of Sports Medicine 2*(2), 99-105.

Hassanpour-Dehkordi, A., & Jalali, A. (2016). Effect of progressive muscle relaxation on the fatigue and quality of life among Iranian aging persons. *Acta Medica Iranica*, *54*, 1-7.

Huber, J. J. (2013). *Applying educational psychology in coaching athletes.* Champaign, IL: Human Kinetics Ltd.

Humara, M. (1999). The relationship between anxiety and performance: A cognitive-behavioral perspective. *Journal of Sport Psychology*, *1*(2), 1-14.

Isa, M.-R., Moy, F. M., Razack, A.-H. A., Zainuddin, Z. M., & Zainal, N.-Z. (2013). Impact of applied progressive deep muscle relaxation training on the health related quality of life among prostate cancer patients - A quasi experimental trial. *Journal of Preventive Medicine, 57*, 37- 40. doi:10.7314/APJCP.2013.14.4.2237

Jacobson, E. (1938). *Progressive Relaxation.* Chicago, IL: Chicago Press.

Johnson, M. B., Edmonds, W. A., Moraes, L. C., & Filho, M. (2007). Linking affect and performance of an international level archer incorporating an idiosyncratic probabilisitic method. *Psychology of Sport and Exercise*, *8*(3), 317-335. doi:10.1016/j.psychsport.2006.05.004

Johnson, M. B., Edmonds, W. A., Tenenbaum, G., & Kamata, A. (2007). The relationship between affect and performance in competitive intercollegiate tennis: A dynamic conceptualization and application. *Journal of Clinical Sport Psychology, 1*, 130-146. doi:10.1123/jcsp.1.2.130

Jokela, M., & Hanin, Y. (1999). Does individual zones of optimal functioning model discriminate between successful and less successful athletes? A meta-analysis. *Journal of Sport Science, 17*, 873-887. doi:10.1080/026404199365434

Jones, M. V., & Uphill, M. (2004). Responses to the competitive state anxiety inventory-2(d) by athletes in anxious and excited scenarios. *Psychology of Sport and Exercise*, *5*, 201-212. doi:10.1016/S1469-0292(02)00054-7

Kerr, J. H., Yoshida, H., Hirata, C., Takai, K., & Yamazaki, F. (1997). Effects on archery performance of manipulating metamotivational state and felt arousal. *Perceptual and Motor Skills, 84*, 819-828. doi:10.2466%2Fpms.1997.84.3.819

Kolayis, I. E., Cilli, M., Ertan, H., & Knicker, J. (2014). Assessment of target performance in archery. *Social and Behavioral Sciences*, *152*, 451-456. doi:10.1016/j.sbspro.2014.09.230

Kouli, O., Bebetsos, E., Kamperis, I., & Papaioannou, A. (2010). The relationship between emotions and confidence among Greek athletes from different competitive sports. *Kineziologija*, *42*(2), 194-200.

Kuan, G., Terry, M., & Terry, P. (2012). Comparison of the effect of arousing and relaxing music during imagery training for power and fine motor skill sport tasks. *2nd International Congress of Science, Education and Medicine in Sport (ICSEMIS 2012) In: Sport: Inspiring a Learning Legacy, 19-24 Jul 2012.* Glasgow, United Kingdom.

Lane, A. M., Sewell, D. F., Terry, P. C., Bartram, D., & Nesti, M. S. (1999). Confirmatory factor analysis of the competitive state anxiety inventory-2. *Journal of Sports Sciences*, *17*, 505-512. doi:10.1080/026404199365812

Lanier, L. (1930). Review: Progressive muscle relaxation. *The American Journal of Psychology 42*(3), 473-475. doi:10.2307/1415459

Lehrer, P. (1996). Varieties of relaxation methods and their unique effects. *International Journal of Stress Management*, *3*(1), 1-14. doi:10.1007/BF01857884

Leroyer, P., Hoecke, V., & Helal, N. (1993). Biochemical study of the final push-pull in archery. *Journal of Sport Sciences 1*, 63-69. doi:10.1080/02640419308729965

Levi, L. (1971). *Society, Stress and Disease: The Psychosocial Environment and Psychosomatic Disease.* London: Oxford University Press.

Lohaus, A., & Klein, J. H. (2003). Relaxation in children: Effects of extended and intensified training. *Psychology and Health*, *18*(2), 237-249. doi:10.1080/0887044021000057257

Lu, S. M., Lin, M. F., & Chang, H. J. (2019). Progressive muscle relaxation for patients with chronic schizophrenia: A randomized controlled study. *Perspectives in Psychiatric Care*. 1-9. doi:10.1111/ppc.12384

Luft, A. R., & Buitrago, M. M. (2005). Stages of motor skill learning. *Journal of Molecular Neurobiology*, *32*(3), 205-216. doi:10.1385/MN:32:3:205

Martens, Vealey, R., Burton, R., Bump, D., & Smith, D. (1990). *Development and validation of the competitive sports anxiety inventory 2.* Champaign, IL: Human Kinetics.

