Sports Exercise and Health Science Extended Essay

Title: A study of the effects of Mindfulness Meditation Therapy (MMT) on accuracy in competitive 10 metre Air Pistol Shooting

Research Question: ***How does Mindfulness Meditation Therapy (MMT) effect accuracy in 10 metre Air Pistol Shooting in a competitive environment when comparing two groups of amateur male shooters from Mumbai with 6-8 years of training experience?***

Word Count: 3968

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Introduction

In India's sporting history, shooting has played a key role. In terms of medal tally, shooting is India's most successful individual sport at both the Olympic and Commonwealth Games. For example, shooting accounts for 33% of India's Commonwealth Games gold medals (Commonwealth Games Federation 2014) and the only individual Olympic Gold medal won by an Indian athlete is in shooting (Ashutosh 2008). The success of Indian athletes in shooting sport does not come primarily from their physical fitness, instead, success in shooting sport is generally credited to mental toughness. In fact, according to psychologist Dr. Keyes of the American National Rifle Association, "shooting is 90% (a) mental (sport)" and only 10% physical (Keyes 2015).

This statement by Dr. Keyes can be backed up by statistics of the age of past Olympic champions. Even though athletes achieve their physical peak in their early to mid-twenties (Malinowski 2011) the mean age for a World and Olympic Champion in 10 metre and 50 metre Pistol over the years 2010-2016 is 35.4 (ISSF 2017). This is because, it takes a long period of experience to develop the psychological toughness (for eg. a large attention span, ability to withstand stress, mental pressure etc.)

Shooting has long been my passion and I have been competing at the national level for over 5 years. Through my EE I wanted to help the shooting community by researching on new and innovative training methodologies.

Success in this sport relies largely on the attention span of the shooter. This is because one has to have the mental capacity to focus on serial skills involved in each individual shot. Each individual shot can take up to a minute or more in Olympic disciplines such as 10 metre Air

Pistol and the athlete has to maintain a certain degree of concentration for the entirety of the process. Therefore, in order to increase the accuracy of a shooter an important aspect would be increasing one's attention span. This is why Mindfulness Meditation Therapy (MMT) has been chosen as the area of research. Numerous studies show the positive effects of MMT on brain cognition. MMT has been researched to "improve working memory capacity" (Michael D. Mrazek 2013) and even "brief MMT" has been found to "reduce mind wandering" (Rahl, et al. 2017).

All of the aforementioned research implied that MMT might have a strong correlation with accuracy. Since I am passionate about improving the training methods of Indian shooters at the grassroots level, I formulated the following research question:

Research Question: How does mindfulness meditation therapy effect accuracy in 10 metre Air Pistol Shooting in a competitive environment when comparing two groups of amateur male shooters from Mumbai with 6-8 years of training experience?

Hypothesis: There will be a positive correlation between MMT and accuracy in 10m Air Pistol shooting.

The reason for choosing to study the effects of MMT on amateur shooters is because it is important to find new, efficient training methodologies at the grassroots level (shooters with 6-8 years training) so that more amateur shooters can improve their scores and start shooting at the professional level. The experiment design shall have 2 competitions. There will be an experimental and control group. Both the groups will be initially made to shoot a match. Then, both groups will have a fixed 3-week training programme to follow. Only the

experimental group will undergo MMT for 3 weeks. Then both groups will play another match. It is important to test the subjects in a competitive environment because competition is a true test of a shooter's attention span and ability to perform in a high stress situation.

If my hypothesis holds true, then my research will reinforce that MMT increases attention span and reduces anxiety. Therefore, my research may inspire more members of society to take up MMT and lead a more enjoyable relaxed life.

Theoretical Background

10-meter air pistol shooting is a unique sport that involves fine and serial motor skills. A match consists of 60 shots over 90 minutes. Each shot has a maximum value of 10 and the scores are added to a total out of 600. Every individual shot involves a series of several discrete biomechanical movements that require fine muscular movement and immense focus by the athlete when he is shooting. For example, before taking a shot, the shooter has to maintain a constant muscle tone in his arm in order to ensure accuracy. While doing this, the shooter also has to align his rear sight aperture with the front sight (Findley 2013) and simultaneously apply a constant amount of force on the trigger to increase the precision of the shot. The motor skill is also closed, ie – aspects of the environment such as distance of target, equipment and lighting is predictable. Figure 1 depicts the various aspects of technique a shooter has to focus on when shooting a shot.

