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RELATIONSHIP BETWEEN SHOOTING PERFORMANCE AND MOTORIC CHARACTERISTICS, RESPIRATORY FUNCTION TEST PARAMETERS OF THE COMPETING SHOOTERS IN THE YOUTH CATEGORY

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Abstract:
Shooting is a high precision sport, where high level performance requires several physical capacities, striking control, experience, posture control and skill of a shooter. The purpose of this study is to investigate the relationship between the shooting performance and physical capacities of the competing shooters. A total of 19 shooters participated as volunteers in the Turkish Championship youth category. Anthropometric measurements and shooting scores were recorded. Hand grip strength, flexibility, reaction time, dynamic balance, maximal oxygen consumption and respiratory function tests were applied. The correlation between shooting performance and respiratory function parameters, motoric characteristics were examined by Pearson Correlation analysis. A statistically significant correlation was found between the flexibility and shooting performance ($p<0.05$). There was a statistically significant correlation between right-left hand grip strengths and shooting performance ($p<0.05$). There was no statistically significant correlation between shooting performance and reaction time, respiratory function parameters, endurance, balance parameters ($p>0.05$). Motoric properties and respiratory control are important factors for successful shooting. The results of this study can provide for trainers for determining the developments and deficiencies of the different age group shooters at the point of preparation of the training plan by determining the motor characteristics during the season.

Keywords: physical capacities; breathing; shooting performance

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1. Introduction

The air pistol shooting is a sports field that requires physical capacities as well as technical infrastructure and high mental focus and complex skills. The shooters shoot at the polygon located in the indoor environment, with air pistol or rifle to targets located 10 m away. Technical knowledge during shooting performance is used with mental focus. Physical strength and endurance are critical to sustaining this process throughout the entire competition. The shooter has to control a lot of extremities, joints and muscles from the feet to the wrist to keep the rifle and gun in the desired position. An air-pistol shooter should attempt to optimize their shooting position which will improve their postural stability, hold, aim, trigger control and ultimately score. To properly score a maximum value shot, a shooter must correctly perform all areas of their shooting process (NRA, 2008).

A proper marksmanship in pistol shooting is depends on many variables. Those variables include the skill of the shooter, experience, upper extremity and core strength, and posture control. Shooting is a high precision sport, where high level performance requires control of all body movements. The muscular strength, posture control and close coordination between eye, nervous system and the musculoskeletal system. In general, it is thought that heart rate, anxiety level, anthropometric measurements, health and sport related physical fitness parameters (endurance, balance, coordination, reaction time) directly affect the shooting (İskender, 2010; González Chas, 1997). Assessment of the physical capacities of athletes is one of the most important issues in modern sports, many test used in order that selection procedures, for screening candidates, or to monitor the efficacy of training regimes (Mon, 2006; Mon, 2009).

Motoric properties and respiratory control are important factors in deviation from target. Being able to focus on the goal and be successful is to become an aerobic endurance, to finish it from the first shot to the last, to plan appropriateness and to have a significant effect on performance (González Chas, 1997; Belinchon, 2010; Balasubramaniam and Riley, 2000). The adaptive changes of human performance induced by high training to optimise the motor and functional capacity are the main goals of sports field and in the trends of interdisciplinary scientific researches (Badau et al., 2018; Gorucu et al., 2017; Dusa et al., 2017). While some studies have investigated the relationships between shooting performance and postural balance, shoulder strength, forearm muscular control, an insufficient number of studies have been evaluated many physical capacities in elite shooters. Therefore, the purpose of this study was to investigate the relationship between the shooting performance and physical capacities (strength, endurance, flexibility, reaction time, balance, respiratory function parameters) of the competing shooters in the youth category.

2. Material and Methods

2.1. Participants

A total of 19 female shooters participated as volunteers in the Turkish Championship youth category (age: 16.37±1.38 year, body height: 162.46±8.78 cm, body mass: 55.1±8.39 kg). The subjects have no health problems. They were all nonsmokers. Shooters had three years of training experience. The shooters were informed about the experimental procedures and signed an informed consent form. Participants were informed about the purpose and methods of the study prior to giving their informed consent. The study was approved by the Pamukkale University Ethics Committee, and was conducted in a manner consistent with the institutional ethical requirements for human experimentation in accordance with the Declaration of Helsinki.

2.2. Procedures

All measurements were evaluated 3 days and randomization was used. On the first day, the players participated in anthropometric measurements followed by hand grip strength, flexibility, dynamic balance measurements. On the second day, reaction time, respiratory function measurements were performed respectively. On the third day, shooters performed the multi-stage 20-m shuttle run test.