Melo-Dias, C., Lopes, R. C., Cardoso, D. F. B., Bobrowicz-Campos, E., & Apostolo, J. L. A. (2019). Schizophrenia and progressive muscle relaxation - A systematic review of effectiveness. *Heliyon*, *5*(4), 1-27. doi:10.1016/j.heliyon.2019.e01484

Mesagno, C., Harvey, J. T., & Janelle, C. M. (2004). Choking under pressure: The role of fear of negative evaluation. *Psychology of Sport and Exercise, 13*(1), 60-68. doi:10.1016/j.psychsport.2011.07.007

Meyer, B., Keller, A., Wohlbier, H.-G., Overath, C. H., Muller, B., & Kropp, P. (2016). Progressive muscle relaxation reduces migraine frequency and normalizes amplitudes of contingent negative variation (CNV). *The Journal of Headache and Pain*, *17*(1), 1-37. doi:10.1186/s10194-016-0630-0

Nasiri, S., Akbari, H., Tagharrobi, L., & Tabatabaee, A. S. (2018). The effect of progressive muscle relaxation and guided imagery on stress, anxiety, and depression of pregnant women referred to health centers. *Journal of Education and Health, Promotion*, *7*, 23-41. doi:10.4103/jehp.jehp_158_16

Navaneethan, B., & Rajan, R. S. (2010). Effect of progressive muscle relaxation training on competitive anxiety of male inter-collegiate volleyball players. *International Journal of Sports Science and Engineering*, *4*(3), 161-164.

Nishizono, H., Shibayama, H., Izuta, T., & Saito, K. (1987). Analysis of archery shooting techniques by means of electromygraphy. *Proceedings. Symposium V*, (pp. 365-371). Athens, Greece.

North, M. (2012). *Guide to Target Archery Rounds, Scoring, Handicaps and Classification.* [Module] Herts Group of Archery Coaches.

OriginLab. (2017, April 25). *OriginLab Corporation*.

Ozgundondu, B., & Gok Metin, Z. (2019). Effects of progressive muscle relaxation combined with music on stress, fatigue, and coping styles among intensive care nurses. *Intensive and Critical Care Nursing*, *9*, 2-10. doi:10.1016/j.iccn.2019.07.007

Page, S. J., Wesley, S., & Kelly, N. (1999). The Effects of imagery on female college swimmers' perceptions of anxiety. *Sport Psychologist*, *13*(4), 458-469. doi:10.1123/tsp.13.4.458

Parnabas, V. A., Mahamood, Y., Parnabas, J., & Abdullah, N. M. (2014). The relationship between relaxation techniques and sport performance. *Universal Journal of Psychology*, *2*(3), 108-112. doi:10.13189/ujp.2014.020302

Parnabas, V., Parnabas, J., & Parnabas, A. M. (2015). The relationship between somatic anxiety and sport performance on running athletes. *European Academic Research*, *2*(10), 72-79.

Pavlidou, M., & Doganis, G. (2008). The effects of a psychological intervention program in swimming. *Journal of Excellence, 12*, 71-77.

Pawlow, L. A., & Jones, G. E. (2002). The impact of abbreviated progressive muscle relaxation on salivary cortisol. *Journal of Biological Psychology*, *60*(1), 1-16. doi:10.1016/S0301-0511(02)00010-8

Peciuliene, I., Perminas, A., Gustainiene, L., & Jarasiunaite, G. (2015). Effectiveness of progressive muscle relaxation and biofeedback relaxation in lowering physiological arousal among students with regard to personality features. *Social and Behavioral Sciences*, *205*, 228-235. doi:10.1016/j.sbspro.2015.09.064

Pekalski, R. (1990). Experimental and theoretical research in archery. *Journal of Sport Sciences*, *8*, 259-279. doi:10.1080/02640419008732150

Ranjita, L., & Sarada. (2014). Progressive muscle relaxation therapy in anxiety: A neurophysiological study. *Journal of Dental and Medical Sciences*, *13*(2), 25-28.

Revelle, W., & A. Loftus, D. (1992). The implications of arousal effects for the study of affect and memory. In S. Christianson, *The handbook of emotion and memory: Research and theory* (pp. 113-149). Hillsdale, NJ: Lawrence Erlbaum Associates.