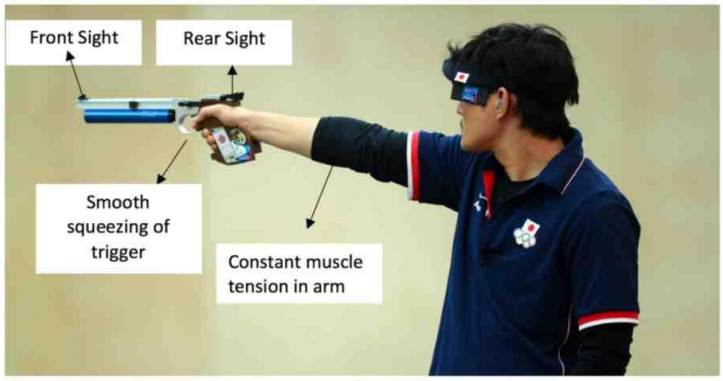


Figure 1 – Aspects of a shot

Source: https://www.wired.com/2012/07/olympic-gear-firearms/

It is often said that "the deciding factor between winning and losing is not the skill but the ability to perform it under stress" (Sproule 2012) and this statement holds true particularly in pistol shooting. It is very common to see novice athletes perform very well in training but suddenly perform drastically worse in high-pressure competitions due to high levels of

physiological arousal (Keyes 2015). This implies that it generally takes several years of competing for an athlete to develop the psychological toughness to withstand stress and mental pressure. This idea is reinforced by the mean age for a World and Olympic Champion in 10 metre and 50 metre Pistol being 35.4 over the years 2010-2016 (ISSF 2017).

Figure 2 – 19-year old Pavlo competes at the senior World Cup

Source: http://galsports.com/Files/News/2014/11/29/Korostylov.jpg

Therefore, the world shooting fraternity has been shocked to see a very young 19-year old Ukrainian shooter named Pavlo Korostylov consistently win gold medals in the senior's category at the world level. In early 2017 he won gold at both, the World Cup in Munich and the European Championships in Baku (ISSF 2017). Pavlo's successes made me curious about what mental factors influence sport performance and prompted me research what arousal is and how it effects performance in competition.

Physiological arousal refers to the level of activeness of the sympathetic nervous system. The sympathetic nervous system consists of the pre-ganglionic and post-ganglionic neurons and is responsible for the release of adrenaline and the fight or flight response of the human body. Therefore, the greater the arousal level, the greater will be the pupil dilation, sweating, heart rate and blood pressure (Science Daily 2017).

According to the Inverted U theory created by psychologists Yerkes and Dodson in 1908, there is an optimal level of arousal needed for performance to peak when carrying out a complex task such as pistol shooting. The level of arousal needed for optimum performance

depends on how intellectually demanding the task is (Dodson 1908). If a task is very difficult or intellectually demanding (such as pistol shooting), it will have an optimum performance level at a higher arousal as compared to an easy task (such as walking).

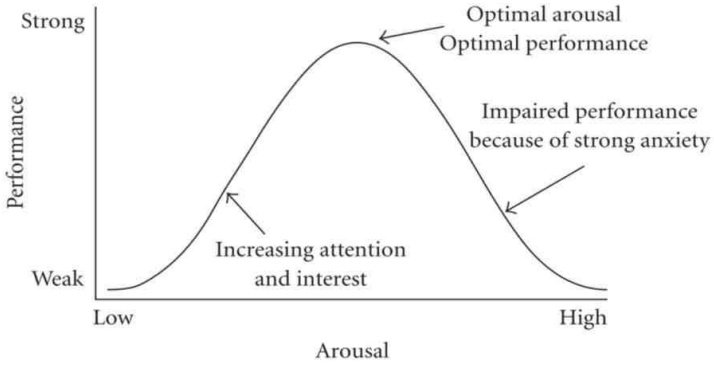


Figure 3- Inverted-U Theory

Source:
http://resource.download.wjec.co.uk.s3.amazonaws.com/v

At low arousal levels, the athlete has a very wide attentional field. This results in an information overload by the external and internal stimuli sensors and will prevent the shooter from making correct decisions on the actions to be taken for a good shot. At the optimal arousal level, the attentional width is ideal, allowing the athlete to selectively focus on the important aspects of the task being carried out (Dodson 1908). At extremely high arousal levels the perceptual field narrows which results in a panicked state known as hypervigilance. Consequently, decision making is effected which in turn effects accuracy. In summary, if an athlete's level of arousal is below or above the optimal level the performance level will drop. The Inverted U theory is depicted in Fig 3.

Upon further research, the three-dimensional Catastrophe theory was developed by sports psychologists Hardy and Fazey. The extra dimension added was cognitive anxiety, which refers to the mental manifestations of anxiety. According to the Catastrophe theory, an increase in cognitive anxiety will improve performance if physiological arousal is low (Hardy

1991). However, if cognitive anxiety is high, increases in physiological arousal will result in an extreme drop in performance after an optimal level of arousal where performance peaks.

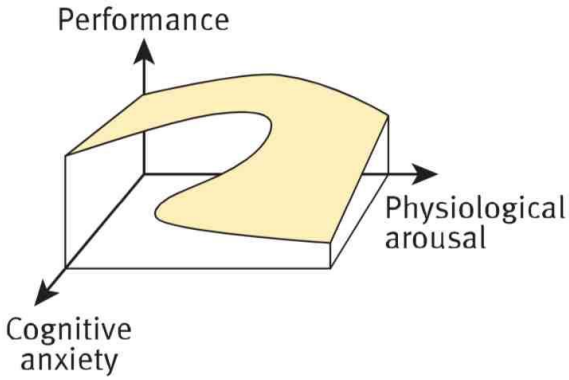


Figure 4- Catastrophe Theory

Source: (Sproule, 2012)

The catastrophe theory is depicted in Fig 4. One can see the extreme performance decline that occurs when arousal levels exceeds an optimum level.