2.2.1. Anthropometric Measurements

The body height of the participants was measured using a stadiometer with an accuracy ± 1 cm (Seca, Germany), and an electronic scale (Tanita BC-418, Japan) with an accuracy of ± 0.1 kg was used to measure body mass. Leg length was measured the lower extremity length, two different starting points were identified: spina iliac anterior superior (SIAS) and umbilicus (Norton et al., 2004).

2.2.2. Shooting Point Measurements

The participants' performance was measured by use of official paper targets, according to the Turkey Shooting Federation Rules and Regulations and as provided by the referees of the Turkish Olympic shooting federation after the competition. All shooters participated as volunteers in the Turkish Championship youth category. According to Turkey shooting federation rules, in 10 m air pistol; female were evaluated over a total of 400 points in 60 shoots in 50 minutes. After the warm-up and trial shoots, the 60 shoot results were recorded as the shoot performance score.

2.2.3. Hand Grip Strength Measurements

Grip strengths were measured using a hand grip dynamometer (Takei Japan) at standing position with shoulder adducted and neutrally rotated and elbow in full extension. Results were recorded as kilograms. For standardization, the dynamometer was set at the second or third handle position of which the participant claims to be more suitable. All measurements were performed for both dominant and non-dominant hands. Subjects performed three maximum attempts for each measurement and the average value of these trials was recorded. One-minute rests were given between each attempt and hands were alternated to minimize fatigue affects. No verbal encouragements were performed. The calibration of both instruments was tested periodically during the study (Arinci et al., 2002).

2.2.4. Flexibility Measurement

Flexibility measurements of the subjects were performed by sit-and-reach test on the flexibility stand. The subjects were applied to this test after warm-up. When the subjects rested their naked soles of feet on the test stand while sitting on the ground, they pushed forward ruler on the table extending forward without bending the knees and the stretching distance was recorded by standing 2 sec at the farthest point to extend (Özer, 2001; Sporis et al., 2011).

2.2.5 Reaction Time Measurements

The Plate Tapping Test (Reaction Tap Test) is a reaction test using an alternating wall tapping action which measures upper body reaction time, hand-eye quickness and coordination. This test is part of the Eurofit Testing Battery. The two yellow discs are placed with their centers 60 cm apart on the table. The rectangle is placed equidistant between both discs. The non-preferred hand is placed on the rectangle. The subject moves the preferred hand back and forth between the discs over the hand in the middle as quickly as possible. This action is repeated for 25 full cycles (50 taps). The time taken to complete 25 cycles is recorded. Performed the test twice and the best result is recorded. 1 minute rest was given between repetitions. All movements were recorded with a camera to check the score during the measurements (Eurofit, 1993).

2.2.6. Dynamic Balance Measurements

A verbal and visual demonstration of the SEBT (Star Excursion Balance Test) was provided to each participant by the investigator. There are 8 directions for the stance leg; only 3 directions were assessed in this study. Eight directions are redundant, so excursions were limited to anteromedial, medial, and posteromedial. Participants warmed up using a stationary bike for 5 minutes at a self-selected pace. Following the warm-up, each participant was asked to stand on her dominant limb in the center of the Combo grid (Engineering Fitness International, Inc, San Diego, California). Four practice trials for each of the 3 excursions were performed. Following a rest break, participants completed 3 trials in randomized order with a 10-second break between trials and 20 seconds between directions. The trial was completed when the participant returned to the starting position by placing the reaching leg within 5 in. (12.7 cm) of the stance leg. The trial was repeated if she lost balance, lost foot contact, or was unable to return the reaching foot to the starting position. Reach distance was normalized to the participant's leg length. For normalization, the mean reach distance of the 3 trials was divided by leg length (cm) and multiplied by 100 for a percentage score. The composite reach distance was calculated using the sum of the 3 normalized reach distances divided by 3 times the leg length, multiplied by 100 (Coughlan et al., 2012).

2.2.7. VO_2 max Measurements

Subjects' maximal oxygen uptake (VO_2max) was indirectly obtained using a multi-stage 20-m shuttle run test. It involved running between two lines set 20 m apart at a pace dictated by a recording emitting tones at appropriate intervals. Velocity was 8.5 $km.h^{-1}$ for the first minute, which increased by 0.5 $km.h^{-1}$ every minute thereafter. The test score achieved by the subject was the number of 20 m shuttles completed before the subject either withdrew voluntarily from the test, or failed to be within 3 m of the end lines on two consecutive tones. All subjects performed a 10 min warm-up that included prescribed jogging and stretching. Test results for each subject were expressed as a predicted VO_2max obtained by cross-referencing the final level and shuttle number (completed) at which the subject volitionally exhausted with that of the VO_2max table provided in the instruction booklet accompanying the multi- stage 20-m shuttle run test. Only fully completed 20 m shuttle runs were considered (Léger and Gadoury, 1989).