Robazza, C., Bortoli, L., & Nougier, V. (1998). Physiological arousal and performance in elite archers: A field study. *European Psychologist*, *3*(4), 263-270. doi:10.1027/1016-9040.3.4.263

Robazza, C., Pellizzari, M., & Hanin, Y. (2004). Emotion self-regulation and athletic performance: An application of the IZOF model. *Psychology of Sport and Exercise*, *5*(4), 379-404. doi:10.1016/S1469-0292(03)00034-7

Sadeghi, B., Sirati-Nir, M., Hajimini, Z., Ebadi, A., & Ali-Asgari, M. (2018). Comparing the effects of progressive muscle relaxation and physical activity on pregnant women's general health. *Iranian journal of nursing and midwifery research*, *23*(4), 298–304. doi:10.4103/ijnmr.IJNMR_54_17

Sakhare, N., Sharma, K., Syal, A. (2018). Effect of progressive muscular relaxation technique and autogenic relaxation technique on pre competitive state anxiety and self confidence in athletes. *International Journal of Advance Research, Ideas and Innovations in Technology*, *4*(6), 403-410.

Seo, J., Kim Y. T., Song, H. J., Lee, H. J., Lee, J. M., Jung, T. D., Lee G. Y., Eunjin, Kwon, Kim, J. G., Chang, Y. M. (2012). Stronger activation and deactivation in archery experts for differential cognitive strategy in visuospatial working memory processing. *Behavioural Brain Research*, *229*(1), 185-193. doi:10.1016/j.bbr.2012.01.019

Soylu, A., Ertan, H., & Korkusuz, F. (2006). Archery performance level and repeatability of event-related EMG. *Human Movement Science*, *25*(6), 767-774. doi:10.1016/j.humov.2006.05.002

Srilekha, S., Soumendra, S., & Chattopadhyay, P. (2013). Effect of muscle relaxation training as a function of improvement in attentiveness in children. *Journal of Social and Behavioral Sciences*, *91*, 606-613. doi:10.1016/j.sbspro.2013.08.460

Stevens, J. P. (1999). *Intermediate statistics: A modern approach.* Mahwah, NJ: Lawrence Erlbaum Associates.

Sundram, B. M., Dahlui, M., & Chinna, K. (2015). Effectiveness of progressive muscle relaxation therapy as a worksite health promotion program in the automobile assembly line. *Industrial Health*, *54*, 204-214. doi:10.2486/indhealth.2014-0091

Surendra Sharma, H., Sunderlal Singh, N., & Bimol Singh, T. (2015). Effectiveness of six weeks training on static strength of archery players. *International Journal of Physical Education, Sports and Health*, *1*(5), 34-36.

Sureyya, Y. (2017). The impact of hand grip strength exercises on target shooting accuracy score for archers. *Journal of Education and Training Studies*, *5*(5), 6-16.

Tatenda, C. M. (2013). *The development of an arousal and anxiety control mental skills training programme for the Rhodes University archery club.* Rhodes University: Master of Arts in Clinical Psychology (Cwk/Thesis).

Vadoa, E. A., Hall, C. R., & Moritz, S. E. (1997). The relationship between competitive anxiety and imagery use. *Journal of Applied Sport Psychology, 9*(2), 241-253. doi:10.1080/10413209708406485

Parnabas, V. A., Mahamood, Y., Parnabas, J., Abdullah, N. M. (2014). The relationship between relaxation techniques and sport performance. *Universal Journal of Psychology*, 2(*3*), 108-112. doi:10.13189/ujp.2014.020302

Weinberg, R., & Gould, D. (2010). *Foundations of sport and exercise psychology 5th Ed.* Champaign, IL: Cloth Pass/Kycd.

Williams, A., Singer, R., & Frehlich, S. (2002). Quiet eye duration, expertise and task complexity in near and far aiming tasks. *Journal of Motor Behavior*, *34*, 197-207. doi:10.1080/00222890209601941

Woframm, I. A., & Micklewright, D. (2011). The effect of a mental training program on state anxiety and competitive dressage performance. *Journal of Veterinary Behavior: Clinical Applications and Research*, *6*(5), 267-275. doi:10.1016/j.jveb.2011.03.003

Yerkes, R., & Dodson, J. (1908). The relation of strength of stimulus to rapidity of habit-formation. *Journal of Comparative Neurology and Psychology*, *18*, 459-482. doi:10.1002/cne.920180503

Zamenjani, N. M., Masmouei, B., Harorani, M., Ghafarzadegan, R., Davodabady, F., Zahedi, S., & Davodabady, Z. (2019). The effect of progressive muscle relaxation on cancer patients' self-efficacy. *Complementary Therapies in Clinical Practice*, *34*, 70-75. doi:10.1016/j.ctcp.2018.10.014