The young Ukranian shooter Pavlo Korostylov and all other top shooters would be able to consistently control their arousal levels near the optimum in order to maintain consistent high performance in air pistol shooting. Pavlo's astounding victories at such a young age made me wonder if there can be specific ways to train to handle the high arousal levels that pistol shooters face in competition. Upon research I learned that there are various training methods to control arousal in sports.

A commonly used method is known as progressive muscle relaxation (PMR). PMR involves an athlete consciously focusing on contracting the fibres in a specific muscle group and then relaxing them (Vincent Parnabas 2014). If repeated several times, an athlete will be able to be in greater control of their muscle tension during competition. For example, when a footballer (who is done regular PMR training) is waiting to take a penalty he can relax his muscles and achieve the optimum arousal level needed to score the penalty. Another method to control

anxiety is imagery and visualization (Ekeocha 2015). Imagery is theorized to strengthen "muscle memory" and "mental blueprint" for the movement patterns of a task (Hall 1999). Lastly, mindfulness can be one of the ways to reduce the arousal of an athlete.

Mindfulness is the psychological process of "bringing one's attention to the bodily experiences occurring in the present moment" (Baer 1994). When the skill of mindfulness is developed using meditation, it is known as mindfulness meditation therapy. Mindfulness helps reduce stress and arousal while competing and is also linked to better sleep quality for athletes (P. Furrer 2015). The reason for researching on the effects of MMT instead of the other techniques is because meditation was originated in India (Everly 2013) and is therefore very well known amongst the general population. This implies that the experimental group will be relatively more familiar to MMT as compared to PMR or mental imagery and will therefore be more willing to practice it continually at home.

In an air pistol match, shooters often dwell too much on bad shots they have shot in the past, rather than focusing on their process in the present. For example, a shooter may shoot a 6 out of 10 points in his first shot of a sixty shot match. If he continues to think about the badly executed 6 that he shot in the past, it will impact the quality of his remaining fifty-nine shots in a match (Moore 2009). Mindfulness allows an athlete to filter out negative thoughts and focus on the task at hand (Bernier 2009). Athletes can react to situations objectively, without viewing a moment as 'positive' or 'negative' (Gardner 2004). This non-judgmental present-moment awareness maximizes concentration, and thereby performance (Bernier 2009). In essence, it is important for every pistol shooter to be "aware" of his "present bodily experiences", ie – develop mindfulness.

MMT has already been researched on "elite Norwegian" air rifle shooters in a 1996 study that concluded that "meditation may enhance performance amongst elite rifle shooters" (Solberg 1996). However, the reason for conducting a study on amateur pistol shooters was to see whether MMT is a practical training method for Indian pistol shooters at the grassroots level.

Methodology

Step 1 : Selection of Volunteers

Step 2 : Randomly allocating volunteers to an experimental and control group

Step 3 : Orienting the volunteers on their role in the experiment and making them fill a PAR-Q on July 2nd

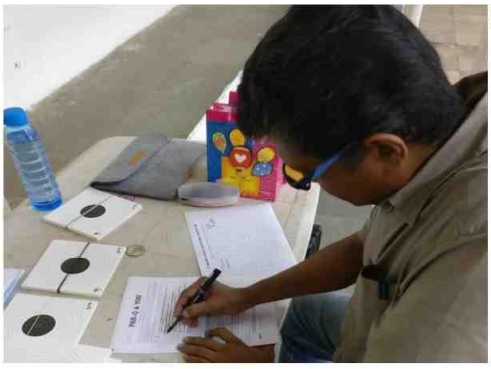


Figure 5- Subject Filling PAR-Q

Step 4 : Conducting 1st Competition Match on July 2nd for the experimental and control group

Figure 6 – Volunteers competing during the 1st Competition

Step 5 : Giving orientation to experimental group on how to do Mindfulness Meditation Therapy (MMT) at home

Figure 7 - Giving orientation to experimental group on MMT

Step 6: Both groups would follow a fixed training program for the following 3 weeks. The experimental group would also do MMT alongside the fixed training program

Step 7 : Conduct 2nd Competition Match on July 23rd for experimental and control group