2.2.8. Respiratory Function Measurements

Respiratory function characteristic were evaluated by vital capacity (VC), forced vital capacity (FVC), forced expiratory volume in one second (FEV1), the ratio of FEV1 to FVC (the Tiffeneau index), tidal volume (TV) and maximum voluntary ventilation (MVV). Respiratory analyses were measured with a BTL brand Spirometer.

2.3. Statistical Analysis

The descriptive analyzes of all the test motoric characteristics of the shooters were calculated as mean and standard deviation. The correlation between shooting performance and pulmonary function parameters, motor performance were examined by Pearson Correlation analysis. All analysis were executed in SPSS for Windows version 17.0 and the statistical significance was set at $p<0.05$.

3. Results

The descriptive statistics of subjects and physical capacities measurements are given in Table 1.

Table 1: Descriptive statistics of subjects and physical capacities measurements

n = 19	Mean	Std. Dev.
Age (year)	16.37	1.38
Training Age	3.89	1.7
Body Height (cm)	162.46	8.78
Body Mass (kg)	55.19	8.4
Flexibility (cm)	21.58	8.14

Right hand grip strength (Nm)	28.59	8.29
Left hand grip strength (Nm)	27.26	8.23
Reaction time (s)	9.63	1.12
Right dynamic balance (cm)	118.30	1.35
Left dynamic balance (cm)	123.34	1.34
VO_2max ($ml.kg^{-1}.min^{-1}$)	57.64	1.26
FVC (l)	3.13	0.85
FEV (l)	2.75	0.82
PEF (l/s)	3.90	1.13
FEV/FVC (%)	88.64	1.51
TV (l)	0.75	0.31
MVV (l/min)	91.61	1.81
Shooting performance	371.42	9.55

The relationship between the shooting performance and the motor characteristics of the shooters is given in Table 2.

Table 2: Pearson Correlation analysis table between shooting performance and motoric characteristics in shooters

Shooting Performance		
Parameters r p		
Flexibility (cm)	-0.58	0.01*
Right hand grip strength (Nm)	0.48	0.04*
Left hand grip strength (Nm)	0.54	0.02*
Reaction time (s)	-0.04	0.87
Right dynamic balance (cm)	-0.03	0.89
Left dynamic balance (cm)	-0.15	0.54
VO_2max ($ml.kg^{-1}.min^{-1}$)	0.24	0.33

*p<0.05

A statistically significant relationship was found between the flexibility and shooting performance of the shooters ($p<0.05$). There was a statistically significant relationship between right-left hand grip strengths and shooting performance ($p<0.05$). There was no statistically significant relationship between shooting performance and reaction time, right and left dynamic balance and VO_2max ($p>0.05$).

Table 3 shows Pearson correlation analysis between shooting performance and respiratory parameters of the shooters.

Table 3: Pearson Correlation analysis table between shooting performance and respiratory function parameters in shooters

Shooting Performance		
Parameters	**r**	**p**
FVC (l)	0.33	0.16
FEV (l)	0.17	0.50
PEF (l/s)	0.04	0.86
FEV1/FVC (%)	-0.26	0.28

TV (l)	0.15	0.53
MVV (l/min)	-0.04	0.86

*p<0.05

There was no statistically significant relationship between the shooting performance and the forced vital capacity, forced expiratory volume, peak expiratory flow, the ratio of the Tiffeneau index (FEV1 to FVC), tidal volume and maximum voluntary ventilation values (p>0.05).

4. Discussion

In our study, we found that there was a statistically significant relationship between the flexibility and shooting performance. Previous studies have demonstrated (Aalto et al., 1990; Zatsiorsky and Aktov, 1990; Era et al., 1996; Konttinen et al., 1998; Mononen et al., 2007; Kayıhan et al., 2013) significant differences were found between the sets of students according to shooting accuracy groups for wrist circumference, biceps circumference, femur diameter, hand grip strength, flexibility, aerobic capacity, reaction time, balance, coordination, state anxiety level, anxiety variability, average heart rate, maximal heart rate and heart rate changes.