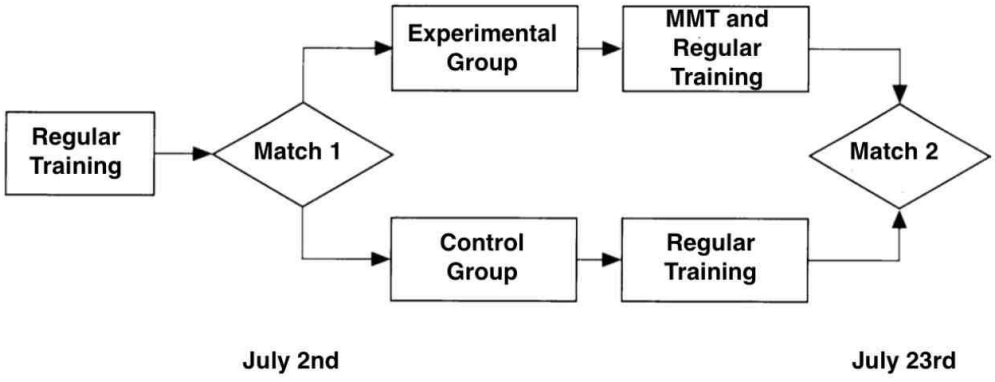
Explanation of method used:

For step 1, the member directory from the local club was used to identify 28 male shooters who had been training for 6 to 8 years. In step 2, the 28 subjects were randomly allocated into two groups, experimental and control, through random block sampling with 14 in each group. Also, the volunteers were made to fill out the PAR-Q (attached in appendix) to ensure that they were physically fit to partake in the experiment.

In step 4, the subjects were then made to compete in the first competition, which followed rules of the 10m Air Pistol event according to the International Shooting Sports Federation. Results were recorded and medals were distributed to the winners. No measuring instrument is needed to collect the data since the scores are clearly visible on the targets by the human eye. In step 5, the experimental group were demonstrated how they should conduct MMT. They were instructed to do it daily at home for 30 minutes. MMT is practiced sitting with eyes closed and back straight (Komaroff 2014). Attention is either put on the inhalation and exhalation of air, or on the rise and fall of the abdomen. If the mind wanders one has to passively notice that their mind has wandered and then refocus their thoughts on their breath or the abdomen.

Then, for the next 3 weeks both groups were to follow a given training program (attached in the appendix) and the experimental group had to do additional 30 minutes MMT daily. In step 7, the 2nd competition match was conducted after 3 weeks from the first and followed the same rules and regulations.

The following flowchart summarizes the timeline:



Justification of the use of MMT:

MMT was used over other methods of mental training because the experimental group felt culturally comfortable with MMT since meditation was invented in India (Everly 2013) and is a common practice in Indian culture. Secondly, performing MMT is relatively easy to understand and requires no purchase of any extra equipment (Komaroff 2014). Therefore, even though some of the volunteers were from a lower socio-economic class, lack of money did not restrict them from doing MMT daily.

Justification of the testing used:

The purpose of this extended essay was to determine the effects of MMT on the "accuracy" of shooters in a *"**competitive environment**"*. According to the study design principal of specificity, simulating a competitive environment is necessary because only if athletes truly feel the arousal they face during important matches can we understand the effectiveness of MMT as a tool to control and achieve optimum arousal.

To simulate a competitive environment, the matches were organized to follow the exact rules and regulations of the International Shooting Sports Federation. This allows the experiment to conform to the study design principal of validity. Moreover, to further simulate competition conditions, athletes were informed that after the match there would be a prize distribution where winners would receive medals on a podium. This created a spirit of competition amongst the athletes because all of them were now competing for medals. Lastly, reliability of the experiment was ensured by preventing a habituation effect, since all of the participants chosen had 6-8 years of competing in the sport.

Results

Raw Data Tables:

Table 1.0 - Raw data for match 1 (before MMT) of experimental group (±1 point):

NAME	SERIES 1 (±1 point)	SERIES 2 (±1 point)	SERIES 3 (±1 point)	SERIES 4 (±1 point)	SERIES 5 (±1 point)	SERIES 6 (±1 point)
Participant 1	91	92	92	93	93	90
Participant 2	78	76	70	79	71	74
Participant 3	92	90	91	93	90	90
Participant 4	88	91	90	89	90	92
Participant 5	93	92	91	92	90	91
Participant 6	92	97	89	95	91	93
Participant 7	88	91	95	89	92	93
Participant 8	88	86	86	88	87	85
Participant 9	91	89	86	92	88	87
Participant 10	87	88	91	90	88	89
Participant 11	88	93	90	90	91	90
Participant 12	87	85	87	86	88	85
Participant 13	92	90	95	93	90	94
Participant 14	84	82	88	86	84	85

Table 1.1 – Raw data collected for match 1 of control group (±1 point)

NAME	SERIES 1 (±1 point)	SERIES 2 (±1 point)	SERIES 3 (±1 point)	SERIES 4 (±1 point)	SERIES 5 (±1 point)	SERIES 6 (±1 point)
Participant 15	91	92	94	93	95	92
Participant 16	94	92	91	94	94	92
Participant 17	86	85	94	90	90	89
Participant 18	88	85	85	89	88	85
Participant 19	89	87	85	86	90	87
Participant 20	85	85	93	94	91	87
Participant 21	95	95	95	95	93	96
Participant 22	93	93	96	92	93	94
Participant 23	91	86	89	87	86	88
Participant 24	84	91	87	88	86	90
Participant 25	85	91	86	90	85	88
Participant 26	90	90	86	84	90	90
Participant 27	93	92	91	91	90	87
Participant 28	90	91	87	84	90	90

Table 1.2 - Raw data for match 2 of experimental group (after MMT) and regular training (±1 point)

NAME	SERIES 1 (±1 point)	SERIES 2 (±1 point)	SERIES 3 (±1 point)	SERIES 4 (±1 point)	SERIES 5 (±1 point)	SERIES 6 (±1 point)
Participant 1	92	93	91	92	93	93
Participant 2	76	77	77	70	84	71
Participant 3	90	88	88	91	93	90
Participant 4	89	91	93	90	92	90
Participant 5	92	93	95	91	92	95
Participant 6	95	94	94	93	95	95
Participant 7	93	91	92	95	89	92
Participant 8	84	89	87	86	88	92
Participant 9	91	89	86	86	92	91
Participant 10	88	91	91	91	90	88
Participant 11	84	90	93	90	90	91
Participant 12	89	84	88	91	86	88
Participant 13	92	93	94	95	93	90
Participant 14	84	84	86	88	86	90

Table 1.3 - Raw data for match 2 of control group after regular training (±1 point)

NAME	SERIES 1 (±1 point)	SERIES 2 (±1 point)	SERIES 3 (±1 point)	SERIES 4 (±1 point)	SERIES 5 (±1 point)	SERIES 6 (±1 point)
Participant 15	91	92	94	93	95	92
Participant 16	94	92	91	94	94	92
Participant 17	86	85	94	90	90	89
Participant 18	88	85	85	89	88	85
Participant 19	89	87	85	86	90	87
Participant 20	85	85	93	94	91	87
Participant 21	95	95	95	95	93	96
Participant 22	93	93	96	92	93	94
Participant 23	91	86	89	87	86	88
Participant 24	84	91	87	88	86	90
Participant 25	85	91	86	90	85	88
Participant 26	90	90	86	84	90	90
Participant 27	93	92	91	91	90	87
Participant 28	90	91	87	84	90	90

Calculations

Key:
- Data for which total score is calculated

Calculating Total Score:

Total Score = Sum of scores in each series

E.g. for participant 1 from table 1.3: Total score: 91 + 92 + 94 + 93 + 95 + 92 = 557

Key:
- Data for which net improvement is calculated

Calculating Net Improvement:

Net Improvement= Match 2 Total Score - Match 1 Total Score

E.g. for participant 1 from table 2.0: Total score: 554 – 551 = 3

Table 2.0 Processed data table depicting the total score and net improvement of the experimental group after MMT and regular training (±1 point):

Name	Match 1 Total Score (±1 point)	Match 2 Total Score (±1 point)	Net Improvement (±1 point)
Participant 1	551	554	3
Participant 2	448	455	7
Participant 3	546	540	-6
Participant 4	540	545	5
Participant 5	549	558	9
Participant 6	557	566	9
Participant 7	548	552	4
Participant 8	520	526	6
Participant 9	533	535	2
Participant 10	533	539	6
Participant 11	542	538	-4
Participant 12	518	526	8
Participant 13	554	557	3
Participant 14	509	518	9

Table 2.1: Processed data table depicting the total score and net improvement of the control after regular training (±1 point):

Name	Match 1 Total Score (±1 point)	Match 2 Total Score (±1 point)	Net Improvement (±1 point)
Participant 15	560	557	-3
Participant 16	558	557	-1
Participant 17	536	534	-2
Participant 18	519	520	1
Participant 19	520	524	4
Participant 20	540	535	-5
Participant 21	561	569	8
Participant 22	554	561	7
Participant 23	526	527	1
Participant 24	530	526	-4
Participant 25	529	525	-4
Participant 26	531	530	-1
Participant 27	533	544	11
Participant 28	539	532	-7

Calculating Mean

$$\overline{X} = \frac{\sum X}{N}$$

Key:
- Data used for calculating mean net improvement

Here, the mean of net improvement in score = $\bar{X}$;Number of participants = N

∑X refers to the addition of the net score improvement of each participant.