Shooting is an individual sport and lots of parameters affect shooter's performance. The muscular strength, posture control, precision, experience, skill of a shooter and upper extremity and core strength, may determine the accuracy of their shooting. The ability to stabilize the gun, related to movement of the various kinetic lines of the shooter's body, also plays a very important role. The movements of the center of pressure on the X axis (mainly related to body movements) as well as on the Y axis (mainly related to shoulder and wrist movement control) have been associated to the vertical and the lateral movements of the gun respectively (Zatsiorsky and Aktov, 1990). That's why all body movements is important. Also during shooting, shooters the lower extremity is static, the upper extremity is more dynamic. The increase in flexibility is important in the increase of posture control, upper extremity and core strength. The effect of flexibility on the shooting success; it is thought to be due to the positive effect of body-target harmony, which has an important place in shooting techniques. The relaxed position of the head on the shoulder and spine is thought to increase shoot success by increasing body-goal alignment.

In our study we found that there was a statistically significant relationship between right-left hand grip strengths and shooting performance (p<0.05). Shooting requires forearm muscle strength and mass, hand-eye coordination, grip strength, self-control and concentration (Era et al., 1996). The stability of the gun in the shooting position has been associated with the size of the grip of the gun. Muscles of the forearm dictate the strength of the hand. These muscles control the grip on a gun and the trigger pull (NSSF, 2009; Anderson and Plecas, 2000). Anderson and Plecas (2000) found significant correlations between shooting score, dominant grip strength (r=0.38) and forearm girth (r=0.28). Earlier studies revealed a positive association between handgrip strength and handgun qualifying score (Copay and Charles, 2001; Rodd et al., 2010; Charles and Copay, 2003; Vuckovic, G.; Dopsaj, 2007) show that 11.79 per cent of the efficiency of shooting from hand fire-arms. Under the control of gun and hand in harmony for successful shooting emphasizes that eclipse is the most important step for shooting success (Tang et al., 2008).

In our study, we found that there was no statistically significant relationship between shooting performance and respiratory function parameters, VO_2max, dynamic balance, reaction time. Shooting requires breath control, hand-eye coordination, concentration, close coordination between eye, nervous system and the musculoskeletal system. High attention level of shooters, particularly on respiratory timing and heart rate (a low heart rate facilitating shooting between two heart beats), could also contribute to increase the performance (Konttinen et al., 1998; Tremayne et al., 1993). Shooters have to implement breathing control during the shooting process. They have to achieve eye sight alignment while breathing and finish aiming and shooting while holding breath. As soon as breathing is suspended, the body's functions begin to depreciate as oxygen starvation sets in. One of plausible explanation for the lack of association between shooting performance and respiratory function parameters, VO_2max values could be due to the particular characteristics of the subjects.

Good postural balance is a vital component of a successful shooting performance. The study of Mononen et al. (2007) examined the relationships (r=0.33) between shooting accuracy and postural balance. The results of the Mononen et al. (2007) also suggested that postural balance is related to the shooting accuracy both directly and indirectly through rifle stability. Balance control is regulated through mechanisms of postural maintaining and stabilization, requiring management of body orientation in space by central processing of visual, vestibular and somatokinesthetic afferences (Horak et al., 1994; Massion, 1994). Static and dynamic motor skills are much important in activities such as shooting and fencing. Static balance is of major importance for shooters, fencers take much more advantage on dynamic balance (Benson et al., 1986; Fitzpatrick and McCloskey, 1994; Winter et al., 1998). Examples of field tests of dynamic balance include The Star Excursion Balance Test (SEBT). SEBT which involves stable stance with maximal targeted reach distance of the free limb in a number of directions; results from the SEBT might also be influenced by our subject's strength, flexibility or coordination. In general, reaction time had a larger number of significant shoot variable correlates compared to accuracy, regardless of shooter skill level. A differences between skilled shooters and less-skilled shooters in not only the number of accurate shoots made during the shooting task, but also shoot reaction time, number of accurate shoots per second (Ranes et al., 2014). Despite the fact that our study group consists of elite young shooters, it may be that the test we use the reason for not finding a meaningful result for reaction time.

The lack of significance may be due to a gender related differences and subject characteristics such as age and training age. This issue should also be noted as "limitations of the study". It is the power of this study that there are no comparative studies on several physical capacities in elite young shooters during national championship. There is therefore the need for further study on the importance of physical conditioning for shooting.

5. Conclusions

Motoric properties and respiratory control are important factors for successful shooting. The findings of the present study indicated that correlation between shooting performance and flexibility, right-left hand grip strengths, there was no correlation between reaction time, respiratory function parameters, endurance, balance parameters and shooting performance. The results of this study can provide for trainers for determining the developments and deficiencies of the different age group shooters at the point of preparation of the training plan by determining the motor characteristics during the season.

Conflicts of interest

The author declares no conflict of interest.

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