The total number of participants in each group was 14. Hence, an example calculation for the mean net improvement for the control group is:

Eg: Average net improvement of participants in table 2.1

$$= \frac{-3-1-2+1+4-5+8+7+1-4-4-1+11-7}{14}$$

$$= 0.357$$
$$\approx 0.36$$

Table 2.2

Mean Net Improvement of Experimental Group (±0.05 points)	Mean Net Improvement of Control Group (±0.05 points)
4.36	0.36

Calculating Standard Deviation:

The following formula is used to calculate the Standard Deviation:

$$s_x = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}}$$

(Courtney 2017)

n = The number of data points
$\bar{x}$ = The mean of the x_i
x_i = Each of the values of the data

Key:
- Data used for calculating Standard Deviation

Eg.: To calculate the Standard Deviation for the data in athletes in table 2.1, we calculate as under:

$$(n-1) = 14 - 1 = 13$$

$$\sum_{i=1}^{n}(x_i - \bar{x})^2 = 370.7$$

$$\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2} = 19.25$$

Hence,

$$\sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{(n-1)}} = 5.34$$

Table 2.3

Standard Deviation of Net Improvement of Experimental Group (±0.05 points)	Standard Deviation of Net Improvement of Control Group (±0.05 points)
4.61	5.34

Conducting T-Test

Conducting the T-test is important to understand the statistical reliability of the data obtained in the experiment. The t-test gives a value of the probability (p). If $p < 0.05$, the experiment supports the alternative hypothesis, and rejects the null hypothesis (Frost 2017). A null hypothesis is the hypothesis "that proposes that no statistical significance exists in a set of given observations" (Investopedia 2017). In this case, the null hypothesis is that "there does not exist a statistically significant positive correlation between MMT and accuracy in 10m Air Pistol" while the alternative hypothesis would be that "there exists a statistically significant positive correlation between MMT and accuracy in 10m Air Pistol".

The T-Test was conducted using Microsoft Excel using the following formula shown in Cell C60

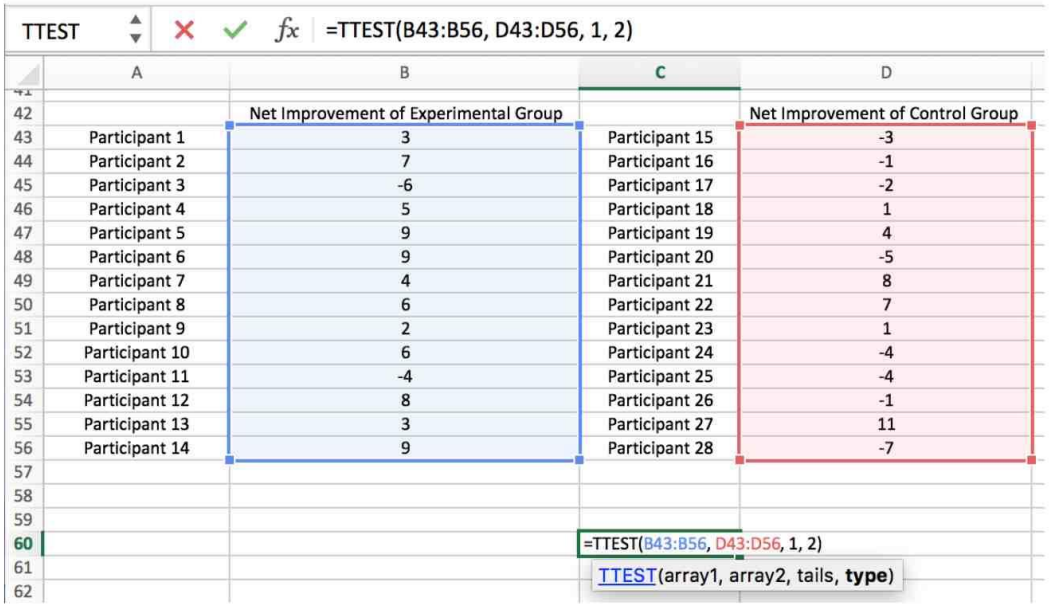
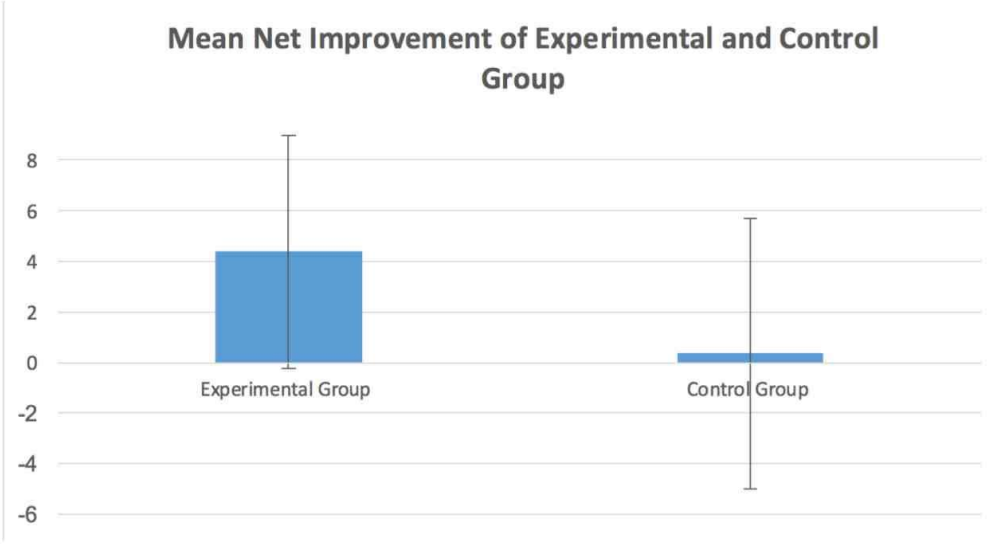


Table 2.4

Value of p from t-test
0.0218

Graph 1 showing the mean net improvement of experimental and control group (± 0.05 points)



Analysis

Graph 1 depicts the mean net increase of 4.36 (±0.05 points) in the mean score of the experimental group and a 0.36 point (±0.05 points) increase in the score of the control group. Table 2.3 depicts that the standard deviation of the control group was greater at 5.34 (±0.05 points) than the experimental groups standard deviation of 4.61 (±0.05 points). This conveys that the shooters in the control group were more inconsistent than shooters in the experimental and had a larger spread of values around the mean (Sproule 2012). Table 2.4 depicts that the correlation of the data collected is statistically significant since the p value is 0.0218, which is lower than the critical value of 0.05 (Frost 2017).

Conclusion and Discussion

The data obtained allows us to conclude **that MMT increases accuracy in amateur male 10m air pistol shooters with 6-8 years of training from Mumbai in a competitive environment.** There was a 4.36-point (±0.05 points) increase in the mean score of the experimental group who underwent MMT while only a 0.36-point (±0.05 points) increase in the score of the control group who did not. The standard deviation of the experimental group was 4.61 (±0.05 points) while the control group's was 5.34 (±0.05 points). Moreover, the t-test allows us to reject the null hypothesis and accept the alternate hypothesis that "there exists a statistically significant positive correlation between MMT and accuracy in 10m Air Pistol"

It is important to note that in 10m air pistol it takes relatively large amounts of training to increase scores by small amounts (Brijnath 2013). For example, the difference between first and second place during competition can be very minimal. An example would be at the 2016 Olympics where the difference between the first and second place was only 0.4 points (Rud 2016). Therefore, an increase in the average score by 4.36 (±0.05 points) of the experimental group depicts that MMT is quite an efficient way of increasing accuracy in sport.

As discussed in the theoretical background, the primary reasons for MMT increasing accuracy is that it allows athletes to control arousal levels and also increases the ease of information processing. When pistol shooters compete, they tend to face arousal levels higher than the optimum. Therefore, athletes tend to go into a state of hyper-vigilance, theorized by the Inverted-U theory. During hyper-vigilance, the attentional width of the athlete narrows and there is an exaggerated intensity of behaviours, which effects information

processing. The Catastrophe theory also theorizes an extreme drop in result at arousal levels greater than the optimum. Through MMT, an athlete's arousal levels lower and they are able to perform closer to the optimum, resulting in improved performance.

The conclusion supports research that similarly states that MMT improves performance in sport (Theinot 2009) (Si 2016). Therefore, it is important for amateur shooters worldwide to immediately start adopting MMT in preparation for when they start competing in higher-level competitions at the national and international-level.

However, a recent paper published in the "Perspective on Psychological Science" journal titled "Mind the Hype (on MMT)" states that almost all research on Mindfulness till date has been "wrought by significant conceptual and methodological problems" (Dam 2017). It states that future research on MMT has to be significantly more rigorous to scientifically prove the benefits of MMT. Furthermore, certain sports scientists argue that the benefits of MMT may come with certain side-effects. A 2009 paper in the "Advanced Journal" claims that MMT may have the "potential to create emotional and psychological disturbances" in individuals (Lustyk 2009). MMT is an exercise that forces individuals to focus on their own thoughts in isolation. Therefore, if an individual has faced certain traumatic experiences (for eg. a disastrous performance in an important match) in the recent past, the negative emotions from these experiences may be amplified by MMT.

Moreover, there exist various other forms of mental training such as progressive muscle relaxation (PMR) and mental imagery. A 2016 study on a group of "elite Indian rifle shooters" concluded that the group that performed PMR and visual imagery mental training

faced “significant improvement in rifle scores” while the group that underwent meditation faced “non-significant improvement” (Singh 2016).

Therefore, although we can conclude that MMT improves accuracy in 10m air pistol, it is important to question whether it is the most efficient training method in achieving this goal. Further study must be done on the effects of other mental training methods such as PMR and mental imagery on accuracy in 10m air pistol with comparison to MMT to come to a certain answer.

Evaluation

One of the limitations of the experiment can be attributed to sample size. 28 athletes is a relatively small number and is therefore not an accurate microcosmic representation of the entire pistol shooting community in Mumbai. Smaller the sample size, greater the statistical likelihood of insignificant data (Dell RB 2003) and increasing sample size will decrease the conclusion's margin of error (Ashley Kingman 2008). In future, a larger sample size of shooters from several clubs all over the city could be taken.

Secondly, it is possible that because of the extra amount of attention given to the experimental group (such as the orientation on MMT) they may have felt excess pressure to perform well in the matches. This is known as the Hawthorne effect and it might have affected the accuracy of the experimental group shooters (Jim McCambridge 2014). Another limitation of the experiment is that all of the volunteers were part of the same pistol club, which means that they knew one another as friends and colleagues. 10m air pistol is a co-active sport, therefore, knowing your opponents beforehand would make the matches a little informal and reduce their competitive nature and reduce competitor arousal levels.

Furthermore, the athletes were of various economic strata in society. Consequently, they would had varying levels of nutrition. Athletes from a lower economic stratum would be unable to afford similar amounts of protein than others who are from higher strata. Also, a confounding variable was that 16 out of the 28 athletes were vegan while others were not. This implies varying levels of protein consumption and therefore varying levels of muscle hypertrophy and power (Krieger 2013) which may have affected accuracy of athletes.

The various athletes in both groups had exposure to competitive sports at different levels. For example, participants 1, 6, 13, 15, 21 and 22 were national level players whereas others were competitors predominantly at the state or district level. Having more experience in competitive environments would allow the national level shooters to perform better during high pressure situations like the matches in the experiment, which may have affected the accuracy of the conclusion.

Also, despite having similar years of training, the age of athletes varied significantly. The range of age of the subjects was between 18-54 years and standard deviation of the experimental and control group was 14.12 years and 9.64 years respectively. As one ages, cardiovascular endurance and muscular endurance of an individual diminishes (Rittweger 2009). Muscular endurance is a key factors effecting performance in pistol shooting because matches are up-to 90 minutes long and involve long isometric holds of a 1 kg pistol. Therefore, the varying age may have affected the accuracy of the results.

Lastly, even though there was an attempt to motivate the athletes by awarding medals, the achievement motivation of the athletes would have been relatively low. The competition would not have been seen as very important for the athletes since it wasn't organized by an official shooting sports body (such as the state or national rifle association). The athlete's performances in the study would have no effect on their rankings at the district, state or national level. This would have reduced the athlete's need to achieve and consequently their achievement motivation, as theorized by Dr. Atkinson and Mclelland (Atkinson 1964). Therefore, the initial and final match scores may be more accurate of "competitive environment" "performance" if the matches were officially organized by the state or national sports authority.

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Appendix

PAR-Q (Forms 2013)

PAR-Q

If you are planning to take part in physical activity or an exercise class, start by answering the questions below. If you are between the ages of 15 and 69 the questionnaire will tell you if you should consult with your doctor before you start. If you are over 69 years of age, and you are not used to being very active, check with your doctor. **All information will be treated confidentially.**
Answer YES or NO:

1. Has your doctor ever said you have a heart condition and that you should only do physical activity recommended by a doctor?	Y	N
2. Do you ever feel pain in your chest when you do physical activity?	Y	N
3. Have you ever had chest pain when you were not doing physical activity?	Y	N
4. Do you ever feel faint or have spells of dizziness?	Y	N
5. Do you have a joint problem that could be made worse by exercise?	Y	N
6. Have you ever been told that you have high blood pressure?	Y	N
7. Are you currently taking any medication of which the instructions should be made aware?	Y	N
7a. If yes, what?		
8. Are you pregnant or have you had a baby in the last six months?	Y	N
9. Is there any other reason why you should not participate in physical activity?	Y	N
9a. If yes, what?		

If you have answered 'YES' to one or more questions
Talk to your doctor by phone or in person before you start becoming more physically active and before you have a fitness assessment.
Tell your doctor about the questionnaire and which question(s) you answered yes to. You may be able to do any activity you want – as long as you begin slowly and build up gradually, or you may need to restrict your activities to those which are safe for you. Talk with you doctor about the kind of activity you wish to participate in and follow his/her advice.

If you have answered 'NO' to all questions:
You can be reasonably sure that you can start to become more physically active and take part in a suitable exercise programme. Remember – begin slowly and build up gradually.

Please note:
If your health changes so that subsequently you answer yes to any of the above questions, inform your fitness or health professional immediately. Ask whether you should change your physical activity or exercise plan. Delay becoming more active if you feel unwell because of a tempory illness such as cold or flu – wait until you are better.

☐ I have read, understood and completed this questionnaire
All questions have been answered to the best of my knowledge

First Name_____ Surname_____ Signature_____
Address_____
Post Code_____ Date of Birth_____
Phone Number_____ Date_____
Emergency contact's name and phone number_____
Preferred method of contact: Post / E-mail / Text Message (Mobile No. or E-mail address)_____

Fixed Training Program Given to both experimental and control group to follow for 3 weeks

	Exercise	Reps/time	Sets	Rest time/rep	Rest time/set
1	Isometric Holding	5 reps	2	45 seconds	90 secs
2	Eyes-Closed Holding	5 reps	2	45 seconds	90 secs
3	Feet-Closed holding	5 reps	2	45 seconds	90 secs
4	Dry-fire on back target	5 reps	2	45 seconds	90 secs
5	Live fire on back target	20 reps	1	30 secs	120 secs
6	Live fire on front target	25 reps	1	30 secs	120 secs